Resource Conservation and Recovery Act
Post-Closure Care
Permit Application

For U.S.D.O.E.-Rocky Flats Plant
Hazardous & Radioactive Mixed Wastes

CO7890010526

5 October 1988

Volume I

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By [signature] UNM
Date 4/1/90

ADMIN RECORD

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Volume I

Prepared by:

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REVIEWED FOR CLASSIFICATION/UCNI
By
Date 2/9/90

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ADMIN RECORD

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SECTION A

INTRODUCTION

This application for a post-closure care permit has been completed for the: solar evaporation ponds; present landfill; west spray field; and the original process waste lines.

The post-closure care permit application parallels the structure of the Part B permit application and is specific to post-closure care requirements. This permit will address only units that will require, or may require, post-closure care and monitoring. Section A of this permit application specifies the regulations with which the permit application has been prepared and briefly discusses the units delineated above. A description of the facility, the generated wastes, and the current waste management policies are incorporated in Section B. Section C describes the waste analyses processes for wastes generated during the post-closure care period. Process information applicable to post-closure care is presented in Section D. Ground-water monitoring activities and corrective action required for the different units during post-closure care are delineated in Section E.

Section F incorporates the preparedness and prevention security measures for post-closure care while Section G discusses necessary contingencies should failure at a unit occur during post-closure. Personnel training for post-closure care is discussed in Section H while Section I references closure plans and related financial requirements and discusses notices required for disposal facilities. Section J is reserved and Section K contains the certification and signature page verifying that the information in the permit application is true, accurate, and complete.

Appendices pertaining to individual sections have the same letter designation. There are no appendices associated with Sections A, B and E. Appendix C will contain information pertinent to waste characterization specific to units operating during the post-closure care period. Appendix D will contain waste process information specific to units operating during the post-closure care period. Appendix F contains tank inspection information and the inspection logs for security, emergency response and safety equipment delineated in Section F. Appendix G will contain the contingency plans for the units undergoing post-closure care. The RCRA hazardous materials response team initial

training and the RCRA hazardous waste training checklist and course material are located in Appendix H. The exposure information report and the interim status closure plans for the hazardous waste management units are located in the I Appendices. A number of the interim status closure plans concern units that are currently expected to be "clean closed" with no hazardous waste or contaminated materials left in place. These units include: 1) the container storage facilities; 2) Building 443 No. 4 fuel oil tank; 3) the hazardous waste storage area SWMU No. 203; 4) the original uranium chip roaster, Building 447; 5) acid dumpsters, Building 444; 6) the bench scale treatment Unit No. 32; and 7) the Building 460 acid dumpsters and solvent dumpsters. If any of these units are found in the future to require post-closure care and monitoring, the associated closure plans and the Post-Closure Care Permit will both be appropriately updated.

The closure plans for the four units that will be permitted are also found in Section I of the Post-Closure Care Permit. Closure of the four hazardous waste management units may require the construction of "active" treatment systems to treat contaminated ground water from these areas. Any such active systems treating waste that meets the definition of

hazardous waste will be appropriately permitted in this Post-Closure Care Permit and will be designed and operated to meet all requirements of 6 CCR 1007-3, Part 264, and all requirements of 40 CFR Part 264. These units have not yet been designed or constructed, so details regarding them cannot currently be given. When the design of these units has been approved by the Colorado Department of Health (CDH) and the Environmental Protection Agency (EPA), this permit will be updated to include appropriate process descriptions, waste analyses, procedures to prevent hazards, contingency plans, personnel training and appropriate RCRA closure procedures. Until approved designs have been obtained, these details cannot be provided.

The post-closure care permit application has been constructed such that future revisions of the appendices will not necessitate a change in the post-closure care permit application.

This permit application has been prepared in accordance with 40 CFR 270.1(c) and 264.118. 40 CFR 270.1(c) requires owners or operators of hazardous waste management units that

close after July 26, 1982, to have permits during the post-closure care period required under 40 CFR 264.117. The requirements of post-closure care under 264.117 are:

(a) Post-closure care must continue for 30 years after the date of completing closure and must consist of at least the following:

(i) Monitoring and reporting in accordance with the requirements of the following subparts of Part 264.

(1) Subpart F: Ground-water Protection

(2) Subpart K: Surface Impoundments

(3) Subpart L: Waste Piles (not applicable to this post-closure care permit)

(4) Subpart M: Land Treatment

(5) Subpart N: Landfills

(ii) Maintenance and monitoring of waste containment systems in accordance with the requirements of the above subparts.

(b) Post-closure use of property on or in which hazardous wastes remain after closure must never be allowed to disturb the integrity of the final cover, liner(s), or any other components of any containment system, or the function of the facility's monitoring systems.

(c) All post-closure care activities must be in accordance with 40 CFR 264.118.

As required by 40 CFR 270.10(j), an Exposure Information Report for the solar evaporation ponds, present landfill and west spray field is presented in Appendix I-1.

Characterization of the solar evaporation ponds was completed during 1987. As contaminated soil and possibly the liner will remain in place at the time of closure, post-closure care of the solar ponds will extend for 30 years past the date of closure. The closure plan for the solar evaporation ponds is presented in Appendix I-2.

The date of closure of the present landfill is presented in the Present Landfill Closure Plan. Hazardous constituent disposal in the landfill was eliminated in November, 1986. Solid wastes will no longer be accepted at the landfill after June 1, 1989. Post-closure care of the present landfill will extend for 30 years past the date of closure. The closure plan for the present landfill is presented in Appendix I-3.

The date of closure of the west spray field is presented in the West Spray Field Closure Plan. If unacceptable concentrations of hazardous waste constituents and/or radionuclides remain in the soil at the time of closure and/or if ground water has been impacted, post-closure care will extend for 30 years past the date of closure. The closure plan for the west spray field is presented in Appendix I-4.

The date of closure of the original process waste lines is presented in the Original Process Waste Lines Closure Plan. If unacceptable concentrations of hazardous waste constituents and/or radionuclides remain in the soils at the time of closure and/or if ground water has been impacted, post-closure care will extend for 30 years past the date of closure. The closure plan for the original process waste lines is presented in Appendix I-5.

The applicable Code of Colorado Regulations (CCR) and Code of Federal Regulations (CFR) are cited throughout the text and appendices of the post-closure care permit application. Preceding Section A, a checklist has been included to address the Colorado Department of Health (CDH) and the

Environmental Protection Agency (EPA) comments in the Notice of Deficiency (NOD).

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SECTION B

FACILITY DESCRIPTION

This section provides a general description of the Rocky Flats Plant, its location and environs, and a description of the units to be closed and the units requiring post-closure care. This description is intended to provide the reader with an overview of the facility. Complete details on the operating facilities can be found in the two RCRA Part B permit applications: 1) U.S. DOE - Rocky Flats Plant Hazardous and Radioactive Mixed Wastes (HRMW) for low level wastes, dated December 15, 1987, and 2) U.S. DOE - Rocky Flats Plant Transuranic (TRU) Mixed Wastes for TRU wastes, dated July 1, 1988.

B-1 GENERAL DESCRIPTION [CCR 100.41(a)(1); 40 CFR 270.14(b)(1)]

B-1a Facility Name

United States Department of Energy Rocky Flats Plant

B-1b Facility Contact

Albert E. Whiteman, Area Manager
Phone: 303-966-2025

B-1c Facility Mailing Address

P.O. Box 928
Golden, Colorado 80402

B-1d Facility Location

The Rocky Flats Plant is located in north central Colorado, northwest of the City of Denver (Figures B-1 and B-2). The plant site covers approximately 6,550 acres of federally-owned land in northern Jefferson County, Colorado, Sections 1 through 4 and 9 through 15 of R70W, T2S. The facility is centered at 105° 11' 30" west longitude, 39° 53' 30" north latitude.

As shown in Figures B-1 and B-2, this location is 16 miles northwest of downtown Denver and nine to 12 miles from the communities of Boulder, Broomfield, Golden, and Arvada. It is approximately bounded on the north by State Highway 128, on the west by State Highway 93, on the south by State

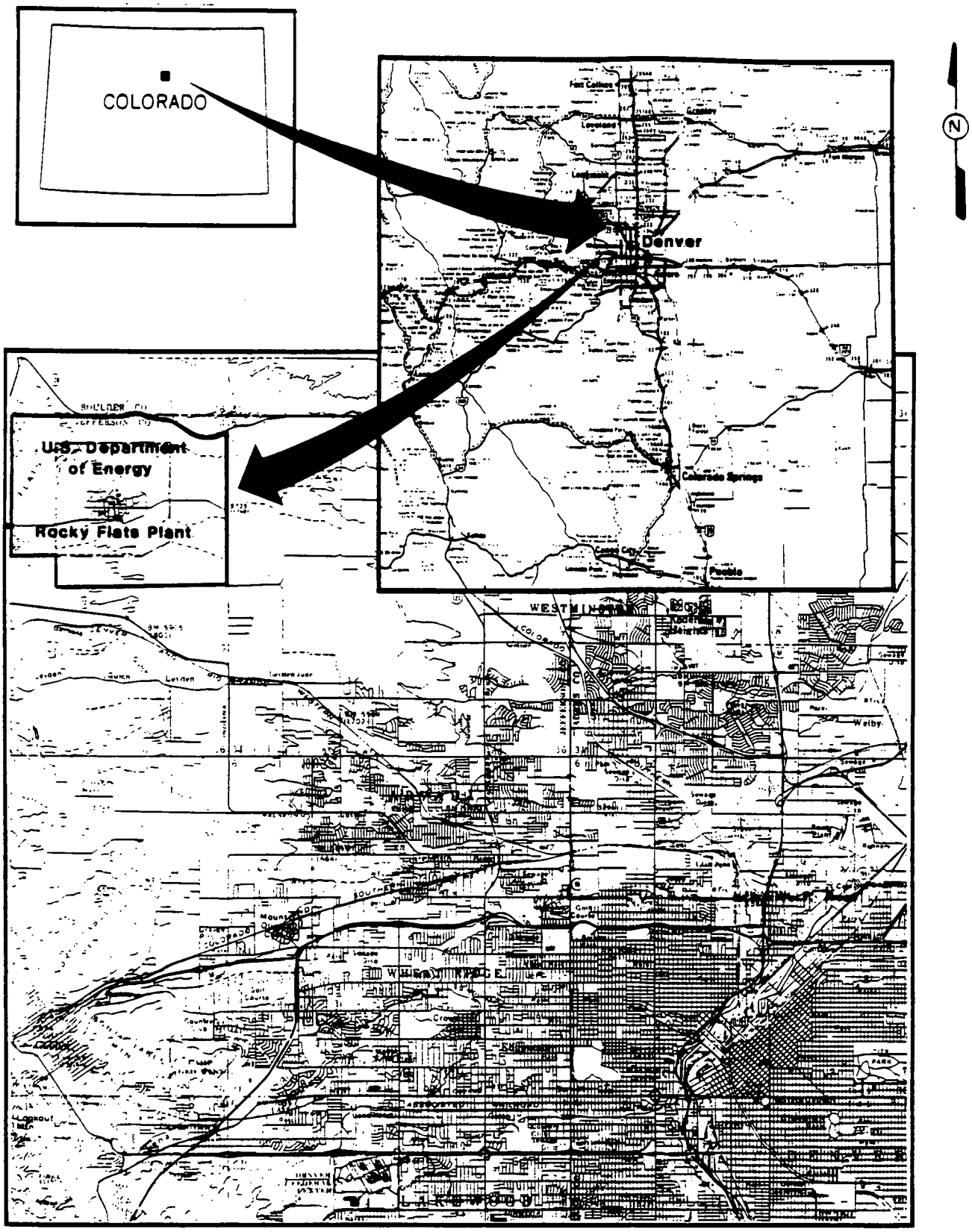


Figure B-1 General Location, Rocky Flats Plant

Not To Scale

December 15, 1987

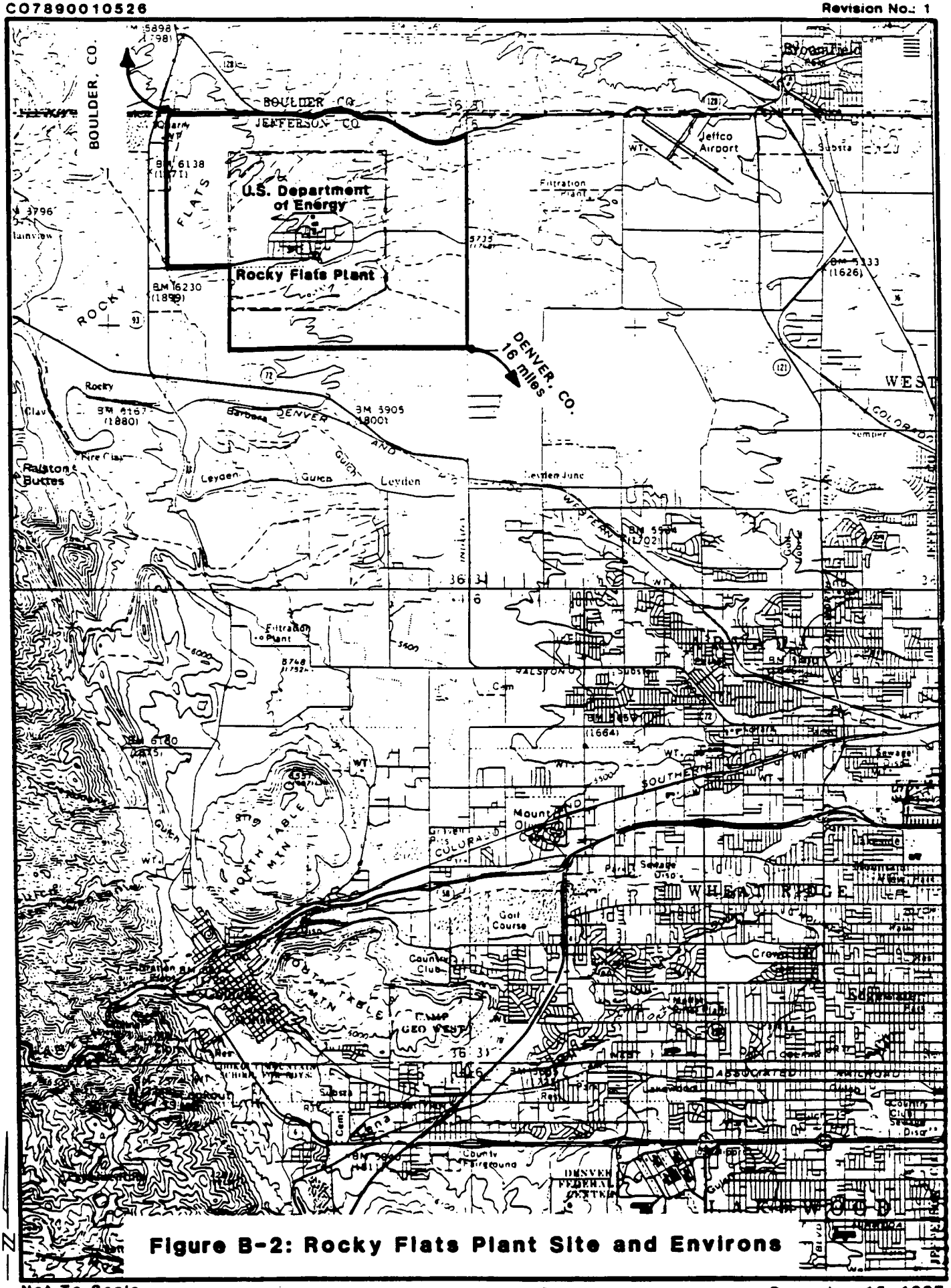


Figure B-2: Rocky Flats Plant Site and Environs

Not To Scale

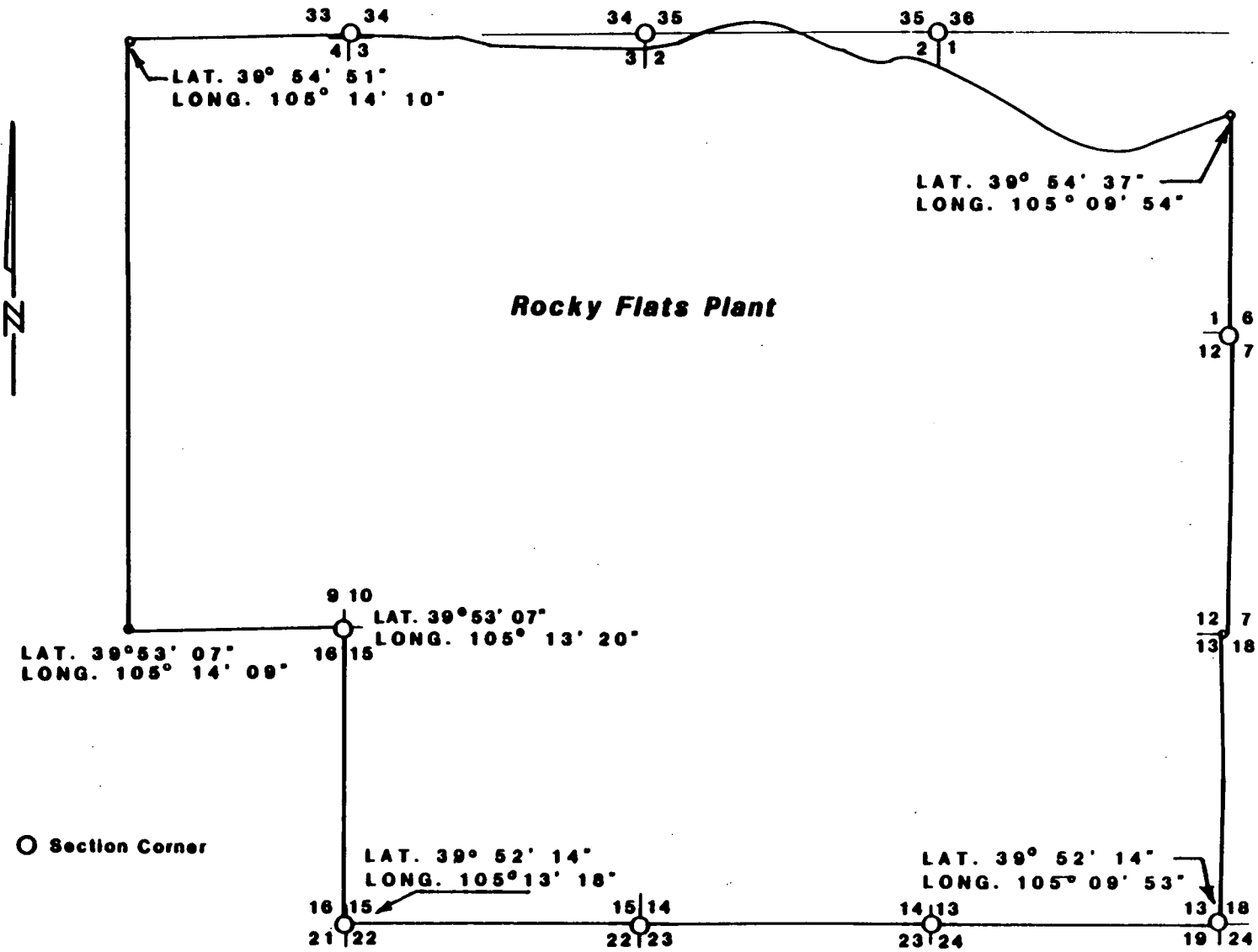
December 15, 1987

Highway 72, and on the east by Jefferson County Highway 17. The legal boundaries of the Plant property are shown in Figure B-3.

B-1e Site Environment and Climate

The plant is situated on the eastern edge of a geological bench known locally as Rocky Flats. This rocky bench, about five miles wide in an east-west direction, flanks the eastern edge of the abruptly rising piedmont of the Front Range of the Rocky Mountains. The piedmont rises about five miles west of the plant site and crests at the Continental Divide, approximately 20 miles west of the plant.

The natural environment of the plant site and vicinity is influenced primarily by the Front Range of the Rocky Mountains and the site elevation, which is 6,000 feet above sea level. The surface geology of Rocky Flats consists of a thin layer of gravelly topsoil underlain by a 20-to-50-foot-thick layer of coarser, clayey gravel. Water retention in the soil is poor, and the vegetation in the area is sparse. Cacti, Spanish bayonet, and grasses, representative of a mixed short- and mid-grass plain, constitute the main ground cover. Introduced Eurasian weeds are also present in the



Adapted from Rocky Flats Plant Boundary Survey. See for more detailed descriptions of field data.

Not To Scale

Figure B-3: Legal Boundary Description, Rocky Flats Plant

flora. Cottonwood trees grow adjacent to watercourses that traverse the property.

The climate at Rocky Flats is characterized by dry, cool winters with some snow cover and warm, somewhat moister summers. There is considerable sunshine, and the average precipitation and relative humidity are low. The annual average precipitation for the site is slightly over 15 inches, water equivalent, with more than 80 percent falling between the months of April and September (U.S. Department of Energy, 1980).

The elevation of the plant and the major topographic features of the area significantly influence climate and meteorological dispersion characteristics of the site. Winds at Rocky Flats, although variable, are predominantly northwesterly, with stronger winds occurring during the winter.

B-1f Nature of Business

The Rocky Flats Plant is a government-owned and contractor-operated facility. It is part of a nationwide nuclear weapons research, development, and production complex

administered by the Albuquerque Operations Office of the U.S. Department of Energy (DOE). The prime operating contractor for the Rocky Flats Plant is the Aerospace Operations Group of Rockwell International. Rockwell has served as prime contractor for DOE since July 1975. Prior to that date, Dow Chemical Company was the prime operating contractor and served in this capacity from inception of the plant in 1951 until 1975.

The primary mission of the Rocky Flats Plant is production of metal components for nuclear weapons. The plant is involved in fabricating components from plutonium, uranium, beryllium, and stainless steel. Production activities include metal fabrication, assembly, chemical recovery and purification of recyclable transuranic radionuclides, and related quality control functions. Other activities include R&D work in metallurgy, machining, nondestructive testing, coatings, remote engineering, chemistry, and physics. Parts made at the Plant are shipped elsewhere for final assembly.

B-1g Description of Processes Involved in Generation of Wastes

B-1g(1) Solar Evaporation Ponds

The five existing solar evaporation ponds (Plate B-1) were constructed primarily to store and treat (by evaporation) low level radioactive process wastes containing high nitrates and treated acidic wastes containing aluminum hydroxide. During their use, the ponds are known to have received additional wastes such as sanitary sewage sludge, lithium metal, sodium nitrate, ferric chloride, lithium chloride, sulfuric acid, ammonium persulfates, hydrochloric acid, nitric acid, hexavalent chromium and cyanide solutions. Solvents and other organics have not been routinely discharged to the ponds; however, low concentrations may have been present as a minor constituent in other aqueous wastes.

The first solar pond, located in the northeast plant area, was a clay lined impoundment constructed in 1953. The pond had a maximum of two containments measuring 100 by 200 feet and 200 by 200 feet, respectively. This pond was operated until 1956 when its regular use was discontinued and was

NOTICE

This document (or documents) is oversized for 16mm microfilming, but is available in its entirety on the 35mm fiche card referenced below:

Document # 000283

Titled: Plate B-1: Facility Topographic Map with Major Location Details

Fiche location: A-5W-M4

removed in 1970. The pond was then replaced by the existing Pond 207C at nearly the same location.

East of the original pond, Pond 207A was constructed and placed in service in 1956. Pond 207A is approximately 230 by 505 feet with two feet of freeboard and a maximum operating depth of 7.5 feet. The pond was used to evaporate process wastes until 1986. Since then, the pond has been used to accommodate transfer of water storage from the other ponds.

Ponds 207B North, Center and South were constructed east of Pond 207A and placed in service in June 1960. Each pond is approximately 175 by 245 feet with two feet of freeboard. Ponds 207B North and Center have maximum operating depths of 6.5 feet; Pond 207B South has a maximum operating depth of 5.5 feet. The 207B ponds were used to evaporate process wastes until 1977.

In 1977, all of the 207B ponds were cleaned of sludge and relined. These ponds had held process wastes up to that time, but were renovated to hold and evaporate treated sanitary effluent, reverse osmosis backwash (brine), and intercepted ground water pumped from the interceptor

trenches (and subsequent french drain system) located on the hillside north of the solar ponds. Since the 1977 cleanout, the 207B ponds have not contained process waste.

Pond 207C, constructed and placed in service in 1970, is approximately 155 by 245 feet with two feet of freeboard and a maximum operating depth of seven feet. Pond 207C was constructed to provide additional storage capacity and to enable the transfer and storage of liquids from the other ponds.

The Solar Evaporation Ponds will be closed in accordance with the closure plan presented in Appendix I-2. Post-closure inspection, maintenance and monitoring of the Solar Evaporation Ponds will be performed for 30 years after closure.

B-1g(2) Present Landfill

The present landfill was placed in operation on August 14, 1968, after a study determined that a landfill operation would be the most efficient and economical means to dispose of the plant's nonradioactive solid waste. The landfill is

located on the western end of an unnamed tributary to North Walnut Creek (Plate B-1).

Currently, the landfill is accepting nonhazardous solid waste at a rate of approximately 115 cubic yards per work day. Hazardous constituent disposal in the landfill was eliminated in November 1986. Solid wastes will no longer be accepted at the landfill after June 1, 1989. As of July 1988, the landfill covered approximately 765,000 square feet of land. In order to reduce wind dispersion and infiltration, approximately three feet of compacted soil has been placed on top of the waste in areas where disposal is no longer occurring.

The landfill will be closed in accordance with the closure plan presented in Appendix I-3. Post-closure inspection, maintenance and monitoring of the present landfill will be performed for 30 years after closure.

B-1g(3) West Spray Field

The west spray field is located within the Rocky Flats property boundary just west of the controlled area of the Rocky Flats Plant (Plate B-I). This site was identified as

a regulated unit because materials contaminated with listed hazardous wastes were disposed at the west spray field.

The west spray field was in operation from April 1982 to October 1985. During operation, excess liquids from solar evaporation ponds 207B North and Center were pumped periodically via pipeline to the west spray field for spray application. Based on interviews and aerial photographs, direct application of the liquids occurred in portions of the spray field designated as Areas 1, 2 and 3 (see Closure Plan, Appendix I-4).

The west spray field is no longer in operation and will be closed in accordance with the closure plan presented in Appendix I-4. Post-closure care at the west spray field will be required for surface runoff and ground-water monitoring.

B-1g(4) Original Process Waste Lines

The original process waste lines (OPWL) consist of a system of tanks and associated lines within the process boundary (Plate B-1). The system was constructed to transport and

temporarily store process wastes from point of origin to on-site treatment points. The OPWL was placed in operation in 1952 and additions were made to the system through 1975. The original system was replaced over the period of 1975 to 1983 by the new process waste system. Some of the tanks from the original system have been incorporated into the new process waste system or the fire water deluge collection system.

The original system is known to have transported or stored various aqueous process wastes containing low-level radionuclides, nitrates, caustics and acids. Small quantities of other liquids were also introduced in the system including pickling liquor from foundry operations; medical decontamination fluids; miscellaneous laboratory liquids; and laundry effluent.

Fifty-seven designated pipe sections in the OPWL have a total length of approximately 35,000 feet. The lines vary from one to ten inches in diameter and are composed of cast iron, polyethylene, vitrified clay, cement asbestos, saran lined steel, stainless steel, carbon steel, fiberglass, PVC, pyrex glass and teflon. The lines are generally buried

three to five feet below the ground surface and below building floors.

Thirty-nine designated tank locations have a total of 73 tanks. The tanks vary from 250 to 200,000 gallons and are constructed of concrete or stainless steel. Approximately half of the tanks are buried underground; the other half are aboveground tanks or sumps.

Releases of process waste from the lines and tanks occasionally occurred during the long operating life of the system. Releases have occurred as a result of leakage from fittings, joints, junction boxes, and at valve vaults; from breakage or lines due to construction, settlement of buildings, or man-placed fill; from overflows at junction boxes and valve vaults; and from deterioration of the lines and tanks due to the chemistry of the process wastes.

The Original Process Waste Lines will be closed in accordance with the closure plan presented in Appendix I-5. Post-closure inspection, maintenance and monitoring of the original process waste lines will be performed for 30 years after closure.

B-2 TOPOGRAPHIC MAP [CCR 100.41 (a)(18); 40 CFR 270.14(b)(19)]

Rockwell International contracted with Scharf and Associates, Inc., Denver, Colorado to prepare topographical maps of the Rocky Flats Plant site, and continguous areas surrounding the facility. Scharf and Associates prepared two sets of topographic maps based on aerial photographs flown May 20, 1986, a single sheet map at a scale of one inch equals 500 feet with a contour interval of five feet, and a six-segment map at a scale of one inch equals 200 feet with a contour interval of two feet.

Two exhibits, Plates B-I and B-II, have been prepared based on Scharf and Associates maps to summarize the topographic map information required by 6 CCR 100.41(a) and 40 CFR 270.14(b)(19). Plate B-I is a map of the entire 6,550-acre facility and the surrounding areas at a one inch equals 500 feet scale with contour intervals equal to five feet. Plate B-I also includes the approximate locations of the hazardous waste units undergoing closure. Plate B-II is a composite map created from the six-segment, one inch equals 200 feet scale, contour interval equals two feet, map of the 384-acre internal process area and surrounding areas. This exhibit is intended to supply required information for Plate B-II

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Document # 000283

Titled: Plate B-11: Process Area Topographic Map with Waste Management Features

Fiche location: A-SW-M4

the waste management units addressed in this permit application. In addition, topographic maps at a scale of one inch equals 200 feet of the individual hazardous waste units with a 1,000-foot extension beyond the unit boundary, have been included in the closure plans.

Plate B-I, Facility Topographic Map with Major Location Details, presents the following information:

- Facility legal boundaries
- Facility access roads and access control locations
- Process area boundaries and buildings
- Surface waters
- Floodplain information
- Runon, runoff control structures
- Hazardous waste unit boundaries

Plate B-II, Process Area Topographic Map with Waste Management Features, presents the following information:

- Locations of regulated waste management units
- Storm drains and culverts
- Flood control structures
- Process waste transfer and collection system
- Access and internal roads

- Site fences and access gates
- Fire department

Additional site related information is presented in the following subsections.

B-2a Land Uses

Land use plans and zoning maps were acquired for Adams, Boulder and Jefferson counties and for the cities of Arvada, Broomfield, Golden, Westminster and Wheat Ridge. A composite land use planning map was developed from the above sources and is presented in Figure B-4.

B-2b Surface Waters, Drainage Patterns, Flood Controls

Five streams flow on or near the Rocky Flats Plant site. Of these, North Walnut Creek, South Walnut Creek and Woman Creek drain the areas surrounding the plant buildings; all of these are intermittent wet weather creeks. The other two streams in the area are Coal Creek and Rock Creek.

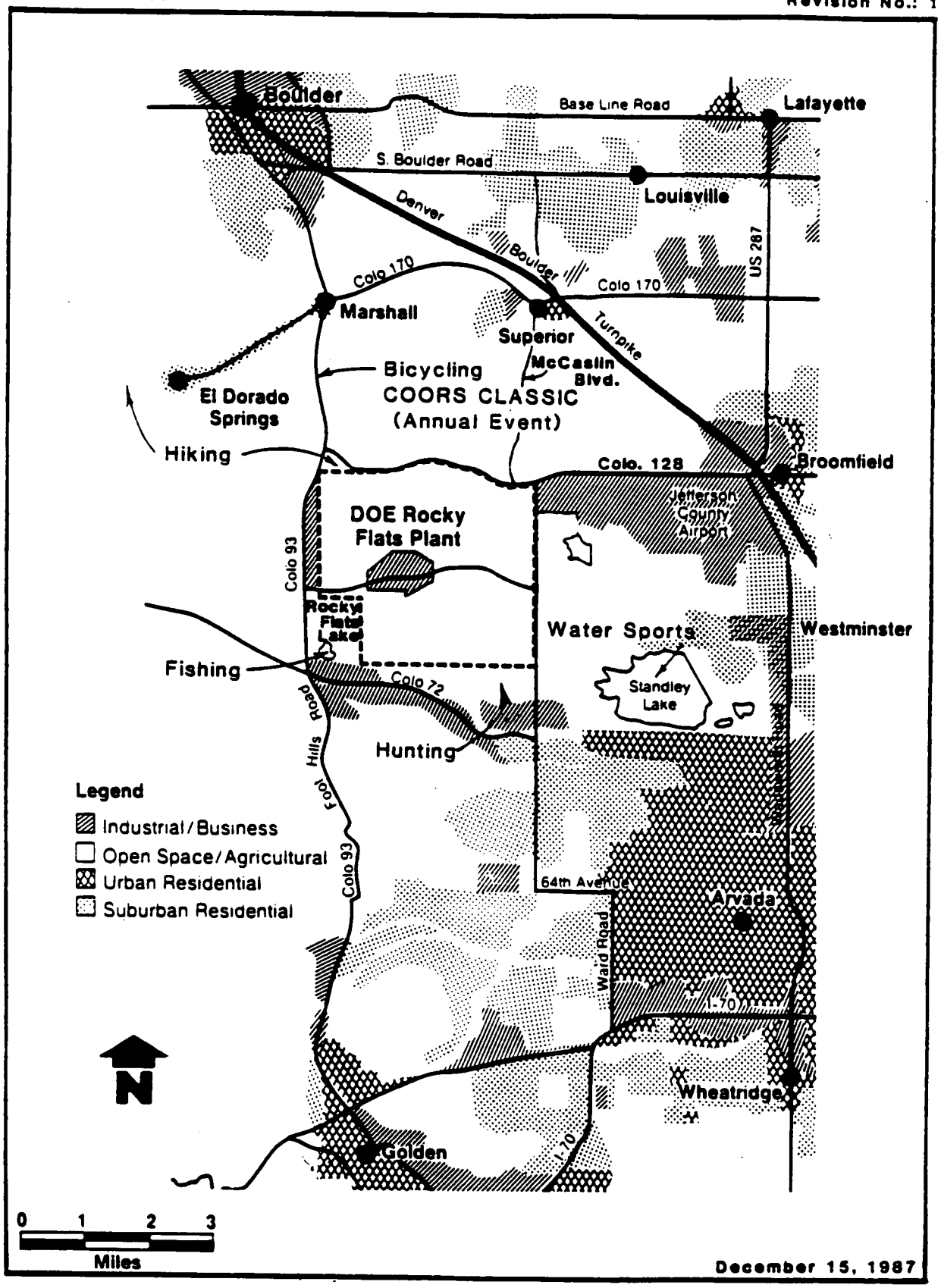


Figure B-4: Land Use Map, Rocky Flats Plant

North Walnut Creek and South Walnut Creek flow eastward into Great Western Reservoir. Great Western Reservoir is one of the two water supplies for the City of Broomfield.

Woman Creek originates west of the Plant, drains the south portion of the Plant site and flows eastward into Standley Lake. Standley Lake provides irrigation storage and a municipal water supply for the City of Westminster and portions of the cities of Northglenn and Thornton.

Coal Creek and Rock Creek drain the area north of the Plant. Coal Creek has its headwater in the Front Range and is the largest stream near the Plant. Rock Creek is a small intermittent stream which originates on the site.

The Rocky Flats site and environs drainage pattern and the location of streams are shown on Figure B-5 and Plate B-I.

Figure B-6 is a schematic diagram for the monitoring and holding ponds shown in Figure B-5 and Plates B-I and B-II, which are associated with controlling surface water discharges from the Plant site. Additionally, these ponds are integral parts of emergency spill control plans and are discussed in Sections F and G.

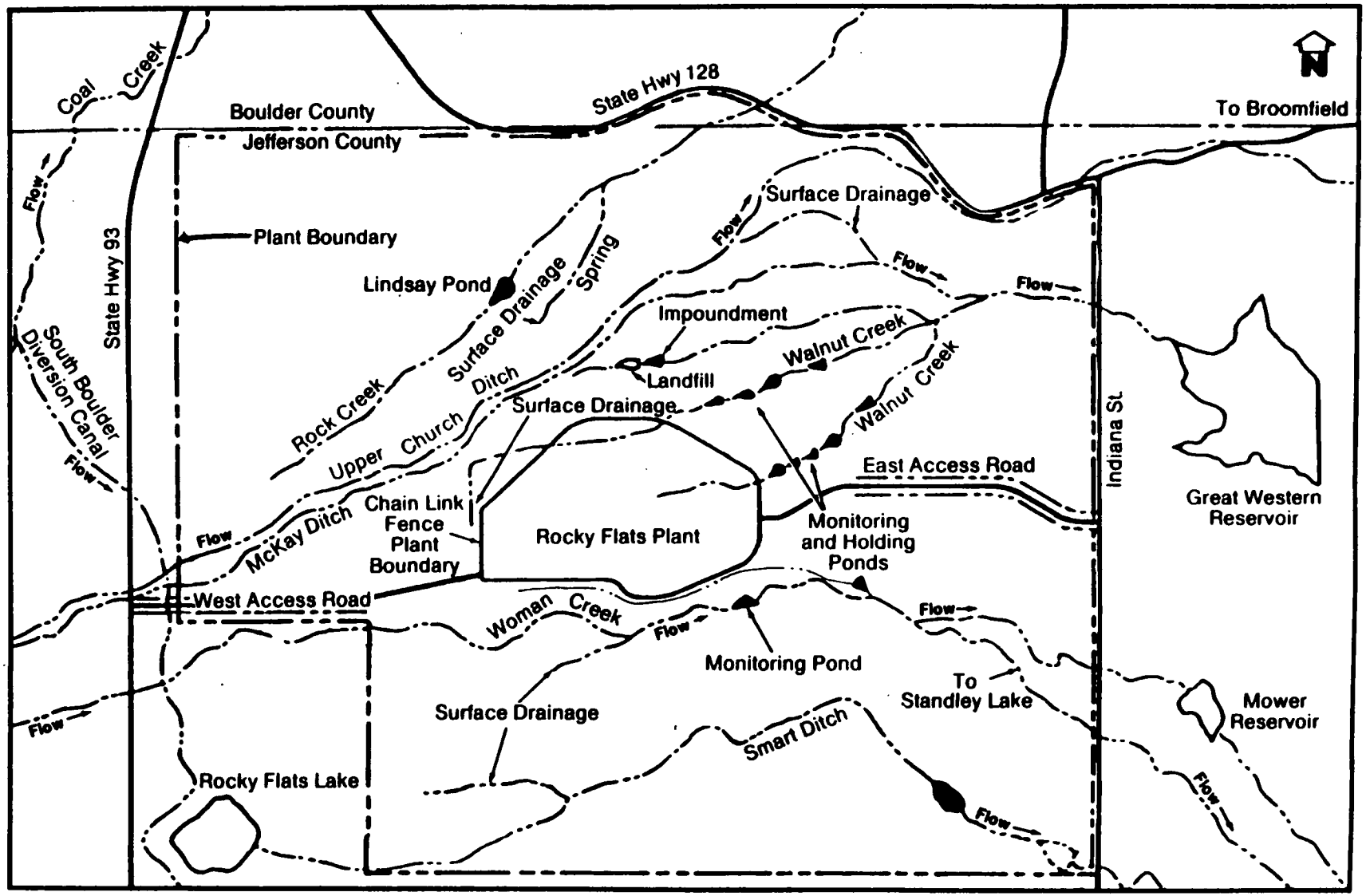


Figure B-5: Site Drainage Pattern, Rocky Flats Plant

Not To Scale

Not To Scale

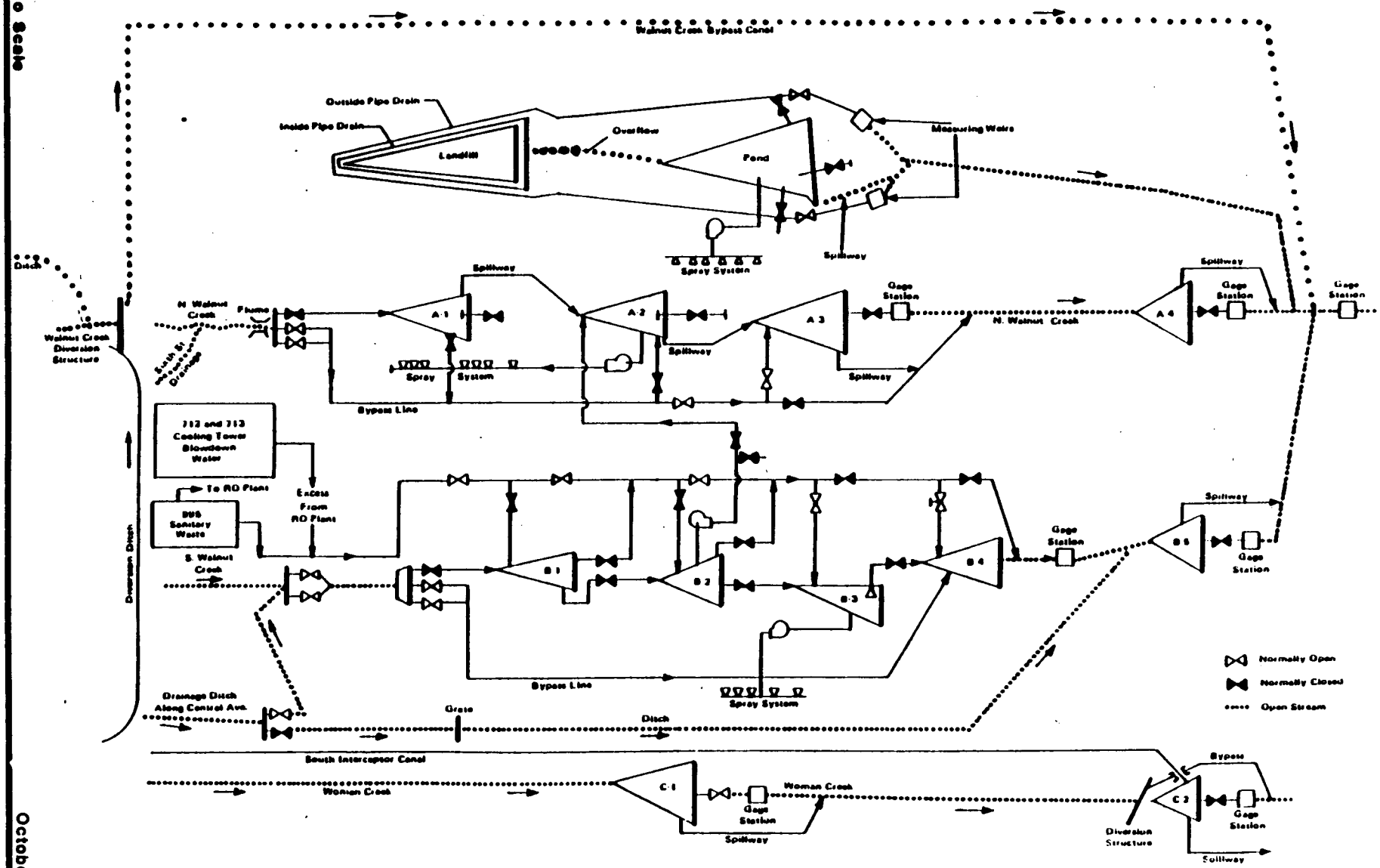


Figure B-6: Holding Pond Schematic

B-2c Floodplain

Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps were obtained for the areas surrounding the Rocky Flats site. These maps exclude the areas within the facility's boundaries from coverage. The FEMA maps do indicate a narrow 100-year floodplain for Woman Creek up to the eastern Rocky Flats boundary. This floodplain has been included on Plate B-I. The FEMA map floodplain has been extrapolated upstream into the facility and is so indicated on Plate B-I. The precipitation from a 100-year storm for the Rocky Flats Plant site is postulated to be four inches in a six-hour time period.

A review of the topographic maps of Plates B-I and B-II clearly indicates that the permitted waste management units at Rocky Flats are well above any potential 100-year flood plains in the area. The elevation for sites where permitted waste management units are located ranges from 5,975 to 6,025 feet above MSL.

Average stream channel elevations for the intermittent flow streams near these sites average 50 to 100 feet lower. In addition, the stream channels are narrow and are

characterized by steep gradients of 125 to 150 feet per mile. These factors favor very narrow floodplain conditions with minimal flood pool.

B-2d Injection and Withdrawal Wells

The site has no injection wells for waste disposal or withdrawal wells for water supply. Wells for monitoring ground-water and geohydrologic conditions at the facility are situated at various locations throughout the Plant site. Further information for the monitoring wells is provided in Section E. There are no registered injection or withdrawal wells off-site within 1,000 feet of the plant boundaries.

B-2e Access Control

The entire 6,550-acre plant site is surrounded by a three-strand barbed wire cattle fence which is posted to identify the land as a government reservation/restricted area. The production area portion of the site is surrounded by a six-foot high chain link fence, topped by two feet of three-strand barbed wire. Entrance ways into the outer fenced area and inner fenced areas are controlled 24 hours per day

by armed guards at two controlled gates (Plates B-I and B-II) on each access road. Additional information pertaining to Plant access control is provided in Section F.

B-2f Building and Structures

The locations of existing buildings or structures, paved or unpaved parking areas, fences, and railroad tracks are shown on Plates B-I and B-II.

Plant buildings are concentrated in a small area (384 acres) surrounded by a security fence. Land between that fence and the site boundaries, encompassing 6,166 acres, serves as a buffer zone between the Plant and the public. Developments in the buffer zone include firebreaks, holding ponds on three watercourses, environmental monitoring instrumentation, a sanitary landfill area, a hazardous waste storage area, a salvage yard, two office buildings, a warehouse, power lines, inactive gravel pits, clay pits, and a target range. Additionally, a former wind energy test site now used as an office building and a Ground Wave Emergency Network (GWEN) tower being installed by the U.S. Air Force are located in the buffer zone.

Two access roads, one from State Highway 93 to the west and one from County Highway 17 (Indiana Street) to the east, pass through the security fence that encircles the main area of the Plant. Within this central facility are about 136 buildings, none over three stories above the ground. Plant visibility from nearby highways varies, depending on a viewer's location. The most prominent structures are the 200-foot meteorology tower, 155-foot water tower, three building stacks measuring, 69, 98, and 151 feet in height and a security lighting system.

B-2g Storm and Sanitary Sewers and Utilities

Sanitary waste lines collect human wastes and convey them to the sanitary waste (sewage) treatment plant. Effluents from the sewage plant flow into holding ponds which are monitored on a regular basis. These discharges are regulated under the Clean Water Act under a National Pollutant Discharge Elimination System (NPDES) permit. Water for domestic use, process uses and fire-fighting is provided by the Denver Water Board.

Rocky Flats has ditches, culverts and underground pipes for collecting and controlling surface water runoff (Plate B-II). Surface water runoff from inside the security fence leaves the plant through North and South Walnut Creek and Woman Creek drainages. These waters are monitored prior to leaving the property.

B-2h Wind Rose

Wind, temperature and precipitation data are collected on the plant site and summarized annually. Table B-1 presents the 1985 annual summary of the percent frequency of wind directions (16 compass points) divided into four speed categories. The compass point designations indicate the true bearing when facing against the wind. These frequency values are represented graphically in Figure B-7. The wind rose vectors also represent the bearing against the wind (i.e., wind along each vector blows toward the center). The predominance of northwesterly winds is typical of Rocky Flats. The low frequency of winds greater than seven meters per second (15.6 mph) with easterly components is also normal.

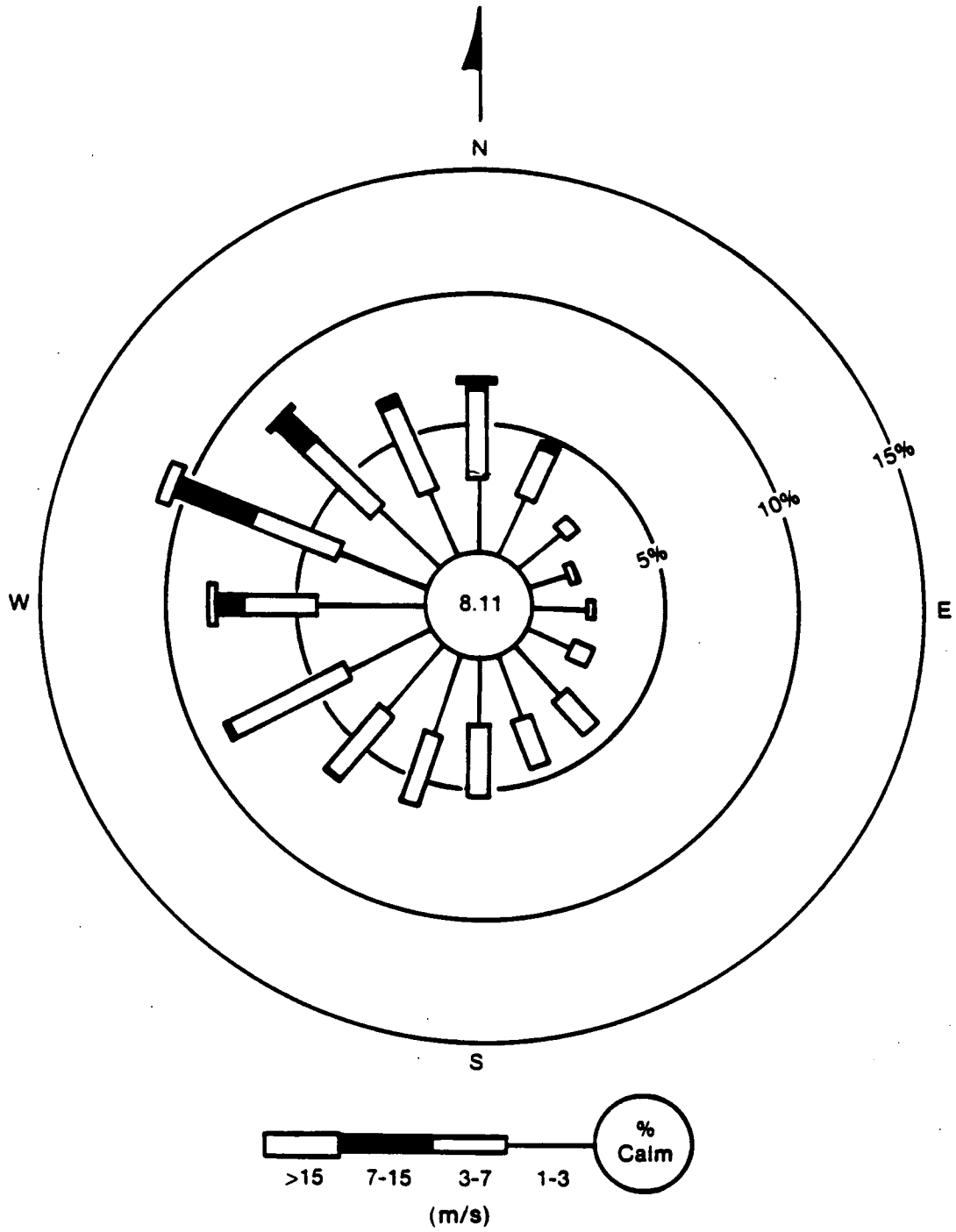


Figure B-7:
1987 Annual Wind Rose for the Rocky Flats Plant

TABLE B-1

WIND DIRECTION FREQUENCY (PERCENT),
BY FOUR WIND-SPEED CLASSES,
AT THE ROCKY FLATS PLANT

(Fifteen-Minute Averages-1987[b])

	Calm	1-3 (m/s)[c]	3-7 (m/s)	7-15 (m/s)	>15 (m/s)	TOTAL
-	8.11	-	-	-	-	8.11
N	-	2.71	3.61	0.50	0.01	6.82
NNE	-	2.55	1.97	0.19	0.00	4.72
NE	-	1.84	0.75	0.02	0.00	2.62
ENE	-	1.44	0.26	0.00	0.00	1.70
E	-	1.99	0.20	0.01	0.00	2.19
ESE	-	1.91	0.83	0.01	0.00	2.75
SE	-	2.62	1.72	0.02	0.00	4.37
SSE	-	2.49	2.02	0.13	0.00	4.64
S	-	2.52	2.63	0.19	0.00	5.34
SSW	-	3.05	3.00	0.19	0.00	6.25
SW	-	3.43	3.32	0.12	0.00	6.86
WSW	-	3.74	4.85	0.35	0.00	8.94
W	-	4.31	2.95	0.96	0.15	8.38
WNW	-	3.67	3.65	3.19	0.38	10.89
NW	-	3.17	3.77	1.41	0.01	8.37
NNW	-	2.82	3.66	0.24	0.00	6.72
TOTALS	8.11	44.26	39.20	7.54	0.56	100.00

a. May data taken from 1986 due to data recording failure in May 1987.

b. Data obtained from sensors located approximately 10 m (33 ft) above the ground.

c. For conversion purposes, miles per hour (mph) equals 2.237 multiplied by meters per second (m/s).

B-2i Fire Control Facilities

The Rocky Flats Plant maintains a completely self-contained Fire Department with permanent staff and equipment on-site. As a unit of the Plant and Security Department, the Fire Department is responsible for:

- Responding to all fire alarms and fire related emergencies.
- Performing fire prevention inspections of all buildings and areas within the Plant site for potential fire hazards.
- Ensuring the proper inspection, testing, and maintenance of fire fighting equipment at the Central Fire Station and other equipment located throughout the Plant.
- Maintaining classroom and field education and training programs in fire fighting techniques and emergency medical service and providing other specialized training.
- Providing mutual aid on an informal basis to surrounding metropolitan communities, if requested and approved through the DOE.
- Emergency medical service.
- Responding to all hazardous waste spills.

The Fire Department has a staff of 31 people, including seven firefighter/emergency medical technicians who provide 24-hour service on a platoon schedule. As additional support, volunteer employees in manufacturing buildings

comprise Building Emergency Support Teams (BEST). All members of the Fire Department and BEST teams receive ongoing training in fire fighting techniques and response to hazardous and radioactive mixed waste material spills. Members are also trained in first aid procedures and as Emergency Medical Technicians (EMT) for health and safety purposes related to possible accidents. The location of the Rocky Flats Fire Department is shown on Plate B-II.

The Fire Department equipment currently consists of:

- Two pumper trucks
- Two fully equipped ambulances
- One fully equipped rescue vehicle/"brush" truck
- One fully equipped hazardous materials response van
- Four general purpose vehicles
- Survive Air brand self-contained breathing apparatus
- Assortment of organic vapor and acid gas respirators
- Tyvek suits
- Gloves
- PVC hip boots
- Six fully encapsulating suits including two butyl, two chlorinated polyethylene, and two PVC suits

Note: All equipment is stored in the Fire Department when not in use.

Plant buildings are protected with various types of fire detection and suppression systems. All major buildings are protected by automatic sprinkler systems.

The Fire Department is also capable of responding to hazardous material spills and incidents with a trained and well-equipped Environmental Incident Response Team (EIRT). All EIRT members are receiving approximately 104 hours of Haz-Mat training from the Colorado Safety Institute. Each member will be trained to Haz-Mat Level I as outlined by the National Fire Protection Agency (NFPA) and National Fire Academy (meets OSHA requirements). In addition, 24 hours per year of continuing education will be offered to each member.

In the event of a small or large scale hazardous material incident, EIRT shall provide: product identification, product containment, scene stabilization, and personnel decontamination. After initial determination of what level of team response will be needed, activation will be initiated by the Fire Department through the Shift

Superintendent. Additional support can be obtained from the Industrial Hygiene, Industrial Safety, Environmental Management, Waste Operations and Plant Services Organizations.

Response to the scene shall be made by way of a dedicated response vehicle which will be housed in the Fire Station. The Haz-Mat van will carry a multitude of support equipment (See Table B-2 for a partial list). In addition, large equipment and materials are located in the Haz-Mat cargo containers south of Building 335.

Additional information regarding the plant Fire Department capabilities is presented in Sections F and G.

B-2j Water Supplier

Raw water is purchased from the Denver Water Board and is drawn from the Ralston Reservoir and the South Boulder Diversion Canal. This raw water is treated at an on-site potable water treatment plant. The Rocky Flats Plant used approximately 120 million gallons of water during 1987.

TABLE B-2

PARTIAL HAZ-MAT RESPONSE EQUIPMENT AND SUPPLIES

PERSONNEL PROTECTION	- Gloves (Nitrile, PVS, Butyl, etc.) - Splash suits - Disposable acid suits - 8 encapsulated suits - Head set communications radios - Personal safety alert system - SCBA
HAZ-MAT EVALUATION EQUIPMENT	- All plant MSDS - Haz-Mat library - Binoculars - Weather station - pH meters - Dragger tubes (samplers) - Sample containers
PLUG AND PATCH EQUIPMENT	- Type A capping kit - Type B capping kit - Assorted wood and rubber plugs - Plug and patch - Oil dry - Oil and Haz-Zorb pillow - Oil absorbent boom - Sparking and non-sparking tools - Grounding cables - Sump pumps

B-2k Electric and Gas Utilities

All of the Plant's heating requirements are met by in-plant steam boilers that normally use natural gas and are capable of using low-sulfur fuel oil. During calendar year 1987, approximately 574 million cubic feet of natural gas were used. Approximately 1,300,000 gallons of fuel oil were used during 1987.

B-3 LOCATION INFORMATION [CCR 100.41(a)(11); 40 CFR 260.14(b)(11)]

The Rocky Flats Plant site is located primarily in Jefferson County, Colorado. The north border of the plant is defined by the county line between Boulder County and Jefferson County. There is one small portion of a few acres that extends into Boulder County. This area is north of the plant proper and is an unoccupied open space within the buffer zone.

B-3a Seismic Considerations

B-3a(1) Tectonic History

The Rocky Flats Plant site is located about four miles east of the Front Range Foothills in the Colorado Piedmont Section of the High Plains. The predominant geologic structure in this area is the Front Range Monocline which forms the western limb of the Denver Structural Basin. North trending hogback ridges along the west side of the Monocline are formed by steeply dipping to overturned sedimentary beds. These sedimentary beds are flanked on the west by the Precambrian crystalline terrain of the Front Range Uplift and on the east by the gently dipping sedimentary beds of the Denver Structural Basin. The Golden Fault, a large reverse fault, cuts the Front Range Monocline about two miles southwest of the Rocky Flats Plant site. The fault extends about 17 miles to the south. The stratigraphic throw on the Golden Fault is reported to be about 9,000 feet (Dames and Moore, 1981).

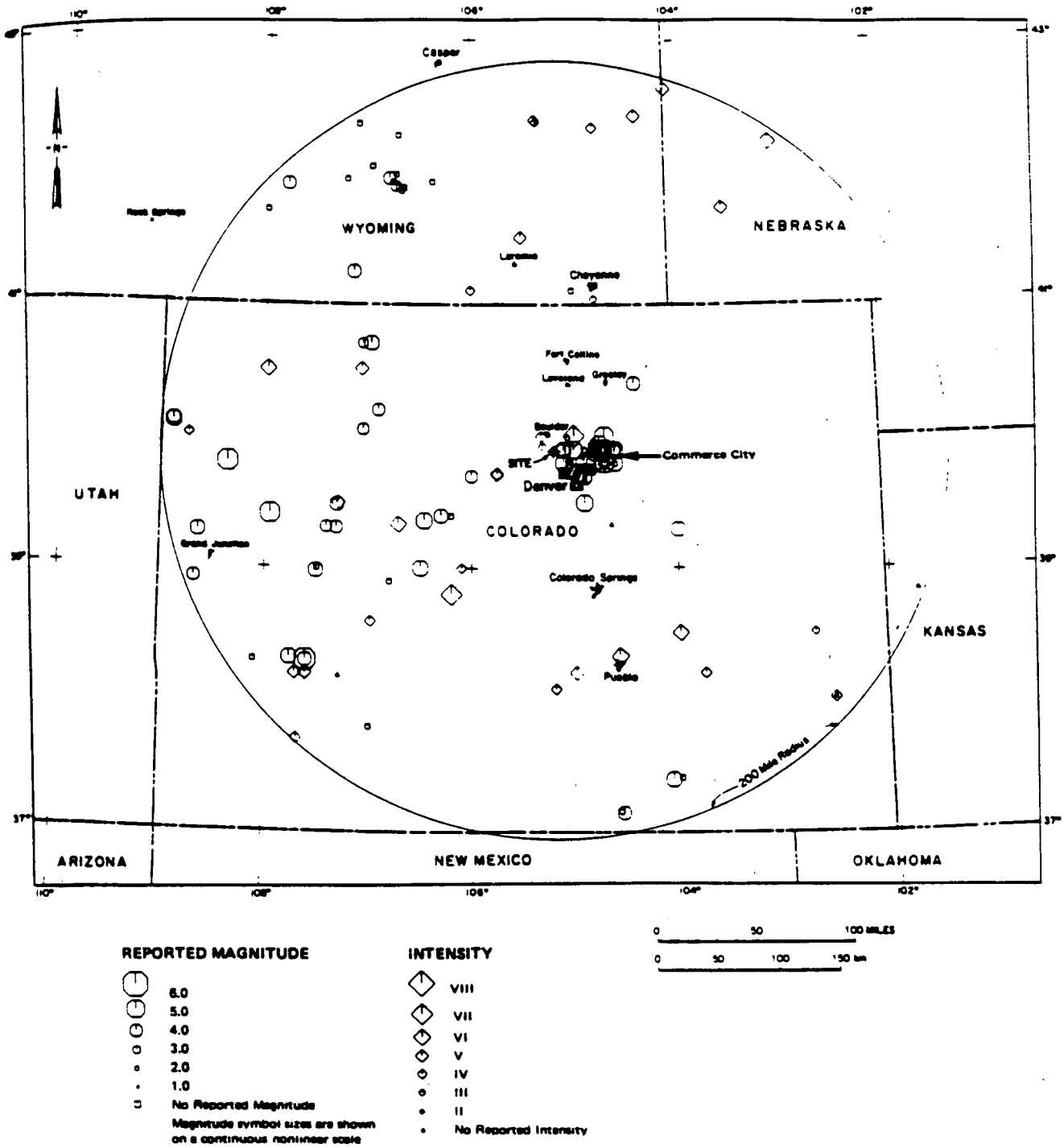
The majority of the displacement on the Golden Fault, the uplift of the Front Range and subsidence of the Denver Basin occurred during the late Cretaceous to early Eocene

Laramide Orogeny about 40 to 70 million years ago (Martin, 1965). Erosion during the Laramide Orogeny is believed to have kept pace with uplift and the Front Range probably never stood very high above the Denver Basin during the Orogeny. By the late Eocene an erosional surface of low relief covered much of the Rocky Mountain Region.

The present rugged topography to the west of the Rocky Flats Plant site is the result of Post-Laramide tectonics and erosion. About 5,000 to 10,000 feet of uplift has taken place in the Rocky Mountain Region since the early Miocene about 25 million years ago. Late Tertiary block faulting is believed to have accompanied the regional uplift as indicated by apparent displacements of the late Eocene erosional surface (Scott, 1975 and Epis, 1975). There is some evidence that block faulting has continued into the Quaternary (Scott, 1970; Whitkind, 1976; and Kirkham, 1981).

B-3a(2) Historic Seismicity

Historically, seismicity in Colorado has been relatively low. Figure B-8 shows the epicenters of historical earthquakes that have occurred within 200 miles of the Rocky Flats Plant. The first reported earthquake occurred



FROM U.S. DOE FINAL ENVIRONMENTAL IMPACT STATEMENT, 1980

Figure B-8: Epicenter Plot of Historical Seismicity Within 200 miles of the Rocky Flats Plant Site

in 1870. Of the earthquakes recorded during this historical period, only three with Modified Mercalli intensities greater than VI have occurred within 200 miles of the Plant site. These larger earthquakes were reported on November 8, 1882, November 15, 1901, and August 9, 1967.

A great deal of speculation has been centered about the location and size of the November 8, 1882, earthquake. Hadsell (1968) assigned an intensity of VI to VII to the 1882 earthquake and placed the epicenter north of Denver about 13 miles northeast of the Rocky Flats Plant site. Earlier studies reported the epicenter near Vail Pass about 100 miles west of the Rocky Flats Plant site. Reexamination of available historic data, by Dames and Moore (1981), which relied primarily on newspaper accounts, was done in an attempt to better understand the 1882 earthquake. The Dames and Moore Study suggests a tentative epicenter in northwestern Colorado about 170 miles northwest of the Rocky Flats Plant site. Dames and Moore assigned a local magnitude range of 6.0 to 7.0 which would correspond to an epicentral intensity of about VII-VIII. The 1882 earthquake caused intensity VI-VII ground shaking in the Denver area which is similar to the ground shaking caused by the August 9, 1967 Derby earthquake discussed below.

On November 15, 1901, a strong earthquake was reported near Buena Vista, Colorado. This earthquake was located about 90 miles southwest of the Rocky Flats Plant site and had an epicentral intensity of VI-VII.

From April 1962 through June 1972, over 1,800 earthquakes occurred in the Derby area about 30 miles east of the Rocky Flats Plant site. The Derby earthquakes were near a deep waste disposal well at the Rocky Mountain Arsenal. The earthquake activities started soon after initiation of pumping of wastes into the disposal well. Subsequent investigations of the Derby earthquake sequence supports the hypothesis that the earthquakes resulted from the release of natural tectonic stresses by increases in hydrostatic fluid pressures as a result of pumping wastes into the disposal well (Healy, 1966; Major, 1968; and Hsieh, 1981). The largest Derby earthquakes, with magnitudes greater than 5.0, occurred about one and one-half years after the pumping stopped in February 1966. After 1967, the number of Derby earthquakes has declined and the present indication is that the swarm of activity that occurred between 1962 and 1967 has virtually disappeared (Hsieh, 1981). The largest earthquake in the Derby swarm had a local magnitude of 5.3 and occurred on August 9, 1967. The epicenter of this

earthquake was located about 26 miles east of the Rocky Flats Plant site. This earthquake resulted in intensity VI-VII ground shaking in the epicentral region and intensity VI ground shaking occurred at the Rocky Flats Plant site.

B-3a(3) Quaternary Faulting

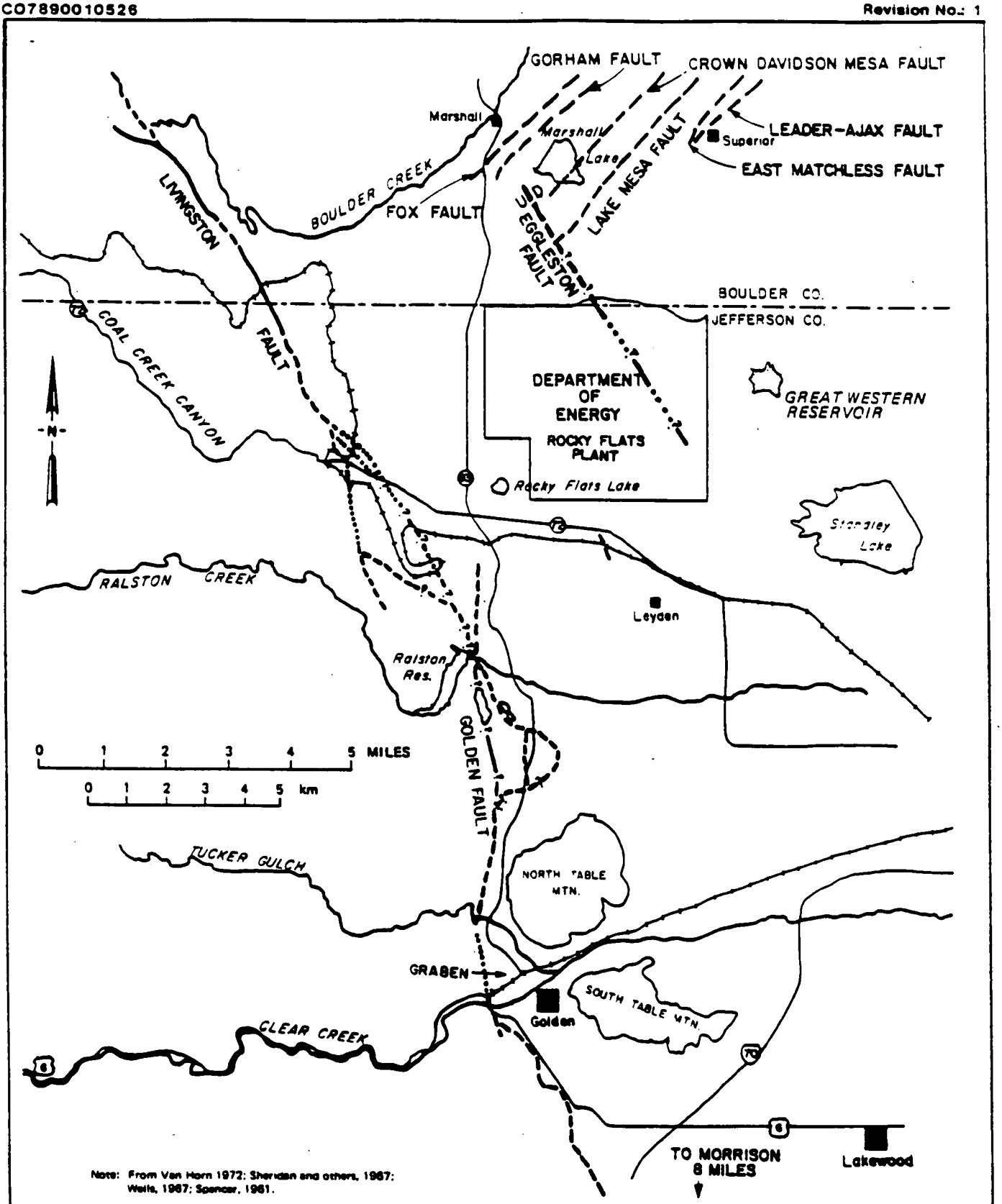
In 1981, extensive studies were done to evaluate the Quaternary history of the Golden Fault and other faults at the Rocky Flats Plant site and vicinity (Dames and Moore, 1981).

The Golden Fault studies did not produce any compelling evidence of tectonic activity along the Golden Fault within the past 500,000 years and the fault does not have surficial expressions characteristic of geologically young fault zones. Some of the exploratory trenches encountered anomalous "tongues" of bedrock extending into the overlying alluvium along the fault zone. The mechanisms responsible for the bedrock "tongues" has not been clearly established. Both tectonic and nontectonic processes have been proposed; however, regardless of their origin, the bedrock "tongues" certainly appear to have been produced by processes

associated with very slow rates of deformation (Dames and Moore, 1981).

A graben structure is located north of Golden and about 800 feet to the east of the Golden Fault. The Colorado Geological Survey studied the graben in 1976 and concluded that the graben is part of the Golden Fault structural zone and is characterized by at least two episodes of fault movement since the Yarmouth or within the last 600,000 years (Kirkham, 1981). Dames and Moore (1981) performed extensive studies of the graben but were unable to develop sufficient evidence to conclusively determine if the graben is the result of tectonic or nontectonic processes. Based on the overall studies of the Golden Fault, it is unlikely that the graben is tectonically or structurally related to the Golden Fault and it is believed the graben was more likely formed in response to nontectonic processes.

The northwest trending Eggleston fault, mapped by Spencer (1961), is located approximately three miles north-northwest of the Rocky Flats Plant site. The fault was later given a different orientation by Hurr (1976). Hurr believed the fault trended more to the northwest and passed 1/2 mile east of the Plant site (Figure B-9). This was based on 1975 and



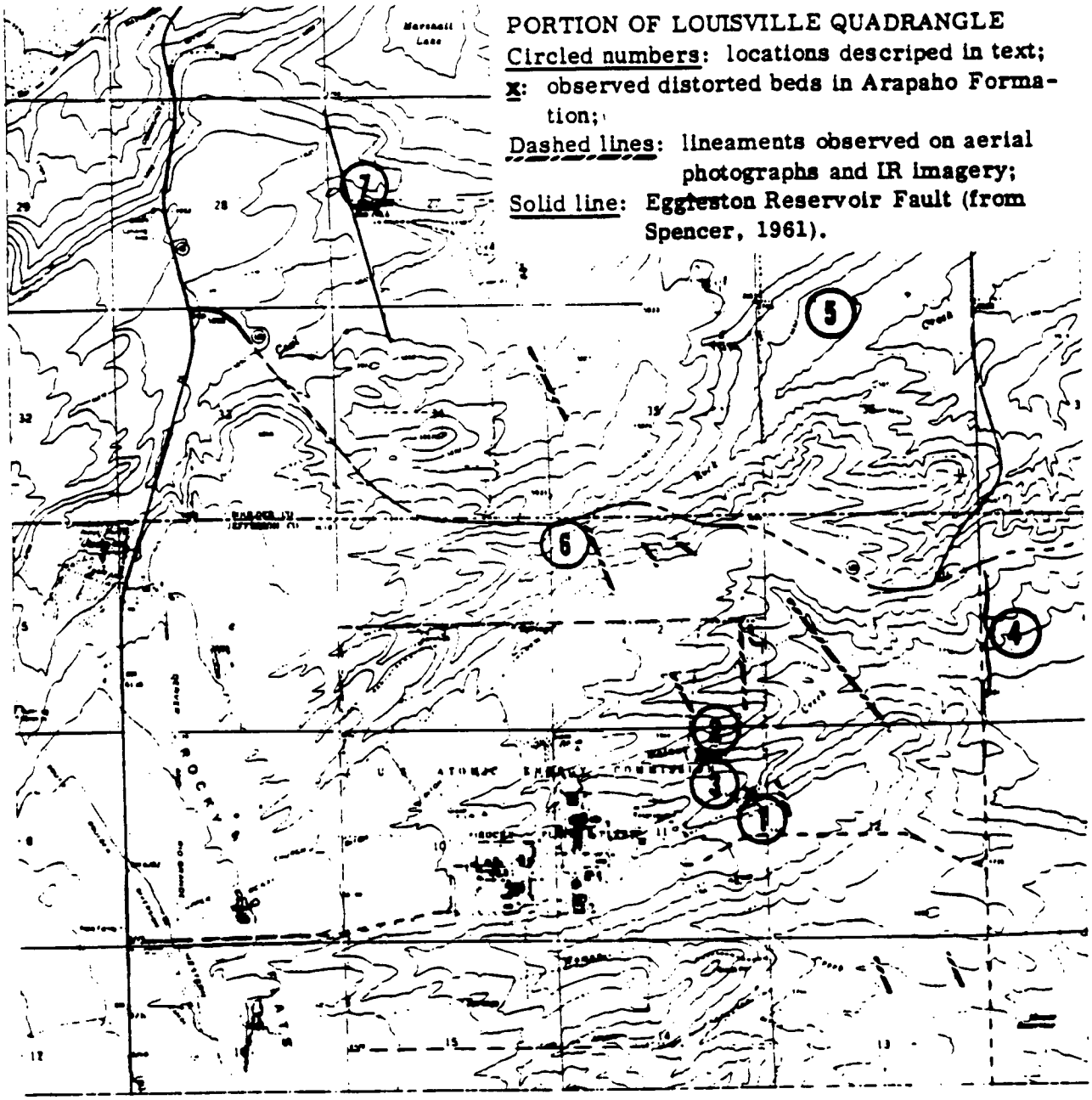
Modified from U.S. Department of Energy, Final Environmental Impact Statement, 1980

Figure B-9: Location of Faults Between Golden and Marshall, Colorado

1976 field investigations by Hurr when three features, suggestive of possible fault control, aligning in a northwesterly direction with the Eggleston fault were identified. These features are No. 1, 2 and 6 (Figure B-10). Further studies of these features (Dames and Moore, 1981) concluded that Features 1, 2 and 6 are not fault related as discussed below. Hurr (1985) concurred with the findings of the Dames and Moore investigation.

Feature No. 1, located south of holding ponds B-3 and B-4, shows displacement of bedrock units in a deeply eroded drainage channel on South Walnut Creek. The Dames and Moore 1980 investigation showed no evidence of lateral continuation of the displacement. Excavation studies in 1980 revealed bedrock displacements, but a noted downward decrease in dip of the fault plane suggested a possible landslide origin.

Feature No. 2 is located north of holding pond A-2 on the main fork of Walnut Creek. Hurr noted an apparent vertical separation in sandstone beds was suggestive of faulting. The Dames and Moore 1980 investigation found no evidence of displacement and concluded that faulted blocks do not exist.



FROM U.S. DOE FINAL ENVIRONMENTAL IMPACT STATEMENT, 1980

Modified from U.S. Department of Energy, Final Environmental Impact Statement, Appendix C-1, 1980

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Figure B-10: Potential Fault Features Near Rocky Flats

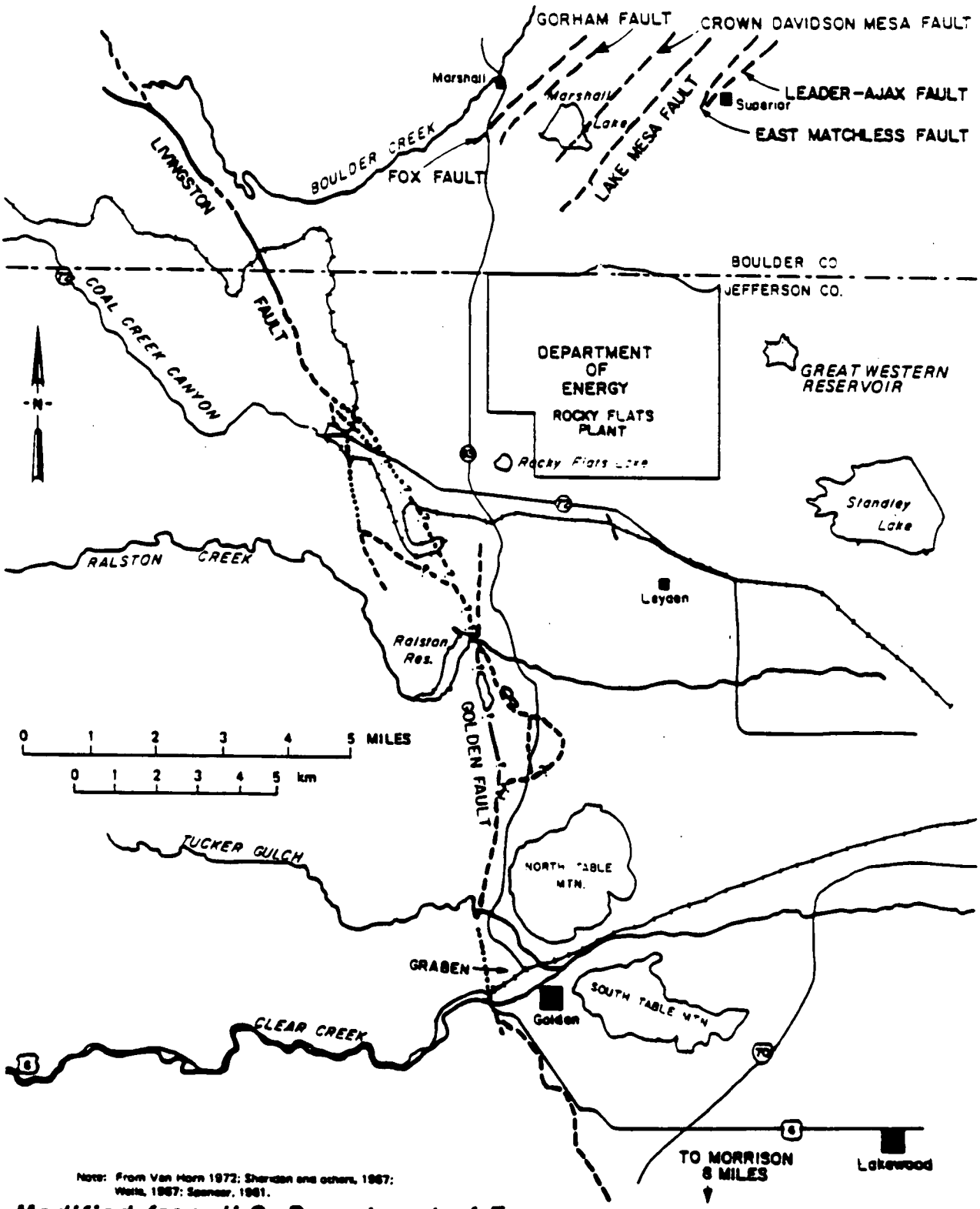
Not To Scale

December 15, 1987

Feature No. 6 was not investigated by Dames and Moore (1981) because Feature Nos. 1 and 2 were shown not to be an extension of the Eggleston Fault. Feature No. 6 was described as an apparent offset of spring lines on the north-facing slope of Rock Creek Valley.

The area around Eggleston Reservoir (Feature 7 on Figure B-10) was investigated in 1980 to determine if a fault existed in the vicinity of the reservoir. The results of mapping, trenching and auger boring did not reveal any displacements or disturbances in the area. Therefore, this study concluded the Eggleston fault does not exist (Figure B-11) as earlier believed.

A photo lineament study in 1981 found only one lineament suggestive of having possible fault control. Field investigations revealed this feature as erosional in origin, not fault related. A previous aerial photography study by EG & G in 1980 showed an east-west trending linear feature just north of pond A-2 (Feature 3 in Figure B-10). Investigation of the area by EG & G concluded the linear feature was probably the result of changes in ground moisture and vegetation in the area.



Note: From Van Horn 1972; Sheridan and others, 1967; Weiss, 1967; Spencer, 1981.

Modified from U.S. Department of Energy, Final Environmental Impact Statement, 1980

Figure B-11: Location of Faults Between Golden and Marshall, Colorado. Excluding Eggleston Fault

Geomorphic features suggestive of possible fault control that Dames and Moore (1981) investigated were:

- A bedrock step near Rocky Flats Lake located 1.3 miles southwest of the Plant site. It was found that relief on the bedrock surface was erosional and not related to shear zone faulting.
- Denver and Rio Grande Railroad cut south of the Plant was found to be an old infilled channel and not a north-northwest trending fault.
- Tilted bedrock overlain by quaternary gravels at McCaslin Boulevard, north of the Plant, is the result of gravity faulting along a landslide slip plane.

None of the features discussed in this subsection are considered to present a seismic hazard to the Rocky Flats Plant.

B-3b <u>Floodplain Standard</u>

Documentation, including the source, has been provided in subsection B-2c, indicating that no hazardous waste management facilities are located within a 100-year floodplain. As stated in B-2c, the precipitation from a 100-year storm is postulated to be four inches in a six-hour time period.

B-4 TRAFFIC INFORMATION [CCR 100.41(a)(10); 40 CFR 270.14(b)(10)]

Transportation of hazardous waste during post-closure care is not anticipated. If transportation of hazardous waste should become necessary, a detailed description of traffic conditions can be found in both of the RCRA Part B Permit Applications.

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SECTION C

WASTE CHARACTERISTICS

C-1 INTRODUCTION

This permit has been prepared to cover post-closure activities anticipated to occur after closure of the individual hazardous waste units. Section C-2 discusses the wastes that may occur during the post-closure care period. The waste analysis plans, Section C-3, contains information on the parameters chosen for analysis, rationale for their selection, and the sampling frequency for the individual hazardous waste units in Section C-3a. The test methods are discussed in Section C-3b(1). Quality Control and Quality Assurance for the entire program are described in Section C-3b(2). Sampling methods are presented in Section C-3c.

A description of the procedures used to determine the existence and concentration of 40 CFR 261, Appendix IX constituents in any ground-water contamination plume is contained in Section E, Ground-Water Monitoring and Protection. The analytical procedures for these analyses are presented in this section.

C-2 CHEMICAL AND PHYSICAL ANALYSES [40 CFR 270.14(b)(2); CCR 100.41(a)(2)]

C-2a Solar Evaporation Ponds

Construction of ITW storage tanks will be necessary to achieve closure of the solar ponds, replacing the ponds for surge storage. Prior to the construction of the tanks and in accordance with CCR Regulations 100.41, 264.13(a), and 100.22(d) and 40 CFR 270.14(b)(2), 264,13(a), and 2670.62(b)(2)(i), the following information will be provided:

- General description of the waste
- Hazardous characteristics
- Basis for hazard designation
- Laboratory report on analysis results
- Existing published or documented data on hazardous waste from similar process

In accordance with CCR 264.191(a) and 40 CFR 264.191(a), the tank analyses will include:

- Specific gravity
- Waste specific parameters based on hazardous designation
- Other information required for safe operation

This information will be located in Appendix C-1.

C-2b Present Landfill

The landfill is unlined and, therefore, the compatibility of liner and mobility of hazardous constituents through the liner is not applicable. The existing leachate system at the present landfill is buried under the waste. It does not collect leachate and has been abandoned. In its place a ground-water collection system has been proposed for closure. In addition, diversion drainage ditches will be installed in order to divert runon/runoff away from the landfill and, thereby, minimize infiltration. A passive gas collection system will be installed in the cap during closure to provide venting of gas generated during aerobic decomposition.

Based on the recent sampling and analysis, the quality of water collected by the ground-water interception systems will not require treatment prior to discharge into the east pond. However, closure activities for the landfill will result in reduction of ground-water levels within the landfill area. Changes in ground-water conditions within the landfill may result in variations in water quality. Water collected by the systems will be analyzed on a quarterly basis at the discharge point and in the east pond,

and appropriate management methods instituted if contamination is found (see Proposed Treatment System).

Runon/Runoff Control Systems

An impermeable cap will be placed on the present landfill area during closure to minimize precipitation infiltration and thereby reduce recharge to the landfill. In addition, regrading of the ground surface adjacent to the landfill will be conducted as part of closure to reduce impacts of surface runon on the final cover. Diversion ditches will be designed to divert the peak storm runoff from the one-hour, 100-year storm event in each drainage. A six-inch compacted clay layer will be placed in the bottom of the diversion ditches for erosion control from the design storm. Contaminated runon/runoff will, therefore, be eliminated. Runoff analyses will be conducted after major storm events on a quarterly basis to verify that upgraded runoff management is not needed.

As a precaution against future generation of landfill gases and to reduce the potential for vegetative cover stress due to concentrated leakage of gases through the cap's membrane, a passive gas collection and venting system will be installed on the landfill.

A soil-gas survey conducted at the landfill (Appendix I-3) indicated little or no methane and hydrogen sulfide generation from the landfill. However, readings from the portable gas chromatograph utilized in the survey did indicate the presence of other volatile compounds. After closure of the landfill, the landfill gas analysis will include methane, hydrogen sulfide and the HSL VOA list as defined in Section C-3.

Proposed Treatment System

HSL volatile organics, semi-volatiles, and pesticide/PCBs were not detected in landfill pond samples taken in 1986 and 1987 (Appendix I-3). 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. Total dissolved solids (TDS) also exceeded the surface water quality criterion. Elevated TDS, iron and manganese are typical of landfill leachate. Should variations in the water quality upon completion of closure be sufficient to require treatment of the ground water, a treatment system will be constructed. After approval by CDH and EPA of design documents, and prior to the construction of the treatment facility and in accordance with CCR Regulations 100.41, 264.13(a), and

100.22(d) and 40 CFR 270.14(b)(2), 264.13(a), and 270.62(b)(2)(i), the following information will be provided:

- General description of the waste
- Hazardous characteristics
- Basis for hazard designation
- Laboratory report on analysis results
- Existing published or documented data on hazardous waste from a similar process

This information will be located in Appendix C-2.

C-2c <u>West Spray Field</u>

The west spray field may be closed with contaminated soil remaining in place. Should this be the case, a drainage diversion system will then be installed to control runon/ runoff at the site. In accordance with 40 CFR 265.280(a), owners or operators of land treatment facilities must address the following objectives regarding waste containment and indicate how they will be achieved.

- Controlling migration of hazardous waste and hazardous waste constituents from the treated area into the ground water.
- Controlling the release of contaminated run-off from the facility into surface water.
- Controlling the release of airborne particulate contaminants caused by wind erosion.

These objectives will be met by the closure plan for the West Spray Field (Appendix I-4) and by any post-closure care activities required.

C-2d Original Process Waste Lines

The tanks associated with the original process waste lines will have undergone closure in accordance with the Closure Plan located in Appendix I-5. The tanks will be closed with no wastes remaining. Post-closure care will entail ground-water sampling and monitoring as outlined in Section E.

C-3 WASTE ANALYSIS PLAN [40 CFR 270.14(b)(3); CCR 100.41(a)(3)]

The HRMW RCRA Part B Permit Application contains the Rocky Flats Generator Sampling and Analysis Plan (GSAP). The plan was developed to provide adequate waste analysis information needed to treat, store, or dispose of wastes in a manner which will not threaten human health or the environment, 6 CCR 264.13(b), 40 CFR 264.13(b). This waste analysis plan has been adapted from Rocky Flats GSAP and uses the initial waste characterization information as a basis for the ongoing sampling and analysis program, 6 CCR 262.11, 40 CFR

262.11. This plan, in its most current form, will be utilized during post-closure care for sampling and analysis. The generated information will then be recorded in the records for each unit requiring post-closure care. The plan has been designed to be flexible, in that, as results are added to the information base, the sampling schedule and analytes assignments can be amended, as discussed in 6 CCR 260.20 and 40 CFR 260.20. The plan will identify each hazardous waste stream, sampling method, the analytes requested, and sampling frequency.

One or more of the following analytes are required for each waste stream:

EP Toxicity	6 CCR 261.24, 40 CFR 261.24
Reactivity	6 CCR 261.23, 40 CFR 261.23
Corrosivity	6 CCR 261.22, 40 CFR 261.22
Ignitability (including oxidizer testing)	6 CCR 261.21, 40 CFR 261.21 40 CFR 173.151
HSL Volatile Organic Compounds (Table C-1)	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)
Semi-Volatile HSL Organic Compounds (Table C-2)	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)
Inorganic Compound List (Table C-3)	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)
Specific Conductivity	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)

TABLE C-1

CONTRACT LAB PROGRAMS (CLP)
VOLATILE ORGANIC COMPOUND
HAZARDOUS SUBSTANCE LIST (HSL)

Chloromethane
Bromomethane
Vinyl Chloride
Chloroethane
Methylene Chloride
Acetone
Carbon Disulfide
1,1-Dichloroethene
1,1-Dichloroethane
Trans-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-1,3-Dichloropropene
Trichloroethene
Dibromochloromethane
1,1,2-Trichloroethane
Benzene
Cis-1,3-Dichloropropene
2-Chloroethyl Vinyl Ether
Bromoform
4-Methyl-2-pentanone
2-Hexanone
Tetrachloroethene
Toluene
Chlorobenzene
Ethyl Benzene
Styrene
Total Xylenes

TABLE C-2

CLP SEMI-VOLATILE HSL ORGANIC COMPOUNDS

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-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic acid
bis(2-Chloroethoxy)methane
2,4-Dichlorophenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
N-Nitrosodiphenylamine
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol
Phenanthrene
Anthracene
Di-n-butylphthalate
Fluoranthene
Pyrene
Butylbenzylphthalate
Hexachlorobutadiene
4-Chloro-3-methylphenol
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
Diethylphthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline
4,6-Dinitro-2-methylphenol
3,3'-Dichlorobenzidine
Benzo(a)anthracene
bis(2-Ethylhexyl)phthalate
Chrysene
Di-n-octylphthalate
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-cd)pyrene
Dibenz(a,h)anthracene
Benzo(g,h,i)perylene

TABLE C-3

CLP INORGANIC COMPOUND LIST

Element	Symbol
Aluminum	Al
Antimony	Sb
Arsenic	As
Barium	Ba
Beryllium	Be
Cadmium	Cd
Calcium	Ca
Chromium	Cr
Cobalt	Co
Copper	Cu
Iron	Fe
Lead	Pb
Magnesium	Mg
Manganese	Mn
Mercury	Hg
Nickel	Ni
Potassium	K
Selenium	Se
Silver	Ag
Sodium	Na
Thallium	Tl
Tin	Sn
Vanadium	V
Zinc	Zn

Total Dissolved Solids	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)
Nitrates	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)
Radionuclides (Table C-4)	6 CCR 264.13(a)(1), 40 CFR 264.13(a)(1)

TABLE C-4

RADIONUCLIDES PARAMETER LIST

Gross Alpha
Gross Beta
Plutonium 239
Americium 241
Uranium 233
Uranium 234
Uranium 235
Uranium 238
Strontium 90
Tritium

The selection of specific analytes required for each unit is discussed in Section C-3b. With this characterization information, proper treatment or storage methods can be identified.

C-3a Parameters, Rationale, and Frequency

C-3a(1) Solar Evaporation Ponds

Contaminated ground water is currently being collected and analyzed from the interceptor trench pump house (ITPH) located at the base of the french drain. The ITPH and the surrounding monitoring wells will continue to be sampled on a quarterly basis during the post-closure care period. The objectives of the sampling are to evaluate the effectiveness of the ground-water interceptor program, to determine if additional closure activities are necessary, and to determine whether the alluvial water is still affected by the solar evaporation ponds. Table C-5 contains the list of parameters the ground-water samples will be analyzed for during post-closure care. Those parameters that are not found in the samples will be eliminated from analysis after the first year.

C-3a(2) Present Landfill

Water Treatment

Based on recent sampling and analysis (Appendix I-3), the quality of water collected by the ground-water interception

TABLE C-5

GROUND-WATER SAMPLING PARAMETERS

Field Parameters

pH
Specific Conductance
Temperature

Indicators

Total Dissolved Solids

Metals*

Hazardous Substances List - Metals

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

Molybdenum
Strontium
Chromium (hexavalent)
Lithium

Anions

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate

TABLE C-5

GROUND-WATER SAMPLING PARAMETERS

Organics

Hazardous Substances List - Volatiles (Table C-1)
Hazardous Substances List - Semi-Volatiles (Table C-2)
Oil and Grease

Radionuclides

Gross Alpha
Gross Beta
Uranium 233, 234, 235, and 238
Americium 241
Plutonium 239
Tritium

* Total and dissolved metals for ground-water samples.

systems would not require treatment prior to discharge into the east pond. However, closure activities for the landfill will result in reduction of ground-water levels within the landfill area. Changes in ground-water conditions within the landfill may result in variations in water quality. The surrounding ground-water monitoring wells in addition to the water collected by the systems will be analyzed on quarterly basis at the discharge point and in the east pond. Table C-6 contains the list of parameters the ground water and surface water samples will be analyzed for during post-closure care. Those parameters that are not found in the samples will be eliminated from analysis after the first year. If variations in the water quality upon completion of closure are sufficient to require treatment of the east pond waters, a treatment system will be constructed to handle contaminated waters at the plant site.

In addition to the quarterly sampling, flow measurements from the discharge point to the east pond will be taken and the surface elevation of the east pond will be measured. The surface elevation of the east pond will also be measured after major storm events to check for potential overflow. The objectives of the sampling and monitoring are to characterize the site hydrology, evaluate the effectiveness

TABLE C-6

GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

Field Parameters

pH
Specific Conductance
Temperature
Dissolved Oxygen*

Indicators

Total Dissolved Solids
Total Suspended Solids*

Metals

Hazardous Substances List - Metals**

Aluminum	Antimony
Arsenic	Barium
Beryllium	Cadmium
Calcium	Cesium
Chromium (total)	Cobalt
Copper	Iron
Lead	Magnesium
Manganese	Mercury
Molybdenum	Nickel
Potassium	Selenium
Silver	Sodium
Thallium	Tin
Vanadium	Zinc

Chromium (hexavalent)
Lithium
Strontium
Molybdenum

Anions

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate

Organics

Hazardous Substances List - Volatiles (Table C-1)
Hazardous Substances List - Semi-Volatiles (Table C-2)
Oil and Grease

TABLE C-6

GROUND-WATER AND SURFACE WATER SAMPLING PARAMETERS

Radionuclides
Gross Alpha
Bross Beta
Uranium 233, 234, 235, and 238
Americium 241
Plutonium 293
Tritium

* For surface water samples only.

** Total and dissolved metals for both surface water samples and ground-water samples.

of the ground-water collection system, prevent overflow from the east pond and to determine whether a treatment system will be necessary.

Should variations in water quality from the landfill be sufficient to require treatment of the east pond water, a treatment system will be constructed to handle contaminated waters at the plant site. After approval of a design for this system by CDH and EPA, and prior to construction, a sampling and waste analysis plan will be written in accordance with CCR 264.13(b)(1)-(4) and 40 CFR 264.13(b)(1)-(4) and will be located in Appendix C-3.

As a precaution against future generation of landfill gases and to reduce the potential for vegetative cover stress due to concentrated leakage of gases through the membrane, a passive gas collection and venting system will be installed on the landfill.

During the first year, the passive gas vent system will be monitored quarterly with an explosimeter for a gross determination of methane and/or other combustible vapors and a photoionization detector for volatile organic analyses (VOAs) and hydrogen sulfide. After the first year the

passive gas vent system will be monitored once a year with the explosimeter and photoionization detector. Approximately three vent locations will be selected upon cap completion to be consistently sampled once a year during the third quarter for the duration of the post-closure care period. The samples will be analyzed by a GC for hydrogen sulfide in accordance with 40 CFR 261 Appendix IX in addition to the VOA hazardous substance list (HSL) delineated in Table C-1.

The data obtained from the first year will provide a statistical data base for comparison to the following years. Variations in atmospheric conditions and in-situ conditions at the time of sampling may obscure the presence of trends. If monitoring indicates significant increases in the gas generation from the landfill, modification of the gas collection and ventilation system may be implemented.

C-3a(3) West Spray Field

Operation of the west spray field stopped in October 1985. Wastes will not be applied to the west spray field in the future. However, the west spray field may be closed with contaminated soil remaining in place. Should this be the

case, diversion ditches will be installed to prevent runon/ runoff. The ditches will then be sampled and discharge rates will be measured quarterly after major storm events when there is sufficient runoff. Surface water samples will be analyzed in the field for pH, specific conductance, temperature, and dissolved oxygen, and in the laboratory initially for the parameters listed in Table C-7. Analyses thereafter will be for the parameters listed in Table C-8 in addition to any hazardous substances identified at or above their quantitation limit during the initial investigations.

Ground-water monitoring and sampling will be conducted on a quarterly basis and is addressed in Section E. Table C-5 contains the list of parameters the ground-water samples will be analyzed for during post-closure care.

C-3a(4) Original Process Waste Lines

Use of the original process waste lines stopped in late 1984 when the new process waste system became fully operational. The physical and chemical characteristics of the underlying and surrounding soil are unknown. Soil characterization will be conducted during closure in order to evaluate

TABLE C-7

INITIAL SURFACE WATER SAMPLING PARAMETERS

Field Parameters
pH
Specific Conductance
Temperature
Dissolved Oxygen

Indicators
Total Dissolved Solids
Total Suspended Solids

Metals
CLP Inorganic Compound List (Table C-3)
Cesium
Molybdenum
Strontium

Anions
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate
Cyanide
Phosphate

Organics
Hazardous Substance List - Volatiles (Table C-1)
Hazardous Substance List - Semi-Volatiles (Table C-2)

Radionuclides
Gross Alpha
Gross Beta
Uranium 233, 234, and 238
Americium 241
Plutonium 239
Tritium

TABLE C-8

FINAL SURFACE WATER SAMPLING PARAMETERS

Field Parameters
pH
Specific Conductance
Temperature
Dissolved Oxygen

Indicators
Total Dissolved Solids
Total Suspended Solids

Metals
Cesium
Molybdenum
Strontium

Anions
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate
Cyanide
Phosphate

Radionuclides
Gross Alpha
Gross Beta
Uranium 233, 234, and 238
Americium 241
Plutonium 239
Tritium

closure alternatives. Post-closure care for cap maintenance and ground-water monitoring may be required as for a landfill under 6 CCR 1007-3, Section 265 Subpart G and 265.310. Ground-water sampling will be conducted on a quarterly basis and is discussed in Section E. Table C-5 contains the list of parameters the ground-water samples will be analyzed for during post-closure care. Those parameters that are not found in the samples will be eliminated from analysis after the first year.

C-3b Analytical Methods

C-3b(1) Test Methods

It is intended that the majority of the required analytical work be performed at the Rocky Flats Plant. The Rocky Flats analytical laboratories have developed a series of in-house procedures referred to as "L-Procedures." The guidelines for developing and maintaining quality control when implementing the procedures are described in Section C-3b(2). Where appropriate, procedures presented in SW-846 are followed. Rocky Flats reserves the right to send

samples off site for analysis or to substitute equivalent methods.

Table C-9 shows the methods used in analyzing nonradioactive wastes. Slightly different methods are used for low-level contaminated wastes. These procedures are presented in Table C-10.

C-3b(2) Quality Assurance/Quality Control (QA/QC)

Quality Engineering and Control, an organization not associated with Waste Management Operations, has the responsibility for quality assurance. This organization will be responsible for (1) reviewing analytical results to determine validity of the information, (2) conducting and documenting periodic system and performance audits, (3) use of blind or performance samples in the sampling/analysis process, (4) documenting observed problems with recommendations directly to Waste Operations for resolution and, (5) ensuring that the requirements of the Quality Laboratories Quality Assurance Program are implemented, periodically (at least annually) reviewed and revised as appropriate.

TABLE C-9

ANALYTICAL METHODS FOR NON RADIOACTIVE WASTES

Analyte	Instrument	Guidance** Method
HSL Inorganic	ICP	
	Extraction aqu.	3010
	Extraction solids	3050
	Analysis	6010
HSL Inorganic	AA and/or ICPES	3000 series
	Extraction solids	7000 series
HSL Volatile	GC-MS	8240
HSL Base/Neutral/Acid	GC-MS	
	Extraction liqu/liqu	3510
	Extraction soxhlet	3540
	Extraction sonication	3550
	Analysis	8270
Pesticides and PCB	Analysis	8080
EP Toxicity		1310
EP TOX Leachate	AA or ICPES	7000 series
Reactivity: Cyanide		7.3.3.2 and 9010
Hydrogen Sulfide		7.3.4.2
Corrosivity	pH meter	9040
Ignitability	Setaflash	D 3278-82
	IR-Gas-Sniff	L-6211

** Exact methods may vary slightly.

TABLE C-10

ANALYTICAL METHODS FOR LOW LEVEL WASTES

Analyte	Instrument	Guidance** Method
HSL Inorganic	ICP	
	Extraction aqu.	3010
	Analysis	6010
	except Na,K,Hg and Se	
	Sodium	7770
	Potassium	7610
	Mercury	7470
	Selenium	Sodium Boro-hydride
HSL Volatile and HSL Base/Neutral/Acid	Extraction	*
HSL Volatile	GC-MS	8240
HSL Base/Neutral/Acid	GC-MS	8270
EP Toxicity		1310
EP TOX Leachate	ICP	6010
Reactivity:		
Cyanide		7.3.3.2 w/ Draeger tube
Sulfide		7.3.4.2
Corrosivity	pH meter	9040 9045
Ignitability	Pensky-Martens	1010 (ASTM D93-80)

* As described in: "Preparation of Radioactive Mixed Waste Samples for Measurement of RCRA Organic Compounds" a Rockwell International Lab Procedure, L-4142, written by Celia Moyniham in July 1988.

** Exact methods may vary slightly.

Quality Engineering and Control is responsible for ensuring that the following procedures are implemented during the sampling and analysis program for waste characterization.

C-3b(2)(a) Sample Collection

Trip Blank

A full set of sample container glassware or plastic will be filled with laboratory grade water prior to beginning sampling each day, taken to the sampling site, and submitted for analysis as a routine sample. Sample analysis is performed for the sum of all the analytes required for samples on the day of the trip blank, with the exception of pH. The purpose of this sample is to detect contaminant contributions from the glassware, and/or plastic containers.

Field Blanks

Field Blanks will consist of laboratory-grade water exposed to the sampling environment. A container of water will be opened at the sampling location and poured into the sample containers utilizing the appropriate sampling devices. The sampling devices will be decontaminated prior to obtaining the field blank following the same procedure as used for a routine field sample. Field Blanks will be taken every time

a field sampling procedure is changed, when the sampling personnel are changed, or once for every 20 routine field samples, whichever is more frequent. This frequency may be decreased when disposable sampling equipment is used.

Field Blanks will be assigned a sample number similar to that of a routine field sample.

Field Duplicates

Ten percent (10%) of the samples collected will be sampled twice to provide duplicate samples. The field sampling team will use a random procedure to determine when duplicates will be taken. Duplicates will be assigned a number similar to that of a routine sample and submitted to the analytical laboratory. The duplicates are collected, handled, and analyzed as separate samples. The duplicate is an indicator of variation of the sample and of the representativeness of the sampling and analytical procedure. Adequate duplicate analyses are not possible for oil or solid matrices, and will not be attempted.

C-3b(2)(b) Laboratory QA/QC Program

This subsection of the Quality Assurance/Quality Control Program briefly describes the organization and guidelines used to produce reliable analytical data in the RFP Quality Laboratories. A more detailed and comprehensive presentation of the Quality Laboratories' (QL) organization and quality assurance guidelines may be found in the QL Quality Assurance Program.

Organization

The ultimate responsibility for the generation of reliable laboratory data rests with the laboratory management. Laboratory management is vested with the authority to effect those policies and procedures to ensure data of acceptable quality.

Laboratory management, as well as the Quality Assurance Coordinator and the Laboratory Quality Assurance/Quality Control Officer are ultimately responsible for the implementation of the established policies and procedures. They possess the authorities commensurate with their responsibilities for the day-to-day enforcement and monitoring of laboratory activities.

Laboratory management has the following responsibilities:

1) Direct implementation of the Quality Assurance Program.

2) Ensuring that their personnel are adequately trained to perform analyses.

3) Ensure that equipment and instrumentation under their control are calibrated and functioning properly.

4) Review and perform subsequent corrective action on internal and external audits.

The Quality Assurance Coordinator and the Laboratory Quality Assurance/Quality Control Officer have the following responsibilities:

1) On-going review of individual Quality Assurance procedures.

2) Providing assistance in the development and implementation of specific quality assurance plans for special analytical programs.

3) Coordination of internal quality assurance audits.

4) Coordination of Quality Assurance training.

5) Review special project plans for consistency with organizational requirements and will advise laboratory management and Waste Operations of inconsistencies.

6) Overall coordination of the Quality Laboratories' Quality Assurance Program manual.

7) Review procedures and QA plans of any outside laboratory.

Sample Management

An organized, efficient sample management system is a necessary and critical foundation on which analyses of samples are based. Sample management includes document creation, bottle preparation, sample preservation, sample receipt, sample storage, chain-of-custody documentation, reporting, sample and records retention. Sample management is practiced as specified in L-Procedure L-6002, "Sample Administration - General Laboratory."

Sample bottles will be prepared by the laboratory and made available to the sampling team. The bottles will be prepared according to the analysis plan procedures. Sample preservatives appropriate to the analytes and matrices of concern will be added in the laboratory, due to varying amounts of preservatives needed for various amounts of a sample that may be collected.

Samples received at the laboratories are inspected for integrity, and any field documentation is reviewed for accuracy and completeness.

Chain-of-custody and sample integrity problems are noted and recorded during sample log-in.

As each group of samples is received by the laboratory, it is assigned a unique sequential sample name and number which will identify the sample in the laboratory's internal tracking system. References to a sample in any communication will include the assigned sample number.

C-3b(2)(c) Analytical System

Instrument Maintenance

Instruments will be maintained in accordance with the manufacturer's specifications. More frequent maintenance may be dictated dependent on operational performance. Instrument logs will be maintained to document the date and type of any maintenance performed, and rationale for maintenance.

Contracts on major instruments with manufacturers and service agencies, may be used to provide routine preventive maintenance and to ensure rapid response to emergency repair service.

Instrument Calibration

Before any instrument can be used as a measurement device, the instrumental response to known reference materials must be determined. The manner in which the various instruments are calibrated is dependent on the particular instrument and the intended use of the instrument. All sample measurements will be made within the calibrated range of the instrument. After calibration, satisfactory instrument response is verified by use of calibration check standards. Failure to confirm concentrations of such standards will result in recalibration of the instrument. All data on calibration and standards will be kept in the operating log of the instrument.

Personnel Training

Prior to conducting analyses on an independent basis, analysts are trained by experienced personnel in the complete performance of an analytical method. The analyst is required to independently generate data on several methods and/or matrix spikes to demonstrate proficiency in that analytical method. The type of data to be generated will be dependent on the analytical method to be performed. Results of this "certification" are then reviewed for adequacy.

Since standards, method blanks and method spikes are routine samples with batches of samples analyzed, performance on a day-to-day basis can be monitored by comparison with the original and cumulative data on similar samples. Laboratory management is responsible for ensuring that samples are analyzed by only competent analysts.

Analytical Methods

All analytical measurements are made using methodology appropriate for the specific purpose and performed according to a plan individually developed and optimized for each situation. The requirements of each problem are studied and thoroughly understood before hand, in order to ensure that the measurements planned will be adequate both in kind, number, and quality. All measurements are made using standard methods, methods with peer recognition, methods developed in the specific laboratory, or those mandated by outside requirements. No method will be used for data output purposes until it is known to be applicable and competence has been acquired in its use. If or when it appears that available techniques are not adequate to solve a particular problem, the requester of the services is usually informed of any preliminary investigations or

research required, including estimated costs in terms of laboratory time.

To control routinely employed analytical laboratory analyses and avoid errors leading to unsatisfactory results, formal procedures are written to provide direction for those doing the work. Instructions for performing most routine analytical laboratory operations are provided in L-Procedures, also known as Analytical Laboratory Procedures. L-Procedures are developed and written by the Quality Laboratories' technical staff and apply to routinely performed analytical work.

These procedures are reviewed prior to approval by laboratory management and are subject to periodic audits. The L-Procedures for Environmental Analytical Methods are usually adaptations of SW-846. L-Procedures also cover other standard operating practices such as sample handling protocols, security procedures, and nuclear accountability practices. L-Procedures for analytical methods perform the following functions:

1) Describe operations, materials, and equipment required.
2) Serve as training guide for indoctrination and education of personnel.

3) Identify potential hazards, safety requirements, and safeguards considerations associated with the procedure.

4) Describe calibration and standardization procedures.

5) Describe techniques for quality assessment of data (e.g., measurement control samples, replicate measurements, etc.).

6) Describe sample preparation and handling.

A comprehensive Quality Assurance/Quality Control Plan is being prepared by Rockwell International to address all sampling and remediation activities at the hazardous waste management units. The QA/QC document will be completed in January 1989. The plan will include methods for reporting data uncertainties and providing a statistical analysis of the data. It will also provide a format for report generation.

For non-routine analysis investigations that are encountered infrequently, written procedures are not generated. The analytical methodology, in these cases, is based upon the analyst's knowledge and skill. The data from such work are supported by documentation of good laboratory practices and data verification steps.

The control of written procedures and the policies for changing procedures are defined in Procedure L-1000. Master copies of all qualified procedures are maintained by the managers of the laboratory groups to which the procedures apply. Working copies of approved procedures are distributed to the responsible managers and technical staff members.

Reference Materials

If possible, primary reference materials will be obtained from the National Bureau of Standards (NBS) or the U.S. Environmental Protection Agency (EPA). In the absence of available reference materials from these organizations, other reliable sources may be sought. When available reference materials will be used for instrument calibration, quality control spikes, and/or performance evaluations. Secondary reference materials may be used for these functions provided that they are traceable to an NBS standard or have been compared to an NBS standard within the laboratory.

Reagents

Laboratory reagents will be of a quality to minimize or eliminate background concentrations of the analyte to be

measured. Reagents must also not contain other contaminants that will interfere with the analyte of concern.

Corrective Actions

When an analytical system is deemed to be questionable or out-of-control at any level of review, corrective action is taken. If possible, the cause of the out-of-control situation is determined, and efforts are made to bring the system back into control. Demonstration of the restoration of a reliable analytical system will normally be accomplished through acceptance of quality control sample data. The major consideration in performing corrective action is ensuring that only reliable data are reported from the laboratory.

C-3b(2)(d) Data Management

Data Collection

In addition to the data collected in the field and recorded on the chain-of-custody forms, data describing the processing of samples will be accumulated in the laboratory and recorded. Laboratory records may contain:

- Date and time of processing
- Sample numbers
- Project (optional)

- Analyses or operation performed
- Calibration data
- Quality control samples included
- Dates of Analysis
- Concentrations/dilutions required
- Instrument readings
- Special observations
- Analyst's signature

Data Reduction

Data reduction is performed by the individual analysts and consists of calculating results in samples from the raw data obtained from the measuring instruments. The complexity of the data reduction will be dependent on the specific analytical method and the number of discrete operations (extractions, dilutions, and concentrations) involved in obtaining a sample that can be measured.

Copies of raw data will be retained in the laboratory, or sent to Rocky Flats record storage.

Data Review

System reviews are performed at all levels. The individual analyst constantly reviews the quality of data through calibration checks, quality control sample results, and performance evaluation samples. These reviews are performed

prior to submission of data to the laboratory management or designee.

Laboratory management or designee will review the data for consistency and validity with other generated data and determine if program requirements have been satisfied. Unusual or unexpected results will be reviewed, and a determination will be made as to whether the analysis should be repeated.

The Quality Assurance/Quality Control Officer independently conducts a complete review of results from randomly selected samples to determine if laboratory and program quality assurance/quality control requirements have been met. Discrepancies will be consistent with the limits of uncertainty inherent in the analytical method.

Data Archiving

The laboratory will maintain on file all of the raw data, laboratory notebooks, and other pertinent documentation. This file will be maintained at the laboratory for a period that will, at a minimum, comply with CLP procedures. This time period will be detailed in the January, 1989 QA/QC Plan.

Data retrieval from archives may be handled only with the approval of laboratory management.

Data Reporting

All data will be reported in a format in accordance with the January, 1989 QA/QC Plan which will, at a minimum, comply with CLP procedures. Data reports may include the following information:

- Laboratory Sample Identification
- Sample Date
- Extraction Date (if appropriate) or Digestion Date
- Analysis Date
- For each Analyte (Section C-3, Tables C-1 to C-4)
  - Parameter
  - Units
  - Value
  - Detection Limit
  - Flags (where appropriate)
  - Counting error (for radioactive parameters)
- Laboratory Blank Results
- Laboratory Spike Results

When errors are detected in laboratory results, subsequent reports will clearly designate which results have been revised.

C-3b(2)(e) Special Measurement - Control Programs

In addition to internal laboratory Quality Assurance and Quality Control Programs, formal measurement control programs have been established and are administered by groups outside the laboratory. These programs provide for additional measurement quality assurance for data.

Sample Exchange Programs

There are three special sample exchange programs in place which are administered independent of the Rocky Flats operation. They are:

a) The Environmental Monitoring Systems Laboratory Exchange Program provides for radiological analysis control among approximately 40 environmental laboratories nationwide.

b) The U.S. Geological Survey Exchange Program addresses environmental pollutant monitoring parameters. This program involves 160 government agency laboratories.

c) The Environmental Protection Agency QA Laboratory Performance Evaluation Study is a quality assurance compliance check for the National Pollutant Discharge Elimination System (NPDES). Compliance with this program assures continuation of the DOE Discharge Permit for Rocky Flats Plant waste discharge. The Rocky Flats Plant Health, Safety, and Environment Department administers this program for the plant and is responsible for reporting all data.

C-3b(2)(f) Standards Laboratory Measurement Control Programs

Analytical Measurement Control

The Standards Laboratory administers the Interactive Measurement Evaluation and Control System (IMECS). IMECS involves on-line computer data collection into a data base management system and is capable of producing a variety of user-specified reports. (The IMECS is documented in Introduction to IMECS and Measurement Control.)

Regardless of the method of data collection, the Standards Laboratory prepares control samples for a variety of laboratory analyses, including analyses for accountable materials, nuclear safety measurements, and environmental analyses. The control samples are submitted to the appropriate laboratories on a predetermined schedule. The control samples are analyzed in the laboratory at the specified frequency and results are either reported to the Standards Laboratory or are entered directly into the IMECS via a local computer terminal. The January, 1989 QA/QC Plan will incorporate reporting procedures which will, at a minimum, produce a trackable deficiency report.

Weight Measurement Control

Within the Quality Laboratories, balances that are used for critical applications requiring certified accuracy and precision are included in the Weight Measurement Control Program. The Standards Laboratory supplies balance users with certified check weights. Balance operators must make periodic check weighings on their balances in accordance with the Standards Laboratory Procedure M1307, "Weight Measurement Control Check Weight Procedure." Data is either recorded on specially provided data entry forms or is entered directly into the Weight Measurement Control Program in the IMECS. The Standards Laboratory maintains all records on the check weights and the Weight Measurement Control Program.

Performance and System Audits

Quality assurance audits will be conducted during the sampling and analysis program as mandated by the QL Quality Assurance Program. The audits are a key mechanism for ensuring the technical and procedural accuracy of hazardous waste and environmental sampling and analysis. A field audit will be periodically performed.

Specific system audits of deliverables, field notebooks, calculations, and data entry will be conducted by the Quality Assurance Coordinator throughout the year at random, unscheduled intervals. Procedures will be developed to allow auditing of laboratory analysis components at random as a part of the January, 1989 QA/QC Plan.

Specific audits will be planned, organized, and clearly defined before they are initiated. Auditors will identify non-conformances or deficiencies, initiate corrective action through appropriate channels, and follow up with a compliance review.

Annually, or more frequently if appropriate, a quality assurance audit will be performed in accordance with an established schedule by the Quality Assurance Coordinator. A report will be prepared that summarizes any deviations from approved plans or procedures and their impacts on results.

Field Audits

Periodically, for randomly selected sites where samples are collected, an unannounced audit, investigating conformance with QA/QC procedures, will be performed. A written report

on the results of this audit, along with a notice of non-conformance (if necessary), will be submitted to management.

Corrective Action

After each audit, auditors will identify non-conformances in a written non-conformance notice and initiate corrective action. The non-conformance notice will describe any non-conforming conditions and sets a date for response and corrective action. A written response outlining the proposed corrective action is required. Follow-up review will be performed as necessary to confirm that the corrective actions have been implemented.

C-3c Sampling Methods

Sampling methods used to collect samples at the present landfill, west spray field, original process waste lines and solar evaporation ponds will follow the methods delineated in the sampling plans utilized during closure. Representative samples will be collected in accordance with 6 CCR 264.13(b)(3), 40 CFR 264.13(b)(3). Table C-11 lists waste matrices and appropriate sample tools. All ground-water sampling, including the interceptor trench pump house

at the solar evaporation ponds, will follow procedures delineated in Section E.

Surface water monitoring in the drainages and ditches at the west spray field and the east pond at the present landfill will consist of grab sample collection and discharge measurement. A Cutthroat flume will be temporarily placed in the drainages at the west spray field after a major storm event to measure discharge rates. If channel dimensions or flow conditions render a flume installation infeasible, discharge rates will be estimated by measuring channel dimensions and flow velocity. The ground-water collection discharge pipes at the present landfill will have a monitoring device installed during closure which will enable measurement of flow.

TABLE C-11

MATRIX SPECIFIC SAMPLE METHODS

MATRIX	ABBREVIATIONS	SAMPLE TOOLS
Aqueous	aqu	bailer, coliwasa, dipper, pour, pump, thief, weighted bottle
Liquid	liq	bailer, coliwasa, dipper, pour, pump, thief, weighted bottle
Oil	oil	coliwasa, dipper, pour, pump, scoop, thief
Sludge	slu	scoop, shovel
Solid	sol	grab (hands, tongs, tweezers), scoop, tin snips
Gas	gas	sampling pump, teflon bag

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SECTION D

PROCESS INFORMATION

D-1 SOLAR EVAPORATION PONDS

The solar evaporation ponds were originally constructed to store and treat (by evaporation) low level radioactive wastes containing high nitrates, treated acidic wastes, and sanitary sewage sludge. In 1977, all of the 207B ponds were cleaned of sludge and relined. A tank is currently being used to treat Pond 207A sludge at the solar evaporation ponds. As this tank may be used to treat wastes from other areas of the Rocky Flats Plant, it is covered in the HRMW RCRA Part B Permit Application for the Plant. Treatment of the sludge and sediments in all of the existing solar evaporation ponds, if necessary, will be completed during closure (see Appendix I-2 for Closure Plan).

The liquids in the solar ponds are currently being treated on a full-time basis by solar evaporation and on a part-time basis by forced evaporation in Building 374. Upon completion of closure, the total interceptor trench water (ITW) will consist of ground water collected from the existing french drain system in the hillside north of the

solar ponds and from an interceptor drain that will be located at the downgradient toe of the final solar pond cover during closure. The total ITW flow will be routed to Building 374 in February 1990. Surge capacity storage to handle flows which cannot go directly to Building 374 will be held in Pond 207B South. Construction of an ITW storage tank(s) (see Closure Plan in Appendix I-2) will be completed by December 1990, if it is necessary to replace the surge capacity of Pond 207B South for storage. The tanks will be designed in accordance with CCR 100.41(b)(2), 264.192(a), 264.191(a), and 264.17(c) and 40 CFR 270.16, 264.17(c), 264.191(a) and 264.192(a). The tank management practices will conform to CCR 100.41(b)(2), 264.191(a), 264.192(b) and 40 CFR 270.16(d) through (f), 264.192(b), and 264.191(a). The ITW will be sampled quarterly during post-closure care to monitor the effectiveness of the french drain. The final tank design and management practices will be located in Appendix D-1 when the need for the tank has been defined.

D-2 PRESENT LANDFILL

The RCRA Part B permit regulations require information regarding wastes to be landfilled, sampling and record-keeping, liner system design, construction and integrity,

the leachate collection and removal system, the runon and runoff control systems be presented in this section. Since hazardous constituent disposal in the landfill was eliminated November 1986 and solid wastes will no longer be accepted at the landfill after June 1, 1989, information on the wastes to be landfilled, and sampling and record-keeping is not applicable. Information on a liner is also not applicable since the landfill does not have a liner.

As the landfill is still being utilized and site investigations and engineering studies are still being conducted, the information necessary for the final landfill design is incomplete. When completed, the final landfill design and management practices will be located in Appendix D-2.

D-2a Proposed Ground-Water Collection System

The landfill does not appear to be impacting ground water with hazardous constituents. However, a ground-water collection system is proposed at the east end of the landfill for the following reasons: 1) there are impacts to ground-water quality at the site; 2) relatively high water levels exist within the landfill; and 3) closure activities

may result in changes in the quality of water beneath the landfill.

The ground-water collection system will be constructed at the downstream toe of the final landfill cover (see Closure Plan in Appendix I-3). The collection system will be a gravel drain excavated through the surface colluvial and alluvial material into the underlying claystone bedrock. The drain will lower water levels within the landfill and collect potentially impacted ground-water flows within the surface soils and shallow bedrock. Collected water will be pumped to the east pond area for storage and evaporation.

Based on current water quality information, no significant chemical reactions such as oxidation, reduction or precipitation would occur as intercepted waters enter the drain system which could affect drain functioning. Pump and piping repair and/or replacement may be required during the operating life of the collection system. It is anticipated that stable ground-water levels and water quality will be achieved during closure of the landfill such that long-term pumping operation of the collection system will not be required. However, the potential exists that the water

quality may deteriorate sufficiently to require a treatment system. This is addressed in Section D-2e.

The proposed ground-water collection system is estimated to have a discharge of about one gallon per minute. The actual volume collected by the system will be dependent on subsurface conditions encountered during construction of the drain. The presence of more pervious soils and sandstone lenses within the bedrock may increase flows. Other factors influencing volumes collected by the system are long-term stabilized water levels within the landfill and the effectiveness of repairs to the existing ground-water control system. A 30-mil HDPE membrane will be placed on the downstream side of the drain to reduce inflow from the east pond.

During final design, an evaluation of the site will be made to determine if a cut-off wall extending deeper than the existing systems can be installed to eliminate ground-water migration into the landfill. Based on the engineering studies during final design, the cut-off wall may be installed to effect additional ground-water control.

D-2b Runon/Runoff Control Systems

Regrading of the ground surface adjacent to the landfill will be conducted as part of closure to reduce impacts of surface runon on the final cover. Regrading will involve enlargement and renovation of existing diversion ditches around the landfill. The proposed diversion ditches will be designed to divert the peak storm runoff from the one-hour, 100-year storm event around the landfill. A six-inch compacted clay layer will be placed in the bottom of the diversion ditches for erosion control from the design storm.

The existing landfill surface will be regraded to divert surface runoff to the center of the top of the landfill, down the eastern face and into the east pond (see Closure Plan, Appendix I-3). The final cover elevations will be based on actual ground surface of the landfill at time of final design.

During closure of the landfill, the water elevation in the east pond will be lowered to a maximum elevation of about 5915 feet above mean sea level. This maximum pool elevation will be maintained during post-closure resulting in approximately 11 acre-feet of excess storage in the pond.

This excess storage will hold all the runoff from the 100-year design storm. Excess pond water will be spray evaporated, pumped to an existing National Pollutant Discharge Elimination System (NPDES) permitted discharge point or discharged under a new NPDES permit for the east pond. Final excess storage volume and water elevations will be determined during final design.

D-2c Gas Collection System

A soil-gas survey indicated low levels of methane and hydrogen sulfide at the landfill. Closure activities will lower water levels within the landfill. Therefore, landfill material previously below the water surface may undergo aerobic digestion upon dewatering, resulting in gas generation. The amount of gas generated during water level drawdowns will be dependent on the amount of drawdown achieved, types of landfill material within the area of drawdown and amount of previous biodegradation which has occurred in the materials.

As a precaution against future generation of landfill gases and to reduce the potential for vegetative cover stress due to concentrated leakage of gases through the cap's membrane,

a passive gas collection and venting system will be installed on the landfill.

As part of the post-closure maintenance of the cover, explosimeter and photoionization detector measurements will be taken in the gas vent pipes to monitor the performance of the system and potential changes in gas generation from the landfill. If monitoring indicates significant increases in the gas generation from the landfill, modification of the gas collection and ventilation system may be implemented. These modifications could include installation of additional passive vents, installation of an active vent system and/or installation of air filter units.

D-2d Ground-Water Monitoring Exemption

An exemption from ground-water monitoring in the vicinity of the landfill is not being requested.

D-2e Proposed Water Treatment System

Based on recent sampling and analysis (Appendix I-3), the quality of water collected by the ground-water interception systems will not require treatment prior to discharge into

the east pond. However, closure activities for the landfill will result in reduction of ground-water levels within the landfill area. Changes in ground-water conditions within the landfill may result in variations in water quality. Water collected by the systems will be analyzed quarterly during post-closure at the discharge point and in the east pond, and appropriate management methods instituted if contamination is found. Criteria for evaluating water contamination is located in the Closure Plan in Appendix I-3 and in Section C of the Post-Closure Care Permit.

Should variations in the water quality from the landfill be sufficient to require treatment of the east pond waters, a treatment system will be constructed to handle contaminated waters at the plant site. The treatment system design and management practices will conform to CCR and 40 CFR regulations and will be delineated in Appendix D-3.

D-3 WEST SPRAY FIELD

The west spray field was in operation from 1982 to October 1985. During operation, excess liquids from solar evaporation ponds 207B North and Center were pumped periodically via pipeline to the west spray field for spray

applications (see Appendix I-4 for Closure Plan). If the west spray field is closed with contaminated soil remaining in place, closure activities will consist of the installation of drainage diversion ditches and additional monitoring wells around the west spray field. Post-closure care will then consist of quarterly sampling and measuring the flow rate of runoff after a major storm event and quarterly sampling of the observation wells.

D-4 ORIGINAL PROCESS WASTE LINES

Consisting of a system of tanks and associated lines within the process boundary, the OPWL was constructed to transport and temporarily store process wastes from point of origin to on-site treatment points from 1952 to 1983. Releases of process waste from the lines and tanks occasionally occurred during the OPWL period of operation. Closure (see Appendix I-5 for Closure Plan) will entail capping in areas, contaminated soil and line removal in other areas, and clean closing the remaining areas. As a cap will be in place over the contaminated areas, the runoff will not become contaminated. Post-closure care will entail cap maintenance

and quarterly ground-water sampling to monitor the effectiveness of closure.

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E-1 INTRODUCTION

Ground-water monitoring during the post-closure care period is required for the Present Landfill, Original Process Waste Line, the West Spray Field, and the Solar Evaporation Ponds. This section of the Post-Closure Care Permit Application addresses the ground-water monitoring requirements of 6 CCR 1007-3 Part 265 (40 CFR Part 265 Subpart F) for interim status monitoring, and 6 CCR 1007-3 Part 264 (40 CFR Part 264 Subpart F) for the post-closure care period. Presented are results of interim status monitoring to date and plans for continued interim status monitoring until issuance of the permit pursuant to 6 CCR 1007-3 Part 265 (40 CFR Part 265). Also presented are descriptions of the uppermost aquifer, points of compliance, contaminant plumes, general ground-water monitoring requirements, detection monitoring programs, compliance monitoring programs, and corrective action programs for the post-closure care period in accordance with 6 CCR 1007-3 Part 264 (40 CFR Part 264).

E-2 INTERIM STATUS MONITORING

Pursuant to 6 CCR 1007-3 100.41(c)(1) and 40 CFR 270.14(c)(1), a summary of the interim status ground-water monitoring program and resulting data are included in this section. In addition, plans for continued interim status monitoring are presented.

Owners and operators of hazardous waste management units, must have permits during the active life (including the closure period) of the units, and for any unit which closes after January 26, 1983, during any post-closure care period required under 264.117 and during any compliance period specified under 6 CCR 1007-3 and 40 CFR 264.96 (6 CCR 1007-3 100.10; 40 CFR 270.1(c)). According to 6 CCR 1007-3 100.10 and 40 CFR 270.70(a), the owner or operator of an existing facility will have interim status and shall be treated as having been issued a permit to the extent that the owner or operator has complied with the requirements of Section 3010(a) and 270.10.

During the interim status period the facility will comply with the interim status standards of 6 CCR and 40 CFR Part 265 (6 CCR 1007-3 100.20(3)(b)(1); 40 CFR 270.71(b)). Interim status monitoring of each regulated unit at Rocky Flats Plant will continue until closure of that unit is certified. (6 CCR 1007-3 100.20(c); 40 CFR 270.73(b)). At that time the Rocky Flats Plant will comply with 6 CCR 1007-3 and 40 CFR Parts 264.90 through 264.100 for ground-water monitoring and response programs. The

following sections describe the requirements of the interim status ground-water monitoring programs under Part 265; describe the interim status monitoring program conducted to date at the Rocky Flats Plant; and describe the monitoring programs which will be conducted under interim status until closure of the units. Ground-water monitoring programs pursuant to 6 CCR 1007-3 and 40 CFR Part 264 (i.e., during the permitted closure and post-closure phases) are discussed in Sections E-6, E-7, and E-8.

E-2a Interim Status Regulatory Requirements

The Part 265.90 regulations require that a surface impoundment, landfill, or land treatment facility which is used to manage hazardous waste must implement a ground-water monitoring program capable of determining the facility's impact on the uppermost aquifer underlying the facility. Implementation of the ground-water monitoring program includes the installation, operation, and maintenance of a ground-water monitoring system which meets the requirements of 265.91 and 265.92 through 265.94. The ground-water monitoring program must be carried out during the active life of the facility and during the post-closure care period for disposal facilities.

If the owner or operator assumes that ground-water monitoring of indicator parameters in accordance with 265.91 and 265.92 would show statistically significant increases when evaluated under 265.93(b), he may install, operate, and maintain an alternate

ground-water monitoring system. The alternate ground-water monitoring system may differ from that described in Parts 265.91, the ground-water monitoring system, and 265.92, sampling and analysis (6 CCR 1007-3 and 40 CFR 265.90(d)). If the owner or operator uses an alternate ground-water monitoring system, he must:

- Within one year after the effective date of these regulations, submit a specific plan which satisfies the requirements of 265.93(d)(3) for an alternate ground-water system (6 CCR 1007-3 and 40 CFR 265.90(d)(1)).

- The written plan must be submitted not later than one year after the effective date of the regulations. The plan will include the number, location and depth of wells; sampling and analytical methods for those hazardous wastes or waste constituents at the facility; evaluation procedures including the use of previously gathered ground-water quality information; and a schedule of implementation (6 CCR 1007-3 and 40 CFR 264.90(d)(2), 264.93(d)(3)).

- The ground-water plan must be implemented, and at a minimum, the rate and extent of migration of the hazardous constituents in the ground water, and the concentrations of the hazardous constituents in ground water will be determined. Within fifteen days after the evaluation of the data, a written ground-water quality assessment report including the results of the determinations will be submitted to the Regional Administrator (6 CCR 1007-3 and 40 CFR 265.90(d)(4), 265.90(d)(5) and 265.93(d)(4), 265.93(d)(5)).

- The rate and extent of migration of the hazardous constituents, and the concentrations of the hazardous constituents, as specified in 265.93(d)(4) will be determined on a quarterly basis until final closure of the facility (6 CCR 1007-3 and 40 CFR 265.90(d)(4)).

- Recordkeeping and reporting requirements must comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan must be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

- A report must be submitted to the Regional Administrator on an annual basis until final closure, and no later than March 1st following each calendar year. The report will include the results of the ground-water quality assessment reports of the quarterly ground-water quality data (6 CCR 1007-3 and 40 CFR 264.94(b)(2)).

Unless the owner or operator intends to propose an alternate ground-water monitoring system, or demonstrate that there is a low potential for migration of hazardous waste constituents from the facility via the uppermost aquifer or surface water, the owner or operator of the facility must install, operate, and maintain a ground-water detection monitoring system which complies with Parts 265.91, and 265.92 through 265.94. The Present Landfill, Original Process Waste Line, and West Spray Field are and/or will be in an alternate ground-water monitoring system, therefore, detection monitoring is not applicable to these regulated units. The Solar Evaporation Ponds are in assessment monitoring as described below.

If the ground-water analytical data from a specific unit indicate the facility may be affecting ground-water quality, then the unit must begin assessment monitoring. Requirements of the assessment monitoring program are as follows:

- The plan will include the number, location and depth of wells; sampling and analytical methods for those hazardous wastes or waste constituents at the facility; evaluation procedures including the use of previously gathered ground-water quality information; and a schedule of implementation (6 CCR 1007-3 and 40 CFR 264.90(d)(2), 264.93(d)(3)).

- The ground-water plan must be implemented, and at a minimum, the rate and extent of migration of the hazardous constituents in the ground water, and the concentrations of the hazardous constituents in ground water will be determined. Within fifteen days after the evaluation of the data, a written ground-water quality assessment report including the results of the determinations will be submitted to the Regional Administrator (6 CCR 1007-3 and 40 CFR 265.90(d)(4), 265.90(d)(5), 265.93(d)(4), and 265.93(d)(5)).

- The rate and extent of migration of the hazardous constituents, and the concentrations of the hazardous constituents, as specified in 265.93(d)(4) will be determined on a quarterly basis until final closure of the facility (6 CCR 1007-3 and 40 CFR 265.90(d)(4)).

- Recordkeeping and reporting requirements must comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan must be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

- A report must be submitted to the Regional Administrator on an annual basis until final closure, and no later than March 1st following each calendar year. The report will include the results of the ground-water quality assessment reports of the quarterly ground-water quality data (6 CCR 1007-3 and 40 CFR 264.94(b)(2)).

E-2b Interim Status Ground-water Monitoring at Rocky Flats Plant

The hazardous waste management units regulated under interim status at the Rocky Flats Plant include the Present Landfill, the Original Process Waste Lines, the West Spray Field and the Solar Evaporation Ponds. An alternate monitoring program is being conducted at the Present Landfill and the West Spray Field pursuant to 6 CCR 1007-3 and 40 CFR Part 265.90(d). An alternate monitoring system is proposed but not presently active at the

Original Process Waste Line. Assessment monitoring is on-going at the Solar Evaporation Ponds in accordance with 6 CCR 1007-3 and 40 CFR Parts 265.93(d). The following sections describe the ground-water monitoring programs conducted to date under interim status.

E-2b(1) Present Landfill

Pursuant to 6 CCR 1007-3 and 40 CFR 265.90(d), a specific plan for the installation, maintenance, and operation of the alternate ground-water monitoring system at the Present Landfill was submitted to the Colorado Department of Health (CDH) and the U.S. Environmental Protection Agency (EPA). The submitted plan, Comprehensive Environmental Assessment and Response Program (CEARP) Phase 2 Site Specific Monitoring Plan (SSMP) (DOE, 1987), included a plan for the installation and quarterly sampling, and analysis of upgradient and downgradient wells. The plan also included the procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain of custody control.

Four wells (two alluvial and two bedrock) were installed at the Present Landfill as part of Plant-wide hydrogeologic site investigations in 1986 (7-86, 8-86, 9-86, and 10-86). Sixteen additional wells were installed in and around the landfill in 1987 according to the CEARP Phase 2 SSMP (40-87, 41-87, 42-87, 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). These wells were designed to monitor ground-water quality and elevations within and downgradient of the landfill. In addition, wells were placed around the ground-water intercept system and slurry wall to evaluate their performance. Conclusions of these investigations are presented in the Present Landfill Hydrogeologic Characterization Report (Appendix 6 of Appendix I-3).

Quarterly monitoring of wells at the landfill was initiated immediately upon their completion and development. The 1986 wells were sampled once during 1986 and quarterly during 1987 and 1988. The 1987 wells were sampled once during 1987 and quarterly during 1988. Water levels were measured monthly as well as at the time of sampling. The unconfined water table in surficial materials at Rocky Flats Plant is quite dynamic. Thus, some wells were dry upon inspection for quarterly sampling, and no sample was collected.

Ground-water samples were analyzed for the parameters listed in Table E-1. During 1986 ground-water samples were analyzed for the entire Target Compound List (TCL) volatiles, semi-volatiles, and metals as well as major ions and radionuclides. In 1987 and 1988 analyses were performed by an on-site Rockwell International laboratory. During the first three quarters of 1987, ground-water sample analytes consisted of nine volatile organic compounds (VOCs), metals, major ions, and radionuclides (Table E-1).

TABLE E-1
GROUND-WATER SAMPLING PARAMETERS

FIELD PARAMETERS

Ph
Specific Conductance
Temperature

INDICATORS

Total Dissoloved Solids
Total Suspended Solids

METALS

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

Chromium (hexavalent)
Lithium
Strontium

ANIONS

Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate
Cyanide
Phosphate

TABLE E-1
GROUND-WATER SAMPLING PARAMETERS
(continued)

ORGANICS

Target Compound List - Volatiles*
- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chloroethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1,-Dichloroethene
- 1,1,-Dichloroethane
- trans-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-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromehtane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzène
- Styrene
- Total Xylenes

Oil and Grease

Target Compound List - Semi-Volatiles
- 2,4,6-Trichlorophenol
- 2,4,5-Trichlorophenol(2)
- 2-Chloronaphthalene
- 2-Nitroaniline(2)
- Dimethyl Phthalate
- Acenaphthylene
- 3-Nitroaniline(2)
- Acenaphthene
- 2,4-Dinitrophenol(2)
- 4-Nitrophenol(2)
- Dibenzofuran
- 2,4-Dinitrotoluene

TABLE E-1
GROUND-WATER SAMPLING PARAMETERS
(continued)

2,6-Dinitrotoluene
Diethyl Phthalate
4-Chlorophenyl-phenylether
Fluorene
4-Nitroaniline(2)
4,6-Dinitro-2-methylphenol(21)
N-Nitrosodiphenylamine(1)
4-Bromophenyl-phenylether
Hexachlorobenzene
Pentachlorophenol(2)
Phenanthrene
Anthracene
di-n-Butyl Phthalate
Fluoranthene
Pyrene
Butyl Benzyl Phthalate
3,3'-Dichlorobenzidine(3)
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
Phenol
bis(2-Chloroethyl)Ether
2-Chlorophenol
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Benzyl Alcohol
1,2-Dichlorobenzene
2-Methylphenol
bis(2-Chloroisopropy)Ether
4-Methylphenol
N-Nitroso-di-n-propylamine
Hexachloroethane
Nitrobenzene
Isophorone
2-Nitrophenol
2,4-Dimethylphenol
Benzoic Acid(2)
bis(2-Chloroethoxy)Methane
2,4-Dimethylphenol
1,2,4-Trichlorobenzene
Naphthalene
4-Chloroaniline
Hexachlororbutadiene
4-Chloro-3-methylphenol
2-Methylnaphthalene
Hexachlorocyclopentadiene

TABLE E-1
GROUND-WATER SAMPLING PARAMETERS
(continued)

PESTICIDES

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
Methoxychlor
Endrin Keone
Chlordane
Toxaphene
Arochlor-1016
Arochlor-1221
Arochlor-1232
Arochlor-1242
Arochlor-1248
Arochlor-1254
Arochlor-1260

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

* Ground-water samples from the first quarter of 1987 were analyzed for 9 of the TCL 2nd, 3rd and Part of 4th volatiles. These volatiles are the chlorinated solvents historically detected in the ground water and are as follows: PCE, TCE, 1,1-DCE, 1,2-DCA, t-1,2-DCE, 1,1,1-TCA, 1,1,2-TCA, CCl_4 and $CHCl_3$.

TABLE E-1
GROUND-WATER SAMPLING PARAMETERS
(continued)

Strontium 89,90 was not analyzed during first quarter 1988.

Cyanide was not analyzed during fourth quarter 1987.

Lithium was analyzed for in fourth quarter 1987 and first quarter 1988 only.

Phosphate and total suspended solids were determined for groundwater samples analyzed in 1986.

TCL and Semi-Volatiles were analyzed during 1986 analyses only.

Chromium T6 was analyzed in fourth quarter 1987 ground water samples only.

The VOC analyte list was reduced to the nine volatiles commonly detected in ground water at the Plant, because the laboratory was equipped with only a gas chromatograph. During the fourth quarter of 1987, the Rockwell laboratory obtained a gas chromatograph/mass spectrometer and began analyzing for the entire TCL volatile organic list.

Again due to the dynamic nature of the unconfined water table at the Plant, there was sometimes insufficient water in wells to analyze for the entire parameter list. Samples were collected in the following order when this situation occurred:

- VOCs;
- Plutonium, Uranium, and Americium;
- Nitrate;
- Metals;
- Other Major Ions; and
- Gross Alpha and Gross Beta.

Sampling and analysis records are maintained quarterly in compliance with 6 CCR 1007-3 and 40 CFR 265.94(b). An annual report was compiled in March 1988, which described ground-water elevations, ground-water migration rates, and included the results of the ground-water sample analyses (Rockwell International, 1988a).

E-2b(2) Original Process Waste Line

At present no detection or alternate monitoring program specific to the Original Process Waste Line is being conducted. The

proposed alternate monitoring program is described in Section E-2c(2).

E-2b(3) West Spray Field

Pursuant to 6 CCR 1007-3 and 40 CFR 265.90(d), a specific plan for the installation, maintenance, and operation of the alternate ground-water monitoring system at the West Spray Field was submitted to the CDH and the EPA. The submitted plan, Draft Work Plan, Geological and Hydrological Site Characterization (Rockwell International, 1986a), included a plan for the installation and quarterly sampling and analysis of upgradient and downgradient wells. The plan also included the procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain of custody control.

Eight wells (five alluvial and three bedrock) were installed at the West Spray Field during the fall and winter of 1986 (45-86, 46-86, 47-86, 48-86, 49-86, 50-86, 51-86, and 52-86). Quarterly monitoring of these wells was initiated immediately upon their completion and development. Wells 45-86, 46-86, 47-86, 49-86, 50-86, and 51-86 were sampled once during 1986; however, wells 48-86 and 52-86 were not completed in time for the 1986 sampling. All West Spray Field wells were sampled quarterly during 1987 and 1988. Water levels were measured monthly as well as at the time of quarterly sampling.

Ground-water samples were analyzed for the parameters listed in Table E-1. Analyte lists were the same as those discussed for the Present Landfill.

The records of the analyses and evaluations are maintained in compliance with 6 CCR 1007-3 and 40 CFR 265.94(b). An annual report was compiled in March 1988, which described ground-water elevations, ground-water migration rates, and included the results of the ground-water sample analyses. In addition, ground-water sampling results for the West Spray Field are presented in the West Spray Field Hydrogeologic Characterization Report (Appendix 4 of Appendix I-4).

E-2b(4) Solar Evaporation Ponds

Ground-water sample results from the uppermost aquifer at the Solar Evaporation Ponds indicated that the facility may have been affecting the ground-water quality in the uppermost aquifer. Therefore, in accordance with 6 CCR 1007-3 and 40 CFR Part 265.93(d), an assessment monitoring program was implemented at the Solar Evaporation Ponds. A ground-water quality assessment plan, which included the numbers of proposed wells, well locations and depths, sampling and analytical plans, evaluation procedures, and a schedule for implementation, was submitted in the Draft Work Plan, Geological and Hydrological Site Characterization (Rockwell International, 1986a). The CEARP Phase 2 SSMP (DOE, 1987) contained additional guidance on ground-

water monitoring at the Solar Evaporation Ponds. Also included in the CEARP Phase 2 SSMP (DOE, 1987) were procedures and techniques for sample collection, sample preservation and shipment, analytical procedures, and chain of custody control.

Twenty-two wells were installed at the Solar Evaporation Ponds in 1986 (13-86, 14-86, 15-86, 16-86, 17-86, 18-86, 20-86, 22-86, 23-86, 24-86, 25-86, 26-86, 27-86, 28-86, 29-86, 30-86, 31-86, 32-86, 33-86, 34-86, 35-86, and 36-86), and four additional wells were installed in 1987 (37-87, 38-87, 39-87, and 56-87). Quarterly monitoring of these wells was initiated immediately upon their completion and development. The 1986 wells were sampled once during 1986 and quarterly during 1987 and 1988. 1987 wells 37-87, 38-87, and 39-87 were sampled once during 1987 and quarterly during 1988. Well 56-87 was not completed in time for the fourth quarter 1987 sampling event but was sampled quarterly during 1988. Water levels were measured monthly as well as at the time of quarterly sampling.

Ground-water samples were analyzed for the parameters listed in Table E-1. Analyte lists were the same as those discussed for the Present Landfill.

Sampling and analysis records are maintained in compliance with 6 CCR 1007-3 and 40 CFR 265.94(b). An annual report was compiled in March 1988, which described ground-water elevations, ground-water migration rates, and included the results of the ground-water sample analyses. The Solar Evaporation Ponds Hydrogeologic

Characterization Report (Appendix 4 of Appendix I-2) also contains results and discussions of ground-water monitoring to date at the solar ponds.

E-2c Proposed Interim Status Monitoring

Interim status monitoring will continue at each regulated unit (Present Landfill, Original Process Waste Line, West Spray Field, and Solar Evaporation Ponds) until final closure of the unit. After final closure certification, the Present Landfill, the Original Process Waste Line, the West Spray Field, and the Solar Evaporation Ponds will be regulated under 6 CCR 1007-3 and 40 CFR Part 264. Presented below are plans for continued interim status monitoring at the Present Landfill, West Spray Field, and Solar Evaporation Ponds. A proposed alternate monitoring system for the Original Process Waste Line is also presented.

E-2c(1) Present Landfill

The current ground-water monitoring program at the Present Landfill has not detected a contaminant plume. However, ground-water monitoring at the Present Landfill will continue as alternate monitoring. The present monitoring system will be improved during interim status to more effectively monitor ground water beneath the waste management unit as described below.

- Quarterly monitoring will continue in 19 existing wells (Plate E-1, Tables E-2 and E-3).

TABLE E-2
PRESENT LANDFILL ALTERNATE MONITORING SYSTEM

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Purpose
EXISTIN MONITORING WELLS				
9-86	Bedrock	122.57-135.57	135.57	Monitor ground-water quality and water levels in alluvium.
10-86	Alluvium	3.29-23.78	23.78	Monitor ground-water quality and water levels in alluvium.
58-87	Alluvium	3.50-22.26	22.26	Monitor ground-water quality and water levels in alluvium.
60-87	Alluvium	3.5-27.47	27.47	Monitor ground-water quality and water levels in alluvium.
61-87	Alluvium	3.5-28.24	28.5	Monitor ground-water quality and water levels in alluvium.
62-87	Alluvium	3.5-26.56	26.8	Monitor ground-water quality and water levels in alluvium.
63-87	Alluvium	3.5-25.40	25.5	Monitor ground-water quality and water levels in alluvium.
64-87	Alluvium	13.0-23.33	23.8	Monitor ground-water quality and water levels in alluvium.
65-87	Alluvium	10.7-23.96	24.2	Monitor ground-water quality and water levels in alluvium.
66-87	Alluvium	3.4-17.96	17.96	Monitor ground-water quality and water levels in alluvium.
67-87	Alluvium	11.7-16.46	16.8	Monitor ground-water quality and water levels in alluvium.
68-87	Alluvium	11.2-15.75	16.0	Monitor ground-water quality and water levels in alluvium.
72-87	Alluvium	3.5-6.76	6.76	Monitor ground-water quality and water levels in alluvium.
71-87	Alluvium	3.50-13.51	13.51	Monitor ground-water quality and water levels at alluvial water table.
40-87	Alluvium	3.50-6.46	6.46	Monitor ground-water quality and water levels in alluvium.
41-87	Sandstone	81.21-93.79	93.79	Monitor ground-water quality and water levels sandstone which subcrops within waste management unit (Plate E-6).
PROPOSED ALTERNATE MONITORING WELLS				
LF-1	Sandstone	7.5-14	14	Monitor ground-water quality and water levels in subcropping sandstone.
LF-2	Alluvium	3.5-13.5	13.5	Monitor ground-water quality and water levels in alluvium.
LF-3	Claystone	14.5-24.5	24.5	Monitor ground-water quality and water levels in weathered claystone.
LF-4	Alluvium	3.5-10	10	Monitor ground-water quality and water levels in alluvium.
LF-5	Sandstone	32.5-53	53	Monitor ground-water quality and water levels sandstone which subcrops within waste management unit (Plate E-6).
LF-6	Claystone	6-16	16	Monitor ground-water quality and water levels in weathered claystone.
LF-7	Alluvium	3.5-13.5	13.5	Monitor ground-water quality and water levels in alluvium.
LF-8	Claystone (W)	14.5-24.5	24.5	Monitor ground-water quality and water levels in weathered claystone.

NOTE: (1) Depths in feet.
(2) Anticipated depths shown for proposed wells.

TABLE E-3
PRESENT LANDFILL ALTERNATE MONITORING WELLS

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Bedrock Lith. at Contact	Bedrock Depth from Ground Surf.	Approx. Elev. Top Bedrock	Approx. GW Elevation	Sat. Alluv. Thickness	Depth Surf. Casing
EXISTIN MONITORING WELLS									
9-86	Bedrock	122.57-135.57	135.57	Claystone (NW)	22.0	5974	5968	-	
10-86	Alluvium	3.29-23.78	23.78	Siltstone (NW)	23.0	6022	5988	34	
58-87	Alluvium	3.50-22.26	22.26	Sandy Claystone (NW)	22.0	5973	5988	15	
60-87	Alluvium	3.5-27.47	27.47	Claystone (W)	27.2	5957	5976	19.2	
61-87	Alluvium	3.5-28.24	28.5	Claystone (W)	28.0	5956	5973	17	
62-87	Alluvium	3.5-26.56	26.8	Claystone (W)	26.3	5958	5973	15	
63-87	Alluvium	3.5-25.40	25.5	Claystone (W)	25.0	5960	5972	12	
64-87	Alluvium	13.0-23.33	23.8	Claystone (W)	24.5	5962	5969	7	
65-87	Alluvium	10.7-23.96	24.2	Sandstone	21.0	5962	5973	11	
66-87	Alluvium	3.4-17.96	17.96	Claystone (W)	17.8	5964	5973	9	
67-87	Alluvium	11.7-16.46	16.8	Claystone	16.4	5953	5962	9	
68-87	Alluvium	11.2-15.75	16.0	Sandstone	15.3	5953	5962	9	
72-87	Alluvium	3.5-6.76	6.76	Sandstone (W)	6.5	5963	5967	4	
71-87	Alluvium	3.50-13.51	13.51	Claystone (W)	13.5	5950	5959	9	
40-87	Alluvium	3.50-6.46	6.46	Claystone (W)	6.2	5876	5879	2.5	
41-87	BR Sand # 3	81.21-93.79	93.79	Claystone (W)	4.5	5878	5841	-	
PROPOSED ALTERNATE MONITORING WELLS									
LF-1	Sandstone	7.5-14	14	Sandstone	6.5	5963	-	-	8
LF-2	Alluvium	3.5-13.5	13.5	Sandstone	13.5	5953	5959	6	
LF-3	Claystone	14.5-24.5	24.5	Claystone (W)	13.5	5953	-	-	
LF-4	Alluvium	3.5-10	10	Claystone	10	5928	5930	2	-
LF-5	Sandstone	32.5-53	53	Claystone (W)	5	5877	-	-	
LF-6	Claystone (W)	6-16	16	Claystone (W)	5	5877	-	-	-
LF-7	Alluvium	3.5-13.5	13.5	Claystone (W)	13.5	5950	5959	9	
LF-8	Claystone (W)	14.5-24.5	24.5	Claystone (W)	13.5	5960	-	-	-

NOTE: (1) "W" Indicates bedrock is weathered.
(2) "NW" Indicates bedrock is not weathered.
(3) Depth in feet; elevation in feet above mean sea level.
(4) Anticipated depths and elevations shown for proposed wells.
(5) "-" Indicates value unknown.

- Eight new wells will be installed in the uppermost aquifer sidegradient and downgradient of the landfill. (Plate E-1, Tables E-2 and E-3). LF-1 will be drilled adjacent to existing alluvial well 72-87 to monitor the subcropping Arapahoe sandstone at this location, and well LF-5 will be completed in the uppermost sandstone encountered while drilling well 42-87. Both of these wells will monitor the uppermost Arapahoe sandstones beneath the landfill. Proposed wells LF-2, LF-4, and LF-7 will be completed in surficial materials (Rocky Flats Alluvium and/or colluvium) at the edge of the waste management unit. Three wells (LF-3, LF-6, and LF-8) are also proposed for completion in weathered claystone at the landfill. These wells will be used to assess the extent of saturation and hydraulic conductivity of weathered claystone.

- The proposed wells will be constructed according to the procedures described in Section E-6(a)(4).

- Ground-water samples will be collected and analyzed on a quarterly basis. Ground-water elevations will be measured at the time of sample collection. Procedures for sampling, analysis, and measuring ground-water elevations are presented in Section E-6(b).

- Ground-water samples will be analyzed for the analytes listed in Section E-6c.

- Analytical results of the ground-water samples will be evaluated quarterly using the statistical methods described in Section E-6d.

- The rate and extent of migration of any hazardous constituents and the concentrations of the hazardous constituents, as specified in 265.93(d)(4), will be determined on a quarterly basis until final closure of the facility (6 CCR 1007-3 and 40 CFR 265.90(d)(4)).

- Tables E-1 and E-2, Sections E-2c(2) and E-6 satisfy the requirement that a specific plan be submitted for an alternate ground-water system. This includes the number, locations and depths of wells; sampling and analytical methods; and data evaluation procedures (6 CCR 1007-3 and 40 CFR Parts 265.93(d)(3), 265.90(d)(1)).

- This ground-water plan will be implemented immediately. As described in Section E-6d, four quarters of data will be collected, and within fifteen days after the evaluation of the data, a written ground-water quality report including the results of concentrations, rate,

and extent of any hazardous constituents detected in the ground water will be submitted to the Regional Administrator (6 CCR 1007-3 and 40 CFR 265.90(d)(4), 265.90(d)(5) and 265.93(d)(4), 265.93(d)(5)). It is anticipated that the data evaluation will be completed for the March 1, 1990 annual report.

- Recordkeeping and reporting requirements will comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan will be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

- A report will be submitted to the Regional Administrator on an annual basis until final closure no later than March 1st following each calendar year. The report will include the results of the ground-water monitoring program, including the calculated rate of migration of any hazardous waste or hazardous waste constituents in the ground water during the reporting period (6 CCR 1007-3 and 40 CFR 264.94(b)(2)).

E-2c(2) Original Process Waste Line

Because of documented spills, it is possible that the ground-water indicator parameters (6 CCR 1007-3 and 40 CFR 265.91 and 265.92) would show statistically significant increases when evaluated under Part 265.93(b). Therefore, an alternate monitoring system will be installed, operated, and maintained at the Original Process Waste Line. The proposed alternate ground-water monitoring system includes the following.

- Ground-water flow directions are poorly defined within the Plant security area and adjacent to the Original Process Waste Line. In order to better evaluate ground-water flow directions and thus design a more effective ground-water monitoring plan for the waste line, a series a piezometers (26) will be installed around the lines during interim status monitoring (Plate E-2). In addition, piezometers will be installed on approximately 400 foot centers within the

entire Plant security area to define ground-water flow within the Plant. Data from these piezometers will also allow evaluation of the influence of building footing drains on ground water flow direction. A post-closure ground-water monitoring program will be developed following one year of monthly water level measurements.

- Quarterly monitoring will continue in 13 existing wells located adjacent to the Original Process Waste Lines (20-86, 24-86, 35-86, 36-86, 44-86, 1-87, 37-87, 38-87, 51-87, 52-87, 53-87, 54-87, and 56-87) (Plate E-2, Tables E-4 and E-5).

- Three new alluvial wells will be installed adjacent to and presumably downgradient of the Original Process Waste Lines (Plate E-2, Tables E-4 and E-5).

- The new wells will be constructed according to the procedures described in Section E-6(a)(4).

- Ground-water samples will be collected and analyzed on a quarterly basis. Ground-water elevations will be measured at the time of sample collection. Procedures for sampling, analysis, and measuring ground-water elevations are presented in Section E-6(b).

- Ground-water samples will be analyzed for the analytes listed in Section E-6c.

- Analytical results of the ground-water samples will be evaluated quarterly using the statistical methods described in Section E-6d.

- The rate and extent of migration of any hazardous constituents and the concentrations of the hazardous constituents, as specified in 265.93(d)(4), will be determined on a quarterly basis until final closure of the facility (6 CCR 1007-3 and 40 CFR 265.90(d)(4)).

- Tables E-4 and E-5, Sections E-2c(2) and E-6 satisfy the requirement that a specific plan be submitted for an alternate ground-water system. This includes the number, locations and depths of wells; sampling and analytical methods; and data evaluation procedures (6 CCR 1007-3 and 40 CFR Parts 265.93(d)(3), 265.90(d)(1)).

- This ground-water plan will be implemented immediately. As described in Section E-6d, four quarters of data will be collected, and within fifteen days after the evaluation of the data, a written ground-water quality

TABLE E-4

ORIGINAL PROCESS WASTE LINE ALTERNATE MONITORING SYSTEM

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Purpose
EXISTING MONITORING WELLS				
44-86	Alluvium	3.23-26.25	26.25	Monitor ground-water quality and water levels in saturated alluvium.
1-87	Alluvium	3.38-11.83	12.08	Monitor ground-water quality and water levels in saturated alluvium.
51-87	Alluvium	3.58-13.84	14.00	Monitor ground-water quality and water levels in saturated alluvium.
53-87	Colluvium	3.50-9.05	9.30	Monitor ground-water quality and water levels in saturated colluvium
54-87	Colluvium	1.33-4.55	4.68	Monitor ground-water quality and water levels in saturated colluvium
52-87	Alluvium	3.50-20.25	20.50	Monitor ground-water quality and water levels in saturated alluvium.
35-86	Alluvium	24.86-11.60	11.60	Monitor ground-water quality and water levels in saturated alluvium.
36-86	Alluvium	3.50-6.49	6.50	Monitor ground-water quality and water levels in saturated alluvium.
38-87	Alluvium	3.50-9.27	9.50	Monitor ground-water quality and water levels in saturated alluvium.
24-86	Alluvium	2.95-7.45	7.45	Monitor ground-water quality and water levels in alluvium.
37-87	Alluvium	3.5-13.0	13.0	Monitor ground-water quality and water levels in alluvium.
56-87	Alluvium	3.5-13.4	13.4	Monitor ground-water quality and water levels in alluvium.
20-86	Alluvium	4.21-10.55	10.55	Monitor ground-water quality and water levels in alluvium.
PROPOSED ALTERNATE MONITORING WELLS				
OP1	Alluvium	5-25	25	Monitor ground-water quality and water levels at alluvial water table.
OP2	Alluvium	3-12	12	Monitor ground-water quality and water levels at alluvial water table.
OP3	Alluvium	3-7	7	Monitor ground-water quality and water levels at alluvial water table.

NOTE: (1) Depth in feet.

TABLE E-5

ORIGINAL PROCESS WASTE LINE ALTERNATE MONITORING WELLS

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Bedrock Lith. at Contact	Bedrock Depth from Ground Surf.	Approx. Elev. Top Bedrock	Approx. GW Elevation	Sat. Alluv. Thickness
EXISTING MONITORING WELLS								
44-86	Alluvium	3.23-26.25	26.25	Claystone (NW)	25.5	5999.5	6019	19.5
1-87	Alluvium	3.38-11.83	12.08	Sandstone (to 11.87)	11.75	5981	5984	3
51-87	Alluvium	3.58-13.84	14.00	Claystone (W)	13.5	5950	5950	dry
53-87	Colluvium	3.50-9.05	9.30	Claystone (W)	8.8	5951	5954	3
54-87	Colluvium	1.33-4.55	4.68	Claystone (W)	4.2	5952	5955	3
52-87	Alluvium	3.50-20.25	20.50	Claystone (W)	20.0	5948	5958	10
35-86	Alluvium	4.86-11.60	11.60	Claystone (W)	10.5	5899	5905	6
36-86	Alluvium	3.50-6.49	6.50	Claystone (W)	5.5	5876	5878	2
38-87	Alluvium	3.50-9.27	9.50	Claystone (W)	7.50	5964	dry	dry
24-86	Alluvium	2.95-7.45	7.45	Claystone (W)	7.2	5973	5974	1
37-87	Alluvium	3.5-13.0	13.0	Claystone (W)	8.5	5954	5962	8
56-87	Alluvium	3.5-13.4	13.4	Claystone (W)	9.4	5964	5973	9
20-86	Alluvium	4.21-10.55	10.55	Claystone (W)	12.5	5948	5950	2
PROPOSED ALTERNATE MONITORING WELLS								
OP1	Alluvium	5-25	25	Claystone (W)	25	5995	6010	15
OP2	Alluvium	3-12	12	Claystone (W)	12	5983	(5980)	dry
OP3	Alluvium	3-7	7	Claystone (W)	7	5978	5980	2

NOTE: (1) "W" Indicates bedrock is weathered.
(2) "NW" Indicates bedrock is not weathered.
(3) Depth in feet; elevation in feet above mean sea level.
(4) Parentheses around alluvial ground-water elevations indicate projected alluvial ground-water elevations where alluvium is anticipated to be dry; elevation top of bedrock is higher than projected water level.

report including the results of concentrations, rate, and extent of any hazardous constituents detected in the ground water will be submitted to the Regional Administrator (6 CCR 1007-3 and 40 CFR 265.90(d)(4), 265.90(d)(5) and 265.93(d)(4), 265.93(d)(5)). It is anticipated that the data evaluation will be completed for the March 1, 1990 annual report.

- Recordkeeping and reporting requirements will comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan will be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

- A report will be submitted to the Regional Administrator on an annual basis until final closure no later than March 1st following each calendar year. The report will include the results of the ground-water monitoring program, including the calculated rate of migration of any hazardous waste or hazardous waste constituents in the ground water during the reporting period (6 CCR 1007-3 and 40 CFR 264.94(b)(2)).

E-2c(3) West Spray Field

The current ground-water monitoring program at the West Spray Field has indicated the presence of nitrate above background in the downgradient wells. Therefore, interim status monitoring will continue as alternate monitoring. The alternate monitoring program will include the following.

- Quarterly ground-water monitoring will continue in seven existing wells (Plate E-3, Tables E-6 and E-7). Alluvial wells 45-86, 47-86, 49-86, 50-86, and 51-86 are completed in Rocky Flats Alluvium, and well 56-86 is completed in Woman Creek valley fill alluvium. Nitrate has been elevated in wells 49-86 and 51-86 to date. Wells 48-86 and 52-86 are completed in subcropping sandstones.

TABLE E-6
WEST SPRAY FIELD ALTERNATE MONITORING SYSTEM

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Purpose
EXISTING MONITORING WELLS				
51-86	Alluvium	4.83-79.06	79.06	Monitor ground-water quality and water levels in saturated alluvium.
52-86	Bedrock	92.00-125.80	125.65	Monitor ground-water quality and water levels in bedrock sandstone.
50-86	Alluvium	2.90-96.15	96.15	Monitor ground-water quality and water levels in saturated alluvium.
48-86	Bedrock	191.99-207.07	207.07	Monitor ground-water quality and water levels at point of compliance in sandstone which subcrops within waste management unit (Plate E-16).
49-86	Alluvium	4.10-67.60	67.60	Monitor ground-water quality and water levels in saturated alluvium.
56-86	Alluvium	2.60-9.60	9.60	Monitor ground-water quality and water levels at alluvial water table.
45-86	Alluvium	2.99-48.20	48.20	Monitor ground-water quality and water levels in saturated alluvium.
47-86	Alluvium	6.23-94.49	94.49	Monitor ground-water quality and water levels in saturated alluvium.
PROPOSED ALTERNATE MONITORING WELLS				
SF-1	Alluvium	46-66	66	Monitor ground-water quality and water levels at alluvial water table.
SF-2	Alluvium	38-58	58	Monitor ground-water quality and water levels at alluvial water table.
SF-3	Alluvium	40-60	60	Monitor ground-water quality and water levels at alluvial water table.
SF-4	Alluvium	36-56	56	Monitor ground-water quality and water levels at alluvial water table.
SF-5	Alluvium	36-56	56	Monitor ground-water quality and water levels at alluvial water table.
SF-6	Alluvium	43-63	63	Monitor ground-water quality and water levels at alluvial water table.
SF-7	Alluvium	45-65	65	Monitor ground-water quality and water levels at alluvial water table.

NOTE: (1) Depth in feet.
(2) All wells at or adjacent to point of compliance.

TABLE E-7

WEST SPRAY FIELD ALTERNATE MONITORING WELLS

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Bedrock Lith. at Contact	Bedrock Depth from Ground Surf.	Approx. Elev. Top Bedrock	Approx. GW Elevation	Sat. Alluv. Thickness
EXISTING MONITORING WELLS								
51-86	Alluvium	4.83-79.06	79.06	Claystone	78.5	6064	6087	23
52-86	Bedrock	92.00-125.80	125.80	Claystone	72.0	6070	-	-
50-86	Alluvium	2.90-96.15	96.15	Claystone	98.0	6024	6076	52
48-86	Bedrock	191.99-207.07	207.07	Claystone	70.0	6027	6040	-
49-86	Alluvium	4.10-67.60	67.60	Claystone	68.0	6029	6052	23
56-86	Alluvium	2.60-9.60	9.60	Claystone	9.0	5981	5987	6
45-86	Alluvium	2.99-48.20	48.20	Siltstone	47.0	6003	6045	42
47-86	Alluvium	6.23-94.49	94.49	Siltstone	93.0	5989	6027	38
PROPOSED ALTERNATE MONITORING WELLS								
SF-1	Alluvium	46-66	66	Claystone	71	6049	6070	21
SF-2	Alluvium	38-58	58	Claystone	66	6049	6065	16
SF-3	Alluvium	40-60	60	Claystone	68	6025	6050	25
SF-4	Alluvium	36-56	56	Claystone	56	6022	6040	18
SF-5	Alluvium	36-56	56	Claystone	46	6032	6040	8
SF-6	Alluvium	43-63	63	Claystone	73	6032	6060	28
SF-7	Alluvium	45-65	65	Claystone	88	6030	6070	40

NOTE: (1) Depth in feet; elevation in feet above mean sea level.
(2) Anticipated depths and elevations shown for proposed wells.

- Seven new alluvial wells will be installed in and around the waste management unit (Plate E-3, Tables E-6 and E-7). Six new wells (SF-1, SF-2, SF-3, SF-4, SF-5, and SF-6 will be completed at the downgradient edge of the spray field to monitor ground-water quality leaving the unit. Since well 51-86 appears impacted by the spray field, well SF-7 will be installed near the west central portion of the waste management unit to evaluate gradients within the unit.

- The proposed wells will be constructed according to the procedures described in Section E-6(a)(4). The wells will be completed in the upper 15 feet of saturated Rocky Flats Alluvium, where a release from the West Spray Field would be first detected.

- Ground-water samples will be collected and analyzed on a quarterly basis. Ground-water elevations will be measured at the time of sample collection. Procedures for sampling, analysis, and measuring ground-water elevations are presented in Section E-6(b).

- Ground-water samples will be analyzed for the analytes listed in Section E-6c.

- Analytical results of the ground-water samples will be evaluated quarterly using the statistical methods described in Section E-6d.

- The rate and extent of migration of any hazardous constituents and the concentrations of the hazardous constituents, as specified in 265.93(d)(4), will be determined on a quarterly basis until final closure of the facility (6 CCR 1007-3 and 40 CFR 265.90(d)(4)).

- Tables E-6 and E-7, Sections E-2c(2) and E-6 satisfy the requirement that a specific plan be submitted for an alternate ground-water system. This includes the number, locations and depths of wells; sampling and analytical methods; and data evaluation procedures (6 CCR 1007-3 and 40 CFR Parts 265.93(d)(3), 265.90(d)(1)).

- This ground-water plan will be implemented immediately. As described in Section E-6d, four quarters of data will be collected, and within fifteen days after the evaluation of the data, a written ground-water quality report including the results of concentrations, rate, and extent of any hazardous constituents detected in the ground water will be submitted to the Regional Administrator (6 CCR 1007-3 and 40 CFR 265.90(d)(4), 265.90(d)(5) and 265.93(d)(4), 265.93(d)(5)). It is

anticipated that the data evaluation will be completed for the March 1, 1990 annual report.

- Recordkeeping and reporting requirements will comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan will be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

- A report will be submitted to the Regional Administrator on an annual basis until final closure no later than March 1st following each calendar year. The report will include the results of the ground-water monitoring program, including the calculated rate of migration of any hazardous waste or hazardous waste constituents in the ground water during the reporting period (6 CCR 1007-3 and 40 CFR 264.94(b)(2)).

E-2c(4) Solar Evaporation Ponds

The current ground-water monitoring program at the Solar Evaporation Ponds has indicated the presence of TCL metals, radionuclides, cyanide, and non-hazardous major ions above background in the downgradient wells. Therefore, interim status monitoring will continue as assessment monitoring. The assessment monitoring program will include the following.

- Quarterly monitoring will continue in 26 existing wells upgradient, within, and downgradient of the Solar Evaporation Ponds (Plate E-4, Tables E-8 and E-9).

- Twenty-one new wells will be installed upgradient, within, and downgradient of the solar ponds to further assess the extent of ground-water contamination (Plate E-4, Tables E-8 and E-9). Wells SEP-1, SEP-4, SEP-6, SEP-8, SEP-10, SEP-11, SEP-13, SEP-15, and SEP-20 will be completed in surficial materials to evaluate the extent of alluvial saturation as well as ground-water quality. Wells SEP-2, SEP-3, SEP-5, SEP-7, SEP-9, SEP-12, SEP14, and SEP-21 will be completed in weathered claystone to evaluate the extent of saturation and water quality in the weathered bedrock. The remaining

anticipated that the data evaluation will be completed for the March 1, 1990 annual report.

- Recordkeeping and reporting requirements will comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan will be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

- A report will be submitted to the Regional Administrator on an annual basis until final closure no later than March 1st following each calendar year. The report will include the results of the ground-water monitoring program, including the calculated rate of migration of any hazardous waste or hazardous waste constituents in the ground water during the reporting period (6 CCR 1007-3 and 40 CFR 264.94(b)(2)).

E-2c(4) Solar Evaporation Ponds

The current ground-water monitoring program at the Solar Evaporation Ponds has indicated the presence of TCL metals, radionuclides, cyanide, and non-hazardous major ions above background in the downgradient wells. Therefore, interim status monitoring will continue as assessment monitoring. The assessment monitoring program will include the following.

- Quarterly monitoring will continue in 26 existing wells upgradient, within, and downgradient of the Solar Evaporation Ponds (Plate E-4, Tables E-8 and E-9).

- Twenty-one new wells will be installed upgradient, within, and downgradient of the solar ponds to further assess the extent of ground-water contamination (Plate E-4, Tables E-8 and E-9). Wells SEP-1, SEP-4, SEP-6, SEP-8, SEP-10, SEP-11, SEP-13, SEP-15, and SEP-20 will be completed in surficial materials to evaluate the extent of alluvial saturation as well as ground-water quality. Wells SEP-2, SEP-3, SEP-5, SEP-7, SEP-9, SEP-12, SEP14, and SEP-21 will be completed in weathered claystone to evaluate the extent of saturation and water quality in the weathered bedrock. The remaining

TABLE E-8
SOLAR EVAPORATION PONDS ASSESSMENT MONITORING SYSTEM

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Purpose
EXISTING MONITORING WELLS				
16-86	Bedrock	39.06-45.06	45.06	Monitor ground-water quality and water levels in bedrock sandstone.
17-86	Alluvium	3.73-13.98	13.98	Monitor ground-water quality and water levels at alluvial water table.
18-86	Alluvium	3.74-7.50	7.50	Monitor ground-water quality and water levels in saturated alluvium.
25-86	Bedrock	59.90-82.00	82.00	Monitor ground-water quality and water levels in bedrock sandstone.
26-86	Alluvium	3.75-11.00	11.00	Monitor ground-water quality and water levels at alluvial water table.
29-86	Alluvium	2.83-8.77	8.77	Monitor ground-water quality and water levels at alluvial water table.
38-87	Alluvium	3.50-9.27	9.50	Monitor ground-water quality and water levels at alluvial water table.
PROPOSED UPGRADIENT ASSESSMENT MONITORING WELLS				
SEP-1	Alluvium	3-8	8	Monitor ground-water quality and water levels in alluvium.
SEP-2	Bedrock	9-19	19	Monitor ground-water quality and water levels in subcropping sandstone.
SEP-15	Alluvium	3-20	20	Monitor ground-water quality and water levels in alluvium.
SEP-20	Alluvium	3-8	8	Monitor ground-water quality and water levels at alluvial water table.
SEP-21	Bedrock	9-19	19	Monitor ground-water quality and water levels in weathered claystone.
PROPOSED ASSESSMENT MONITORING WELLS				
SEP-3	Bedrock	14.5-21.5	21.5	Monitor ground-water quality and water levels in weathered claystone.
SEP-4	Alluvial	5-14	14	Monitor ground-water quality and water levels in alluvium; sidegradient plume delineation.
SEP-5	Bedrock	15-25	25	Monitor ground-water quality and water levels in weathered claystone.
SEP-6	Alluvium	3-8	8	Monitor ground-water quality and water levels in alluvium.
SEP-7	Bedrock	9-19	19	Monitor ground-water quality and water levels in weathered claystone.
SEP-8	Alluvium	14-19	19	Monitor ground-water quality and water levels in alluvium; sidegradient plume delineation.
SEP-9	Bedrock	20-30	30	Monitor ground-water quality and water levels in weathered claystone.
SEP-10	Alluvium	3-16	16	Monitor ground-water quality and water levels in alluvium; sidegradient plume delineation.
SEP-11	Alluvium	3-7	7	Monitor ground-water quality and water levels in alluvium at center of plume.
SEP-12	Bedrock	8-18	18	Monitor ground-water quality and water levels in weathered claystone.
SEP-13	Alluvium	2.5-4	4	Monitor ground-water quality and water levels in alluvium; plume delineation.
SEP-14	Bedrock	10-20	20	Monitor ground-water quality and water levels in weathered claystone; plume delineation.
SEP-16	Bedrock	5-25	25	Monitor ground-water quality and water levels in subcropping sandstone.
SEP-17	Bedrock	2-15	15	Monitor ground-water quality and water levels in subcropping sandstone.
SEP-18	Bedrock	10-13	13	Monitor ground-water quality and water levels in subcropping sandstone.
SEP-19	Bedrock	11-35	35	Monitor ground-water quality and water levels in subcropping sandstone.

NOTE: (1) Depth in feet.
(2) Anticipated depths shown for proposed wells.

TABLE E-9
SOLAR EVAPORATION PONDS ASSESSMENT MONITORING WELLS

Well Number	Zone of Completion	Screen Depth	Total Depth of Well	Bedrock Lith. at Contact	Bedrock Depth from Ground Surf.	Approx. Elev. Top Bedrock	Approx. GW Elevation	Sat. Alluv. Thickness
EXISTING MONITORING WELLS								
16-86	Bedrock	39.06-45.06	45.06	Claystone (W)	7.0	5858	5861	-
17-86	Alluvium	3.73-13.98	13.98	Claystone (W)	12.5	5856	5863	7
18-86	Alluvium	3.74-7.50	7.50	Claystone (dry)	8.0	5883	dry	dry
25-86	Bedrock	59.90-82.00	82.00	Claystone (NW)	17.0	5957	5936	-
26-86	Alluvium	3.75-11.00	11.00	Sand + Clay (W)	9.5	5964.5	5966	2.5
29-86	Alluvium	2.83-8.77	8.77	Claystone (W)	8.7	5949	dry	dry
38-87	Alluvium	3.50-9.27	9.50	Claystone (W)	7.50	5964	dry	dry
PROPOSED UPGRADIENT ASSESSMENT MONITORING WELLS								
SEP-1	Alluvium	3-8	8	Claystone (W)	8	5970	-	-
SEP-2	Bedrock	9-19	19	Claystone (W)	8	5970		
SEP-15	Alluvium	3-20	20	Claystone (W)	20	5880	5900	20
SEP-20	Alluvium	3-8'	8	Claystone (W)	8	5970		
SEP-21	Bedrock	9-19'	19	Claystone (W)	8	5970		
PROPOSED ASSESSMENT MONITORING WELLS								
SEP-3	Bedrock	14.5-21.5	21.5	Sand + Claystone	9.5	5967	-	-
SEP-4	Alluvial	5-14	14	Claystone	14	5953	5958	5
SEP-5	Bedrock	15-25	25	Claystone	14	5953	-	-
SEP-6	Alluvium	3-8	8	Claystone	4	5954	5958	4
SEP-7	Bedrock	9-19	19	Claystone	4	5954	-	-
SEP-8	Alluvium	14-19	19	Claystone	19	5915	5915	dry
SEP-9	Bedrock	20-30	30	Claystone	19	5915	-	-
SEP-10	Alluvium	3-16	16	Claystone	16	5835	5846	11
SEP-11	Alluvium	3-7	7	Claystone	7	5870	(5862)	dry
SEP-12	Bedrock	8-18	18	Claystone	7	5870	-	-
SEP-13	Alluvium	2.5-4	4	Claystone	4	5848	5852	4
SEP-14	Bedrock	10-20	20	Claystone (W)	10	5855	-	-
SEP-16	Bedrock	5-25	25	Sandstone	5	5942	-	-
SEP-17	Bedrock	2-15	15	Sandstone	1	5957	-	-
SEP-18	Bedrock	10-13	13	Sandstone	9.5	5963	-	-
SEP-19	Bedrock	12-35	35	Sandstone	11	5969	-	-

NOTE: (1) "W" Indicates bedrock is weathered.
(2) "NW" Indicates bedrock is not weathered.
(3) All depths in feet; elevation in feet above mean sea level.
(4) Anticipated depths and elevations shown for proposed wells.
(5) "-" Indicates that value is unknown.

four wells (SEP-16, SEP-17, SEP-18, and SEP-19 will be completed in known subcropping Arapahoe sandstones. These wells are located within the waste management area to detect contaminated ground water as it enters the bedrock sandstones.

- The proposed wells will be constructed according to the procedures described in Section E-6(a)(4).

- Ground-water elevation will be measured, the wells will be sampled and the samples analyzed on a quarterly basis. The procedures described in Section E-6(b) will be followed for determining ground-water elevations and for ground-water sampling and analysis.

- Tables E-8 and E-9, Sections E-2c(2) and E-6 satisfy the requirement that a specific plan be submitted for an assessment ground-water system, including the number, location and depth of wells; the sampling and analytical methods for those hazardous wastes or hazardous waste constituents in the facility, an evaluation of procedures, and a schedule of implementation (6 CCR 1007-3 and 40 CFR Parts 265.93(d)(3), 265.90(d)(1)).

- The ground-water plan will be implemented immediately, and at a minimum, the rate and extent of migration of the hazardous constituents in the ground-water, and the concentrations of the hazardous constituents in ground-water will be determined. As described in Section E-6d, four quarters of data will be collected, and within fifteen days after the evaluation of the data, a written ground-water quality assessment report including the results of the determinations will be submitted to the Regional Administrator (6 CCR 1007-3 and 40 CFR 265.90(d)(4), 265.90(d)(5), 265.93(d)(4), and 265.93(d)(5)). It is anticipated that the data evaluation will be completed for the March 1, 1990 annual report.

- The rate and extent of migration of the hazardous constituents, and the concentrations of the hazardous constituents, as specified in 265.93(d)(4) will be determined on a quarterly basis until final closure of the facility (6 CCR 1007-3 and 40 CFR 265.90(d)(4)).

- Recordkeeping and reporting requirements must comply with Part 265.94(b) (6 CCR 1007-3 and 40 CFR 265.90(d)(5)). The records of the analyses and evaluations specified in the plan must be kept throughout the post-closure care period (6 CCR 1007-3 and 40 CFR 264.94(b)(1)).

E-2c(5) Ground-Water Quality Evaluation Procedures

The interim status alternate and assessment monitoring programs, regulated under 6 CCR 1007-3 and 40 CFR Part 265, have been designed to evaluate each unit in compliance with applicable aspects of Part 264 detection and compliance monitoring programs. Section E-6 provides the quality assurance/quality control (QA/QC) requirements, methods for establishing background ground-water conditions, and data evaluation procedures to be used in the interim status alternate and assessment monitoring programs.

E-3 GENERAL HYDROGEOLOGIC INFORMATION

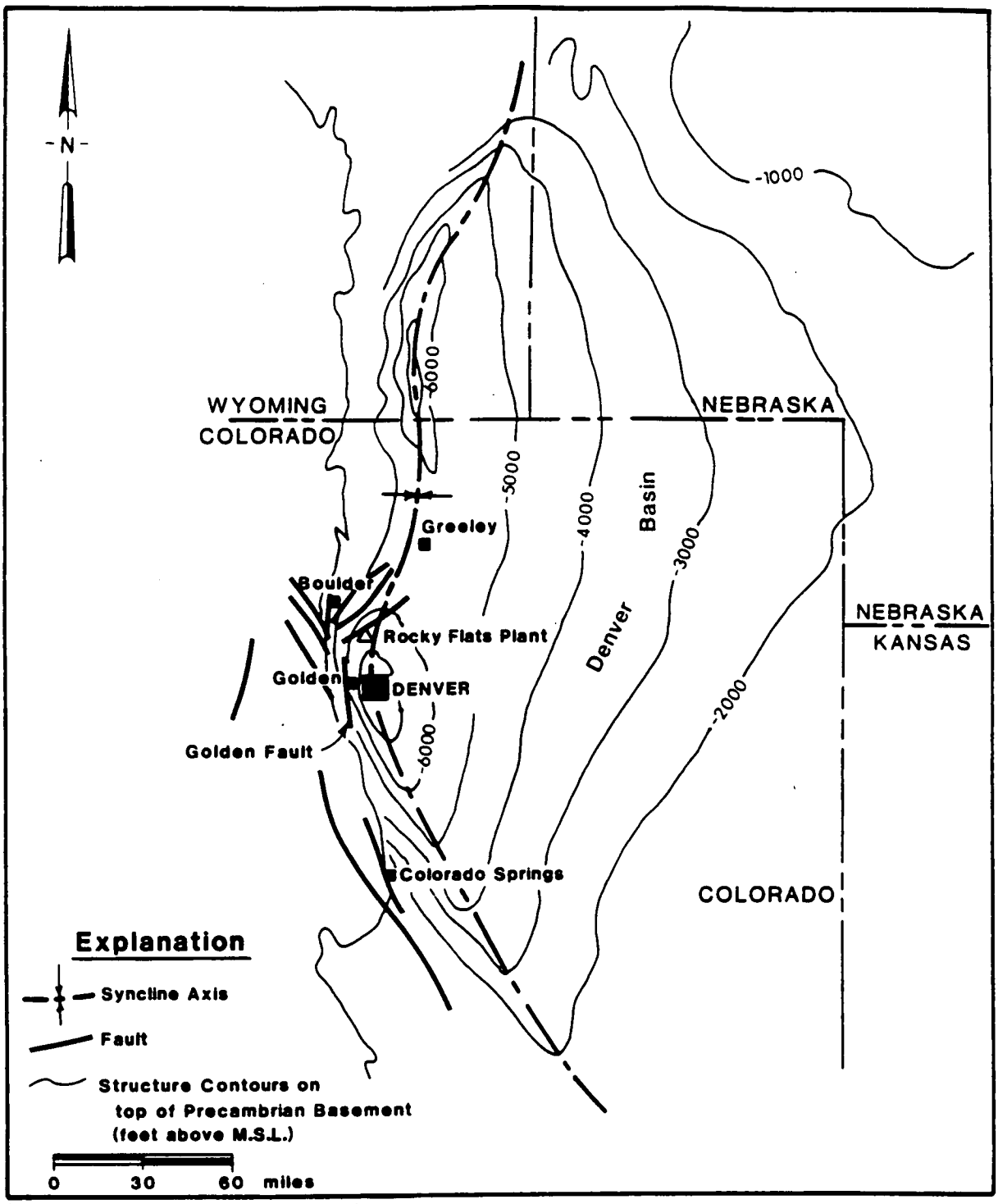
E-3a Introduction

This section describes the hydrogeologic setting of the Rocky Flats Plant and associated regulated units. The geologic materials in the vicinity of the Plant are described together with their hydrologic properties. In accordance with 6 CCR 100.41(c)(2) and 40 CFR 270.14(c)(2), this section presents for each regulated unit an identification of the uppermost aquifer. Descriptions of ground-water flow directions and rates are also presented below.

E-3b Regional Geology

This section describes the regional geologic and stratigraphic history in the vicinity of the Plant, including the Denver Basin.

The Rocky Flats Plant is located on the northwestern flank of the Denver Basin; the Plant is underlain by about 12,000 feet of Paleozoic and Mesozoic sedimentary rocks (Hurr, 1976). The Denver Basin is an asymmetric syncline that formed during the Late Cretaceous Laramide Orogeny. The western limb of the basin dips steeply to the east, and the eastern limb dips gently to the west (Figure E-1).



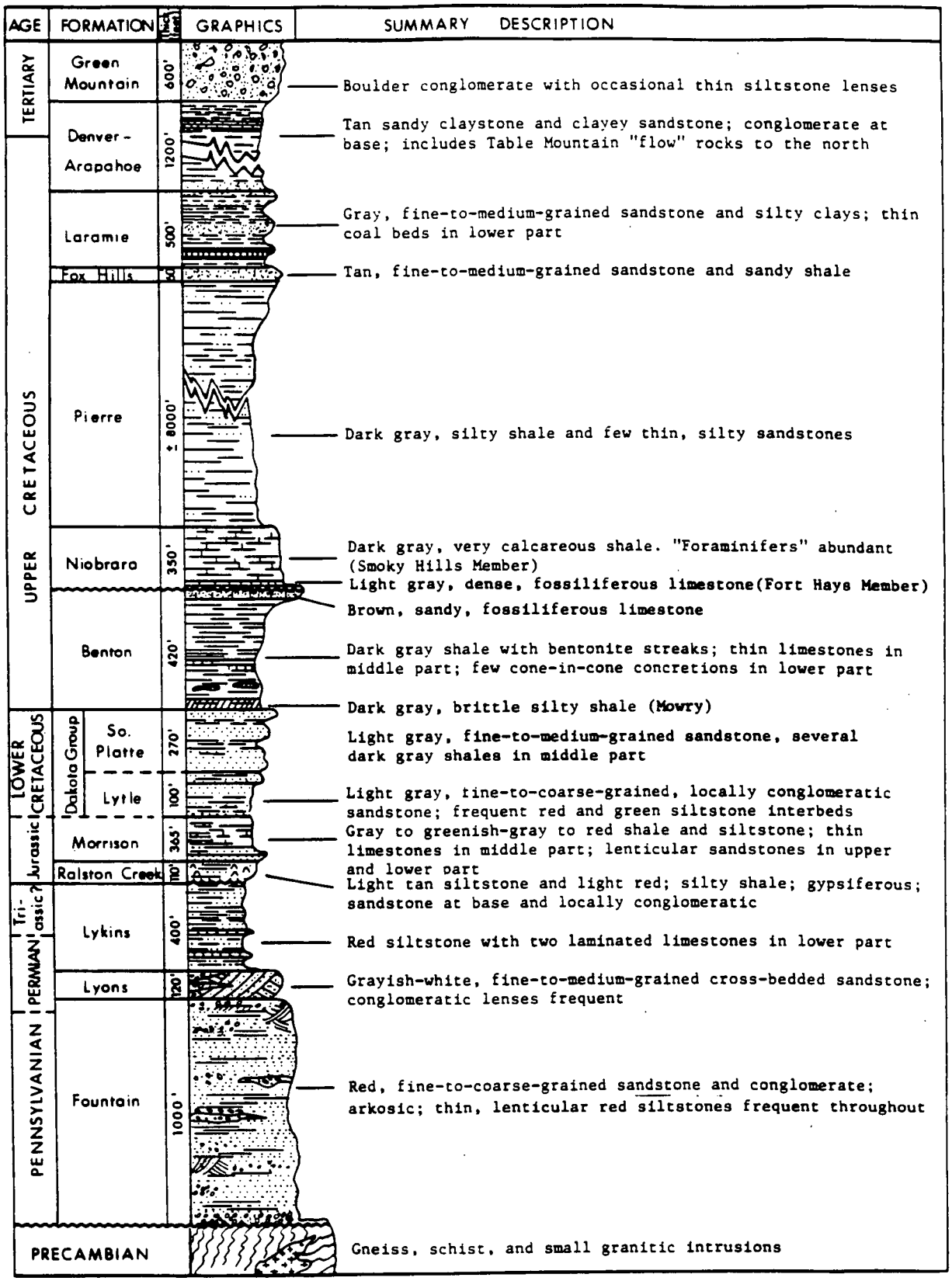
(after: Rockwell International, 1986a)

Figure E-1: STRUCTURE OF THE DENVER BASIN

The geologic history of northeastern Colorado involves several episodes of mountain building and oceanic transgression and regression, resulting in the deposition of thousands of feet of sedimentary rock on top of the Precambrian basement. This section describes the geologic history beginning with Precambrian time. Geologic descriptions of the various units are provided within this context. More detailed descriptions of the units present on site are provided in Section E-3d.

Early Precambrian tectonic, metamorphic, and plutonic igneous activity created a complex fabric in the basement rock of Colorado (Grose, 1972). The Precambrian units were covered by marine and continental sedimentation during the lower Paleozoic (carbonate and siliciclastic rock units were deposited unconformably on the Precambrian basement). Most of these units were later eroded by multiple Paleozoic diastrophisms, thus removing Cambrian to Mississippian rocks from the Denver Basin area (Kent, 1972).

Middle Pennsylvanian orogenic activity formed the Ancestral Rockies, and the Fountain Formation was deposited unconformably on the uplifted Precambrian basement (Figure E-2). The Fountain Formation contains coarse clastics derived from the erosion of the Ancestral Rockies and deposited as alluvial fans along a continental margin (Martin, 1965). The result was nonmarine sedimentation that occurred in northeastern Colorado from the Triassic to early Cretaceous. This sedimentation deposited a



(after: LeRoy and Weimer, 1971)

Figure E-2: GENERALIZED STRATIGRAPHIC SECTION, Golden-Morrison Area

sequence of aeolian, fluvial-deltaic, and lacustrine units known as the Lyons, Lykins, Ralston Creek, Morrison, and Dakota Formations (Figure E-2) (Kent, 1972).

The Pierre Shale, consisting of more than 5,600 feet of shales and siltstones, was deposited in the final phases of oceanic sedimentation. The sedimentation resulted from the last oceanic transgression occurring 100 million years ago during the late Cretaceous. This transgression formed an epicontinental sea called the Cretaceous Seaway that covered the eastern portions of New Mexico, Colorado, and Wyoming.

Following deposition of the Pierre, the ocean began to regress and deposition of the Upper Cretaceous Fox Hills and Laramie Formations occurred. These formations contain sandstones, siltstones, claystones, and coals deposited in fluvial-deltaic and lacustrine environments (Weimer, 1973). Deposition of the Laramie was influenced and then stopped by the Laramide Orogeny, a major mountain building event that began in the late Cretaceous and caused uplift of the Colorado Front Range Mountains and the eastward tilting of the Denver Basin.

The Upper Cretaceous Arapahoe Formation was deposited on an erosional surface marking the end of deposition of the Laramie. Major uplift of the Front Range and downwarp of the Denver Basin continued during deposition of the Arapahoe Formation. Coarse pebble conglomerate lenses deposited in alluvial fans commonly occur in the Lower Arapahoe; however, conglomerate lenses have

not been found at Rocky Flats Plant. Claystone and sandstone units flank and top the alluvial fan deposits (Weimer, 1973).

The Denver Formation was deposited above the Arapahoe and is over 600 feet thick. This formation contains a variety of lithologies including siltstones, arkoses, conglomerates, and basalt flows (near Golden, Colorado) (Robson, 1987).

The Dawson Formation was deposited above the Denver in a similar geologic environment during the late Cretaceous and early Tertiary. Robinson (1972) described the Dawson Formation as a stratigraphic equivalent to the Denver Formation in southern portions of the Denver Basin. However, Robson (1987) mapped the Dawson as a separate, younger (Tertiary) formation occurring above the Denver. The Dawson is up to 600 feet thick and consists of conglomerates, sandstones, and shales (Robson, 1987).

The Tertiary Green Mountain Conglomerate was deposited unconformably on the Denver Formation, and consists of conglomerates, sandstones, siltstones, and claystones deposited by a local fluvial system that occurred only in the Golden, Colorado, area. This unit is only found capping Green Mountain, approximately 15 miles south of Rocky Flats Plant (Costa and Bilodeau, 1982).

The Rocky Flats Alluvium was deposited on top of a major erosional surface that developed in late Tertiary time. Before deposition of the Rocky Flats Alluvium, both the Dawson and

Denver Formations were completely removed by erosion. The Green Mountain Conglomerate may never have been deposited at the site, but if it was, it also was removed by erosion. The Rocky Flats Alluvium contains boulders, cobbles, gravels, sands, silts, and clays deposited in alluvial fans at the base of the Colorado Front Range Mountains (Hurr, 1976).

Following deposition of the Rocky Flats Alluvium, the material was partially removed by erosion and the resulting drainages repeatedly infilled with more recent sediments. The Verdos Alluvium and the younger Slocum Alluvium are the result of drainage infilling associated with glacial activity. Similar processes are occurring now with an active valley fill alluvium in the stream channels and a recent but stable terrace above the valley fill.

E-3c Regional Ground-Water Hydrology

The Denver ground-water basin underlies a 6,700 square mile area extending from the Front Range on the west to near Limon, Colorado on the east and from Greeley on the north to Colorado Springs on the south. The four major bedrock aquifers occurring in the basin from deepest to shallowest are the Laramie-Fox Hills, the Arapahoe, the Denver, and the Dawson. The Pierre Shale underlies these units and is considered the base of the bedrock aquifer system due to its great thickness (up to 8,000

feet) and its low permeability (Robson and others, 1981a).

Presented below are discussions of the two Denver Basin bedrock aquifers which occur beneath Rocky Flats Plant - the Laramie-Fox Hills and the Arapahoe. The Denver and Dawson do not occur in the vicinity of Rocky Flats Plant.

E-3c(1) Laramie-Fox Hills

The Laramie-Fox Hills Aquifer is composed of the upper sandstone and siltstone units of the Fox Hills Formation and the lower sandstone units of the Laramie Formation. The thickness of the aquifer ranges from zero near the aquifer boundaries to 200 to 300 feet near the center of the basin. The upper Laramie coals and claystones separate the Laramie-Fox Hills sandstones from the overlying Arapahoe sandstones (Robson and others, 1981b).

There are three primary methods of ground-water recharge to the Laramie-Fox Hills. In outcrop and subcrop areas recharge occurs as infiltration of incident precipitation and as infiltration from alluvial materials. However, Robson (1987) reports that recharge to the Laramie-Fox Hills from the overlying Arapahoe is negligible because of its thickness and low permeability.

On a regional scale ground-water in the Laramie-Fox Hills flows from outcrop recharge areas toward the center of the basin and discharges to remote stream valleys. In addition, ground water discharges to pumping wells in the basin (Robson and others,

1981b). In the vicinity of Rocky Flats Plant ground-water flow is generally from the west to the east (Figure E-3).

E-3c(2) Arapahoe Aquifer

The Arapahoe Aquifer is defined as the saturated portion of the Arapahoe Formation by Robson and others (1981a). The Arapahoe Formation consists of a 400 to 700 foot thick sequence of interbedded claystones, siltstones, sandstones, and conglomerates with claystones and shale being more prominent in the northern third of the basin (Robson and others, 1981a). Individual sandstone beds are commonly lens shaped and range from a few inches to 30 to 40 feet in thickness (Robson and others, 1981b). Beneath the Plant the majority of ground-water flow in the Arapahoe is in the lenticular sandstones contained within the claystones (Rockwell International, 1986a).

Recharge to the Arapahoe occurs by the same mechanisms as those described for the Laramie-Fox Hills. In outcrop and subcrop areas, recharge occurs from infiltration of incident precipitation and as infiltration of water from alluvial materials. However, on a regional scale the primary recharge mechanism for the Arapahoe is leakage from the overlying Denver (Robson and others, 1981a).

Ground-water flow in the Arapahoe is from recharge areas at the edges of the basin toward discharge areas along incised stream valleys. Ground-water is also discharged to pumping wells

(Robson and others, 1981a). Ground-water flow in the vicinity of Rocky Flats Plant is from west to east toward the area of regional discharge along the South Platte River (Figure E-4).

E-3d Plant Site Geology

Presented in this section are discussions of bedrock and surficial geology of the Rocky Flats Plant.

Bedrock Geology

Bedrock units mapped at the Plant (Plate E-5) consist of the Pierre Shale, the Fox Hills Sandstone, the Laramie Formation and Arapahoe Formation. These are shown in a generalized cross section in Figure E-5. Because of the thickness (750 to 800 feet) and low permeability of the Upper Laramie, it is considered to be the base of the hydrologic system which could be affected by Plant operations (Hurr, 1976). The Laramie and overlying Arapahoe Formations are described below.

Laramie Formation

The Laramie Formation is a fluvial sequence of sandstones, siltstones, claystones, and coals, which is subdivided into two major lithologic units: a lower sandstone unit and an upper claystone unit. The lower sandstone unit is exposed in clay pits west of the Plant, and the upper claystone unit was observed in outcrop and in cores of several 1986 monitor wells west of the

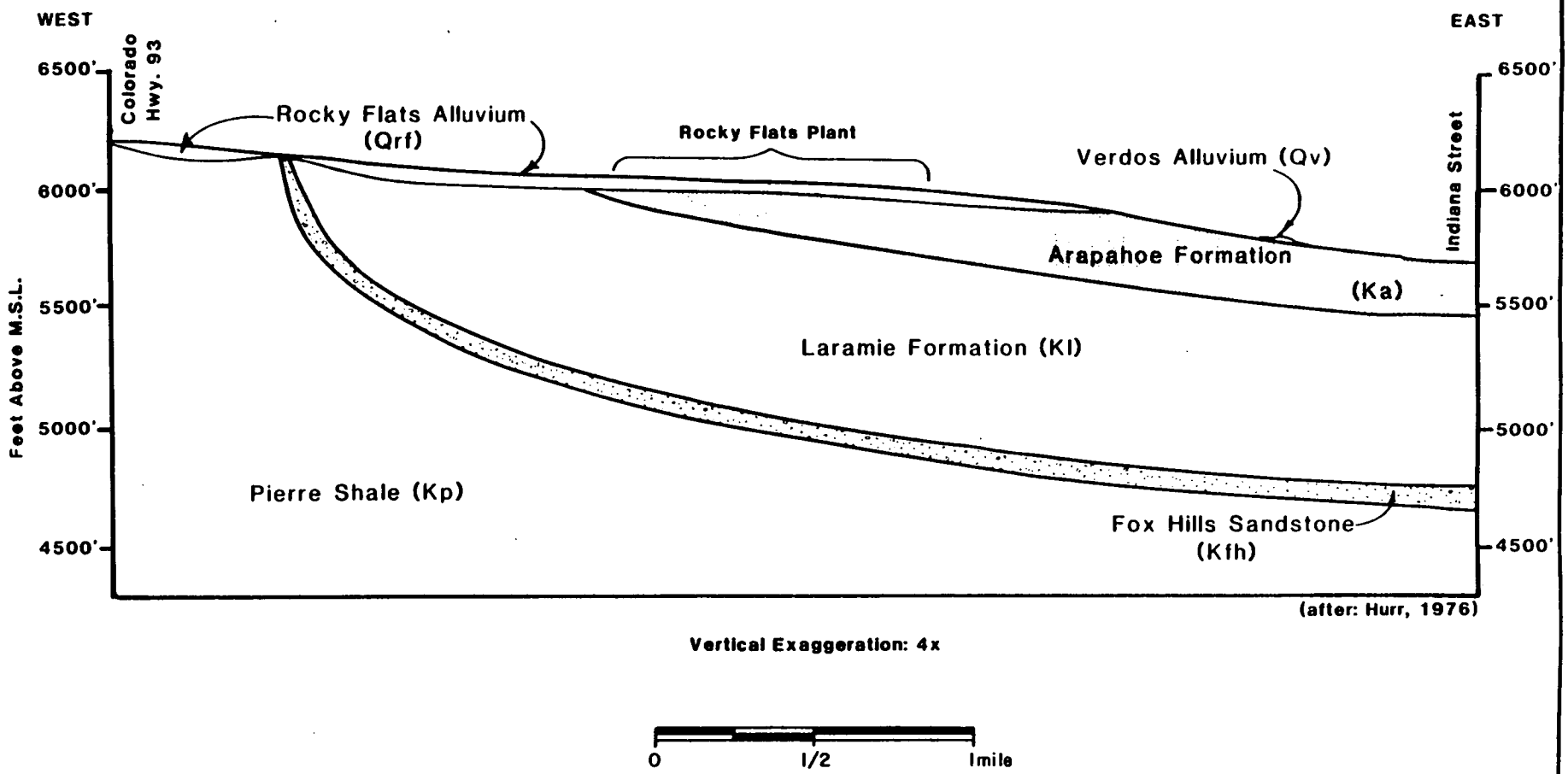


Figure E-5: GENERALIZED CROSS SECTION OF ROCKY FLATS PLANT

Plant. The descriptions presented below are taken from Rockwell International (1986b).

Lower Sandstone Unit: The lower sandstone unit consists of light to medium gray, very fine- to medium-grained, well sorted, subrounded to subangular quartzose sand with up to 25 percent lithic fragments. Sandstones are typically fair to poorly indurated and cemented with silica. Individual sandstone beds are 5 to 15 feet thick and are interbedded with white to light gray claystones. The claystones are organic-rich and kaolinitic and have been mined from the clay pits west of the plant. Individual claystone beds are 10 to 15 feet thick. Sedimentary structures observed in outcrop include planar, angular, and trough crossbeds, load structures, fluid escape structures, and ripple marks. Plant fossil casts and molds of branches, stems, and leaves are concentrated along bedding planes. The contact between the lower sandstone unit and the upper claystone unit is gradational and was selected where thick sandstone beds and kaolinite-rich claystones are less abundant.

Upper Claystone Unit: The upper claystone unit consists primarily of dark olive gray (5 Y 2/1) (GSA Rock Color Chart), poorly indurated claystones. Upper Laramie claystones generally weather to a light olive gray (5 Y 4/1) and may have dark yellowish orange (10 YR 6/6) iron staining along bedding planes and secondary fractures. These

claystones appear quite similar to Arapahoe claystones in outcrop.

Thin sandstone lenses (less than three feet thick) also occur in the upper Laramie. These sandstones are typically yellowish gray (5 Y 8/1), fine- to very fine-grained, well sorted, subangular, and calcareous. Core data (well 50-86) indicate that thin beds of white, kaolinite-rich claystone typical of the Lower Laramie occur in the Upper Laramie as well.

The contact between the Upper Laramie claystones and the Lower Arapahoe sandstones is gradational and was selected using core data. The contact was picked below the first Arapahoe sandstone greater than five feet thick (Rockwell International, 1986b). This is consistent with the stratigraphic horizon picked as the base of the Arapahoe Formation at Rocky Flats Plant by Hurr (1976, 1985).

Arapahoe Formation

The Arapahoe Formation consists of fluvial claystones with interbedded lenticular sandstones and siltstones. Contacts between these lithologies are both sharp and gradational. The claystones are olive gray (5 Y3/2) to dark gray (N 3/0), poorly indurated, silty, and contain up to 15 percent organic material. Weathering has penetrated from 10 to 40 feet into bedrock. The weathered claystone is light olive gray, blocky, slightly

fractured, and has iron staining as mottles and along bedding planes and fractures (Rockwell International, 1986b).

Sandstones in the Arapahoe Formation are light gray (N 6/0) to yellowish gray (5 YR 8/1), very fine- to medium-grained, with approximately 15 percent silt and clay. The sandstones are lenticular, discontinuous, and stratigraphically complex. The sand grains are subangular to subrounded and are predominantly quartzose with 10 percent lithic fragments. The sandstones are poorly to moderately cemented and exhibit ripple marks, load casts, and planar, angular, and trough crossbedding. Arapahoe Formation siltstones exhibit the same coloration, constituents, bedding characteristics, and sedimentary structures as the sandstones; however, they consist predominantly of silt-sized particles (Rockwell International, 1986b).

Bedrock Structure

The general bedrock structure of the area is north-striking sedimentary beds with dips to the east away from the Front Range Monocline. Dips are quite steep west of the Plant in the Fox Hills Sandstone and Laramie Formation (on the order of 50 degrees or greater). These units are flanked on the west by Precambrian terrain of the Front Range Uplift and on the east by gently dipping sedimentary beds of the Denver Basin. However, because the axis of the monocline onto the Front Range appears to be inclined to the east, dips become rapidly more gentle, on the

order of 7 to 15 degrees beneath the Plant itself (Rockwell International, 1986b).

The majority of the displacement on the Golden Fault, the uplift of the Front Range and subsidence of the Denver Basin, occurred during the late Cretaceous to early Eocene Laramide Orogeny about 40 to 70 million years ago (Martin, 1965). Erosion during the Laramide Orogeny is believed to have kept pace with uplift and the Front Range probably never stood very high above the Denver Basin during the orogeny. By the late Eocene, an erosional surface of low relief covered much of the Rocky Mountain Region.

The mountains west of the Rocky Flats Plant is the result of Post-Laramide tectonics and erosion. About 5,000 to 10,000 feet of uplift has taken place in the Rocky Mountain Region since the early Miocene about 25 million years ago. Late Tertiary block faulting is believed to have accompanied the regional uplift as indicated by apparent displacements of the late Eocene erosional surface (Scott, 1975 and Epis and Chapin, 1975). There is some evidence that block faulting has continued into the Quaternary (Scott, 1970; Whitkind, 1976; and Kirkham and Rogers, 1981).

In 1981, extensive studies were done to evaluate the Quaternary history of the Golden Fault and other faults at the Rocky Flats Plant and vicinity (Dames and Moore, 1981). The Golden Fault studies did not produce any evidence of tectonic activity along the Golden Fault within the past 500,000 years, and the fault

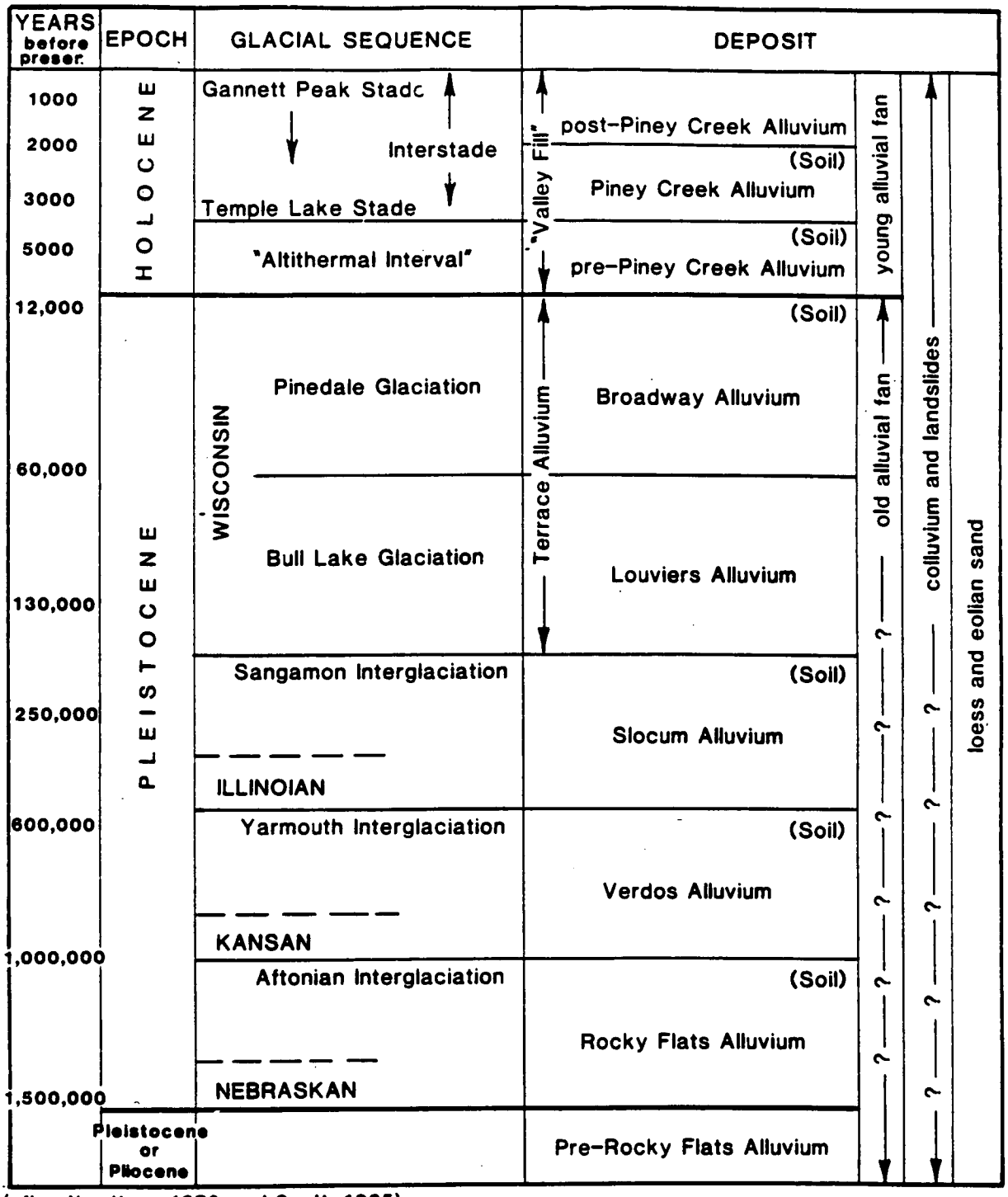
does not have surficial expressions characteristic of geologically young fault zones.

Hurr (1976) showed a fault crossing the eastern edge of the Plant, based on a series of bedding irregularities that appeared to be an extension of the previously mapped Eggleston Fault (northwest of the site). Further investigations of the feature (Dames and Moore, 1981) revealed that it is probably a penecontemporaneous growth fault attributed to slumping of the unconsolidated Arapahoe Formation before burial and lithification. The Denver Basin has been tectonically stable for about 28 million years with the exception of a series of earthquakes associated with waste injection at the Rocky Mountain Arsenal in the 1960s and possible surface rupture on the Golden Fault approximately 600,000 years ago (Kirkham and Rogers, 1981).

Plant Surficial Geology

There are six distinct Quaternary unconsolidated units of surficial materials in the vicinity of the Plant: Rocky Flats Alluvium, Verdos Alluvium, Slocum Alluvium, terrace alluvium, valley fill alluvium, and colluvium (Figure E-6 and Plate E-6).

The Rocky Flats Alluvium is topographically the highest and the oldest of the alluvial deposits. The alluvium unconformably overlies the Laramie and Arapahoe Formations in the vicinity of the Plant. The deposit is a series of laterally coalescing alluvial fans deposited by streams (Hurr, 1976). The fans were



(after: Van Horn, 1976, and Scott, 1965)

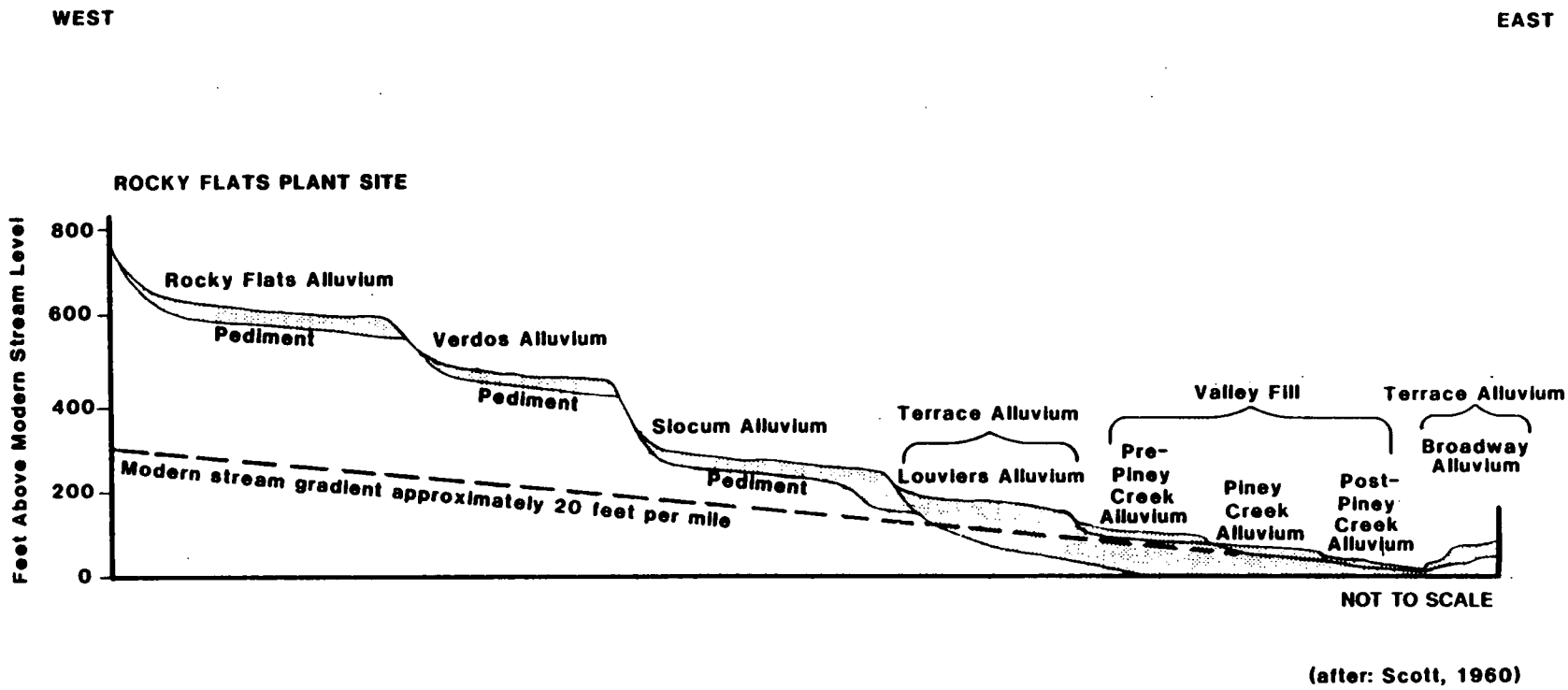
Figure E-6: SURFICIAL ALLUVIAL DEPOSITS IN THE ROCKY FLATS AREA

deposited on an erosional surface cut into the bedrock units, including channelization around the hogbacks of the lower Laramie.

The alluvium consists of sand, clay, silt, gravel, cobble, and occasional boulder deposits. Locally, the alluvium is cemented with calcium carbonate in the form of caliche. Color of the alluvium is pale to dark yellowish brown. The sands range from very fine-grained to medium-grained and poorly to moderately sorted. The thickness of the alluvium is variable due to deposition on an erosional surface and recent erosional processes. The alluvium is thickest to the west of the Plant, where less has been eroded, and thinnest to the east of the Plant (Rockwell International, 1986b).

Various alluvial deposits occur topographically below the Rocky Flats Alluvium in the drainages and include the Verdos, Slocum, terrace, and valley fill alluviums and colluvium (Figure E-7). These deposits are primarily composed of reworked Rocky Flats Alluvium with the addition of some bedrock material. Each unit is described below.

The Verdos Alluvium occupies a topographic position about 0 to 100 feet below the adjacent top of the Rocky Flats Alluvium. The Verdos was deposited around the periphery of the present extent of the Rocky Flats Alluvium as fans and channel filling derived by erosion of the older Rocky Flats Alluvium. The maximum



(after: Scott, 1960)

Figure E-7:
EROSIONAL SURFACES AND ALLUVIAL DEPOSITS EAST OF THE FRONT RANGE, COLORADO

thickness is about 40 feet, occurring as terraces in valleys east of the Plant. The alluvium consists of unsorted gravels, sands, and clays similar to the Rocky Flats Alluvium, but the material is whitish gray in color (Rockwell International, 1986b).

The Slocum Alluvium is a poorly sorted gravel deposit containing much sand, silt, and clay derived from erosion of bedrock and the older gravel deposits. The formation has a maximum thickness in the vicinity of the Plant of about 20 feet, but is commonly 5 to 10 feet thick. It occupies a topographic position of about 150 to 300 feet below the top of the Rocky Flats Alluvium, and occurs downslope of the Verdos Alluvium in valleys east of the Plant site (Rockwell International, 1986b).

Locally, two Wisconsin-age terraces are associated with the present drainages. The terrace alluvium occurs 5 to 35 feet above recent valley floors. The alluvium is comprised of gravels, sands, and clays, derived from bedrock and reworking of older alluvial deposits. The terrace alluvium can rarely occur up to 30 feet in thickness; however, the thickness is usually around 5 feet. The alluvium occurs in valleys surrounding the Plant (Rockwell International, 1986b).

Valley fill alluvium occurs in the bottom of the present stream valleys around the Plant. The valley fill ranges from dark-brown, sandy, clayey silt to moderately sorted cobbles and small boulders, recently reworked from previously deposited alluviums. The valley fill along streams which head on the Rocky Flats

Alluvium and have not yet cut through to bedrock tends to be coarse and have little or no fine material. However, where the valley fill is deposited on bedrock, 0.5 to 2 feet of cobbly sand and gravel commonly is overlain by several feet of sandy, clayey silt (Rockwell International, 1986b). Subsequent erosion and deposition locally may have added more sand, gravel and cobbles on top of the silt, or cut through the valley fill to expose bedrock along the channel bottom (Hurr, 1976).

Colluvium, produced by mass wasting and downslope creep, collects on the sides and at the base of hills and slopes. These deposits are poorly sorted mixtures of soil and debris from bedrock clay and sand mixed with gravel and cobbles derived from the older Rocky Flats Alluvium. The colluvium consists predominantly of clay with common occurrences of sandy clay and gravel. Color is yellowish brown to dusky brown and caliche is common locally. The thickness of the colluvium ranges from 3 to 22 feet (Rockwell International, 1986b).

E-3e Plant Site Ground-Water Hydrology

There are two hydraulically connected ground-water systems at the Rocky Flats Plant. An unconfined flow system occurs in the surficial material (Rocky Flats Alluvium, disturbed ground, colluvium, and valley fill material) and in subcropping weathered Arapahoe Formation. Confined bedrock flow occurs in the underlying bedrock formations.

Unconfined Flow Systems

Recharge/Discharge Conditions

The shallow ground-water flow system occurs in the Rocky Flats Alluvium and other surficial materials under unconfined conditions. Unconfined flow also occurs in the subcropping sandstones and weathered claystones of the Arapahoe Formation where they are in good hydraulic connection with the overlying alluvial materials. This system is recharged by infiltration of incident precipitation, irrigation, and surface water diversion canals (primarily through the Rocky Flats Alluvium). In addition, the retention ponds in the various drainages recharge the valley fill alluvium.

The unconfined system appears to be quite dynamic within surficial materials, with large water level changes in response to seasonal and other stresses. Hurr (1976) describes the rapid response of water levels in wells completed in the Rocky Flats Alluvium to irrigation. Similarly, there are several 1986 and 1986 alluvial wells which contain water during the spring months (April through June) that are dry in the fall.

Ground-Water Flow Directions

As shown on Plate E-7, flow directions follow topography to the east and toward the drainages. In addition, flow directions are

controlled by the configuration of the top of bedrock beneath surficial materials (Plate E-5). The ground water in the drainages flows to the east in the valley fill materials and discharges as subsurface flow across the eastern Plant boundary during some portions of the year. In addition, water in surficial materials recharges the bedrock to some extent.

Confined Flow Systems

As discussed in Section E-3c, the upper Laramie and Arapahoe Formations are present at Plant site. The Pierre Shale underlies these units.

Recharge Conditions

The bedrock flow system is recharged primarily by downward infiltration of water from the unconfined surficial flow system to subcropping sandstones. Alluvium/bedrock well pairs throughout the Plant site indicate a downward hydraulic gradient.

Ground-Water Flow Directions

Confined ground-water flow in the Arapahoe Formation within the vicinity of the Rocky Flats Plant has been characterized as eastward by Hurr (1976). Eastward flow is consistent with the regional potentiometric map for the Arapahoe constructed by Robson (Robson et al., 1981a). No potentiometric surface has been

constructed for the Arapahoe Formation at Rocky Flats Plant. Because the Arapahoe sandstones are locally being recharged along an angular unconformity, and because these sandstones are lenticular and discontinuous, a separate potentiometric surface must be constructed for each Arapahoe sandstone.

E-3f Hydrogeology of RCRA Units

In accordance with 6 CCR 100.41(c)(2) and 40 CFR 270.14 (c)(2), the uppermost aquifer is defined and described for each of the RCRA units requiring post-closure care.

E-3f(1) Present Landfill

The hydrogeology of the Present Landfill area is detailed in the Present Landfill Hydrogeologic Characterization Report (Appendix 6 of Appendix I-3). Presented below is a summary of that characterization as it pertains to the uppermost aquifer.

E-3f(1)(a) Uppermost Aquifer Identification

The basis for this identification of the uppermost aquifer is the Present Landfill Hydrogeologic Characterization Report (Appendix 6 of Appendix I-3). Plate E-8 is a surficial geology map identifying disturbed ground, Rocky Flats Alluvium, and valley fill within the waste management area; Plate E-9 identifies subcropping Arapahoe sandstones; and Plates E-10, E-11, and E-12 locate these sandstones in cross section.

The uppermost aquifer in the Present Landfill area is comprised of the saturated surficial materials: Rocky Flats Alluvium, disturbed ground, colluvium, and North Walnut Creek valley fill alluvium. In addition the uppermost aquifer includes weathered claystones of the Arapahoe Formation which outcrop or subcrop beneath the surficial materials within the waste management area (Plate E-9). At present, no site-specific data on the extent of saturation and hydraulic conductivity of weathered claystones are available. Consequently, three wells will be installed and tested within the weathered claystone at the landfill area. Data from these wells will facilitate an assessment of the extent to which weathered claystone is a part of the uppermost aquifer.

The depth of weathering varies within the claystone subcropping under this waste management area. Table E-10 lists the depth of weathering for monitor wells within the waste management unit.

Arapahoe sandstones which potentially subcrop within the waste management unit of the Present Landfill have been encountered in wells 65-87, 8-86, 41-87, 64-87BR, and 70-87. The basis for determining which, if any, of these sandstones will be included within the uppermost aquifer, is hydraulic conductivity data.

Hydraulic conductivity data for the Present Landfill area are listed in Tables E-11, E-12, and E-13. The geometric mean for Rocky Flats Alluvium varies from 1.8×10^{-5} cm/s for

TABLE E-10

DEPTH OF WEATHERING IN THE ARAPAHOE CLAYSTONE PRESENT LANDFILL

Well Number	Depth of Weathering: Below Ground Level (ft)	Depth of Weathering: Below Bedrock (ft)
7-86*	10+	5+
8-86	13.8	12.1
59-87*	25.5+	5+
61-87*	34.1+	6.1+
62-87*	30+	3.7+
63-87*	30+	5+
64-87*	25.5+	2.3+
65-87**	26+	5+
67-87*	21.3+	4.9+
68-87*	20+	4.7+
70-87*	17+	3.5+

* Minimum Value: Weathering at total depth of well
** Minimum Value: Base of lowest described claystone

TABLE E-11

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS OF SURFICIAL MATERIALS: PRESENT LANDFILL

Well No.	Formation	Lithology Screened	Drawdown Recovery Test (cm/s)	Slug Tests (cm/s)
45-86	Q_{RF}	Sand and poorly sorted gravel	2.1×10^{-5}	
58-87	Q_{RF}	Sand, poorly sorted gravel, and clayey sand	1.6×10^{-5}	
60-87	Q_{RF}	Sand and gravel grading to clayey sand and clay		1.3×10^{-3}
61-87	Q_{RF}	Sand		9.9×10^{-4}
62-87	Q_{RF}	Sand and gravel, clayey sand and clay		6.2×10^{-4}
63-87	Q_{RF}	Sand and gravel, sandy clay		6.7×10^{-4}
65-87*	Q_{RF}, KA_{SS}	Clayey sand, sandstone		4.6×10^{-4}
66-87	Q_{RF}	Sand and sandy clay		1.8×10^{-4}
67-87	Q_{RF}	Clayey sand		6.4×10^{-5}
71-87	Q_{RF}	Clayey sand grading to sandy clay		6.6×10^{-4}
Geometric mean for Rocky Flats Alluvium			1.8×10^{-5}	4.6×10^{-4}

Q_{RF} = Rocky Flats Alluvium

KA_{SS} = Arapahoe Sandstone

Geometric mean for Q_{RF}	1.8×10^{-5}	4.6×10^{-4}

* Completed in two formations. Not used in calculation of geometric mean.

Note: To convert from cm/s to ft/year, multiply by

$$\frac{365.25 \text{ day}}{\text{year}} \cdot \frac{86400 \text{s}}{\text{day}} \cdot \frac{\text{ft}}{30.48 \text{ cm}}$$

TABLE E-12

RESULTS OF PACKER TESTS IN ARAPAHOE FORMATION PRESENT LANDFILL

Well No.	Interval (ft)	Lithology	1st P 1/3 (cm/s)	P 2/3 (cm/s)	2nd P 1/3 (cm/s)	Geometric mean (cm/s)
8-86	33.50 - 43.53	Claystone	6.90×10^{-6}	5.06×10^{-6}	3.10×10^{-6}	4.8×10^{-6}
	43.50 - 53.53	Claystone	Aborted	2.1×10^{-7}	Aborted	2.1×10^{-7}
	53.50 - 63.53	Claystone	1.13×10^{-6}	3.0×10^{-8}	Aborted	1.8×10^{-7}
		Claystone		Geometric mean for 8-86:		5.7×10^{-7}
9-86	87.64 - 97.67	Siltstone	-	1.0×10^{-8}	-	1.0×10^{-8}
	97.87 - 107.70	Siltstone	6.0×10^{-8}	3.0×10^{-8}	Aborted	4.0×10^{-8}
	107.70 - 117.93	Siltstone	-	1.0×10^{-8}	-	1.0×10^{-8}
	121.00 - 131.03	Sandstone	1.9×10^{-7}	4.0×10^{-8}	-	9.0×10^{-8}
	135.00 - 145.03	Sandstone/Siltstone				
		Siltstone		Geometric mean for 9-86:		2.0×10^{-8}
		Sandstone		Geometric mean for 9-86:		9.0×10^{-8}
41-87BR	20.85 - 30.50	Claystone	5.7×10^{-7}	1.71×10^{-6}	9.9×10^{-7}	9.9×10^{-7}
	32.50 - 42.15	Sandstone	3.5×10^{-7}	1.0×10^{-7}	2.0×10^{-8}	9.0×10^{-8}
	41.55 - 51.20	Sandstone	9.0×10^{-7}	2.46×10^{-6}	1.75×10^{-6}	1.6×10^{-6}
	53.05 - 62.70	Claystone	2.0×10^{-7}	3.9×10^{-7}	1.0×10^{-7}	2.0×10^{-7}
	62.70 - 72.35	Sandstone	4.2×10^{-7}	6.6×10^{-7}	1.70×10^{-7}	3.6×10^{-7}
	73.35 - 82.00	Claystone	9.1×10^{-7}	2.58×10^{-6}	-	1.5×10^{-6}
	82.00 - 91.65	Sandstone	5.7×10^{-7}	5.0×10^{-8}	-	1.7×10^{-7}
		Claystone		Geometric mean for 41-87BR:		6.7×10^{-7}
		Sandstone		Geometric mean for 41-87BR:		6.7×10^{-7}

TABLE E-13

RESULTS C HYDRAULIC TESTS IN ARAPAHOE FORMATION PRESENT LANDFILL

Well No.	Lithol-gy	Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test (cm/s)
8-86	Clayst e	-	-	5.7×10^{-7}
	Sandst. e	7×10^{-8}	-	
9-86	Siltst e	-	-	2.0×10^{-8}
	Sandstc e	4×10^{-8}	-	9.0×10^{-8}
41-87BR	Claystc e	-	-	6.7×10^{-7}
	Sandstc e	-	2.78×10^{-8}	3.1×10^{-7}
Geometric mean fc	laystone			6.2×10^{-7}

drawdown/recovery tests to 4.6×10^{-4} cm/s for slug tests. These values are two to three orders of magnitude in excess of the geometric mean for the unweathered claystone of the Arapahoe Formation at the Present Landfill, 6.2×10^{-7} cm/s. Arapahoe sandstones which subcrop within the waste management unit will be included in the definition of the uppermost aquifer if they exhibit a measured hydraulic conductivity in excess of one order magnitude of the geometric mean for unweathered claystones. Any Arapahoe sandstone for which hydraulic conductivity data are not available will be tested in the future and will be included in the monitoring of the uppermost aquifer if measured hydraulic conductivities exceed that of unweathered claystone.

Weathered claystone and subcropping sandstones of sufficient hydraulic conductivity are included within the definition of the uppermost aquifer because these portions of the Arapahoe Formation are more permeable than unweathered bedrock, and they are in direct contact with the saturated surficial materials of the waste management unit.

Each subcropping Arapahoe sandstone which is included in the uppermost aquifer on the above criteria shall be considered part of the uppermost aquifer to such depth where the sandstone pinches out.

Unweathered claystone is not considered a part of the uppermost aquifer because of its low hydraulic conductivity. Arapahoe

sandstones which do not subcrop beneath the surficial materials of the waste management unit are not considered a part of the overlying aquifer because of the low hydraulic conductivity claystone separating these sandstones from surficial materials.

E-3f(1)(b) Ground-Water Flow Directions and Rates in Uppermost Aquifer

Ground-Water Flow Directions

As shown in Plates E-13 and E-14, ground water flows eastwardly in the vicinity of the Present Landfill in surficial materials. This flow is primarily influenced by topography. Locally, ground-water flow is influenced by a ground-water diversion system around the western perimeter of the Present Landfill. Along the eastern end of the landfill, slurry trenches have been emplaced. These trenches may also be influencing ground-water flow; future pump tests are planned to evaluate the effectiveness of the slurry trenches as hydraulic barriers.

In order to control ground-water flow around the landfill, a two-part leachate and ground-water collection system was constructed in 1974. This system was designed to collect and divert ground-water around the outside of the landfill and to collect leachate generated in the landfill.

As shown on Plate E-12, the two-part system is approximately 24 feet in width at its base. The design drawings show the leachate collection trench (shown on Plate E-12 as "landfill trench")

approximately 12 feet in width at the bottom with side slopes of 2:1. A five-foot thick gravel blanket was placed in the bottom of the system to facilitate greater flow of leachate collected in the system. The collection system was constructed by excavating a trench around the perimeter of the solid wastes to depths of 10 to 25 feet. The ground-water collection portion of the system is located on the exterior of the excavation and is separated from the leachate collection portion of the system by a 4.5-foot wide zone of clayey soil (clayey silt/sandy clay). The clayey soil zone was designed to be extended 2 feet into bedrock in order to prevent ground-water flow into the landfill. An 8-inch perforated pipe is located on the outside of the wall immediately above the bedrock contact. Ground water flows into the pipe drain and is diverted around the landfill. A series of valves determine the discharge area for the flow.

Field reconnaissance and a review of the borehole logs, topographic maps, and previous reports have shown that the landfill wastes bury the leachate collection system and extend beyond the system (Rockwell International, 1986b). Therefore, leachate generated outside the landfill trench would be collected by the ground-water diversion system. In addition, the clay cutoff wall no longer extends to the surface of the landfill; this would allow ground water to flow across the clay cutoff wall if the water table were high enough.

The following conclusions regarding the effectiveness of the leachate/ground-water intercept system have been made based on water level and ground-water quality data.

1) The ground-water intercept system is diverting ground-water away from the west end of the landfill along cross section E-E' (Plate E-12).

2) The ground-water intercept is not diverting ground-water away from the north and south sides of the landfill along cross section D-D' (Plate E-12).

3) The clay barrier is holding ground water in the landfill along the west and north sides.

4) The clay barrier is ineffective on the south side of the landfill and is allowing contaminated ground water to leave the landfill.

5) The leachate collection system appears to function intermittently on the north side of the landfill.

The efficiency of the ground-water intercept system at the west end of the landfill is displayed in cross section E-E' (Plate E-12). Three wells (10-86, 58-87, and 59-87) are screened in the Rocky Flats Alluvium west of the ground-water intercept. The water level in well 59-87 (immediately adjacent to the intercept) is lower that those in wells 10-86 and 58-87 indicating the ground-water intercept is accepting ground water at this location. No conclusion can be drawn as to the effectiveness of the leachate collection system at this location as there is no well east of 59-87 and the intercept system.

In contrast, the water table profiles in cross section D-D' (Plate E-12) indicate ground-water is not effectively draining into the system at the north and south ends of the cross section.

There is no appreciable difference in water levels across the ground-water intercept system.

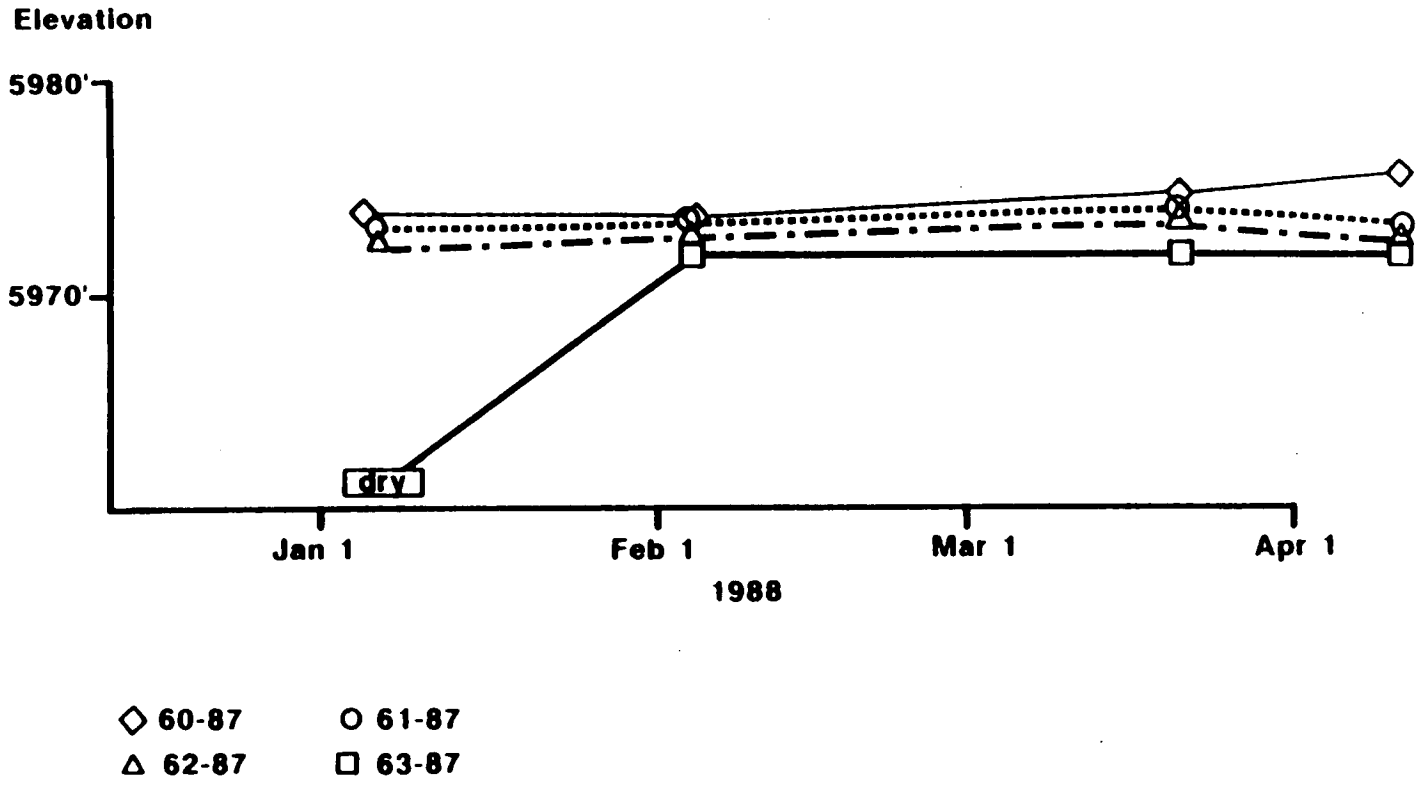
A comparison of water levels through time along the northern end of cross section D-D' (Plate E-12) suggests the clay liner and leachate collection system work intermittently. Figure E-8 presents water levels for wells along the northern half of cross section D-D' plotted by date. Water levels in well 63-87 (inside the landfill) track those in wells 60-87, 61-87, and 62-87 (outside the landfill and intercept system) for three of the four months of available data. However, in January, 1988, well 63-87 is dry, while water levels outside the landfill remain relatively constant. This indicates the clay liner is acting as a hydraulic barrier, and the leachate collection system is draining intermittently. In addition, water levels in well 62-87 (outside the interceptor system) have remained below the top of the clay liner estimated at an elevation of 5,980 feet. This further supports the contention that the barrier is effectively separating ground water inside the landfill from ground water outside the landfill. Ground-water quality data also support the conclusions that the hydraulic gradient at this location is into the landfill and that the clay barrier appears to function (Appendix 6 of Appendix I-3).

It should be noted that the above conclusions are drawn on a total of four water levels per well. Because the only significant discrepancy occurs in the first month of sampling,

Figure E-8

Elevation of Water Table for Wells 60-87 through 63-87

(Present Landfill)



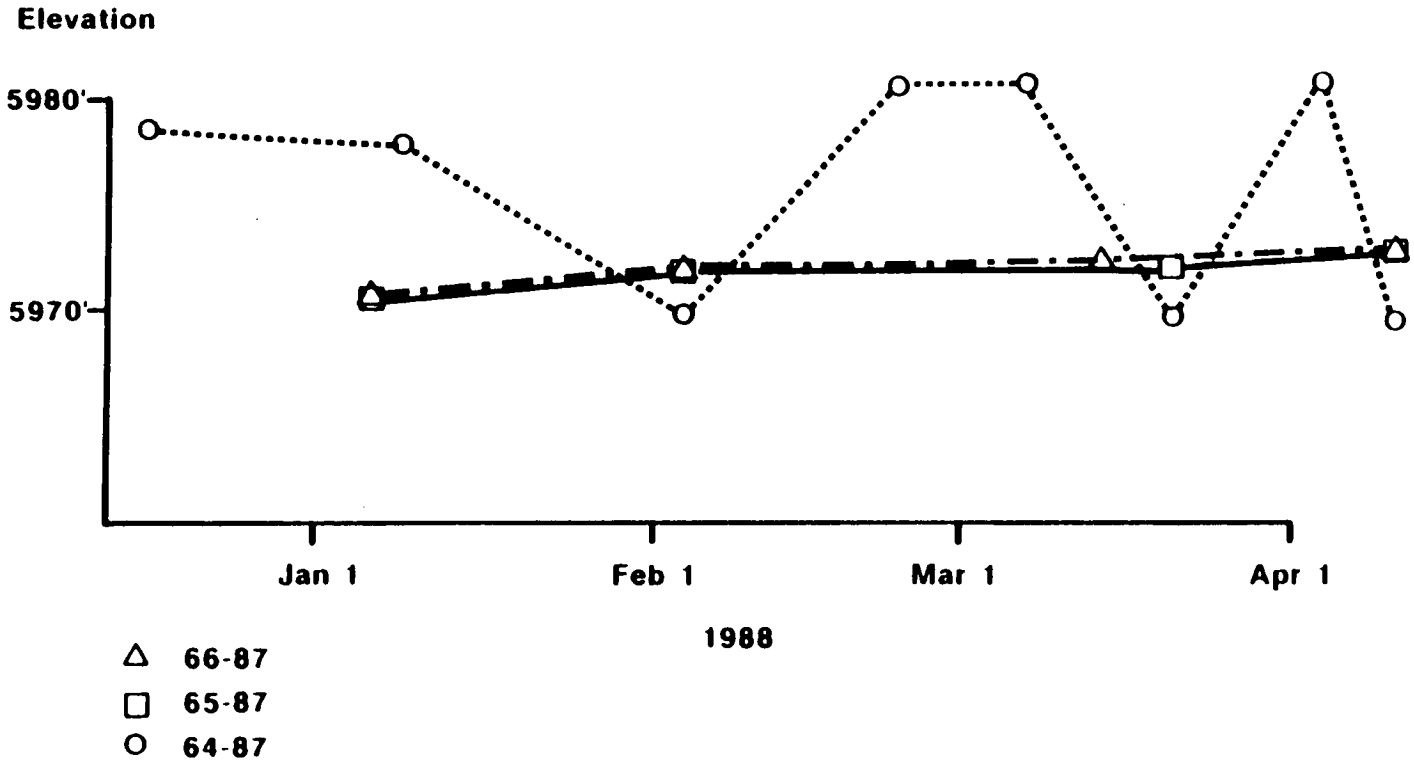
the possibility exists that this is due to an initially poor well development in 63-87; however, this is not documented.

Based on water levels in wells along the southern end of cross section D-D' (Plate E-12), the clay liner and leachate collection system at this location are not functioning properly. Figure E-9 presents water levels through time along this cross section. Water levels in well 64-87 (inside the landfill) fluctuated up to ten feet over the four month period, while water levels in wells 65-87 and 66-87 (outside the landfill) remained constant. In fact, water levels in well 64-87 exceeded those in wells 65-87 and 66-87 during January, March, and April, 1988, when water levels in 64-87 reached elevations of 5979.83, 5980.43, and 5980.63, creating the potential for ground-water flow out of the landfill toward the south. As shown in cross section D-D' (Plate E-12), well 65-87 intersected the top of the clay liner. This clay liner is associated with the clay encountered 2.5 feet below ground surface in this well. This places the elevation of the clay liner at this location at 5980.58 feet. This suggests that water elevations at well 64-87 will not exceed approximately 5981 feet in elevation because at this elevation water within the landfill will overspill the clay liner and discharge to the south across the clay liner. Ground-water quality data from wells 64-87, 65-87, and 66-87 also support the conclusion that the hydraulic gradient is away from the landfill at this location (Appendix 6 of Appendix I-3).

Figure E-9

Elevation of Water Table for Wells 64-87 through 66-87

(Present Landfill)



The determination of the ground-water flow direction within a subcropping Arapahoe sandstone requires potentiometric surface data from three wells which are not located in a straight line and which are completed within the same sandstone. This criteria is not met within the Present Landfill Area. Although as discussed below under Ground-Water Flow Rates, a vectorial component of flow to the northeast has been documented between monitor wells 65-87 and 8-86. Because sufficient data is not available to a site specific flow direction, it is assumed that ground-water flow within Arapahoe sandstones in the Present Landfill Area is eastward. Hurr (1976) characterized ground water movement in the Arapahoe Formation at the Rocky Flats Plant as eastward. Eastward flow is consistent with the regional potentiometric map for the Arapahoe constructed by Robson (Robson et al., 1981a).

Mapped water tables are presented for January and April 1988, Plates E-13 and E-14 respectively. Insufficient data precludes the construction of water-table maps prior to January 1988. The principal differences in these two water table maps occur at the western end of the landfill. Both mounding and unsaturated surficial materials are evident within the landfill in January but not in April 1988. The ground-water flow pattern outside of the landfill is very similar over this period.

Ground-Water Flow Rates

Ground-water flow rates are a function of hydraulic conductivity, hydraulic gradient, and effective porosity. Following Anderson (1979), the equation for average linear velocity in ground water is:

$$\bar{v} = K \quad i/n$$

where $\bar{v}$ = average linear velocity
K = hydraulic conductivity
n = effective porosity
i = hydraulic gradient

Hydraulic conductivities are derived from well tests as discussed in the Present Landfill Hydrogeologic Characterization Report Appendix 6 of Appendix I-3. Results of these tests are presented in Tables E-11, E-12, and E-13. No representative hydraulic gradient is available for weathered claystone or disturbed ground in the Present Landfill area.

Hydraulic gradients are derived from the April 1988 water table map of the Present Landfill area, Plate E-14. The hydraulic conductivity of the subcropping Arapahoe sandstones is estimated at 0.10 ft/ft. This is based on the April 11, 1988 water-level elevations at well 65-87 (5,972.62 ft) and well 8-86 (5,901.87 ft). Well 65-87 is completed in 11 feet of Rocky Flats Alluvium, sand to clayey sand, and in three feet of subcropping weathered Arapahoe sandstone. Well 8-86 is completed in approximately 4 feet of silty sandstone. To view the hydraulic connection between these well, refer to cross section A-A' on Plate E-10.

The difference in water elevation (70.75 ft) divided by the distance separating wells 65-87 and 8-86 (920 ft) is 0.077 ft/ft. This is the hydraulic gradient from well 65-87 to 8-86.

Effective porosity has not been measured for local strata to date. Effective porosity is assumed to be 0.1 for the purpose of ground-water flow rate calculations. Hurr (1976) assumed an effective porosity in the range 0.10 to 0.15.

The horizontal ground-water flow velocity for Rocky Flats Alluvium is estimated in the range of 11 to 90 ft/yr. A velocity of 19 ft/yr is based on a hydraulic conductivity of 1.8×10^{-5} cm/s (19 ft/yr); a velocity of 90 ft/yr is based upon a hydraulic conductivity of 4.6×10^{-4} cm/s (480 ft/yr). Both velocities are based on a hydraulic gradient of 0.060 ft/ft representative of the flow system near well 71-87 and an assumed effective porosity of 0.1.

The horizontal ground-water flow velocity for Arapahoe sandstones between well 65-87 and 8-86 is estimated at 0.040 ft/yr. This is based on a hydraulic conductivity of 5 x 10-8 cm/s (0.052 ft/yr), an average horizontal gradient of 0.077 ft/ft, and an assumed effective porosity of 0.1. No horizontal ground-water flow velocity can be estimated for weathered claystones in the Present Landfill area because a representative hydraulic conductivity for weathered claystones is unavailable.

E-3f(2) Original Process Waste Line

The geology of the Original Process Waste Lines area is detailed in the Original Process Waste Lines Geologic Characterization Report appended to this report (Appendix 4 of Appendix I-5).

E-3f(2)(a) Uppermost Aquifer Identification

The uppermost aquifer in the Original Process Waste Line area is comprised of saturated Rocky Flats Alluvium, disturbed ground, colluvium, and valley fill alluvium. There is insufficient data at this time to determine if any portion of the underlying bedrock is part of the uppermost aquifer. Additional characterization studies will be performed as part of the interim status monitoring to determine what part, if any, of the bedrock is part of the uppermost aquifer. As part of this characterization, a shallow seismic program is currently being implemented to identity the bedrock units underlying the Original Process Waste Line area.

Hydraulic conductivity data for surficial materials in the Original Process Waste Line area are presented in Table E-14. As part of the additional characterization studies to be performed as part of the interim status monitoring, three alluvial wells will be installed in surficial materials adjacent to the Original Waste Process Line to further establish site specific hydraulic conductivities.

TABLE E-14

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS OF SURFICIAL MATERIALS ORIGINAL PROCESS WASTE LINE

Well Number	Formation	Lithology Screened	Drawdown Recovery Test cm/s
17-86	Q_{VF}	Gravel	4.8×10^{-6}
22-86	Q_{RF}	Gravel	8.7×10^{-6}
26-86	Q_D	Gravel and Sand	4×10^{-8}

Q_{VF}: Valley Fill

Q_{RF}: Rocky Flats Alluvium

Q_D: Disturbed Ground

The basis for understanding the geologic framework of this area is the Original Process Waste Line Geologic Characterization Report (Appendix 4 of Appendix I-5). Plate E-15 is a surficial geology map identifying the surficial materials and outcropping Arapahoe claystones and sandstones within the waste management area; Plate E-16 identifies subcropping Arapahoe sandstones and weathered claystone; and Plate E-17 displays these sandstones in cross section.

E-3f(2)(b) Ground-Water Flow Directions and Rates in Uppermost Aquifer

As shown in the Plant wide water table map, Plate E-7, ground-water flow in surficial materials is toward the east-northeast in the Original Process Waste Line area. This flow is locally influenced by topography and the various water drainage systems throughout the Plant site. Further characterization of ground-water flow directions as well as the estimation of ground-water flow rates for the uppermost aquifer will be undertaken upon completion of the additional characterization studies being performed as part of the interim status monitoring.

E-3f(3) West Spray Field

The hydrogeology of the West Spray Field area is detailed in the West Spray Field Hydrogeologic Characterization Report (Appendix 4 of Appendix I-4). Presented below is a summary of that

characterization as it pertains to the uppermost aquifer.

E-3f(3)(a) Uppermost Aquifer Identification

The basis for this identification of the uppermost aquifer is the West Spray Field Hydrogeologic Characterization Report (Appendix 4 of Appendix I-4). Plate E-18 is a surficial geology map identifying Rocky Flats Alluvium within the waste management area; Plate E-19 identifies the subcropping Arapahoe sandstone encountered in well 48-86 within the waste management area; and Plate E-20 displays this sandstone in cross section.

The uppermost aquifer in the West Spray Field area is comprised of the saturated Rocky Flats Alluvium. Hydraulic conductivities for Rocky Flats Alluvium are presented in Table E-15. Hydraulic conductivities range from 2.1×10^{-5} to 5.3×10^{-4} cm/s.

Hydraulic conductivities for the Upper Laramie Formation are presented in Tables E-16 and E-17. Upper Laramie claystones, siltstones, and sandstones are not included within the uppermost aquifer because of the low hydraulic conductivity calculated for claystone (4×10^{-8} cm/s at well 46-86), for siltstone (1.6×10^{-7} cm/s at well 48-86), and for sandstone (6×10^{-8} at well 48-86). In order to ensure that no permeable Upper Laramie sandstone is bypassed, each Upper Laramie sandstone which subcrops within the waste management area will be tested to determine a hydraulic conductivity. Sandstones which exhibit a hydraulic conductivity in excess of the general range established for the Upper Laramie

TABLE E- 15

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN ROCKY FLATS ALLUVIUM WEST SPRAY FIELD AREA

Well	Lithology	Hydraulic Conductivities Drawdown Recovery Test (cm/s)	Slug Test (cm/s)
45-86	Gravel, sand & silt		2.1×10^{-5}
47-86	Gravel & silt	2.6×10^{-5}	
49-86	Gravel, sand & silt		9.7×10^{-5}
50-86	Gravel, sand & silt		5.3×10^{-4}
56-86	Boulders + Silt		5.0×10^{-5}
	Geometric Mean (cm/s)		
	Gravel:	2.6×10^{-5}	1.0×10^{-4}
	Boulders + Silt		5.0×10^{-5}

TABLE E- 16

RESULTS OF PACKER TESTS IN THE UPPER LARAMIE FORMATION WEST SPRAY FIELD AREA

Well Number	Interval (Depth below Ground Level ft)	Lithology	1st P1/3 (cm/s)	P2/3 (cm/s)	2nd P1/3 (cm/s)	Geometric Mean (cm/s)
46-86	107.27-117.30	Claystone	$3x10^{-8}$	Aborted		$3x10^{-8}$
	130.22-140.25	Claystone	$1x10^{-8}$	$1.7x10^{-7}$	$6x10^{-8}$	$5x10^{-8}$
	140.64-150.67	Siltstone	$1x10^{-8}$	$5.1x10^{-7}$	$1.1x10^{-7}$	$8x10^{-8}$
	151.00-161.03	Siltstone	$1x10^{-8}$	$7x10^{-8}$	$1x10^{-8}$	$2x10^{-8}$
		Geometric Mean for Claystone:				$4x10^{-8}$
		Geometric Mean for Siltstone:				$4x10^{-8}$
48-86	101.23-110.88	Siltstone & Claystone*	$2x10^{-8}$	Failed		
	113.80-123.53	Siltstone	$1.6x10^{-7}$	$6x10^{-8}$	$1x10^{-8}$	$5x10^{-8}$
	124.69-134.34	Siltstone	$2.3x10^{-7}$	$7.0x10^{-7}$	$1.0x10^{-7}$	$2.5x10^{-7}$
	128.05-137.70	Siltstone	$3.8x10^{-7}$	Failed		$3.8x10^{-7}$
	130.05-139.70	Siltstone	$5.5x10^{-7}$	Failed		$5.5x10^{-7}$
	141.03-150.39	Siltstone	$9x10^{-8}$	$6.5x10^{-7}$	$3x10^{-8}$	$1.2x10^{-7}$
	141.03-150.39	Siltstone	$3.4x10^{-7}$	Failed		$3.4x10^{-7}$
	144.00-153.65	Siltstone	$2.5x10^{-7}$	Failed		$2.5x10^{-7}$
	145.94-155.59	Siltstone	$1.9x10^{-7}$	Failed		$1.9x10^{-7}$
	160.00-169.65	Siltstone	$4.3x10^{-7}$	Failed		$4.3x10^{-7}$
	161.88-171.53	Siltstone	$1.3x10^{-7}$	Failed		$1.3x10^{-7}$
	165.20-174.80	Siltstone	$1.0x10^{-7}$	Failed		$1.0x10^{-7}$
	167.10-176.74	Siltstone	$3.1x10^{-7}$	Failed		$3.1x10^{-7}$
	175.85-185.50	Siltstone	$2.2x10^{-7}$	Failed		$2.2x10^{-7}$
	177.75-187.40	Siltstone	$1x10^{-8}$	Failed		$1x10^{-8}$
	181.21-190.86	Siltstone	$1.5x10^{-7}$	Failed		$1.5x10^{-7}$
	183.11-192.76	Siltstone	$4x10^{-8}$	Failed		$4x10^{-8}$
	192.00-201.65	Siltstone & Sandstone*	$1x10^{-8}$	Failed		
	194.00-203.60	Siltstone & Sandstone*	$3.0x10^{-7}$	Failed		
	196.15-206.80	Sandstone	$1.1x10^{-7}$	Failed		$1.1x10^{-7}$
	198.76-208.41	Sandstone	$3x10^{-8}$	Failed		$3x10^{-8}$
		Geometric Mean for Siltstone:				$1.6x10^{-7}$
		Geometric Mean for Sandstone:				$6x10^{-8}$

* Mixed lithology tests not used in calculating geometric means

TABLE E-17

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN THE UPPER LARAMIE FORMATION WEST SPRAY FIELD AREA

Well	Lithology	Hydraulic Conductivities: Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test (cm/s)
46-86	Claystone			$4x10^{-8}$
	Siltstone	$5x10^{-8}$		$4x10^{-8}$
48-86	Siltstone & Sandstone		$5.4x10^{-7}$	
	Siltstone			$1.6x10^{-7}$
	Sandstone			$6x10^{-8}$
	Geometric Mean (cm/s)			
	Sandstone:			$6x10^{-8}$
	Siltstone:	$5x10^{-8}$		$8x10^{-8}$
	Claystone:			$4x10^{-8}$

claystone (Tables E-16 and E-17) will be included in the definition of the uppermost aquifer. If any other sandstones which subcrop within the waste management area are encountered during the installation of a monitoring system, these sandstones will be included in the description of the uppermost aquifer.

E-3f(3)(b) Ground-Water Flow Directions and Rates in Uppermost Aquifer

Ground-Water Flow Directions

In the West Spray Field area, ground water flows east-northeastwardly following the regional topography of the Rocky Flats Alluvium. Locally, in the vicinity of the drainage system of Woman Creek, ground water flows southeastwardly into this drainage system.

This general pattern of ground-water flow is evidenced by the water-table maps constructed for May, June, August, and November 1987 and April 1988 (Plates E-21 through E-25, respectively). Seasonal variations in ground-water flow appear to be related to the overall elevation of the water table. When the water table is relatively high, May, June, and August 1987 (Plates E-21, E-22, E-23), ground-water flow is more eastwardly than in periods when the water table is lower, November 1987 and April 1988 (Plates E-24, E-25).

The water table elevations recorded at monitor well 47-86 are generally low with respect to the overall water table. An

exception is the water table of November 1987 (Plate E-24), where water table elevations in monitor wells 47-86 and 45-86 are very similar and imply north-northeastward ground-water flow in the northeast corner of the study area.

The water level elevation of the raw water supply pond located south of monitor well 49-86 was not used in the construction of the water table maps. This pond is lined and consequently not hydraulically connected with the ground-water system in the Rocky Flats Alluvium.

Ground-Water Flow Rates

Ground-water flow rates are a function of hydraulic conductivity, hydraulic gradient, and effective porosity. Following Anderson (1979), the equation for average linear velocity in ground water is:

$$\bar{v} = K\, i/n$$

where $\bar{v}$ = average linear velocity
K = hydraulic conductivity
n = effective porosity
i = hydraulic gradient

Hydraulic conductivities are derived from well tests as discussed in the West Spray Field Hydrogeologic Characterization Report (Appendix 4 of Appendix I-4). Results of well tests are presented in Table E-15.

The hydraulic gradient for the Rocky Flats Alluvium is derived from the April 1988 water table map, Plate E-25, of the West Spray Field area.

Effective porosity has not been measured for local strata to date. Effective porosity is assumed to be 0.1 for the purpose of ground-water flow rate calculations.

The horizontal ground-water flow velocity within the Rocky Flats alluvium is estimated at 33 ft/yr. this is based on a hydraulic conductivity of 9.7×10^{-5} cm/s (100 ft/yr), from the 49-86 well, Table E-17, an average horizontal gradient of 0.033 ft/ft in the vicinity of well 49-86, and an assumed affective porosity of 0.1.

E-3f(4) Solar Evaporation Ponds

The hydrogeology of the Solar Evaporation Pond area is detailed in the Solar Evaporation Pond Hydrogeologic Characterization Report (Appendix 6 of Appendix I-2). Presented below is a summary of that characterization as it pertains to the uppermost aquifer.

E-3f(4)(a) Uppermost Aquifer Identification

The basis for this identification of the uppermost aquifer is the Solar Evaporation Ponds Hydrogeologic Characterization Report (Appendix 6 of Appendix I-2). Plate E-26 is a surficial geology map identifying the disturbed ground and Rocky Flats Alluvium

within the waste management area. Plate E-27 identifies subcropping Arapahoe sandstones within the waste management area.

The uppermost aquifer in the Solar Evaporation Pond area is comprised of the saturated surficial materials: Rocky Flats Alluvium, disturbed ground, colluvium, and North Walnut Creek valley fill alluvium. In addition the uppermost aquifer includes outcropping weathered claystones and those sandstones and weathered claystones of the Arapahoe Formation which subcrop beneath the surficial materials within the waste management area. Any sandstone which does not meet this criteria but is hydraulically connected with sandstones that subcrop beneath the surficial materials within the waste management area shall be considered part of the uppermost aquifer. Each subcropping or hydraulically connected sandstone is a part of the uppermost aquifer to such depth where the sandstone pinches out. Subcropping weathered claystones are a part of the uppermost aquifer to the base of weathering.

Weathered claystone and subcropping sandstones are included within the definition of the uppermost aquifer because these portions of the Arapahoe Formation are in direct contact with saturated surficial materials.

The depth of weathering varies within the claystone subcropping under this waste management area. Table E-18 lists the base of weathering for monitor wells and boreholes within the waste management unit.

TABLE E-18

DEPTH OF WEATHERING IN ARAPAHOE CLAYSTONE: SOLAR EVAPORATION PONDS

	Below Ground Surface (ft)	Below Top of Bedrock (ft)
Well		
20-86 (a)	22.5+	10+
22-86	21.0	9
27-86	15.5	6.3
28-86 (a)	15.5+	7.1+
30-86 (a)	16.0+	14+
31-86 (a)	22+	21.1+
32-86	72	71.2
37-87 (a)	13.0+	10.3+
39-87BR	39.0	33.8
56-87 (a)	13.4+	4.0+
Borehole		
SP01-87 (b)	25.9+	12.7+
SP02-87 (c)	NA	NA
SP03-87 (b)	18+	4.8+
SP04-87 (a)	32.0+	22.5+
SP05-87 (a)	21.8+	4.0+
SP06-87 (a)	30.7+	12.7+
SP07-87 (a)	31.0+	9.7+
SP09-87 (a)	11.0+	5.0+
SP10-87 (a)	27.7+	25.3+
SP13-87 (a)	16.5+	13.8+
SP15-87 (a)	19.5+	4.6+

(a) Minimum value: weathering at total depth of well.
(b) Minimum value: weathering at base of lowermost clay.
(c) No Arapahoe claystone encountered.

Specifically, subcropping Arapahoe sandstones that are part of the uppermost aquifer are encountered in wells 22-86, 31-86, 32-86, 39-87BR and in boreholes SP01-87, SP02-87, and SP04-87. In addition, an Arapahoe sandstone encountered between 11.5 and 13.5 feet below ground surface (between 8.8 and 10.8 feet below top of bedrack) in borehole SP13-87 is part of the uppermost aquifer. Assuming a 7 degree dip to the east and a continuous sandstone, it is possible that this sandstone would subcrop approximately 72 to 88 feet west of SP13-87 in an area within the waste management area. A review of cross sections A-A', C-C'. D-D', and E-E' in Plate E-28 identifies additional sandstones at depth in wells 23-86, 27-86, 32-86, 39-87BR. As depicted in these cross sections, none of these sandstones subcrop within the waste management area; consequently, these sandstones are not a part of the uppermost aquifer. If any other sandstones which subcrop within the waste management area are encountered during the installation of the monitoring system, these sandstones will be included in the description of the uppermost aquifer.

Unweathered claystone is not considered a part of the uppermost aquifer because of the low hydraulic conductivities calculated for claystone in the Solar Pond Area. As tabulated in Tables E-19 and E-20, hydraulic conductivities for unweathered claystone range from 1.34×10^{-6} cm/s for well 14-86 to 4×10^{-8} cm/s in wells 25-86 and 39-87BR. Arapahoe sandstones which do not subcrop beneath the surficial materials of the waste management unit are

TABLE E-19

RESULTS OF PACKER TESTS IN ARAPAHOE FORMATION SOLAR EVAPORATION PONDS AREA

Well Number	Interval (ft)	Lithology	1st P1/3 (cm/s)	P2/3 (cm/s)	2nd P1/3 (cm/s)	Geometric Mean (cm/s)
14-86	32.46-43.64	Claystone	7.8×10^{-7}	3.47×10^{-6}	8.8×10^{-7}	1.34×10^{-6}
	43.26-54.44	Sandstone	2.11×10^{-6}	7.34×10^{-6}	6.5×10^{-7}	2.16×10^{-6}
	53.91-65.09	Claystone/Siltstone				
16-86	28.68-38.68	Claystone	3.89×10^{-6}	7.10×10^{-6}	Aborted	5.26×10^{-6}
	34.43-44.42	Claystone/Siltstone/Sandstone				
	42.49-52.59	Claystone/Siltstone				
	52.43-62.43	Siltstone	4.0×10^{-7}	1.88×10^{-6}	3.0×10^{-7}	6.1×10^{-7}
23-86	37.25-48.43	WClaystone	2.0×10^{-7}	Aborted	Aborted	2.0×10^{-7}
	44.68-52.35	WClaystone	4.3×10^{-7}	1.41×10^{-6}	4.0×10^{-8}	2.9×10^{-7}
	52.35-63.55	Claystone/Siltstone				
	66.10-77.30	Siltstone/Claystone				
	67.80-79.00	Siltstone/Claystone				
	71.80-83.00	Siltstone/Claystone				
	78.00-79.00	Siltstone	3.08×10^{-6}	Aborted	Aborted	3.08×10^{-6}
	82.72-93.92	Siltstone	2.9×10^{-7}	Aborted	Aborted	2.9×10^{-7}
	84.05-95.25	Siltstone	3.6×10^{-7}	Aborted	Aborted	3.6×10^{-7}
	104.21-115.40	Sandstone/Siltstone				
		Geometric Mean for Weathered Claystone:				2.4×10^{-7}
		Geometric Mean for Siltstone:				6.9×10^{-7}
25-86	35.88-47.06	WClaystone	7.8×10^{-7}	2.14×10^{-6}	6.3×10^{-7}	1.02×10^{-6}
	48.05-59.23	Claystone	1.0×10^{-8}	2.0×10^{-8}	Aborted	1.0×10^{-8}
	58.86-70.04	Claystone	2.0×10^{-8}	5.9×10^{-7}	3.3×10^{-7}	1.6×10^{-7}
	69.36-80.54	Sandstone*	2.0×10^{-8}	2.65×10^{-6}	7.7×10^{-7}	3.4×10^{-7}
	83.29-94.47	Test Interval in Excess of TD				
		Geometric Mean for Weathered Claystone:				1.02×10^{-6}
		Geometric Mean for Claystone:				4.0×10^{-8}
27-86	24.29-35.84	WClaystone	2.00×10^{-6}	2.70×10^{-6}	Aborted	2.32×10^{-6}
	24.65-35.84	WClaystone	2.04×10^{-6}	2.75×10^{-6}	Aborted	2.37×10^{-6}
	35.84-47.03	WClaystone	4.7×10^{-7}	6.5×10^{-7}	$4. \times 10^{-8}$	2.3×10^{-7}
	42.58-53.77	WClaystone	$1. \times 10^{-8}$	$1. \times 10^{-8}$	-	$1. \times 10^{-8}$
	70.96-82.15	Claystone	1.01×10^{-6}	2.98×10^{-6}	3.36×10^{-6}	2.16×10^{-6}
	82.15-93.34	Claystone	3.4×10^{-7}	3.84×10^{-6}	3.8×10^{-7}	7.9×10^{-7}
	96.43-107.62	Siltstone	3.1×10^{-7}	2.1×10^{-7}	$4. \times 10^{-8}$	1.4×10^{-7}
	107.62-118.81	Claystone/Siltstone				
	118.81-130.0	Claystone	$1. \times 10^{-8}$	1.1×10^{-7}	$2. \times 10^{-8}$	$3. \times 10^{-8}$
	130.00-141.19	Claystone/Sandstone				
	138.37-149.56	Claystone	$1. \times 10^{-8}$	$6. \times 10^{-8}$	-	$2. \times 10^{-8}$
		Geometric Mean for Weathered Claystone:				3.4×10^{-7}
		Geometric Mean for Claystone:				1.8×10^{-7}

TABLE E-19 (Continued)

RESULTS OF PACKER TESTS IN ARAPAHOE FORMATION SOLAR EVAPORATION PONDS AREA

Well Number	Interval (ft)	Lithology	1st P1/3 (cm/s)	P2/3 (cm/s)	2nd P1/3 (cm/s)	Geometric Mean (cm/s)
32-86	45.20-55.20	WClaystone	5.6×10^{-7}	1.59×10^{-6}	2.8×10^{-7}	6.3×10^{-7}
	55.20-65.20	WClaystone	2.8×10^{-7}	$6. \times 10^{-8}$	Aborted	1.3×10^{-7}
	65.20-75.20	Claystone	4.6×10^{-7}	6.4×10^{-7}	1.9×10^{-7}	3.8×10^{-7}
	75.20-85.20	Claystone	$8. \times 10^{-8}$	3.7×10^{-7}	$6. \times 10^{-8}$	1.2×10^{-7}
	85.20-95.20	Claystone/Sandstone				
	95.20-105.20	Claystone	3.7×10^{-7}	4.1×10^{-7}	7.0×10^{-8}	2.1×10^{-7}
	95.20-105.92	Claystone	3.5×10^{-7}	3.9×10^{-7}	$6. \times 10^{-8}$	2.0×10^{-7}
	105.20-115.20	Claystone	6.0×10^{-8}	4.6×10^{-7}	1.3×10^{-7}	1.5×10^{-7}
	116.08-126.08	Claystone/Sandstone				
		Geometric Mean for Weathered Claystone:				2.9×10^{-7}
		Geometric Mean for Claystone:				2.0×10^{-7}
34-86	46.01-56.00	Sandstone	1.73×10^{-6}	---	6.30×10^{-6}	3.30×10^{-6}
	55.01-65.00	Claystone	4.14×10^{-6}	5.73×10^{-6}	1.56×10^{-6}	3.33×10^{-6}
	76.71-86.70	Claystone	4.7×10^{-7}	---	---	4.7×10^{-7}
	85.10-95.09	Claystone	5.6×10^{-7}	4.28×10^{-6}	---	1.55×10^{-6}
		Geometric Mean for Claystone:				1.34×10^{-6}
39-87BR	50.10-59.75	Claystone	Aborted	$3. \times 10^{-8}$	Aborted	$3. \times 10^{-8}$
	59.75-69.40	Claystone	-	$6. \times 10^{-8}$	-	$6. \times 10^{-8}$
	69.40-79.05	Claystone	-	$4. \times 10^{-8}$	-	$4. \times 10^{-8}$
	79.05-88.70	Claystone/Siltstone/Sandstone				
	88.70-98.35	Siltstone/Sandstone				
	98.35-108.00	Claystone/Siltstone				
	108.00-117.65	Sandstone/Siltstone				
	115.65-125.00	Siltstone	Aborted	3.9×10^{-7}	Aborted	3.9×10^{-7}
	122.68-132.33	Sandstone	$2. \times 10^{-8}$	$4. \times 10^{-8}$	Aborted	$3. \times 10^{-8}$
		Geometric Mean for Claystone:				$4. \times 10^{-8}$

TABLE E-20

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS IN ARAPAHOE FORMATION: SOLAR EVAPORATION PONDS AREA

Well	Lithology	Drawdown Recovery Test (cm/s)	Slug Test (cm/s)	Packer Test (cm/s)
14-86	Sandstone	1.9×10^{-7}		2.2×10^{-6}
	Claystone			1.3×10^{-6}
16-86	Siltstone & Sandstone*	6×10^{-8}		
	Siltstone			6.1×10^{-7}
	Claystone			5.3×10^{-6}
23-86	Sandstone		1×10^{-8}	
	Siltstone			6.9×10^{-7}
	Weathered Claystone			2.4×10^{-7}
25-86	Claystone & Sandstone*	7×10^{-8}		
	Sandstone			3.4×10^{-7}
	Claystone			4.0×10^{-8}
	Weathered Claystone			1.0×10^{-6}
27-86	Sandstone	1.9×10^{-7}		
	Siltstone			1.4×10^{-7}
	Claystone			1.8×10^{-7}
	Weathered Claystone			3.4×10^{-7}
32-86	Sandstone & Claystone*	9×10^{-8}		
	Claystone			2.0×10^{-7}
	Weathered Claystone			2.9×10^{-7}
34-86	Sandstone	3.1×10^{-6}		3.3×10^{-6}
	Claystone			1.3×10^{-6}
39-87	Sandstone			3×10^{-8}
	Siltstone			3.9×10^{-7}
	Claystone			4×10^{-8}
	Geometric Mean (cm/s)			
	Sandstone:	4.8×10^{-7}	1×10^{-8}	5.2×10^{-7}
	Siltstone:			6.7×10^{-7}
	Claystone:			3.4×10^{-7}
	Weathered Claystone			3.9×10^{-7}

* Mixed lithology tests not used in calculating geometric means.

not considered a part of the overlying aquifer because of the low hydraulic conductivity of the claystone separating these sandstones from surficial materials.

E-3f(4)(b) Ground-Water Flow Directions and Rates in Uppermost Aquifer

Ground-Water Flow Directions

Ground water flows toward the east and northeast in the solar pond area in surficial materials and in the underlying sandstones and weathered claystones. This flow is locally influenced by topography, the configuration of the base of weathering, and the operation of the ground-water intercept system north of the solar ponds. Consistent with the regional recharging of the Arapahoe Formation in this locality, it is assumed that ground-water flows eastward within the subcropping sandstones.

As shown in the map of the April 1988 water table (Plate E-34), ground water moves east and north through the waste management area. Areas of unsaturated or absent surficial materials are present to the south, associated with monitor wells 38-87 and 33-86; to the east, associated with well 29-86; to the north-east, associated with well 18-86; and to the north-west, associated with wells 31-86 and 20-86. These unsaturated surficial materials reflect bedrock highs (See Plate E-29) and the action of the ground-water intercept system located on the slope north of the solar ponds.

Mapped water tables are presented for April, June, August, and November 1987, and April 1988 (Plates E-30 through E-34, respectively). Although ground-water contours shift slightly, the directions of ground-water flow remain essentially the same over the course of a year. The extent and shape of the areas of unsaturated surficial materials do change extensively over this time frame, however, particularly south of the solar ponds.

The ground-water intercept (French drain) system was installed in the hillside north of the Solar Evaporation Ponds sometime between June 1980 and April 1981. Depths of the drains range from approximately 1 to 27 feet below ground surface with a typical depth of 4 to 16 feet. The seepage intercepted by the French drain system flows by gravity into the interceptor trench pump house. The amount of pumpage from the pump house is estimated at four million gallons per year. Not all of this flow is ground-water seepage from the slope north of the solar ponds. Included is a yet unmeasured flow from the foundation drains in the 774 Building, west of the solar pond area. The water collected in these foundation drains is piped to the interceptor trench pump house, where it and the ground water collected by the French drains are currently pumped to Pond 207-B North.

A comparison of water quality data from monitor wells which are located above and below the French drain system and are completed within the uppermost aquifer indicates that the French drains are only partially effective in intercepting the movement of

contaminated ground water from the solar pond area to North Walnut Creek.

Well 30-86 is a bedrock well located north of the solar ponds but upslope of the French drain. It is completed in the shallow weathered claystone immediately beneath the artificial fill/disturbed ground. Ground water in this well is unconfined and is in communication with the overlying surficial materials. Ground water at this well shows the most contamination anywhere in the Solar Pond Area. Chlorides, sulfates, nitrates, TDS, and uranium all exceed the proposed ground-water quality criteria (Appendix 6 of Appendix I-2).

Ground water at this well shows the most contamination anywhere in the Solar Pond Area. Chlorides, sulfates, nitrates, TDS, and uranium all exceed the proposed ground-water quality criteria (Appendix 6 of Appendix I-2).

Well 31-86, west of well 30-86, is completed in subcropping Arapahoe sandstone. It is located north of pond 207A. It is upgradient and upslope of the French drain. This well is screened from 2.46 to 17.32 feet below ground surface and has been dry since its installation.

Well 20-86 is an alluvial well located north of pond 207C and upgradient and upslope of the French drains. This well was dry during all sampling periods.

Well 18-86 was also dry during all sampling periods. This well is downgradient and downslope of the French drains. Wells 17-86, 15-86, and 13-86, screened in valley fill alluvium adjacent to North Walnut Creek are downslope and downgradient of the French drain. These wells contain variable concentrations of the contaminants associated with the solar ponds.

Strontium, nitrate, sodium, potassium, tritium, and uranium are elevated at well 17-86. The source of these contaminants appears to be the solar ponds because all of these constituents are notably elevated at well 30-86. These constituents are all diluted by about a factor of 5 to 10 at well 17-86 relative to 30-86. The interceptor pump house water quality (metals data only) indicates concentrations of sodium and potassium intermediate to the range observed for wells 30-86 and 17-86 (Appendix 4 of Appendix I-2). This is expected given the location of the French drain system. It is likely that contamination at 17-86 has arisen from the solar ponds because of the inability of the French drain system to capture all contaminated ground water exiting the solar ponds during periods of high precipitation.

Ground-Water Flow Rates

Ground-water flow rates are a function of hydraulic conductivity, hydraulic gradient, and effective porosity. Following Anderson

(1979), the equation for average linear velocity in ground water is:

$$\bar{v} = K\ i/n$$

where $\bar{v}$ = average linear velocity
K = hydraulic conductivity
n = effective porosity
i = hydraulic gradient

Hydraulic conductivities are derived from well tests as discussed in the Solar Evaporation Pond Hydrogeologic Characterization Report (Appendix 6 of Appendix I-1). Results of these well tests are presented in Tables E-19, E-20, and E-21. Hydraulic gradients are derived from the April 1988 water table map of the Solar Pond Area, Plate E-30. A review of cross section E-E' in Plate E-24 suggests that two wells 39-87BR and 27-86 are completed in physically connected Arapahoe sandstones. A comparison of the water level data for these two wells found in Appendix B of the Solar Evaporation Hydrogeologic Characterization Report (Appendix 6 of Appendix I-1) indicates, however, that only limited hydraulic continuity exists between these wells.

Hurr (1976) estimated the hydraulic gradient of the Arapahoe Formation as 0.03 ft/ft to the east. The map of the 1978 potentiometric surface of the Arapahoe Formation (Robson et al., 1981a) indicates a 0.05 ft/ft hydraulic gradient toward the east-southeast for the Arapahoe Formation west of Standley Lake. Wells completed in the same sandstones at the 903 Pad, Mound, and East Trenches Areas (Rockwell International, 1987) provide a hydraulic gradient of 0.03 ft/ft and 0.09 ft/ft. As discussed in

TABLE E- 21

RESULTS OF HYDRAULIC CONDUCTIVITY TESTS OF SURFICIAL MATERIALS: SOLAR EVAPORATION PONDS AREA

Well Number	Formation	Lithology Screened	Drawdown Recovery Test cm/s
17-86	Q_{VF}	Gravel, sand, silt, clay	4.8×10^{-6}
22-86	Q_{RF}	Gravel, sand, silt	8.7×10^{-6}
26-86	Q_D	Gravel and Sand	4×10^{-8}

Section E-3f(1)(b) of this report, the estimated hydraulic gradient from well 65-87 to 8-86 in the Present Landfill area is 0.077 ft/ft. For the purpose of calculating ground-water flow velocities, the hydraulic gradient of the Arapahoe Formation will be estimated at 0.03 to 0.09 ft/ft.

Effective porosity has not been measured for local strata to date. Effective porosity is assumed to be 0.1 for the purpose of ground-water flow rate calculations. Hurr (1976) assumed an effective porosity in the range of 0.1 to 0.15.

The horizontal ground-water flow velocity within the Rocky Flats Alluvium is estimated at 3.6 ft/yr. This is based on a hydraulic conductivity of 8.7×10^{-6} cm/s (9.0 ft/yr), a horizontal gradient of 0.04 ft/ft, and an assumed effective porosity of 0.1. The horizontal gradient of 0.04 ft/ft is representative of the hydraulic gradient between the 207-B ponds and well 29-86.

The horizontal ground-water flow velocity within disturbed ground is estimated at 0.0066 ft/yr. This is based on a hydraulic conductivity of 4×10^{-8} cm/s (.041 ft/yr), a horizontal gradient of 0.016 ft/ft, and an assumed effective porosity of 0.1. The horizontal gradient of 0.016 ft/ft is representative of flow under the ponds.

The horizontal ground-water flow velocity within the weathered Arapahoe claystone is estimated at 0.68 ft/yr. This is based on a hydraulic conductivity of 3.9×10^{-7} cm/s (0.40 ft/yr), a

horizontal gradient of 0.17 ft/ft, and an assumed effective porosity of 0.1. The horizontal gradient of 0.17 ft/ft is representative of the slope north of the solar ponds.

The horizontal ground-water flow velocity within Arapahoe sandstone is estimated at 0.16 to 0.49 ft/yr. A velocity of 0.16 ft/yr is based upon a hydraulic conductivity of 5.2×10^{-7} cm/s (0.54 ft/yr), a horizontal gradient of 0.03 ft/ft and an assumed effective porosity of 0.1. A velocity of 0.49 ft/yr is based upon a hydraulic conductivity of 5.2×10^{-7} cm/s (0.54 ft/yr), and horizontal gradient of 0.09 ft/ft, and an assumed effective porosity of 0.1.

E-4 TOPOGRAPHIC MAP REQUIREMENTS AND POINT OF COMPLIANCE

In accordance with 6 CCR 1007-3 100.41 (a)(18) (40 CFR 270.14(b)(19)), Plates E-35, E-2, E-36, and E-37 are topographic maps of the Rocky Flats Plant showing a distance of at least 1000 feet around the Present Landfill, the Original Process Waste Line, the West Spray Field, and the Solar Evaporation Ponds, respectively. The maps are at a scale of one inch equals 100 or 200 feet. Two foot contour intervals show the pattern of surface water flow in the vicinity of the each unit. In addition, in accordance with 6 CCR 1007-3 100.41(c)(3) (40 CFR 270.14(c)(3)) the maps delineate the waste management areas, the proposed point of compliance for each unit, and the proposed location of ground-water monitoring wells for each unit. The property boundary for the Rocky Flats Plant is shown on the one inch to 500 foot scale topographic map presented in Section B of this permit application.

The location of the point of compliance is defined as the vertical surface located at the hydraulically downgradient limit of the waste management area that extends into the uppermost aquifer underlying a regulated unit (6 CCR 1007-3 264.95(a), 40 CFR 264.95(a)). Ground-water detection and compliance monitoring of the uppermost aquifer is conducted along the point of compliance according to the ground-water monitoring requirements described in Sections E-6, E-7, and E-8. Section E-3 presents descriptions of the uppermost aquifer at each regulated unit

including ground-water flow directions. The following discussion describes the location and extent of the proposed point of compliance for the Present Landfill, the Original Process Waste Lines, the West Spray Field, and the Solar Evaporation Ponds.

E-4a Present Landfill

The Present Landfill is located to the north of the Rocky Flats Plant security area. A description of the Present Landfill, its operation, and hydrogeologic characterization are located in the Closure Plan for the Present Landfill, Appendix I-3 of this permit application. The Present Landfill Waste Management Unit includes the landfill and the landfill pond located immediately east of the landfill.

The proposed point of compliance and the extent of the Present Landfill Waste Management Unit are depicted on Plate E-35. The point of compliance is located at the hydraulically downgradient limit of the landfill, extending partially around the northern side of the landfill, around the eastern edge of the landfill pond, and partially around the southern side of the unit. Ground-water flow in the uppermost aquifer, as described in Section E-3, is to the east in the landfill area. In order to monitor potential ground-water flow out of the landfill to the north or south, the point of compliance is extended around the north and south sides of the landfill.

E-4a Original Process Waste Line

The Original Process Waste Line is a below grade pipeline system which transported wastes from Rocky Flats Plant buildings to the on-site treatment facilities. A description of the operation of the pipeline system is located in the Closure Plan for the Original Process Waste Line (Appendix I-5). The location of the pipelines are depicted on Plate E-2.

Ground-water flow in the area of the Original Process Waste Line is generally from the west to the east. However, there are relatively few wells adjacent to the Original Process Waste Line at this time. Thus, insufficient ground-water level data are available to determine site-specific ground-water flow directions. A series of piezometers will be installed around the Original Process Waste Lines during interim status monitoring (Section E-2). Following one year of water level measurements, a post-closure care monitoring system and a point of compliance will be proposed for the waste management unit.

E-4c West Spray Field

The West Spray Field is located to the west of the Rocky Flats Plant on security area. A description of the purpose and operation of the West Spray Field is located in the Closure Plan for the West Spray Field (Appendix I-4). Plate E-36 depicts the extent of the West Spray Field operations, the proposed point of compliance, and proposed compliance monitoring wells locations.

Ground-water flow in the West Spray Field area is to the northeast, east and southeast (Section E-3). The proposed point of compliance, as shown on Plate E-36, is located along the hydraulically downgradient limit of the West Spray Field Waste Management Unit.

E-4d Solar Evaporation Ponds

The Solar Evaporation Ponds are located on the northeast side of the Perimeter Security Zone (PSZ) at the Rocky Flats Plant. The Solar Evaporation Pond Waste Management Unit includes Ponds 207-C, 207-A, and Ponds 207-B North, Center, and South; and the French drain system associated with the Solar Evaporation Ponds. A description of the purpose, construction and operation of the ponds and the French drain system is presented in the Closure Plan for the Solar Evaporation Ponds (Appendix I-2).

The French drain system has been a part of the standard operations for management of solar pond wastes since its construction. Therefore, the proposed point of compliance is located along the hydraulically downgradient edge of the French drain system. The proposed point of compliance as depicted on Plate E-37 extends around the hydraulically downgradient limit of the French drain system to the north and around the hydraulically downgradient limit of the ponds to the east and south. Ground-water flow in the solar ponds area is to the northeast, east and southeast (Section E-3) in the uppermost aquifer.

E-5 CONTAMINANT PLUME DESCRIPTION

In accordance with 6 CCR 1007-3 100.41(c)(4) 40 CFR 270.14(c)(4) it is necessary to describe any plume of contamination that has entered the ground water from a regulated unit. The description must include a map delineating the extent of the plume, and identification of the concentration of Appendix IX constituents throughout the plume or their maximum concentrations in the plume. Subsequent sections within E-5 describe the plumes entering ground water from the West Spray Field and Solar Evaporation Ponds. As discussed below, data is not available to assess whether a plume is emanating from the Original Process Waste Line, and ground water quality data for the Present Landfill indicate that a plume does not exists.

At the time of permit application, no monitoring wells have been installed to specifically monitor ground water beneath the Original Process Waste Line. Thus, it is unknown if any plume of contamination has entered the ground water from this waste management unit. An interim status monitoring system will be installed at the proposed point of compliance around the Original Process Waste Line during the fall/winter of 1988.

The hydrogeologic investigation for the Present Landfill concludes that the landfill does not alter alluvial or bedrock ground-water quality. Although it appears the landfill may be contributing calcium, bicarbonate, and to a lesser extent sodium, sulfate, iron, manganese, and strontium to the alluvial ground

water, ground water to the north which is sidegradient and unimpacted by the landfill has similar concentrations of these analytes. Bedrock ground-water quality is conjectured to be influenced largely by mineral dissolution within the sandstones and claystone. High salt concentrations observed in bedrock wells are not seen in alluvial ground water within the landfill.

E-5a <u>West Spray Field</u>

Hydrogeologic investigations of the West Spray Field indicate that the major impact of West Spray Field operation on alluvial ground-water quality is a modest increase in total dissolved solids (TDS) (primarily sodium and sulfate) and the wide-spread occurrence of above background nitrate concentrations. Above background nitrate occurs in immediately upgradient wells 10-81 and 51-86, and in wells 5-82 and 49-86, which are located within the waste management unit. Ground-water velocity calculations indicate that contaminants could have potentially traveled a distance of 1000 feet since the beginning of the West Spray Field operation. However, ground water at wells 45-86 and 47-86 which are downgradient of the West Spray Field does not contain above background concentrations of nitrate. These wells are within 1000 feet of the compliance point which suggest nitrate has not migrated this distance.

Bedrock ground water at the West Spray Field does not appear impacted by the waste management activities. Above background

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REGULATION NO. 8
PART A

The Control of Hazardous Air Pollutants

Regulation No. 8 sets forth specific emission control requirements for hazardous air pollutants not dealt with in other regulations. These pollutants are determined to be hazardous because they may reasonably be anticipated to result in an increase in mortality or an increase in serious, irreversible, or incapacitating reversible, illness. Five of these: asbestos, beryllium, mercury, benzene, and vinyl chloride, are included in the Federal "National Emission Standards for Hazardous Air Pollutants" (NESHAPS). One pollutant, lead, is of concern along Colorado's front range; ambient air standards have been promulgated for this material. The seventh pollutant, hydrogen sulfide, is an emission problem from various sources within the state. The Regulation contains work standards as well as emission limitations and ambient air standards. Ambient air concentrations shall be based upon application of a suitable dispersion model or monitoring data as approved by the Division.

I. GENERAL PROVISIONS

A. Applicability

The provisions of this regulation apply to the owner or operator of any stationary source in the state of Colorado which emits an air pollutant that is toxic or hazardous.

B. Prohibited Activities for Sources Affected by the provisions in Sections II through VIII of this Regulation.

1. Existing Sources - No owner or operator shall operate any existing stationary source in violation of the standards and procedures prescribed in this regulation.

2. New sources - No owner or operator shall operate any new source in violation of the standards and procedures prescribed in this regulation.

3. No owner or operator subject to the provisions of this regulation shall fail to report, revise reports, or report source test results to the Division as required under this regulation.

C. Test Methods Incorporated by Reference

1. The following test methods referred to in Regulation No. are incorporated by reference. The incorporation shall not include later editions or amendments of these documents.

2. EPA Reference Methods (as published in the Code of Federal Regulations, Title 40 Part 61, Appendix B, revised July 1, 1985):

Method 101: Determination of Particulate and Gaseous Mercury Emissions from Chlor-alkali Plants -- Air Streams.

Method 101A: Determination of Particulate and Gaseous Mercury Emissions from Sewage Sludge Incinerators.

Method 102: Determination of Particulate and Gaseous Mercury Emissions from Chlor-alkali Plants -- Hydrogen Streams.

Method 103: Beryllium Screening Method.

Method 104: Reference Method for Determination of Beryllium Emissions from Stationary Sources.

Method 105: Determination of Mercury in Wastewater Treatment Plant Sewage Sludge.

Method 106: Determination of Vinyl Chloride from Stationary Source

Method 107: Determination of Vinyl Chloride Content of Inproce Wastewater Samples, and Vinyl Chloride Content of Polyvinyl Chloride Resin, Slurry, Wet Cake, and Latex Samples.

Method 107A: Determination of Vinyl Chloride Content of Solvents, Resin-solvent Solution, Polyvinyl Chloride Resin Slurry, Wet Resin, and Latex Samples.

3. American Society for Testing and Materials (ASTM) Standards:

ASTM D2986-71: Standard Method for Evaluation of Airy, Assy Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test, Reapproved 1978.

ASTM D2267-68: Aromatics in Light Naphthas and Aviation Gasolines by Gas Chromatography, Reapproved 1983.

ASTM D2382-76: Heat of Combustion of Hydrocarbon Fuels by Bomb Calorimeter (High Precision Method), Reapproved 1983.

ASTM D2504-67: Noncondensable Gases in C_3 and Lighter Hydrocarbon Products by Gas Chromatography, Reapproved 1983.

major ion, metal and radionuclide concentrations are concluded to represent natural geochemical variations in ground water either because of their low concentrations (near background) or their infrequent occurrence.

As required by 6 CCR 1007-3 100.41(c)(4)(ii) 40 CFR 270(c)(4)(ii), Table E-22 presents the concentration of Appendix IX constituents in alluvial ground water at the West Spray Field. These data are presented to comply with the cited regulation, but as previously stated only nitrate and possibly major ions are the contaminants at the West Spray Field. These data and other non-Appendix IX constituents in the ground water are discussed below.

E-5a(1) Metals

Barium, beryllium, cadmium, chromium, cobalt, copper, mercury, nickel, lead, selenium, silver, thallium, vanadium, and zinc are the Appendix IX metals that were detected in alluvial ground water at the West Spray Field. None of these metals represent a release from the historical waste management operation. Metal concentrations are generally similar to background concentrations except for occasional high concentrations of some metals that do not show any cross correlation with other metals or analytes above background, or any spatial or temporal trends. Also, p
concentrations of metals significantly above background levels are generally outliers as determined by Dixon's Test (see Section E-6 for an explanation of Dioxin's Test).

TABLE E-22

TABLE IX - CONSTITUENTS ABOVE DETECTION LIMITS - ALLUVIAL GROUND WATER WEST SPRAY FIELD

Well Number	Sample Date	(0.071) Ba	(0.011) Be	(0.005U) Cd	(0.01U) Cr	(0.012) Cu	(0.0002u) Hg	NA MeCl	(0.037u) Ni	(0.01) Pb	(0.0076U) Ag	(0.021U) V	(0.086) Zn
5786	08/20/87	0.150	-	-	0.017	-	-	-	-	-	-	-	0.034
	05/13/87	0.133	-	-	-	-	-	-	-	-	-	-	0.07
	06/17/87	0.051	-	-	-	-	-	-	-	0.036	-	-	-
	11/07/86	0.110	-	0.006	0.027	0.023	-	83	0.029	-	-	-	0.039
	12/10/87	0.075	-	-	0.015	0.0141	-	-	-	-	-	-	-
	02/08/88	0.0997	-	-	-	-	-	-	-	-	-	-	0.168
5086	10/31/86	0.190	-	-	-	-	-	-	-	0.054	-	-	0.063
	05/11/87	0.156	-	0.001	0.1356	0.0261	-	-	0.0701	-	0.008	-	0.07
	06/16/87	0.060	-	-	-	-	-	-	-	0.015	-	-	-
	08/14/87	0.082	-	-	0.011	-	-	-	-	-	-	-	0.024
	12/10/87	0.161	-	-	0.015	0.0383	-	-	-	-	-	-	0.027
4986	11/24/86	0.116	-	-	-	-	-	-	-	-	-	-	-
	04/08/87	0.516	-	-	-	-	-	-	-	-	-	-	0.49
	06/18/87	0.055	-	-	-	-	-	-	-	0.020	-	-	-
	08/25/87	0.120	-	-	-	0.0084	-	-	-	-	-	-	0.027
	12/14/87	0.105	-	-	-	0.0080	-	8	-	-	-	-	-
4786	11/07/86	0.10	-	0.007	-	-	-	-	-	-	-	-	0.047
	05/13/87	0.066	-	-	-	0.0087	-	-	-	-	-	-	0.020
	06/22/87	0.047	-	-	-	-	0.003	-	-	0.036	-	0.028	-
	08/14/87	0.102	-	-	-	0.0068	-	-	-	-	-	-	0.026
	10/05/87	0.049	-	-	-	-	-	-	-	-	-	-	-
	02/08/88	0.055	-	-	-	-	-	-	-	-	-	-	0.107
4586	10/16/86	0.160	0.011	-	-	-	0.0021	-	-	-	-	-	0.006
	05/14/87	0.031	-	-	-	-	-	-	-	-	-	-	-
	06/12/87	0.027	-	-	-	-	-	-	-	-	-	-	-
	08/14/87	0.062	-	-	0.012	-	-	-	-	0.011	-	-	0.050
	09/30/87	0.056	-	-	0.017	-	-	-	-	-	-	0.033	-

NOTE: Numbers in parentheses are ground water protection standards

Ba = Barium
Be = Beryllium
Cd = Cadmium
Cr = Chromium
Cu = Copper
Hg = Mercury
Ni = Nickel
Pb = Lead
MeCl = Methylene chloride
Ag = Silver
V = Vanadium
Zn = Zinc

E-5a(2) Volatile Organics

Acetone and methylene chloride were the only volatile organic compounds from Appendix IX detected in alluvial wells at the West Spray Field during interim status monitoring. Acetone occurred once at 90 micrograms per liter (ug/l) and methylene chloride occurred once at 83 ug/l in well 51-86 (November, 1986). Methylene chloride also occurred once at 8 ug/l in well 49-86 (December, 1987). Concentrations of these compounds in samples are not considered representative of contamination unless these analytes do not occur in the blanks, or if they occur in the blanks, the concentration in the sample is ten times the concentration in the blank (EPA, 1985). As shown in Table E-23, the occurrence of methylene chloride in the sample from well 49-86 is considered laboratory artifact. On the contrary, the concentrations of methylene chloride and acetone in the sample from well 51-86 are greater than ten times the corresponding blank values. However, the absence of these compounds in previous and subsequent sampling of the well suggest that they are not ground-water contaminants at this location. It is concluded that VOC contamination of alluvial ground water at the West Spray Field does not exist.

E-5a(3) Major Ions

Major ion chemistry indicates above background nitrate sodium, and sulfate in alluvial ground water at the West Spray Field.

TABLE E-23

VOLATILE ORGANIC COMPOUNDS ABOVE THE DETECTION LIMIT IN WEST SPRAY FIELD WELLS AND THEIR ASSOCIATED BLANK SAMPLES

Well No.	Sample No.	Sample Date	Compound	Concentration (ug/l) Sample	FB	TB	LB
Alluvial Wells							
8-81	G088108860	08/18/86	MeCl	62	ND	ND	ND
45-86	G458610860	10/16/86	Acetone	15B	5BJ	47B	7J
49-86	49-86-12-14-87	12/14/87	MeCl	8	17	18	ND
51-86	G518611860	11/07/86	MeCl	83	1J	7	ND
			Acetone	90B	4BJ	5BJ	4J

Notes: FB = Field Blank
TB = Trip Blank
LB = Laboratory Blank

NR = Not reported (no associated blank)
ND = Not detected
B = Compound present in blank
J = Value estimated below the detection limit

MeCl = Methylene Chloride
MEK = 2-Butanone
PCE = Tetrachloroethene
CCl_4 = Carbon Tetrachloride
1,1-DCE = 1,1-Dichloroethene
1,1,2-TCA = 1,1,2-Trichloroethane
$CHCl_3$ = Chloroform
TCE = Trichloroethene
CS_2 = Carbon Disulfide
1,1-DCA = 1,1-Dichloroethane
1,1,1-TCA = 1,1,1-Trichloroethane

Laboratory blank data not provided for samples analyzed by 881 Laboratory, Rocky Flats Plant.

Sodium (range 13 - 36 milligrams per liter [mg/l]) and sulfate (range 27 - 90 mg/l) concentrations are generally within a factor of two to three of background levels, exceptions representing outliers according to Dixon's Test. Nitrate (range ND - 32 mg/l) is the major ion that is the prevalent contaminant of the alluvial ground water. It occurs at greater than three times background levels and in excess of the proposed concentration limit within the West Spray Field area.

E-5a(4) Radionuclides

Of the radionuclides, only uranium 233+234 (maximum concentration 15(2) pico Curies per liter [pCi/l]) and -238 (maximum concentration 16(2) pCi/l) appear at elevated concentrations with regularity in the wells of the West Spray Field. However, the highest concentrations occur in 1986 and appear to be outliers according to Dixon's Test. In late 1987 and first quarter 1988, uranium concentrations are at background levels. Even if the elevated concentrations represent historical ground-water contamination, the concentrations were below the proposed concentration limits.

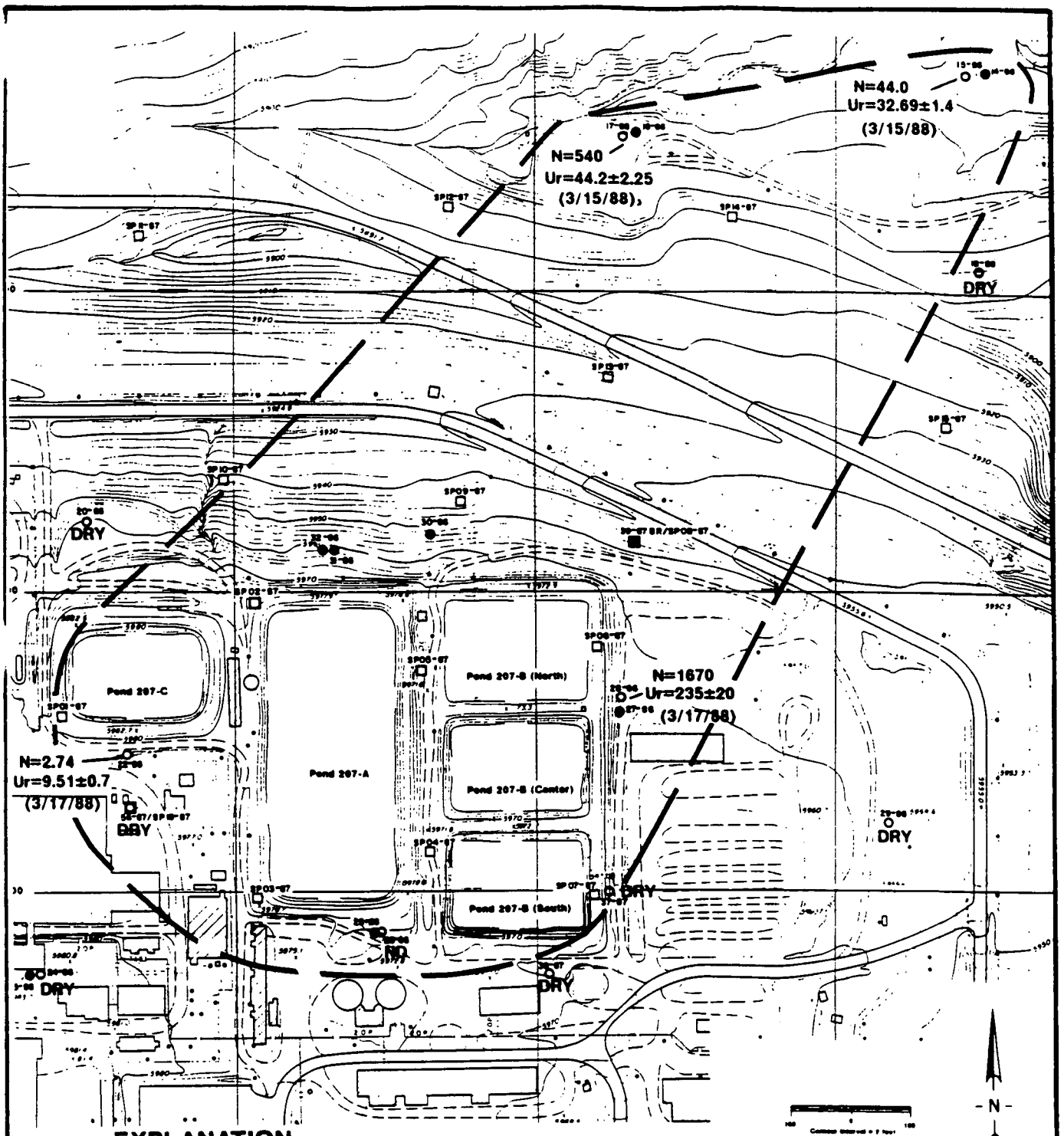
E-5b <u>Solar Evaporation Ponds</u>

The hydrogeologic investigation of the Solar Evaporation Ponds (Appendix 6 of Appendix I-2) has shown that the solar ponds are contaminating alluvial ground water migrating to the north into

the North Walnut Creek drainage. The contaminants of the alluvial ground-water system are volatile organic compounds major ions, tritium, uranium, and nitrate. VOCs, total dissolved solids, sulfate, chloride, uranium, and nitrate all occur above the proposed concentration limits.

In accordance with 40 CFR 270(c)(4)(i), Figure E-10 delineates the approximate extent of the contaminant plume. Nitrate and total uranium concentrations are posted on the map for data from the March, 1988 ground-water analytical results. Nitrate was chosen because it is considered an indicator parameter for the solar pond contaminants and is the most mobile of the contaminants of concern. Therefore, it represents the maximum lateral extent of the contaminant plume. Total uranium was chosen because it is the contaminant of greatest concern in the alluvial ground-water system.

Ground water in deep sandstones does not appear to be impacted by the solar ponds. However, there are several subcropping sandstones at the solar ponds and the extent of contamination of these is unknown at this time (Appendix 6 of Appendix I-2). The subcropping sandstone in which well 39-87 is completed contains nitrate, chloride, and sulfate above background. The subcropping sandstone at wells 31-86 and 32-86 is partially dry (at well 31-86). Well 32-86 contained concentrations of potassium, molybdenum, sodium, nickel, selenium, zinc, lead, chloride, nitrate, sulfate, TDS, and uranium above background. The extent



EXPLANATION

U = Total Uranium Concentration (pCi/l)
N = Nitrate Concentrations (mg/l)
(3/15/88) = Date Sampled
(5.04) = Uncertainty Term

Background for Nitrate = 1.5 mg/l
for Uranium = 9(9.63) pCi/l

Figure E-10:
APPROXIMATE EXTENT OF TOTAL URANIUM AND NITRATE IN THE ALLUVIAL GROUND WATER - SOLAR PONDS AREA

of the contamination can not be determined at this time due to the lack of information concerning the extent of the subcropping sandstone.

As required by 6 CCR 1007-3 40 CFR 270(c)(4)(ii), Tables E-24 and E-25 present the concentration of Appendix IX constituents within the plume at the Solar Evaporation Ponds. Presented below is a discussion of the plume constituents (some of which are Appendix IX constituents) released by the Solar Evaporation Ponds as well as a discussion of the other Appendix IX constituents within the contaminant plume that are not considered to be contaminants released by the Solar Evaporation Ponds.

E-5b(1) Metals

Antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, lead, selenium, silver, thallium, vanadium, and zinc are the metals detected in the ground-water samples from the alluvial wells in the solar pond area (Table E-24). Of these metals barium, mercury, molybdenum, nickel, antimony, selenium, strontium, thallium, and zinc were reported above their background concentrations (Appendix 6 of Appendix I-2). Barium, mercury, nickel, antimony, selenium, thallium, and zinc are the Appendix IX metals reported above background in the alluvial wells.

Mercury, antimony, seleniun, thallium, and zinc are not considered contaminants because they were not consistently

TABLE E-24

TABLE IX CONSTITUENTS ABOVE DETECTION LIMITS FOR ALLUVIAL GROUND WATER SOLAR PONDS AREA

Well Number	Sample Date	Sb NA	As (0.05)	Ba (1.0)	Be (0.1)	Cd (0.01)	CCl_4 NA	$CHCl_3$ NA	Cr (0.05)	Co (0.05)	Cu (1.0)	1,1-DCA NA	1,2-DCA NA	Trans 1,2-DCE (NA)	Pb (0.5)
13-86	08/04/87	-	-	-	-	-	-	125	-	-	-	-	-	-	-
	03/14/88	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-86	09/09/86	-	-	0.120	-	-	-	-	-	0.065	-	-	-	-	-
	03/05/88	0.039	-	0.4361	-	0.001	-	-	0.218	-	0.0121	-	-	-	-
	04/22/87	-	-	0.2264	-	-	-	-	-	-	-	-	-	-	-
	06/11/87	-	-	0.2386	-	-	-	-	-	-	-	-	-	-	-
	08/06/87	-	-	0.2849	-	-	-	-	-	-	0.0083	-	-	-	-
17-86	09/25/86	-	-	0.160	0.005	-	-	-	-	-	-	-	-	-	-
	03/15/88	-	-	0.3887	-	-	-	-	0.0289	-	-	-	-	-	-
	04/22/87	-	-	0.1933	-	-	-	-	-	-	-	-	-	-	-
	06/11/87	-	-	0.3333	0.007	-	-	-	-	-	0.0076	-	-	-	0.009
	08/06/87	-	-	0.2893	-	-	-	-	-	-	-	-	-	-	-
	12/09/87	-	-	0.2634	-	-	-	-	-	-	0.0118	-	-	-	-
22-86	09/09/86	0.062	-	-	-	-	350	147	-	-	-	-	-	36	-
	03/17/87	-	-	0.0924	-	-	-	-	-	-	-	-	-	-	-
	03/24/87	-	-	0.0419	-	0.001	-	100	-	-	0.0066	-	-	28	-
	06/24/87	-	-	-	-	-	3000	36	-	-	-	-	8000	-	-
	06/25/87	-	-	0.1908	-	-	-	-	-	-	-	-	-	-	0.015
	08/27/87	-	-	-	-	-	491	80	-	-	-	-	-	-	-
	08/28/87	-	-	0.2045	-	-	-	-	-	-	0.0099	-	-	-	-
	12/18/87	-	-	0.1368	-	-	161	38	0.0127	-	-	-	-	-	-
26-86	09/18/86	-	-	0.150	-	-	-	-	-	-	-	-	-	-	-
	03/18/87	-	0.40	0.0902	-	-	-	-	-	-	-	-	-	-	-
	08/28/87	-	-	0.1191	-	-	-	-	-	-	0.0117	-	-	-	-
28-86	03/17/88	-	-	0.1665	-	0.001	-	-	0.0122	0.0502	-	-	-	-	-
	03/19/87	-	-	0.1802	-	-	-	-	-	0.0312	-	-	-	-	-
	06/24/87	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	06/25/87	-	-	0.3422	-	-	-	-	-	0.0428	0.0114	-	-	-	0.011
56-87	03/16/88	-	-	-	-	-	-	6	-	-	-	6	-	-	-

NOTE: Numbers in parentheses are ground-water protection standards.
NA: No standard available

TABLE E-24 (Continued)

TABLE IX CONSTITUENTS ABOVE DETECTION LIMITS FOR ALLUVIAL GROUND WATER SOLAR PONDS AREA

Well Number	Sample Date	Hg (0.002)	MeCl NA	Ni (0.2)	Se (0.01)	Ag (5.0)	PCE NA	Tl NA	1,1,1-TCA NA	1,1,2-TCA NA	TCE NA	V (0.1)	Zn (5.0)
13-86	08/04/87	-	-	-	-	-	-	-	-	6	5	-	-
	03/14/88	-	-	-	-	-	-	-	-	-	55	-	-
15-86	09/09/86	-	-	-	-	-	-	0.024	-	-	-	-	-
	03/05/88	-	-	0.0458	-	-	-	-	-	-	-	-	0.1261
	04/22/87	-	-	-	-	-	-	-	-	-	-	-	-
	06/11/87	-	-	-	0.0025	-	-	-	-	-	-	-	0.0580
	08/06/87	-	-	-	0.022	-	-	-	-	-	-	-	0.0396
17-86	09/25/86	-	-	-	-	-	-	0.120	-	-	-	-	0.042
	03/15/88	-	-	-	0.29	-	-	-	-	-	-	-	0.0476
	04/22/87	-	-	-	-	-	-	-	-	-	-	-	-
	06/11/87	-	-	0.0562	0.150	-	-	-	-	-	-	0.0300	0.0957
	08/06/87	-	-	-	0.18	-	-	-	-	-	-	-	-
	12/09/87	-	-	0.0474	-	-	-	-	-	-	-	-	-
22-86	09/09/86	-	-	-	0.0076	0.0067	-	-	-	-	410	-	-
	03/17/87	-	-	0.1695	-	-	-	-	-	-	-	-	-
	03/24/87	-	-	0.1097	-	-	-	-	1400	-	650	-	0.0380
	06/24/87	-	-	-	-	-	8	-	-	-	6000	-	-
	06/25/87	-	-	0.1054	-	-	-	-	-	-	-	0.0308	0.0240
	08/27/87	-	-	-	-	-	-	-	-	-	490	-	-
	08/28/87	-	-	0.0938	-	-	-	-	-	-	-	-	0.0485
	12/18/87	-	10	0.1973	0.005	-	-	-	-	-	186	-	-
26-86	09/18/86	-	-	-	-	0.00026	-	0.044	-	-	6	-	-
	03/18/87	-	-	-	0.02	-	-	-	-	-	8	-	0.05
	08/28/87	-	-	-	0.18	-	-	-	-	-	-	-	0.0251
28-86	03/17/88	-	-	0.1512	0.005	-	-	-	-	-	-	-	0.0657
	03/19/87	-	-	0.0869	-	0.0076	-	-	-	-	-	-	0.03
	06/24/87	-	-	-	-	-	-	-	-	-	4	-	-
	06/25/87	0.0003	-	0.2854	-	-	-	-	-	-	-	-	0.0275
56-87	03/16/88	-	-	-	-	-	-	-	29	-	57	-	-

NOTE: Numbers in parentheses are ground-water protection standards.
NA: No standard available

TABLE E-24

TABLE IX CONSTITUENTS ABOVE DETECTION LIMITS - ALLUVIAL GROUND WATER SOLAR PONDS AREA

(continued)

Key to Symbols for Constituents

As -	Arsenic
Ba -	Barium
Be -	Beryllium
MEK -	2-Butanone
Cd -	Cadmium
CCl_4 -	Carbon tetrachloride
$CHCl_3$ -	Chloroform
Cr -	Chromium
Co -	Cobalt
Cu -	Copper
1,1-DCA -	1,1-Dichloroethane
1,2-DCA -	1,2-Dichloroethane
t-1,2-DCE -	trans-1,2-dichloroethene
Hg -	Mercury
MeCl -	Methylene Chloride
Ni -	Nickel
Pb -	Lead
Sb -	Antimony
Se -	Selenium
Ag -	Silver
PCE -	Tetrachloroethene
Tl -	Thallium
1,1,1-TCA	1,1,1-trichloroethane
1,1,2-TCA	1,1,2-trichloroethane
TCE -	Trichloroethene
V -	Vanadium
Zn -	Zinc

TABLE E-25

TABLE IX CONSTITUENTS ABOVE DETECTION LIMITS - BEDROCK GROUND WATER
SOLAR PONDS AREA

Well Number	Sample Date	As (0.05)	Ba (1.0)	MEK NA	Cd (0.01)	CCl_4 NA	Cr (0.05)	Co (0.05)	Cu (1.0)	Hg (0.002)	MeCl NA	Ni (0.2)	Pb (0.5)	Se (0.01)	Ag (0.05)	Tl NA	TCE NA	V (0.1)	Zn (5.0)
14-86	05/15/88	-	0.0432	-	-	-	0.0204	-	0.0113	-	-	-	-	-	-	-	-	-	0.0321
	04/16/87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.09
	06/11/87	-	-	-	-	-	-	-	-	-	-	0.0476	-	-	-	-	-	-	0.1309
	08/06/87	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.0226
	12/09/87	-	-	-	-	-	-	-	0.0134	-	-	-	-	-	-	-	-	-	0.0226
16-86	09/18/86	-	-	-	-	-	-	-	-	0.0003	-	-	-	0.0045	-	-	-	-	0.005
	03/15/88	-	0.0989	-	-	-	0.0452	-	0.0570	-	-	-	-	-	-	-	-	-	0.1149
	04/22/87	-	0.0516	-	-	-	-	-	0.0452	-	-	-	-	-	-	-	-	-	0.02
	06/11/87	-	0.0296	-	-	-	-	-	0.0725	-	-	-	0.006	-	-	-	-	-	0.0492
	08/07/87	-	0.0418	-	-	-	0.0198	-	0.0545	-	-	0.089	-	-	-	-	-	-	0.0578
	12/18/87	-	0.0315	-	-	-	0.0120	-	0.0203	-	12	0.0464	-	0.005	-	-	-	-	0.0295
23-86	01/15/88	-	-	-	-	7	-	-	-	-	13	-	-	-	-	-	-	-	-
	01/16/88	0.005	0.0328	-	-	-	-	-	0.0287	-	-	-	-	0.007	-	0.0288	-	-	0.1830
	03/22/88	-	0.0308	-	-	-	0.0146	-	0.0101	-	16	-	-	-	-	-	-	-	-
25-86	11/07/86	-	-	15	-	-	-	0.025	-	-	-	0.965	-	-	0.009	-	-	-	0.059
	01/16/88	0.019	0.0214	-	-	7	0.0378	-	0.0307	-	-	0.0757	-	-	0.0333	-	-	-	0.0232
	03/18/87	-	0.0210	-	-	-	-	-	-	-	-	0.1249	-	-	-	-	-	-	0.07
	03/22/88	-	0.0223	-	-	-	0.0161	-	0.0108	-	17	-	-	-	-	-	-	-	0.0635
	06/25/87	-	0.0301	-	-	-	-	-	-	0.0003	-	0.2102	-	-	-	-	-	-	0.0323
	08/28/87	-	0.0412	-	-	-	0.0158	-	0.0082	-	-	0.1005	-	-	-	-	-	-	0.0237
27-86	03/19/87	-	0.0213	-	-	-	-	-	-	-	-	0.1271	-	-	-	-	-	-	-
	03/22/88	-	0.0268	-	-	-	-	-	0.0477	-	17	0.0415	-	-	-	-	-	-	0.0507
	04/15/87	-	0.0313	-	-	-	-	-	0.0067	-	-	0.1869	-	-	-	-	-	-	0.3
	06/25/87	-	0.0279	-	-	-	-	-	0.0067	-	-	0.1158	0.016	-	0.0089	-	-	-	-
	09/23/87	-	0.0574	-	-	-	-	-	0.0315	-	-	0.0993	-	0.005	-	-	-	0.0300	-
	12/17/87	-	0.0258	-	-	-	-	-	0.0374	-	13	0.0622	-	0.006	-	-	-	-	0.0218
30-86	09/19/86	-	0.580	-	-	-	-	-	-	0.0011	-	-	-	0.010	0.030	0.644	-	-	0.023
	01/16/88	0.011	0.2230	-	-	-	0.0122	-	0.0375	-	14	-	-	0.017	-	-	-	-	0.0267
	03/17/88	-	0.2364	-	-	-	0.0188	-	-	-	-	-	-	0.005	-	-	5	-	0.0360
	03/23/87	-	0.2099	-	-	-	-	-	-	-	-	-	-	-	0.0102	-	-	-	0.03
	04/15/87	-	0.3108	-	-	-	-	-	-	-	-	-	-	0.007	0.0130	-	-	-	0.3
	06/25/87	-	0.3155	-	-	-	-	-	-	-	-	-	0.006	-	-	-	-	-	-
	09/24/87	-	0.3511	-	-	-	0.0169	-	0.0064	-	-	-	-	0.011	-	-	-	-	0.0265
32-86	11/07/86	-	0.100	-	-	-	-	-	-	-	-	-	0.012	-	0.010	-	-	-	0.077
	03/22/88	-	0.1159	-	-	-	-	-	-	-	17	-	-	-	-	-	-	-	0.2735
	03/23/87	-	0.0385	-	-	-	-	-	0.0104	-	-	-	-	-	-	-	-	-	-
	04/15/87	-	0.1404	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.4
	06/30/87	-	0.1323	-	-	-	-	-	-	-	-	0.0622	0.009	-	-	-	-	-	-
	09/23/87	-	0.1358	-	-	-	-	-	0.0154	-	-	-	-	-	-	-	-	-	0.0988
	12/17/87	0.005	0.1174	-	-	-	-	-	0.0465	-	14	-	-	0.005	-	-	-	-	0.0416
39-87	03/17/88	-	0.0202	-	0.001	-	-	-	-	-	15	-	-	-	-	-	-	-	-

NOTE: Values in parentheses are ground-water protection standards.
NA: No standard available

TABLE E-25

TABLE IX CONSTITUENTS ABOVE DETECTION LIMITS - BEDROCK GROUND WATER SOLAR PONDS AREA

(continued)

Key to Symbols for Constituents

As -	Arsenic
Ba -	Barium
MEK -	2-Butanone
Cd -	Cadmium
CCl_4 -	Carbon tetrachloride
Cr -	Chromium
Co -	Cobalt
Cu -	Copper
Hg -	Mercury
MeCl -	Methylene Chloride
Ni -	Nickel
Pb -	Lead
Se -	Selenium
Ag -	Silver
Tl -	Thallium
TCE -	Trichloroethene
V -	Vanadium
Zn -	Zinc

present in the samples. However, barium and nickel were frequently reported above background, and represent a possible release from the regulated unit.

Arsenic, barium, cadmium, chromium, cobalt, copper, mercury, molybdenum, nickel, lead, selenium, silver, strontim, vanadium, and zinc were detected in the bedrock samples. Table E-25 lists the Appendix IX constituents detected in the samples from the bedrock wells in the solar pond area, which include silver, arsenic, barium, cobalt, cadmium mercury, molybdenum, nickel, selenium, strontium, thallium, lead, and zinc. Of these metals present above background, only nickel and strontium were frequently reported at values significantly higher than background (greater than two times background) and are considered to be constituents of the bedrock contaminant plume. Also, nickel is characteristic of the liquid and sludge from the Solar Evaporation Pond and therefore is a constituent that was probably released from the regulated unit. The remaining metals are not considered contaminants due to the infrequency of their detection and their low concentration relative to background levels.

E-5b(2) Volatile Organics

Appendix IX volatile organic compounds carbon tetrachloride (CCl_4), chloroform ($CHCl_3$), 1,1-dichloroethene (1,1-DCE), 1,2-dichloroethane (1,2-DCA), trans-1,2-dichloroethene (t-1,2-DCE), methylene chloride, tetrachloroethene (PCE), 1,1,1-

trichloroethane (1,1,1-TCA), 1,1,2-trichloroethane (1,1,2-TCA) and trichloroethene (TCE) were detected in samples of alluvial ground water during interim status monitoring at the Solar Evaporation Ponds (Table E-24).

The VOC constituents of the alluvial ground water contaminant plume in the solar pond area are TCE, $CHCl_3$, and CCl_4. The remaining VOCs listed above are isolated low concentration occurrences or are considered laboratory artifact, and are therefore not considered to be releases from the regulated unit. This determination is based on the frequency of the detection of a VOC and on the value of the VOC in the QA/QC samples. Only sample concentrations of an analyte exceeding ten times the blank concentration are considered truly representative of the presence of that analyte in ground water (EPA, 1985). Table E-26 compares the volatile organic compound concentrations found within in each sample to its correlative field or laboratory blank concentration. TCE, $CHCl_3$, and CCl_4 are believed to be true contaminants since they were present in the samples at concentrations greater than ten times the concentration in its associated blank (or no QA/QC data were provided).

Volatile organic compounds were also detected in two bedrock wells at the Solar Evaporation Ponds during interim status monitoring at concentrations meeting the aforementioned criteria of ten times the associated blank concentration. However, the sporadic occurrence of low concentrations of VOCs in bedrock

TABLE E-26

VOLATILE ORGANIC COMPOUNDS ABOVE THE DETECTION LIMIT IN SOLAR EVAPORATION PONDS AND THEIR ASSOCIATED BLANK SAMPLES

Well No.	Sample No.	Sample Date	Compound	Concentration (ug/l) Sample	FB	TB	LB
Alluvial Wells							
13-86	13-86-08-14-87	08/04/87	$CHCl_3$	125	NR	NR	NR
			1,1,2-TCA	6	NR	NR	NR
22-86	G228609860	09/09/86	TCE	410	ND	2J,4J	ND
			$CHCl_3$	147	ND	ND	ND
			CCl_4	350	ND	ND	ND
	22-86-03-24-87	03/24/87	$CHCl_3$	100	NR	ND	NR
			1,1,1-TCA	1400	NR	ND	NR
			TCE	650	NR	ND	NR
	22-86-06-24-87	06/24/87	1,2-DCA	8000	ND	ND	NR
			CCl_4	3000	ND	ND	NR
			TCE	6000	ND	ND	NR
	22-86-08-28-87	08/28/87	$CHCl_3$	80	NR	NR	NR
			CCl_4	491	NR	NR	NR
			TCE	490	NR	NR	NR
	22-86-12-18-87	12/18/87	$CHCl_3$	38	ND	ND	NR
			CCl_4	161	ND	ND	NR
			TCE	186	ND	ND	NR
28-86	28-86-06-24-87	06/24/87	TCE	4	ND	ND	NR
			PCE	8	ND	ND	NR
56-87	56-87-03-16-88	03/16/88	1,1-DCA	6	ND	ND	ND
			$CHCl_3$	6	ND	ND	ND
			1,1,1-TCA	29	ND	ND	ND
			TCE	57	ND	ND	ND
Bedrock Wells							
16-86	16-86-12-17-87	12/17/87	MeCl	12	17	18	NR
23-86	23-86-01-15-88	01/15/88	CCl_4	7	ND	ND	NR
	23-86-03-14-88	03/14/88	TCE	55	ND	ND	ND
30-86	30-86-04-15-87	04/15/87	TCE	5	NR	NR	NR
	30-86-06-24-87	06/24/87	PCE	16	ND	ND	NR

Notes: FB = Field Blank
TB = Trip Blank
LB = Laboratory Blank

NR = Not reported (no associated blank)
ND = Not detected
B = Compound present in blank
J = Value estimated below the detection limit

MeCl = Methylene Chloride
MEK = 2-Butanone
PCE = Tetrachloroethene
CCl_4 = Carbon Tetrachloride
1,1-DCE = 1,1-Dichloroethene
1,1,2-TCA = 1,1,2-Trichloroethane
$CHCl_3$ = Chloroform
TCE = Trichloroethene
CS_2 = Carbon Disulfide
1,1-DCA = 1,1-Dichloroethane
1,1,1-TCA = 1,1,1-Trichloroethane

Laboratory blank data not provided for samples analyzed by 881 Laboratory, Rocky Flats Plant.

ground water does not appear to indicate that the deep and shallow bedrock sandstone ground water is impacted by VOCs from the solar ponds.

E-5b(3) Major Ions

Calcium, potassium, magnesium, manganese, sodium, chloride, nitrate, sulfate, bicarbonate, and total dissolved solids (TDS) were consistently reported above background in the samples collected from the alluvial wells. These ions are considered to be constituents of the alluvial ground-water plume. These contaminants were present in alluvial and bedrock wells throughout the solar pond area.

Major ion concentrations are elevated in the alluvial ground water with chloride as high as 336 mg/l, sulfate at 500 mg/l, and TDS at 16,776 mg/l. Nitrate concentrations in the alluvial ground water range from one (1) to 2,200 mg/l. Although these substances are not listed in Appendix IX they are released to ground water from the Solar Evaporation Ponds. Figure E-10 exhibits the extent of the nitrate plume in the alluvial ground water based on the available analytical data from the solar pond wells.

Nitrate, the most prominent indicator of contamination arising from the solar ponds, is with few exceptions below 0.5 mg/l in bedrock ground water. The exceptions are the occurrence of 42 mg/l in well 27-86 and the occurrence of 6.9 and 1.9 mg/l on two

sampling events of well 32-86. These wells are both completed in lower deep sandstones, contamination of which by the solar ponds is a remote possibility. These nitrate concentrations appear to be outliers. The nitrate data tend to support that the deep bedrock ground water is not impacted by the solar ponds.

The high salt concentrations in deep bedrock ground water relative to background is likely due to dissolution of minerals in the bedrock west of the Plant. Ground water in the upper sandstones is a calcium/magnesium bicarbonate water, although sodium, chloride, and sulfate also occur above background. In contrast, ground water in the lower sandstones had low, (generally within background ranges) of calcium, magnesium, strontium, and bicarbonate. This water is only elevated in sodium, chloride, and sulfate.

At this time, no evaluation of the extent of ground-water contamination within the subcropping sandstone units at the solar ponds can be made. However, it appears that chloride, nitrate, sulfate, bicarbonate and TDS are constituents of the bedrock contaminant plume. Major ion concentrations are elevated in the bedrock ground water samples with chloride concentrations as high as 318 mg/l, nitrate at 1440 mg/l, sulfate at 1100 mg/l, bicarbonate at 437 mg/l, and TDS at 14,019 mg/l.

E-5b(4) Radionuclides.

Radionuclides are not Appendix IX constituents but they are discussed here as they are constituents of the contaminant plume. Plutonium was found in one well on two occasions (22-86). Because plutonium was not frequently reported above background, it is not considered to be a contaminant released from the solar ponds. Uranium and tritium consistently exceeded background in the bedrock wells in the solar pond area. These radionuclides are elevated in the alluvial ground water with uranium-233+234 as high as 1,000(300) pCi/l, uranium-235 at 47(15), uranium-238 at 750(200) pCi/l, and tritium at 12,000 pCi/l. The well completed in shallow weathered claystone, 30-86, contained radionuclide concentrations, specifically uranium and tritium, elevated above background. Plate E-10 illustrates the lateral extent of total uranium in the alluvial ground water based on the available ground-water analytical results.

The radionuclide data indicate elevated uranium and tritium in the bedrock ground-water samples frequently above background concentrations. Total uranium concentrations ranged from 0.14(0.10) to 239.2(25.8) pCi/l and tritium concentrations ranged from 210 to 8611(825) pCi/l. These radionuclides are constituents of the bedrock ground water contaminant plume. No evaluation can be made at this time concerning the extent of any contamination within the subcropping sandstones at the Solar Evaporation Ponds.

E-6 GENERAL GROUND-WATER MONITORING REQUIREMENTS

In accordance with 6 CCR 1007-3 100.41(c)(5) and 40 CFR 270.14(c)(5) the following ground-water monitoring program is the proposed plan by which the Rocky Flats Plant will meet the requirements of 6 CCR 1007-3 264.97 and 40 CFR 264.97 for the Present Landfill, the Original Process Waste Line, the West Spray Field, and the Solar Evaporation Ponds. The ground-water monitoring plan complies with requirements at 6 CCR 1007-3 100.41(c)(6) and 264.98 for detection monitoring (40 CFR 270.14(c)(6) and 264.98), 6 CCR 1007-3 100.41(c)(7) and 264.99 for compliance monitoring (40 CFR 270.14(c)(7) and 264.99), and 6 CCR 1007-3 100.41(c)(8) and 264.100 for corrective action programs (40 CFR 270.14(c)(8) and 264.100). The interim status alternate and assessment ground-water monitoring programs have been designed to meet the requirements of 264 detection monitoring and most of the requirements of 264 compliance monitoring. This will allow a smooth transition from interim status to permitted ground-water monitoring at the regulated units. Changes that will be made to the ground-water monitoring programs for 264 detection and 264 compliance monitoring are addressed in Sections E-7 and E-8. The following subsections discuss the general ground-water monitoring requirements applicable to each unit.

E-6a Description of Wells

E-6a(1) Number, Location, and Depth of Wells

In accordance with 6 CCR 264.97(1),(2) and 40 CFR 264.97(a)(1),(2), the proposed ground-water monitoring systems will consist of a sufficient number of wells, installed at appropriate locations and depths to yield ground-water samples from the uppermost aquifer which represent the quality of ground-water passing the point of compliance. In addition, the proposed ground-water monitoring program will represent the quality of background ground water that has not been affected by leakage from a regulated unit. The number of wells at each unit, well locations, and well depths are discussed in Sections E-2c1) and E-67c1) for the Present landfill, Sections E2c3) and E-8c1) for the West Spray Field and Sections E-2c4) and E-8c(2) for the Solar Evaporation Ponds. In addition, well locations are shown on Plates E-35, E-36, and E-37 for the Present Landfill, West Spray Field, and Solar Evaporation Ponds, respectively. Background well locations are presented in Section E-6c and shown on Plate E-38.

E-6a(2) Well Construction Materials

Regulations 6 CCR 1007-3 40 CFR Part 264.97(c) require that all monitoring wells be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be

screened or perforated and packed with gravel or sand, where necessary, to enable collection of ground-water samples. The annular space above the sampling depth must be sealed to prevent contamination of samples and the ground water. The three types of monitoring wells proposed for the ground-water detection and compliance monitoring systems will be installed in accordance with these regulations.

The alluvial, shallow bedrock, and deep bedrock wells will be constructed of four-inch outside diameter (O.D.) Schedule 40 flush-threaded PVC. The screened interval will consist of four-inch O.D. Schedule 40 PVC with 0.01" machine slots. The sand pack will consist of 16-40 silica sand and will extend from the base of the screen to not more than two feet above the screen. If the borehole is deeper than the required well depth, a bentonite pellet seal will be placed beneath the bottom cap before well construction is initiated. In addition, a bentonite pellet seal will be placed above the sand pack interval in the well annulus. Neat cement grout will extend from the top of the bentonite seal to the ground surface. A protective casing and lockable cap will be installed at the surface, and a three foot by three foot concrete pad will be poured around the protective casing to protect the well from damage.

The alluvial wells will be screened in surficial materials. In order to maintain discrete sampling intervals, the screened interval will not exceed 20 feet (Figure E-11). If more than 15

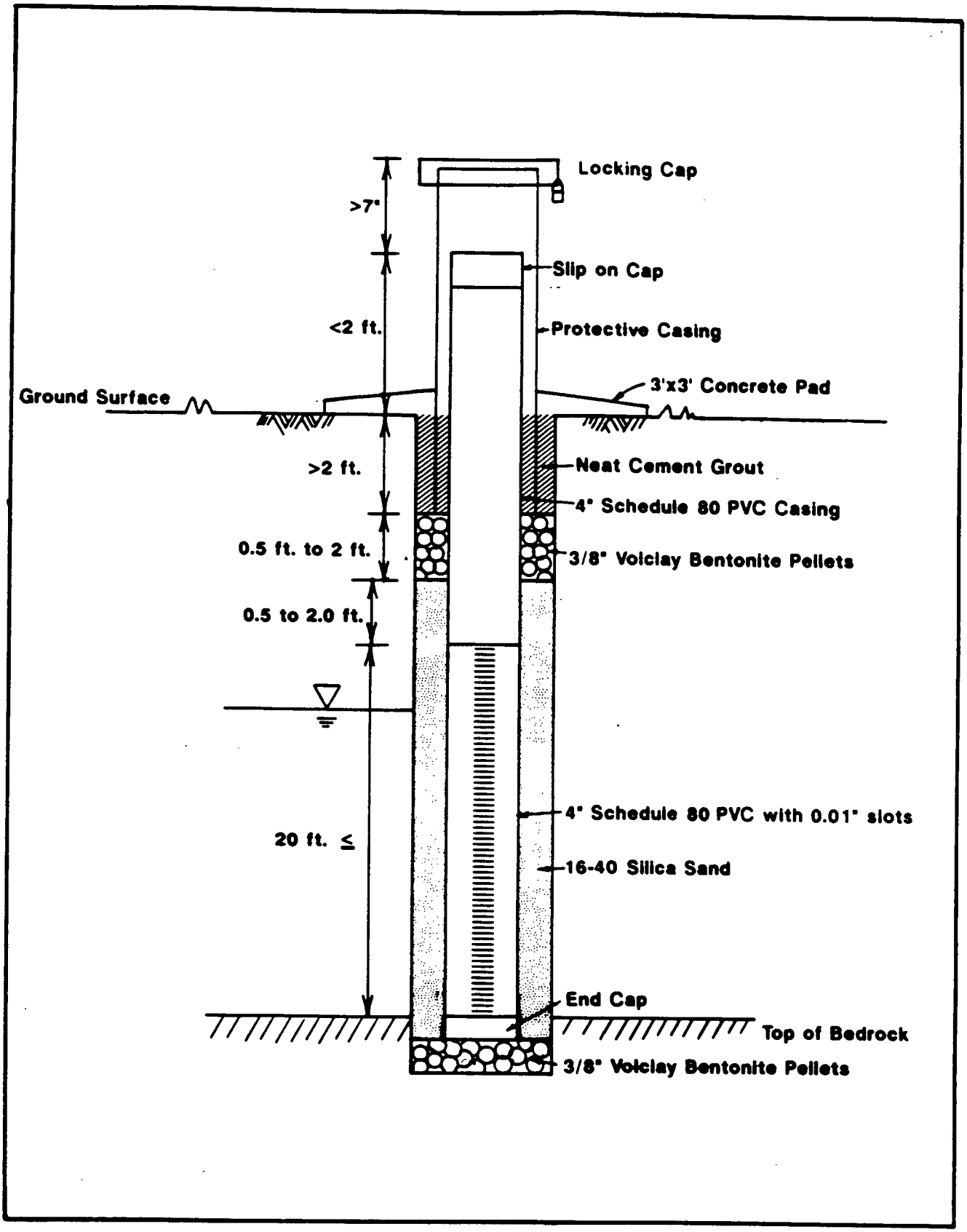


Figure E-11: PROPOSED ALLUVIAL MONITOR WELL CONSTRUCTION

feet of saturated thickness are encountered, only the upper 15 feet will be screened. The 20 foot screened interval will extend five feet above the maximum anticipated water level to allow for seasonal fluctuations. Should a clay layer greater than one foot in thickness be encountered, a second borehole will be drilled and two wells will be installed. One well will be completed above the clay layer, and the second well will be completed beneath the clay to evaluate vertical hydraulic and chemical gradients.

The sandpack in an alluvial well well extend from the bottom of the screened interval to less than two feet above the screen. A one-half to two foot thick bentonite pallet seal will overlie the sand pack. Neat cement grout will be placed from the top of the bentonite seal to the surface, where the protective casing and the concrete pad will be installed.

Shallow bedrock wells will be installed to monitor ground-water quality and water levels in weathered claystone and subcropping sandstones. The screened interval in the shallow bedrock wells will extend from one foot below the bedrock/ alluvium contact to the base of severe weathering for weathered clay stone wells and to the base of the sandstone for subcropping sandstone wells (Figure E-12). The sandpack will extend from the base of the screened interval to one foot below the bedrock/alluvium contact in order to effectively separate the well from surficial materials. A bentonite pellet seal will extend from the

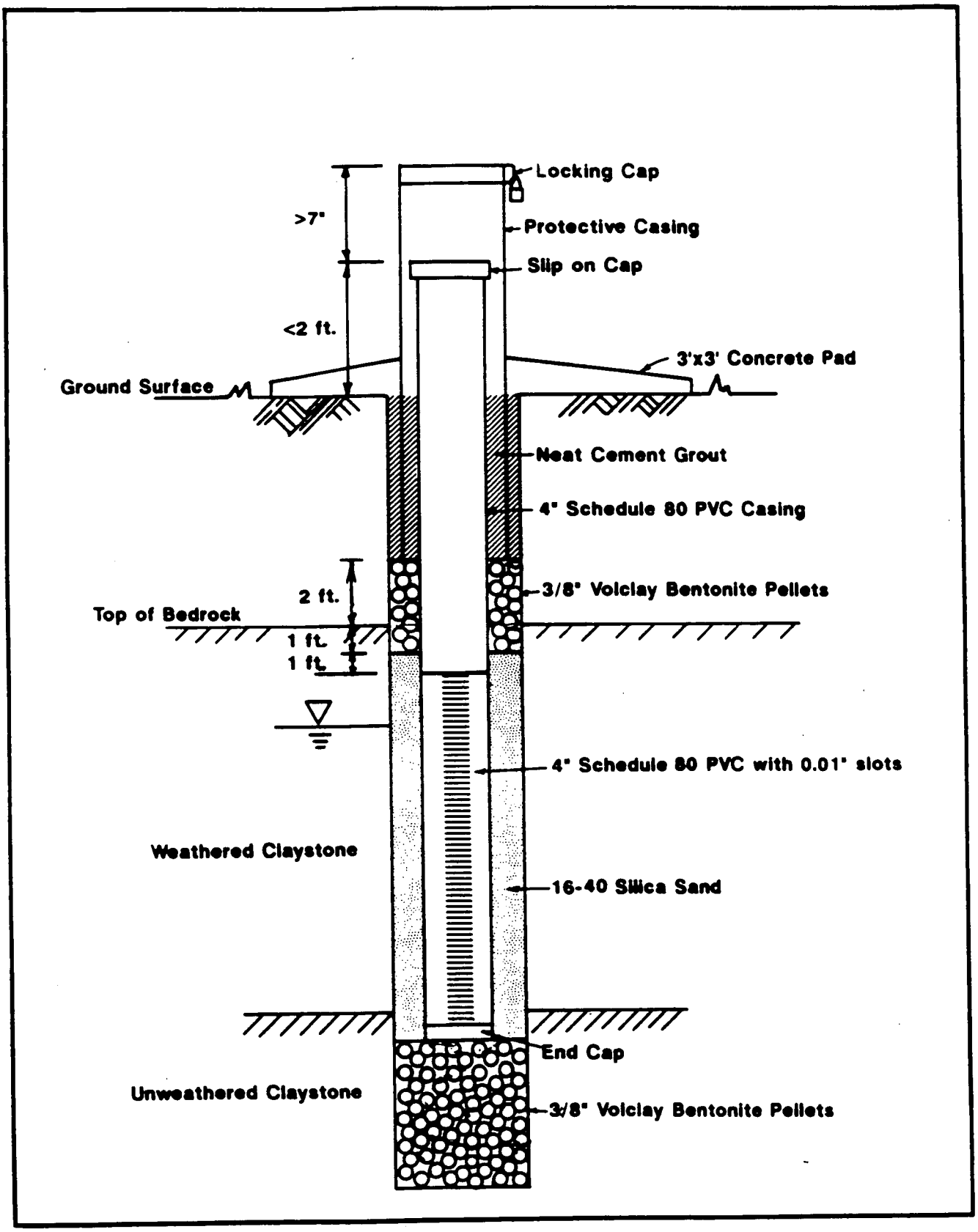


Figure E-12: PROPOSED SHALLOW BEDROCK MONITOR WELL CONSTRUCTION

bedrock/alluvium contact to two foot above the contact in order to effectively separate the well from surficial materials. Neat grout cement will extend from the top of the bentonite seal to the ground surface where the protective cover and concrete pad will be installed.

The proposed deep bedrock well construction is depicted in Figure E-13. To avoid potential transmission of alluvial ground-water into bedrock, eight inch O.D. steel casing will be installed from the ground surface to three to five feet into unweathered bedrock as surface casing prior to drilling the deep bedrock borehole. After allowing the surface casing cement to cure, the well will be drilled through the surface casing to the targeted bedrock sandstone. Bedrock sandstones will be screened through their entire thickness. The sandpack will extend one foot above the screened interval. A two foot bentonite pellet seal will be placed above the sandpack. Neat cement will be tremied from the top of the bentonite pellet seal to the ground surface where the protective casing and the concrete pad will be installed.

E-6b <u>Sampling and Analysis Procedures</u>

In accordance with 6 CCR 1007-3 100.41(c)(6)(iv) and 100.41(c)(7)(iv), 40 CFR 270.14(6)(iv) and 270.14(7)(iv), the following is a description of the sampling, analysis, and statistical comparison procedures to be utilized in evaluating ground-water monitoring data. The ground-water monitoring programs will include consistent sampling and analysis procedures

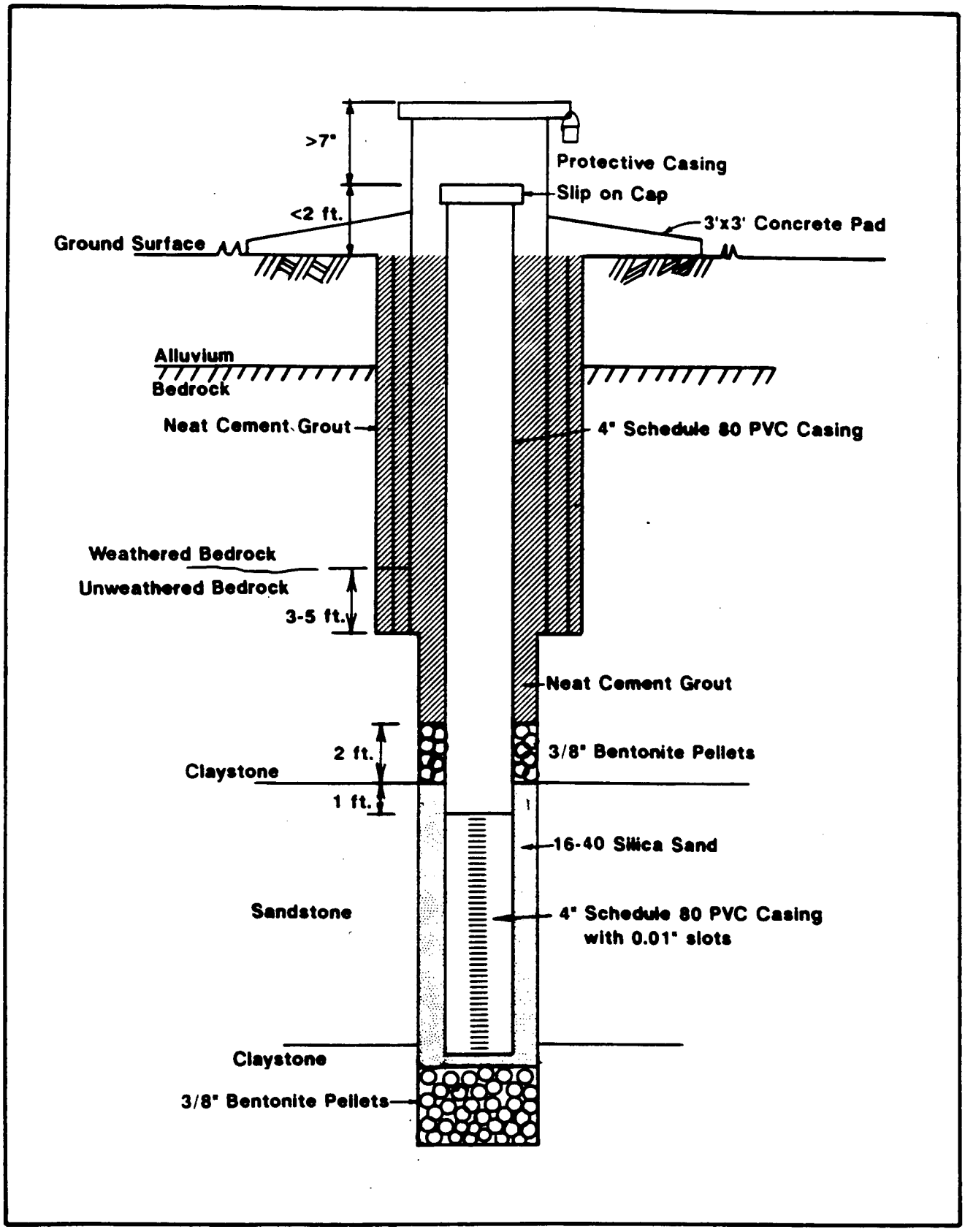


Figure E-13: PROPOSED DEEP BEDROCK MONITOR WELL CONSTRUCTION

designed to provide monitoring results which are reliable indications of ground-water quality exiting the waste management area. The program description includes the procedures and techniques for ground-water level measurement, sample collection, sample preservation and shipment, analytical procedures, and chain of custody control (6 CCR 1007-3 and 40 CFR Parts 264.97(d) and (f)).

E-6b(1) Groundwater Elevation Measurements

Each time ground-water is sampled from a well, the ground-water elevation will be determined (6 CCR 1007-3 and 40 CFR Parts 264.97(f)) prior to purging the well. Ground-water levels will be measured with a steel tape, an electric sounder, a petroleum product probe, or a transducer. Ground-water levels will be measured from the surveyed mark on the top of the casing to the ground-water surface with an accuracy of 0.01 feet. The measuring device will be decontaminated prior to use in each well.

E-6b(2) Sample Collection Methods

E-6b(2)(a) Equipment Decontamination

All non-dedicated sampling equipment will be decontaminated prior to use in each well. Decontamination procedures will consist of cleaning with a non-phosphate detergent followed by a triple

rinse with distilled water. The effectiveness of the decontamination procedure will be evaluated by the analysis of daily field blanks collected during sampling, as discussed in Section E-6b(2)(g).

E-6b(2)(b) Detection of Immiscible Layers

Prior to purging the well, the surface of the standing water in the well will be checked for floating layers. Either a hydrocarbon interface probe or a bailer gently lowered into the upper one foot of the water table and raised will be used to identify floating hydrocarbon layers in the well water. No floating or sinking immiscible layers have been observed in the presently operational wells at the Rocky Flats Plant during the 1986 through 1988 sampling. Therefore, no floating or sinking layers are expected in the detection or compliance monitoring wells.

E-6b(2)(c) Well Evacuation

The water standing in the well may have different chemical characteristics than the water in the formation because of volatilization of constituents and/or changes in oxidation and pH conditions. For this reason, the water standing in the well must be purged and water representative of the formation water brought into the well before the actual sample is collected.

Purging will consist of removing a minimum of three well bore storage volumes from high production wells or a minimum of one wellbore storage volume from low production wells. A high production well is a well from which three wellbore storage volumes can be removed without stopping to wait for the well to recharge. When volume drops below 0.5 liters, purging is complete. A low production well is a well from which three wellbore storage volumes cannot be removed in eight hours due to insufficient inflow to the well from the formation. PUrging is a continuous process and only takes place until three volumes of water are removed or the well goes dry.

Wellbore storage volume is the volume of water standing inside the well casing, i.e., the distance between the water level and the bottom of the casing (length of the water column in the well), multiplied by the inner cross sectional area of the casing. A well is considered dry if before purging, the wellbore storage volume is below two liters calculated volume. The appropriate number of calculated wellbore storage volumes will be removed from the well using the dedicated pump bailer or portable sampling pump. Regardless of the type of equipment used to purge the well the total volume purged and the time when purging begins and ends will be recorded. Dedicated sampling pumps will be used to purge and sample wells where available. Stainless steel or teflon bailers will be used otherwise, unless the well is a high production well and is more easily purged with a portable sampling pump.

E-6b(2)(d) Sample Collection

If immiscible floating or sinking layers are observed in the well water, those layers will be sampled prior to purging the well. A peristaltic pump may be used to "vacuum" a sample from the top of the floating layer, or a top-filling bailer may be used to collect the sample, if the floating layer is only inches thick. To sample dense immiscible sinking layers a double check valve bailer or a point source sampler will be slowly and gently lowered to the base of the well for sample collection.

After evacuating the well, ground-water samples will be taken with a dedicated pump if available. Otherwise either a stainless steel or teflon bailer will be used. Care will be taken to minimize sample agitation, avoid aeration, and reduce sample contact with the atmosphere during transfer of the sample from the sampling device to the sample container. The bottled sample will be filtered, preserved and/or stored on ice, as appropriate, immediately after sampling.

E-6b(2)(e) In Situ or Field Analyses

The field parameters of temperature, pH, and specific conductance will be measured according to the manufacturers specifications for the instruments prior to sample collection. The pH and conductivity meters will be standardized prior to sampling with

standard solutions. Temperatures of the standard solutions will be taken at the time that the pH and conductivity measurements are taken.

E-6b(2)(f) Sample Containers

Samples will be transferred directly from the sampling equipment to the sample containers. The type of sample container will be determined based on the analyses to be performed and the requirements specified in the "Test Methods for Evaluating Solid Waste-Physical/Chemical Methods" (SW-846) (EPA, 1985), "Methods for Chemical Analysis of Water and Wastes" (EPA-600/4-79-020) and/or in "Standard Methods for the Examination of Water and Wastewater". The sample containers will be precleaned according to EPA approved procedures. The specific types of sample containers to be used for the proposed detection and compliance monitoring programs are discussed in Sections E-7d and E-8f.

E-6b(2)(g) Field Quality Assurance/Quality Control

The field quality assurance/quality control program includes two basic areas: documentation of field activities (ie: decontamination procedures, sampling techniques, unusual occurrences, preservation of samples and order in which samples were collected), and the routine collection and analysis of duplicates, trip blanks, and field (equipment) blanks. Field

QA/QC will follow procedures outlined in the IGMP QA/QC Plan (Rockwell International, 1988b).

Field duplicates and blanks will be collected as outlined below.

- One duplicate sample will be collected and analyzed for every ground-water samples collected.
- Trip blanks will be prepared by the laboratory prior to shipping the sample bottles to the sampling team. One of each type of bottle used in sampling will be selected and filled with deionized water by the laboratory. The trip blank will be transported to the field site with the sample bottles and will be subjected to the identical handling procedures and analytical procedures as the samples. One trip blank will be collected and analyzed for every ten investigative samples.
- Field blanks will be collected to evaluate the effectiveness of decontaminating non-dedicated sampling and filtering devices between sample. Field blanks will be collected by either filling the sampling device with distilled water or pumping distilled water through the sampling device after decontamination of the device. The distilled water will then be transferred to sample bottles and sent to the laboratory for analysis with the ground-water samples. One field blank will be collected and analyzed per day of sampling.

E-6b(3) Sample Preservation and Shipment

Samples will be preserved and field filtered according to the analytical procedures described in the "Test Methods for Evaluating Solid Waste-Physical/Chemical Methods" (SW-846) (EPA, 1985), "Methods for Chemical Analysis of Water and Wastes" (EPA-600/4-79-020) and/or in "Standard Methods for the Examination of Water and Wastewater". Preservation of samples includes chemical preservation of the sample (ie: pH control, control of biological

action, and control of hydrolysis and sorption effects), cooling the sample to 4 degrees centigrade, freezing the sample, or protecting the sample from light. For example: Samples for volatile organics, analyses will not be filtered, but will be immediately cooled to 4 degrees centigrade. Samples requiring dissolved metals analyses will be field filtered through a 0.45 micron cellulose acetate or cellulose nitrate filter. After filtering the dissolved metals, samples will be preserved with nitric acid to a pH less than two. Samples requiring total metals analyses will not be filtered but will be preserved with nitric acid to a pH less than two.

Shipment of ground-water samples will be accomplished in containers with packing materials designed to prevent breakage, spills, and contamination of samples. Where appropriate, the samples requiring refrigeration will be placed in waterproof containers with ice or freezer packs. The shipment of samples will comply with Department of Transportation (DOT) regulations, as appropriate.

E-6b(4) Analytical Procedures

Details of the laboratory analysis program are presented in the Rocky Flats Plant Installation Generic Monitoring Plan (IGMP) Quality Assurance/Quality Control (QA/QC) Plan (Rockwell International, 1988b). The plan specifies the analytical methods and QA/QC requirements for the RCRA and CERCLA programs.

Specific analyses to be performed for the proposed interim status alternate monitoring programs, as well as detection and compliance monitoring programs are presented in Table E-27. Table E-28 summarizes from the QA/QC Plan the analytical procedures, recommended container type, and the minimum volume of sample required for monitoring the Table E-27 parameters. It will also be necessary to analyze Appendix IX constituents during compliance monitoring. This is discussed in Section E-8.

E-6b(5) Chain of Custody Documentation

The ground-water monitoring programs will include chain of custody control of sample integrity to guard against manipulation and/or unknowing contamination of the samples. Chain of custody procedures document the custody of the samples with a written tracking system that lists each person responsible for the samples from the time of sample collection through the analytical procedures at the laboratory.

Chain of custody documentation includes the following:

- Sample labels which specify sample number, date and time of collection, parameters requested, sample location, samplers initials, and preservatives added.
- Sample seals attached to the shipping container or the individual sample bottles to demonstrate that the samples have not been disturbed during transport.
- Field notebook or sampling documentation forms to record sampling times, dates, preservatives, filtering, evacuation and sampling methods, well sampling sequence, etc.

TABLE E-27

PROPOSED POST-CLOSURE GROUND-WATER SAMPLING PARAMETERS

FIELD PARAMETERS
Ph
Specific Conductance
Temperature

INDICATORS
Total Dissolved Solids

METALS (dissolved)
Hazardous Substances List - Metals
- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Calcium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Magnesium
- Manganese
- Mercury
- Nickel
- Potassium
- Selenium
- Silver
- Sodium
- Thallium
- Tin
- Vanadium
- Zinc

Chromium (hexavalent)
Lithium
Strontium

TABLE E-27 (Continued)

PROPOSED POST-CLOSURE GROUND-WATER SAMPLING PARAMETERS

ANIONS
Carbonate
Bicarbonate
Chloride
Sulfate
Nitrate

ORGANICS
Hazardous Substances List - Volatiles*
- Chloromethane
- Bromomethane
- Vinyl Chloride
- Chlorethane
- Methylene Chloride
- Acetone
- Carbon Disulfide
- 1,1-Dichloroethene
- 1,1-Dichloroethane
- trans-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-1,3-Dichloropropene
- Trichloroethene
- Dibromochloromethane
- 1,1,2-Trichloroethane
- Benzene
- cis-1,3-Dichloropropene
- 2-Chloroethyl Vinyl Ether
- Bromoform
- 2-Hexanone
- 4-Methyl-2-pentanone
- Tetrachloroethene
- Toluene
- Chlorobenzene
- Ethyl Benzene
- Styrene
- Total Xylenes

Oil and Grease

TABLE E-27 (Continued)

PROPOSED POST-CLOSURE GROUND-WATER SAMPLING PARAMETERS

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

*Ground-water samples from the first quarter of 1987 were analyzed for 9 of the TCL 2nd, 3rd and part of 4th volatiles. These volatiles are the chlorinated solvents historically detected in the ground water and are as follows: PCE, TCE, 1, 1-DCE, 1, 2-DCA, t-1, 2-DCE, 1, 1, 1-TCA, 1, 1, 2-TCA, CCl_4 and $CHCl_3$.

TABLE E-28
PROPOSED GROUND-WATER PARAMETERS ANALYSIS METHODS

Analyte	SW-846 Method (3rd edition)	Recommended Container	Preservative	Maximum Holding Time	Minimum Volume Required
Aluminum	6010,7000,7020	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Antimony	6010,7000,7040,7041	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Arsenic	7000,7060,7061	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Barium	6010,7000,7080	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Beryllium	6010,7000,7090,7091	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Cadmium	6010,7000,7130,7131	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Chromium	6010,7000,7190,7191	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Cobalt	6010,7000,7200,7201	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Copper	6010,7000,7210	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Iron	6010,7000,7380	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Lead	6010,7000,7421	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Manganese	6010,7000,7460	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Mercury	7000,7470	P,G**	HNO_3 to pH <2	28 days	100 ml
Molybdenum	6010,7000,7480,7481	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Nickel	6010,7000,7520	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Selenium	7000,7740,7741	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Silver	6010,7000,7760	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Thallium	6010,7000,7840,7841	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Vanadium	6010,7000,7910,7911	P,G**	HNO_3 to pH <2	6 mos.	100 ml
+ Zinc	6010,7000,7950	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Cesium	To be determined for final report.				
+ Lithium	To be determined for final report.				
Strontium	To be determined for final report.				
Calcium	7000,7140	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Magnesium	7000,7450	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Potassium	7000,7610	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Sodium	7000,7770	P,G**	HNO_3 to pH <2	6 mos.	100 ml
Bicarbonate	To be determined for final report.				
Chloride	9250,9251,9252	T,P,G**	4 degrees C.	28 days	50 ml
Nitrate	9200	T,P,G**	4 degrees C., H_2SO_4 to pH <2	14 days	1000 ml

TABLE E-28
PROPOSED GROUND-WATER PARAMETERS ANALYSIS METHODS (continued)

Analyte	SW-846 Method (3rd edition)	Recommended Container	Preservative	Maximum Holding Time	Minimum Volume Required
Sulfate	9035,9036,9038	T,P,G**	4 degrees C.	28 days	50 ml
++Cyanide	9010,9012	P,G**	4 degrees C., NaOH to pH >12	14 days	500 ml
++Phenols	9065,9066,9067	G**	4 degrees C., H_2SO_4 to pH <2	28 days 7 days until extraction	500 ml
TCL VOA	8040	G** Teflon-lined cap	4 degrees C., 0.008%$Na_2S_2O_3$	40 days after extraction	1000 ml
TCL VOA	8240	G**	4 degrees C.	14 days	2 - 40 ml
TCL VOA	8010 + 8015	G**	4 drops conc. HCl, 4° C.	14 days	2 - 40 ml

Radionuclides	Method
Gross Alpha	HASL 300
Gross Beta	HASL 300
*Uranium^{233,234}	HASL 300
*Uranium^{235}	HASL 300
*Uranium^{238}	HASL 300
Plutonium^{239,240}	HASL 300
Americium^{241}	HASL 300
Strontium^{89,90}	HASL 300
Tritium	HASL 300

+ Appendix IX Metals
++ Appendix IX Non-metals
* Total Uranium
** "P" indicates plastic; "T" indicates teflon; "G" indicates Glass

- Chain of Custody form to trace sample possession from the time of sample collection through the analytical procedure.
- Sample analyses request sheets (may be combined with chain of custody form) inform the laboratory of the analyses to be conducted on each sample.
- Laboratory logbook and analysis books record all pertinent information about the sample, including instrument methods, temperatures, personnel performing each analytical procedure, use of specific reagents, etc.

E-6b(6) Documentation of Proper Sampling and Analysis Procedures

Sample control and documentation will ensure the quality of the field and laboratory work performed. Documentation will be accomplished with the use of the following records:

- Field notebook or sampling documentation forms to record sampling times, dates, preservatives, filtering, evacuation and sampling methods, well sampling sequence, etc. Field notebooks will be numbered and assigned to individuals. Pages of the notebooks will be sequentially numbered, dated, and initialed by field personnel. Waterproof ink will be used when making entries in field notebooks.
- Laboratory logbook and analysis books record all pertinent information about the sample, including instrument methods, temperatures, personnel performing each analytical procedure, use of specific reagents, etc.
- Written correspondence to document any variations to the sampling protocol or the analytical procedures.
- Sample labels or tags.
- Chain of Custody documentation.
- Analytical Records.

E-6c Procedures for Establishing Background Ground-water Quality

In accordance with 6 CCR 1007-3 264.97(g) (40 CFR 264.97(g)), background ground-water quality will be established for each of the hazardous constituents or monitoring parameters specified in Table E-27 for the Present Landfill, Original Process Waste Line, West Spray Field, and Solar Evaporation Ponds. Background ground-water quality will be based on data from quarterly sampling of wells upgradient of the waste management area for one year (6 CCR 1007-3 264.97(g)(1); 40 CFR 264.97(g)(1)).

Background ground-water quality may be based on samples from wells not immediately upgradient of the unit if it cannot be determined which wells are upgradient or if other wells will provide more representative background data (6 CCR 1007-3 264.97(g)(3); 40CFR 264.97(g)(3)). Because of the large number of Solid Waste Management Units (SWMUs) at the Rocky Flats Plant, wells west, south, and north of the Plant will serve as background wells. The specific wells proposed to serve as background wells for the regulated units are discussed below.

In support of remedial investigations and RCRA closure activities at Rocky Flats Plant, new background wells are being completed in Rocky Flats Alluvium, colluvium, and Arapahoe Formation sandstones upgradient and sidegradient of the Plant. Plate E-38 presents these proposed well locations. Alluvial ground-water

quality will be characterized by construction and sampling of ten wells completed in Rocky Flats Alluvium and ten wells completed in colluvial materials. Ground water occurs in both of these units at the regulated units. In addition, ten wells will be installed in Arapahoe Formation sandstones at three locations on Plant site. Details of this background sampling plan are presented in Rockwell International (1988b).

Background alluvial water quality will be established using wells 55-86, 100-88, 101-88, 102-88, 103-88, 104-88, 105-88, 106-88, 108-88, and 110-88, and colluvial background ground-water quality will be determined using data from wells. Proposed bedrock wells 107-88, 109-88, 112-88, 115-88, 116-88, 119-88, 122-88, 123-88, and 128-88 will serve to characterize background bedrock ground-water quality.

It is noted that the proposed background wells are located sidegradient and downgradient of the West Spray Field. Wells 55-86, 100-88, 101-88, 102-88, and 103-88 are not impacted by any solid waste management unit (SWMU) or regulated unit at Rocky Flats Plant. Wells 104-88, 105-88, 106-88, 108-88, and 110-88 are located downgradient of the West Spray Field; however, as discussed in Section E-5, the nitrate plume from the spray field is within the waste management units. All of these wells are also completed in the same materials as alluvial wells at the spray field.

Ground-water samples will be collected from background and upgradient wells on a quarterly basis and analyzed for monitoring parameters listed in Table E-27. Background sampling results will be presented as concentration ranges, means, and standard deviations for each analyte detected.

E-6d Ground-Water Quality Evaluation Procedures

Data evaluation will consist of first determining the acceptability of the analytical data and then performing a statistical analysis to determine if a significant difference exist between background and downgradient concentrations of an analyte.

E-6d(1) Determining Data Acceptability

Several criteria will be used to judge the acceptability of the analytical data:

- Sufficiency of data reporting
- Presence and sufficient documentation of QA/QC
- Presence and documentation of custody
- Validity of sampling and analysis methodology
- Conceptual validity.

The first four criteria will be applied to the data through implementation of the Quality Assurance\Quality Control (QA/QC) plan and the procedures identified in Sections E-6a and E-6b. Conceptual validity is assessed by comparing an analyte

concentration to previously collected data for that analyte at that well. The comparison is performed to preliminarily assess if the new datum is an outlier, i.e., an extreme observation that does not conform to the pattern established by the other observations.

Dixon's Test for outliers (Dixon, 1953) will be used to determine if individual data are outliers. If a new datum is determined to be an outlier, it will be necessary to determine if the datum is a result of a sample coding error, data transcription error, or an instrument error. If an error cannot be identified, the datum will not be excluded from subsequent statistical analysis because the datum may actually reflect greater spatial or temporal variability than expected (background well), or a release from a regulated unit (downgradient well).

Dixon's outlier test determines the probability that the datum would be observed if the data were normally distributed, by computing the fraction of the range between the datum and the nearest data point and the entire range of the data set. The calculated fraction is compared to the test criterion, r, at the 95% confidence interval. The calculation begins with the ordering of the data set from highest to lowest, assigning X_N to the highest value and X_1 to the lowest value. For less than eight measurements (typical of the Rocky Flats data base), reject X_N if:

$$\frac{X_N - X_{N-1}}{X_N - X_1} > r$$

Critical values for r at the 95% confidence level are shown:

Number of Measurements	r
3	0.941
4	0.765
5	0.642
6	0.560
7	0.507

Dixon's test can result in false negatives (an outlier is not identified) if there are two (2) high or two (2) low outliers; however, the test is applicable to small data sets. When 25 or more data points are available, an alternate test for outliers may be used, such as Rosner's method or Nalimov's test which are not sensitive to masking by multiple outliers (Gilbert, 1987; Zanker, 1984).

An issue related to conceptual validity of a datum is the introduction of organic contaminants into a sample by the sample container, field sampling procedure, or laboratory environment. This is assessed with the use of trip blanks, field blanks, and reagent blanks (laboratory blanks), respectively. A sample datum will be considered usable for subsequent evaluation provided the following two criteria are met (EPA, 1986):

1. It is verified that the reagent blank analysis(es) contain less than the Contract Required Detection Limits (CRDL) of any TCL compound; (5 X CRDL) for the following specific compounds:

a. Methylene Chloride
b. Acetone
c. Toluene
d. Common phthalate esters

2. The concentration of the compound in the sample exceeds 10 times the amount in any blank for the common contaminants listed above or 5 times the amount for other compounds.

E-6d(2) Statistical Analysis

A paired difference test is proposed as an alternate to the Student t-test presented at 6 CCR 1007-3 265.93(b) and 264.97(h)(1) [(40 CFR 265.93(b) and 264.97(h)(1)]. This statistical analysis will be used for both the interim status alternate monitoring programs [6 CCR 1007-3, 265.93(d)(3)(iii), (40 CFR 265.93(d)(3)(iii)], and the permitted detection monitoring programs [6 CCR 1007-3 264.97(h)(2), 40 CFR 264.97(h)(2)] and compliance monitoring programs [6 CCR 1007-3 264.99(h), 40 CFR 264.99(h)]. The test is proposed because the Student t-test requires that the background and downgradient data sets be independent, a requirement that may be violated due to seasonal influences on both background and downgradient chemical conditions. Seasonal effects could result in a large standard deviation of the mean of each data set. Consequently, it would be less likely that the test statistic would reject the null hypothesis (H_o) if it is false. The null hypothesis is that the background concentration is not different than the downgradient concentration. The paired t-test eliminates season-to-season variability and thereby yields more information on the mean difference in the concentration of a parameter for background and

downgradient.

The statistical analysis will be a moving four quarter paired difference testing between the mean background concentration for an analyte and the value of the analyte at a downgradient (or upgradient) well. The analysis will not be performed until the background wells (and proposed downgradient wells at the compliance point) are installed and four quarters of analytical data are collected (265.92(c)(2) and 264.97(g)(1)). The null hypothesis (H_o) to be tested is that the average difference over four quarters between the mean background concentration and the downgradient concentration at a well for an analyte is zero. The procedure is as follows:

1. Compute the mean background concentration for an analyte for each of the four quarters:

$$\bar{X}b_{jk} = \frac{1}{n} \sum_{i=1}^{n} Xb_{ijk}$$

where Xb_{ijk} = the concentration at the ith background well for the jth analyte, for the kth quarter

2. Compute the difference between the mean background concentration for an analyte and the downgradient concentration at each well for each of the four quarters:

$$d_{ijk} = \bar{X}b_{jk} - Xd_{ijk}$$

where Xd_{ijk} = the concentration at the ith downgradient well for the jth analyte, for the kth quarter.

3. Compute the mean difference over the four quarters:

$$\bar{d}_{ij} = \frac{1}{4} \sum_{i=1}^{4} d_{ijk}$$

4. Compute the stanadard deviation of the mean computed in 3.

$$s\bar{d}_{ij} = \frac{1}{\sqrt{4}} \sqrt{\frac{\sum_{k=1}^{4} (d_{ijk} - \bar{d}_{ij})^2}{4 - 1}}$$

5. Compute the t-statistic:

$$t\bar{d}_{ij} = \frac{\bar{d}_{ij}}{s\bar{d}_{ij}}$$

6. Reject H_o if $t\bar{d}_{ij} > t_{a/2}(n - 1)$ where a = the significance level = 0.05, and n - 1 are the degrees of freedom = 4 - 1 = 3. $t_{.025}(3) = 3.182$.

If the value of the t-statistic is negative then there is no significant difference between the mcnitoring data and the background data. Significantly large negative values may be indicative of a failure of the assumption made for test validity or errors have been made in collecting the background data.

The process is repeated every quarter by adding the latest quarterly data and deleting the oldest quarterly data in the analysis. If two successive quarters show the difference is significant, it will be concluded that a statistically significant increase has occurred. The increase may have

resulted from a release from the regulated unit or from another upgradient SWMU. The latter will be tested by performing the statistical analysis on upgradient well data.

With respect to organics, if two successive quarters show the presence of volatiles above Contract Laboratory Program (CLP) Contract Required Detection Limits (CRDLs) and meeting the usability criteria identified above, it will be concluded that organics are present at the compliance point and originate from the regulated unit or another SWMU.

The results of these evaluations will be presented in the annual reports submitted to the Regional Administrator.

E-7 DESCRIPTION OF DETECTION MONITORING SYSTEMS

Detection monitoring programs will be implemented for the Present Landfill and the Original Process Waste Lines where the presence of hazardous constituents has not been detected in the ground water at the time of permit application. The detection monitoring plans provide sufficient information and supporting data to meet the requirements of 6 CCR 1007-3 100.41(c)(6), 264.98 and 40 CFR 270.14(c)(6), 264.98. The following sections discuss the proposed ground-water monitoring system for each unit.

E-7a List of Indicator Parameters

To monitor the water quality of ground-water passing the point of compliance at the Present Landfill and the Original Process Waste Line, the parameters listed in Table E-27 will be analyzed on a semi-annual basis. Although interim status alternate ground-water monitoring for these units is on a quarterly basis, if these parameters are not shown to be significantly elevated at the compliance point, ground-water monitoring will be semi-annual in accordance with 264 detection monitoring requirements.

E-7b Background Ground-Water Concentration Values for Proposed Parameters

Background ground-water concentrations for indicator parameters will be established by sampling Plant background wells quarterly during the first year after their installation pursuant to 6 CCR 1007-3 and 40 CFR Parts 264.97(g)(1). Samples from background wells will be collected and analyzed following the procedures outlined in Section E-6b.

E-7c Description of Proposed Monitoring System

In accordance with 6 CCR 1007-3 and 40 CFR Parts 264.97(a)(2), the proposed detection monitoring systems for the Present Landfill and Original Process Waste Line will consist of a sufficient number of wells installed at appropriate locations and depths to yield ground-water samples from the uppermost aquifer which represent the quality of ground-water passing the point of compliance in the uppermost aquifer. The following sections describe the proposed detection monitoring systems for the Present Landfill and the Original Process Waste Line.

E-7c(1) Present Landfill

Sixteen monitoring wells completed in the uppermost aquifer and located at the point of compliance will form the post-closure detection monitoring system at the Present Landfill (Plate E-35). Wells 10-86 and 58-87 will monitor alluvial ground-water quality

immediately upgradient of the unit. Alluvial wells 66-87, 72-87, LF-2, LF-4, 40-87, LF-7, 71-87, 67-87, and 60-87 form a ring around the landfill and will monitor alluvial ground water exiting the unit. Bedrock wells LF-1 and LF-5 will monitor Arapahoe sandstones known to subcrop beneath the Present Landfill. If weathered claystone is found to be a significant ground-water pathway during interim status monitoring of wells LF-3, LF-6, and LF-8, these wells will also be included in the detection monitoring system. No wells inside the waste management unit are proposed for post-closure detection monitoring. Well details for detection monitoring wells, including well depths and anticipated screened intervals, are presented in Tables E-2 and E-3.

E-7c(2) Original Process Waste Line

Hydrogeologic characterization of the area surrounding the Original Process Waste Line is incomplete at this time. Therefore, over 100 piezometers will be installed within the Plant Security Area and adjacent to the Original Process Waste Lines during interim status monitoring.

Water levels in these piezometers and nearby monitor wells will be measured for one year to assess ground-water flow directions. This program will also assist in defining the flow relationship between surficial materials, building foundation drains, and the Original Process Waste Lines.

Also during this year, soil sampling will be performed adjacent to the lines to evaluate the extent of soil contamination. Based on soil sampling results, post-closure ground-water monitoring may not be required for all areas of the Original Process Waste Line. Post-closure ground-water monitoring for this unit will be proposed as necessary following these hydrogeologic and soils investigations.

E-7d Proposed Sampling, Analysis, and Statistical Comparison Procedures

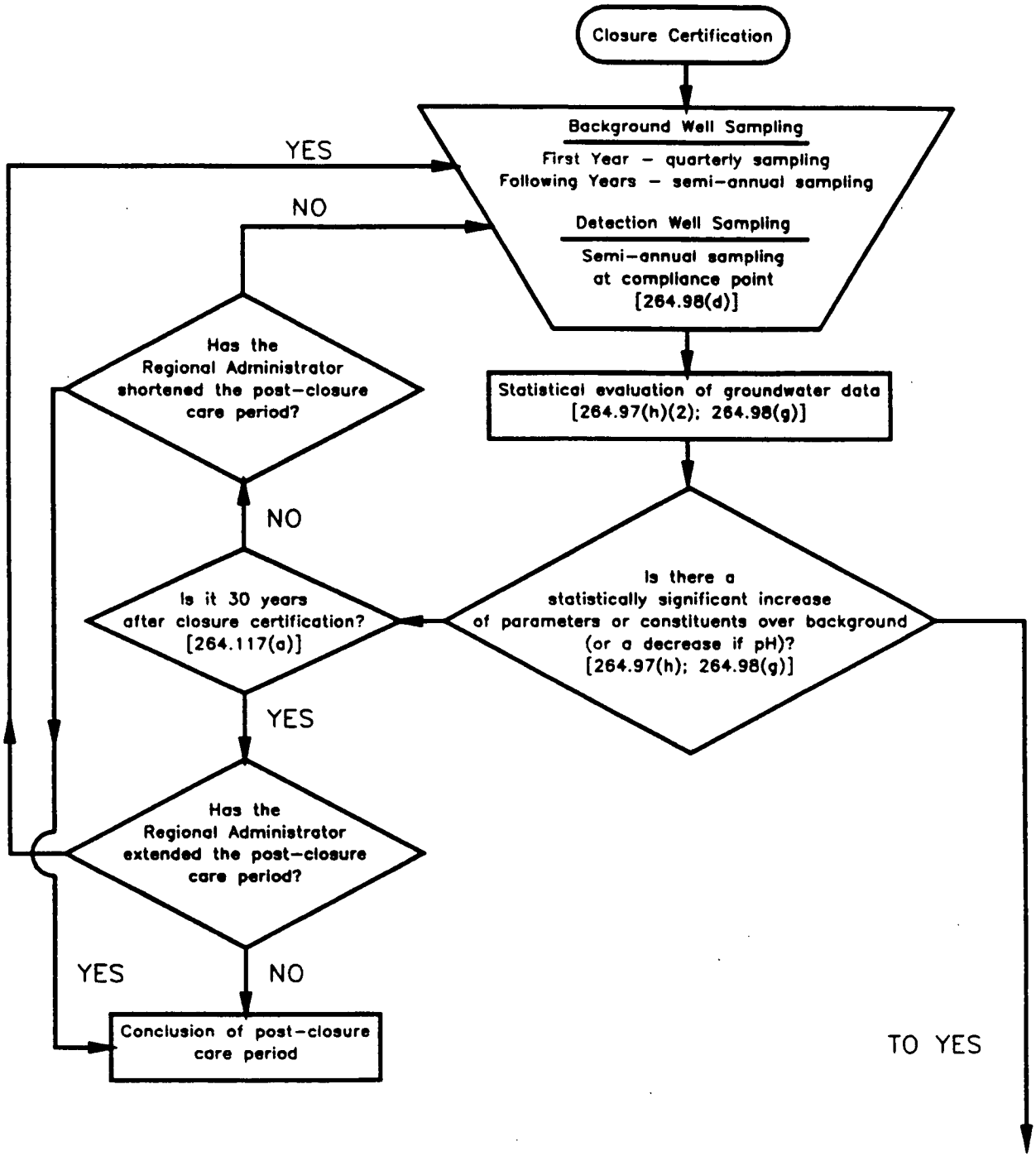
Ground-water samples collected from detection monitoring wells will be analyzed for the parameters listed in Table E-27. Sampling and analysis methods will follow the procedures outlined in Section E-6b. Statistical analysis will be the paired difference test described in Section E-6d.

E-7e Required Actions for Statistically Significant Increases in Monitoring Parameters

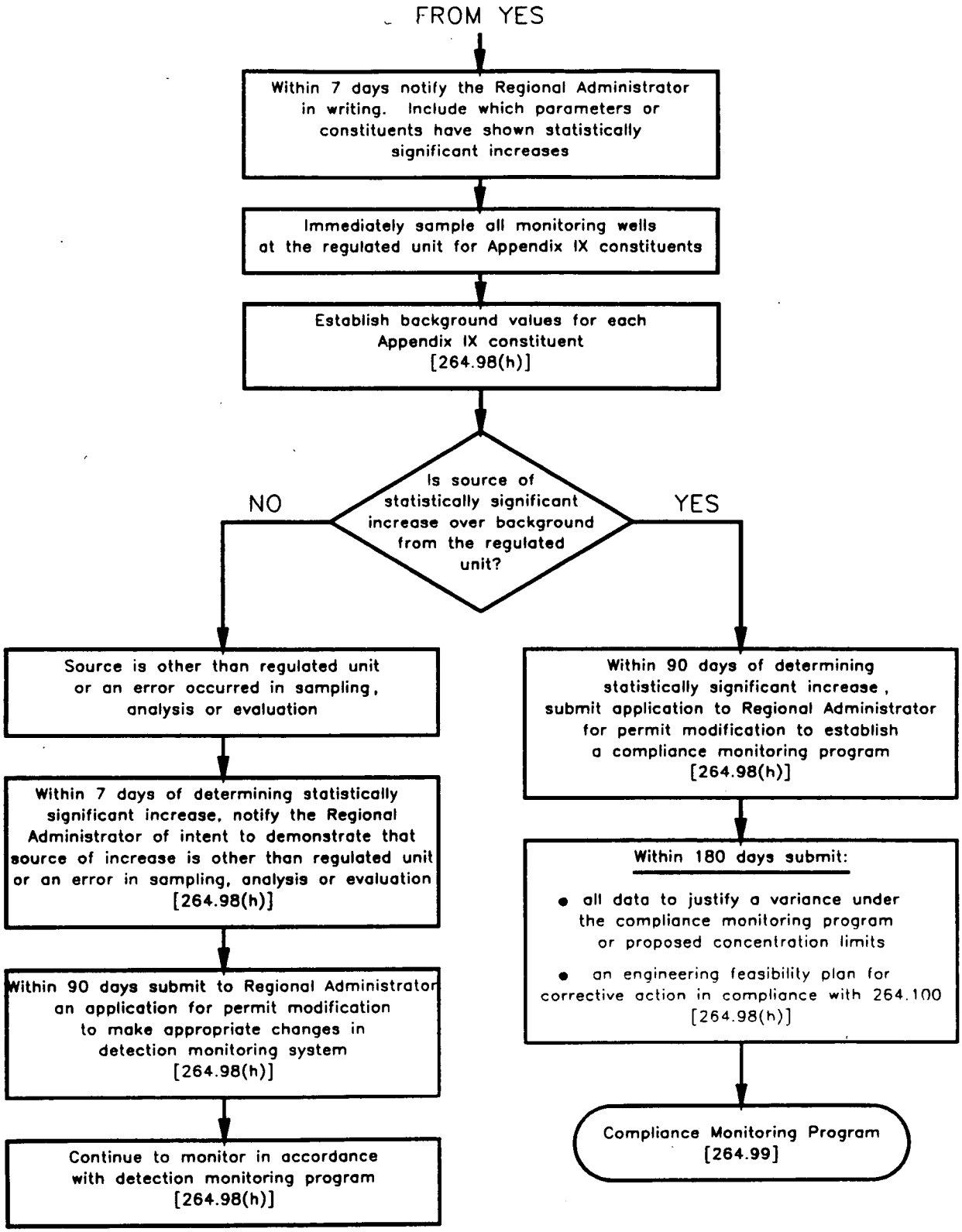
If the statistical analysis performed as referenced in Section E-7d indicates a significant increase (or pH decrease) for the monitoring parameters, it will be necessary to comply with a series of reporting and additional sampling and analysis requirements. These requirements are outlined in Figure E-14.

Figure E-14:

DETECTION MONITORING DECISION FLOWCHART



DETECTION MONITORING DECISION FLOWCHART (continued)



E-8 DESCRIPTION OF COMPLIANCE MONITORING PROGRAMS

If, at the point of compliance, there is a statistically significant increase over background values for any parameter specified in the permit for detection monitoring (Table E-27), the owner or operator of the facility must provide sufficient information and supporting data to establish a compliance monitoring program which meets the requirements of 6 CCR 1007-3 100.41(c)(7) and 264.99 [40 CFR 270.14(c)(7) and 264.99]. The following compliance monitoring programs proposed for the Solar Evaporation Ponds and the West Spray Field demonstrate compliance with these regulations by addressing the following regulatory requirements:

- A schedule for submittal of an engineering feasibility plan for corrective action in accordance with 6 CCR 1007-3 100.41(c)(8), 264.100 [40 CFR 270.14(c)(7)].
- A description of the wastes previously handled at the facility [6 CCR 100.41(c)(7)(i); 40 CFR 270.14(c)(7)(i)].
- A characterization of the contaminated ground water, including concentrations of hazardous constituents [6 CCR 1007-3 100.41(c)(7)(i), 264.99(a)(i); 40 CFR 270.14(c)(7)(ii), 264.99(a)(1)].
- A list of hazardous constituents for which compliance monitoring will be undertaken [6 CCR 1007-3 100.41(c)(7)(iii); 40 CFR 270.14(c)(7)(iii)].
- Proposed concentration limits for each hazardous constituent, including a justification for establishing alternate concentration limits or a ground-water protection standard [6 CCR 1007-3 100.41(c)(7)(iv), 264.99(v); 40 CFR 270.14(c)(7)(iv), 264.94, 264.99(a)(2)].

- Detailed plans describing the proposed ground-water monitoring system [6 CCR 100.41(c)(7)(v), 264.99(b); 40 CFR 270.14(c)(7)(v), 264.99(b)].
- A description of proposed sampling and analysis plans, and statistical comparison procedures to be utilized in evaluating the ground-water monitoring data [6 CCR 100.41(c)(7)(vi), 264.99(c), (d), (f), (g), (h); 40 CFR 270.14(c)(7)(vi), 264.99(c), (d), (f), (g), (h)].

It is noted that there are insufficient data to determine if there is a statistically significant increase in Table E-27 parameters at the compliance point for the West Spray Field. It has only been concluded at this time that nitrate has been released to alluvial ground water beneath the unit. Further sampling and analysis at the point of compliance, and a statistical evaluation as described in E-6d must be performed to be conclusive. The compliance monitoring program described here is presented to comply with the Part 264 regulations if it is determined that Table E-27 parameters are significantly elevated above background levels at the compliance point.

The focus of compliance monitoring is to determine statistically significant increases in Appendix IX constituents at the point of compliance.

E-8a Description of Wastes Previously Handled at the Facility

The characterization of the waste handled at the West Spray Field and Solar Evaporation Ponds are presented in the Appendices I-4 and I-2, Closure Plans for the West Spray Field and the Solar

Evaporation Ponds, respectively. Tables E-29, E-30, E-31, E-32, E-33, and E-34 summarize the results of the analyses conducted on the Solar Evaporation Pond wastes collected from 1984 through 1986. The liquids sprayed at the West Spray Field were pumped from the solar ponds 207-B north and center to the West Spray Field.

E-8b Characterization of Hazardous Constituents in Ground Water

A discussion of the hazardous constituents detected in ground water at the West Spray Field and the Solar Evaporation Ponds is presented in Section E-5, Contaminant Plume Description. Tables presented in Section E-5 list the Appendix IX constituents above detection limits in each area. Well 55-86, located on the western side of the Rocky Flats Plant, is considered background for the purposes of this evaluation. This well is currently the only alluvial well present on the site which is isolated from all past and present waste management areas. It is, therefore, the well least likely to be influenced by past hazardous materials management practices. Ground-water quality results for this well are shown in Table E-35.

E-8c Proposed Monitoring Parameters

Hazardous constituents have been detected at the point of compliance for the Solar Evaporation Ponds. Therefore, these constituents will be included in the compliance monitoring system (6 CCR 1007-3 100.41(c)(7)(iii), 40 CFR 270.14(c)(7)(iii).

Table E-29

SUMMARY OF QUARTERLY SAMPLING - 1984, 1985

ANALYSIS	POND 207-A RANGE	POND 207-C RANGE
Number of Samples	7	7
pH	8.3 - 11.0	7.7 - 12.5
Nitrate/Nitrite/ Nitrogen (ppm)	ND - 21,739	0.4 - 18,841
Cyanide (ppm)	ND - 1.7	ND - 1.9
Beryllium (ppm)	ND - 0.1	ND - 0.6
Gross Alpha (pCi/l)	32(16) - 56,000(0.0)	10,000(17,000) - 15,000 (3,000)
Gross Beta (pCi/l)	2(27) - 27,000(600)	405(79) - 11,000(2,000)
Pu 239 (pCi/l)	0.0(420) - 240(100)	210(320) - 1,400(300)
Am 241 (pCi/l)	0.0(1,000) - 200(120)	12 - 13,000(1,000)
Uranium (pCi/l)	0.69(0.79) - 26,000(2,000)	1,800(300) - 15,000(1,000)
Tritium (pCi/l)	620(230) - 3,000(800)	0.0(0.0) - 6,400(600)

NOTE: (1) "ND" Indicates value less than detection limit.

(2) Values in parentheses indicate counting errors.

TABLE E-30

SUMMARY OF WEEKLY SAMPLING FOR PONDS 207-B, NORTH AND CENTER LIQUIDS, 1984 AND 1985

ANALYSIS	POND 207-B NORTH RANGE	POND 207-B CENTER RANGE
Number of Samples	76	75
pH	7.5 - 9.6	7.3 - 11.3
Nitrate (as N) (ppm)	335 - 1,367	ND - 15.6
Gross Alpha (pCi/l)	13(50) - 323(33)	-4(0) - 59(23)
Gross Beta (pCi/l)	5(25) - 163(25)	-8(11) - 73(0)

NOTE: (1) "ND" Indicates value less than detection limit.

(2) Values in parentheses indicate counting errors.

TABLE E-31

SUMMARY OF TWO SETS OF METAL ANALYSES OF
PONDS 207-B NORTH AND CENTER LIQUID
TAKEN IN OCTOBER 23, 1984 AND APRIL 23, 1985

ELEMENT	POND 207-B NORTH (mg/L)	POND 207-B CENTER (mg/L)
	Apr 1985, Oct 1984	Apr 1985, Oct 1984
Aluminum	0.16, 1	0.15, 2
Boron	0.29, 0.31	0.24, 0.67
Calcium	20.0, 290	2.9, 45.0
Cesium	ND[a]	ND, 0.041
Copper	ND	0.016, 0.037
Iron	0.28, 0.29	0.074, 0.2
Lead	ND, 0.0035	ND, 0.002
Lithium	0.37, 3.5	0.052, 0.41
Manganese	ND	0.022, 0.081
Magnesium	87.0, 120.0	3.9, 13.0
Molybdenum	ND, 0.0069	0.016, 0.037
Nickel	ND	0.015, 0.016
Phosphorous	ND	0.074, 0.2
Potassium	82.0, 120.0	30.0, 36.0
Selenium	0.01, 0.02	ND
Silicon	2.1, 5.6	2.4, 5.5
Silver	ND, 0.082	0.0016, 0.015
Sodium	370.0, 620.0	67.0, 250.0
Strontium	1.2, 3.5	0.28, 0.52
Tritium	ND, 0.069	0.022, 0.041
Vanadium	ND	ND, 0.0081
Zinc	ND	ND, 0.041
Zirconium	ND	ND, 0.0041

(a) ND indicates concentration below detection limit.

TABLE E-32

SUMMARY OF RADIOCHEMICAL ANALYSES APRIL AND MAY 1986

COMPOUND	POND 207-A Liquid (pCi/L)	POND 207-A Sludge (pCi/g)	POND 207-B NORTH Liquid (pCi/L
Gross Alpha	46,000(4,000) to 80,000(6,000)	4,700(200) to 14,000(1,000)	74(58) to 120(50)
Gross Beta	35,000(2,000) to 40,000(2,000)	160(20) to 1,400(100)	56(32) to 100(92)
Plutonium-239	56(16) to 660(50)	1,000(100) to 3,700(100)	ND
Americium-241	ND to 45(14)	1,400(200) to 4,400(100)	ND
Uranium-233+234	14,000(1,000) to 20,000(1,000)	71(10) to 570(30)	50(2) to 53(2)
Uranium-238	21,000(1,000) to 28,000(1,000)	130(10) to 480(30)	31(1) to 33(1)
Tritium	240(180) to 930(260)	1,300(500) to 12,000(1,000)	1,200(300) to 1,300(300)

Note: (1) ND indicates levels below the detection error limits.
(2) Units for tritium in sludge = pCi/l
(3) Values in parentheses indicate counting uncertainty.

TABLE E-33

SUMMARY OF METALS AND PHENOLS TESTING
APRIL AND MAY 1986

TOTAL COMPOUND (Total)	POND 207-A Liquid (ug/L)	POND 207-A Sludge (mg/kg)	POND 207-B NORTH Liquid (ug/L)
Aluminum	2,310-2,640	11,000-11,900	ND
Arsenic	150	ND	ND
Barium	ND	ND	ND-220
Beryllium	27-43	309-1,570	ND
Cadmium	70-150	1,110-10,500	ND
Calcium	ND	19,600-50,000	176,000-198,000
Chromium	13,700-16,700	1,010-19,700	ND
Cobalt	200-500	ND	ND
Copper	1,610-1,800	425-1,590	ND
Iron	1,500-8,000	3,590-6,900	ND
Lead	ND	65-455	ND
Magnesium	ND	6,110-21,000	66,400-72,600
Manganese	95-115	153-595	ND-15
Mercury	ND-0.2	7.5-25	ND
Nickel	1,900-2,000	124-1,320	ND-50
Potassium	13,200,000-14,300,000	50,000-65,300	56,100-62,700
Selenium	ND	ND	9
Silver	310-370	153-237	ND
Sodium	36,300,000-42,900,000	130,000-166,000	363,000-451,000
Tin	7,000-13,000	ND	ND
Vanadium	100-210	ND	ND
Zinc	620-780	227-595	ND-22
Phenols	13-35	ND-3.3	3-46

Note: "ND" indicates compound not detected above the detection limit.

TABLE E-34

SUMMARY OF PARAMETERS MONITORED
IN POND 207-A SLUDGE IN MAY 1985

ANALYSIS	POND 207-A SLUDGE
pH	9.5
Nitrate-Nitrogen (ppm)	8,800
Beryllium (ppm)	170
Hexavalent Chromium (ppm)	<1
Gross Alpha (pCi/l)	860,000
U-235 (pCi/l)	28(19)
U-238 (pCi/l)	520(90)

NOTES: (1) "<" indicates result is less than detection limit (value shown)

(2) Values in parentheses indicate counting errors.

TABLE E-35

BACKGROUND ALLUVIAL GROUND-WATER QUALITY

Appendix IX	Concentration Range (mg/l)
Metals	
Antimony	0.02U
Arsenic	0.005U
Barium	0.0477-0.071
Beryllium	0.005U-0.011
Cadmium	0.005U
Chromium	0.01U
Cobalt	0.022U
Copper	0.0063U-0.012
Lead	0.005U-0.010
Lithium	0.1U
Mercury	0.0002U
Nickel	0.037U
Selenium	0.005U
Silver	0.0076U
Thallium	0.01U
Vanadium	0.024U
Zinc	0.02U-0.086
Nonhazardous Metals & Major Ions	
Aluminum	0.029U-0.22
Cesium	0.02U
Iron	0.0069U-0.125
Manganese	0.005U-0.066
Molybdenum	0.022U
Strontium	0.1134-0.154
Calcium	21.86-33.78
Magnesium	3.66-5.89
Potassium	0.70-4.70
Sodium	8.05-13.09
Bicarbonate	70-80
Chloride	5.8-19.3
Nitrate	0.80-1.50
Sulfate	15.3-27.0
Non-metals	
Cyanide	1.0U

The basic monitoring program at both sites will consist of extensive annual monitoring, with more limited quarterly monitoring. Annual monitoring will occur for all Appendix IX constituents, as required under 40 CFR 264.99 (52FR 25946). Quarterly monitoring at both sites will include those Appendix IX constituents found above background in the wells that make up the monitoring system for each unit. Table E-27 parameters will continue to be analyzed quarterly, because these parameters include hazardous compounds and their hazardous degradation products that are found in the waste managed in these areas. Table E-27 parameters also include most of the nonhazardous constituents listed in the July 9, 1987, Federal Register preamble to the regulations (52 FR 25944). The nonhazardous constituents are shown in Table E-36. Only boron, fluoride, and silica are not currently analyzed because they do not represent waste constituents and are not considered important parameters for characterizing ground-water quality of the area.

E-8c(1) West Spray Field

Well 49-86, although not at the point of compliance for the West Spray Field, it is within the waste management area. The hazardous constituents detected above background in at least one sampling of this well include barium, lead, selenium, and zinc. The nonhazardous constituents found to be above background in at least one sampling of the well are calcium, magnesium, manganese, sodium, strontium, chloride, sulfate, nitrate, uranium$^{233+234}$,

TABLE E-36

NONHAZARDOUS CONSTITUENTS FOR ANNUAL MONITORING

Aluminum

Bicarbonate/Carbonate

Boron

Calcium

Chloride

Fluoride

Hydrogen Ion (pH)

Magnesium

Manganese

Nitrate

Potassium

Silica

Sodium

Strontium

Sulfate

uranium^{238}, americium^{241}, and tritium. The West Spray Field received excess liquids from the Solar Evaporation Ponds 207B North and Center. The majority of the liquids in the ponds came from the interceptor trench pump house with pond 207B center also receiving some sanitary effluent. The application liquids for the West Spray Field are characterized in Appendix I-4, the West Spray Field Closure Plan.

The data suggest that the liquids contained low concentrations of metals and that nitrate and uranium are the only constituents of the applied water that were consistently and significantly elevated relative to the proposed ground-water concentration limits. The proposed quarterly monitoring parameters (Table E-27) include these waste constituents and the constituents previously identified as occasionally elevated in alluvial ground water. If, during annual compliance monitoring, additional Appendix IX constituents are detected above background levels, those constituents will be added to the list for quarterly monitoring. Concentration limits for the monitoring compounds are discussed in Section E-8d.

E-8c(2) Solar Evaporation Ponds

The solar pond waste, as described above, contains metals, radionuclides, cyanide, and a number of the nonhazardous major ions. In addition, there is an abandoned pond south of Pond 207C. The characteristics of the waste disposed of in this

abandoned pond are unknown, but ground water from well 22-86, which is in the area of the abandoned pond, contain a number of volatile organics. The compounds identified include trichloroethylene, tetrachloroethene, 1,1-dichloroethylene, 1,2-dichloroethane, t-1,2-dichloroethylene, 1,1,1-trichloroethane, 1,1,2-trichloroethane, chloroform, and methylene chloride. The quarterly monitoring parameters (Table E-27) include these above cited constituents. As with the West Spray Field, should other Appendix IX constituents be determined to be above background, they will be added to the quarterly monitoring parameters.

E-8d Proposed Concentration Limits

The ground-water protection standards established in 6 CCR 1007-3 264.94 (40 CFR 264.94) for hazardous constituents are either background levels or the SDWA drinking water standards for specific metals. Alternate concentration limits may be established if approved by the Regional Administrator.

Concentration limits may be established for chemicals outside of Appendix IX where necessary to protect human health and the environment. The July 9, 1987, Federal Register discusses these compounds, which are listed in Table E-37 . Concentration limits are proposed for the nonhazardous constituents seen in the wastes managed at the West Spray Field and the Solar Evaporation Ponds.

TABLE E-37

PROPOSED CONCENTRATION LIMITS

Constituent	Concentration	
Metals	(mg/l)	
Aluminum	5.0	AG
+ Antimony	0.02U *	BG
+ Arsenic	0.05 *	
+ Barium	1.0 *	
+ Beryllium	0.011	BG
+ Cadmium	0.01 *	
Cesium	0.02U	BG
+ Chromium	0.05 *	
+ Cobalt	0.022U	BG
+ Copper	0.012	BG
Iron	0.3 **	
+ Lead	0.05 *	
+ Lithium	0.1U	BG
Manganese	0.05 **	
+ Mercury	0.002 *	
Molybdenum	0.1	AG
+ Nickel	0.037U	BG
+ Selenium	0.01 *	
+ Silver	0.05 *	
Strontium	0.16	BG
+ Thallium	0.01U	BG
+ Vanadium	0.024U	BG
+ Zinc	0.086	BG
Radionuclides	(pCi/l)	
Gross Alpha	15	
Gross Beta	50	
Uranium-233,234	40 **	
Uranium-235	40 **	
Uranium-238	40 **	
Plutonium-239,240	40	
Americium-241	4	
Tritium	20,000	

TABLE E-37

PROPOSED CONCENTRATION LIMITS
Continued

Constituent	Concentration
Major Ions	(mg/l)
Calcium	NA
Magnesium	NA
Potassium	NA
Sodium	NA
Bicarbonate	NA
Chloride	250 **
Nitrate	10 **
Sulfate	250 **
Appendix IX Nonmetals	(mg/l)
Cyanide	0.2 *
Phenols	0.01
TCL Volatiles	CRDL***

++ Safe Drinking Water Act and Appendix IX metals
+ Appendix IX metals
* Primary Drinking Water Standards
** Secondary Drinking Water Standards
*** CRDL - CLP Contract Required Detection Limits
BG Background
AG Colorado Ground Water Agricultural Standards

Since two reservoirs are located downgradient of the plant, drinking water and human health standards are considered primary when setting concentration limits for hazardous and nonhazardous constituents. The ground-water protection standard in 6 ccr 1007-3 264.94 (40 CFR 264.94) is used for the SDWA metals specified (standards equivalent to the SDWA drinking water standards). The major ions, cyanide, and non-Appendix IX metals have concentration limits set by the Colorado Department of Health (CDH) as ground-water standards for the protection of human health, or for the protection of agriculture if human health standards have not been established. For non-SDWA Appendix IX metals and cases where no standards have been established, background water quality for Rocky Flats Plant is used.

The limits for radionuclides have been taken from a variety of sources. The plutonium and americium limits are the proposed drinking water standards for these compounds (51 FR 34859). The uranium limit is a CDH surface water standard (5 CCR 1002-8, Sec. 3.8.5 (3)). The other radionuclide limits are the SDWA maximum contaminant levels. The proposed concentration limits are shown in Table E-37.

Rockwell is proposing background concentration limits for a number of compounds. However, at this time, background is based on only one well, 55-86. Additional background wells are scheduled for installation. Since background water quality

information for all constituents is incomplete, the proposed concentration limits set here are preliminary. If sampling results from other background wells indicate higher background levels of contaminants, those levels will be adopted as the proposed concentration limits.

A number of the major ions included in annual ground-water monitoring do not have proposed concentration limits. These are calcium, magnesium, potassium, sodium, and bicarbonate. These compounds are not known to have adverse health effects and should not have an adverse effect on the environment surrounding the Rocky Flats Plant.

Bedrock ground-water concentration limits are shown in Table E-38. These limits differ from those in Table E-36, because background concentrations are different for bedrock and alluvial ground water.

E-8e Description of Proposed Monitoring System

E-8e(1) West Spray Field

Twelve monitor well will serve as post-closure compliance monitoring wells at the West Spray Field (Plate E-36). Alluvial wells SF-1, SF-2, SF-3, SF-4, SF-5, and SF-6 are located along the point of compliance and essentially ring the waste management unit. In addition, alluvial wells 51-86, 45-86, 47-86, and 56-86 will serve to monitor alluvial ground-water quality up- and

TABLE E-38

BACKGROUND BEDROCK GROUND-WATER QUALITY AND PROPOSED GROUND-WATER CONCENTRATION LIMITS

	Element	Concentration Range (mg/l) Background*	Proposed Ground-water Concentration Limits
METALS			
	Aluminum	.029U	5.0
++	Antimony	.02U	0.02U
+	Arsenic	.01U	0.05
+	Barium	.057-.106	1.0
++	Beryllium	.005U	0.005
+	Cadmium	.005U	0.01
	Cesium	.02U	0.02U
+	Chromium	.01U-.015	0.05
++	Cobalt	.022U	0.022U
++	Copper	.0063U-.048	0.048
	Iron	.0069U-.011	0.3
+	Lead	.005U-.019	0.05
++	Lithium	.1U	0.1U
	Manganese	.026-.228	0.05
+	Mercury	.0002U	0.002
	Molybdenum	.022U	0.1
++	Nickel	.037U	0.037U
+	Selenium	.005U	0.01
+	Silver	.0076U	0.05
	Strontium	.33-.87	0.87
++	Thallium	.01U	0.01U
++	Vanadium	.024U	0.024
++	Zinc	.02U-.05	0.05
RADIONUCLIDES		Concentration Range (pci/l)	
	Gross Alpha	Below MDA-57(32)	15
	Gross Beta	Below MDA-65(48)	50
	Uranium 233,234	Below MDA-2.4(1.3)	40 ***
	Uranium 235	Below MDA	40 ***
	Uranium 238	Below MDA-.64(.13)	40 ***
	Plutonium 239,240	Below MDA	40
	Americium 241	Below MDA-.048(.045)	4
	Strontium 89,90	Below 1.02	8
	Tritium	Below 593	20,000

TABLE E-38
(CONTINUED)
BACKGROUND BEDROCK
GROUND-WATER QUALITY
AND PROPOSED GROUND-WATER CONCENTRATION LIMITS

	Element	Concentration Range (mg/l) Background	Proposed Ground-water Concentration Limit
MAJOR IONS			
	Calcium	43-111	NA
	Magnesium	10-25	NA
	Potassium	5U-6	NA
	Sodium	32-37	NA
	Bicarbonate	246-347	NA
	Carbonate	ND	NA
	Chloride	8-24	250
	Nitrate	ND	10
	Sulfate	41-52	250
	Total Dissolved Solids	425-467	400

* Plant background water quality conditions (Rockwell International, 1988)
*** Total Uranium
\+ SDWA metal and Appendix IX hazardous constituents
++ Appendix IX hazardous constituent that is not an SDWA metal
NA Not available
MDA Theoretical Minimum Detectable Activity
U Values less than Detection Limit
ND Non-Detectable

downgradient of the West Spray Field. Alluvial wells 49-86, 50-86, and SF-7 are not included in the compliance monitoring program, as they are located within the waste management unit. Monitoring will also continue in bedrock wells 52-86 and 48-86, which are completed in subcropping upper Laramie sandstones. Well completion details of these wells are presented in Table E-6 and E-7.

E-8e(2) Solar Evaporation Ponds

The compliance monitoring system at the Solar Evaporation Ponds will consist of 19 monitor wells completed in alluvium, seven wells completed in weathered claystone, and wells completed in subcropping sandstones. Alluvial wells 24-86, SEP-1, 26-86, 38-87, SEP-4, SEP-6, 29-86, 33-86, 21-87, 35-86, 36-86, SEP-8, SEP-10, SEP-11, 18-86, SEP-13, 17-86, SEP-15, and SEP-20 will serve to monitor surficial materials up- and downgradient of the point of compliance. Wells SEP-3, SEP-5, SEP-7, SEP-9, SEP-12, SEP-14, and SEP-21 will monitor weathered Arapahoe claystones. Well completion details for these wells are presented in Tables E-8 and E-9.

Bedrock wells SEP-16, SEP-17, SEP-18, and SEP-19 are proposed assessment monitor wells for interim status monitoring. These wells are located within the waste management unit and the point of compliance. Should a statistically significant increase in ground-water monitoring parameters be detected in these wells

during interim status monitoring, additional bedrock wells will be installed in these sandstones for continued assessment monitoring under 6 CCR 1007-3 Part 265 (40 CFR Part 265) and for compliance monitoring under 6 CCR 1007-3 Part 264 (40 CFR Part 264).

E-8f Proposed Sampling, Analytical, and Statistical Procedures

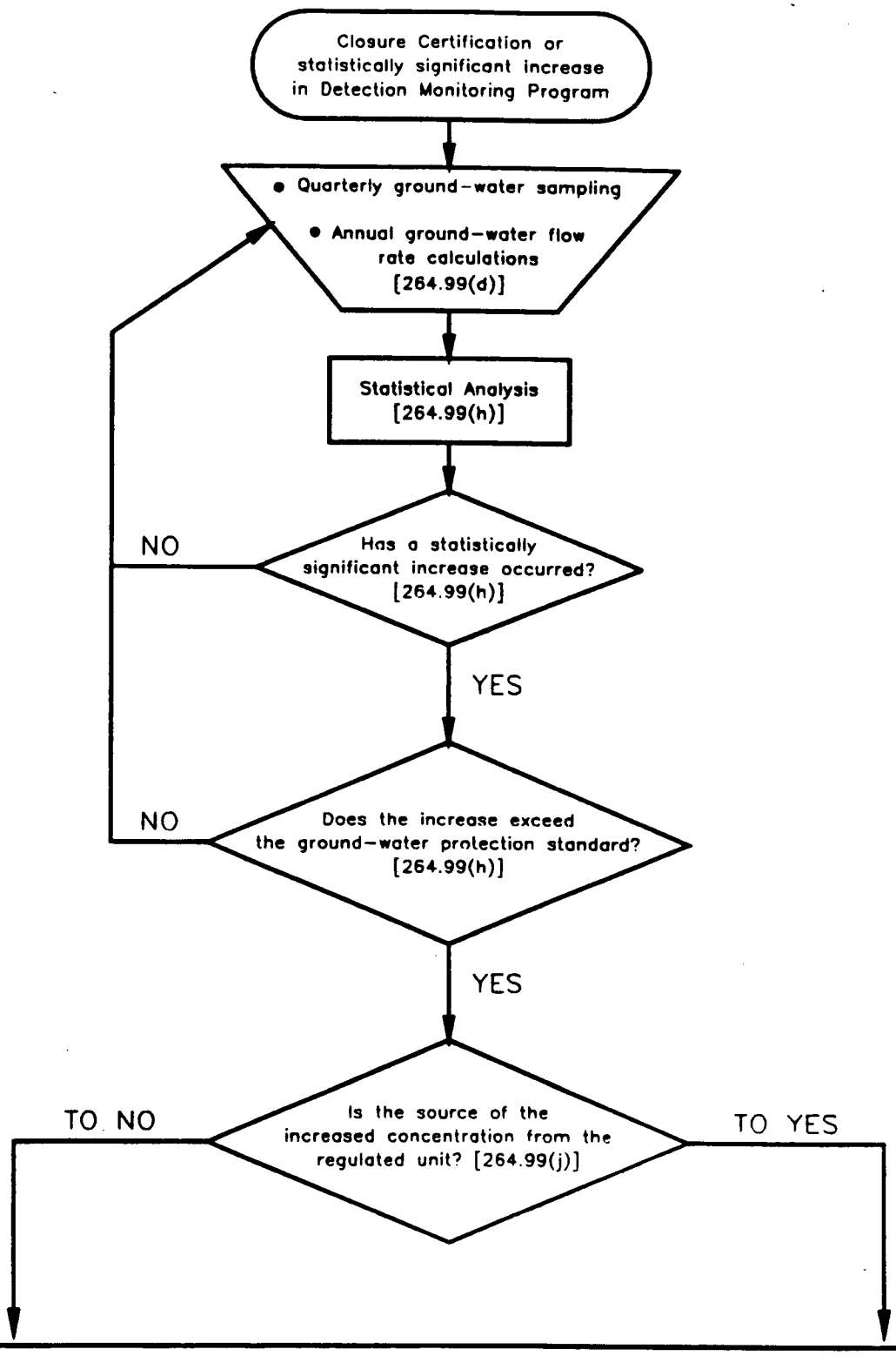
In accordance with 40 CFR 270.14(c)(7)(vi), the proposed sampling, analysis and statistical evaluations described in Sections E-6b, E-6c, and E-6d will be used for the evaluation of waste constituents in ground-water along the point of compliance for the West Spray Field and the Solar Evaporation Ponds. The analytical data will be expressed in a format that will allow determination of statistically significant increases in concentrations per 6 CCR 1007-3 and 40 CFR Part 264.97(h), (6 CCR 1007-3 and 40 CFR Part 264.99(d)).

E-8g Actions Required for Statistically Significant Increases of Appendix IX Constituents Above the Concentration Limits

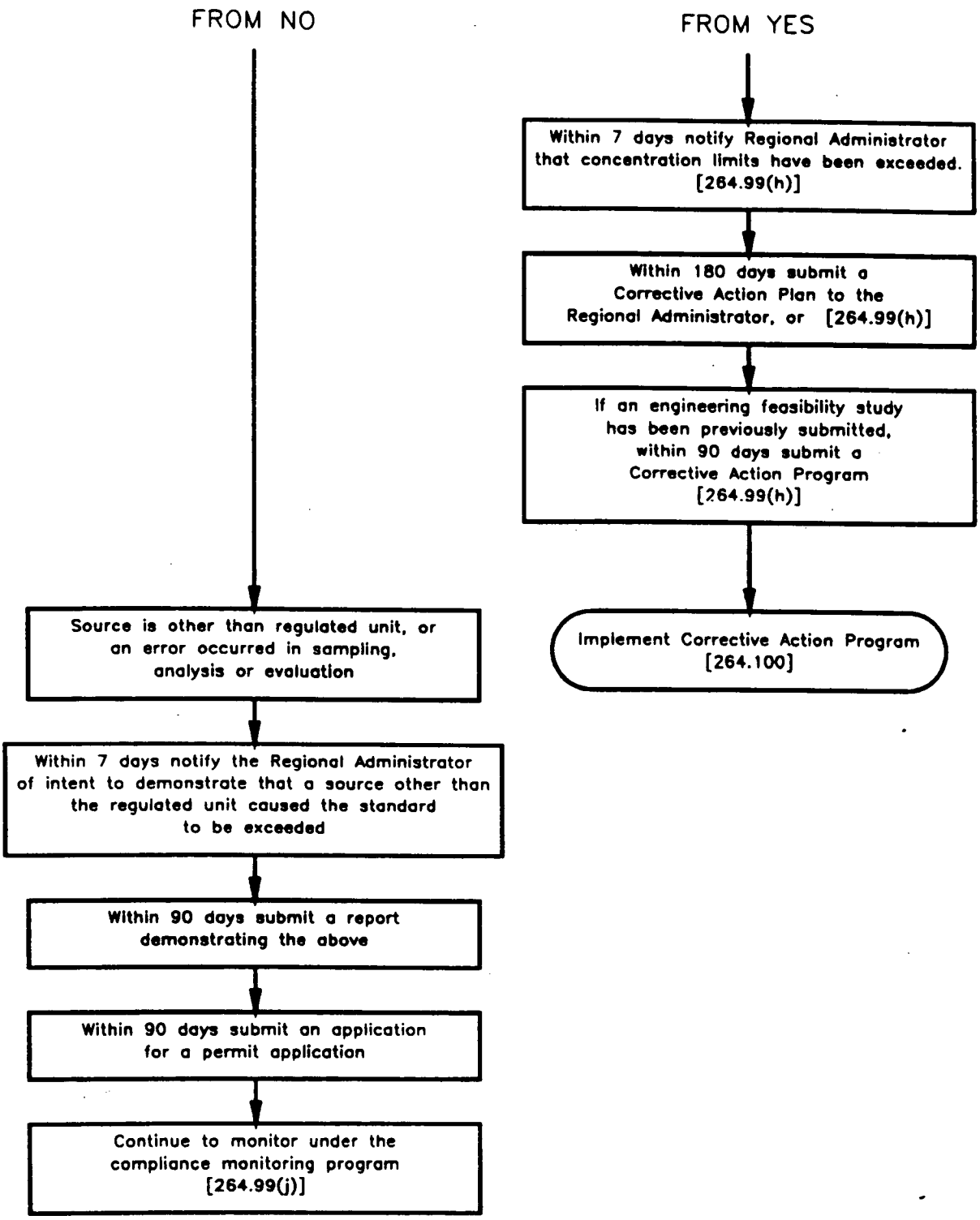
Should the statistical analysis referenced in Section E-8f show a significant increase in the Appendix IX constituents above the concentration limits at the point of compliance, the reporting requirements identified in Figure E-15 will be met.

Figure E-15:

COMPLIANCE MONITORING DECISION FLOWCHART



COMPLIANCE MONITORING DECISION FLOWCHART (continued)



E-9 CORRECTIVE ACTION PROGRAM

Appendix IX constituents have been detected in ground water at the Solar Evaporation Ponds and the West Spray Field. Analyses will be performed to determine if the levels at the point of compliance represent a statistically significant increase above the concentration limits. In addition, nonhazardous constituents are found in the ground water at these units at levels that may pose a threat to human health and the environment if corrective action is not undertaken. Upon completion of the statistical analysis, a corrective action program will be outlined and submitted for approval. The corrective action process is outlined in Figure E-16.

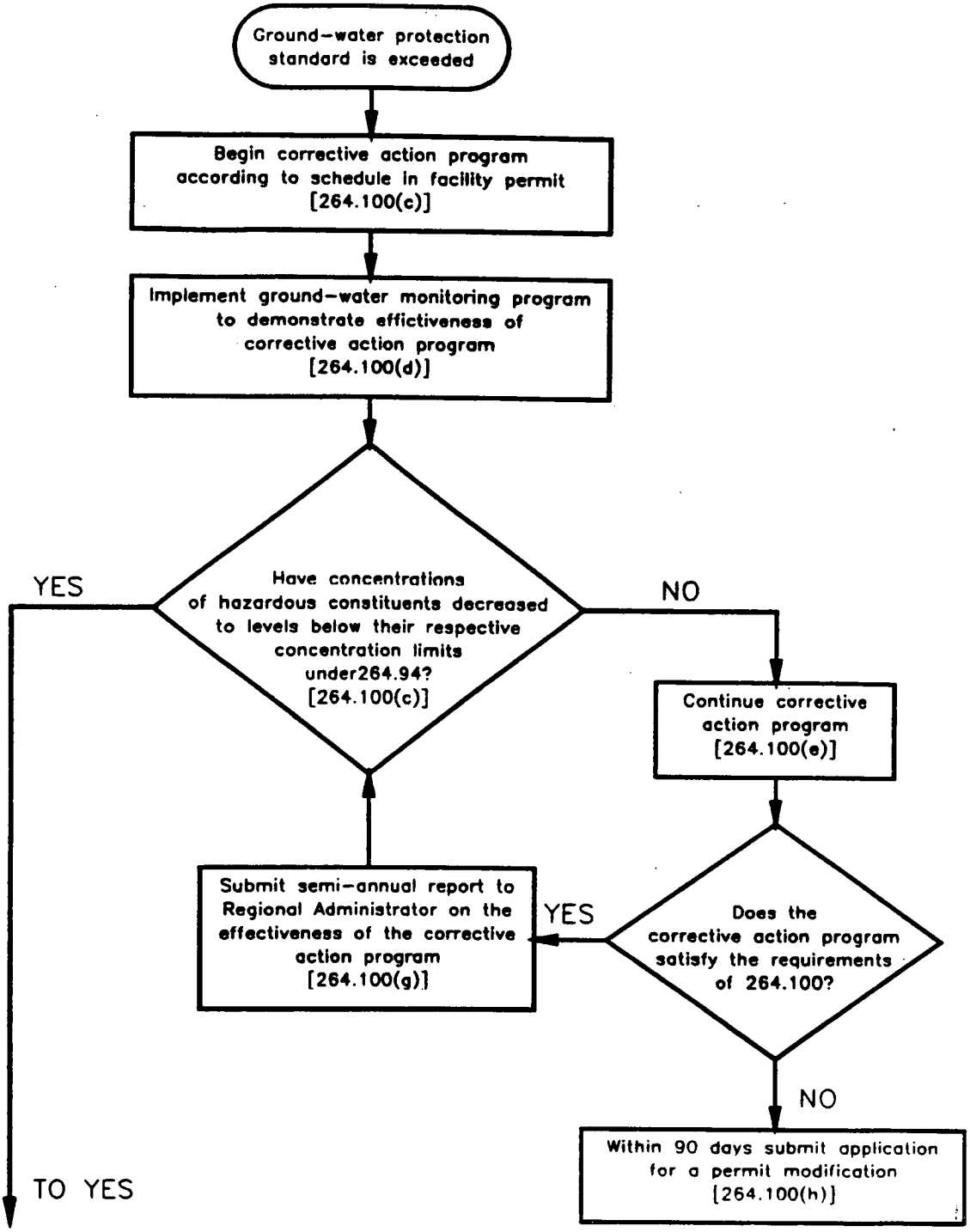
The schedule for submittal of a corrective action plan is as follows:

- Complete Statistical Analyses . . . . . after 4 quarters of data
- Notify Director of Statistically Increased Constituents . . . . . within 15 days
- Submit Corrective Action Plan . . . . . within 180 days

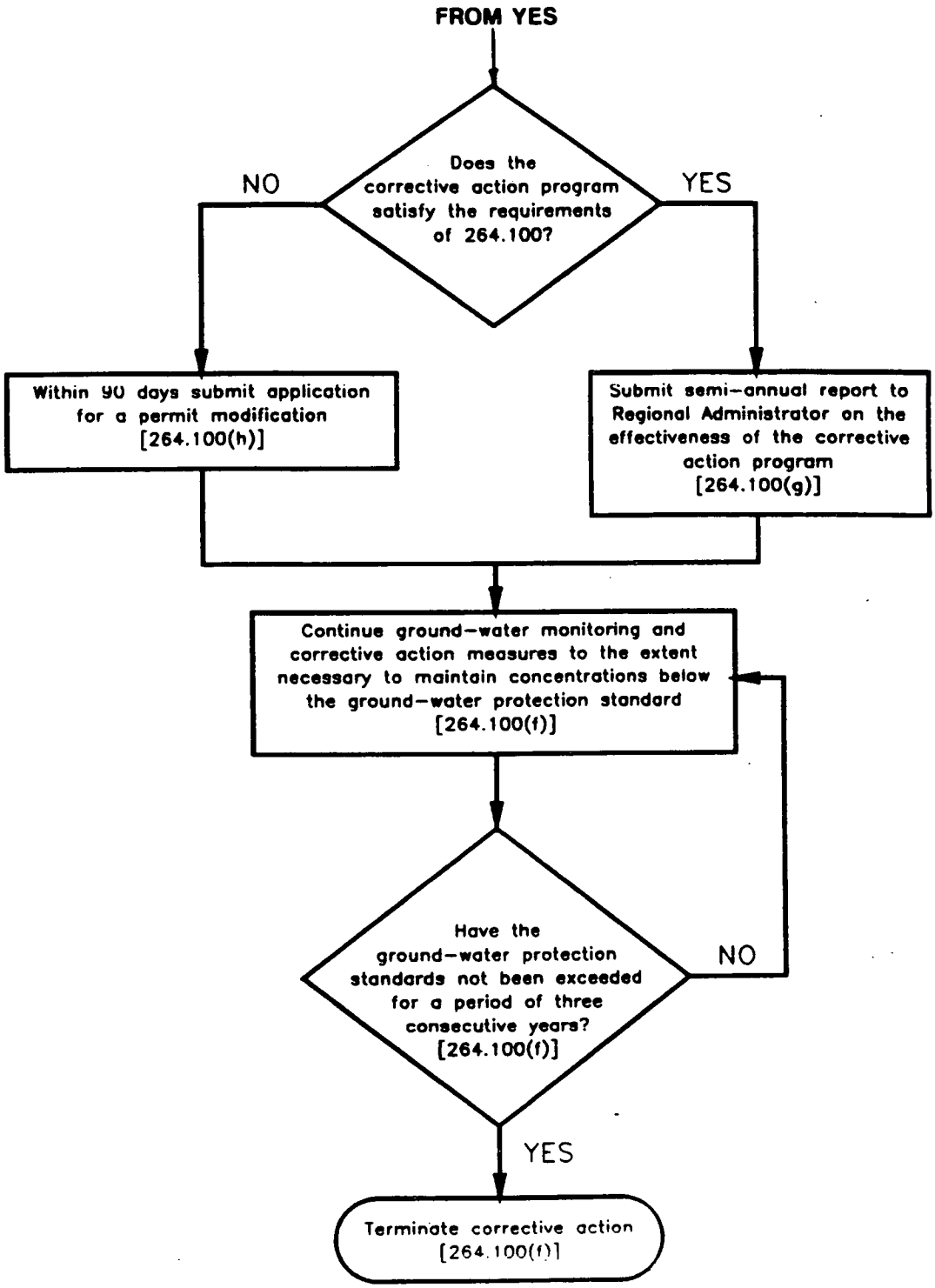
The plan will include a schedule for all proposed corrective actions so that actions are taken in a reasonable time period once it is determined the ground-water protection standard is exceeded. The actions will prevent hazardous constituents from exceeding the concentration limits at the compliance point.

Figure E-16:

CORRECTIVE ACTION DECISION FLOWCHART



CORRECTIVE ACTION DECISION FLOWCHART (continued)



Ground water monitoring will continue during any corrective action period.

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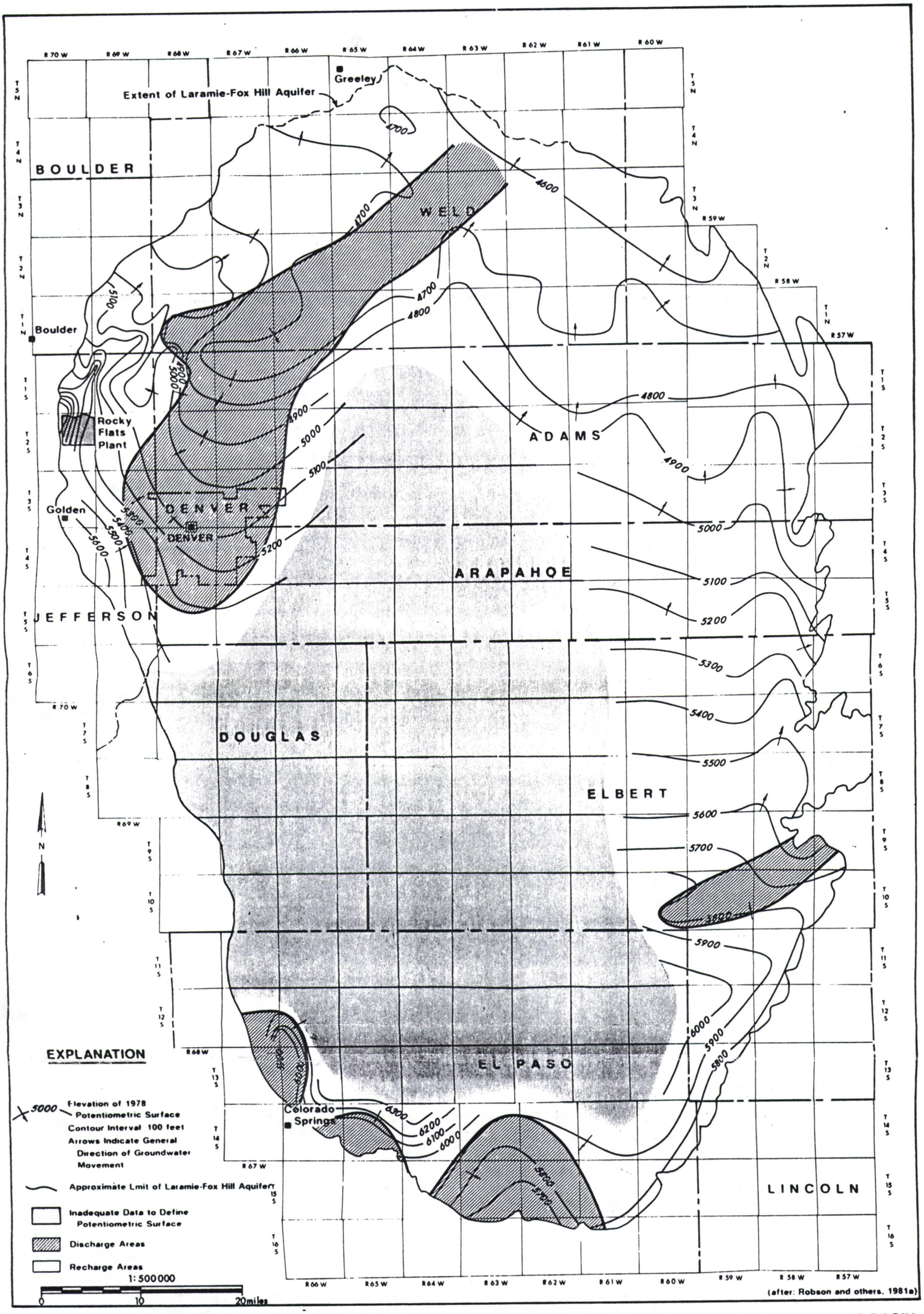

Figure E-3 ELEVATION OF 1978 POTENTIOMETRIC SURFACE IN THE LARAMIE-FOX HILL AQUIFER, DENVER BASIN

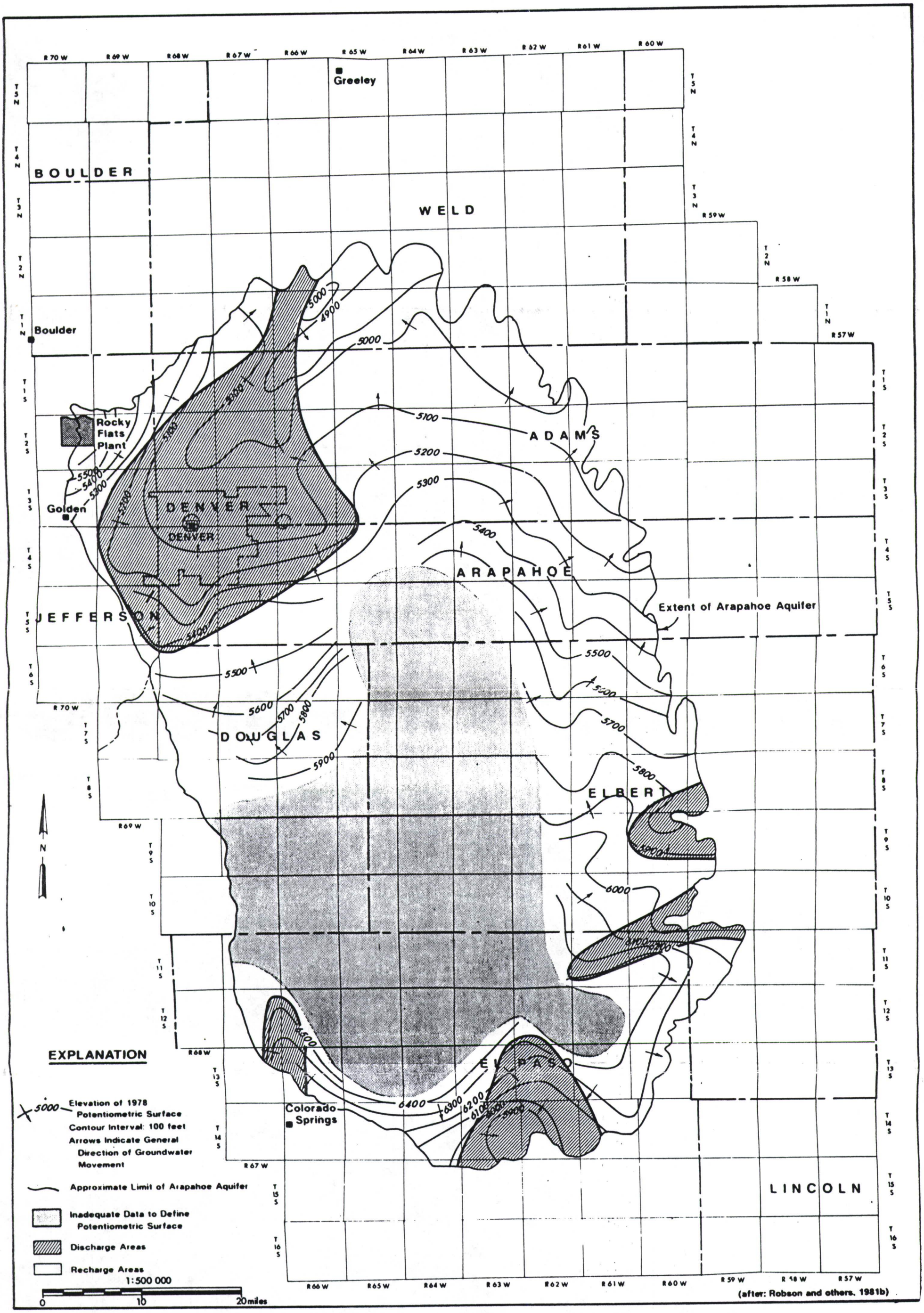

Figure E-4 ELEVATION OF 1978 POTENTIOMETRIC SURFACE IN THE ARAPAHOE AQUIFER, DENVER BASIN