#85

PHASE I - RFI/RI WORK PLAN

SOIL/SOURCE CHARACTERIZATION

PRESENT LANDFILL (SWMU 114)
INACTIVE HAZARDOUS WASTE STORAGE AREA (SWMU 203)
OPERABLE UNIT 3
ROCKY FLATS PLANT

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U.S. Department of Energy
Rocky Flats Environmental Restoration
Program Office

EG&G Rocky Flats, Inc.
Rocky Flats Office
Golden, Colorado

INITIAL DRAFT FOR
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APRIL 6, 1990

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1.0 INTRODUCTION

This document presents the work plan for the Phase I RCRA Facility Investigation/Remedial Investigation (RFI/RI) for two Solid Waste Management Units (SWMUs) in Operable Unit (OU) 3, the Present Landfill (SWMU 114), and the Inactive Hazardous Waste Storage Area (SWMU 203) at the Rocky Flats Plant. It addresses characterization of source materials and soils in the area of these units. A subsequent Phase II plan will focus on groundwater contamination and the nature and extent of contaminant migration.

This investigation is part of a comprehensive, phased program of site investigation and characterization, remedial/feasibility evaluations, and remedial actions currently in progress at the Rocky Flats Plant. These activities are being administered to the U.S. Department of Energy (DOE), Environmental Restoration (ER) Program (formerly known as the Comprehensive Environmental Restoration Assessment and Response Program [CEARP]), pursuant to an Inter-Agency Agreement (OAG) (DOE 1989) among DOE, U.S. Environmental Protection Agency (EPA), and Colorado Department of Health (CDH). The IAG addresses Resource Conservation and Recovery Act (RCRA) and Comprehensive Environmental Response, Compensation and Liability Act of 1980 (CERCLA) issues and has been integrated with the ER Program. In accordance with the draft IAG, the CERCLA terms Remedial Investigation and Feasibility Study in this document are considered equivalent to the RCRA terms RCRA Facility Investigation (RFI) and Corrective Measures Study (CMS).

1.1 ENVIRONMENTAL RESTORATION PROGRAM

The ER Program is designed to investigate and clean up contaminated sites at DOE facilities. The ER Program is being implemented in five phases. The initial phase (Installation Assessment) includes preliminary assessments and site inspections to assess potential environmental concerns. The second phase (RFI/RI) includes planning and implementation of sampling programs to delineate the magnitude and extent of contamination at specific sites and evaluate potential contaminant migration pathways. The third phase (FS/CMS) evaluates remedial alternatives and develops remedial action plans to mitigate environmental problems identified as needing correction in the section phase. The fourth phase (Remedial Design/Remedial Action) includes design and

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implementation of site-specific remedial actions selected on the basis of the third phase (FS's /CMSs). The fifth phase (Compliance and Verification) implement monitoring and performance assessments of remedial actions, and verifies and documents the adequacy of remedial actions carried out under the fourth phase. The initial phase has already been completed at the Rocky Flats Plant (U.S. DOE 1986). This Phase I Work Plan initiates the second phase of the ER Program implementation for the Present Landfill.

Previous studies at the landfill site have identified the presence of contamination that potentially could impact human health and the environment if releases occurred from the landfill. Corrective measures are anticipated for the landfill and therefore, an RFI/FI is required to determine the full nature and extent of contamination associated with the site.

1.2 WORK PLAN SCOPE

This Phase I RFI/RI Work Plan presents a summary of existing data and a sampling plan for soil and source characterization. It does not address an assessment of the nature and extent of groundwater contamination, although groundwater quality data are used as a means for evaluating the source. Data were compiled from a number of sources. The following previous studies were the primary sources used in preparing the work plan. A more complete list of references is presented in Section 10.0.

- Background Geochemical Characterization Report (Rockwell International 1989c)
- Annual RCRA Groundwater Monitoring Reports (Rockwell International 1989a, EG&G 1990a)
- Present Landfill Closure Plan (SWMU 114) (Rockwell International 1988b)
- Closure Plan, Inactive Interim Status Facilities, Hazardous Waste Storage Area (SWMU 203) (Rockwell International 1988c)
- Present Landfill Hydrogeologic Characterization Report (Rockwell International 1988d, Appendix 6 to Rockwell International 1988b)

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Preparation of this work plan involved limited additional evaluation of existing data. The work plan will serve as a framework for more rigorous RFI/RI activities that will be conducted independently or as part of the Phase II RFI/RI process. This framework was established considering October 1988 EPA RI/FS guidance.

Section 1.0 of this work plan presents introductory information and a general characterization of the region and plant sites. Section 2.0 presents a preliminary characterization based on existing data and conceptual model for the Present Landfill site. The identification of preliminary alternative actions for remediation of the source, Section 3.0, was based on experience and represents the range of actions normally implemented at landfill sites. The discussion of Applicable or Relevant and Appropriate Requirements (ARAR) (Section 4.0), the Baseline Risk Assessment Plan (BRAP) (Section 8.0), and the Environmental Evaluation Plan (EEP) (Section 9.0), were reproduced with minor editing from the previous Phase III and Phase II Work Plans for 881 Hillside and 903 Pad, respectively. Preliminary identification of data needs and Data Quality Objectives (DQO) (Section 5.0) were developed considering the preliminary site characterization and conceptual model. A Field Sampling Plan (Section 7.0) was then developed, based on the existing data, to further characterize the soils and source.

1.3 REGIONAL AND PLANT SITE BACKGROUND INFORMATION

1.3.1 Background

The Rocky Flats Plant is a government-owned, contractor-operated facility, which 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 30, 1975. Rockwell International was selected to succeed Dow Chemical as the prime contractor responsible for operating the Rocky Flats Plant, beginning July 1, 1975.

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The primary mission of the Rocky Flats Plant is to fabricate nuclear weapon components from plutonium, uranium, and other nonradioactive 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 nonradioactive 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 and radioactive wastes occurred onsite 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.

1.3.2 Physical Setting

The Rocky Flats Plant is located in northern Jefferson County, Colorado, approximately 16 miles northwest of Denver (Figure 1-1). 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 the plant security area of 384 acres. The security area is surrounded by a buffer zone of approximately 6,150 acres (Figure 1-2).

1.3.2.1 Climate

The area surrounding the Rocky Flats Plant has a semiarid climate typical of the Rocky Mountain region. However, the elevation of the plant and the nearby slopes of the Front Range slightly modify the regional climate.

Winds at Rocky Flats Plant, although variable, are predominantly from the west-northwest. Stronger winds occur during the winter, and the area occasionally experiences Chinook winds with gusts up to 100 miles per hour because of its location near the Front Range (U.S. DOE 1980). Figure 1-3 shows the wind direction, frequency, and average velocity for each direction as recorded in 1988 (Rockwell International 1989b).

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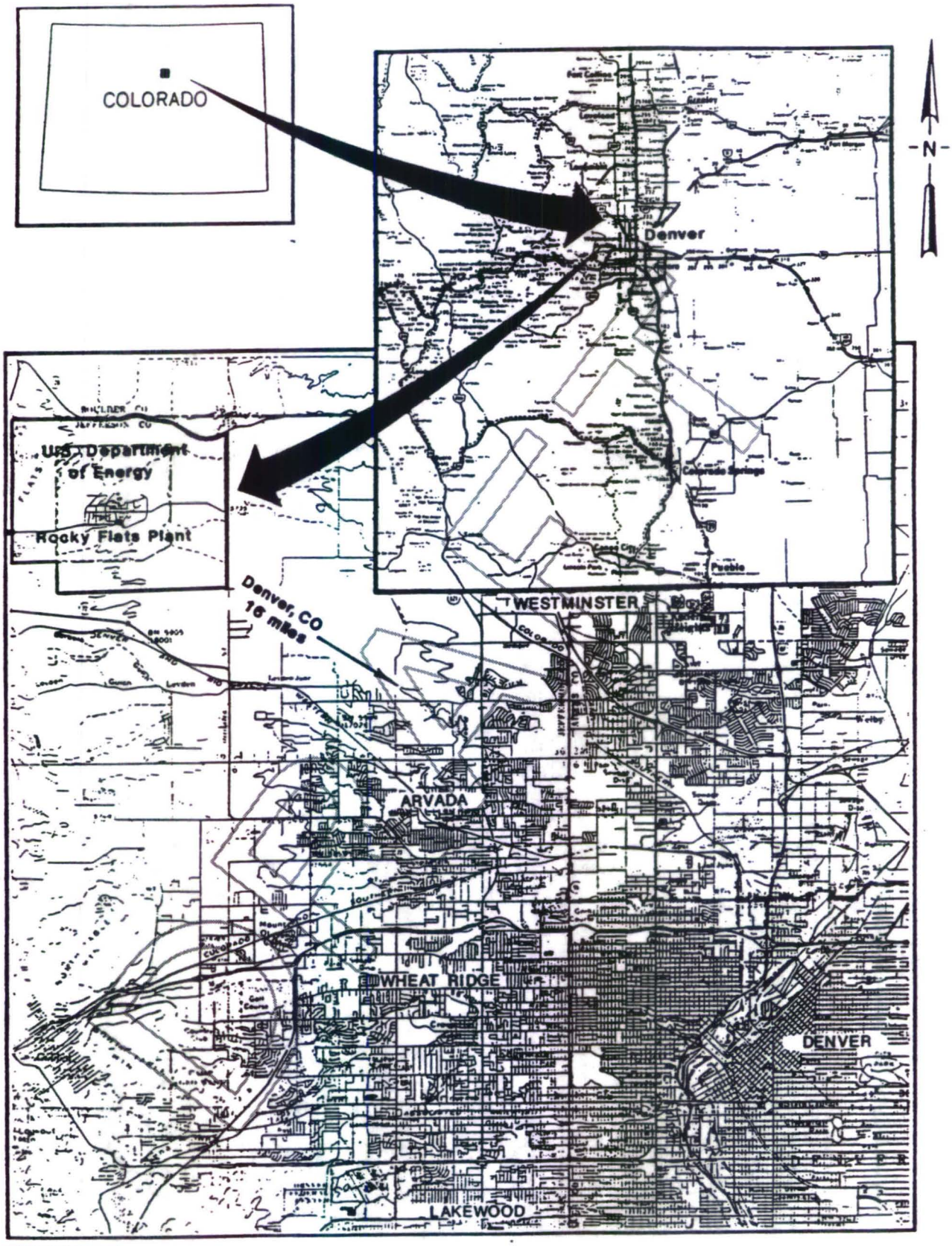

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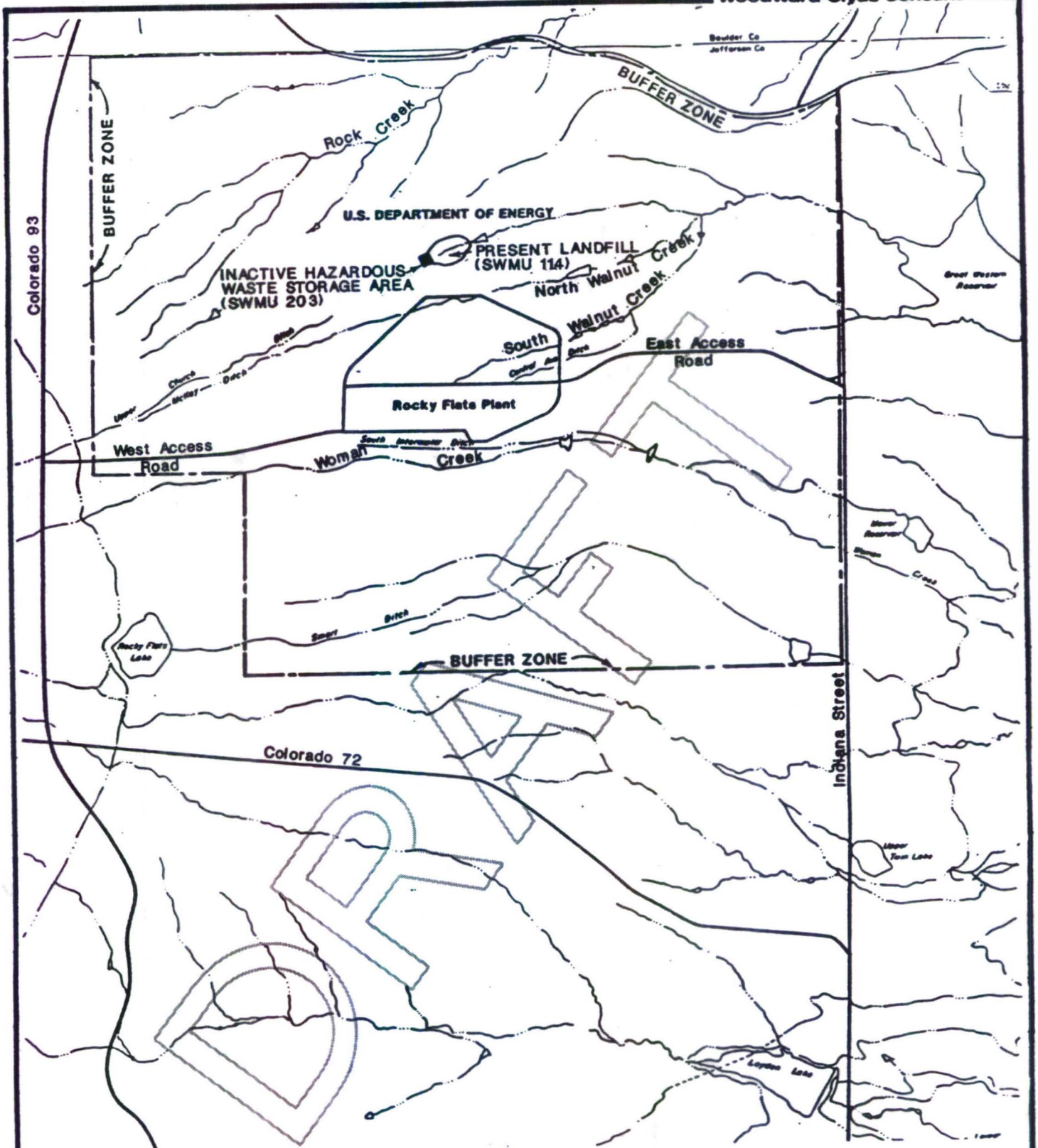
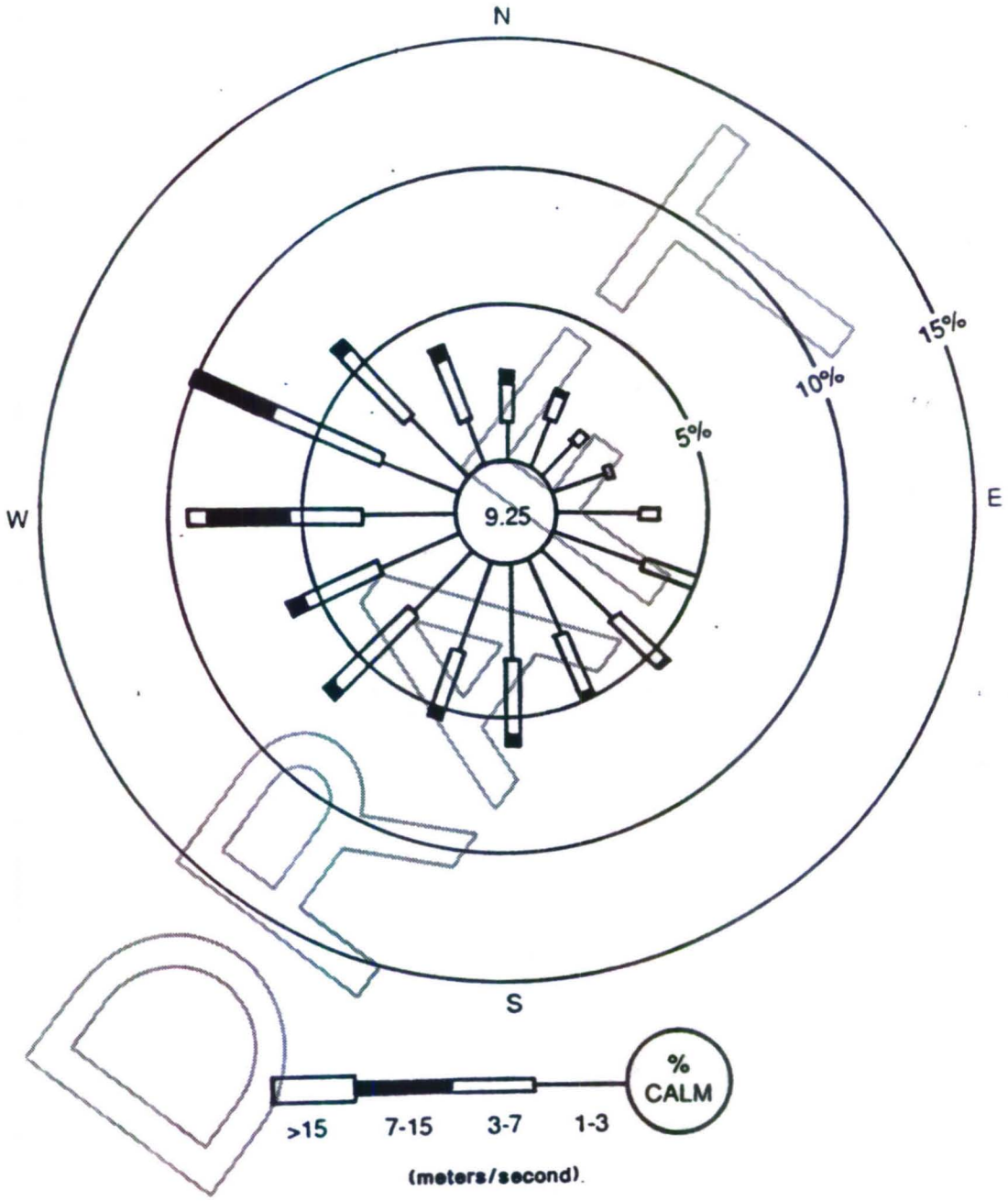
SOURCE: ROCKWELL INTERNATIONAL 1989e

Job No. : 4004-210	LOCATION MAP
Prepared by : A.C./T.K	
Date : 4/6/90	Figure 1-1



Job No. : 4004-210	ROCKY FLATS PLANT BOUNDARIES AND BUFFER ZONE
Prepared by : A.F.C./T.K.	
Date : 4/6/90	Figure 1-2

SOURCE: ROCKWELL INTERNATIONAL 1989e



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SOURCE: ROCKWELL INTERNATIONAL 1989b

Job No. : 4004-210	1988 ANNUAL WIND ROSE FOR THE ROCKY FLATS PLANT
Prepared by : A.F.C./T.K.	
Date : 4/6/90	Figure 1-3

Temperatures are moderate. Extremely warm or cold weather is usually of short duration. On the average, daily summer temperatures range from 55 to 85 degrees Fahrenheit (f), and winter temperatures range from 20 to 45 degrees F. Temperature extremes recorded at the plant have ranged from 102 degrees F on July 12, 1971 to -26 degrees F on January 12, 1963. The 24-year daily average maximum temperature for the period 1952 to 1976 was 76 degrees F, the daily average minimum was 22 degrees F, and the average annual mean was 50 degrees F. Average relative humidity was 46 percent (U.S. DOE 1980).

Based on precipitation averages collected between 1953 and 1976, the mean annual precipitation at the plant is 15.16 inches. Approximately 40 percent of the precipitation falls during the spring season, much of it as snow. Thunderstorms from June to August account for an additional 30 percent of the precipitation. Autumn and winter are drier seasons, accounting for 19 and 11 percent of the annual precipitation, respectively. Snowfall averages 85 inches per year, generally occurring between October and May (U.S. DOE 1980).

Special attention has been focused on dispersion meteorology surrounding the plant because of the remote possibility that significant atmospheric releases might affect the Denver metropolitan area. Studies of air flow and dispersing characteristics (for example, Hodgin 1983 and 1984) indicate that drainage flows (winds coming down off of 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. These drainage flows are of particular interest because they occur under stable atmospheric dispersion conditions (generally at night) when atmospheric mixing is limited (Rockwell International 1986a).

1.3.2.2 Regional and Local Geology

Geologic units at the Rocky Flats Plant (in descending order) are the surficial units (Rocky Flats Alluvium, various terrace alluviums, valley fill alluvium, and colluvium) and bedrock (Arapahoe Formation, Laramie Formation, and Fox Hills Sandstone). Figure 1-4 presents a generalized east-west cross section of the regional. The Denver Formation does not occur in the vicinity of the plant. Groundwater occurs under unconfined conditions in both the surficial and bedrock units. In addition, confined groundwater flow occurs in bedrock sandstones.

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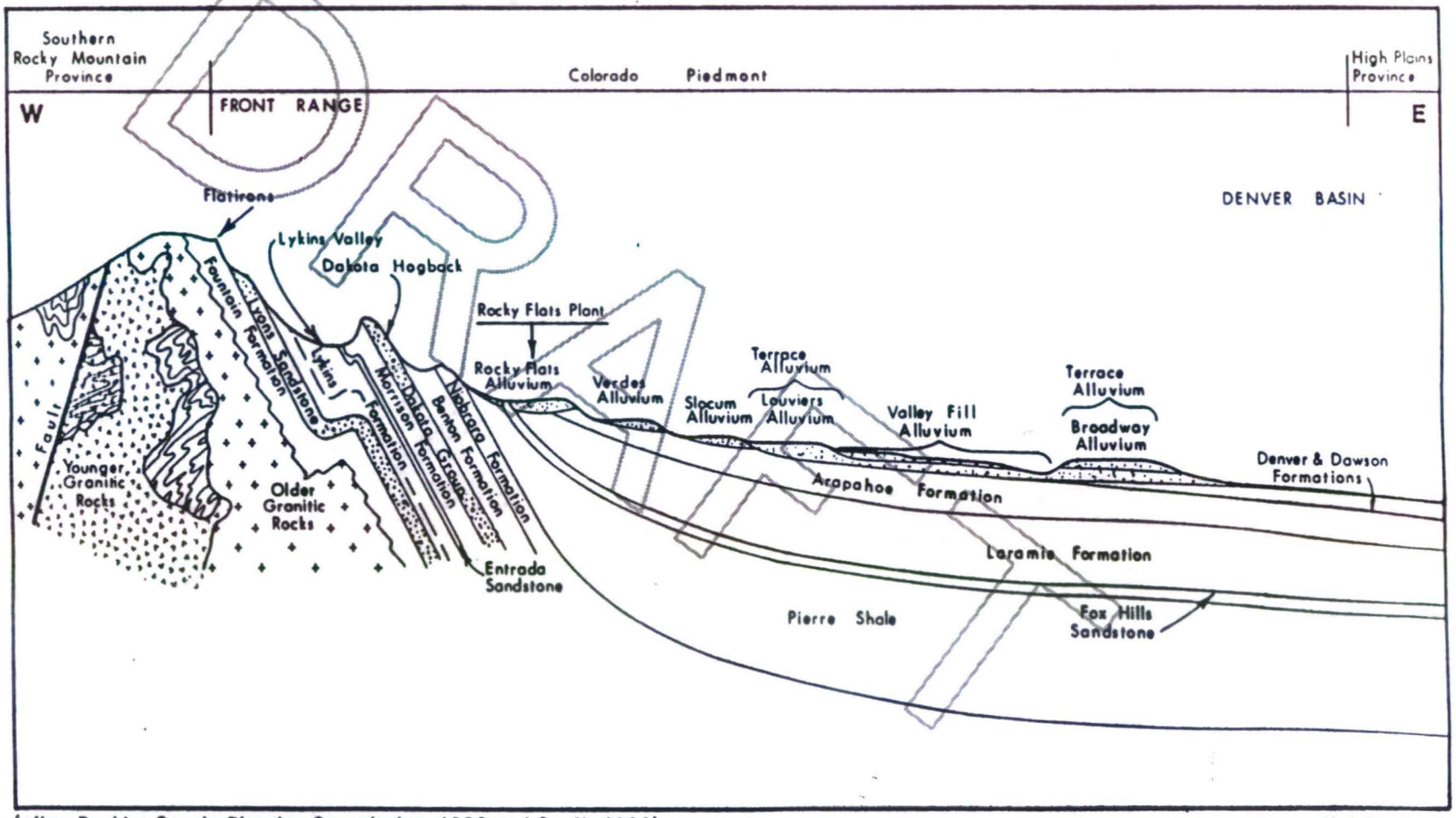

(after: Boulder County Planning Commission, 1983 and Scott, 1960)

Not To Scale

SOURCE: ROCKWELL INTERNATIONAL 1988d

Job No. : 4004-210

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Date: 4/6/90

GENERALIZED EAST-WEST CROSS SECTION FRONT RANGE TO DENVER BASIN

Figure 1-4

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1.3.2.2.1 Rocky Flats Alluvium. The Rocky Flats Alluvium underlies a large portion of the Plant. The alluvium is a broad planar deposit consisting of a topsoil layer underlain by up to 100 feet 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 water movement in the Rocky Flats Alluvium is from west to east and towards the drainages. Groundwater flow is also controlled by buried channels in the top of bedrock. Groundwater in the Rocky Flats Alluvium generally rises in response to recharge during the spring and declines 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. The Rocky Flats Alluvium thins east of the Plant boundary and does not directly supply water to wells located downgradient of Rocky Flats Plant (Rockwell International 1989d).

1.3.2.2.2 Other Alluvial Deposits. Various other alluvial deposits occur topographically below 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 Alluviums occur occasionally along the valley side slopes. Recent valley fill alluvium occurs in the active stream channels.

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

1.3.2.2.3 Arapahoe Formation. The Arapahoe Formation underlies surficial materials beneath the plant. The Arapahoe consists of claystone with thin lenticular sandstones. Total formation thickness varies up to 270 feet (Robson et. al., 1981). The lenticular sandstones are composed of fine-grained sands and silts, and their hydraulic conductivity is low compared to the overlying Rocky Flats Alluvium.

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The Arapahoe Formation is recharged by leakage from streams and groundwater movement from overlying surficial deposits. The main recharge areas are under the Rocky Flats Alluvium, although some 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 flow within individual sandstones is not fully characterized at this time. Regionally, groundwater flow in the Arapahoe Formation is toward the South Platte River in the center of the Denver Basin (Robson et. al., 1981a).

1.3.2.2.4 Laramie Formation and Fox Hills Sandstone. The Laramie Formation underlies the Arapahoe and is composed of two units, a thick upper claystone and a lower sandstone. The claystone is greater than 700 feet thick and is of very low hydraulic conductivity; therefore, the U.S. Geologic Survey (Hurr, 1976) concluded that Rocky Flats operations will not impact any units below the upper claystone unit of the Laramie Formation (Rockwell International 1989d).

The lower sandstone unit of the Laramie Formation and the underlying Fox Hills Sandstone comprise a regionally important aquifer in the Denver Basin known as the Laramie-Fox Hills Aquifer. 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 quickly flatten to the east. Recharge to the aquifer occurs along the rather limited outcrop area exposed to surface water flow and leakage along the Front Range (Robson et. al., 1981b).

1.3.2.2.5 Surface Water Hydrology. Three ephemeral streams drain the Rocky Flats Plant with flow generally from west to east. These drainages are Rock Creek, Walnut Creek, and Woman Creek (Figure 1-2). 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 topographic divide bisects the plant separating the Walnut and Woman Creek drainages. North and South Walnut Creeks and an unnamed tributary drain the northern portion of the plant security area. The Present Landfill is at the head of the unnamed tributary. These three forks of Walnut Creek join in the buffer zone and flow off-site approximately 1 mile east of the confluence. A number of man-made surface water diversions and storage ponds have been constructed to control surface water discharge from the Plant. Discharge from the Plant occurs

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at seven locations in accordance with a National Pollutant Discharge Elimination System (NPDES) permit (Rockwell International 1989b).

1.3.3 Surrounding Land Use and Population Density

The Rocky Flats Plant is located in a rural area. 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). According to the 1973 Colorado Land Use Map, 75 percent of this land at that time was unused or was used for agriculture. Since that time, portions of this land have been converted to residential use, with several new housing subdivisions being started within a few miles of the buffer zone. One such subdivision is located south of the Jefferson County Airport and several are located southeast of the plant (Rockwell International 1989d).

Demographic estimates (Figure 1-5) for 1988 show that approximately 2 million people lived within 50 miles of the Rocky Flats Plant (Rockwell International 1989b). Approximately 10,500 people lived within 5 miles of the plant in 1988. The most populous sector was to the southeast, toward the center of Denver. This sector had a 1988 population of about 630,000 living between 10 and 50 miles from Rocky Flats. Population estimates registered by the Denver Regional Council of Governments (DRCOG) for the 8-county Denver metro region have shown distinct patterns of growth between the first and second halves of the decade. Between 1980 and 1985, the population of the 8-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 1989 population showed an increase of 2,225 (or 0.1 percent) from the same date in 1988 (DRCOG 1989).

There are eight 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.

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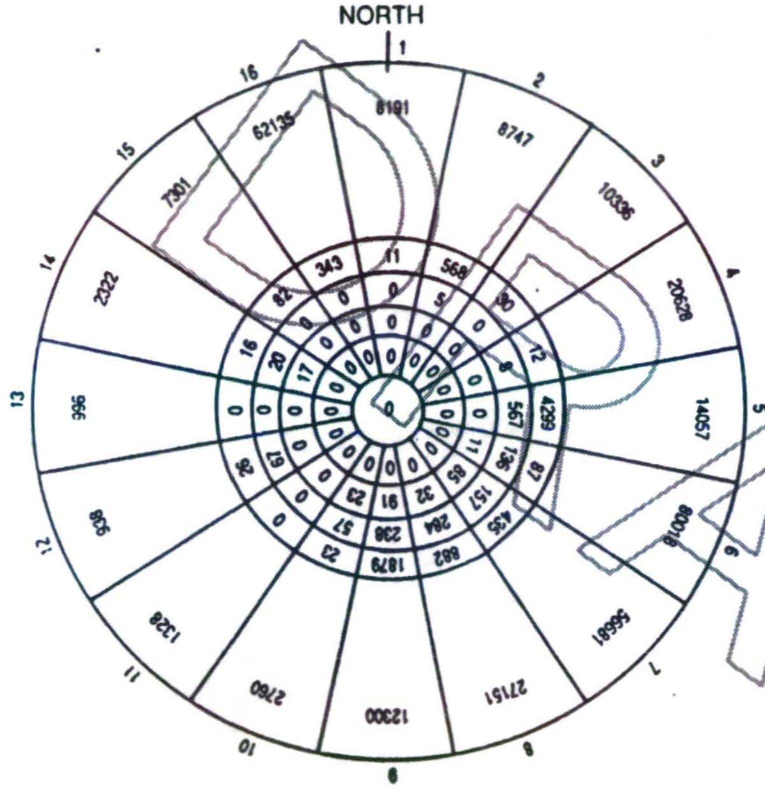
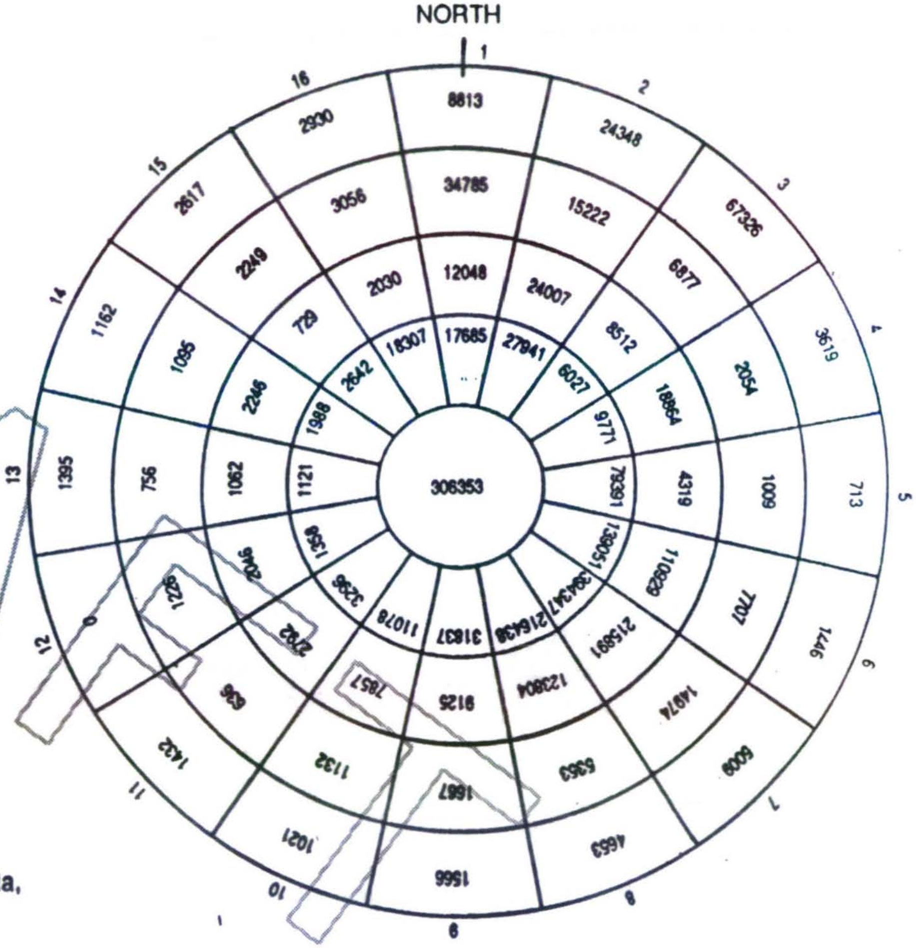


0 TO 16 km (0 to 10 miles) FROM ROCKY FLATS[b]



16 TO 80 km (10 to 50 miles) FROM ROCKY FLATS[c]

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a. These population estimates were calculated from 1980 census tract data, assuming uniform population distribution throughout each section.

b. Concentric circles represent 1.6- to 3.2-, 3.2- to 4.8-, 4.8- to 8.0-, 8.0- to 16.0-km (1- to 2-, 2- to 3-, 3- to 4-, 4- to 5-, and 5- to 10-mi) bands.

c. Concentric circles represent 16- to 32-, 32- to 48-, 48- to 64-, 64- to 80- km (0- to 20-, 20- to 30-, 30- to 40-, 40- to 50- mi) bands.

SOURCE: ROCKWELL INTERNATIONAL 1989b

Job No. : 4004-210

Prepared by : A.C./T.K

Date : 4/6/90

1988 DEMOGRAPHIC ESTIMATES

Figure 1-5

Woodward-Clyde Consultants

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.

Some of the land adjacent to the plant is zoned for industrial development. Industrial facilities within 5 miles include the TOSCO laboratory (a 40-acre site located 2 miles south), the Great Western Inorganics Plant (2 miles south), the Frontier Forest Products yard (2 miles south), the Idealite Lightweight Aggregate Plant (2.4 miles northwest), and the Jefferson County Airport and Industrial Park (990-acre site located 4.8 miles northeast).

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 are 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 (The Denver Post 1989).

1.3.4 Ecology

A variety of vegetation is found within the plant boundary. Included are species of flora representative of tall grass prairie, short grass plains, lower mountane, and foothill ravine regions. Riparian vegetation exists, along the site's watercourses. None of these vegetative species are on the endangered species list (Rockwell International 1989d) Since the acquisition of the Rocky Flats Plant property, vegetative recovery has occurred as evidenced by the presence of grasses like big bluestem and sideoats gama (two disturbance sensitive species).

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, with an estimated

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100 to 125 permanent residents. There are a number of small carnivores, such as the coyote, red fox, striped skunk, and long-tailed weasel. A profusion of small herbivores can be found throughout the plant and buffer zone consisting of species such as the pocket gopher, white-tailed jackrabbit, and the meadow vole (U.S. DOE 1980).

Commonly observed birds include western meadowlarks, horned larks, mourning doves, and vesper sparrow. A variety of ducks, killdeer, and red-winged black birds are seen in areas adjacent to ponds. Mallards and other ducks frequently nest and rear young on several of the ponds. Common birds of prey in the area include marsh hawks, red-tailed hawks, ferruginous hawks, rough-legged hawks, and great horned owls (U.S. DOE 1980).

Bull snakes and rattlesnakes are the most frequently observed reptiles. Eastern yellow-bellied racers have also been seen. The eastern short-horned lizard has been reported on the site, but these and other lizards are not commonly observed. The western painted turtle and the western plains garter snake are found in and around many of the ponds (DOE 1980).

1.4 SITE LOCATIONS AND DESCRIPTIONS

1.4.1 Present Landfill (SWMU 114)

The following historical perspective of the Present Landfill and surrounding area is based entirely on the 1988 Present Landfill Closure Plan (Rockwell International 1988b).

The present landfill is located to the north of the plant security area on the western end of an unnamed tributary of North Walnut Creek. Figure 1-2 shows the general location on the plant property. Operation of the landfill was initiated on August 14, 1968, with a portion of the natural drainage being filled with soils from an onsite borrow area to a depth of up to 5 feet to construct a pad on which to start landfilling.

The landfill was originally constructed to provide a means for disposing of the plant's non-radioactive solid wastes. These wastes included paper, rags, floor sweepings, cartons, mixed garbage and rubbish, demolition material, and miscellaneous items. From 1968 to 1978, the landfill received approximately 20 cubic yards of compacted waste per day. In October 1972, the

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policies concerning disposal of waste at the landfill were reviewed and judged to be in accordance with applicable state and federal regulations.

The landfill was not intended to be used for disposal of radioactive wastes, and in December 1972, guidelines were issued that addressed burial of radioactively contaminated wastes. These guidelines set levels for the permissible radiation limits of wastes to be buried, as well as the minimum depth of burial and the maximum number of burials per year.

Additional guidelines were issued in February 1973 to control the burial of solid and liquid wastes in the landfill. Detectable contaminant concentrations were established for specific radioactive materials, such as plutonium, in both solid and liquid phases. In addition, prior approval was required for the burial of "noncontaminated but potentially hazardous solid materials." and for all liquids to be disposed of in the landfill.

In September 1973, tritium was detected at the drainage of the Rocky Flats landfill. In response, approximately 47 monitoring wells were installed directly into the landfill waste or immediately below the waste materials. In addition, two temporary berms were constructed in the natural drainage just downstream of the landfill to provide management capability for any leachate or surface water generated by the landfill. The two ponds were named Pond No. 1 and Pond No. 2, and were located east of the landfill. These ponds, formed by drainage barriers across the channel, reduced the flow in the tributary. There was a sprinkler pumping station located adjacent to the west pond, Pond No. 1, to pump water to spray fields for enhanced evaporation.

Through the installation of the monitoring wells, the location of the source of tritium was fairly well identified (Rockwell International 1987c). The depth and configuration of the source remain unknown. It was estimated in 1974 that the tritium was disposed of in the landfill in 1970. Several options were evaluated for the correction of the problem, including excavation. The selected action which is discussed below, was to construct surface and groundwater diversion and leachate collection systems around the landfill.

The Health Physics Operation unit of the Plant began a program in 1973 to monitor the waste for radioactivity after it had been dumped and before compaction and burial. A logging procedure

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was instituted at that time to maintain control of where the wastes originated in the event radioactive contamination was identified.

After radiation monitoring was completed, each waste layer was compacted and covered with 6 inches of soil from onsite stockpiles. The disposal of wastes continued in this manner until the waste layer was within 3 feet of the final elevation. The lift was completed by the addition of a 3-foot-thick layer of compacted soil. In different sections of the landfill, the total landfill thickness consists of between one and three such lifts. Based on visual observation (Rockwell International 1988) some areas of the landfill surface may not have received a full 3-foot layer of compacted soil.

By 1974, the landfill had expanded in surface area to approximately 300,000 square feet. The volume occupied by the landfill was estimated to be about 95,000 cubic yards. Of this total, the cover material occupied 30,000 cubic yards. The remaining 65,000 cubic yards consisted of compacted waste intermixed with the daily cover material placed during disposal.

During this time, a project was initiated for the construction of a surface water and groundwater diversion and leachate collection systems to address the presence of tritium source in the landfill. These systems included a engineered pond embankment east of the landfill, a groundwater intercept and diversion system for uncontaminated groundwater, a leachate collection system, and surface water control ditches. The purpose of the west pond (Pond No. 1) was to impound leachate generated by the landfill. The east pond (Pond No. 2) was intended as a backup system for any overflow from Pond No. 1. Pond No. 2 was also to collect intercepted groundwater, as needed. The engineered embankment for Pond No. 2 included a low permeability clay core keyed into bedrock. The area of each pond was approximately one-half acre. The intent of these systems was to protect surface water and groundwater from contamination by leachate generated in the landfill. Construction of these systems began in October 1974, and was completed in January 1975. Details of these structures are discussed in more detail in subsection 2.1.5 (Plate 2-1 and Figure 2-9).

The collection systems consisted of a surface water interceptor ditch and a combined leachate and groundwater interceptor ditch. The surface water collection system intercepted any surface water runoff flowing toward the landfill and directed it away from the landfill. The leachate collection

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constructed in 1981 to extend the groundwater barriers already in place. The slurry walls were intended to reduce groundwater migration into the expanded landfill. These slurry walls were tied into the north and south arms of the groundwater diversion system

When disposal continued after 1974, waste was placed in the collection trenches, and the east face of the waste area was advanced, eventually filling in the west pond area. The volume of the landfill in 1986 was estimated by using topographical maps and by calculating the volume of the collection trenches. These calculation showed that approximately 160,000 cubic yards of material had been dumped between 1974 and 1986, for a total landfill volume of 255,000 cubic yards. This volume includes solid wastes, wastes with hazardous constituents, and soil cover material.

Between 1986 and 1988, waste was disposed of at a rate of 115 cubic yards per work day (Rockwell International 1988b). Using this same rate, and then assuming 260 work days per year for 4 years, approximately 120,000 cubic yards of waste material have been disposed of since 1986. Daily cover volumes are estimated at about 25 percent of the volume of material disposed. The volume of material in the landfills currently estimated to be approximately 405,000 cubic yards.

This waste material consists of the solid waste streams discussed in subsection 2.2.1. In 1987, recommendations were made that outlined where the waste streams identified at the Rocky Flats Plant should be disposed (Weston 1987). The recommendations for the landfill identified 144 waste streams to continue to be disposed of in the landfill. These are also presented in subsection 2.2.1. In the fall of 1986, wastes with hazardous constituents ceased to be disposed of in the landfill. This policy was implemented through the tightening of administrative procedures and the implementation of the findings of the Waste Stream Identification and Characterization Reports (Weston 1986a, b, c, d, and 1987).

After construction of the east and west ponds in 1973, surface runoff, groundwater, and leachate collected in the systems discharged to these ponds. There is no documentation of the flow rates or quantities collected by these systems. When the landfill was expanded in 1981, the leachate collection system and west pond were buried. The groundwater diversion system was also at least partially buried.

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Until January of 1974, the water collected in the ponds was pumped to the solar evaporation ponds. At that time, it became necessary to dispose of the water elsewhere, and the water was diverted to a manhole northwest of Building 990. This line discharged to Pond B-2 in the Walnut Creek drainage.

By September 1975, the water was no longer pumped to the manhole but was sprayed on sprayfields adjacent to the landfill. One of these sprayfields was a 3- to 3 1/2-acre plot, located approximately 1,000 feet northwest of the east pond. This north sprayfield was used for spraying water collected in the west pond. Initially, the spray line ran approximately north-south; however, in about 1975, the line was moved to an east-west direction. Two other sprayfields were located along the banks of the east pond and were used for spray evaporation of water collected in the east pond.

Acceptability guidelines for spraying were issued by the Environmental Control and Analysis Group of Rockwell to ensure that water sprayed from the pond would not cause erosion or other harm to the environment in, around, or downstream of the site. These guidelines included weekly water grab samples and procedures for obtaining authorization for spraying. Authorization was obtained from the Manager of Environmental Analysis and Control's office. The weekly grab samples were analyzed for gross alpha, gross beta, gamma emitting isotopes, and tritium. Control guides were established for each parameter. Spraying on the north sprayfield ceased in 1981.

Before spraying activities, the water was tested and evaluated regarding the acceptability criteria for spraying. Water quality testing indicated some organic constituents in the west pond waters. Testing east pond water did not show impacts from the landfill.

1.4.2 Inactive Hazardous Waste Storage Area (SWMU 203)

The Inactive Hazardous Waste Storage Area is located on the southwest corner of the present landfill (Figure 1-6 and Plate 2-1) and was actively used between 1982 and 1987. This description of the site and its history is from the 1988 closure plan (Rockwell International 1988c). This area was operated as a hazardous waster storage area for both drummed liquids and solids. Fifty-five gallon containers with free liquids were stored within fourteen cargo containers. One additional container was used to store spill control items such as oil sorbent and sorbent pillows. Figure 1-6

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is a diagram of the hazardous waste storage area as it looked during maximum waste inventory. During maximum inventory the hazardous waste area consisted of eight 20 foot long cargo containers each capable of holding eighteen 55-gallon drums, and six 40 foot long cargo containers each capable of holding forth 55-gallon drums. Fifty-five-gallon drums were placed and conveyed in the cargo containers on rollers constructed of aluminum. Two conveyors extended along the full length of the cargo container. A three-foot wide aisle, wide enough to permit inspection and access, extended down the center of the cargo container. The rollers elevated the drums approximately two inches above the catch basin floor (Baker, 1988).

The cargo containers were modified to meet the requirements for secondary containment under 6 CCR 264.175 and 40 CFR 264.175. Containers were fitted with appropriate signs, air vents, electrical ground and locks. Spill containment was afforded by a catch basin constructed of 11-gauge steel with a welded steel rim with a minimum height of six inches within each cargo container. The basins as designed, were capable of containing at least ten percent of the total volume of hazardous waste. The largest container stored in these cargo containers was 55 gallons.

Some storage of drummed solids (55-gallon containers) took place outside the cargo containers. Small spills of less than reportable quantities may have occurred in this area during transfer operations. Total liquid storage capacity for the fourteen cargo containers was 21,120 gallons. Maximum inventory recorded for all wastes including solids is unknown.

RCRA wastes were stored in twelve of the fourteen cargo containers and included solvents; coolants; wastes machining, cutting, and lubricating oils; organics and acids. Two of the 20 foot long cargo containers also were used to store PCB contaminated soil and debris, as well as PCB contaminated oil from transformers taken out of service (Baker 1988).

During the first week of May 1987, all cargo containers were hoisted intact onto flatbed trailers and transported to their current outdoor location in the parking lot, immediately west of the perimeter security zone (Baker 1988). The inactive Hazardous Waste Area has been left vacant.

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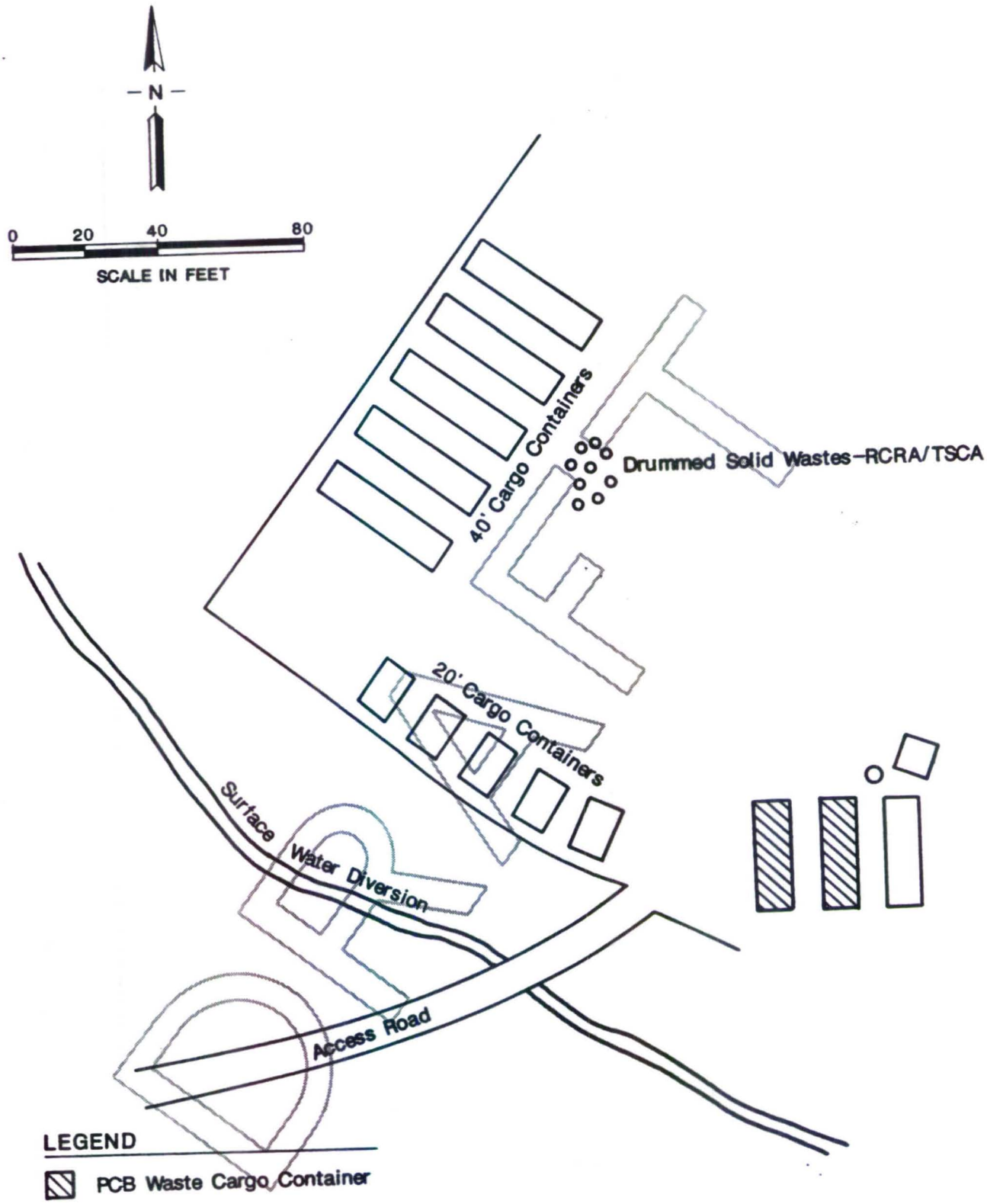

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SOURCE: ROCKWELL INTERNATIONAL 1988c

Job No. : 4004-210	INACTIVE HAZARDOUS WASTE STORAGE AREA SWMU Ref. No. 203
Prepared by : A.C./T.K.	
Date : 4/6/90	Figure 1-6

2.0
PRELIMINARY SITE CHARACTERIZATION

Existing data were compiled to summarize the site's physical characteristics, nature of potential contamination, and pathways to human receptors or the environment. The existing data were obtained from a number of previous site investigations as summarized in subsection 2.1.1. The descriptions of site physical characteristics and nature of contamination presented in subsections 2.1 and 2.2 were combined to develop a site conceptual model, subsection 2.3.

2.1 SITE PHYSICAL CHARACTERISTICS

Physical characteristics of the region and plant site as well as a description of the landfill's history are presented in subsection 1.3. Details of the Present Landfill site and landfill structures are presented in this section.

2.1.1 Previous Investigations

A number of previous investigations have been conducted at the site for the purpose of evaluating physical characteristics and potential contamination. Previous studies that were the primary sources of information for this work plan are listed in subsection 1.2. The majority of the information used in the preparation of this work plan was either developed as part of, or summarized in, the July 1, 1988 Closure Plan (Rockwell International 1988b).

Other studies conducted at the Present Landfill besides those listed in subsection 1.2 include the following, with brief summaries of the results:

- Soil gas survey of methane and hydrogen sulfide on landfill's surface using portable gas chromatography methods (results are appendix to Rockwell International 1988b). Some low levels of methane were detected and other unknown compounds were present in the landfill soil gas.

- Geotechnical engineering study for proposed landfill expansion (Lord 1977). The claystone bedrock beneath the landfill was judged adequate to serve as a hydraulic

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underbarrier, and the overburden soils were judged adequate for daily landfill cover (Rockwell International 1988b).

- Geotechnical engineering study for landfill remediation (Zeff et at. 1974). Recommendations were made and plans developed for a groundwater diversion and leachate collection system around the perimeter of the landfill. (Design drawings included in appendix to Rockwell International 1988b).

- Geotechnical engineering study for three potential future landfill sites and subsurface exploration at Present Landfill (Woodward-Clevenger 1974). The work included 47 borings with numerous soil and waste samples obtained. The samples were turned over to Rocky Flats (Dow Chemical) for analysis. In addition, 3-inch-diameter slotted plastic casings were inserted in the boreholes to allow water level measurements and leachate sampling. Data from testing on the leachate were the basis for Rockwell International (1987c). These data are summarized in subsection 2.2.1.

2.1.2 Geology

The Present Landfill site geology is summarized by the following discussion and by the cross sections presented in Figures 2-1, 2-2, 2-3, and 2-4. A surficial geology map was presented in the hydrogeologic characterization report (Rockwell International 1988d). The cross sections in Figures 2-1 through 2-4 are based on 1986 and 1987 (and some previous) boring data. Boring and well data from 1989 operations are presented in Table 2-1 (EG&G 1990a). Well locations and sections are shown in Plate 2-1. The following description of geology is based entirely on Rockwell International (1988d).

2.1.2.1 Surficial Geology

Surficial materials in the landfill area consist of the Rocky Flats Alluvium, colluvium, valley fill alluvium, and artificial fill or disturbed ground, which unconformably overlie the bedrock units. In addition, there are a few isolated exposures of claystone bedrock located along the side slopes of the drainage. Rocky Flats Alluvium caps the top of the slopes on the north and south sides of the tributary while colluvium (slope wash) covers the hillsides down to the tributary. Artificial

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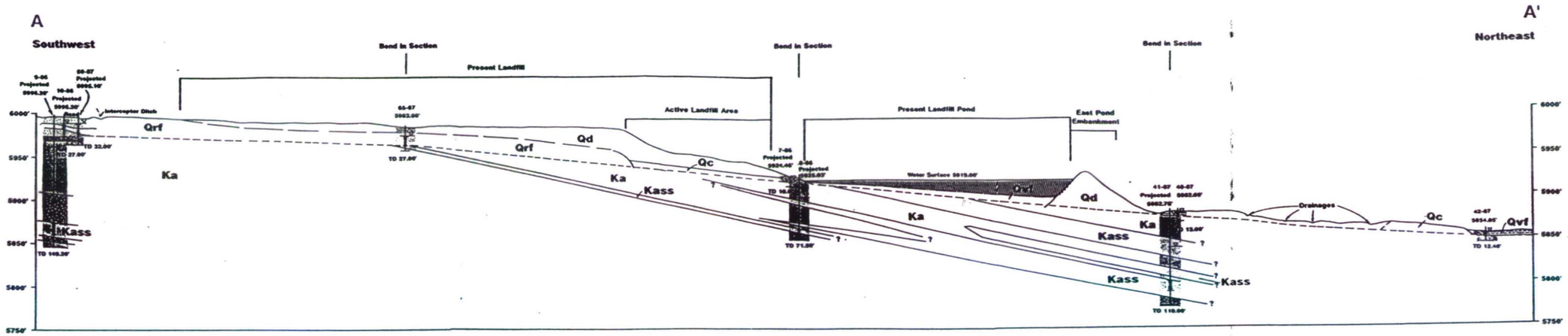

EXPLANATION

41-87 — Well Identification
5931.56' — Ground Surface Elevation (Surveyed)

Water Level (Measured 4/11/88)
Geologic Contact (dashed where inferred)
Screened Interval
TD 110.00' — Total Depth Drilled

QUATERNARY
- Qc — Colluvium
- Qd — Disturbed Ground
- Qrf — Rocky Flats Alluvium
- Qvf — Valley Fill Alluvium

CRETACEOUS
- Ka — Arapahoe Formation (Claystone)
- Kass — Arapahoe Formation (Sandstone & Siltstone)

- Clay
- Clayey Sand or Sandy Clay
- Sand and/or Sandstone
- Sand and/or Gravel
- Silt and/or Siltstone
- Claystone

NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

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SOURCE: ROCKWELL INTERNATIONAL 1988d

Job No.: 4004-210	CROSS SECTION A–A'
Prepared by: A.C.	
Date 4/6/90	Figure 2–1

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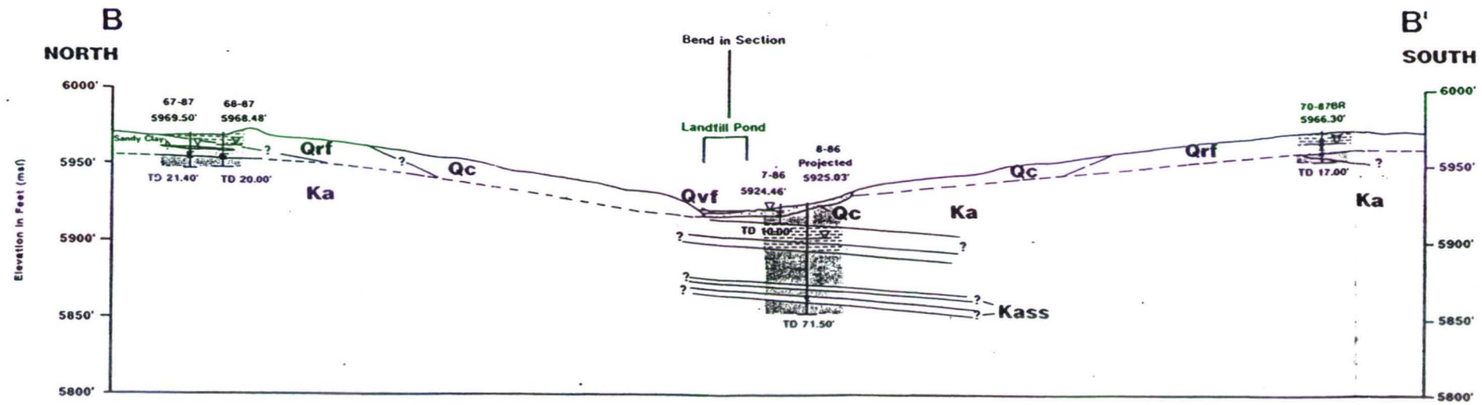

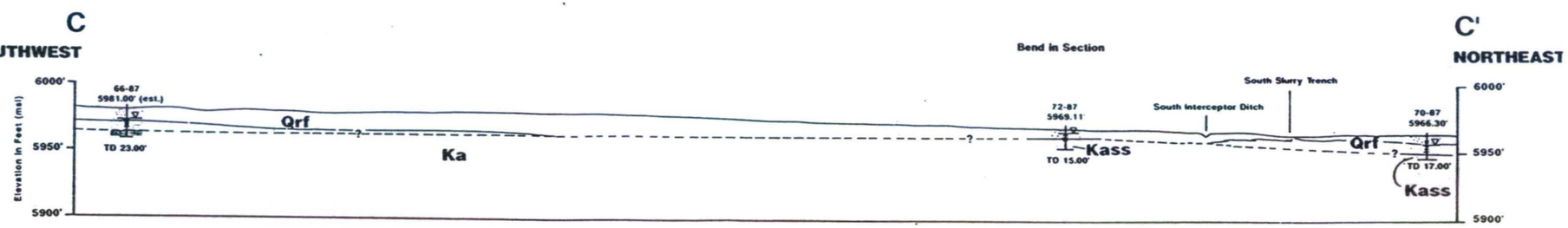

EXPLANATION

41-87 — Well Identification
5931.56' — Ground Surface Elevation (Surveyed)
Water Level (Measured 4/11/88)
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CRETACEOUS
- Ka — Arapahoe Formation (Claystone)
- Kass — Arapahoe Formation (Sandstone & Siltstone)

- Clay
- Clayey Sand or Sandy Clay
- Sand and/or Sandstone
- Sand and/or Gravel
- Silt and/or Siltstone
- Claystone

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NOTE: 1986 Well locations resurveyed during 1988.
This plate reflects new locations and elevations.

SOURCE: ROCKWELL INTERNATIONAL 1988d

Job No.: 4004-210	CROSS SECTIONS B–B' AND C–C'
Prepared by: A.C.	
Date: 4/6/90	Figure 2-2

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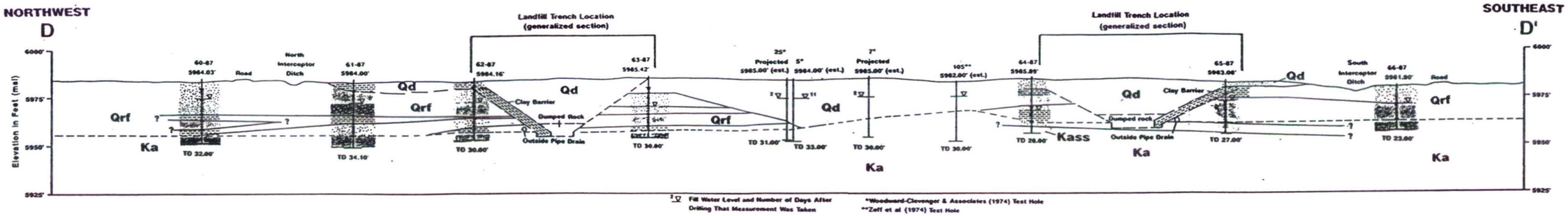

41-87 — Well Identification
5931.56' — Ground Surface Elevation (Surveyed)

Water Level (Measured 4/11/88)
Geologic Contact (dashed where inferred)
Screened Interval
TD 110.00' — Total Depth Drilled

QUATERNARY
- Qc — Colluvium
- Qd — Disturbed Ground
- Qrf — Rocky Flats Alluvium
- Qvf — Valley Fill Alluvium

CRETACEOUS
- Ka — Arapahoe Formation (Claystone)
- Kass — Arapahoe Formation (Sandstone & Siltstone)

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- Sand and/or Gravel
- Silt and/or Siltstone
- Claystone

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SOURCE: ROCKWELL INTERNATIONAL 1988d

Job No.: 4004-210	CROSS SECTION D–D'
Prepared by: A.C.	
Date: 4/6/90	Figure 2–3

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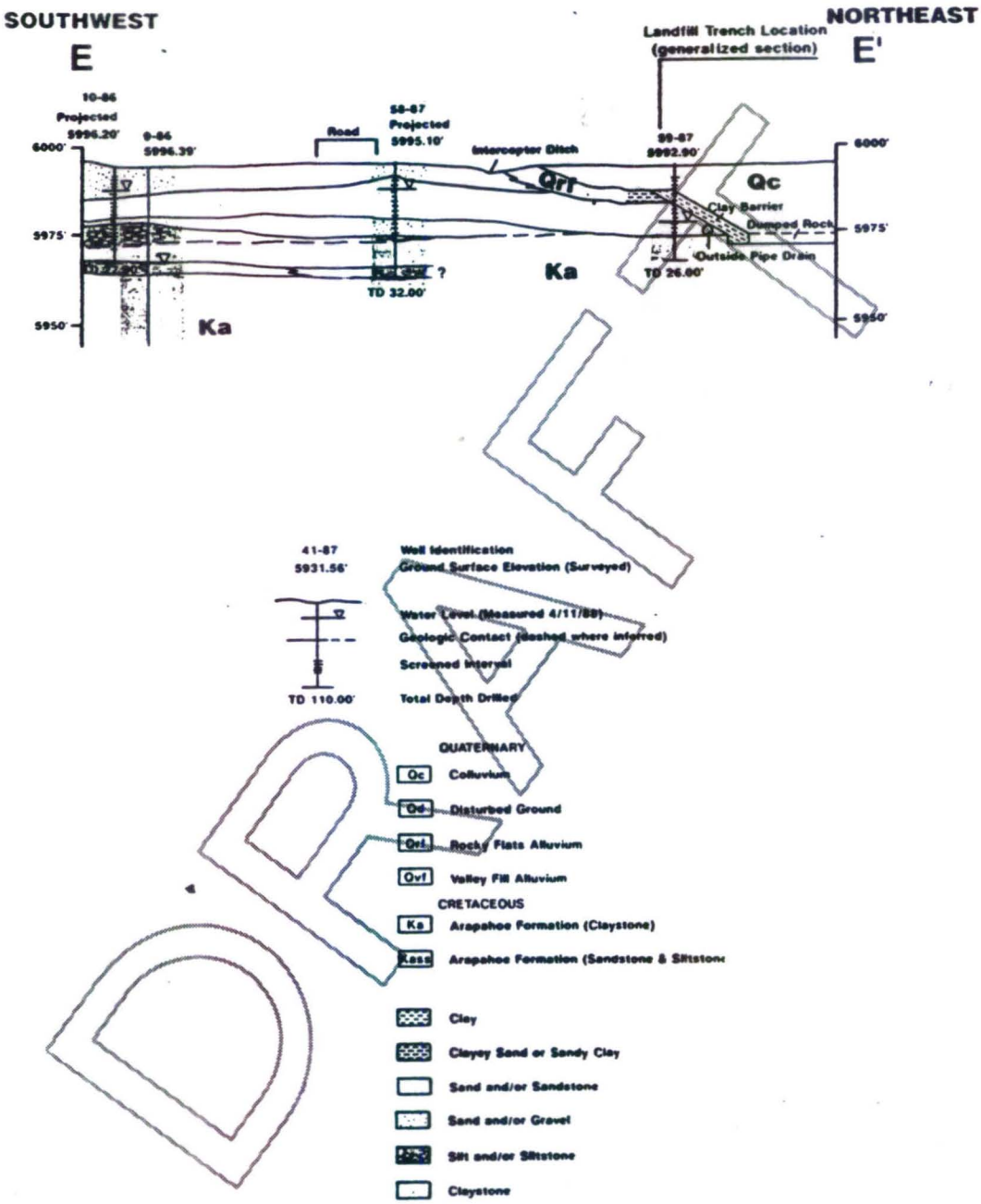

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SOURCE: ROCKWELL INTERNATIONAL 1988d

Job No. : 4004-210	CROSS SECTION E-E'
Prepared by : A.C.	
Date : 4/6/90	Figure 2-4

TABLE 2-1

PRESENT LANDFILL PROPOSED VERSUS ACTUAL CONSTRUCTION DETAILS FOR THE 1989 MONITORING WELLS

Proposed Well No.	Actual Well No.	Proposed Completion Zone	Actual Completion Zone	Proposed Screen Interval (ft.)	Actual Screen Interval (ft.)	Proposed Total Depth (ft.)	Actual Total Depth (ft.)	Reason(s) for Deviations
LF-01	B106089	Qaf	Qaf	13-20	3.66-23.2	20	24.47	Bedrock at 22.7'; screened landfill debris and alluvium.
LF-02	B206189	Kass(w)	Kacl	28-33	25.9-35.36	33	36.61	Screened 5-15' below alluvium/bedrock contract.
LF-03	B206289	Kass(w)	Kacl	28-33	32.37-41.82	33	43.05	Screened sandy interval from 34.5 to 41.0'; no weathered sandstone encountered.
LF-04	B206389	Qaf	Qrf/Qaf	3-15	4.0-13.5	15	14.74	Bedrock at 13.3; screened bottom 10' of alluvium.
LF-05	B206489	Kass(w)	Qrf/Kass(w)	8-18	3.25-10.0	18	11.35	Encountered subcropping sandstone from 7.5-9.5'; screened alluvium and weathered sandstone.
LF-06	B206589	Kass(w)	Kass(w)	15-25	23.5-35.14	25	36.24	Encountered weathered sandstone form 21.5-34.5'; screened bottom 10' of weathered sandstone.
LF-07	Not Drilled	Qrf	N/A	3.5-13.5	N/A	13.5	N/A	Insufficient Qac for completion.
LF-08	B206689	Kacl	Kacl	14.5-24.5	8.7-18.17	24.5	19.41	Screened 5-15' below alluvium/bedrock contact.
LF-09	B206789	Kass(w)	Kacl	13-23	9.8-19.28	23	20.52	Screened 5-15' below alluvium/bedrock contact; no weathered sandstone encountered.
LF-10	B206889	Qc	Kacl	3.5-10	8.0-17.45	10	18.2	Insufficient colluvium for completion; screened 5-15' below colluvium/bedrock contact.
LF-11	B206989	Kacl	Kacl	6-16	11.8-21.3	16	22.5	Screened 5-15' below alluvium/bedrock contact.
LF-12	B207089	Kass(w)	Kass(w)	32.5-53	31.32-53.00	53	54.00	Encountered weathered sandstone and sandy interval 31.5-60.0'; screened upper 20' of sandy interval/sandstone.

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TABLE 2-1
(continued)

PRESENT LANDFILL PROPOSED VERSUS ACTUAL CONSTRUCTION DETAILS FOR THE 1989 AND PRESENT MONITORING WELLS

Proposed Well No.	Actual Well No.	Proposed Completion Zone	Actual Completion Zone	Proposed Screen Interval (ft.)	Actual Screen Interval (ft.)	Proposed Total Depth (ft.)	Actual Total Depth (ft.)	Reason(s) for Deviations
LF-13	B207189	Kass(u)	Kass(u)	68-78	70.98-75.43	78	77.76	Screened sandy interval from 70.98-75.43' (based on geophysical logging).
LF-14	B207289	Qrf	Kacl	3.5-13.5	5.2-14.65	13.5	15.89	Moved south due to inaccessibility. Insufficient alluvium for completion; screened 5-15' below alluvium/bedrock contact.
LF-15	Not Drilled	Kacl	N/A	14.5-24.5	NA	24.5	N/A	Insufficient Qc for completion.

(After EG&G 1990a)

Qaf: Artificial fill
Qvf: Valley Fill Alluvium
Qrf: Rocky Flats Alluvium
Qc: Colluvium
Kacl: Weathered Bedrock Claystone
Kass(w): Weathered Bedrock Sandstone
Kass(u): Unweathered Bedrock Sandstone

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fill or disturbed surficial materials are present within the boundaries of the landfill, along man-made drainage ways surrounding the landfill, and northwest of the landfill. Valley fill alluvium is present along the unnamed tributary channel.

The Rocky Flats Alluvium in the landfill area is described as a generally poorly sorted, unconsolidated deposit of clay, silt, sand, gravel, and cobbles. It ranges between 6 (Well No. 72-87) and 27 feet thick (Well No. 60-87) with an average thickness of approximately 18 feet where undisturbed. Lenses of sand, gravel, and clay within the Rocky Flats Alluvium have been correlated between wells that are close to each other.

Colluvial materials are present on the slopes descending to the unnamed tributary; however, only Well Nos. 7-86 and 8-86 penetrated colluvium in the vicinity of the landfill. Colluvium consists predominantly of clay with common occurrences of sandy clay and gravel layers.

The most recent deposit in the landfill area is the valley fill alluvium along the unnamed tributary channel. The unconsolidated valley fill consists of poorly sorted sand, gravel, and pebbles in a silty clay matrix. This alluvium is derived from reworked and redeposited older alluvium and bedrock materials. Valley fill thickness ranges from 4 feet (Well No. 5-86) to 8 feet (Well No. 40-87) in the landfill area. The valley fill materials are generally finer-grained downstream of the landfill. Alluvial deposits in Well No. 42-87 are described as predominantly gravel with abundant cobbles and pebbles, whereas Well No. 5-86, farther downgradient of the landfill in the unnamed tributary, encountered predominantly very fine-grained sand and gravels with occasional cobbles.

There are two types of artificial fill in the vicinity of the landfill. The first type is comprised of soil materials. Much of this was derived from excavations of Church Ditch located northwest of the landfill. There is also engineered fill associated with the building of the east pond embankment dam across the tributary. The core of the east pond dam was constructed of compacted clay and claystones with the outer shell being composed of clayey sands, gravels, and cobbles. These materials were obtained from borrow areas.

The second type of artificial fill consists of the waste and cover soil materials comprising the landfill source. The source fill is described as a mixture of clay, gravel, coarse sand, asphalt fragments, wire, plastics, surgical gloves, wood particles, and other materials associated with

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landfilling activities. Thicknesses of the source fill material, where drilled, ranged from approximately 1.5 feet to approximately 27 feet in the center of the landfill (Woodward-Clevenger 1974). Based on recent observations of the landfill and considering previous subsurface data, the maximum waste thickness toward the central-east portion of the landfill is estimated to be on the order of 40 to 45 feet. This has not been substantiated by boring and/or survey data.

2.1.2.2 Bedrock Geology

The Cretaceous Arapahoe Formation underlies surficial materials at the Present Landfill. Six wells were completed in various zones of the bedrock during the 1986 and 1987 drilling programs. The Arapahoe Formation beneath the landfill consists of claystone and interbedded sandstones and siltstones with a thin isolated shale layer encountered in Well No. 8-86.

The Arapahoe Formation was deposited by meandering streams flowing generally west to east off the Front Range. Sandstones were deposited as braided stream channel deposits and overbank splays. Claystones were deposited in back swamp and floodplain areas. Leaf fossils, black organic matter, and wood fragments were encountered within the claystones during drilling at the landfill. Contacts between various lithologies are both gradational and sharp.

Claystone was the most frequently encountered lithology of the Arapahoe Formation immediately below the Quaternary/Cretaceous (soil/rock) contact. Claystones are described as massive and blocky containing occasional thin laminae and interbeds of sands and silt.

Weathered bedrock was encountered directly beneath surficial materials in all of the monitoring wells and test holes drilled during previous investigations. Weathering penetrates approximately 2 feet (Well No. 6-86) to 11 feet (Well No. 9-86) into bedrock. Both weathered and unweathered claystone contain horizons of silt and very fine sand.

Bedrock Well Nos. 8-86, 9-86, and 41-87BR were completed in Arapahoe Formation sandstones. In addition, Well Nos. 58-87, 64-87, 70-87, and 72-87 encountered shallow or subcropping bedrock sandstones. These sandstones are generally composed of moderately to well sorted, subrounded to rounded, very fine- to medium-grained quartz sand. Cementation generally increases with depth as weathering decreases. Sandstone bed thicknesses ranged from approximately 2.5 feet in Well

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No. 8-86 to 20 feet in Well No. 41-87. The sandstone in Well Nos. 41-87 and 9-86 are homogeneous and contain thin beds and laminae of fine silt and clay. Crossbedding was also noted in Well No. 9-86. Weathered sandstone is lithologically similar to unweathered sandstone.

Siltstones were encountered in the Arapahoe Formation associated with the sandstones as gradational units of silty sandstone or sandy siltstone. Well No. 9-86 encountered relatively homogeneous layers of unweathered siltstone at 89 to 122 feet and again at 139 to 144 feet.

Subcropping sandstones were encountered during drilling for Well Nos. 65-87, 72-87, and 70-87. Subcropping is defined as consolidated sandstone directly underlying the unconsolidated surficial materials. Subcropping sandstones were not fully penetrated during the drilling of Well Nos. 70-87 and 72-87. Section C-C' (Figure 2-2) depicts the subcropping sandstones in Well Nos. 70-87 and 72-87 as interconnected based on their lithologic descriptions and physical proximity to one another. Plate 2-1 shows the estimated areal extent of subcropping sandstones beneath the alluvium inferred from these two wells based on a 3.5-foot-thick unit and a 7 degree easterly dip and the relatively flat topography capping the slope. This is only an estimate since neither borehole (Well No. 70-87 or 72-87) fully penetrated the sandstone unit. The 7 degree dip is based on the correlation of the sandstone unit previously encountered in Well Nos. 9-87 and 16-87 in the 903 Pad Area. These sandstone units were correlated on the basis of similar lithologies, and a 7 degree dip was established (Rockwell International 1987b).

A second, smaller subcropping sandstone area is associated with Well Nos. 64-87 and 65-87. Approximately 3.2 feet of subcropping sandstone was encountered at Well No. 65-87 while Well No. 64-87 found a weathered clayey sandstone at a depth of approximately 1 foot below the Quaternary/Cretaceous contact. These sandstones are similar except for color.

2.1.3 Groundwater Hydrology

Groundwater occurs in surficial material (Rocky Flats Alluvium, colluvium, valley fill alluvium, and artificial fill) and in Arapahoe sandstones and claystones at the Present Landfill. These two hydraulically connected flow systems are discussed separately below. This discussion is based on Rockwell International (1988d) and more recent groundwater level data presented in Rockwell International (1989a) and EG&G (1990a).

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2.1.3.1 Groundwater System in Surficial Materials

Groundwater is present in surficial materials at the Present Landfill under unconfined conditions. Groundwater recharge occurs as infiltration of incident precipitation and from localized spraying of water from the landfill pond. In addition, intermittent recharge occurs as infiltration from ditches and creeks and possibly as seepage from the landfill pond. Discharge from the water table occurs as evapotranspiration and as seepage into the landfill pond, creeks, and springs. Groundwater is also discharged from the surficial groundwater system into the underlying bedrock groundwater system.

The surficial groundwater flow system is dynamic, with relatively large water level changes occurring in response to precipitation events and to stream and ditch flow (Hurr 1976). There are also seasonal variations in the saturated thickness of the surficial materials. In general, water level data for wells completed in Rocky Flats Alluvium, valley fill, and disturbed ground are available starting September 1986 for the 1986 wells and starting between August 1987 and January 1988 for the 1987 wells. Hydrographs showing water surface elevations for the 10 wells on Sections D-D' and E-E' (Figures 2-3 and 2-4) are shown in Figures 2-5, 2-6, and 2-7.

Hydraulic conductivity values were measured in surficial materials from drawdown-recovery tests performed on 1986 wells during the initial site characterization (Rockwell International 1986b) and from slug tests performed on selected 1987 wells. Drawdown-recovery tests were analyzed using the Residual Drawdown Plot (Driscoll 1986) and the method of Bouwer (1978), and slug tests were analyzed by the method of Bouwer and Rice (1976). Results of these tests are summarized in Table 2-2. Test data and analyses are presented in Rockwell Intenational 1988d.

Test results indicate hydraulic conductivity values for the Rocky Flats Alluvium range from 1.3 x 10^{-3} centimeters per second (cm/s) (1300 feet per year [ft/yr]) at Well No. 60-87 to 1.6 x 10^{-5} cm/s (16 ft/yr) at Well No. 58-87, with a geometric mean of 2.4 x 10^{-4} cm/s (240 ft/yr).

2.1.3.1.1 Impact of Landfill Structures on Alluvial Groundwater. Natural groundwater flow in the vicinity of the Present Landfill is generally eastward through the alluvium following original natural topography toward the center of the drainage. In order to control groundwater flow in and around the landfill, a two-part groundwater diversion and leachate collection system was

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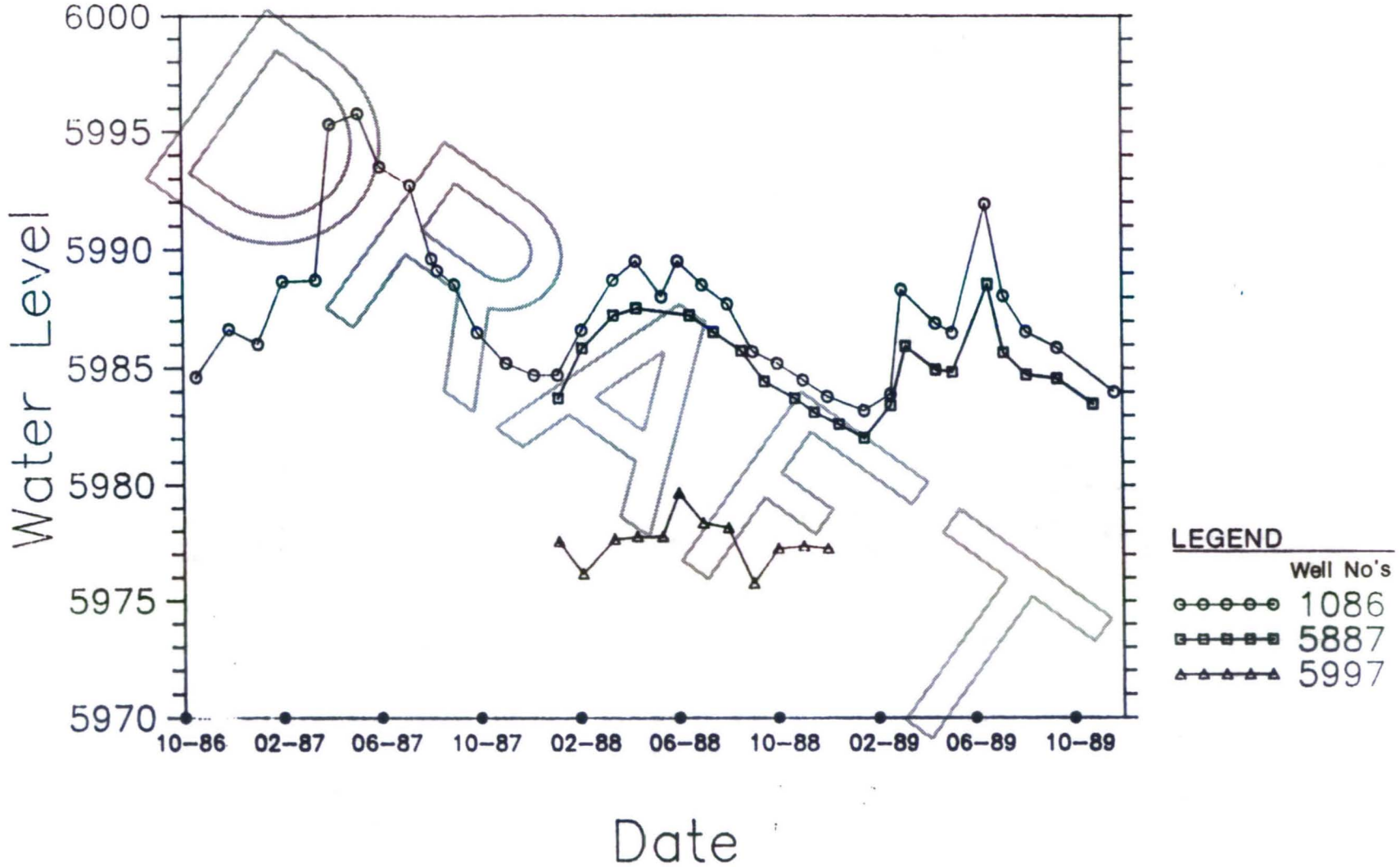

Job No. : 4004-210

Prepared by : A.C.

Date : 4/6/90

GROUNDWATER LEVEL HYDROGRAPH
SECTION E-E'

Figure 2-5

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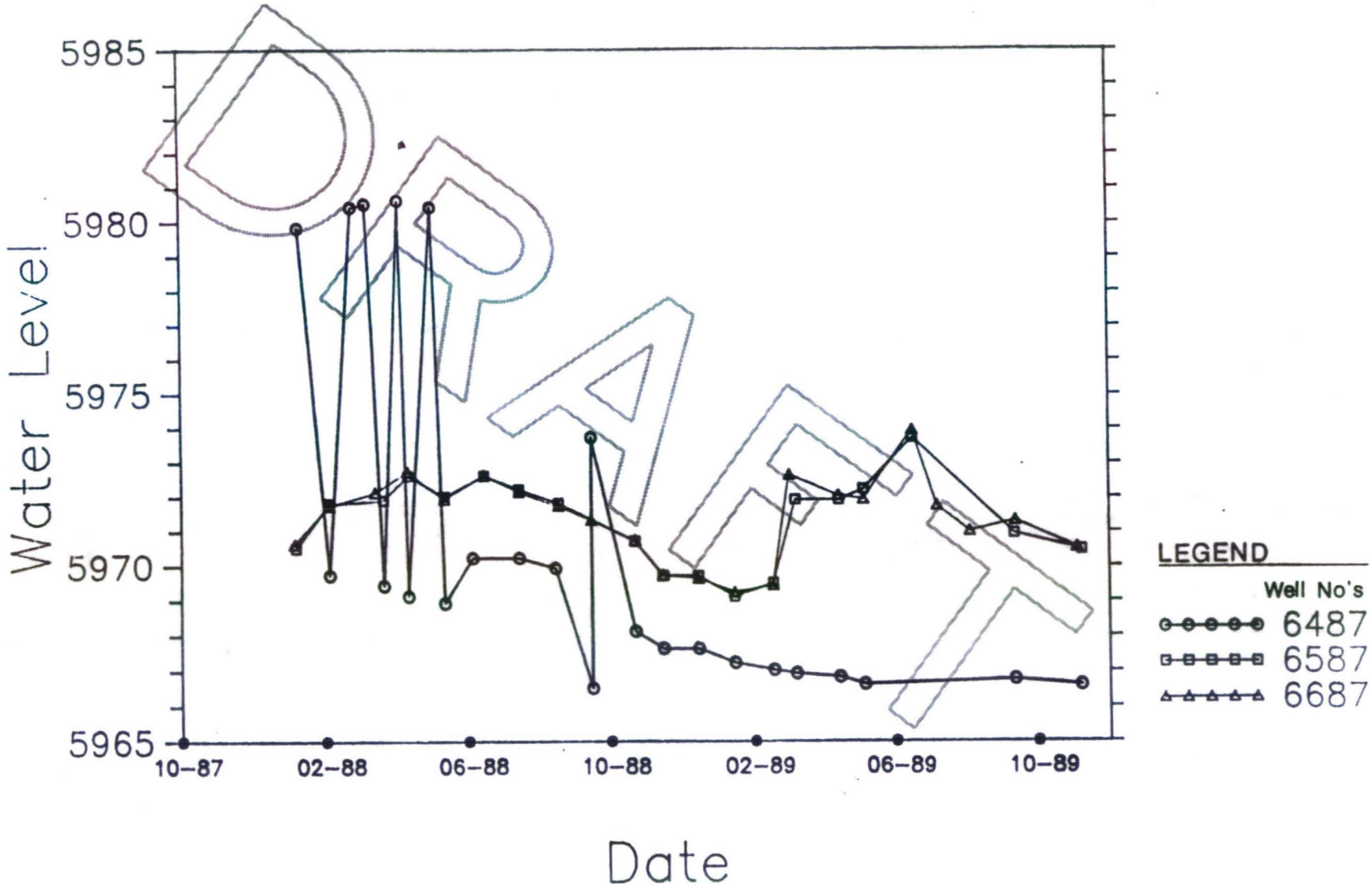

Job No. : 4004-210

Prepared by: A.C.

Date: 4/6/90

GROUNDWATER LEVEL HYDROGRAPH
SOUTH END SECTION D-D'

Figure 2-7

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constructed in 1974. This system was intended to collect and divert groundwater around the outside of the landfill and to collect leachate generated in the landfill and discharge it into the west pond. Details of the design and construction of the system are presented in subsection 2.1.5.

To some extent, the effectiveness of the groundwater diversion and leachate collection system may be judged based on existing water level data. The investigation for the Present Landfill Hydrogeologic Characterization Report (Rockwell International 1988d) included constructing three alluvial monitoring wells along a section just upgradient (west) of the west end of the groundwater diversion and leachate collection system (Section E-E') and seven alluvial monitoring wells along an approximate north-south section through the approximate center of the landfill (Section D-D'). The locations of these sections were shown in Plate 2-1, and Sections D-D' and E-E' are shown in Figures 2-3 and 2-4, respectively. Water level hydrographs for these 10 wells were previously presented in Figures 2-5, 2-6, and 2-7. A potentiometric surface map based on May 1986 groundwater level data is presented in Figure 2-8.

In general, the water level data for Section E-E' (Figure 2-5) indicate the groundwater is drawn down toward the groundwater diversion and leachate collection system. However, water level data are not available on this section just downgradient (east) of the system. Therefore, it can not be determined if the system is collecting and diverting all alluvial groundwater at this location. Similarly, no conclusions can be drawn as to the effectiveness of the leachate collection system at this location.

In general, the groundwater level data from the seven wells along Section D-D' show water levels within the landfill similar to, but somewhat lower than those outside of the groundwater diversion and leachate collection system. Data for the three wells across the southern landfill boundary (Figure 2-7) indicate apparent cyclic fluctuations of abut 10 to 12 feet in the water level just inside the landfill. The water levels in the two wells just outside of the southern landfill boundary were near the water levels north of the north landfill boundary. Rockwell International (1988d) concluded that the lack of groundwater in Well No. 63-87 at the time of the first measurement in 1987 and the fluctuations in water level in Well No. 64-87 may have indicated the groundwater diversion and leachate collection system was functioning intermittently. Additional data indicate water levels in Well No. 63-87 are relatively stable and that Well No. 64-87 has undergone a number of significant fluctuations. The fluctuating levels in Well 64-87 may be in direct response

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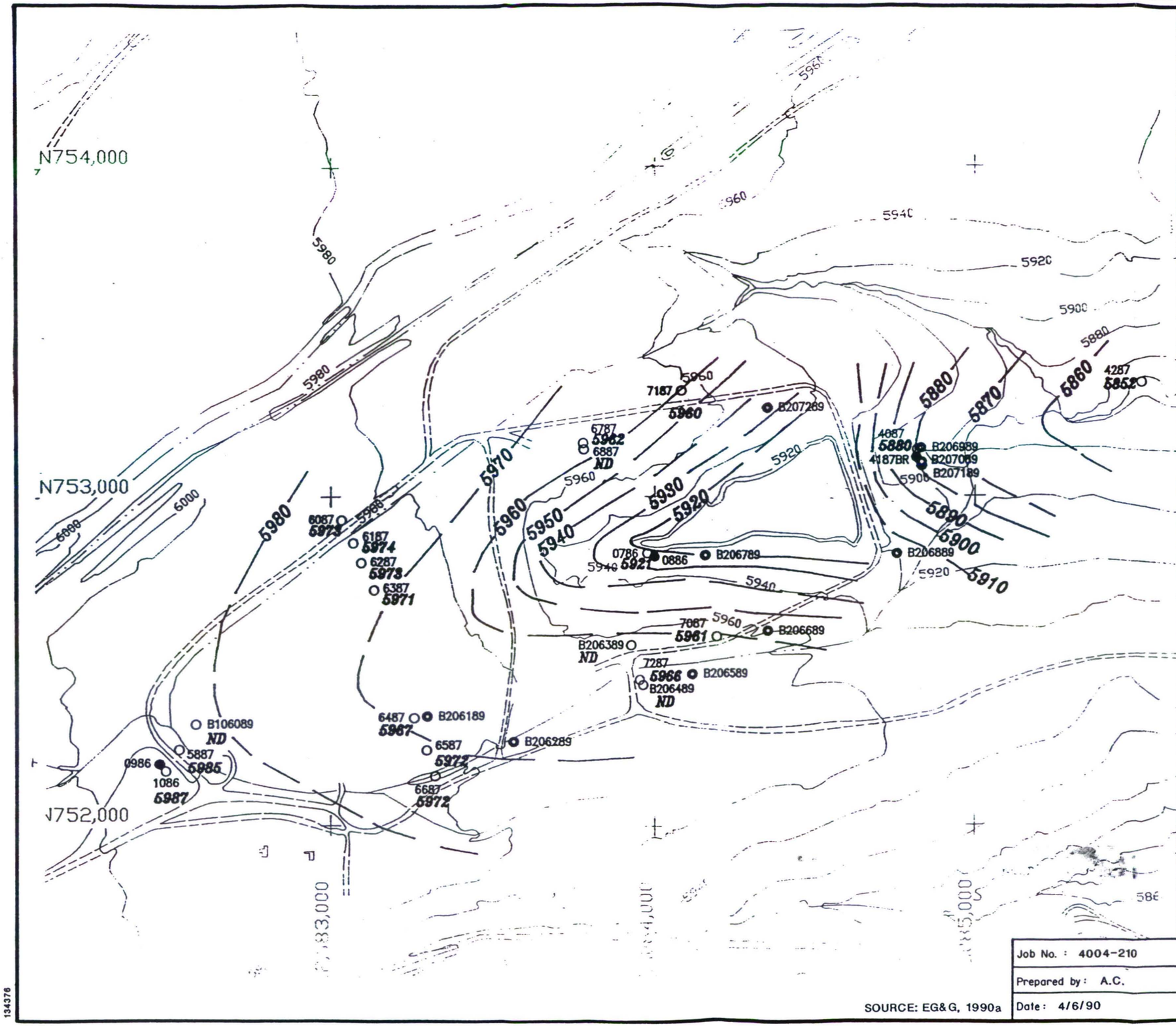

LEGEND

B301889 ○	Alluvial Monitoring Well
B206889 ◐	Weathered Bedrock Monitoring Well
B207189 ●	Unweathered Bedrock Monitoring Well
5960	Potentiometric Surface Elevation May 1989 (feet above mean sea level)
5920	Line of Equal Potentiometric Surface Elevation (feet above mean sea level) Dashed where approximately located Contour Interval – 10 feet
ND	No Data

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FOR COMMENTS & DISCUSSION ONLY
NOT FOR DISTRIBUTION

Scale: 1" = 300'
0' 150' 300'
CONTOUR INTERVAL = 20'

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

PRESENT LANDFILL AREA
1989 RCRA GROUNDWATER
MONITORING REPORT

SOURCE: EG&G, 1990a

Job No. : 4004-210	MAY 1989 POTENTIOMETRIC SURFACE MAP
Prepared by: A.C.	
Date: 4/6/90	Figure 2-8

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to precipitation events although this has not yet been evaluated. The original plans for the system indicate the maximum water levels in Well No. 64-87 are near the original ground surface elevation in that area. This indicates the potential for groundwater within the landfill to have exited to the south above the top of the clay barrier separating the groundwater diversion component from the leachate collection component of the system (see subsection 2.1.5). There may also be a potential for groundwater inflow to occur into the landfill through alluvial materials beneath the system at the locations shown in Plate 2-1 (see subsection 2.1.5).

In addition to the groundwater diversion and leachate collection system, slurry trenches excavated into rock were constructed on the north and south sides of the east portion of the landfill (see subsection 2.1.5 for a more complete description). These slurry trenches were constructed to increase the area surrounded by groundwater controls to allow lateral expansion of the landfill. The purpose of the slurry trenches is to impede the flow of groundwater across them.

The locations of the north and south slurry trenches are shown in Plate 2-1. The well pair 67-87 and 68-87 straddle the north slurry trench. Water levels for well pair 67-87 and 68-87 indicate the water levels are generally within approximately 0.2 to 0.3 foot of each other. Evaluation of the degree of hydraulic continuity existing across the north slurry trench could be assisted by pumping tests in these two wells.

There is not a well pair straddling the south slurry trench. Consequently, evaluation of the effectiveness of the south slurry trench would be difficult. Well No. 70-87 was dry January through March 1988, but had a saturated thickness of approximately 7 feet in April 1988. Water has been found at varying levels, when checked, since then.

Subcropping sandstone was identified in Well Nos. 72-87 and 70-87 (Rockwell International 1988d). It was estimated (Rockwell International 1988d) that approximately 40 percent of the south slurry trench is underlain by subcropping sandstone. This suggests that some degree of hydraulic continuity may extend across the eastern portion of the south slurry trench when saturated alluvium is present.

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2.1.3.2 Groundwater System in Bedrock Materials

Groundwater flow in the Arapahoe Formation occurs within sandstones, siltstones, and claystones. Groundwater recharge to the Arapahoe Formation occurs as infiltration of alluvial groundwater. In general there appears to be a downward gradient between groundwater in surficial materials and bedrock. This has been demonstrated previously at the plant (Hurr 1976 and Rockwell International 1986b, 1988a). Table 2-3 presents vertical hydraulic gradients presented by Rockwell International (1988d) for alluvial/bedrock well pairs 7-86 and 8-86 (bedrock well), 10-86 and 9-86 (bedrock well), and 40-87 and 41-87BR. Calculated vertical gradients range from about 0.2 to 0.5.

Groundwater flow within individual sandstones is from west to east at an average gradient of 0.09 ft/ft based on wells completed in the same sandstones at the 903 Pad and East Trenches Areas (Rockwell International 1987b) and on regional data (Robson et al. 1981a). A site-specific horizontal gradient was not calculated for Arapahoe sandstone (Weston 1988) because it was not believed that any two wells were completed in a common continuous sandstone bed at appropriate locations to do so.

Hydraulic conductivity values for Arapahoe sandstones were estimated from drawdown-recovery tests performed in 1986, a slug test performed in 1987, and packer tests performed in 1986 and 1987. Table 2-4 summarize the results of these tests (Rockwell International 1988). Hydraulic conductivity values in sandstones from drawdown recovery, slug, and packer tests are in reasonably good agreement, varying from 4×10^{-8} cm/s to 3.1×10^{-7} cm/s.

2.1.4 Landfill Area Surface Drainage

The Present Landfill area is drained by an eastward flowing unnamed tributary to North Walnut Creek. The east pond, located immediately downstream of the Present Landfill on the unnamed tributary collects both surface runoff and leachate from the landfill. The unnamed tributary joins North and South Walnut Creek approximately 0.7 mile downstream of the eastern edge of the plant security area before flowing off site.

The surface of the landfill is generally poorly drained. Based on the topography shown in Plate 2-1, the average ground surface slope across the landfill is approximately 1.5 percent down to the

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TABLE 2-3

VERTICAL GRADIENTS

Well No.	Elevation of Potentiometric Surface	Water Level Difference (ft)	Elevation of Saturated Interval Midpoint	Elevation of Saturated Interval	Separator Thickness (ft)	Downview Vertical Gradient
7-86	5920.76		5920.40 - 5917.66	5919.21		
		18.89			56.83	0.33
8-86	5901.87		5864.73 - 5860.02	5862.38		
10-86	5987.93		5991.73 - 5971.24	5979.59		
		20.09			113.32	0.18
9-86	5967.84		5872.66 - 5859.88	5866.27		
40-87	5879.39		5884.19 - 5881.23	5880.31		
		38.44			85.03	0.45
41-87	5840.95		5801.57 - 5788.99	5795.28		

Potentiometric Surface Values Based on April 11, 1988 Measurements

(After Rockwell International 1988b)

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TABLE 2-4

PRESENT LANDFILL RESULTS OF HYDRAULIC TESTS IN THE ARAPAHOE FORMATION

Well No.	Lithology	Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test* (cm/s)
8-86	Claystone	-	-	5.7×10^{-7}
	Unweathered Sandstone	7×10^{-8}	-	
9-86	Siltstone	-	-	2.0×10^{-8}
	Unweathered Sandstone	4×10^{-8}	-	9.0×10^{-8}
41-87BR	Claystone	-	-	6.7×10^{-7}
	Unweathered Sandstone	-	2.78×10^{-8}	3.1×10^{-7}
B2065898R	Weathered Sandtone	-	5.8×10^{-6}	
			5.8×10^{-7}	
B2070898R	Weathered Siltstone	-	2.3×10^{-6}	
B2071898R	Unweathered Siltstone	-	1.4×10^{-7}	
			1.5×10^{-7}	

(After EG&G, 1990a)

* Represents geometric mean value from three tests at various intervals

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east. However, the ground surface is irregular and hummocky, resulting in impeded surface drainage. Standing water collects in many areas during precipitation and snowmelt. Run on to the landfill is controlled by a perimeter interceptor ditch around the north, west, and south sides constructed during the 1974 improvements. This ditch is an approximate 3-foot deep trapezoidal ditch with a 5-foot bottom width. The north and south branches of this ditch discharge into natural drainage features that drain to points downslope of the east pond embankment.

The landfill pond is recharged by groundwater and surface runoff from the landfill located upgradient. The potentiometric surface map (Figure 2-8) indicates groundwater flow from the landfill is in an easterly direction toward the east pond. The potentiometric surface map also indicates groundwater levels well above pond level on the north, west, and south sides. Therefore, groundwater beneath the hillsides north and south of the pond locally flows toward the pond.

Water loss from the pond consists of natural evaporation, which is enhanced by spraying water through fog nozzles and spray irrigation over the pond and on the hill to the south of the pond. Seepage through and beneath the pond embankment is presumed to be limited since the embankment contains a clay core keyed into bedrock (see subsection 2.1.5.3). The pond does not directly discharge surface water to the drainage downgradient (Rockwell International 1988b).

2.1.5 Landfill Structures

2.1.5.1 Subsurface Drainage Structures

As discussed in Section 1.0, a subsurface drainage control system was installed around the perimeter of the landfill in 1974 in response to the detection of tritium downstream of the landfill. The system was designed to collect and remove leachate from within the landfill and to intercept and divert uncontaminated groundwater flow around the landfill. The leachate collection system was intended to collect and discharge leachate and lower groundwater levels within the landfill. During subsequent expansion of the landfill in 1982, the groundwater diversion was extended using soil-bentonite slurry walls. The slurry walls were intended to reduce migration of groundwater into the landfill area.

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The subsurface drainage system consisted of a combined leachate and groundwater interceptor ditch. The leachate and groundwater collection system components were constructed between the surface water interceptor ditch and the landfill, to divert groundwater flow around the landfill, to collect leachate generated in the landfill, and to provide an expanded disposal area. The two-part system was constructed by excavating around the perimeter of the solid wastes to depths of 10 to 25 feet. The trench excavation for the system was 24 feet wide at the base, as shown on Figure 2-9 (Rockwell International 1988b).

The groundwater collection portion of the system was installed on the side of the trench away from the landfill waste. This system consisted of a 1-foot-thick sand and gravel blanket installed along the trench face. This blanket was designed to intercept groundwater and drain to a 6-inch-diameter perforated pipe installed in the bottom of the trench. The intercepted waters could then be discharged to the west pond, east pond, or to surface drainage downslope of the east pond. Control of discharge was accomplished by a series of valves (Plate 2-1). On top of the sand and gravel blanket, a 10-foot-wide clay barrier was placed, which separated the groundwater collection system from the leachate collection system. The design sections and details indicate the trench and clay barrier to be keyed into bedrock. However, the profile sheets in the same set of plans indicate the bottom of the system to be above the bedrock surface at some locations. The locations of these areas are identified in Plate 2-1 as potential breaches beneath the system. The leachate collection system consisted of a 5-foot-thick gravel backfill placed in the bottom of the trench on the landfill side. Collected leachate was discharged into the west pond. The west pond was intended to retain the leachate without discharging to the east pond (Rockwell International 1988b).

Between 1977 and 1981, the leachate collection and groundwater diversion system was buried with waste during landfill expansion. Lateral extension of waste placement has resulted in wastes being located beyond the extent of the subsurface drains (Rockwell International 1988b). The eastward expansion covered the discharge points of the leachate collection system into the west pond.

It is not clear how the groundwater diversion and leachate collection system is functioning. Water level data (subsection 2.1.3) indicate groundwater outside of the landfill is probably not drawn down toward the system in the north and south sides at Section D-D' (Figure 2-3). In addition, water levels within the landfill are relatively high, sometimes higher than those on the outside.

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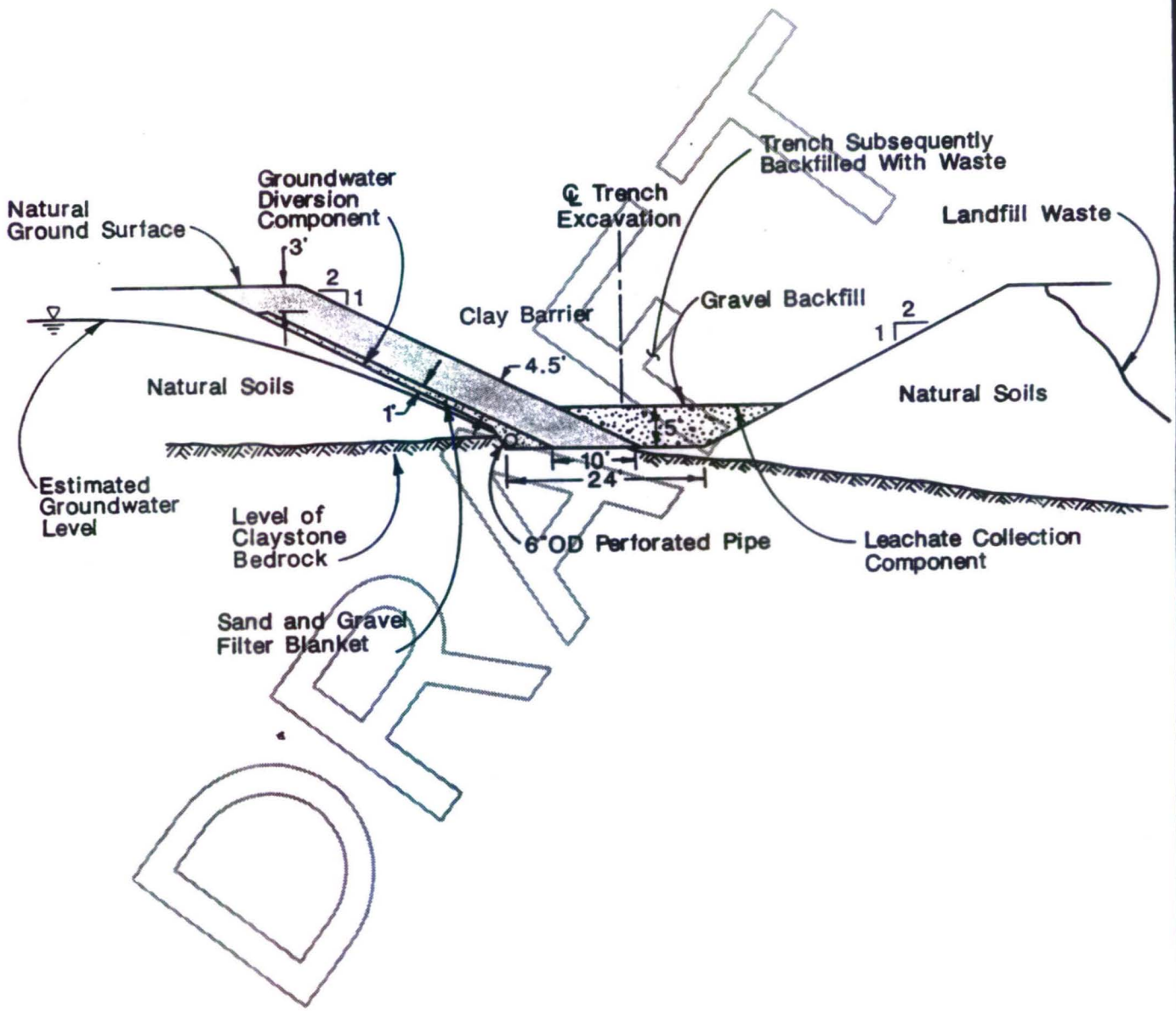

APPROXIMATE SCALE 1"=20'

Job No. : 4004-210	DESIGN SECTION OF GROUNDWATER DIVERSION AND LEACHATE COLLECTION SYSTEM
Prepared by: A.C.	
Date: 4/6/90	Figure 2-9

SOURCE: ROCKWELL INTERNATIONAL 1988d

Considering the poor surface drainage conditions of the landfill, much of the groundwater within the landfill could be from direct vertical infiltration of precipitation and snowmelt. It is not known how much, if any, recharge occurs through or beneath the groundwater diversion system. Drainage of leachate out of the leachate collection system is probably impeded since the discharge points into the west pond have been covered.

2.1.5.2 Slurry Walls

Two soil-bentonite slurry walls were constructed in 1981 to extend the groundwater barriers already in place. The locations of the slurry walls are shown in Plate 2-1. The slurry walls were constructed to reduce groundwater migration from the north and south into the expanded landfill. Design drawings of the construction are presented in an appendix to the 1988 closure plan (Rockwell International 1988b). These slurry walls were tied into the north and south arms of the groundwater diversion system (Plate 2-1). The slurry walls were to tie into the clay barrier constructed in 1974.

The details of the connection in the design drawings indicate the slurry walls extend into the leachate collection system and cut-off the sand drain at the connections. Where the slurry walls intersected the groundwater diversion system at their west ends, the existing perforated pipe was replaced with concrete-encased ductile iron pipe. Therefore, the hydraulic continuity of the sand-gravel drain was interrupted and the only hydraulic connection of the groundwater diversion drain across the slurry trench was through the new segment of pipe. As a result, if these pipes were to be damaged or clogged, there would be no outlet from the groundwater diversion system. The slurry walls extend eastward approximately 700 feet from these points of intersection. Based on design drawings, the slurry walls vary in depth from 10 to 25 feet.

2.1.5.3 East Pond Embankment

In 1974, a new east pond embankment was constructed in approximately the same location as the original dike for Pond No. 2, 1,500 feet east of the 1974 landfill position. The new embankment was an engineered dam structure with a spillway and was designed to retain the majority of the water in the channel. A low permeability clay core keyed into bedrock was constructed within the

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embankment to reduce seepage through it. The remaining shell of the embankment was constructed of more pervious silty to clayey granular soils.

2.1.5.4 Inactive Hazardous Waste Storage Area

The history and operations of the Inactive Hazardous Waste Storage Area (SWMU No. 203) located near the west end of the Present Landfill are discussed in subsection 1.4.2. This area currently consists of a vacant gravel-covered pad. The ground surface appears flat and nearly level. The location of the Inactive Hazardous Waste Storage Area is shown in Plate 2-1.

2.2 NATURE OF CONTAMINATION

The following summary of the nature of contamination consists of edited excerpts from Rockwell International (1988b), Rockwell International (1988d), Rockwell International (1987c), and EG&G (1990a).

2.2.1 Source

The landfill was designed for disposal of the plant's nonradioactive solid waste, including paper, rags, floor sweepings, cartons, mixed garbage and rubbish, demolition materials, and miscellaneous items. Little testing has been performed to characterize the in-place wastes. However, in 1986 and 1987, studies were conducted to identify waste streams generated at the Rocky Flats Plant (Weston 1986a, b, c, and d). At that time, approximately 1,500 waste streams were identified. At the time of the study, 338 of these waste streams were being sent to the landfill for disposal, which included 241 waste streams identified as nonhazardous solid waste (Table 2-5) and 97 solid waste streams that contained hazardous waste or hazardous constituents (Table 2-6).

The nonhazardous solid waste streams being disposed of in the landfill included office trash, empty cans and containers, used filters, and various electrical components. Also included in this waste stream were dried sanitary sewage sludge, solid sump sludge, and other miscellaneous sludges.

The waste streams identified as hazardous fell into four general categories. The first consisted of containers partially filled with paint, solvents, degreasing agents, and foam polymers. Another

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TABLE 2-5
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
111	06780	developer and fixer containers	empty containers	10	lbs/yr	as needed
111	06630	kimwipes and rags	solid	240		continous
111	06610	toner and dispersant containers	empty containers	3		2 per month
111	06820	empty developer and fixer container	empty containers	100		as needed
111	06680	empty solvent containers	empty containers	3		1 per month
111	06640	empty toner containers	empty containers	10		3 per week
111	06690	kimwipes and rags	solid	240		continous
111	06670	empty ink cans	empty containers	12		3-4 per month
111	06800	kimwipes and filmpacks	solid	100		as needed
111	06650	demineralizer system filters	solid	24		1 per month
111	06760	kimwipes and rags	solid	100		
111	06740	empty chemical containers	empty containers	100		as needed
121	04810	solid waste	solid	100		intermittant
121	04780	gun patches	solid	50		continuous
123	02830	waste resin	aqueous	3		batch
123	03080	batteries,metalwire,used elec.comp.	solid	500		continuous
123	03000	empty vials	solid	100		batch
123	02880	waste resin	solid	50		batch
123	03070	kimwipes	solid	200		continuous
124	01910	settling basin sludge	aqueous	500000	gal/yr	batch
124	00010	microstrainer backwash	aqueous	180000	gal/yr	summer operation
124	00020	clarifier underflow	aqueous	1500000	gal/yr	continuous
124	00030	sand filter backwash	aqueous	1500000	gal/yr	intermittent
124	01660	dried sludge	solid	5000	lbs/yr	once/ 6 months
125	02550	kimwipes	solid	100		continuous
125	02730	oil filters	solid	5		intermittant
130	07350	copy machine toner	empty containers	100		as needed
130	07400	rejected bags	solid	200		as needed
130	07330	polaroid film backings	solid	100		as needed
130	07390	kimwipes	solid	100		as needed
130	07360	packing materials	solid	100		intermittent
130	07380	water conditioning filters	solid	5		twice per month
130	07340	floor sweepings	solid	100		as needed
223	06840	compressor oil filter	solid	1		1 filter/2 years
331	06430	oil filters and used parts	solid	500		daily
331	06440	paint and body-filler cans	solid	200		as needed
333	06230	shavings	solid	100		daily
333	06220	sawdust	solid	100		as needed
333	06110	filters	solid	200		weekly
333	06210	blast waste	solid	1500		as needed
333	06140	empty cans	empty containers	100		as needed
333	06080	empty paint cans	solid	200		as needed
333	06200	scrapings	solid	200		as needed
333	06180	empty cans	empty containers	100		as needed
333	06130	rags	solid	300		as needed
333	06150	disposed equipment	solid	1000		as needed
333	06090	empty paint cans	solid	500		as needed
334	07050	wood/plastic shavings	solid	500		continous
334	07060	floor scrap	solid	200		daily
334	07110	other metal waste	metal	500		
334	06950	enamel residue	solid	100		intermittent
334	07250	miscellaneous solid waste	metal	500		daily
334	07140	scrap metal	metal	500		daily
334	07160	fluorescent light tubes	solid	1000		as needed
334	07120	used filters	solid	2		as needed
334	07130	metal and silica waste	solid	500		intermittent
335	07040	fire extinguisher chemicals	aqueous	200	gal/yr	as needed
373	11640	sump sludge	solid	100	lbs/yr	yearly
439	00070	kimwipes and rags	solid	200		as needed
439	00110	empty cans and containers	empty containers	100		as needed
439	00060	metal chips	metal	500		daily

(After Weston, 1986a, b, c, d, 1987)

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Table 2-5
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
439	00090	kimwipes	solid	200	lbs/yr	as needed
440	00140	aluminum and sst chips	metal	500		
440	00180	kimwipes and rags	solid	500		as needed
440	00160	empty containers	empty containers	100		as needed
440	01390	kimwipes and rags	solid	500		
440	00200	kimwipes and rags	solid	500		as needed
441	00220	toner	empty containers	100		as needed
442	00260	respirator cartridges	solid	100		
442	00250	defective HEPA filters	solid	50		as appropriate
445	15340	trash	solid	500		continuous
445	15280	trash	solid	500		continuous
445	15260	carbon dust	solid	20800		continuous
445	15290	steel shavings	metal	5000		continuous
445	15270	carbon scraps	solid	10000		continuous
445	15300	steel scraps	metal	5000		continuous
449	11070	rags	organic	200		
449	11060	empty paint cans and containers	empty containers	10		
449	11090	miscellaneous trash	solid	660		
454	11890	sump sludge	solid	800		intermittent
457	11860	sump sludge	solid	200		intermittent
460	00910	used kimwipes and floor dry	solid	0		as needed
460	00940	used kimwipes	solid	302		as needed
460	23630	bijur filter screen	solid	2		once/6 mon
460	00600	used kimwipes and rags	solid	200		as needed
460	23770	bijur filter screen	solid			once/6 mon
460	00770	used oil filters	solid	70		as needed
460	23690	air filter	solid	2		once/6 mon
460	00880	metal chips	metal	0		to be determined
460	01000	used kimwipes	solid	55		as needed
460	23710	bijur filter screen	solid	2		once/6 mon
460	00370	used oil filters	solid	20		4 per year
460	01080	kimwipes	solid	150		as needed
460	00840	used kimwipes and floor dry	solid	0		as needed
460	01250	kimwipes and rags	solid	165		as needed
460	23800	bijur filter screen	solid			
460	00460	used kimwipes and rags (vap)	solid	280		as needed
460	01310	kimwipes	solid	50		as needed
460	23680	hydraulic intake filter	solid	2		once/6 mon
460	00640	kimwipes and rags	solid	110		
460	23850	air inlet filter	solid			once/6 mon
460	00810	metal chips	metal	0		to be determined
460	01090	empty paint cans	empty containers	100		
460	23700	bijur filter screen	solid	2		once/6 mon
460	00930	used filters	solid	1800		to be determined
460	01360	kimwipes and floor dry	solid	20		as needed
460	23680	hydraulic system filter	solid	2		once/6 mon
460	01060	discarded containers	empty containers	100		intermittent
460	00890	used kimwipes	solid	0		as needed
460	01050	metal chips	metal	300		to be determined
460	01200	empty chem. and solvent containers	empty containers	100		intermittent
460	01230	kimwipes w/Freon	solid	165		as needed
460	00710	kimwipes, gloves and gauze	solid	0		as needed
460	00710	used kimwipes, gloves and gauze	solid	580		as needed
460	00490	used kimwipes and gloves	solid	110		as needed
460	00950	used kimwipes and floor dry	solid	110		as needed
460	01140	kimwipes and rags	solid	165		as needed
460	00570	nuocure	solid	100		
460	00750	metal chips	metal	0		to be determined
460	23780	bijur filter screen	solid			
460	00380	used kimwipes and gauze	solid	150		as needed
460	01280	kimwipes and floor dry	solid	40		as needed

(After Weston, 1986a, b, c, d, 1987)

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Table 2-5
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
460	00820	used kimwipes	solid	0	lbs/yr	as needed
460	00830	used oil filters	solid	0		as needed
460	01110	empty containers	empty containers	100		intermittent
460	01100	kimwipes and rags	solid	165		as needed
460	00450	used kimwipes and rags (ult)	solid	280		as needed
460	01270	kimwipes	solid	40		as needed
460	23650	apron filter	solid	2		once/6 mon
460	23790	bijur filter screen	solid			once 6/mon
460	01240	empty containers	empty containers	100		as needed
460	09000	used oil filters	solid	0		to be determined
460	23640	turret res. filter	solid	2		once/6 mon
460	23750	inline coolant filter	solid	2		once/6 mon
460	01190	kimwipes	solid	100		as needed
460	01340	kimwipes and rags	solid	60		as needed
460	01170	sludge	solid	1200		to be determined
460	01120	kimwipes and rags	solid	165		as needed
460	00630	film packs	solid	48		
460	01110	empty containers	empty containers	100		intermittent
460	23740	rough inline filter	solid	2		once/6 mon
460	23720	oil filter	solid	2		once/6 mon
460	01070	used kimwipes and floor dry	solid	48		as needed
460	00760	used kimwipes	solid	24000		as needed
460	01320	kimwipes	solid	200		as needed
460	01180	used oil filters	solid	2000		weekly
460	00780	used kimwipes and floor dry	solid	350		as needed
460	00980	metal chips	metal	40		
460	01010	used oil filters	solid	15		as needed
551	06320	metal cuttings	metal	300		
551	06310	spray paint cans	empty containers	100		
551	06300	kimwipes and degreasing residue	solid	300		
560	11810	sump sludge	solid	200		1 to 2 years
563	20580	sump sludge	solid	200		intermittent
662	04040	used filters	solid	20		intermittnat
662	04000	kimwipes	solid	200		continuous
662	04030	broken parts	solid	100		as occurs
664	17500	empty containers	empty containers	100		daily
664	17510	used rags	solid	200		daily
664	17590	solid waste	solid	500		continuous
701	17620	solid waste	solid	200		daily
705	20280	kimwipes	solid	1		as needed
705	20240	polishing pads	solid	2		as needed
705	20300	metal and glass scraps	solid	100		daily
705	20250	kimwipes	solid	3		as needed
705	20620	dumpster	solid			
705	20060	kimwipes	solid	20		as needed
705	20310	office trash	solid	1000		daily
705	20410	sump sludge	solid	20		continuous
708	10650	HEPA filters	solid	200		PMO schedule
709	11700	sump sludge	solid	200		varies
711	20530	sump sludge	solid	200		varies
712	20590	sump sludge	solid	200		varies
713	20600	sump sludge	solid	200		varies
732	15020	filters	solid	300		once per month
750	09100	empty toner/developer containers	empty containers	3		intermittent
750	09020	empty fixer/developer containers	empty containers	100		as required
750	09110	kimwipes	solid	100		intermittent
750	09070	microfilm wrapper	solid	100		continuous
750	09060	empty containers	empty containers	100		intermittent
750	09090	kimwipes	solid	100		intermittent
770	22570	rags	solid	365		occasionally
770	22650	combustibles	solid	4700		daily

(After Weston, 1986a, b, c, d, 1987)

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Table 2-5
Solid Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
770	22640	metal chips/scraps	metal	3276	lbs/yr	biweekly
771	22250	empty containers & surgical gloves	solid	5000		every 2 weeks
771	22470	plastic scraps	solid	2900		daily
771	22450	metal chips	metal	3275		weekly
771	22460	combustibles	solid	5000		daily
776	12020	wood & plastic chips/dust	solid	10400		weekly (200 lbs./wk
776	12010	empty containers	empty containers	100		occasionally
776	12030	soiled kimwipes	solid	2080		weekly (40 lbs/wk)
776	12040	empty containers	empty containers	2080		weekly (40 lbs/wk)
778	15040	trash in canisters	solid	800		continuous
778	15210	sanitary trash	solid	500		continuous
778	15050	metal/wood shavings	solid	2000		continuous
778	15060	sanitary trash	solid	500		continuous
778	15090	sanitary trash	solid	500		continuous
778	15210	metal/wood shavings	solid	2000		continuous
778	15140	trash	solid	1000		continuous
778	15310	sanitary trash	solid	500		continuous
779	19050	sanitary trash	solid	1300		continuous
779	15480	trash	solid	1000		continuous
779	15400	kimwipes	solid	480		periodically
779	19060	metal shavings/fines	metal	300		continuous
779	15730	water chiller filters	solid	10		monthly
779	15460	plastics grindings	organic	500	gal/yr	continuous
779	19200	machine fines	metal	300	lbs/yr	continuous
779	15410	mixed trash	solid	500		continuous
779	19190	sanitary trash	solid	500		continuous
779	15450	grindings metal	metal	1000		continuous
783	11780	sump sludge	solid	200		intermittent
850	04940	toner and dispersant bottles	empty containers	5		intermittant
865	04240	stainless steel grinding paper	solid	6		per year
865	04280	mold compound	solid	50		
865	04290	photography lab solid wastes	solid	240		
865	04330	metal scraps	metal	260		
881	04670	aerosol, paint and thinner cans	empty containers	200		
881	04620	dirty kimwipes	solid	200		as needed
881	04710	uncontaminated solid waste	solid	5000		
881	04610	other metal chips	metal	600		
881	05070	rags and kimwipes	solid	100		
885	05110	rags	solid	100		
886	03190	copy machine waste	solid	40		
910	06360	diatomaceous earth	solid	54750		weekly/monthly
910	07560	wastewater sludge	solid	0		intermittant
966	06840	empty containers	empty containers	100		intermittent
980	06550	kimwipes	solid	1500		daily
980	06980	sawdust soaked with oil seepage	solid	900		daily
980	06590	metal scrap	metal	5000		daily
980	06530	metal scrap	metal	2000		daily
980	06520	fiberglass resins and catalysts	solid	1000		intermittent
980	06500	metal scraps	metal	5000		daily
980	06570	oily rags	solid	480		daily
980	06510	rags with mineral spirits	solid	1480		daily
980	06490	empty containers	empty containers	100		intermittent
980	06580	oily rags	solid	480		daily
991	07510	toner & dispersant containers	empty containers	100		monthly
991	07500	empty paint containers	empty containers	100		
T750	06010	empty toner/dispersant containers	empty containers	100		monthly
T750	06040	kimwipes	solid	100		as needed
T750	06020	soiled kimwipes	solid	100		as needed

(After Weston, 1986a, b, c, d, 1987)

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Table 2-6
Hazardous Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
111	06700	film packs and positives	solid	50	lbs/yr	
123	03100	broken badges	solid	200		as occurs
123	03120	waste vials	solid	100		batch
123	02930	waste resin	solid	5		batch
123	03160	waste resin	solid	100		as required
125	02560	filters	solid	5		Change once/year
125	02640	silicone oil filters	solid	5		
125	02580	kimwipes	solid	100		continuous
334	07070	mineral and asbestos dust	solid	200		as appropriate
367	06930	empty cans, bags and containers	empty containers	100		as needed
377	09960	oil filters	solid	5		pmo schedule
440	01500	kimwipes and rags from paint booth	solid	500		
440	00120	composite kimwipe drum	solid	600		
440	01460	foam trimmings	solid	200		
440	01410	empty paint cans	empty containers	100		
440	00390	metal chip dumpster	solid	2000		
440	00170	R-compound	organic	2640		
440	01470	kimwipes and rags	solid	500		
440	01480	kimwipes and rags	solid	500		
440	01440	kimwipes and rags	solid	500		
440	01420	paint filters	solid	300		
443	00320	contaminated rags	solid	200		as needed
444	14120	sst, iron metal chips	metal	1200		continuous
444	11920	sump sludge	solid	200		varies
453	11130	paper towels	solid	2		intermittent
460	23520	metal chips	metal	0		
460	23560	metal chips	metal	0		
460	01640	air filters	solid	0		
460	23540	metal chips	metal	0		
460	23610	metal chips	metal	0		
460	02350	metal chips	metal	0		
460	02460	metal chips	metal	0		
460	23620	metal chips	metal	0		
460	02300	metal chips	metal	0		
460	01750	metal chip composite	metal	100000		
460	23510	metal chips	metal	0		
460	02290	metal chips	metal	0		
460	02480	metal chips	metal	0		
460	02440	metal chips	metal	0		
460	01650	water filters	solid	0		
460	01830	water filters (x-ray)	solid	50		
460	02280	metal chips	metal	0		
460	01600	compressor filters	solid	40		
460	23580	metal chips	metal	0		
460	02270	metal chips	metal	0		
460	02370	metal chips	metal	0		
460	23550	metal chips	metal	0		
460	01370	film packs	solid	30		
460	02390	metal chips	metal	0		

(After Weston, 1986a, b, c, d, 1987)

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Table 2-6
Hazardous Waste Stream to Landfill
(1986)

BUILDING NO.	WASTE NO.	WASTE NAME	WASTE TYPE	QUANTITY GENERATED	UNITS	GENERATION FREQUENCY
460	02410	metal chips	metal	0		
460	02500	metal chips	metal	0		
460	23570	metal chips	metal	0		
460	02340	metal chips	metal	0		
460	00590	mercury light bulbs	solid	5		
460	02320	metal chips	metal	0		
460	02400	metal chips	metal	0		
460	23590	metal chips	metal	0		
460	01780	empty containers	empty containers	100		
460	02380	metal chips	metal	0		
460	02330	metal chips	metal	0		
460	01580	kimwipes and rags	solid	165		
460	02360	metal chips	metal	0		
460	02450	metal chips	metal	0		
460	23600	metal chips	metal	0		
460	23530	metal chips	metal	0		
460	02310	metal chips	metal	0		
460	23470	metal chips	metal	0		
460	02430	metal chips	metal	0		
460	02490	metal chips	metal	0		
460	02420	metal chips	metal	0		
528	15360	kimwipes	solid	10		periodically
549	07300	empty containers	empty containers	100		as needed
562	09840	paper towels with oil	solid	20		varies
668	09570	rags with methyl alcohol	solid	50		intermittant
705	20180	kimwipes	solid	15		as needed
708	10690	rags w/freon and trichloroethane	solid	200		
727	09520	paper towels with oil/freon TF	solid	100		intermittant
771	22010	deionizer exchange resin column	solid	5		yearly
771	22230	bottles, cartons, gloves, kimwipes	solid	15000		continuous
771	22210	liquid chemical containers	solid	4000		continuous
775	22030	trash paper	solid	200		none
776	12120	soiled kimwipes	solid	365		daily
776	12130	empty containers	empty containers	365		daily
776	12100	empty containers	empty containers	365		daily
776	12000	soiled kimwipes	solid	1200		once per day
776	12180	soiled kimwipes	solid	4000		daily
776	12090	soiled kimwipes	solid	365		daily
779	19730	metal chips	metal	10000		2/week
780	09590	rags with trichloroethane	solid	50		infrequent
780	09580	empty paint cans	solid	50		infrequent
881	04660	metal and plastic chips	solid	10000		
881	04760	dirty kimwipes	solid	100		
881	03240	waste resin	solid	4		continuous
886	03180	kimwipes	solid	10		
886	03200	chemicals in cabinet	organic	50		infrequent
910	06340	filter backwash	aqueous	100000		weekly
991	07490	reject rings	solid	1880		weekly

(After Weston 1986a, b, c, d, 1987)

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category was Kimwipes and rags that were contaminated with the same materials. Filters were also included in the hazardous waste streams and were typically silicone oil filters, paint filters, oil filters, and other used filters that may have contained hazardous constituents. The final category consisted of metal cuttings and shavings, including mineral and asbestos dust, and miscellaneous metal chips coated with hydraulic oil and carbon tetrachloride.

In the fall of 1986, wastes with hazardous constituents ceased to be disposed of in the landfill. This policy was implemented through the tightening of administrative procedures and the implementation of the findings of the Waste Stream Identification and Characterization Reports (Weston 1986a, b, c, d, 1987).

In September of 1973, tritium and strontium were detected at the drainage of the Rocky Flats sanitary landfill by the Lawrence Livermore Laboratories (Rockwell International 1987c). Because of this finding, monitoring wells (at the time called environmental test holes) were installed in the landfilled waste to try to identify the sources of tritium and strontium. The following discussion (remainder of subsection 2.2.1) is taken from that report. From September 1973 through January of 1974, the results from strontium 89-90 analyses showed large variations in concentration. The Lawrence Livermore Laboratories sample that had been though to be greatly elevated in strontium (34 pCi/l) was reevaluated and found to be less concentrated (16 pCi/l), but still above background levels. Background levels were considered to be approximately 1 to 25 pCi/l for strontium in water, based upon water samples taken in that time period from Rock Creek. Samples of groundwater/leachate from boreholes in the landfill were analyzed for strontium, and only one sample (from TH-4) appeared elevated in strontium at 7 pCi/l. All other samples of groundwater/leachate had strontium concentrations of less than 1 pCi/l. The detection limit of the method used to analyze for strontium at the time was 0.1 pCi/l. Strontium was analyzed in the landfill ponds, drainages, and groundwater intercept system, and generally found at background levels. Table 2-7 presents the strontium results from the landfill ponds in the period from 1973 to 1984. The data did not appear to indicate a problem with migration of strontium.

Results for tritium were more consistent. Monitoring wells were installed a number of different times resulting in approximately 57 wells installed directly in the landfilled waste or directly below the saturated waste materials by the end of the investigation. Elevated tritium readings were followed until the source of tritium had been fairly well identified. The tritium concentrations in

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TABLE 2

STRONTIUM IN LANDFILL PONDS

MO.	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
JAN.	n.a.[2]	0.5	<3	3.5 E 7.5 W	3.6 E <3 W	n.a.	n.a.	n.a.	n.a.	NO DATA AVAILABLE	NO DATA AVAILABLE	n.a.
FEB.	n.a.	<3	<3	<3 E <3 W	3.0 E 3.0 W	n.a. n.a.	n.a.	<3	n.a.			n.a.
MAR.	2.3	<3	n.a.	3.2 E 3.2 W	4.6 E <3 W	n.a.	7.2	<3	<3			n.a.
APR.	n.a.	2.4	n.a.	n.a.	<3 E <3 W	n.a.	5.7	<3	<3			n.a.
MAY	n.a.	n.a.	<3	<3	3.5 E <3 W	n.a.	n.a.	<3	3.5			n.a.
JUNE		n.a.	<3	4.2	4.3 E <3 W	n.a.	<3	<3	3.3			n.a.
JULY		n.a.	<3	<3	4.3 E <3 W	n.a.	3.3	<3	4			n.a.
AUG.		n.a.	<3	<3	3.5 E 2.1 W	3.2 E	<3	<3	4.5			n.a.
SEP.		n.a.	<3	<3	4.1 E 5.0 W	<3 E	n.a.	n.a.	3			n.a.
OCT.		7.9	<3	<3 3.4 W	4.4 E <3 W	4.3 E <3 W	<3	n.a.	3			16
NOV.		n.a.	<3	<3	3.6 E <3 W	5.8 E <3 W	3.6	n.a.	<10			16
DEC.		n.a.	0.6	<3	3.7 E <3 W	45 E <3 W	n.a.	n.a.	NS	3		n.a.

NOTES
(1) Results prior to April 1983 were for ^{89}Sr+ ^{90}Sr in most cases, exept for 1973 and units are pCi/l.
(2) n.a. means not analyzed.
(3) EPA Drinking Water Standard: ^{89}Sr=80pCi/l, ^{90}Sr=8pCi/l.
(4) Local Background for ^{90}Sr=2pCi/l.

(From Rockwell International 1987c)

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the water near the tritium source were as high as 301,609 pCi/l (TH-46). The depth of the tritium source, total activity, configuration, and container, if any, are unknown. It was estimated in 1974 that the waste containing the source was dumped in approximately 1970. The wells nearing the eastern end of the landfill exhibited decreasing tritium concentrations. Seeps of leachate at the eastern end of the landfill had tritium concentrations of 5,000 to 7,000 pCi/l in 1973/1974. The Derived Concentration Guide (DCG) (based on a Department of Energy [DOE] August 5, 1985 memorandum using DOE dose limit of 0.1 rem/yr to members of the public from all pathways, dose conversion factors given in the memorandum, and intake rates of 2.0 liters/day for water) for tritium is 2,000,000 pCi/l. The current EPA and Colorado standard for drinking water is 20,000 pCi/l, the proposed EPA drinking water standard (based on a September 30, 1986 Advanced Notice of Proposed Rulemaking, and a risk equal to that from a dose rate of 4m rem/yr) is 90,000 pCi/l. These criteria indicate that the leachate found downgradient of the sanitary landfill never exceeded the drinking water standard. The leachate in the immediate area of the tritium source never exceeded the DCG. The tritium levels that were found in the immediate area of the tritium source did not appear to represent a threat to human health or the environment unless tritium was found migrating out of the landfill.

The leachate and runoff water collected in the western leachate pond was found to contain 1,800 to 7,922 pCi/l of tritium in 1974. The tritium concentrations in this pond decreased with time (922 to 1,365 pCi/l in 1977, and 490 to 886 pCi/l in 1980). Table 2-8 shows the tritium concentrations found in the western pond. The western landfill pond was removed for landfill expansion in May/June of 1981.

2.2.2 Soils

Data have not been obtained for the purpose of characterizing the nature and extent of contaminated soil around and beneath the landfill nor at the inactive hazardous waste storage area. It may be reasonable to assume that the nature of contamination is similar to the groundwater contamination (see subsection 2.2.3). Since much of the waste volume is saturated, it is likely some soil contamination exists immediately beneath and downgradient of the landfill.

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2.2.3 Groundwater

Since little data exist on the nature of contamination in the soils and source at the Present Landfill, a comparison of upgradient with downgradient groundwater quality data was used to identify potential contaminants within the landfill.

In order to facilitate the interpretation of groundwater contamination at the Present Landfill, a background characterization program was implemented to define the spatial and temporal variability of naturally occurring constituents. Fieldwork was conducted in 1989, and a draft Background Geochemical Characterization Report for the entire Rocky Flats site was prepared by Rockwell International and submitted to the regulatory agencies (Rockwell International 1989c). The document summarized background data for groundwater, surface water, sediments, and geologic materials, and identified preliminary statistical boundaries of background variability. Spatial variations in the chemistry of geologic materials and water were addressed by placing sample locations throughout areas at the plant. The information in the draft background geochemical report (one round of groundwater samples) was used to preliminarily characterize inorganic contamination at the Present Landfill (Table 2-9).

Two alluvial wells (Well Nos. 7-86 and 10-86) and two bedrock wells (Well Nos. 8-86 and 9-86) were installed at the Present Landfill as part of plant-wide hydrogeologic site investigations in 1986. Three additional wells (alluvial Well Nos. 40-87 and 42-87, and bedrock Well No. 41-87BR) were installed in and around the landfill in 1987 according to the CEARP Phase 2 Site Specific Monitoring Plan. Alluvial Well Nos. 58-87, 59-87, 60-87, 61-87, 62-87, 63-87, 64-87, 65-87, 66-87, 67-87, 68-87, 60-87, and 72-87 were also completed in and around the landfill in 1987 to evaluate groundwater quality and the performance of the groundwater diversion system and the slurry wall.

Fifteen additional wells were proposed for the Present Landfill Area in the 1988 Annual RCRA Ground-Water Monitoring Report (Rockwell International 1989a). These wells were proposed to monitor groundwater quality and water levels within the landfill, in sandstone units that subcrop beneath the landfill, and in the weathered claystone. Thirteen wells (B106089, B206189, B206289, B206389, B206489, B206589, B206689, B206789, B207889, B206989, B207089, B207189, and B207289) were actually installed.

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TRITIUM IN WESTERN LANDFILL POND

MO.	1980	1979	1978	1977	1976	1975	1974	1973
JAN.	738	1316	1136	1365	1740	1143	n.a.	
FEB.	709	780	1368	922	1733	1429	n.a.	
MAR.	520	844	775	1303	1323	1837	7922	
APR.	886	886	944	1113	1431	924	n.a.	
MAY	639	805	956	818	1121	1445	n.a.	
JUNE	530	816	720	740	1172	984	5875	
JULY	546	694	953	856	1378	1520	4797	
AUG.	508	976	1022	983	1305	1258	3724	
SEP.	576	564	768	863	1143	1777	5056	34,000 39,000 57,000
OCT.	495	938	818	806	869	1762	3304	n.a.
NOV.	490	575	1033	812	1005	1553	1800	n.a.
DEC.	530	436	863	880	1067	1542	n.a.	n.a.

NOTES:
(1) Units are pCi/l.

(From Rockwell International 1987c)

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Quarterly monitoring of the wells at the landfill was initiated immediately upon their completion and development. The 1986 wells were sampled once during 1986 and quarterly during 1987, 1988, and 1989. The 1987 wells were sampled once during 1987 and quarterly during 1988 and 1989. The 1989 wells were sampled once in late September 1989. (The September 1989 samples for the 1989 wells were considered fourth quarter samples.)

Results of hydrogeologic investigations of the Present Landfill (Rockwell International 1988d) suggest that the groundwater diversion system may not isolate the landfill from the surrounding groundwater. Based on alluvial groundwater quality data from wells within and surrounding the landfill, Rockwell International 1988d states that it appears the landfill contributes calcium, bicarbonate, and to a lesser extent, sodium, sulfate, iron, manganese, and strontium to the groundwater. Groundwater to the north of the north slurry wall had similar concentrations of these analytes, which may be because of the historical spray irrigation operation north and upgradient of this location. With respect to the public health significance of the water quality directly downgradient of the landfill (Well No. 42-87), only iron and manganese exceeded the proposed concentration limits. However, manganese also exceeds the limit (maximum concentration of 0.63 mg/l) in upgradient groundwater, and it was not elevated downgradient with respect to upgradient conditions. High salt concentrations further down the drainage (Well Nos. 6-86 and 5-86) appear to result from an unidentified source.

Bedrock groundwater quality appears to be influenced largely by mineral dissolution within the sandstones and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial groundwater within the landfill. The following discussions (remainder of subsection 2.2.3) were taken from the 1989 Annual RCRA Groundwater Monitoring Report (EG&G 1990a).

2.2.3.1 Alluvial Groundwater Quality Within the Present Landfill

Groundwater data show that there are areas of alluvial groundwater at the landfill that appear to have elevated concentrations of 1,1,1-TCA, TCE, barium, calcium, iron, magnesium, manganese, sodium, strontium, zinc, sulfate, chloride, total dissolved solids (TDS), tritium, and uranium. For pre-1989 wells, this assessment is based on second quarter 1989 volatile organics, dissolved metals, and inorganics data, and second quarter radiochemistry data. Fourth quarter 1989 inorganics data, and to a lesser extent, dissolved metals and volatile organics data, exist for the 1989 wells. The

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Table 2
(Continued)

BACKGROUND GROUND-WATER (ROUND 1)
TOLERANCE INTERVAL UPPER LIMITS
OR MAXIMUM DETECTED VALUE

Analyte	Units	Rocky Flats Alluvium (11 Samples)	Colluvium (2 Samples)	Valley Fill Alluvium (8 Samples)	Weathered Claystone (4 Samples)	Weathered Sandstone (2 Samples)	Unweathered Sandstone (7 Samples)
Other							
Total Dissolved Solids	mg/l	352	520*	947	320*	170*	1761
Carbonate	mg/l	ND	ND	ND	ND	ND	49
Bicarbonate	mg/l	436	470*	719	400*	140*	412
Chloride	mg/l	15.6	20*	40.29	11*	15*	607
Sulfate	mg/l	45.1	86*	150	44*	16*	950
Nitrate	mg/l	2.98	0.18*	0.69*	0.58*	1.6*	0.610
Cyanide	mg/l	.0038*	ND	ND	0.0036*	ND	ND
pH	----	8.6 (5.98)	7.4* (7.1)**	8.68 (6.12)	8.2* (7.4)**	7.5* (7.2)**	10.57 (7.43)***
Dissolved Radionuclides							
Gross Alpha	pCi/l	12.543	27*	13.515	12*	7*	13*
Gross Beta	pCi/l	14.570	12*	18.530	7*	2*	15*
Uranium 233, 234	pCi/l	1.647	11*	6.481	5.8*	1.1*	12.936
Uranium 235	pCi/l	0.000	0.3*	0.232	0.2*	0*	0.135
Uranium 238	pCi/l	0.195	7.7*	5.084	3.2	0.6*	3.3507
Strontium 89, 90	pCi/l	0.552	0.1*	0.878	0.1	-0.1*	0.2*
Plutonium 239, 240	pCi/l	0.009	0*	0.012	0.03	0.01*	0.000
Americium 241	pCi/l	0.000	0*	0.012	0	0.01*	0.019
Cesium 137	pCi/l	0.603	0.2*	0.776	0.4	0.3*	0.7*
Tritium	pCi/l	309	100*	505	100	100*	731

* - Maximum Detected Value
** - Minimum Detected Value
*** - It is conjectured that bentonite may have been introduced into the screened section of the well during placement of the bentonite bottom seal. A bentonite/water slurry has a pH between 10 and 11.
ND - Not Detected at Contract Required Detection Limit
() - Tolerance Internal Lower Limit for Two-Sided Parameter

(After Rockwell International 1989 c)

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fourth quarter 1989 data base is more extensive than for previous sampling events caused by the installation of several 1989 monitoring wells.

Based on the number and concentration of the inorganic parameters exceeding background levels, groundwater at Well Nos. 63-87 and 70-87 within the landfill was most elevated above background, at Well Nos. 65-87 and 72-87 was moderately above background, and at Well Nos. 58-87, 66-87, 67-87, 71-87, B206089, and B206489 was slightly above background. Groundwater at all other wells completed in the Rocky Flats Alluvium did not appear contaminated, although it was noted that nitrate occurred slightly above background in many of these wells including the upgradient Well No. 10-86. Iron and manganese concentrations at Well No. 63-87 were on an order of magnitude greater than the proposed concentration limits (5.38 mg/l and 3.9 mg/l, respectively). At both Well Nos. 63-87 and 70-87, strontium (0.67 mg/l, 0.64 mg/l), TDS (597 mg/l, 581 mg/l [second quarter 1988]), and total uranium (6.5 pCi/l, 18.4 pCi/l [second quarter 1988]) exceeded proposed concentration limits.

Although insufficient samples existed for second quarter 1989 radiochemical analysis for Well No. 63-87, and tritium was at background concentrations during the second quarter 1988, tritium concentrations ranged from 1,800 $\pm$ 100 to 2,100 $\pm$ 100 pCi/l in the first, third, and fourth quarters of 1988, respectively. Zinc and copper exceeded background (background is the proposed concentration limit) in Wells Nos. 58-87 (zinc only), 66-87, 67-87, 70-87, and 72-87.

Typical of most sanitary landfills, the Present Landfill is observed to impact groundwater quality through increased major ion, iron, manganese, and zinc concentrations. Strontium and copper concentrations were also elevated. Atypical of most sanitary landfills, there were areas of elevated uranium and tritium.

Generally, volatile organic contamination as low and sporadic in occurrence. TCE and 1,1,1-TCA were present above detection limits in Well Nos. 65-87 and 66-87 during the second quarter, 1989. The frequent occurrence of these compounds in other quarters suggest TCE and TCA are contaminants at Well No. 66-87, and TCE is a contaminant at Well No. 65-87 (and Well No. 72-87 based on data from previous quarters).

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Methylene chloride, toluene, and chloroform were each present in at least one sample from almost every landfill area well in 1988 (including upgradient Well No. 10-86). However, these compounds were also commonly found in the laboratory blanks and were not detected in second quarter 1989 samples from these wells. This suggests these concentrations may have represented laboratory contamination.

2.2.3.2 Downgradient Valley Fill Groundwater Quality

Wells Nos. 7-86, 40-87, 42-87, 6-86, and 5-86 are located progressively downgradient of the Present Landfill and are completed in the valley fill material. Except for dissolved metals and volatile organics data for Well No. 42-87 during second quarter 1988 and 1989, these wells were either dry or an insufficient sample existed for chemical analysis. The second quarter 1989 dissolved metals and volatile organics data, and the first quarter 1988 inorganic and radionuclide data, indicated groundwater at Well No. 42-87 is not contaminated.

The high concentrations of analytes at Well No. 5-86 during the first quarter 1988 were not characteristic of the groundwater within or immediately downgradient of the landfill (Well No. 42-87), indicating that another source of high TDS water may exist downgradient of the landfill. Since no SWMUs are known to be located downgradient of the landfill, this source may be caused by natural saline mineral dissolution. Because gross alpha (110 pCi/l), total uranium (169 pCi/l), strontium (7.9 mg/l), sulfate (4,125 mg/l), chloride (271 mg/l), and TDS (7,430 mg/l) exceeded the proposed concentration limits at Well No. 5-86, the source of this groundwater is under investigation.

2.2.3.3 Weathered Claystone Bedrock Groundwater Quality

Well Nos. B206189, B206689, B206789, B206889, B206989, and B207289 were installed in 1989 to monitor groundwater within weathered claystone at the Present Landfill. Some fourth quarter 1989 data were available for these wells: inorganics data for Well Nos. B206189, B206289, B206689, B206789, and B206989; dissolved metals data for Well Nos. B206189 and B206789; and volatile organics data for Well Nos. B206689, B206889, and B206989. Well No. B207289 was dry.

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Chloroform was the only volatile organic compound present above detection limits in groundwater samples from the weathered claystone. It occurred in the sample from Well No. B206889 (7 µg/l). Because chloroform is not an apparent contaminant of alluvial groundwater at the Present Landfill, this datum may not have significance with respect to contamination characterization.

Inorganics were above background levels in all five wells for which inorganics data were available. The proposed concentration limit for TDS (400 mg/l) was exceeded at Well No. B206169 (720 mg/l) and B206789 (1,200 mg/l), and the proposed concentration limit for sulfate (250 mg/l) was also exceeded at Well No. B206789 (590 mg/l). Chloride did not exceed the proposed concentration limit in any well. Nitrate was elevated above background (0.58 mg/l) at Wells Nos. B206669 (1.1 mg/l), B205789 (6.3 mg/l), and B206989 (32 mg/l). As nitrate concentrations in alluvial groundwater within the landfill are generally below 5 mg/l, further sampling and analysis would be required to understand the occurrence of these nitrate levels in weathered bedrock. Nitrate was not elevated in weathered sandstone Well No. B207089 adjacent to Well No. B206989.

Dissolved metals above background in either Wells No. B206189 or B206789 included calcium, lithium, manganese, molybdenum, selenium, sodium, strontium, and zinc. Concentrations of these metals notably exceeding background included lithium in Well No. B206789 (0.2 mg/l; background [bkg] 0.005 mg/l) and sodium in both wells (217 and 130 mg/l, respectively; bkg 37 mg/l). Elevated molybdenum had been observed in the alluvial groundwater at Well No. 64-87 (0.355 mg/l) during first quarter 1988, but molybdenum was below background during the subsequent two quarters. Fourth quarter 1989 dissolved metals data have not been received for Well No. 64-87. This information is necessary to better understand the alluvial/bedrock groundwater interaction at this location. Additional groundwater quality data are necessary to determine the significance of the elevated selenium at Well No. B206789, which significantly exceeds the proposed concentration limit of 0.01 mg/l.

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2.2.3.4 Weathered Sandstone Bedrock Groundwater Quality

Well Nos. B206589 and B207089 were completed in the weathered sandstone at the Present Landfill. Only fourth quarter 1989 inorganics data are available for these wells. Elevated TDS, sulfate, and chloride occurred in groundwater at both wells. Concentrations were more notable in Well No. B207089 were sulfate (460 mg/l), chloride (520 mg/l), and TDS (1900 mg/l) all

exceeded the proposed concentration limit in Well No. B206589 (550 mg/l). Sulfate and TDS in this well were similar in magnitude to the alluvial groundwater in this vicinity (Well No. 72-87); however, chloride was considerably higher in the weathered sandstone groundwater (57 mg/l) than in the alluvial groundwater (<16 mg/l). The alluvium was dry in the vicinity of Well No. B207089, which did not allow a comparison to be made.

2.2.3.5 Unweathered Sandstone Bedrock Groundwater Quality

Four bedrock wells completed in unweathered sandstone currently exist outside the landfill to monitor bedrock groundwater quality. Well No. 9-86 is located immediately west of the landfill; Well No. 8-86 is located immediately east of the landfill; and Well Nos. 41-87BR and B207189 are downgradient of the landfill embankment in the unnamed tributary on North Walnut Creek. For Well Nos. 9-86, 8-86, and 41-87BR, the following assessment was based on second quarter 1989 volatile organics, dissolved metals, and inorganics data, and first quarter 1989 volatile organics, dissolved metals, and inorganics data. Volatile organics were not detected in any of these wells.

Bedrock groundwater at Well Nos. 41-87 and B207189 was similar in quality and appeared to have elevated concentrations of barium, calcium, magnesium (Well No. 41-87 only), manganese (Well No. 41-87 only), strontium, chloride, and TDS (Well No. 41-87 only), while all groundwater quality at Well No. 8-87 was within the background tolerance intervals. However, the upgradient bedrock groundwater appeared to have elevated concentrations of some of these constituents. Well No. 9-86 had above background concentrations of barium, magnesium, and manganese, suggesting the upper limit background ranges for these compounds was higher than estimated in the background characterization program. The high concentrations of major ions and metals at Well Nos. 41-87 and B207189 were not observed in alluvial groundwater within, adjacent to, or immediately downgradient of the landfill. It may be concluded that the quality of the groundwater in this sandstone, as in the claystone, reflects dissolution of minerals within the sandstone and claystone. The background characterization provides further evidence that, in general, unweathered sandstone groundwater was higher salinity than groundwater in surficial materials. The concentrations of the above cited metals and inorganics are not notably above background levels.

Based on an examination of alluvial water quality data from wells within the landfill, it appears the landfill is impacting groundwater with major ions, manganese, strontium, iron, tritium, and

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uranium. High salt concentrations further down the drainage (Well No. 5-86) may result from another unidentified and possibly natural source. Bedrock groundwater quality may be influenced by mineral dissolution within the sandstone and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial groundwater within the landfill.

2.2.4 Surface Water

The following description of surface water quality consists of edited excerpts from Rockwell International (1988d). The Present Landfill area is drained by an eastward flowing unnamed tributary to North Walnut Creek. A landfill retention pond, also known as the east pond, is located immediately downstream of the Present Landfill on the unnamed tributary. The pond was designed to receive surface and subsurface flow from the landfill. The unnamed tributary joins North and South Walnut Creek approximately 0.7 mile downstream of the eastern edge of the plant security area before flowing off site.

Three surface water stations were established on the unnamed tributary of Walnut Creek draining the area near the Present Landfill as part of the initial Rocky Flats Plant site characterization (Rockwell 1986b). These stations are SW-10 (upslope and west of the landfill), SW-13 (upstream of the landfill retention pond), SW-14 (immediately downstream of the landfill retention pond), and SW-15 (immediately upstream of the confluence with North Walnut Creek). There was no flow in the tributary at these stations in late August 1986. Flow in the tributary is seasonal and is dependent upon precipitation and groundwater flow. The landfill pond, however, was sampled.

Surface water quality data collected to date consist of samples collected in August 1986 and September 1987 from the landfill pond, and from historical data. The 1986 and 1987 samples were analyzed for HSL volatile organics, semivolatiles, pesticide/PCBs, major ion inorganics, metals, and radionuclides. HSL volatile organics, semivolatiles, and pesticide/PCBs were not detected in the 1986 and 1987 landfill pond samples. As shown in Table 2-10, radionuclide concentrations were detected but did not exceed the water quality criteria. The only trace metals exceeding the surface water quality criteria were manganese and iron. TDS also exceeded the surface water quality criterion. Elevated TDS, iron, and manganese are typical of landfill leachate.

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TABLE 2-10

ANALYTE CONCENTRATIONS IN LANDFILL POND
COMPARED TO SURFACE WATER CRITERIA

Analyte	Surface Water Concentration Range *	Surface Water Quality Criteria **
METALS (mg/l)		
Silver	<0.01	0.05
Aluminum	0.120–0.704	0.95
Arsenic	<0.01	0.05
Barium	<0.1–.58	1.00
Beryllium	<0.005	0.1
Cadmium	<0.005	0.01
Cobalt	<0.05	NS
Chromium	0.011–0.019	0.05
Cesium	<0.2	NS
Copper	<0.02	1.0
Iron	<0.03–2.3	0.3
Mercury	<0.0002–0.00063	0.002
Mangenese	0.06–0.42	0.05
Molybdenum	<0.1	NS
Nickel	<0.04	0.05
Lead	<0.005	0.005
Antimony	<0.05	NS
Selenium	<0.005	0.01
Strontium	0.4–1.05	NS
Thallium	<0.01	0.015
Vanadium	<0.024	NS
Zinc	<0.02–.89	5.0
MAJOR IONS (mg/l)		
Calcium	40–100	NS
Magnesium	21–75	NS
Sodium	75–226	NS
Potassium	9–68	NS
Chloride	91–124	250
Sulfate	8–52	250
Bicarbonate	190–402	NS

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TABLE 2-10
(continued)

Analyte	Surface Water Concentration Range *	Surface Water Quality Criteria **
MAJOR IONS (mg/l) (cont.)		
Nitrate	<0.2	10
TDS	533-1082	500
RADIONUCLIDES (pCI/l)		
Gross Alpha	0(7)-23(11)	15
Gross Beta	11(5)-27(22)	50
Plutonium	0.00(.97-0.02(.05)	40
Uranium		
233 + 234	0.0(2.0-1.1(.2)	40
Uranium 238	0.00(.55)-1.0(.2)	40
Americium	0.00(.51)-0.04(.04)	4
Tritium	110(220)-440	20,000

* Based on August 1986 and September 1987 dta
** From SDWA Maximum Concentration Limit

(Source: Rockwell international 1988d)

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Comparison of the historical gross alpha, gross beta, tritium, nitrate, pH, total organic carbon (TOC), conductivity, chemical oxygen demand (COD), metals, and TDS data show the water quality of the west and east ponds to be similar. At times both gross alpha and gross beta exceeded the water quality criteria in both ponds. At times, tritium was also elevated (on the order of 1,000 pCi/l), which would appear to be related to the known disposal of tritium in the landfill. Tritium concentrations in the west pond during the years 1974 through 1977 were higher than in subsequent years, but they are below the surface water quality criterion. Gross alpha, gross beta, and tritium were lower during the 1986 sampling of the east pond relative to the historical data. There are inadequate data to interpret the significance of this finding; however, in general, there are no apparent historical trends in water quality for the east or west landfill ponds (with the exception of tritium in the west landfill pond).

2.2.5 Air

The disposal of solid waste by landfilling employs engineering principles and construction methods to confine waste to the smallest area practical by compacting the waste into the lowest volume practical and then covering the waste with layers of soil to limit exposure of the materials to the environment. These methods can create conditions in which gases are produced. If unconfined, these gases can either be vented to the atmosphere or migrate through the soil.

Gas production is stimulated by biodegradable materials such as food wastes, paper, textiles, and wood. The period of gas generation from a solid waste landfill may range from a few years to tens of years. The active gas production life is dependent on site-specific conditions including oxygen levels, moisture content of the wastes, pH, temperature, and waste composition. Some components of landfill-generated gas are methane, hydrogen sulfide, and carbon dioxide. Other gases may also be present as a result of the types of wastes disposed.

A soil-gas survey was conducted at the landfill to evaluate the levels of methane and hydrogen sulfide being generated by the landfill. The results of the survey are presented in an appendix to the Present Landfill Closure Plan (Rockwell International 1988b). The results of the survey did not indicate significant methane or hydrogen sulfide generation by the landfill. However, readings from the portable gas chromatograph used in the survey did indicate the presence of other compounds, which were neither identified nor quantified as part of the survey.

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2.3 SITE CONCEPTUAL MODEL

A site conceptual model was developed based on the site physical characteristics and nature of contamination discussed in subsections 2.1 and 2.2. This model is intended to describe known and suspected scores of contamination, types of contamination, affected media, contaminant migration pathways, and environmental receptors. It will be used to assist in identifying sampling needs and potential remedial alternatives.

2.3.1 Sources of Contamination

The primary source of contamination at the Present Landfill is the landfilled wastes. At the Inactive Hazardous Waste Storage Are (SWMU No. 203), the primary source of contamination is contaminated soil near the ground surface. Soils that have been contaminated by leachate from the landfill and sediments deposited by or in contaminated surface water may be considered secondary sources of contamination. Currently, there is not sufficient data to know whether a secondary source of contamination exists. Existing groundwater level data indicate water occurs within the wastes. Therefore, contaminated groundwater within the wastes may also be considered a secondary source of contamination.

2.3.2 Types of Contamination

Little direct characterization of the types of contaminants in the landfill has been conducted to date. Most of what is known is based on waste stream identification studies (see subsection 1.4.3) and groundwater and surface water quality monitoring. As discussed in subsection 2.2, groundwater monitoring has indirectly identified a number of potential contaminants in the landfill. Groundwater at the landfill appears to have elevated concentrations of 1,1,1-TCA, TCE, barium, calcium, iron, magnesium, manganese, sodium, strontium, zinc, sulfate, chloride, TDS, tritium, and uranium. Typical of sanitary landfills, groundwater quality has been impacted through increased major ion, iron, manganese and zinc concentrations. There are also elevated uranium and tritium levels in some areas. Soil contamination at SWMU No. 203 has not been characterized.

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2.3.3 Release Mechanisms/Affected Media

Contaminants in the landfill may have impacted the soil and bedrock beneath the landfill and the groundwater within and downgradient from the landfill. Groundwater within the landfill may also have migrated into the pond or drainage downstream of it thereby affecting the quality of surface water and sediment.

The potential generation and/or migration of gases in the landfill could impact air quality. A previous soil-gas survey identified only low concentrations of methane and hydrogen sulfide. However, organic compounds were also detected but not identified or quantified.

The primary mechanism for release of contaminants from the Present Landfill into the affected media is by percolation of groundwater through the wastes and then out of the landfill. Groundwater occurs within the landfill as a result of infiltration of precipitation and also possibly from infiltration of groundwater through or beneath the perimeter groundwater diversion system. Groundwater flow exiting the wastes can then distribute contamination vertically downward and laterally downgradient. Secondary release mechanisms include the runoff of storm water, migration of landfill gases either laterally or to the ground surface, and percolation of groundwater through contaminated soils. The primary mechanisms for release of contaminants from SWMU No. 203 are by percolation into the landfill wastes and by wind dispersal of gases or contaminated dust.

2.3.4 Exposure Pathways

There are two primary potential pathways of migration for contaminants related to the primary release mechanisms described above, those are alluvial groundwater flow and bedrock groundwater flow. The primary exposure pathways to a receptor are therefore either by seepage (where groundwater flow intersects the ground surface) or by water supply wells tapping the affected groundwater. Other exposure pathways include wind dispersal of contaminated dust or soil gas, and surface water runoff and sediment transport.

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2.3.5 Receptors

Table 2-11 summarizes potential receptors of contaminants via the various exposure pathways described above. For each pathway, there are three potential routes by which contaminants may find their way into a receptor: ingestion, inhalation, and dermal contact.

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TABLE 2-11

POTENTIAL RECEPTORS

Exposure Pathway	Route to Receptor	Receptor			
		Human		Biota	
		Area Visitors	Site Visitors	Terrestrial	Aquatic
Groundwater	Ingestion	X	X		
	Inhalation	X	X		
	Dermal Contact	X	X		
Wind	Ingestion	X	X	X	
	Inhalation	X	X	X	
	Dermal Contact	X	X	X	
Surface Water and Sediments	Ingestion	X	X	X	X
	Inhalation				X
	Dermal Contact	X	X	X	X

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3.0
DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

This section identifies potential technologies applicable to closure and corrective action at the Present Landfill and the Inactive Hazardous Waste Storage Area. The identified technologies are based on the preliminary site conceptual model developed in Section 2.0. This Phase I RFI/RI Work Plan is the first step in the evaluation process illustrated in Figure 3-1 and focuses on potentially contaminated soils and source characterization. The Final Phase I RCRA Facility Investigation (RFI) Report will include final identification and screening of technologies, and assembly and initial screening of alternatives for soil/source remediation.

This section consists of three parts. Subsection 3.1 provides an overview of the Environmental Protection Agency's (EPA) recommended process for developing and screening of remedial alternatives. Subsection 3.2 identifies general response actions applicable to the preliminary site model, and identifies technologies that fall within each general response action. Subsection 3.3 discusses the general data requirements for the general response actions.

3.1 ALTERNATIVES DEVELOPMENT AND SCREENING PROCESS

This section provides a brief overview of the EPA Superfund process that will be employed to develop and evaluate alternatives for Resource Conservation and Recovery Act (RCRA) closure and corrective action for the Present Landfill. The Superfund Comprehensive Environmental Recovery, Compensation and Liability Act (CERCLA) process is described in detail in Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (USEPA 1988a), and is substantially identical to that described for RCRA corrective action programs in RCRA Corrective Action Plan (USEPA 1988b). 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.

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The alternatives development process steps (Figure 3-1) for the landfill and inactive storage area are discussed below:

- Develop site closure and corrective action objectives based on: chemical- and radionuclide-specific standards; site-specific, risk-related factors; and other criteria as appropriate (for example, RCRA closure performance standards).

- Develop a list of general types of actions appropriate for the landfill and inactive storage area (such as containment, treatment, removal) that may be taken singly or in combination 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.

- Identify and screen technology groups for each general response action. For example, the general response action of containment for the landfill can be further defined to include the capping and vertical barrier technology groups. Screening should eliminate those groups that are not technically feasible at the site.

- Identify and evaluate technology process options for each technology group to select a representative process for each group under consideration. Although specific process options are selected for alternative development and evaluation, these processes are intended to represent the broader range of process options within a general technology group. For example, a soil-bentonite slurry wall may be selected 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 landfill and inactive storage area 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

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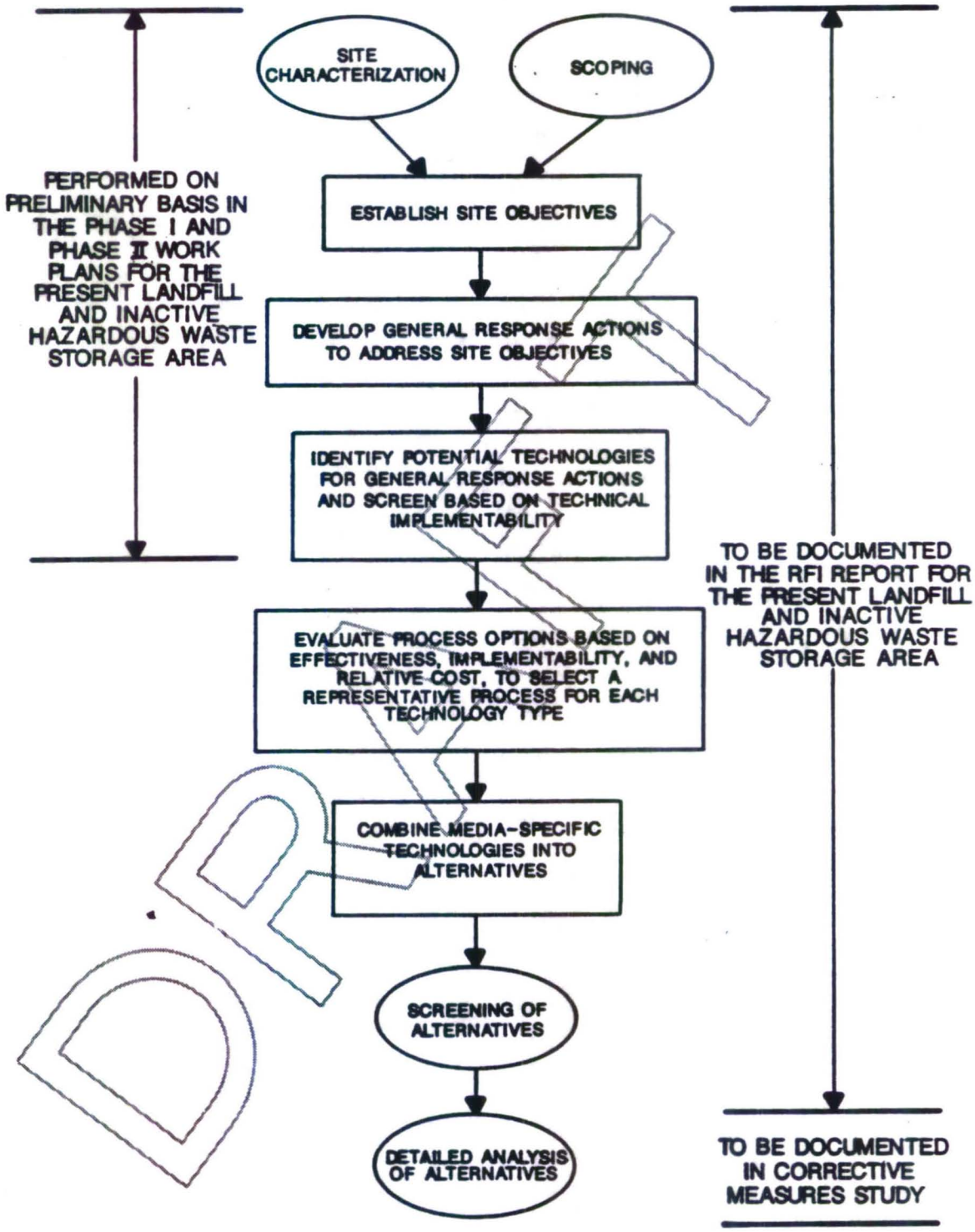

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Job No. : 4004-210	ALTERNATIVES DEVELOPMENT AND ANALYSIS
Prepared by : A.C./T.K	
Date : 4/6/90	Figure 3-1

evaluation is to reduce the number of alternatives that will undergo a more thorough and extensive analysis, alternatives will be evaluated in less detail than subsequent evaluations.

The preceding six steps will be documented in the Present Landfill Phase I and Phase II RFI Reports. The final step, involving a detailed analysis of each alternative, will be performed during the Corrective Measures Study (CMS). During detailed analysis, each alternative is evaluated against the nine specific evaluation criteria 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 (1988a). The initial two criteria are considered threshold criteria because all 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 CMS.

3.2 IDENTIFICATION OF GENERAL RESPONSE ACTIONS

3.2.1 Listing of General Response Actions

At the Phase I RFI/RI Work Plan stage, the appropriate level of alternatives analysis is to list the 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 ultimately defined for the Present Landfill. Table 3-1 provides a list and description

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TABLE 3-1

GENERAL RESPONSE ACTIONS, TYPICAL ASSOCIATED REMEDIAL TECHNOLOGIES, AND EVALUATION

General Response Action	Description	Typical Technologies	Applicability of General Response 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 not 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 to 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 media, will control corresponding pathway. Must be used with treatment or disposal response actions to be effective.

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TABLE 3-1
(continued)

General Response Action	Description	Typical Technologies	Applicability of General Response 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 media, 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 media, 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 media, 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 will require post-closure monitoring to assess performance of closure and corrective action implementation.

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of general response actions and typical technologies associated with remediating soils and landfill waste sources.

Table 3-1 also includes a general statement regarding the applicability of the general response action to potential exposure pathways.

3.2.2 Application of Response Actions to Potential Exposure Pathways

The response actions outlined in Table 3-1 must be applied to the potential exposure pathways that will be identified for the SWMUs 114 and 203. The response actions can 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.

In general terms, potential human exposure may be avoided by prevention of contaminant release, transport, and/or contact. 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.

3.2.3 Identification of Technologies

Multiple remedial technologies exist for each general response action. Figure 3-2 identifies and provides brief descriptions of remedial technologies for the general response actions identified in Table 3-1. Technologies listed range from those that are commonplace (such as capping) to those that are experimented (for example, in situ vitrification).

3.3 DATA NEEDS FOR REMEDIAL ALTERNATIVES EVALUATION

While the identification of general response actions was discussed in the previous section, 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 for the Phase I RFI/RI effort are needed for the characterization of the source and soil contaminants and for the preliminary screening of alternatives:

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- Source characterization
  - Suite of radionuclide analyses on soil, leachate, and soil gas
  - Suite of organic and inorganic analyses on soil, leachate and soil gas

- Site Physical Characterization
  - Groundwater flow regime
  - Soil and rock types and general engineering properties
  - Depth to bedrock
  - Depth to groundwater
  - Soil organic matter

These data will provide for a comparative evaluation of the technologies with respect to implementability, effectiveness, cost, and allow for informed decisions to be made with respect to selection of preferred technologies. The Field Sampling Plan (Section 7.0) reflects the first iteration of collecting these information requirements.

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	DESCRIPTION
TREATMENT	SOLIDS PROCESSING	SOLIDS PROCESSING PREPARES SOLID WASTES FOR FURTHER TREATMENT OR DISPOSAL BY SIZE REDUCTION OR CLASSIFICATION OR MATERIAL SEPARATION.
	SOLIDS TREATMENT	SOILS, SEDIMENTS, AND OTHER SOLIDS ARE PHYSICALLY OR CHEMICALLY TREATED TO REMOVE THE HAZARDOUS AND RADIOACTIVE CONSTITUENTS OR CONVERT THE CONSTITUENTS TO NONHAZARDOUS SUBSTANCES.
	SOLIDIFICATION, FIXATION, STABILIZATION	STABILIZATION AND FIXATION PROCESSES MAINTAIN HAZARDOUS AND RADIOACTIVE CONSTITUENTS IN THEIR LEAST TOXIC AND/OR LEAST MOBILE FORM. SOLIDIFICATION PRODUCES A MONOLITHIC BLOCK OF TREATED WASTE WITH HIGH STRUCTURAL INTEGRITY.
	SOLIDS DEWATERING	SOLID/LIQUID SEPARATION RECOVERS SOLIDS AND LIQUIDS, OR REMOVES EXCESS LIQUID FROM SEDIMENTS AND SLUDGES PRIOR TO DISPOSAL.
	PHYSICAL TREATMENT	LIQUIDS CONTAINING HAZARDOUS CHEMICALS OR RADIOACTIVE CONSTITUENTS ARE TREATED TO CONVERT THE CONSTITUENTS TO A MORE EASILY HANDLED FORM THROUGH EQUALIZATION, CONCENTRATION, AND/OR PHASE CHANGE.
	CHEMICAL TREATMENT	LIQUIDS CONTAINING HAZARDOUS CHEMICALS OR RADIOACTIVE CONSTITUENTS ARE ALTERED BY CHEMICAL REACTIONS TO DETOXIFY HAZARDOUS CHEMICALS OR TO CONVERT THE CHEMICALS OR RADIONUCLIDES TO A MORE EASILY TREATED FORM.
	BIOLOGICAL TREATMENT	A CULTURE OF MICROORGANISMS METABOLIZES BIODEGRADABLE ORGANIC MATERIALS.
	THERMAL TREATMENT	WASTES ARE EXPOSED TO HIGH TEMPERATURES TO TRANSFORM THE HAZARDOUS COMPOUNDS INTO INNOCUOUS OR LESS HARMFUL SUBSTANCES. THERMAL TREATMENT WILL NOT DECREASE RADIOACTIVITY.
	AIR EMISSIONS CONTROL & TREATMENT	VAPOR PHASE IMPURITIES ARE REMOVED FROM LANDFILL GASES THROUGH PROCESSES RANGING FROM ONCE-THROUGH WASH OPERATIONS TO MULTIPLE-STEP RECYCLE SYSTEMS.
IN SITU TREATMENT	IN SITU TREATMENT	PHYSICAL, CHEMICAL, AND BIOLOGICAL PROCESSES ARE EMPLOYED TO TREAT CONTAMINATED SOIL, SOLIDS WASTES OR GROUNDWATER IN PLACE.
DISPOSAL	RESOURCE RECOVERY	CERTAIN MINERALS, METALLIC PRODUCTS AND RADIOISOTOPES CAN BE RECLAIMED FROM HAZARDOUS/RADIOACTIVE WASTES AND REUSED.
	LAND APPLICATION	LIQUID AND SOLID WASTES THAT ARE PRIMARILY ORGANIC ARE INCORPORATED INTO THE UPPER SOIL HORIZON SO THEY CAN BE DEGRADED, TRANSFORMED, OR IMMOBILIZED.
	NUCLEAR WASTE REPOSITORY	RADIOACTIVE WASTES ARE DISPOSED OF IN A LICENSED LOW LEVEL OR HIGH LEVEL RADIOACTIVE WASTE REPOSITORY.
	WASTEWATER DISCHARGE	AQUEOUS STREAMS ARE DISCHARGED TO A TREATMENT PLANT, SURFACE WATER, OR SHALLOW OR DEEP WELLS.
	LANDFILL	SOLID WASTES ARE PERMANENTLY DISPOSED OF IN A LANDFILL. LANDFILLS CANNOT ACCEPT LIQUID WASTES.
MONITORING	MONITORING	SHORT- AND/OR LONG-TERM MONITORING IS IMPLEMENTED TO ASSESS SITE CONDITIONS AND CONTAMINATION LEVELS.

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Prepared by : A.C./T.K

Date : 3/20/90

REMEDIAL TECHNOLOGY DESCRIPTION

Figure 3-2

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GENERAL RESPONSE ACTION	REMEDIAL TECHNOLOGY	DESCRIPTION
NO ACTION	NONE	NO ACTION; REMEDIAL RESPONSES INITIATED AT SITE ARE ABANDONED; NO MONITORING.
ACCESS AND USE RESTRICTIONS	ACCESS AND USE RESTRICTIONS	EXAMPLES INCLUDE LEGAL RESTRICTIONS ON DEEDS TO REGULATE LAND USE, PERMITS TO REGULATE GROUNDWATER USE, FENCES TO REGULATE SITE ACCESS; SIGNS TO WARN POTENTIAL INTRUDERS.
CONTAINMENT	CAPPING	IMPERMEABLE COVER MATERIALS ARE PLACED OVER WASTE DISPOSAL AREAS AND CONTAMINATED SOILS TO REDUCE OR ELIMINATE INFILTRATION, PREVENT EROSION, AND TO PROVIDE INTRUSION BARRIER.
	VERTICAL BARRIERS	WALLS THAT ARE LESS PERMEABLE THAN THE IN SITU SOIL ARE PLACED UPGRADIENT OR DOWNGRADIENT OF WASTE DISPOSAL AREAS, OR MAY BE USED TO ENCIRCLE WASTE DISPOSAL AREAS.
	IN-SITU BARRIERS	LOW-PERMEABILITY MATERIAL IS PLACED INTO VOID SPACES TO REDUCE THE PERMEABILITY OF THE IN SITU WASTE OR SOIL.
	SURFACE CONTROLS	SURFACE SEALING, GRADING, SOIL STABILIZATION, REVEGETATION, AND SURFACE WATER DIVERSION/COLLECTION ARE IMPLEMENTED TO REDUCE SITE RUNON/RUNOFF, SURFACE WATER INFILTRATION AND EROSION, AND TO STABILIZE SURFACE SOILS.
	SEDIMENT CONTROL BARRIERS	A PHYSICAL BARRIER, FILTER SCREEN, OR CAP IS CONSTRUCTED TO MINIMIZE THE SPREAD OF CONTAMINANTS BY SEDIMENT MIGRATION.
	DUST AND VAPOR SUPPRESSION	TARPS, SOIL COVERS, SPRAYS, ETC. ARE APPLIED TO SUPPRESS DUST AND NON-POINT-SOURCE VAPOR.
PUMPING AND REMOVAL	BULK LIQUID PUMPING	BULK LIQUIDS IN OPEN PITS, OPEN PONDS, TANKS, DRUMS, ETC. ARE REMOVED BY A VARIETY OF METHODS, MOST COMMONLY BY PUMPING.
	GROUNDWATER PUMPING	GROUNDWATER AND LEACHATE ARE COLLECTED IN WELLS OR TRENCH DRAINS AND PUMPED SO THEY CAN BE TREATED AND DISPOSED.
	LANDFILL GAS COLLECTION	GASES EMANATING FROM WASTE DISPOSAL AREAS ARE INTERCEPTED BY A PASSIVE OR ACTIVE (PUMPED) SYSTEM.
	DRUM & DEBRIS REMOVAL	DRUMS AND/OR DEBRIS ARE REMOVED BY VARIOUS MECHANICAL MEANS, E.G., CRANES AND OTHER STANDARD CONSTRUCTION EQUIPMENT.
	EXCAVATION	CONTAMINATED SOIL, SEDIMENT, SLUDGES AND OTHER SOLIDS ARE REMOVED WITH STANDARD CONSTRUCTION EQUIPMENT.
	DECONTAMINATION	CONTAMINATED BUILDINGS, BUILDING MATERIALS OR OTHER STRUCTURES ARE WASHED WITH A SUBSTANCE THAT REMOVES CONTAMINANTS UPON RINSING. OFTEN DECONTAMINATION IS DONE WITH A PRESSURIZED STREAM.

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REMEDIAL TECHNOLOGY DESCRIPTION

Figure 3-2 (continued)

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4.0
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Section 121 of the Comprehensive Environmental Resource, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA), requires that, subject to specified exceptions, federal facility remedial actions be undertaken in compliance with applicable or relevant and appropriate requirements (ARAR) and environmental laws, both state and federal. These standards, requirements, criteria, or limitations may be "applicable" or "relevant and appropriate", but not both. A requirement is applicable if the specific terms (or "jurisdictional prerequisites") of the law or regulation directly apply to the circumstances at a site. If not applicable, a requirement may be relevant and appropriate if circumstances at the site are, based on best professional judgement, sufficiently similar to the problems or situation regulated by the requirement.

Other criteria advisories and guidance, referred to as "to-be-considered" (TBC), are nonpromulgated advisories or guidance issued by federal or state governments that are not legally binding and are not ARARs. This material may be considered along with ARARs to set protective goals. If there are no ARARs to address a particular situation or if no ARARs ensure protectiveness, TBC advisories, criteria, or guidelines should be used.

There are several different types of requirements with which actions may have to comply. These are separated into the following three groups of ARARs:

- Chemical- and radionuclide-specific requirements are usually health- or risk-based methodologies resulting in establishment of numerical values. These values establish the acceptable amount or concentration of a contaminant that may be found in, or discharged to, the ambient environment. A list of chemical-/radionuclide-specific ARARs for compounds and elements that have been detected at the Rocky Flats Plant are shown in Table 4-1. This list is a compilation of contaminant-specific ARARs from the Phase III and Phase II work plans for 881 Hillside and 903 Pad, respectively.

- Location-specific requirements are restrictions placed on the concentration of hazardous substances or the conduct of activities solely because they occur in special locations.

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- Action-specific requirements are usually technology- or activity-based requirements or limitations on actions taken with respect to hazardous waste.

The development of ARARs is an ongoing process throughout the baseline risk assessment. During the risk assessment, contaminant-specific and location-specific ARARs are being developed. Action-specific ARARs are developed during the analysis of alternatives. The user also should be cognizant that standards and criteria are constantly being updated and revised. Current information on ARARs and TBCs, and effects of various toxicants, are compiled in the Public Health Risk Evaluation Data Base (PHRED) and Integrated Risk Information System (IRIS) Chemical Data Base. The IRIS data base also includes information on supporting toxicological studies.

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TABLE 4-1
CHEMICAL SPECIFIC ARARs
FOR COMPOUNDS AND ELEMENTS DETECTED
AT THE ROCKY FLATS PLANT

Chemical	ARAR (µg/l)	Standard Criteria or Guidance
Organic Compounds		
Acetone	50	RCRA LDR is relevant and appropriate (R&A)
Carbon Tetrachloride	5	CDH Surface Water; Drinking Water Standard is applicable
Chloroform	100	SDWA Standard for total trihalomethanes is applicable
1,1 Dichloroethane	5µ	RCRA Subpart F, Appendix IX Substance is TBC
1,2 Dichloroethane	5	CDH Surface Water; Drinking Water Standard is applicable
1,1 Dichloroethene	7	CDH Surface Water; Drinking Water Standard is applicable
Methylene Chloride	5µ	RCRA Subpart F is R&A
Tetrachloroethene	10	CDH Surface Water; Fish and Water Ingestion Standard is applicable

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TABLE 4-1
(continued)

Chemical	ARAR (µg/l)	Standard Criteria or Guidance
Toluene	2420	CDH Surface Water; Drinking Water Standard is applicable
1,1,1 Trichloroethane	200	CDH Surface Water; Drinking Water Standard is applicable
1,1,2 Trichloroethane	10	CDH Surface Water; Drinking Water Standard is applicable
1,1,2,2-Tetrachloroethane	5µ	RCRA Subpart F is R&A
Trichloroethene	5	CDH Surface Water; Drinking Water Standard is applicable
Carbon Disulfide	5µ	CDH Surface Water; Drinking Water Standard is applicable
<u>Metals</u>		
Aluminum	0.26	CDH Agriculture Standard is applicable
Antimony	0.06µ	RCRA Subpart F is R&A
Arsenic	0.05	CDH Surface Water; Drinking Water Standard is applicable
Barium	1.0	CDH Surface Water; Drinking Water Standard is applicable

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TABLE 4-1
(continued)

Chemical	ARAR (µg/l)	Standard Criteria or Guidance
Radionuclides		
Gross Alpha	15	CDH Groundwater Standard is applicable
Gross Beta	50	SDWA MCL is applicable
$Pu^{238,239,240}$	15	CDH Groundwater Standard is applicable
Am^{241}	4	CDH Groundwater Standard is applicable

(After Rockwell International 1989d and EG&G 1990b)

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- Migration of groundwater from the landfill has probably resulted in contaminated soils beneath and possibly downgradient of the landfill.

- Soils at the Inactive Hazardous Waste Storage area may be contaminated with organics, metals, and radionuclides. At present, the contamination is believed to be confined to the surface; further delineation of the extent is needed.

- Some organic, metal, and radionuclide contaminants have been identified in groundwater from wells adjacent to the landfill. Data on the contaminants present in the landfill and associated soils is incomplete.

5.2 SITE-SPECIFIC PHASE I RFI/RI OBJECTIVES AND DATA NEEDS

Based on existing data and the conceptual site model, the site-specific Phase I RFI/RI objectives and data needs associated with identifying contaminant sources are shown in Table 5-1. The specific plans and rationale for obtaining the needed data are presented in the Field Sampling Plan, Section 7.0.

The highest quality data possible will be collected by following the Rocky Flats Plant ER Program Standard Operating Procedures (SOP) and through adherence to the Rocky Flats Plant ER Program Quality Assurance/Quality Control (QA/QC) Plan. Organic and metal analyses will be performed using CLP routine analytical services (RAS), and other analyses (radionuclides and inorganics) will be performed in accordance with the QA/QC plan specified methods.

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TABLE 5-1

DATA NEEDS, DQOs AND ANALYTICAL REQUIREMENTS FOR THE PRESENT LANDFILL AND INACTIVE HAZARDOUS WASTE STORAGE SITE PHASE I RFI/RI WORKPLAN

Data Needs	Method	Analytical Level[a]	Data Quality Objectives
Characterize the Site Physical Features			
Soil Types, Engineering Properties	Analyses of Samples from boreholes installed into the landfill	II	Evaluation of Remedial Alternatives
Alluvial Groundwater Flow Regime for the Landfill Area	Measure water levels in new and existing wells installed in the landfill. Soil boreholes that will be converted into groundwater monitoring wells will be identified.	I	Evaluation of Remedial Alternatives
Characterize Contaminant Sources			
Characterize the nature of waste materials in landfill	Collect leachate samples from groundwater monitoring wells installed directly into the landfill and from seepage at east toe of landfill.	IV (V for radiological analyses)	Measure TCL organic, inorganic, and metals and radionuclide constituents for the Baseline Risk Assessment and alternatives evaluation.
	Collect headspace gas samples from each borehole/well.	II	Analysis for methane, hydrogen sulfide and other gas for use in site characterization and alternatives evaluation.

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TABLE 5-1
(continued)

Data Needs	Method	Analytical Level[a]	Data Quality Objectives
Characterize Contaminant Sources (continued)			
	Collect samples of sediment from the east pond	IV (V for radiological analyses)	Measure TCL organic, inorganic, and metals and radionuclide constituents for the Baseline Risk Assessment and Alternatives Evaluation
Identify Groundwater Contaminant Sources	Evaluate existing groundwater data from upgradient and downgradient water quality monitoring wells	III	Utilize data evaluation in contaminant migration evaluation and Baseline Risk Assessment.
Characterize the Nature and Extent of Soil Contamination			
Determine if Contaminants are present in surficial soils at the Inactive Hazardous Waste Storage Area	Collect soil scrapes (<12" depth) from the storage area.	III	Analyze samples for organics, PCBs and radionuclides to be used in Site Characterization.
	Conduct radiological survey	II	Field survey using FIDLER to detect surface radioactive contamination.

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TABLE 5-1
(continued)

Data Needs	Method	Analytical Level[a]	Data Quality Objectives
Characterize the Nature and Extent of Soil Contamination (cont)			
Determine if contamination has occurred in soils beneath and downgradient of the landfill wastes.	Collect soil and bedrock samples from borings	IV (V for radiological analyses)	Measure TCL organic, inorganic, and metals as well as radionuclide constituents for use in the Baseline Risk Assessment and alternative evaluation.

[a] For explanation, see Table 5-2

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TABLE 5-2
LEVEL OF ANALYSIS

REQUIRED ANALYTICAL LEVEL	TASK
Level I (Field Screens)	o Water level measurement o pH measurement o Eh measurement o Screening for organics (OVA/HNu) o Screening for radionuclides (beta-gamma) o Temperature o Specific conductance o Screening for burried objects (magnetometer, pipe locator)
Level II (Field Analyses)	o Screening for organics (GC) o Screening for metals (ICP) o Screening for radionuclides (gross beta/gross alpha gamma spec) o Analysis of engineering properties
Level III (Laboratory Analyses using EPA Standard Methods)	o Major ion analysis o Organics analysis o Inorganics analysis
Level IV (Laboratory Analyses using EPA CLP Methods)	o Analysis of TCL compounds
Level V (Nonstandard Analyses)	o Radiological analyses o Chemical analyses requiring modification of standard methods

Source: EPA (1987)

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6.0
RCRA FACILITY INVESTIGATION/REMEDIAL INVESTIGATION TASKS

6.1 TASK 1 - PROJECT PLANNING

The project planning task includes all efforts required to initiate this Phase I RFI/RI for the Present Landfill and the Inactive Hazardous Waste Storage Area. Activities undertaken for this project have included review of previous site investigation results and the scoping of the Phase I RFI/RI. Results of these activities are presented in Section 2.0.

Two project planning documents, including this work plan, have been prepared which pertain to this Phase I RFI/RI as required by the draft Inter-Agency Agreement (IAG) between DOE, EPA, and CDH. A Field Sampling Plan (FSP) is included in this document which 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 (QAPP) and Standard Operating Procedures (SOP) for all field activities. The current versions (January 1989) of the Rocky Flats Plant ER Program QAPP (Rockwell International 1989d) and SOP have been submitted previously to EPA and CDH and will apply to this RFI/RI effort. The QAPP and SOP are being revised and will be submitted in July 1990 in accordance with the draft IAG.

6.2 TASK 2 - COMMUNITY RELATIONS

In accordance with the draft IAG, the Communications Department at Rocky Flats is developing a Plant-wide Community Relations Plan to actively involve the public in the decision-making process as it relates to environmental restoration activities. A work plan has been completed and forwarded to EPA, CDH, and the public for review. The work plan specifies activities planned to complete the Plant-wide Community Relations Plan, including plans for community interviews. The draft Community Survey Plan was completed in January 1990, and the draft Community Relations Plan will be completed in September 1990 in accordance with the draft IAG schedules. Accordingly, a site-specific Community Relations Plan is not required for the Operable Unit 3 sites discussed in this plan.

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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. An Outreach Program also is in place where 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 during telephone conversations, or by sending written informational materials to the requestor.

6.3 TASK 3 - FIELD INVESTIGATION

The Phase I RFI/RI field investigation is designed to meet the objectives outlined in Section 5.0. The following activities will be performed as part of the field investigation as described in detail in Section 7.0:

- Drill and sample soils and wastes within SWMUs
- Sample surficial soils for organic, inorganic, and radionuclides contaminants
- Identify and install alluvial groundwater monitoring wells
- Collect and analyze groundwater samples from existing upgradient and downgradient wells
- Collect and analyze landfill leachate samples
- Collect sediment samples

Sample locations, frequency, and analyses are presented in the Field Sampling Plan (Section 7.0). All field activities will be performed in accordance with the Rocky Flats Plant ER Program SOP unless otherwise noted in the Field Sampling Plan.

6.4 TASK 4 - SAMPLE ANALYSIS AND DATA VALIDATION

Analytical methods for chemical analyses are provided in the ER Program QA/QC Plan (Rockwell International 1989d). Also provided in this document are the analytical detection limits, sample container and volume requirements, preservation requirements, and sample holding times.

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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 (U.S. EPA 1988c). 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 QA/QC Plan (Rockwell International 1989d).

6.5 TASK 5 - DATA EVALUATION

Data collected during the Phase I RFI/RI will be incorporated into the existing data base and used to better define soil and contaminant source characteristics. These results also will be used in delineating the requirements for the Phase II RFI/RI plans for determining the nature and extent of contamination, and to support the evaluation of proposed remedial alternatives and baseline risk assessment.

6.5.1 Site Characterization

The additional physical data collected during Phase I will be incorporated into existing site characterization. Subsurface data will be used to detail the stratigraphy of surficial materials and weathered bedrock within source areas. Hydrologic data will be used to evaluate the extent of water in the landfill, and to characterize the alluvial groundwater flow regime.

6.5.2 Source Characterization

Analytical data from source boreholes, landfill leachate, and soil samples will be used to:

- Characterize the nature of source contaminants
- Characterize the lateral and vertical extent of source contaminants
- Evaluate the maximum onsite contaminant concentrations

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6.5.3 Nature and Extent of Contamination

Analytical data from soil, sediment, and landfill leachate will be used to characterize the nature of contamination. The criteria for the identification of contamination will be analyte specific. For volatile organic compounds, any detectable concentrations in samples that are not attributable to laboratory contamination will be considered likely evidence of contamination. For inorganic compounds (including radionuclides) only those concentrations which exceed expected concentrations in background shall constitute evidence of contamination. The statistical techniques which shall be used to compare concentrations of inorganic compounds collected as part of the Phase I RFI/RI to background concentrations are documented in the Background Geochemical Characterization Report (Rockwell International 1989c). Essential to the implementation of these statistical techniques for groundwater and borehole samples is the classification of each analytical datum by an appropriate geologic unit (such as Rocky Flats Alluvium or colluvium).

6.5.4 Evaluation of Proposed Remedial Alternatives

The preliminary evaluation of proposed remedial alternatives will be based on the information derived for the purpose of site characterization and soil and source characterization. Geotechnical and groundwater flow data from source boreholes will be used to screen general response actions (Section 3.2).

6.6 TASK 6 - TREATABILITY STUDIES/PILOT TESTING

This task includes efforts to prepare and conduct pilot and bench-scale treatability studies, and/or review data from recently conducted testing. These activities will serve to determine the operability, reliability, cost-effectiveness, and overall implementability of a particular remedial alternative. Studies specific to the OU3 SWMUs 114 and 203 will be identified after completion of the Phase I RFI/RI.

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6.7 TASK 7 - RFI/RI REMEDIAL INVESTIGATION REPORT

A Draft Phase I RFI/RI Report will be prepared to consolidate and summarize the data obtained during the Phase I field work. This report will:

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

- Discuss site physical conditions based on existing data and data derived during the RI. This discussion will include surface features, meteorology, surface water hydrology, surficial geology, groundwater hydrology, demography and land use, and ecology.

- Present site characterization results discussing the nature and extent of contamination. The media to be addressed will be limited to contaminant source and soils.

Prior to submission of the Phase I RFI/RI report a Preliminary Site Characterization Summary will be submitted for review by EPA and CDH. This summary will provide an early description of the initial site characterization effort including a preliminary presentation of analytical data, listing of chemical and radiological contaminants, the affected media, and chemical-specific ARARs.

In addition to the characterization summary, technical memoranda will be prepared with the completion of each field sampling task to provide a preliminary result of field investigations. These tech memos also will be submitted for review by the regulatory agencies.

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7.0
FIELD SAMPLING PLAN

The primary objective of the Phase I RFI/RI will be to collect the data necessary to characterize the soil and source at the Present Landfill. Although Phase I of the RFI/RI process specifically does not address the nature and extent of groundwater contamination, it wil use leachate and groundwater quality data as a means of evaluating the soil and source. A secondary objective will be to obtain more information on site physical characteristics, such as the groundwater flow regime within the landfill, to assist in preliminary identification and evaluation of remedial alternatives and for use in performing baseline risk assessment. Within these broad objectives, site-specific data objectives and needs have been identified in Section 5.0. The purpose of this Field Sampling Plan is to provide a detailed plan for implementing these data objectives and needs of this Phase I RFI/RI.

The RFI/RI process is an iterative one, with Phase I activities intended to identify and quantify the source and soil characteristics. Phase II will concentrate on characterization of groundwater, extent of contamination, risk assessment, and evaluation of remedial alternatives.

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 (SOP) and Quality Assurance Project Plan (QAPP). Existing SOPs (Rockwell International 1989e) will be reviewed and modified as necessary to achieve the Phase I sampling objectives.

7.1 FIELD SAMPLING

7.1.1 Background

As presented in subsection 2.3, Site Conceptual Model, the primary source of contamination at the Present Landfill is the landfill wastes. A potential secondary source may consist of soils that have been contaminated by leachate beneath or downgradient of the wastes. Existing data indicates groundwater (leachate) occurs within the wastes. The total thickness of the wastes is nil at the west end and along the north and south edges and is deeper towards the central east portion

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of the landfill. Although current topographic information is not available at present, it is not available at present, it is estimated that the maximum thickness of waste is on the order of 40 to 45 feet. The saturated thickness of waste varies from nil at the west end to an estimated 20 feet near the east end. It is possible that some leachate drains through the groundwater diversion system.

In general, groundwater level data indicate that groundwater diversion system does not function effectively (Rockwell International 1988d). As discussed in subsection 2.1.5.1, it is possible this system was not keyed into the bedrock in some areas. Those locations are identified in Plate 2-1 and 7-1. Therefore, it appears that recharge to the groundwater within the landfill occurs as a result of infiltration of precipitation directly into the landfill and also possibly from infiltration of groundwater through or beneath the perimeter groundwater diversion system. As indicated in Figure 2-8, the direction of groundwater flow is probably in general accordance with the large-scale slope of original ground surface in this vicinity. The overall gradient is to the east.

In the landfill area the waste materials overlie a relatively thin layer of surficial soils, generally 10 feet or less, which in turn overlie weathered bedrock. In the western portion of the landfill where operations started in the late 1960s, a layer of soil fill up to 5 feet thick was reportedly placed in the valley bottom prior to placement of waste. It is not known whether this type of preparation was conducted for subsequent expansion to the east.

The Inactive Hazardous Waste Storage Area (SWMU 203) is a nearly level gravel-covered vacant area near the west end of the Present Landfill. This pad was operated as a hazardous waste storage area that consisted of drums contained within cargo containers. Site reconnaissance conducted for the 1988 closure plan (Rockwell International 1988c) did not identify soil staining; however, it was reported that some small spills (less than reportable quantities) may have occurred during transfer operations. The closure plan referred to a soil profile consisting of 13 inches of relatively high permeability, cobbly sandy loam overlying approximately 3 feet of sandy clay loam with a significantly lower permeability. Based on this information, it was anticipated in the closure plan that contamination resulting from small spills would be limited to the upper 13 inches of the soils.

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7.1.2 Sampling Rationale

Due to the variability of landfill wastes, it would be exceedingly difficult to characterize them adequately based solely on borehole sampling and analytical testing of the wastes. Discrete waste samples are difficult to obtain and no analytical procedures have been established to analyze these materials, e.g., paper, metal containers, etc. Therefore, characterization of the source will be accomplished by sampling and testing the pore fluids within the wastes. These are groundwater below the water level and soil gas above the water level. This appraoch assumes that contaminant concentrations in the landfill leachate are representative of average contaminant concentrations in waste. Source characterization based on analysis of water and gas sampled directly from the wastes will be supplemented with comparison of groundwater quality data in existing upgradient and downgradient alluvial and bedrock wells. Leachage seeping from the east toe of the landfill wastes and sediments obtained from the upstream end of the existing east pond will also be sampled and analyzed to further characterize the source. It is possible that the existing outlets from the groundwater diversion system contain landfill leachate. Therefore, these will also be sampled and analyzed.

The physical properties and contamination of the soils beneath and downgradient of the source will be characterized by laboratory analysis on soil samples. Soil fill beneath the waste fill, natural alluvial and colluvial soils, and weathered bedrock will be considered soil during soil sampling. Previous work at Rocky Flats indicated that weathered bedrock ranges from 10 to 40 feet in thickness (Rockwell International 1988d). Soil contamination will be evaluated beneath the wastes, at the downstream toe of the landfill, and at the discharge points of the groundwater diversion system. The evaluation of soil contamination will be based on analytical testing of soil samples. The physical characteristics of the soils will be evaluated based on analytical testing of soil samples. The physical characteristics of the soils will be evaluated based on soil classification and standard geotechnical engineering properties, such as grain size distribution and Atterberg limits. Pump-in borehole permeability tests (packer tests) will also be conducted in the weathered bedrock for use in Phase II RI/FS activities. Soil characterization will not include the existing landfill cover soils, since it is presumed any remedial alternative developed will address these materials along with the wastes. The exception to this is in the Inactive Hazardous Waste Storage Area (SWMU 203), where surficial soil sampling will be conducted to evaluate whether special treatment of the soils in this area is warranted.

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7.1.3 Sampling Design, Location and Frequency

7.1.3.1 Present Landfill (SWMU 114)

7.1.3.1.1 Borings. Fifteen borings will be drilled throughout the area of the Present Landfill. The boring locations are shown in Plate 7-1. Since the sampling rationale is predicated on the assumption that contaminant concentrations in the landfill represent average concentrations in the waste, the boring locations are based primarily on site physical characteristic considerations. All of the borings except Boring Nos. 2 and 6 will be used to obtain soil samples for the purpose of evaluating the vertical extent of soil contamination. Boring Nos. 1, 3-5, and 7-12 will be drilled through the landfill waste. Boring Nos. 1, 4, 8, 10, 11, 12, and 13 are located approximately along the longitudinal axis of the landfill, which should be at the section of deepest fill and which is parallel to the direction of groundwater flow. This will provide information along the entire length of the landfill on groundwater horizontal gradient, the upgradient to downgradient distribution of contamination, and site physical characteristics such as subsurface profile and geotechnical engineering parameters with depth. Boring Nos. 7 and 9 will provide additional information along the section perpendicular to this axis previously described by Well Nos. 60-87 through 66-87 (Section D-D').

Drilling through the waste is anticipated to require relatively large and specialized drilling equipment. Procedures for drilling and sampling will be developed prior to implementing the Phse I Work Plan. Rigorous compliance with an appropriate health and safety plan will be mandatory. Samples of the waste will be visually classified during drilling but will not be saved for testing. After drilling to the bottom of the wastes, an 8- to 10-inch diameter temporary casing will be inserted and sealed at the bottom to isolate the underlying samples from the leachate in the wastes. If the soil beneath the waste is coarse granular material judged to have a permeability on the order of or greater than that of the waste, the casing will be sealed at the top of the weathered bedrock after the soil is sampled as described below.

Soil below the waste in Boring Nos. 1, 3, 4, 5, 7, 8, 9, 10, 11, 12 and over the entire depth in Boring Nos. 13, 14, and 15 will be sampled using hollow-stem auger continuous coring techniques. Boring No. 12 is located to penetrate the buried west pond. Care will be taken that continuous auger sampling is started at a sufficiently high elevation in Boring No. 12 to sample the pond

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sediments. In addition, a sample retainer device will be fitted in the tip of the continuous sampler when necessary to assist sample recovery. NX rock core sampling techniques using carbide or diamond bits which will utilize potable water from an approved source as the drilling fluid will be used in at least the bottom 10 feet of each boring. A pump-in borehole permeability test (packer test) will be conducted in the NX-cored section of each boring. From the continuous soil and weathered rock samples, discrete samples will be submitted for laboratory chemical analysis at 2-foot increments in soil and 4-foot increments in weathered rock. During drilling, all cuttings and soil samples will be screened with field instruments for radiation and volatile organic compounds.

The exception to the above sampling design will be in Boring Nos. 2 and 6. These two borings will be drilled only for the purpose of classifying soil types and installing standpipe piezometers. Sampling in these borings will consist of standard split-spoon or California drive samples obtained at 5-foot intervals to a depth of approximately 10 feet below the groundwater level. Analytical testing will not be conducted on samples from Boring Nos. 2 and 6.

Table 7-1 presents a summary of estimated boring information. This information is based on interpolations and extrapolations of existing boring and well data. It should be suitable for planning purposes but should not be considered accurate.

7.1.3.1.2 Groundwater Monitoring Wells. Four-inch diameter groundwater monitoring wells will be constructed in Boring Nos. 1, 3, 4, 5, 7, 8, 9, 10, 11 and 12. These wells will be constructed for the purpose of sampling leachate and soil vapor from the wells. for wells with a staurated thickness of waste of more than 13 to 15 feet, the lower 5 feet of the well will be screened and the upper portion of the well from 5 feet below the water level to within 3 feet of the ground surface will be screened. Therefore, prior to construction of the wells, the portions of the borings below the bottom of the wastes will be grouted. Removal of the temporary casing previously inserted to the bottom of the waste will be required at the time of well construction.

In wells where the saturated thickness of the waste is in the range of 13 to 15 feet or less, the entire length of the well will be screened from the bottom to within 3 feet of the ground surface. This will allow sampling of both leachate and soil vapor from the wells. For wells with a saturated thickness of waste of more than 13 to 15 feet, the lower 5 feet of the well will be screened and the upper portion of the well from 5 feet below the water level to within 3 feet of the ground surface

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TABLE 7-1

PROPOSED BORING SUMMARY

Boring	Well (A)	Piezometer (B)	ESTIMATED ELEVATIONS (ft.)(C)				Estimated Saturated Waste Thickness (ft) (C)	Estimated Total Boring Depth (ft) (C) (E)
			Ground	Water	Bottom of Waste	Top of Bedrock		
1	X		5992	5980	5977	5968	3	34-64
2		X	5988	5980	NA	NA	NA	13-43
3	X		5988	5977	5981	5975	NA	23-53
4	X		5988	5975	5969	5969	6	29-59
5	X		5990	5977	5985(?)	5977	NA	23-53
6		X	5990	5980	NA	NA	NA	15-45
7	X		5986	5970	5966	5958	4	38-68
8	X		5987	5970	5968	5961	2	36-66
9	X		5986	5970	5965	5965	5	31-61
10	X		5983	5965	5951	5951	14(D)	42-72
11	X		5983(?)	5960	5940	5935	20(D)	58-88
12	X		5983(?)	5955	5938	5930	17(D)	63-93
13			5922	5921	NA	5918	NA	14-44
14			5886	5885	NA	5880	NA	16-46
15			5910	5905	NA	5900	NA	20-50

Notes: (A) Wells screened in wastes (see text).
(B) Standpipe piezometers screened from bottom to within 5 feet of ground surface.
(C) Approximate values based on review of available data.
(D) Two separate screened intervals (see text).
(E) Based on 10 to 40 feet of bedrock penetration.

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will be screened. The portion of the well annulus between the upper and lower screened sections will be sealed. Based on available information, it is anticipated Well Nos. 10, 11, and 12 will be of this variety. To isolate the upper frm the lower screened section, purging and sampling these wells will require the use of packers and pumps which can be used to pump water from below the inserted packer. The purpose of double screening the larger saturated thicknesses is to reduce contaminant dilution in the event of contaminants with concentration gradients with depth.

Four rounds of groundwater and well head-space soil gas samples will be collected during the Phase I RFI/RI process. The first round will occur following installation and development of the new wells. The next three rounds will be conducted over approximately the following one year; however, the timing will be developed considering previous well hydrographs to sample at times of water level highs and lows. Water levels will be measured monthly in each of the wells.

7.1.3.1.3 Piezometers. The cross sections described by Boring Nos. 2, 3, and 4 and by Boring Nos. 4, 5, and 6 intersect the portions of the groundwater diversion and leachate collection system which may not be keyed into the bedrock. As discussed in subsection 2.1.5.1, the profile sheets in the construction plans indicate the bottom of the system to be above the bedrock surface at these locations. Groundwater levels along the section described by Well Nos. 10-86, 58-87, B106089, and the new Boring No. 1 will be compared with the groundwater profiles described by the water levels in Well Nos. 2 through 6 to evaluate whether groundwater infiltration is occurring beneath the groundwater diversion and leachate collection system. One-inch diameter standpipe piezometers will be installed in Boring Nos. 2 and 6. These piezometers will be used solely to measure alluvial groundwater levels. They will not be used for obtaining groundwater quality samples. Accordingly, they will be screened from the bottom (approximately 10 feet below the groundwater level) to within 5 feet of the ground surface. Water levels will be measured monthly.

7.1.3.1.4 Sediment Samples. Samples of sediment will be obtained from the east pond at 3 locations toward the upstream end of the pond. At each of these 3 locations, a boring will be advanced with hand-operated equipment from a floating platform to obtain a continuous sample of the entire depth of sediments. The thickness of sediments is anticipated to be between 3 and 6 feet. These hand borings may be terminated when hard soil or rock is encountered at the base of the sediments or at a minimum depth of 3 feet. Discrete samples will be submitted for laboratory chemical analysis every 1 foot with the first sample at the sediment surface.

7.1.3.1.5 Leachate Samples. Samples of leachate seeping from the east toe of the landfill just upgradient of the west end of the east pond will be collected in a temporary reservoir built for this purpose. The reservoir will have an outlet pipe several inches above the level of its bottom. Seep flows will be measured using the bucket and stopwatch method. The location of the temporary reservoir will be identified based on the location of seepage from the toe of the landfill at a time when surface runoff is not occurring on the east face of the landfill.

Samples of the effluent from the groundwater diversion system will also be collected from surface water sampling stations SW99 and SW100. Sampling of leachate from the toe of the landfill and of surface water stations SW99 and SW100 will be conducted at the same time leachate samples are collected from the wells installed in the landfill.

7.1.3.2 Inactive Hazardous Waste Storage Area

The containerized wastes previously stored at the Inactive Hazardous Waste Storage Area generally consisted of 55-gallon drums containing waste machining, cutting and lubricating oils, solvents, organics and acids stored in cargo containers (Section 1.4.2). Some of the containers were used to store PCB-contaminated soil and debris, as well as PCB oil from transformers. Residual contaminants that may be present at the Inactive Hazardous Waste Storage Area are volatile organic compounds (VOCs), heavy metals, and PCBs. Administrative controls have reportedly precluded the storage of radioactive or mixed wastes at this facility; however, no sampling has been done to provide support. It is possible that spills occurred during the transfer of materials or from drums that might have leaked while stored on the area.

7.1.3.2.1 Sample Design. Characterization of soil contamination will be conducted following an approach which was developed for the 1988 closure plan (Rockwell International, 1988c). The initial characterization effort will consist of (a) visual surveys of the Hazardous Waste Storage Area in order to identify possible spill sites and (b) radiological survey. Soil sampling by stratified and random systematic sampling programs for TCL volatile organics, metals, PCBs, and radionuclides will e conducted after the initial surveys. If contamination is found an additional effort will be under taken to further define the horizontal and vertical extent of contamination.

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7.1.3.2.2. Initial Surveys. The initial visual survey is intended to assist in delineating areas within the facility which will receive stratified sampling. It will consist of looking for signs of spills, such as soil staining.

The radiological survey will be conducted near surface using Field Instrument for the Detection of Low Energy Radiation (FIDLER) according to SOP 6.7 "Near Surface and Soil Sample Screening for Low-Energy Gamma Radiation using the FIDLER" to support the visual survey (Rockwell International 1989e). The area to be surveyed corresponds to the area in Figure 7-1 with a reduction in grid size, if necessary, to meet the current SOP requirements.

7.1.3.2.3 Soil Sampling. Soils within the Hazardous Waste Storage Area will be sampled to evaluate the extent of soil contamination. The sampling program will include random systematic sampling and may include some stratified sampling. The random systematic sampling program will include establishing grid points which will be sampled in order to evaluate the probability that a predetermined area of contamination is not present at the facility. The stratified sampling will be dependent on the results of the initial surveys. For both sampling methods, it is assumed that the results will indicate if any contamination is or is not present.

The major soil series over much of the Rocky Flats Plant site is the Flatirons very cobbly sandy loam. This is the soil series present in the vicinity of the cargo container storage area. The soil has a high rock fragment content ranging to 80 percent with a thick clay matrix horizon ranging up to 60 percent clay. The clay is predominantly montmorrillonitic, with a high cation exchange capacity and a moderate shrink/swell potential. The top 13 inches is a very cobbly sandy loam with a permeability ranging from 2 to 6 inches per hour. From 13 to 47 inches, the soil is a very gravelly clay with a permeability range of 0.06 to 0.2 inches per hour. Below 47 inches, the soil is a sandy clay loam with a permeability that ranges from 0.6 to 2.0 inches per hour.

It is assumed that contamination may be limited to the upper 13 inches of the soils based on the soil's characteristics. The relatively low permeability clay layer, extending from a depth of 13 to 47 inches, is anticipated to have restricted the migration of any contaminants that may have been released from container storage in these areas. Therefore, preliminary sampling and analyses of soils will be limited to shallow soils up to 12 inches in depth.

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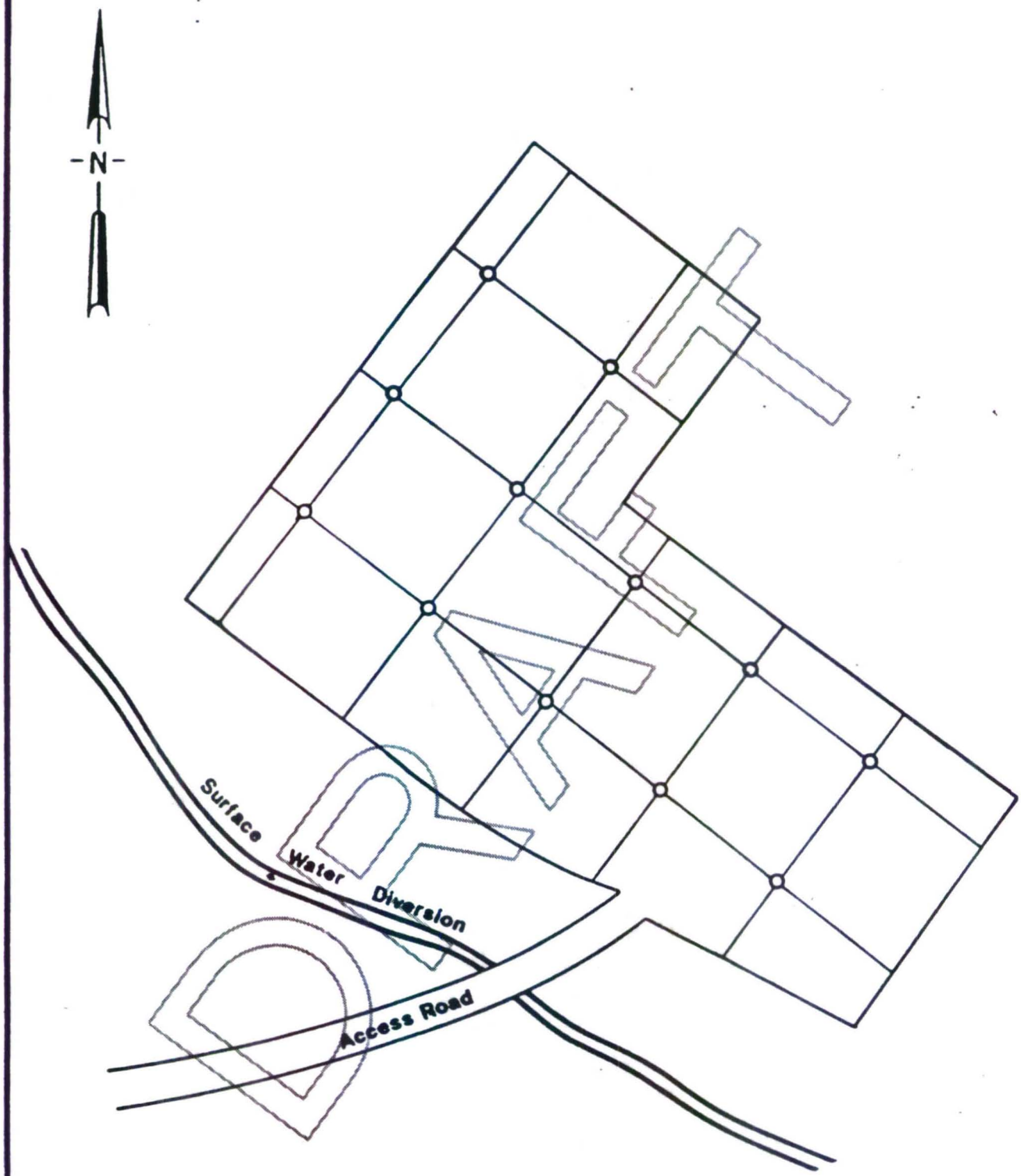

O Soil Sampling Locations

Approximate Scale: 1"=40'

SOURCE: ROCKWELL INTERNATIONAL 1988c

Job No. : 4004-210	RANDOM SAMPLING LOCATIONS HAZARDOUS WASTE STORAGE AREA
Prepared by: A.C./T.K.	
Date: 4/6/90	Figure 7-1

7.1.3.2.4 Sampling Procedures. Soil sampling procedures will be the same regardless of whether random systematic or stratified sampling methods are used to identify sampling locations. At each sampling location, a one-foot deep boring will be made with hand implements or a bucket auger, depending upon soil conditions (Standard Operating Procedure 5.2 "Soil SAmapling with a Spade and Scoop"). (Rockwell International 1989e). Samples will be comprised of the composite of materials exposed over the length of the boring. Samples for volatile organic compounds will be the first sample collected from the boring prior to mixing to minimize volatization of compounds.

7.1.3.2.5 Random Systematic Sampling. A random systematic sampling grid will be used to determine sampling locations. The grid will be developed using published methods (Zirschky, 1984 and Gilbert 1987). The grid points will be sampled regardless of whether they fall within areas delineated by the Phase I surveys. The intent of the random systematic sampling is to identify potential contaminant areas that are not delineated by the Phase I surveys. As samples may happen to be obtained from grid points within the potentially contaminated areas identified by the Phase I surveys, the grid sampling will also provide data for characterization of these areas. Those areas identified by the Phase I surveys which are not sampled by random systematic sampling procedures will be sampled by stratified sampling, as discussed below.

Parameters governing the size of the random systematic sampling grid are the shape and size of the contaminated area or hot-spots of concern and the probability of finding the hot-spots. From past practices, drums are generally stored relatively close together, with approximately one-half foot between drums. Using the number of drums added per year to the area and the average spacing between drums, the area occupied by the drums was determined and an equivalent radius, L, of a potential hot-spot was calculated. The number of drums and equivalent radius, L, of the potential hot-spot for the Hazardous Waste Storage Area will be assumed to be 384 and 20 feet respectively.

To select the desired probability of finding a contaminated area, several factors are evaluated. These factors are the waste characteristics, the volume of waste stored, the overall risk posed by the wastes, and the types of sampling programs selected. Based on available information, the containers were used to store waste oils, organics, solvents, acids, and coolants. It will be assumed that a 70 percent chance of finding a contaminated area is a reasonable goal for preliminary sampling.

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Using a 70 percent chance of finding a contaminated area, the procedure to be followed to determine the grid spacing is illustrated in Figure 7-2. The contaminated area that is under investigation, A, is defined by the equivalent area occupied by the maximum number of drums added at the area per year. The ratio of L to G (the grid spacing) is indicated to equal 0.47 (Gilbert, 1987) for a circular area with a confidence level of not hitting the target = 0.3. Using this L/G ratio, the information used to determine the grid spacing for a square sampling grid is 42 feet. Based on this grid spacing, a total of twelve random systematic samples will be collected (Figure 7-1).

7.1.3.2.6 Stratified Sampling. The sample distribution for stratified sampling will be based on the results of the initial surveys. Each area of visual soil staining of significant size indicating contamination may be present will be sampled for analyses as will any area that is determined to have surface radiological contamination. One sample will be taken in these areas. Significant size shall be taken as a visual stain of approximate diameter similar to a 55-gallon drum. Soil stains less than this size will be evaluated in the field based on their size, amount of visual contamination present, similarity and proximity to other soil staining.

If the soil sampling descirbed above indicates soil contamination is present, further soil analyses will be conducted to define the extent of contamination and to determine further actions. The additional sampling will be conducted to determine both vertical and horizontal extent of contamination and/or to identify the contamination at a 90 percent confidence level based on a statistically valid analysis. Additional background samples may be required in order to establish background levels in the differing soil horizons encountered in the storage area. The vertical extent of contamination will be determined by extending borings to uncontaminated materials or to the groundwater table, whichever is shallower.

7.1.3.3 Civil Survey of Sample Locations

Locations of all borings and surface sample points will be surveyed to within an accuracy of 1 foot prior to drilling or sampling. After drilling and sampling, locations will be resurveyed to the same level of horizontal accuracy. Elevations of the ground surface at borings not completed as wells or piezometers, and the elevations of the tops of well and piezometer casings will be surveyed to an accuracy of ± 0.1 feet.

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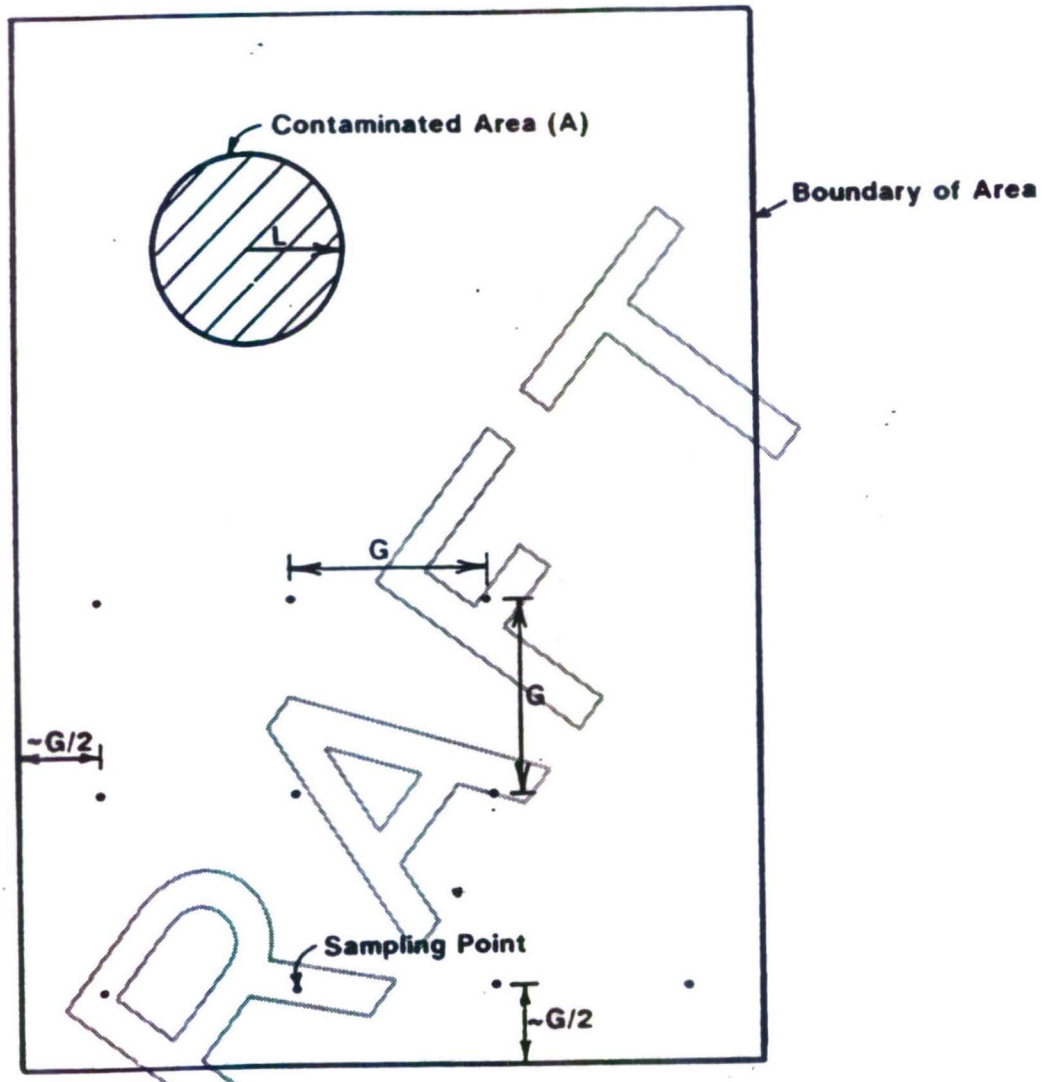

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L=Equivalent Radius (ft) Based on Maximum Number of Drums Added to Storage

A=Equivalent Area (sq. ft.)= πL^2

B=0.3 (B= Probability of Not Hiting the Targed = 1-0.7)

L/G=0.47

SOURCE: ROCKWELL INTERNATIONAL 1988c

Job No. : 4004-210	RANDOM SAMPLING GRID
Prepared by: A.C./T.K.	
Date: 4/6/90	Figure 7-2

7.2 SAMPLE ANALYSIS

7.2.1 Soil, Weathered Bedrock, Sediment Samples

7.2.1.1 Chemical Analysis

Soil and sediment samples will be collected as discussed in Section 7.1. Designated samples will be analyzed for the chemical parameters listed in Table 7-2 following CLP or the methods specified in the Phase I RFI/RI QA/QC plan. Table 5-1 identifies analytical levels required. Surface soils will be analyzed for the organics, metals, PCBs, and radionuclides as listed in Table 7-2.

7.2.1.2 Soil Gas (Headspace Analysis)

Samples of well headspace gas will be collected from each of the wells. Analysis of samples will be by GC to test for methane, hydrogen sulfide, TCE, toluene, 1,1,1-TCA, benzene, methylene chloride, and chloroform.

7.2.1.3 Physical Analysis

Physical analysis on soil and bedrock samples will consist of laboratory classification and moisture content and dry density. Laboratory classification tests include grain size distribution and Atterberg limits. Laboratory classifications will be conducted for a minimum of 5 samples of each general soil or rock material type.

7.2.2 Landfill Leachate and Groundwater Samples

Landfill leachate samples will be collected from all wells screened in the landfill wastes. Groundwater samples will also be obtained from previous upgradient wells in the area of the landfill. Leachate samples will be analyzed in the field for pH, conductivity, and temperature. Laboratory analyses will be performed on unfiltered samples (for leachate) since the objective of the effort is to provide a characterization of contaminants within the landfill. Samples will be analyzed for the parameters listed in Table 7-3. Surface water samples collected from the toe of

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TABLE 7-2

PHASE I RI
SOURCE SAMPLING PARAMETERS
SOIL SAMPLES

METALS

Target Analyte List - Metals

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Vanadium
- Zinc

Other Metals

- Molybdenum
- Cesium
- Strontium
- Lithium
- Tin

INORGANICS

- pH
- Nitrate
- Percent Solids

ORGANICS

Target Compound List - Volatiles

- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- total 1,2-Dichloroethene
- Chloroform
- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,2-Dichloropropene
- Trichloroethene

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TABLE 7-2
(continued)

ORGANICS (CONT.)

Target Compound List - Volatiles (Continued)

- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes
- 1,1-Dichloroethane

Target Compound List -- Semi-volatiles

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

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TABLE 7-2
(continued)

ORGANICS (CONT.)

Target Compound List -- Semi-volatiles (continued)

- Diethylphthalate
- 4-Chlorophenyl Phenyl ether
- Fluorene
- 4-Nitroaniline
- 4,6-Dinitro-2-methylphenol
- N-nitrosodiphenylamine
- 4-Bromophenyl Phenyl ether
- Hexachlorobenzene
- Pentachlorophenol
- Phenanthrene
- Anthracene
- Di-n-butylphthalate
- Fluoranthene
- Pyrene
- Butyl Benzylphthalate
- 3,3'-Dichlorobenzidine
- Benzo(a)anthracene
- bis(2-ethylhexyl)phthalate
- Chrysene
- Di-n-octyl Phthalate
- Benzo(b)fluoranthene
- Benzo(k)fluoranthene
- Benzo(a)pyrene
- Indeno(1,2,3-cd)pyrene
- Dibenz(a,h)anthracene
- Benzo(g,h,i)perylene

Target Compound List -- Pesticides/PCBs

- alpha-BHC
- beta-BHC
- delta-BHC
- gamma-BHC (Lindane)
- Heptachlor
- Aldrin
- Heptachlor Epoxide
- Endosulfan I
- Dieldrin
- 4,4'-DDE
- Endrin
- Endosulfan II
- 4,4'-DDD
- Endosulfan Sulfate
- 4,4'-DDT
- Endrin Ketone
- Methoxychlor
- alpha-Chlordane
- gamma-Chlordane
- Toxaphene
- AROCLOR-1016
- AROCLOR-1221
- AROCLOR-1232
- AROCLOR-1242
- AROCLOR-1248
- AROCLOR-1254
- AROCLOR-1260

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TABLE 7-2
(continued)

RADIONUCLIDES

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

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TABLE 7-3

PHASE I RI
LANDFILL LEACHATE

FIELD PARAMETERS

- pH
- Specific Conductance
- Temperature

INDICATORS

- Total Dissolved Solids

DISSOLVED METALS

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

ANIONS

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

ORGANICS

- Target Compound List - Volatiles
  - Chloromethane
  - Bromomethane
  - Vinyl Chloride
  - Chloroethane
  - Methylene Chloride
  - Acetone
  - Carbon Disulfide
  - 1,1-Dichloroethene
  - 1,1-Dichloroethane
  - total 1,2-Dichloroethene
  - Chloroform

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TABLE 7-3
(continued)

ORGANICS (CONT.)

Target Compound List - Volatiles (Continued)

- 1,2-Dichloroethane
- 2-Butanone
- 1,1,1-Trichloroethane
- Carbon Tetrachloride
- Vinyl Acetate
- Bromodichloromethane
- 1,1,2,2-Tetrachloroethane
- 1,2-Dichloropropane
- trans-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

Target Compound List -- Semi-volatiles

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

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TABLE 7-3
(continued)

ORGANICS (CONT.)

Target Compound List -- Semi-volatiles (Continued)

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

Target Compound List -- Pesticides/PCBs

- alpha-BHC
- beta-BHC
- delta-BHC
- gamma-BHC (Lindane)
- Heptachlor
- Aldrin
- Heptachlor Epoxide
- Endosulfan I
- Dieldrin
- 4,4'-DDE
- Endrin
- Endosulfan II
- 4,4'-DDD
- Endosulfan Sulfate
- 4,4'-DDT
- Endrin Ketone
- Methoxychlor
- alpha-Chlordane
- gamma-Chlordane
- Toxaphene
- AROCLOR-1016

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TABLE 7-3
(continued)

ORGANICS (CONT.)

Target Compound List -- Pesticides/PCBs (continued)

- AROCLOR-1221
- AROCLOR-1232
- AROCLOR-1242
- AROCLOR-1248
- AROCLOR-1254
- AROCLOR-1260

RADIONUCLIDES

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

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the landfill and from the groundwater diversion system discharge points will be considered as leachate samples and will be analyzed for the same constituents shown in Table 7-3. This parameter list may be reduced in subsequent sampling events if certain parameter groups are not detected or are not significantly above background levels.

7.2.3 Sample Containers and Preservation, and Sample Control and Documentation

Sample volume requirements, preservation techniques, maximum holding times, and container material requirements are dictated by the media being sampled and by the analyses to be performed. Table 7-4 lists the requirements for samples collected and analyses specified in this FSP. Field personnel will collect a sufficient volume of each sample in appropriate containers, properly preserved, to allow for the analyses that potentially may be performed on each sample.

Additional specific guidance on the appropriate use of materials is provided in SOP 1.4 "Sample Containers and Preservation."

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. Specific guidance defining the necessary sample control, identification, and chain-of-custody documentation is discussed in SOP 1.3 "Sample Control and Documentation."

7.2.4 Field QC Procedures

Sample duplicates, field preservation blanks, equipment blanks, and trip blanks will be prepared. 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 Table 7-5.

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

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TABLE 7-4

SAMPLE TYPES, CONTAINERS, AND PRESERVATIVES FOR WATER AND SOIL SAMPLES

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity
Water	Inorganic Chemicals - Anions	Two 1-liter polyethylene bottles	No	Iced to 4°C	28 days	Fill to shoulder
	• Nitrate	One 1-liter polyethylene bottle	No	Iced to 4°C	48 hours	Fill to shoulder
	• Sulfide	One 1-liter polyethylene bottle	No	Iced to 4°C Zinc acetate plus sodium hydroxide to pH>9	7 days	Fill to shoulder
	- TKN, TOC, Nitrate and Nitrite	One 1-liter polyethylene bottle	No	H_2SO_4 to pH2; Iced to 4°C	28 days	Fill to shoulder
	- TDS	One 1-liter polyethylene bottle	No	Iced to 4°C	48 hours	Fill to shoulder
	Radiological[a]	One 1-gallon polyethylene bottle	Yes	HNO_3 to pH<2	6 months	Fill to shoulder
	Tritium	One 1-liter polyethylene bottle	Yes	None	6 months	Fill to shoulder

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TABLE 7-4
(continued)

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity
	TCL[b] - Semi-Volatiles	One 1-gallon amber glass jar	No	Iced to 4°C	7 days to extraction 40 days to analysis	Fill to shoulder
	- Volatiles	Two 40-ml Teflon® lined glass (VOA vial	No	Iced to 4°C	7 days	Fill to top, no air space
	- Dioxins	Two 1-liter amber glass jars	No	Iced to 4°C 0.0008% $NA_2S_2O_3$	7 days	Fill to shoulder
	- Metals	One 1-liter polyethylene bottle	No	HNO_3 to pH>12 Iced to 4°C	14 days	Fill to shoulder
	- Cyanides	One 1-liter polyethylene bottle	No	NaOH to pH>12 Iced to 4°C	6 months	Fill to shoulder
	- Pesticides/ PCBs	One 1/2-gallon amber glass jar	No	Iced to 4°C	5 days to extraction 40 days to analysis	Fill to shoulder
Soil	- TCL[b] Metals, Semi-Volatile Organics, Pesticides/PCBs; Cyanide	One 1-liter Teflon® lined wide-mouth glass jar *	No	Iced to 4°C	10 days	Fill to 3/4

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TABLE 7-4
(continued)

Sample Type	Analysis	Bottles	Filtered	Preservation	Holding Time	Quantity
	- TCL[b] Volatile Organics	One 40-ml Teflon• lined wide mouth glass jar	No	Iced to 4•C	10 days	Fill completely to minimize air space
	- Radiological[a]	One 1-liter Teflon• lined wide mouth glass jar *	No	Iced to 4•C	Depends on half-life; not to exceed 45 days	Fill to 3/4

[a] For list of constituents, see Table 5-1

[b] For Target Compound List, (TCL) constituents see Table 5-1

* As an alternative, soil samples obtained using continuous auger coring equipment may be preserved in 12-inch long sections of polybutyrate sampler liner with Teflon• lined plastic end caps sealed with tape.

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required for the samples. They will also be preserved in the same manner and submitted for the same analyses as required for the samples. Duplicate samples will be media-, parameter-, and event-specific.

Field preservation blanks of distilled water, preserved according to the sampling protocol, will be prepared by the sampling team and will be used to provide an indication of any contamination introduced during field sample preparation technique. As indicated by Table 7-5, these QC samples are applicable only to samples requiring chemical preservation.

Equipment blanks will be collected from final decontamination rinsate to evaluate the success of the field sampling team's decontamination efforts on nondedicated equipment. Equipment blanks rinsing cleaned equipment with distilled water prior to sample collection. Equipment blanks are applicable to all analyses for water and soil samples as indicated in Table 7-5.

Trip blanks consisting of distilled water 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. As indicated in Table 7-5, all blanks will be prepared at a frequency of 1/20 per shipment.

Procedures for monitoring field QC are given in the QAPP.

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TABLE 7-5

FIELD QC SAMPLE FREQUENCY

Sample Type	Type of Analysis	Media: Solids	Media: Liquids
Duplicates	Organics (a)	1/10	1/10
	Inorganics (a)	1/10	1/10
	Radiologicals (a)	1/10	1/10
Field Preservation Blanks	Organics (a, b)	NA	NA
	Inorganics (a, b)	NA	1/20
	Radiologicals (a, b)	NA	1/20
Equipment Blanks	Organics (b)	1/20	1/20
	Inorganics (b)	1/20	1/20
	Radiologicals (b)	1/20	1/20
Trip Blanks	Organics (a, b)	NR	1/20
	Inorganics (a, b)	NR	NR
	Radiologicals (b)	NR	NR

NA = Not Applicable
NR = Not Required

(a) Source: EPA (1986c).
(b) Source: DOE (1987).

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8.0
BASELINE RISK ASSESSMENT PLAN

A baseline risk assessment will be prepared for the Inactive Hazardous Waste Storage Area and the Present Landfill as part of the Phase II Remedial Investigation/Feasibility Study (RI/FS) to evaluate the potential threat to the public health and the environment in the absence of remedial action. The baseline risk assessment will provide the basis for determining whether or not remedial action is necessary and serves as the justification for performing remedial action (EPA 1989a). This process is being initiated by implementation of the Phase I Work Plan. Each of the Phase I sampling activities is designed to begin providing the data needed to complete the baseline risk assessment.

Several objectives will be accomplished under the risk assessment task including identification and characterization of the following (EPA 1989a):

- Toxicity and levels of hazardous substances present in relevant media (for example, air, groundwater, soil, surface water, sediment, and biota).
- Environmental fate and transport mechanisms within specific environmental media such as physical, chemical, and biological degradation processes and hydrogeological conditions.
- 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 (such as risk characterization).
- Level(s) of uncertainty associated with the above.

The public health risk assessment and the environmental evaluation will be performed in accordance with EPA and other guidance documents listed in Table 8-1. The risk assessment will

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address the potential public health and environmental impacts associated with the site under the no action alternative (no remedial action taken). This assessment will aid in the selection of site remedies based on the contaminants of concern and the environmental media associated with potential risks to public health and the environment.

TABLE 8-1

EPA GUIDANCE DOCUMENTS THAT WILL BE USED IN THE RISK ASSESSMENT TASK

- Risk Assessment Guidance for Superfund, Human Health Evaluation Manual Part A, Interim Final (EPA 1989a).
- Superfund Exposure Assessment Manual (EPA 1988d).
- Exposure Factors Handbook (EPA 1989b).
- The Endangerment Assessment Handbook (EPA 1985).
- CERCLA Compliance With Other Laws Manual (EPA 1988e).
- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA 1988a).
- Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference (EPA 1989c).
- Risk Assessment Guidance for Superfund -- Environmental Evaluation Manual (EPA 1989d).
- Data Quality Objectives for Remedial Response Activities: Development Process (EPA 1987).

The risk assessment process is divided into four tasks (EPA 1989a), including:

- Contaminant identification

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- Exposure assessment
- Toxicity assessment
- Risk characterization

The task objectives and descriptions of work for each task are described below.

8.1 CONTAMINANT IDENTIFICATION

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 of concern to focus subsequent efforts in the risk assessment process. Previous work characterizing aspects of the Rocky Flats Plant and the surrounding area has been done. Additional sampling and analysis of various media will take place in order to support the human health risk assessment, the ecological assessment, and to characterize the site. For this risk assessment, all of the HSL contaminants at the two Operable Unit No. 3 sites will be considered unless the following criteria are met for their deletion:

- Determination that a chemical has not been detected above risk based detection limits
- Environmental fate information that shows that exposure will not occur
- A low frequency of occurrence (less than 10 percent) in environmental media

All chemicals that are deleted and the rationale for their deletion will be discussed in the completed risk assessment.

8.2 EXPOSURE ASSESSMENT

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

- A source and mechanism of chemical release to the environment.

- An environmental transport medium (for example, air, groundwater) for the released

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contaminant.

- A point of potential contact of humans or biota with the affected medium (the exposure point).

- An exposure route (such as inhalation of contaminated dust) at the exposure point.

The exposure assessment process will include the following actions:

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

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

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

- Develop exposure scenarios for each identified pathway and select those scenarios that are plausible and that can be quantitatively evaluated.

- Identify scenarios assuming both existing and potential future uses.

- Identify the exposure parameters to be used in assessing the risk for all scenarios.

Appropriate exposure scenarios will be identified for the site including a residential scenario. Other scenarios that could potentially be considered include commercial/industrial, and/or recreational. Factors to be examined in the pathway and receptor identification process will include the following:

- Location of contaminant source
- Local topography
- Local geohydrology/surface water hydrology
- Surrounding land use

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- Local water use
- Prediction of contaminant migration
- Persistence and mobility of migrating contaminants

For each migration pathway and for current and future conditions, receptors will be identified and characterized. Potential receptors will be defined by the appropriate exposure scenarios.

8.3 TOXICITY ASSESSMENT

In accordance with EPA's risk assessment guidelines, the projected concentrations of indicator chemicals at exposure points will be compared with applicable or relevant and appropriate requirements (ARAR) to judge the degree and extent of risk to public health and the environment (including plants, animals, and ecosystems). Because many ARARs do not exist for certain media (such as soils) nor are all ARARs necessarily health based, this comparison is not sufficient in itself to satisfy the requirements of the risk assessment process. Moreover, receptors may be exposed to contaminants from more than one medium so that their total dose might exceed Reference Doses (RfDs) or the dose might result in an excess cancer risk for noncarcinogenic health effects (greater than 1 in 1,000,000). Nevertheless, the comparison with standards and criteria is useful in defining the exceedance of institutional requirements. The following criteria will be examined:

- Resource Conservation and Recovery Act (RCRA) Maximum Contaminant Levels (MCL) (40 CFR 264.94).
- Safe Drinking Water Act (SDWA) MCLs (40 CFR 141.11 - 141.16).
- Colorado Department of Health (CDH) Drinking Water Standards, Surface Water Standard, and Groundwater Standard.
- Drinking Water Health Advisories.
- Ambient Water Quality Criteria for Protection of Human Health.

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- Center for Disease Control and Agency for Toxic Substances and Disease Registry Soil Advisories.

- National Ambient Air Quality Standards.

Critical toxicity values (such as numerical values derived from dose-response information for individual compounds) will be used in conjunction with the intake determinations to characterize risk. Toxicity reference values from EPA's Integrated Risk Information System (IRIS) will be used and are preferred to other EPA reference values such as those found in the health effects assessment documents, SPHEM or PHRED.

Summaries of any toxicological studies performed will be provided for target chemicals in the baseline risk assessment. The quality of these studies and their usefulness in estimating human health risks will be described. A more detailed explanation of the toxic effect of target chemicals will be provided in the appendixes to the human health risk assessment and the environmental evaluation. Toxicity reference values will also be summarized. For the human health risk assessment, this will include a brief description of the studies upon which selected reference values were based, the uncertainty factors used to calculate RfDs, and the EPA weight-of-evidence classification for carcinogens. For those chemicals without EPA toxicity reference values, a literature search, including computer data bases, will be conducted for selected compounds. If possible, a toxicity value will then be derived from this information. EPA will be consulted regarding the appropriateness of the data and the methodologies to be used in deriving reference values. Uncertainties regarding the toxicity assessment will be discussed.

Three difference types of critical toxicity values will be used:

- The acceptable daily intake for subchronic exposure (AIS)
- The acceptable intake for chronic exposure (AIC)
- The carcinogenic potency factor (for carcinogenic chemicals only)

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8.4 RISK CHARACTERIZATION

Risk characterization involves integrating exposure assumptions and toxicity information to quantitatively estimate the risk of adverse health effects. Risk characterization will be performed in accordance with EPA guidance. A quantitative risk estimate will be performed for all chemicals. To assess the potential adverse health effects associated with access to the site, the potential level of human exposure to the selected chemicals must be determined. Intakes of exposed populations will be calculated separately for all appropriate pathways of exposure to chemicals. Then for each population-at-risk, the total intake by each route of exposure will be calculated by adding the intakes from each pathway. Total oral, inhalation, and dermal exposures will be estimated separately. Because short-term (subchronic) exposures to relatively high concentrations of chemicals may cause different effects than those caused by long-term (chronic) exposures to lower concentrations, two intake levels will be calculated for each route of exposure to each chemical, such as, a subchronic daily intake (SDI) and a chronic daily intake (CDI).

An uncertainty analysis will be performed to identify and evaluate nonsite- and site-specific factors that may produce uncertainty in the risk assessment, such as assumptions inherent in the development of toxicological endpoints (potency factors, reference doses). Moreover, site-specific factors that may produce uncertainty will also be discussed.

Risk will be quantified by comparison of contaminant intakes at exposure points to quantitative criteria for protection of human health. The risk assessment portion will include examination of scientific literature to identify daily acceptable intakes of contaminants. Quantitative risk estimates will be made if data are available.

The results of the baseline risk assessment will be used to define and evaluate the remedial alternatives during the FS.

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9.0
ENVIRONMENTAL EVALUATION PLAN

The objective of the environmental evaluation for the Inactive Hazardous Waste Storage Area and the Present Landfill will be to evaluate if the contaminants have caused or are causing any adverse environmental impact. The data to be collected will be used in conjunction with existing data to determine the bioavailability and toxicity of the contaminants to the flora and fauna in the area of the Present Landfill.

The environmental evaluation will be conducted per guidance provided in the "Risk Assessment Guidance for Superfund", Volume II, Environmental Evaluation Manual (EPA 1989d) as part of the Present Landfill Phase II Remedial Investigation (RI). The scope of the investigation will include the collection of vegetation, small mammals, arthropods, and aquatic life for determining if bio-accumulation is occurring. The radioecology study (Rocky Flats Plant Radioecology and Airborne Pathway Summary Report) (Rockwell International 1986h), the Final Environmental Impact Statement (DOE 1980), the soils and surface water chemical data, and biological parameters collected during this environmental evaluation will be utilized to assess both the current and future ecological impacts.

Field and laboratory activities will be necessary to determine what effect contaminants at the Present Landfill are having on the area's flora and fauna. These activities may include field assessments, toxicity testing, and biomarkers.

Aquatic and terrestrial field surveys will provide detailed assessments of ecological effects. A field survey for aquatic invertebrates in the east pond and downstream drainage will be conducted in order to determine if these organisms have been adversely affected by contaminants at this site. The survey will include relative abundance, species richness, community organization, and biomass.

Toxicity tests will be conducted for the aquatic systems if the aquatic survey indicates an impact. The toxicity of environmental media can be estimated using two approaches: a chemistry-based approach or toxicity-based approach. The chemistry-based approach will first be applied where chemical analyses of water, air, soil, or sediment will be compared to published criteria to estimate toxicity. If this analysis fails to explain the contaminant impact on the biota, the toxicity-based

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approach will be used. The toxicity-based approach involves the measurements of a biological effect associated with exposure to complex mixtures. For this study, toxicity testing will include acute and chronic toxicity methods for aqueous samples.

The concept of biomarkers is that selected endpoints (such as population-ecosystem density, diversity, or nutrient cycling), which are measured in individual organisms are typically comprised of biochemical or physiological responses that can provide sensitive indices of exposure or sublethal stress. The most direct biomarker to assess exposure is to measure tissue residues, which is a key component of bio-accumulation. Biomarkers for sublethal stress include histopathology, determination of skeletal abnormalities, measurement of gas exchange in plants, and other various measurements (for example, enzymes).

For this evaluation, toxicological endpoints for indicator or target species will be chosen based on a review of available laboratory toxicity tests providing quantitative data for species of concern, when available. In the absence of toxicological indices for the target species, toxicological endpoints will be derived using safety factors that reflect interspecies extrapolation, acute-to-chronic extrapolations, and added protection for endangered and/or threatened species. Procedures to be used for the field and laboratory activities are presented in the "Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference" (U.S. EPA 1989c).

In presenting the conclusions of the environmental evaluation for the two Operable Unit 3 sites, the degree of success in meeting the overall objective of the evaluation will be discussed. Each conclusion will be presented along with items of evidence which would support or fail to support the conclusions and the uncertainty accompanying that conclusion. Any factors that limited or prevented development of definitive conclusions will also be described. Information will be provided to indicate the degree of confidence in the data that was used to assess the site and its contaminants.

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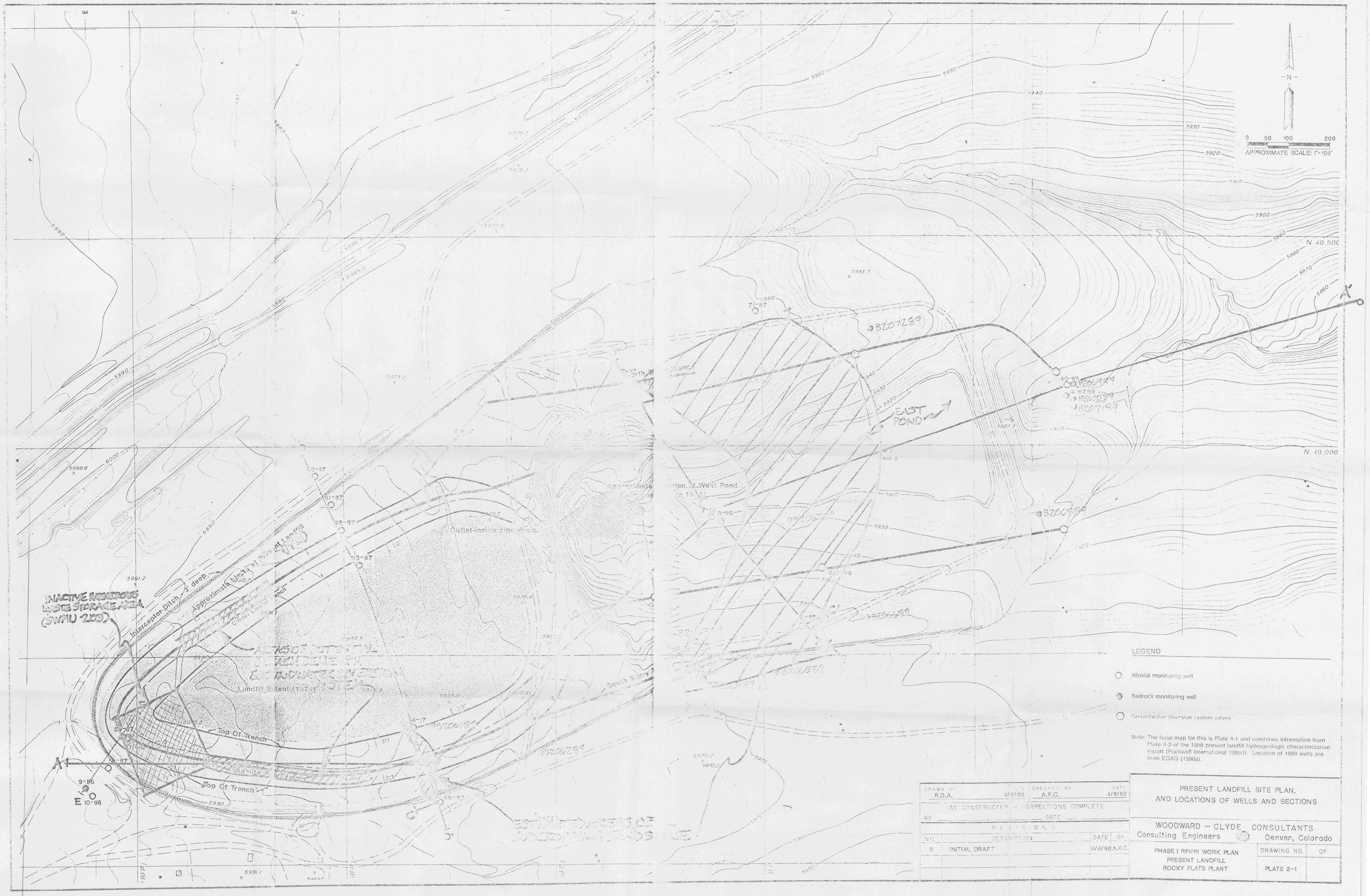
N
APPROXIMATE SCALE: 1"=100'
0 50 100 200
N 40,500
N 40,000
EAST POND
Outlet-inside pipe drain
Top Of Trench
Top Of Trench
Interceptor Ditch 3' deep
Approximate Limits of Present Landfill
Center Line of Trench
Landfill Extent (1987)
South Spur
INACTIVE HAZARDOUS WASTE STORAGE AREA (SWMU 209)
Approximate Location of West Pond
Valves
LEGEND
Alluvial monitoring well
Bedrock monitoring well
Groundwater diversion system valves
Note: The base map for this is Plate 4-1 and combines information from Plate 4-3 of the 1988 present landfill hydrogeologic characterization report (Rockwell International 1988d). Location of 1989 wells are from EG&G (1990a).
DRAWN BY R.D.A. DATE 4/6/90
CHECKED BY A.F.C. DATE 4/6/90
AS CONSTRUCTED – CORRECTIONS COMPLETE
BY DATE
REVISIONS
NO. DESCRIPTION DATE BY
0 INITIAL DRAFT 4/6/90 A.F.C.
PRESENT LANDFILL SITE PLAN, AND LOCATIONS OF WELLS AND SECTIONS
WOODWARD – CLYDE CONSULTANTS
Consulting Engineers Denver, Colorado
PHASE I RFI/RI WORK PLAN
PRESENT LANDFILL
ROCKY FLATS PLANT
DRAWING NO. PLATE 2-1
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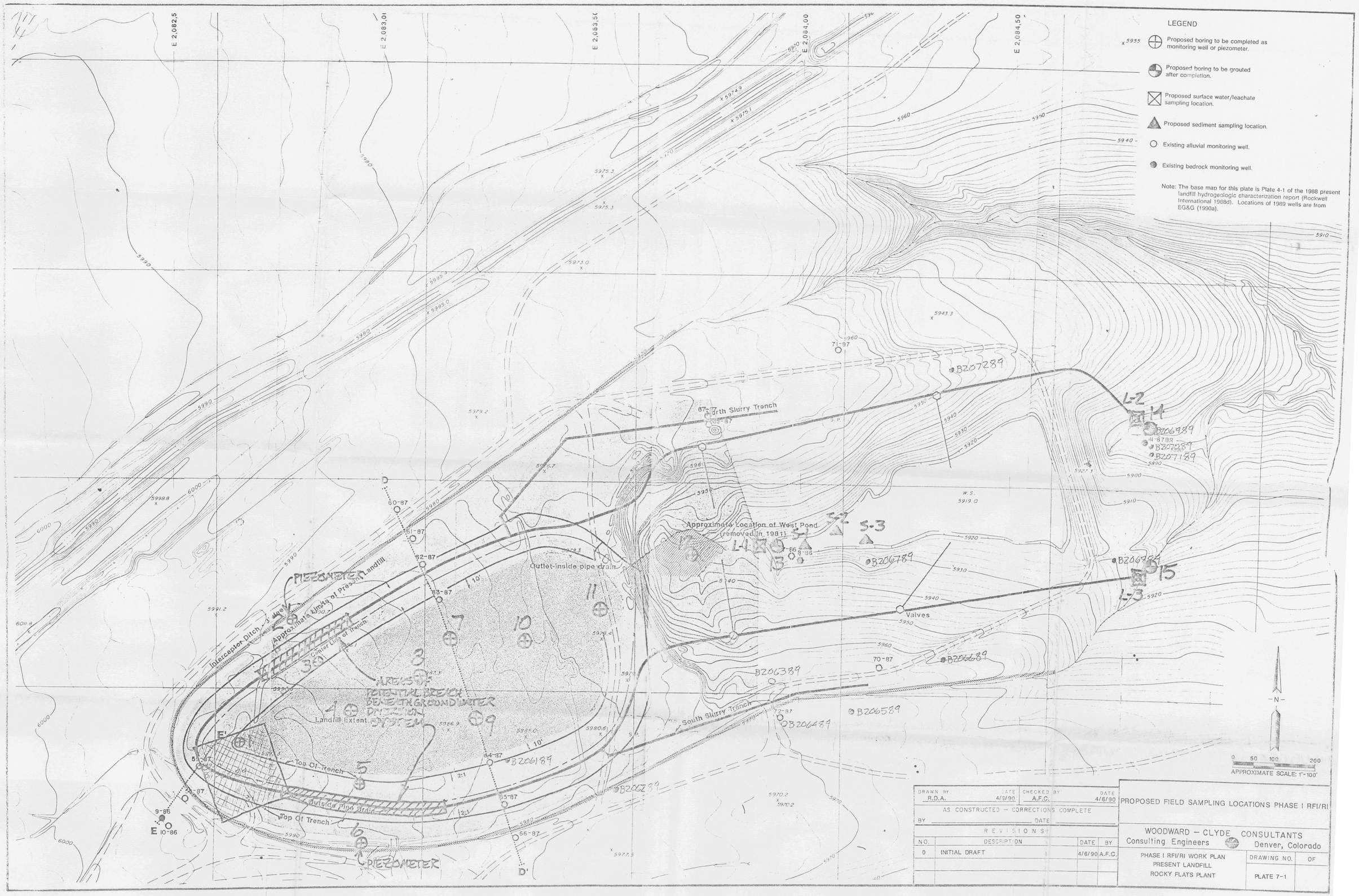

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