RIO ALGOM MINING CORP.
SMITH RANCH FACILITY

SOURCE MATERIAL LICENSE APPLICATION

NRC License No.: SUA-1548
Docket No: 40-8964

Volume I

Chapters 1-10

October 26, 1999

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CHAPTER 1

PROPOSED ACTIVITIES

1.1 Introduction

Rio Algom Mining Corporation (RAMC), Oklahoma City, Oklahoma, is hereby applying to the U.S. Nuclear Regulatory Commission (NRC) and Wyoming Department of Environmental Quality (DEQ) for a license for the Smith Ranch Project to implement a commercial uranium in-situ leaching (ISL) project in the South Powder River Basin, Converse County, Wyoming.

The project lies within Rio Algom mining Corporation (RAMC) approved mining area covered by Wyoming Department of Environmental Quality Permit 304C. RAMC uranium mining operations within the 304C permit area began in the early 1970's and have included two surface mines, one underground mine, and two ISL research and development (R&D) pilots.

The first ISL pilot operation began in October 1981 and continued until aquifer restoration was completed in May 1986. Aquifer restoration and aquifer stability for this one-acre, 100 gallon per minute pilot have been accepted by NRC and DEQ. Operations of the second ISL pilot, a 1. 8 acre - 150 gallon per minute test, began in 1984 and is expected to continue until commercial operations begin. The pilots, authorized under NRC License SUA-1387 and DEQ Licenses 5RD and 13RD, have operated without an excursion of leach solution, without a lost time accident, without serious injury to any employee, and without health or safety risks to the public, or significant impact to the environment.

The Smith Ranch Project area includes 16,200 acres of which only about 500 acres will be affected by well field development over the life of the project. The recovery plant, located at the Bill Smith Mine site, will be designed to process up to 5,000 gallons per minute of leach solution and is expected to operate at an average flow rate of 4000 gallons per minute. In addition, a satellite plant with up to 3,000 gpm capacity may be used. Production from the combined facilities will total up to two and one half million pounds per year of uranium oxide (U_3O_8) from both facilities. The plant design will include provisions for an additional 2,000 gallons per minute of ion exchange capacity for use in aquifer restoration programs. Production over the life of the project is expected to be in excess of 20 million pounds U_3O_8. A Reclamation Performance Bond will be posted with the Wyoming Department of Environmental Quality to ensure funds for aquifer and surface reclamation are available. The reclamation bond will be reviewed annually and adjusted as needed to include new areas as they are disturbed or delete areas that have been reclaimed.

1.2 General Solution Mining Process

The mechanics of uranium ISL mining are relatively straightforward. A carbonate/bicarbonate leach solution and oxidant are injected into the ore bearing sandstone formation through a series of wells that have been drilled, cased, cemented, and tested for mechanical integrity. As the leach solution moves through the formation and contacts the ore, the uranium is oxidized, becomes soluble and dissolves into the leach solution. The uranium bearing solution is drawn to a recovery well where it is pumped to the surface and transferred to the recovery plant. In the plant the uranium is recovered from the leach solution by ion exchange and the solution is reinjected to extract additional uranium.

The ISL mining process selectively removes uranium from the orebody and the sand tailings generated by conventional uranium milling are left in place underground eliminating a major concern associated with conventional uranium mining. When installing a solution mine well field, only limited surface disturbance is required and much of the area disturbed in the wellfields and pipeline rights-of -way will be reseeded and reclaimed during the operating life of the wellfield. The final product of the recovery plant will be vacuum I dried yellowcake (uranium oxide) thus minimizing the potential for airborne uranium particulates and the related concerns experienced with conventional uranium drying and packaging facilities.

1.3 Ore Amenability to ISL Uranium Mining

Amenability of the uranium deposit in the project area to ISL mining has been demonstrated initially through core studies. I Results of the core studies were confirmed in the two pilot projects using a bicarbonate/carbonate leach solution with hydrogen peroxide and oxygen. The pilots were authorized by Wyoming Department of Environmental Quality, Land Quality Division Permits 5RD and 13RD and I by NRC License SUA-13387. These tests conducted in uranium deposits at depths of 500 feet and 750 feet have demonstrated the feasibility of mining the uranium reserves in the project area using ISL methods.

The initial ISL pilot, the Q-Sand pilot, operated until May 1986. Uranium recovery from the pilot exceeded the forecast recovery and aquifer restoration, completed in May, 1986, was deemed acceptable as was the completion of a one-year aquifer stability demonstration period. The second ISL pilot, the O-Sand pilot, was initiated in July 1984 and is performing as forecast confirming the amenability of the ore to solution mining.

There have been no excursion of leach solutions in either pilot to date. Reports concerning the progress of the pilot activities and results of the environmental monitoring programs have been submitted to NRC and Wyoming DEQ on a quarterly basis.

Based on information and experience gained during the pilot programs, RAMC desires to proceed with commercial uranium ISL mining I operations and believes the pilots have demonstrated that such a program can be implemented with only minimal short-term environmental impacts and with no significant risk to the public health or safety. The remainder of this application describes the mining and reclamation plans for this project and the concurrent environmental monitoring programs to be used to ensure that any adverse impact to the environment is minimal.

CHAPTER 2
SITE CHARACTERISTICS

2.1 Site Location and Layout

The permit area for solution mining project is located in the North Platt River drainage of the southern Powder River Basin, Converse County, Wyoming, with the plant site approximately 17 air miles northeast of the town of Glenrock, Wyoming and 23 air miles northwest of Douglas, Wyoming. Access to the site from the intersection of State Highway 93 and Highway 95 is by Ross Road a paved county road to the northwest. Figure 2-1 shows the general location and access to the permit area. There are no active residences within the proposed permit area.

Names and addresses of the surf ace and mineral owners of record within and around the proposed permit area are listed in the Appendices. Figures A-1 and A-2 in Appendix A identify the surface and mineral owners within of the permit area the names and address. Similarly, surface and mineral owners of record within one-half mile of the permit area are listed in Appendix B. Figures B-1 and B-2 identify the surface and mineral owners within one-half mile of the permit area. These appendices also list owners of record with valid legal estate in the permit area and on adjacent lands. Appendix C lists all lands to be included within the permit area by section, township and range and gives an acreage tabulation. The proposed permit area contains 16,200 acres. A blue line copy containing portions of four U.S.G.S. quadrangle sheets (Highland Flats, Gilbert Lake, Fifty-Five Ranch and Hylton Ranch) delineating the permit area boundary is included in Appendix C as Map C-1. Verbal approval to use a blue line print in lieu of an original U.S.G.S. quad sheets was received from Rick Engleman (WDEQ-LQD). Appendix E contains a map showing rights-of-way within and adjacent to the permit area. The recovery plant for the operation will be located at the present Bill Smith Mine site in Section 36, T36N, R74W.

2.2 Uses of Lands and Waters

2.2.1 Permit Area

Lands contained within the permit area have historically been used for sheep and cattle grazing. Rio Algom Mining Corp. controls mineral and surface rights in the areas scheduled for uranium mining and development. Sequoyah Fuels, (the predecessor operator), and Rio Algom Mining Corp. have conducted two in-situ uranium mining Research and Development pilots licensed with the US NRC and the State of Wyoming in the permit area. The proposed use of the land for the immediate future includes continued livestock grazing and in-situ uranium mining on a commercial scale. Appendix D includes additional detail on land use in the area. The maximum area to be removed from grazing is not expected to exceed 400 acres at any time. Subsequent to the mining activities the land will be returned to the pre-mining use of livestock grazing and wildlife use. The reclamation plan to be used to return disturbed areas to a grazing use after mining is included in Chapter 6 of this application.

2.2.2 Agricultural Activity

Livestock grazing is the main source of food production and agricultural activity on the permit area and the adjacent lands. Due to the short growing season the forage provided by natural vegetation, although nutritious, is sparse. According to personnel from the U.S.D.A. Soil Conservation Service Office in Douglas (November 10, 1986) the stocking rate in the vicinity of the mine site averages one-fourth to one-third of an animal unit per acre per month on range that is in good condition. In the past, some isolated areas were homesteaded and dry farmed. Most of these dry farms were ultimately abandoned and left to revegetate by natural processes or seeded with crested wheat grass or other grasses for grazing purpose. There are no known commercial row or grain crops presently cultivated in the proposed permit area.

2.2.3 Recreation

Major recreational activities within a fifty mile radius of the proposed mine site are mostly outdoor activities, such as camping, hunting, picnicking, hiking, skiing and snowmobiling. Water sports, such as water skiing, boating, canoeing and fishing are popular in public use areas designated by the state and counties along the North Platte River and at Alcova Lake and the Glendo Reservoir. In addition to State and Community designated parks and recreation areas, a portion of the Medicine Bow National Forest, approximately forty miles south of the site provides additional area for recreational activities. Figure 2-2 shows the approximate location of these major facilities and points of interest in the general area.

2.2.4 Water Rights

As of Fall 1986, records on file in the Office of the Wyoming State Engineer indicate that there are thirteen adjudicated water rights in the permit area or within three miles of the permit boundary. Sequoyah Fuels does not hold any adjudicated water rights within the permit area. Table 2-1 lists the known adjudicated water rights in the permit area and within three miles of the permit boundary.

Several groundwater rights of record have been filed with the Office of the Wyoming State Engineer. The majority of the wells within the permit area were installed by Sequoyah Fuels and Rio Algom Mining Corp. for the purpose of collecting groundwater quality data, to determine groundwater aquifer characteristics and to conduct the R&D operation. Appendix D-6 lists all known springs and wells inside and within three miles of the permit area.

As is the case with many of the intermontane basins in Wyoming, water in the vicinity of the permit area is available primarily from groundwater sources that are recharged by sporadic runoff from the limited precipitation the Powder River Basin receives. The permit area has five known stock ponds consisting of small earthen dams across dry stream channels that collect the small quantities of runoff that do occur. One of these ponds is supplemented by groundwater pumped from a well by a windmill. Some water also accumulates in small excavations or natural ponds at low points in the Sage Creek drainage. No other significant waterbodies are present in the permit area. During underground mining the local rancher constructed a small reservoir to collect water discharged from the Bill Smith Mine and used the water for irrigating approximately 160 acres of alfalfa and native grass. However, with the absence of pumping from the mine, the reservoir is dry most of the time but is still used as a stock pond when there is runoff.

Wells in the vicinity of the permit area excluding those owned by Rio Algom Mining Corp. are rather uniformly distributed over the area, with the greatest density occurring south of Sage Creek. Only two wells in the permit area and on adjacent lands are known to be used for domestic water supply. These are the water supply well at the Bill Smith Mine site and the waterwell at the Sundquist Ranch site 2.6 miles south of the plant site. Most of the water wells in the vicinity of the permit area are used for watering livestock and wildlife, however two wells located in the Northeast quarter of Section 12, T35N, R74W are used for irrigating an alfalfa field.

Of the 132 known water wells in the permit area and on adjacent lands, 106 are owned and operated by Rio Algom Mining Corp.. Most of these wells have been associated with the Bill Smith Mine or the in-situ mining R&D programs. The remaining company owned wells have been used for testing of hydrologic properties of the aquifers and collecting baseline water quality data for the solution mining permit application. Most of the remaining wells in the general vicinity of the permit area have been constructed by the local ranchers. These wells are generally low-yielding wells used for livestock water supplies. Since the area is very stable, demand for uses other than those associated with the proposed uranium mining activities is not expected to increase significantly during the life of the mining project.

A map locating the adjudicated water rights in the permit area and on nearby lands is provided as Figure 2-3. A map showing the location of the known wells and springs in the permit area and on the adjacent lands is included in Appendix D-6.

2.3 Population Distribution

The population within fifty miles of the proposed recovery plant site is centered within the communities of Casper, Douglas and Glenrock, Wyoming as shown on Figure 2-1. These urban areas are significant in that they provide the major locations of public services such as schools, churches, medical care facilities, and public parks. These communities also provide the majority of the cultural and scenic attractions for the residents of Converse and Natrona Counties.

Casper, Wyoming is the county seat of Natrona County. In 1986 Casper claimed to be the largest city in the state. Casper has developed into a regional retail trade center serving a 150 mile radius which includes all or part of seven counties. Its regional prominence as a retail center is supported by the Eastridge Mall, which opened in the Fall of 1982. The Casper labor force and population peaked in Spring of 1982 and has declined since that time.

Casper has doubled its acre size during the ten years between 1975 and 1985. This growth can be contributed to the energy boom in the late 1970s and early 1980s. From 1970 to 1980 the city experienced a 30% increase in its population. However, with the decrease of price and demand for oil and uranium the city was projected to only increase by 6% between 1980 to 1990. Many feel that even this projection is very optimistic. (See Table 2-2).

Douglas is the county seat of Converse County. Glenrock, also in Converse County, is the closest town to the Smith Ranch site with the site being approximately 25 road miles northeast of the town. Between 1970 and 1980 both Glenrock and Douglas experienced phenomenal growth, 80.6% and 136.9%, respectively. However, with the change in energy demand, through 1984 Glenrock lost 27% of its population and Douglas lost 17% of its population. (See Table 2-2).

The reduction in employment in the area uranium operations illustrates the loss of jobs to the area. In March 1980, uranium producers reported 1,264 people directly employed in the uranium mining and milling operations in Converse County. In September 1987 the same uranium producers reported less than 100 employees in Converse County with many of these employees working on reclamation projects that will be completed within 2 years. Implementation of this solution mining project is expected to increase company employment in the area to about 40 people and provide jobs for 15 to 20 contractor employees. Most of the new positions will be filled from the local population.

There are no residences in the permit area and only two occupied dwellings within the five miles of the proposed plant site. The nearest dwelling, the Sunquist Ranch site, is 2.6 miles south of the plant and the second site, the Vollman Ranch, is 4.2 miles east northeast of the plant. A total of seven people normally reside at these ranch homes for an occupational density of 0.09 persons per square mile for the area within a five mile radius of the plant.

2.4 Regional Historic, Archaeological, Architectural, Scenic, Cultural and Natural Landmarks

A Class III Cultural Resource Inventory for the proposed permit area was completed in November 1985 by Frontier Archaeology of Worland, Wyoming. This data is presented in Appendix D-3. Eighteen sites were located. Ten of the sites are historic and eight are prehistoric. Following review of these sites by the BLM and the Wyoming State Archives, Museums and Historical Department during the Spring 1986, it was determined that only two sites could be potentially affected by the project. The mitigation and protection of these two sites are discussed in the operation plan. If during mining operations any cultural or significant paleontological evidence are exposed during any excavation or other installation work in the permit area, such activities will be delayed until the appropriate state office has been notified and a qualified person has examined the evidence.

Appendix D-3 contains the Cultural Resource Class III Survey plus the appropriate letters from the SHPO, etc. The report also includes a listing of cultural resource (i.e. The Bozeman Trail), sites known in the vicinity of the permit area. This list was compiled through review of the State Archives, WSHPO and Casper BLM office.

Another Cultural Resource Class III Survey was conducted in December 1998 by Pronghorn Archeological Services of Mills Wyoming. The scope of the survey covered the areas within the permit area not previously surveyed in the 1985 survey. The 1998 survey identified three new historic sites, thirteen prehistoric sites, and twenty-two isolated artifacts. Of those, twelve of the prehistoric sites were considered to be eligible for inclusion to the National Register of Historic Places, and none of those sites are located where mining activities are planned. The BLM and WSHPO have reviewed the report. Appendix D-3 contains this report and supporting correspondence.

2.5 Meteorology

2.5.1 General

The project permit area is located in eastern Wyoming, where climate can generally be classified under the Koppen System* (C. R. Itchfield, 1974) as semiarid and cool. The climate in the area is rather dry due to the effective barrier to moisture from the Pacific Ocean offered by the Cascades, Sierra Nevada, and the Rocky Mountains when winds are from the west and northwest. The mountain ranges in the west-central portion of the state, which are oriented in a general north-south direction, are perpendicular to the prevailing winds. These ranges also tend to restrict the passage of storms and thus restrict precipitation in the eastern part of Wyoming.

The official weather station closest to the permit area is located at the Natrona County International Airport near Casper. Meteorological data (wind speed, wind direction, and temperature) for the project area is taken from the Natrona County International Airport near Casper, Wyoming. Figure 2-4 includes a wind rose for Casper and more detailed climatology data is included in Appendix D-4.

2.5.2 Precipitation

Mean annual precipitation for the area is approximately twelve inches (Normals, Means & Extremes, NOAA, Casper, WY, 1985) and the average yearly total evaporation is reported as forty-four inches (U.S. Weather Bureau, NOAA, 1985). The net evaporation for the area is taken as the difference between these numbers and is calculated to be thirty-two inches per year.

The bulk of the annual precipitation is received from moisture laden easterly winds, particularly during spring months. Most of this precipitation is in the form of rain although occasional heavy wet snowfalls in spring months are not uncommon, but these snows are short-lived. Summer precipitation is almost exclusively from thundershower activity and under normal conditions provides sufficient moisture to maintain growth of rangeland grasses. Seasonal snowfall averages about seventy-two inches, but the water content of winter snow is low owing to the cold temperatures at which it usually occurs. The very dry strong west and southwest winds following these winter snows tend to clear the snow from the rangelands thereby permitting winter grazing of livestock.

The average number of days throughout the year with one hundredth of an inch of precipitation is near ninety, most of which occur during the spring and summer. Consequently the absence of rain clouds or clouds usually associated with precipitation results in bright days with considerable sunshine throughout the winter season.

2.5.3 Temperature

The dryness of the air has a considerable modifying effect in preventing discomfort during the warm summer months as well as during periods of subzero temperatures in the winter. The average maximum temperature during summer months of June, July and August is 83° F, while during the winter, the average minimum temperature is 15° F. The average temperature is 67° F (19° C) in the summer and 26° F (-3° C) in the winter. Extreme temperatures in these respective seasons have reached as high as 104° F (40° C) and as low as -40° F (-40° C), between 1940 and 1985. The average length of the growing season is 129 days, with the average date of the last freezing temperature in spring May 22, and the first freezing temperature in fall September 28.

2.5.4 Wind

Wind speed data from the Natrona County International Airport is used to estimate wind speed and direction for the project site. The mean annual wind speed at the airport for the years 1954-1984 is thirteen miles per hour from the southwest. The highest mean monthly wind speed occurs in January and is 16.4 miles per hour from a west-southwesterly direction. The lowest mean monthly wind speed occurs in July and is reported as 10.1 miles per hour from the west-southwesterly direction. The maximum observed wind speed maintained for longer than one minute was eighty-one mph from the southeast during March, 1956. Figure 2-4 is a wind rose diagram for the Casper area indicating that the prevailing winds are from the southwest.

2.6 Geology

2.6.1 Regional Geology

The permit area is located in the southern portion of the Powder River Basin, which is in the unglaciated Missouri Plateau section of the Great Plains physiographic province (Thornbury, 1969). The Missouri Plateau includes the part of the Great Plains north of the northern boundary of Nebraska, with the exception of the Black Hills. It is bounded by the Pine Ridge Encarpment to the south, the Bighorn and Laramie mountains to the west, the Missouri Escarpment to the east, and the glacial moraine plains north of the Missouri River to the north. The Missouri Plateau has often been mistakenly classified as a plain; in fact, it comprises a number of basins separated by uplifts.

The Powder River Basin, named after the north-flowing Powder River, covers approximately 2000 square miles. It is bounded on the west by the Bighorn Mountains and the Casper Arch and on the south by the Laramie Range-Hartville Uplift. The northern and eastern margins of the basin are less distinct. The broad Black Hills Uplift forms the eastern demarcation, the Miles City Arch forms the northern boundary.

The Powder River Basin is synclinal, with the synclinal axis oriented in a general northwest-southeast direction along the western margin of the basin. East of the axis, the sedimentary rock strata exposed at the surface dip gently (about 1° to 2°) to the west. West of the axis, the strata dip more steeply (as much as 200) to the east.

The basin incorporates a sedimentary rock sequence that has a maximum thickness of about 15,000 feet along the synclinal axis. The sediments range in age from Recent (Holocene) to early Paleozoic (Cambrian) (500 million to 600 million years ago) and overlie a basement complex of Precambrian-age (more than a billion years old) igneous and metamorphic rocks (Figure D-5.3). Of particular interest in the permit area are the Tertiary-age formations:

Formation	Age (Years)
White River (Oligocene)	25-40 million
Wasatch (Eocene)	40-60 million
Fort Union (Paleocene)	60-70 million

The uranium-bearing sandstones to be mined lie within the Fort Union and Wasatch formations. With the exception of the Quaternary sediments in the drainage valleys, these are the only formations that outcrop in the permit area.

The Powder River Basin represents a localized depression in what was, for long geologic time, a large basin extending from the Arctic to the Gulf of Mexico. During Paleozoic and Mesozoic time, the configuration of this expansive basin changed as the result of uplifts on its margins. The northern and southern connections of the basin to the open ocean also changed position several times before they both finally closed. By the end of the Cretaceous, many intrusive uplifts had occurred and the remaining portions of the large basin were well removed from connections to the sea.

In the late Paleocene marked uplift, in land masses surrounding the Powder River Basin and accelerated subsidence in the southern portion of the basin resulted in thick sequences of arkosic sediments being deposited. Arkosic sediments were derived from the granitic cores of the Laramie and Granite Mountains exposed to weathering and erosion by the Laramide uplift. Uranium mineralization contained in these arkosic facies constitute the oldest ore zones in the permit area.

Continued acceleration of uplift in the Laramie and Granite Mountains in central Wyoming resulted in further deposits of coarse clastic sediments. Since drainage was generally northward, the finer sediments were carried north toward the center of the basin.

Rapidly flowing streams cut channels through the accumulating sediments near the basin margins. These streams eventually filled with coarse clastic sediments, providing zones of high transmissivity for mineralizing solutions that entered the area later. During that time, and well into the Eocene, the Powder River Basin remained largely flat and portions of it were intermittently cut off from the main channels of surface water flows. However, ample water, provided by runoff from the mountainous uplifts, produced substantial swamps that eventually became large coal deposits.

The Eocene deposits (Wasatch Formation) in the Powder River Basin characteristically consist of nearly 1000 feet of clays and siltstones containing widespread discontinuous lenses of coarse, cross-bedded arkosic sandstones. The coarsest of these are to be found in the southwestern portion of the basin and are the host rock for the uranium deposits to be mined. These sediments gradually diminish in size northward. North of Pumpkin Buttes, the Wasatch sediments become markedly finer-grained and similar in appearance to the Fort Union Formation.

Near the end of the Eocene, northward tilting and deep weathering with minor erosion took place in the basin. Uranium migration and concentrations occurred at that time. Subsidence resumed in the late Oligocene and continued through the Miocene and Pliocene. A great thickness of tuffaceous sediments was deposited in the basin during at least a part of this period of subsidence. By the late Pliocene, regional uplift was taking place, leading to a general rise in elevation of several thousand feet. The massive erosional pattern that characterizes much of the Powder River Basin began with this Pliocene uplift and continues to the present.

The tectonic change at the end of the Paleocene is reflected in some locations by either a depositional or an erosional disconformity between the Fort Union Formation and the overlying Wasatch Formation. As uplift of the highlands continued into the Eocene epoch, the Fort Union Formation was eroded at the margins of the basin and the material redeposited toward the center. The rapidly accumulating sediments of the Wasatch Formation were deposited increasingly farther out into the basin.

2.6.2 Site Geology

Bedrock

The Wasatch Formation is the youngest bedrock unit throughout most of the permit area. It consists of interbedded claystones, silty sandstones, and relatively clean sandstones. In the vicinity of the Pumpkin Buttes, approximately 40 miles north of the permit area, the Wasatch Formation is known to be 1575 feet thick (Sharp and Gibbons, 1964). However, active stream erosion has left only about 500 feet of the formation in the central and east-central portions of the permit area, and none of the formation in the southwestern portion of the area. The surface contact between the Wasatch Formation and the underlying Fort Union Formation, roughly parallels the axis of the Powder River Basin, through the southwestern portion of the permit area. The interbedded claystones, siltstones, and relatively clean sandstones in the Wasatch vary in degree of lithification from uncemented to moderately well cemented sandstones, and from weakly compacted and cemented claystones to fissile shales.

The Fort Union Formation in the Powder River Basin is lithologically similar to the Wasatch Formation. Throughout the permit area, the Fort Union includes interbedded silty claystones, sandy siltstones, relatively clean sandstones, and claystones, with a few thin coal seams occurring locally. The degree of lithification is quite variable, ranging from virtually uncemented sands to moderately well cemented siltstones and sandstones. The total thickness of the Fort Union in the area is approximately 3000 feet.

Both the Wasatch and Fort Union strata are highly lenticular, with numerous facies changes within short lateral distances. In some cases it is essentially impossible to trace even relatively thick stratigraphic units more than a few thousand feet. On the other hand, some units can be traced for miles.

One shale, marking the top of the Fort Union Formation, is believed to persist throughout the permit area. This shale, designated locally as the "P" shale, averages over 60 feet thick. Approximately 500 feet of alternating sandstones and shales of the Wasatch Formation overlie the "P" shale in the vicinity of the Bill Smith Mine. The sandstone beds generally are 40 to 100 feet thick and alternate with shales that range from 20 to 50 feet thick. Some of the lower sands in the Wasatch are mineralized. Below the "P" shale are about 400 feet of sediments, largely sandstone, that include the mineralized zones to be mined. See Appendix D-5 for additional regional and site geological data.

2.7 Hydrology

2.7.1 Surface Waters

The permit area is located in the Sage Creek drainage of North Platte River drainage system in the southern part of the Powder River Basin. The only natural surface water in the permit area is emphemeral runoff in response to intermittent precipitation and seepage into small basins at low points in the Sage Creek drainage. Surface runoff is very limited, as reflected by a 1957-1958, USGS survey of the Box Creek drainage system which starts approximately 2 miles east of the permit area. The recorded mean flow from the 109 square mile drainage for 1957 and the first half of 1958 was 1.79 CFS (Tables 2-3 and 2-4). Stock ponds collect some runoff for watering livestock, however these ponds are dry much of the time.

There is no flowing surface water within the permit area. Prior to commercial operations at the Smith Ranch Facility, the only source of regular flowing surface water was the discharge from the Bill Smith Mine site authorized by Wyoming NPDES Permit WY 0022411. The minewater discharge from the facility resulted in a surface flow for a distance of about two miles downstream of the discharge point but did not normally reach the Sage Creek drainage channel. Though no discharges have occurred through the

NPDES discharge point since the pilot operations were placed on deferred production, Rio Algom has continued the monitoring requirements of the permit. No discharges to surface waters of process solutions will occur through the NPDES discharge point as a result of commercial operations at the Smith Ranch Facility. Results of NPDES sampling and monitoring will continue to be submitted to DEQ and NRC in the required ISL reports.

2.7.2 Groundwater

Descriptions of the geologic formations of the Powder River Basin and their hydrologic properties have been discussed in numerous publications (Hodson, et al., 1973; Hodson, 1971; Whitcomb, et al., 1958; Huntoon, 1976; Davis, 1976) and summarized in Appendix D-5 (Geology). The primary hydrologic units beneath the permit area include alluvial deposits, the Wasatch Formation, the Fort Union Formation, and the Cretaceous-age Lance and Fox Hills formations (Table D-6.1). Some of these units are classified as aquifers and can yield groundwater to wells and springs. The locations of water sources in this area are shown in Appendix D-6.

Alluvium. The alluvial deposits in the permit area consists of thin, unconsolidated, poorly stratified clays, silts, sands, and gravels. The total thickness of these deposits is estimated to range from less than 1 foot to 30 feet. There are no known wells within the permit area less than 30 feet deep and only three wells less than 100 feet deep, therefore very little information on water in the alluvial deposits, if any, is available.

Small amounts of precipitation infiltrate the alluvium during part of the year and the intermittent flow in drainage channels across the alluvium may provide some recharge to localized perched water tables in the alluvium. However, since the water table is typically more than 100 feet below the land surface throughout most of the permit area, most of the recharge flows through the alluvium to the Wasatch formation. In a drainage in the southwest portion of the area, a shallow water table appears to be the source of water for a small water hole but the potential for the development of the alluvium as a groundwater supply is not promising.

Wasatch Formation. The Wasatch Formation typically is lenticular fine- to coarse-grained sandstones with interbedded claystones and siltstones. This formation ranges from 0 to approximately 500 feet thick .in the permit area and includes some of the more important shallow aquifers in the Powder River Basin.

Most properly constructed wells completed in a Wasatch aquifer yield from 5 to 15 gallons per minute (gpm). However, the water supply well (WW-103) for the Bill Smith Mine can produce 140 gpm from a completion interval of approximately 120 feet containing four separate lenses. This well is 474 feet deep.

For the most part, the upper Wasatch aquifers occur under water table (unconfined) conditions. Artesian (confined) aquifers near the base of the formation are separated from overlying formations and from each other by impermeable claystone or mudstone layers.

The Wasatch formation is considered a good water supply for limited development, however the formation does outcrop in the permit area and the amount of groundwater available is difficult to assess. Hydrologic characteristics calculated from the Q-Sand pump test are believed representative of the deeper Wasatch aquifers (Appendix D-6).

Fort Union Formation. The Fort Union Formation underlies the Wasatch Formation beneath most of the permit area but in the southwestern portion of the area, the Fort Union lies directly beneath the surface. Typically, it is comprised of lenticular sandstones with interbedded claystones and siltstones. The Fort Union is as much as 3000 feet thick beneath the plant site.

The Fort Union Formation also include important aquifers in the Powder River Basin, and most of the wells in the vicinity of the plant site penetrate this formation. While most wells tap these aquifers for small (5 to 20 gpm) water volumes, test wells completed in the Fort Union have produced as much as 560 gpm (Table D-6.3).

The Wasatch and Fort Union aquifers are separated by a relatively thick impermeable shale (locally designated the "P" shale). Similar separation of aquifers within the Fort Union are common, and wells completed in these layers are often found to be under artesian pressure.

Substantial volumes of water can be produced from the Fort Union in the Southern Powder River Basin as demonstrated by the Bill Smith Mine. The mine produced 1500 to 1700 gpm from initial development until the mine was allowed to flood, a period of several years. Hydrologic characteristics of the Fort Union are illustrated by the O-Sand pilot pump test and the Section 25 and Section 35 pump tests summarized in Appendix D-6.

Lance and Fox Hills Formations. These formations underlie the Fort Union Formation beginning at depths of about 3000 feet in the permit area. Data from other areas indicate well yields seldom exceed 100 gpm from these aquifers, and the groundwater reserves may not be large. Little is known of their hydrologic characteristics, as no water wells are known to tap these aquifers in the vicinity of the permit area, it appears unlikely that these formations will be tapped for water supply in the near future because of depth and availability of water form the Wasatch and Fort Union Formation.

The Wasatch and the Fort Union aquifers are of the greatest importance to the proposed mining activities since they contain all the mineralized zones currently proposed for development. Results of pump tests conducted in these formations to date are included in Appendix D-6.

2.8 Seismology

The area of east central Wyoming where the project site is situated lies in a seismically relatively quiet region of the United States. Although distant earthquakes may produce shocks strong enough to be felt on the Powder River Basin, the region is ranked to be one of minor seismic risk, as shown on Figure 2-5. Few earthquakes capable of producing damage have originated in this region as indicated on the Regional Seismicity Map provided on Figure 2-6. The seismically active region closest to the site is the Intermountain Seismic Belt of the Western United States which extends in a northerly direction between Arizona and British Columbia. It is characterized by shallow earthquake foci between 10 and 25 miles in depth, and normal faulting. Part of this seismic belt extends along the Wyoming-Idaho border, more than 250 miles west of the permit area and would be the most probable source of earthquakes affecting the project site.

Table 2-5 lists the largest recorded earthquakes that have occurred within 300 miles of the Smith Ranch Site and gives the maximum ground acceleration that would be realized at the Site as a result of these disturbances. The earthquake of highest intensity that occurred nearest the Site is presumed to be the Casper, Wyoming earthquake of 1897. This earthquake has been assigned a probably maximum intensity of VII, based on damage incurred. Figure 2-7 provides a means for estimating the intensity of earth tremors at the Smith Ranch Site originating from such an epicentral intensity 47 miles away. The small figure insert shows that the probable magnitude for an earthquake with an epicentral intensity of VII is 5.67 on the Richter Scale. Assuming that the distance from the recovery plant site to the epicenter is approximately 47 miles, then the acceleration of the ground at the site would be 0.04 **g**, or slightly greater than intensity V.

No faulting in the project area has been reported, nor is any faulting evident from geophysical log interpretations. The ground accelerations reported in Table 2-5 (.01 g to .04 g) are not considered to be of a magnitude that would disturb the operations in the unlikely event that an earthquake occurred during the life of the mine.

2.9 Ecology

Topography in the permit area has a general gradient from northwest to the southeast. The northern and southwestern portions of the permit area contain the higher ground. The ephemeral channel of Sage Creek runs to the southwest. This drainage enters the permit area from the west in the western portion of Section 33, T36N, R74W, and runs southeasterly exiting in the southeast portion of Section 11, T35N, R74W. Drainage from the Bill Smith Mine site is via an unnamed draw to Frank Draw then to Sage Creek. Mine water discharge from the Bill Smith Mine provides a limited flow for a distance of about 2 miles downstream from the mine.

Soils on the hilltops and higher areas are shallow and sometimes associated with materials from rock outcrops. The soils become deeper on the side slopes of the hills and in the lower areas and drainages. Soils in the permit area generally pose no special problems and are rated as good for reclamation purposes. A low intensity soil survey, as well as detailed soils information, is contained in Appendix D-7.

Vegetation is a typical northern plains short grass prairie forage characteristic of areas of low annual precipitation. Dominant plant species present are Sage brush, Western Wheatgrass, Needlegrasses, Blue Gramma and Threadleaf Sedge. A vegetation study presented in Appendix D-8 provides details including productivity and cover information.

The wildlife in the area is typical for the region. Studies and observations of wildlife on the permit area and in the surrounding vicinity are presented in Appendix D-9. Important game species include the Pronghorn Antelope, Cottontail Rabbit, Sage Grouse, Mourning Dove and Mule Deer. Non-game species are typical of the sage brush grassland habitat in the region. No rare or endangered species were observed.

2.10 Background Radiological Characteristics

A background pre-mining radiological survey of the O-Sand pilot area was conducted and is summarized in Table 2-6. Background radiation for the surface and air were normal and no anomalies were found. A background gamma survey for each mining unit will be conducted on a 200 foot interval grid pattern and will be submitted to NRC and DEQ with the baseline water quality data for the mining unit prior to beginning leaching operations in that unit. Field gamma readings will be made 3 feet above the ground surface at each grid intersection in the projected well field area and recorded on a mining unit map. Radiological data concerning groundwater in the vicinity are reported in the baseline water quality data in Appendix D-6. The only airborne radioactive constituent of concern in regard to background is radon-222. The upwind radium-222 monitoring station for the ISL pilot is considered a representative of background. The data for this monitor point is summarized in Table 2-7.

2.11 Background Non-radiological Characteristics

Background non-radiological characteristics of the site are discussed in the applicable sections of Appendix D. Groundwater background concentrations of substances that could potentially be mobilized by leaching such as trace metals are presented with other baseline values as part of the groundwater-quality data in Appendix D-6.

Because of the relatively low surface disturbance necessary to construct the wellfield facilities and atmospheric pollution in the form of dust and no significant change to the existing anticipated.

Summaries of the results of ambient air sample for particulates collected near the 28-33 mine area approximately 5 miles northeast of the permit area are presented in Table 2-8 and 2-9 for the first quarter of 1982 through the end of 1986. This data was collected for the permit 304C-Rl annual reports.

Table 2-1

Adjudicated Water Rights (Surface and Groundwater) Inside and Within 3 Miles of the Proposed Permit Area

#	Certificate	Permit	Div	Dist.	Proof	Appropriator	Facility	Use	Source	Priority	T R S	Adj. Ac. Ft.	Adj. GPM	Adj. C.F.S	Adj. Acres	Ht. of Dam Ft.
1	CR1/269	P5393R	2	1	23378	Jos. W. Reynolds Douglas, WY	Silver Spoon Res.	Sto.	Hold Up Hollow Dr. Willow Ck. S. Fork Cheyenne R. Cheyenne R. SD.	1-24-41	36 74 12	17.25	-	-	-	20.0
2	CR2/198	P1965S	1	15	26144	Otis Barber Glenrock, WY U.S.D.I., BLM Casper, WY	Federal #1 Stock Red.	Sto.	Federal Dr. Wenzinger Dr. Sage Ck. N. Platte R. Platte R. NB.	4-15-57	35 74 29	3.85	-	-	-	14.1
3	CR2/199	P1966S	1	15	26145	Otis Barber Glenrock, WY	Bruce Mine Stock Res.	Sto.	Bruce Mine Dr. Sand Ck. N. Platte R. Platte R. NB.	4-15-57	35 75 30	6.60	-	-	-	18.2
4	CU2/439	P15611W	1	15	938U	Pacific Pwr. & Lt. Portland, OR 97204	D. J. Mine #2 Well	Mis.	G W	10-18-72	35 74 3	-	95	-	0.00	-
5	CR6/017	P2718S	1	15	29740	Leland Crouch Glenrock, WY	Leland #1 Stock Res.	Sto.	Leland Dr. Sage Ck. N. Platte R. Platte R. NB.	4-29-59	36 74 30	14.28	-	-	-	18.0
6	C27/159	P1881D	1	02	8013	John T. Williams Douglas, WY	Pipeline Ditch	Sto.	White Rock Springs Sage Ck. N. Platte R. Platte R. NB.	7-08-98	35 74 06	(There was no amount of appropriation adjudicated)				
7	C27/153	P1878D	1	15	8007	John T. Williams Douglas, WY	Williams #1 Ditch	Irr. Sto.	Sage Ck. N. Platte R. Platte R. NB.	7-08-98	36 74 33	-	-	.078	5.5	-

Table 2-1 (cont'd)

Adjudicated Water Rights (Surface and Groundwater) Inside and Within 3 Miles of the Proposed Permit Area

#	Certificate	Permit	Div	Dist.	Proof	Appropriator	Facility	Use	Source	Priority	T R S	Adj. Ac. Ft.	Adj. GPM	Adj. C.F.S	Adj.. Acres	Ht. of Dam Ft.
8	C27/154	P1879D	1	15	8008	John T. Williams Douglas, WY	Williams #2 Ditch	Irr. Sto.	Sage Ck. N. Platte R. Platte R. NB	7-08-98	36 74 33	-	-	.135	9.5	-
9	C27/156	P1883D	1	02	8010	John T. Williams Douglas, WY	Pipeline Ditch	Sto.	Lake Spring Sage Ck. N. Platte R. Platte R. NB.	7-08-98	36 73 32	(There was no amount of appropriation adjudicated)				
10	C27/157	P1882D	1	02	8011	John T. Williams Douglas, WY		Sto.	Willow Springs Sage Ck. N. Platte R. Platte R. NB.	7-08-98	35 73 04	(There was no amount of appropriation adjudicated)				
11	C72/184	P23404D	1	15	31373	Smith Sheep Co. Douglas, WY	Amspoker #1 Ditch	Itt.	Amspoker Dr. Sage Ck. N. Platte R. Platte R. NB.	2-19-70	34 74 02	-	-	2.28	159.7	-
12	C74/031	P25312D	2	1	32700	Hornbuckle Ranch Douglas, WY	Brown Spring Pipeline #1	Sto.	Brown Spring Cr. Dry Fork S. Fork Cheyenne R. Cheyenne R. SD.	2-2-76	36 74 04	-	-	.044	-	-
13	C72/032	P25313D	2	1	32071	Hornbuckle Ranch Douglas, WY	Brown Spring Pipeline #2	Sto.	Brown Spring Cr. Dry Fork S. Fork Cheyenne R. Cheyenne R. SD.	9-9-76	36 74 04	-	-	.044	-	-

TABLE 2-2

POPULATION TRENDS

Percentage of Population Change
Converse County

	1970	1980[1]	Percent Change	1983-4[2]	Percent Change
Glenrock Area	1,515	2,736	80.6%	2,000	-27%
Douglas Area	2,677	6,030	152.5%	5,000	-17%
Converse County	5,938	14,069	136.9%	11,256	-20%

Population Summary
Converse and Natrona Counties

	NATRONA COUNTY[3]		CONVERSE COUNTY		
Year	Casper	County	Douglas	Glenrock	County
1970	39,361	51,264	2,677	1,515	5,938
1980	51,016	71,856	6,030	2,736	14,069
1990	53,852	76,509			13,944[4]

1 . Wyoming Data Handbook 1985, Department of Administration and Fiscal Control, Division of Research and Statistics.

2 . Estimated projections by Mike Sierz, Converse County Planning Director, November 13, 1986.

3 . Economic Profile for the City of Casper, 1986, Planning Department, Community Planners Commission.

4 . Furtney, Steve and Sormners, Steve; Wyoming Population and Employment Report", Division of Research and Statistics, Department of Administration and Fiscal Control, State of Wyoming, 8th Edition, September 1985.

Table 2-5

MAXIMUM EXPECTED EARTHQUAKE INTENSITIES AND GROUND ACCELERATIONS AT THE SMITH RANCH SITE

	Maximum Epicentral Intensity of Record	Distance from Epicenter to Smith Ranch Site	Maximum Probable Intensity at Smith Ranch Site	Maximum Ground Acceleration at Smith Ranch Site
Hebgen Lake, Montant (1959)	X	285 miles	III-IV	Less than 0.01 g
Northeastern Nebraska (1934)	VI	121 miles	IV	Approximately 0.02 g
Black Hills, South Dakota (1928)	V	100 miles	III-IV	Less than 0.02 g
Powder River Basin (1967)	VI	36 miles	IV	Approximately 0.02 g
Casper, Wyoming (1897)	VII	47 miles	V-VI	Approximately 0.04 g

TABLE 2-6

O-SAND BASELINE SURFACE
RADIOLOGICAL ENVIRONMENTAL MONITORING

Sample Type	Sample ID	Sample Location	Depth cm	Ra 226 pci/g	Th 230 pci/g	mg/g	u Date
Vegetation	OI-7	Wellfield	NA	0.33		.002	4/17/84
	OI-9	Wellfield	NA	3.22	-	.100	4/17/84
	D-4	Down Drainage	NA	1.69	0.04	.006	8/13/84
	F-2	Wellfield	NA	0.76	0.02	.002	8/13/34
Soil	OI-9	Wellfield	5	2.15	1.18	.006	4/17/84
	OI-9	Wellfield	15	1.57	0.99	.005	4/17/84
	OI-7	Wellfield	5	2.35	1.36	.006	4/17/84
	OI-7	Wellfield	15	1.14	0.87	.006	4/17/84
	U-1	Up Drainage	5	0.74	0.40	.002	8/13/84
	u-1	Up Drainage	15	0.61	0.35	.002	8/13/84
	F-2	Wellfield	5	1.34	0.57	.007	8/13/84
	F-2	Wellfield	5	1.20	0.70	.008	8/13/84
	F-2	Wellfield	15	0.95	0.80	.002	8/13/84
	F-2	Wellfield	15	0.90	1.10	.001	8/13/84
	F-3	Wellfield	5	1.34	0.30	.001	8/13/84
	F-3	Wellfield	15	0.90	0.50	.002	8/13/84
	F-7	Wellfield	5	5.10	4.00	.017	8/13/84
	F-7	Wellfield	15	2.45	2.00	.006	8/13/84
	F-8	Wellfield	5	1.84	0.70	.003	8/13/84
	F-8	Wellfield	15	1.58	1.52	.002	8/13/84
	F-9	Wellfield	5	1.40	0.80	.002	8/13/84
	F-9	Wellfield	15	1.46	0.90	.002	8/13/84
	D-4	Down Drainage	5	15.00	3.80	.029	8/13/84
	D-4	Down Drainage	5	18.00	8.10	.033	8/13/84
	D-4	Down Drainage	15	3.60	0.90	.006	8/13/84
	D-4	Down Drainage	15	4.60	1.80	.006	8/13/84
	D-5	Down Drainage	5	7.40	3.40	.015	8/13/84
	D-5	Down Drainage	15	1.25	1.40	.002	8/13/84
	D-6	Down Drainage	5	1.05	1.60	.002	8/13/84
	D-6	Down Drainage	15	0.80	0.50	.001	8/13/84

TABLE 2-7

RADON-222 VALUE
UPWIND OF PILOT
CONVERSE COUNTY, WYOMING

	Average Radon-222 pCi/l (in Air)		Direct Gamma uR/Hr.	
	Upwind Location	Downwind Location	Upwind Location	Downwind Location
Baseline	1.1	1.3	-	-
1st Qtr. 1982	0.4	0.7	6	6
2nd Qtr. 1982	0.6	0.3	20	30
3rd Qtr. 1982	0.5	0.8	20	26
4th Qtr. 1982	1.5	2.1	20	25
1st Qtr. 1983	0.8	0.8	20	22
2nd Qtr. 1983	1.0	0.7	20	22
3rd Qtr. 1983	0.2	0.3	21	23
4th Qtr. 1983	0.2	0.2	21	25
1st Qtr. 1984	0.3	0.2	20	26
2nd Qtr. 1984	0.4	0.8	20	24
3rd Qtr. 1984	0.4	0.9	20	24
4th Qtr. 1984	0.5	0.6	16	19
1st Qtr. 1985	0.8	0.7	16	11
2nd Qtr. 1985	0.9	1.0	14	12
3rd Qtr. 1985	(1)	(1)	14	12
4th Qtr. 1985	(2)	0.7	11	14
1st Qtr. 1986	-	0.7	12	25
2nd Qtr. 1986	-	1.0	12	16
3rd Qtr. 1986	-	1.2	14	16
4th Qtr. 1986	-	0.5	20	20
1st Qtr. 1987	-	0.3	11	14
2nd Qtr. 1987	-	1.2	11	14

(1) Contractor terminated service; license amendment terminating requirement requested.
(2) Deleted per License Amendment No. 14

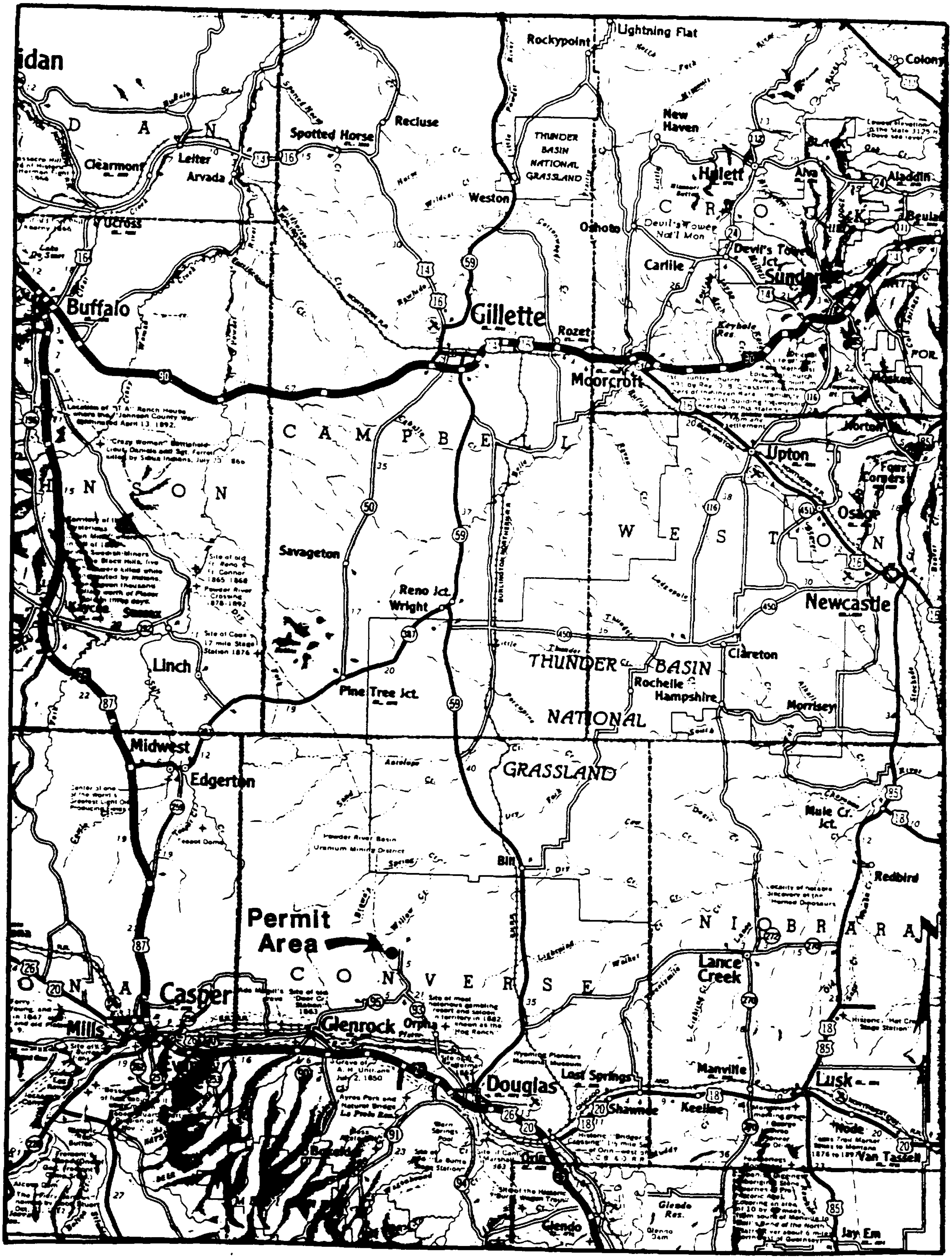
TABLE 2-8

AIR MONITORING DATA*

Date	monitoring Station	Dust 3 (ug/m
01-05-82	28-33 Pit	18.7
02-01-82	28-33 Pit	7.4
03-02-82	28-33 Pit	15.5
03-30-82	28-33 Pit	27.4
04-30-82	28-33 Pit	15.7
05-30-82	28-33 Pit	4.1
07-01-82	28-33 Pit	36.0
07-30-82	28-33 Pit	24.1
08-31-82	28-33 Pit	25.0
10-04-82	28-33 Pit	16.2
11-08-82	28-33 Pit	30.9
12-07-82	28-33 Pit	10.7
01-10-83	28-33 Pit	5.2
02-07-83	28-33 Pit	63.7
03-15-83	28-33 Pit	7.5
04-21-83	28-33 Pit	48.9
05-25-83	28-33 Pit	21.1
06-15-83	28-33 Pit	22.2
07-20-83	28-33 Pit	35.3
08-10-83	28-33 Pit	56.9
09-13-83	28-33 Pit	56.0
10-19-83	28-33 Pit	8.6
05-23-84	28-33 Pit	63.3
06-19-84	28-33 Pit	22.9
07-18-84	28-33 Pit	31.3
08-08-84	28-33 Pit	32.8
09-12-84	28-33 Pit	28.3
10-30-84	28-33 Pit	49.4
11-29-84	28-33 Pit	23.1
12-12-84	28-33 Pit	19.1

*28-33 Mine Area

Annual Mining and Reclamation Report



LOCATION OF and ACCESS TO
RECOVERY PLANT SITE
FIGURE 2-1

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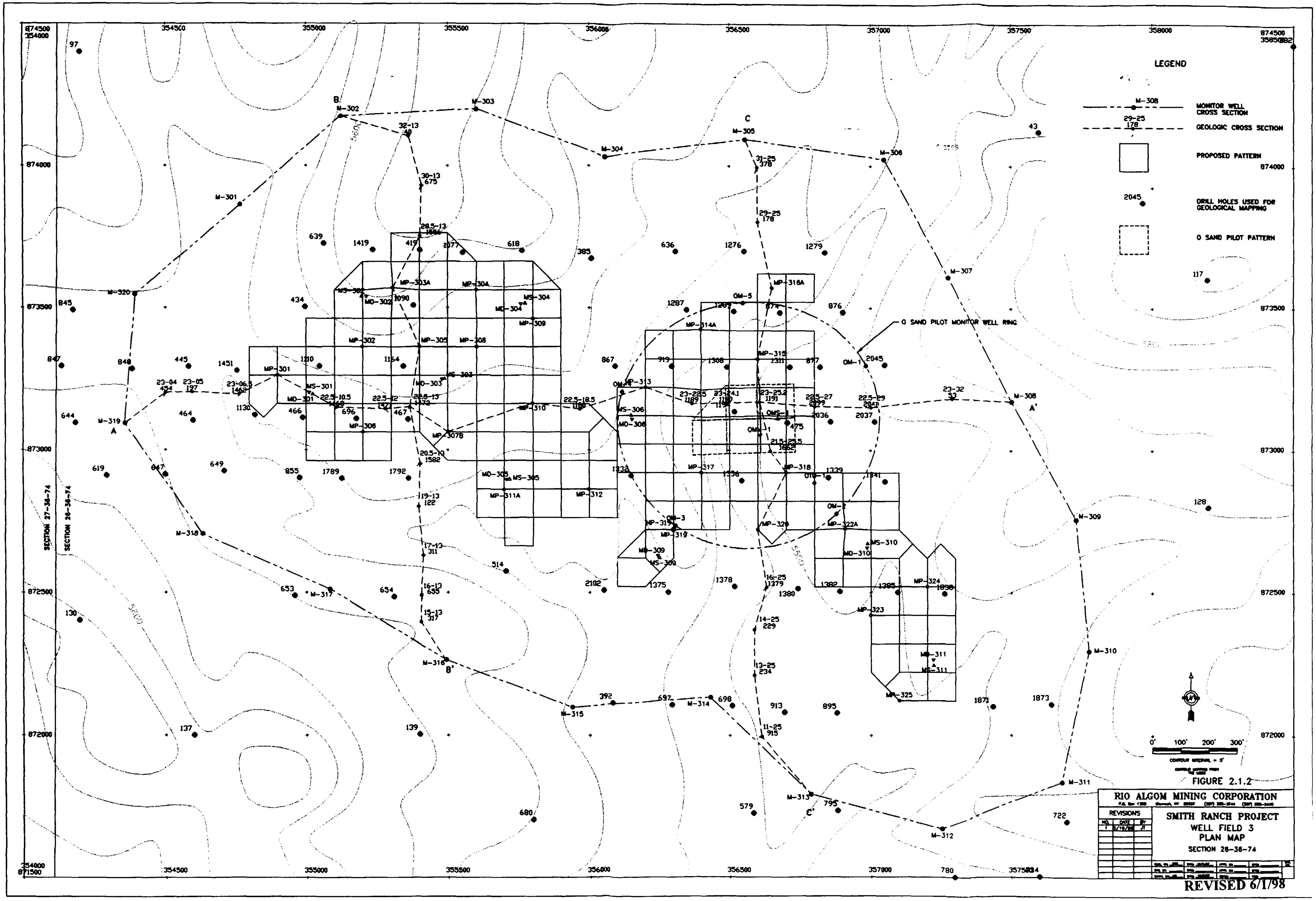
LEGEND
M-308
MONITOR WELL CROSS SECTION
29-25
178
GEOLOGIC CROSS SECTION
PROPOSED PATTERN
2045
DRILL HOLES USED FOR GEOLOGICAL MAPPING
O SAND PILOT PATTERN
O SAND PILOT MONITOR WELL RING
SECTION 27-36-74
SECTION 26-36-74
0' 100' 200' 300'
CONTOUR INTERVAL = 5'
FIGURE 2.1.2
RIO ALGOM MINING CORPORATION
REVISIONS
NO. DATE BY
SMITH RANCH PROJECT
WELL FIELD 3
PLAN MAP
SECTION 26-36-74
REVISED 6/1/98

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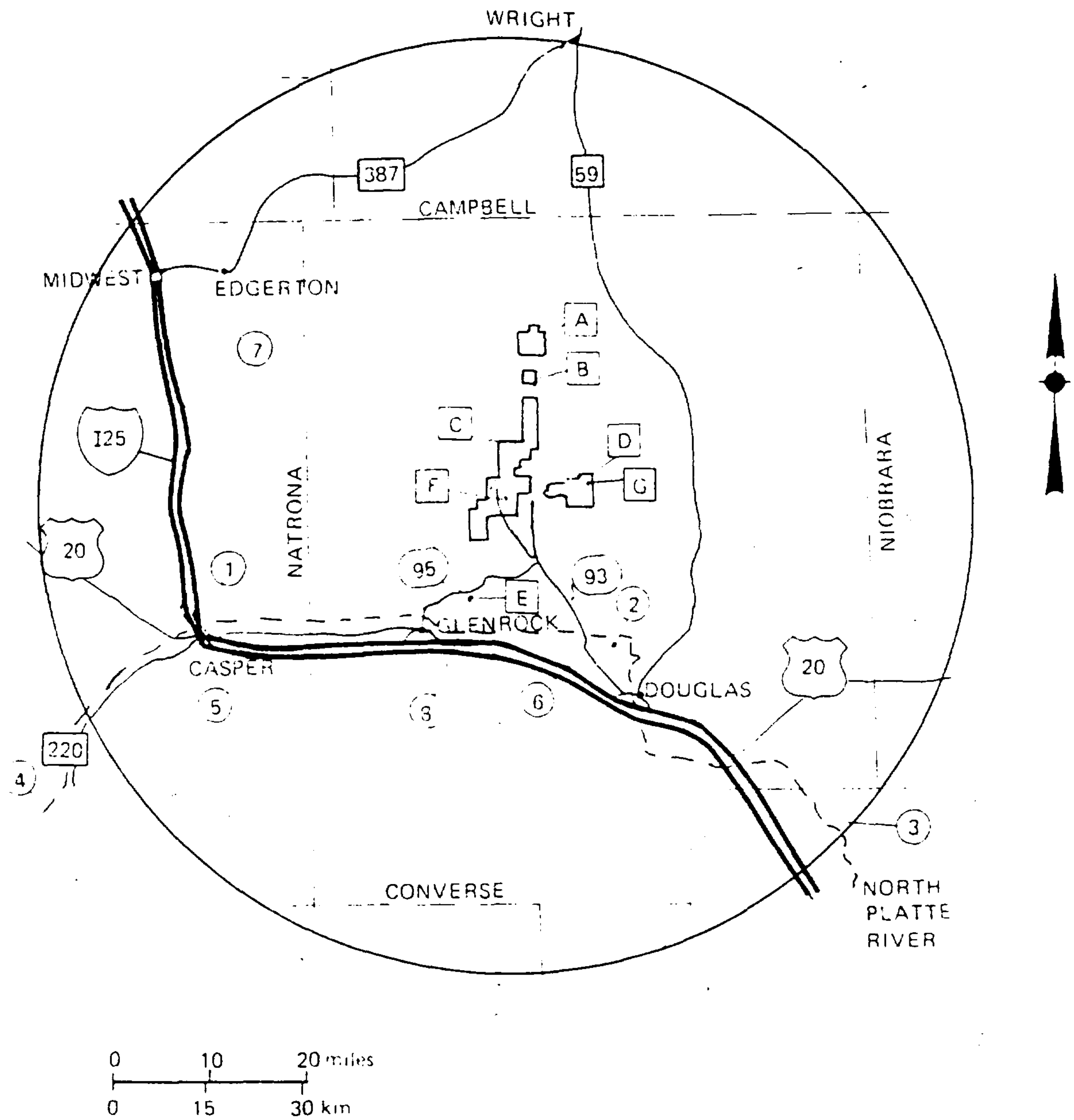
FIGURE 2 - 2



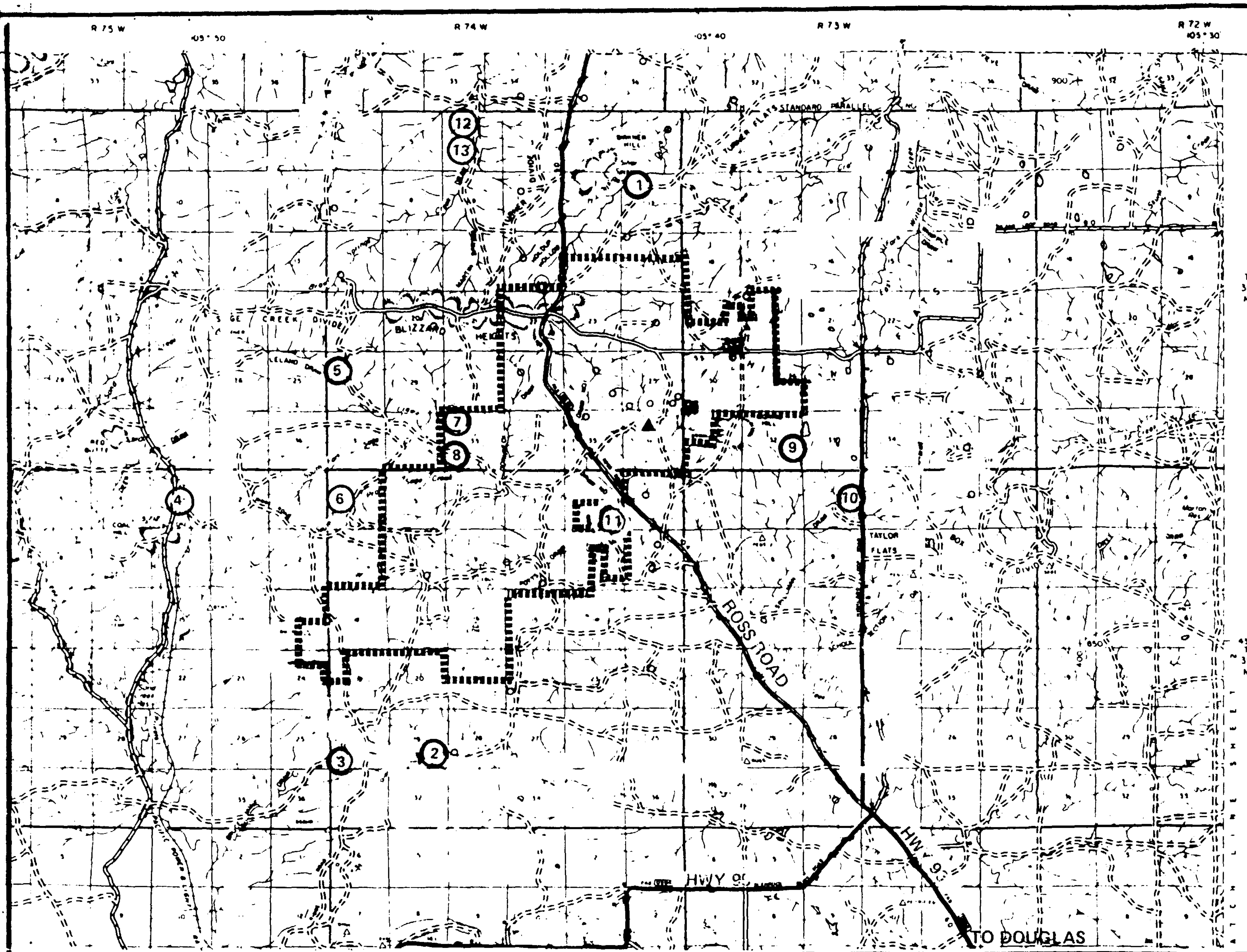
URANIUM MINING AREAS

A. BEAR CREEK URANIUM CO.
B. PIONEER NUCLEAR
C. SEQUOYAH FUELS CORP
D. EVEREST MINERAL CO
E. LEUENBERGER SITE (CEGB)
F. PROJECT PLANT SITE
G. EXXON MILL SITE

LOCATION OF POINTS OF INTEREST

1. FORT CASPER
2. FORT FETTERMAN
3. GLENDO STATE PARK
4. ALCOVA RECREATION AREA
5. CASPER MOUNTAIN RECREATION AREA
6. AYRES NATURAL BRIDGE
7. SALT CREEK OILFIELD - TEAPOT DOME
8. DAVE JOHNSTON COAL POWER PLANT

POPULATION AND ACTIVITY CENTERS WITHIN 50 MILES
OF THE PROJECT RECOVERY PLANT SITE.



TO GLENROCK

LEGEND

▲ PLANT SITE

▮▮▮▮▮▮▮▮ PROJECT PERMIT AREA

(1) FOR LIST OF ADJUDICATED WATER RIGHTS, SEE TABLE 2-1

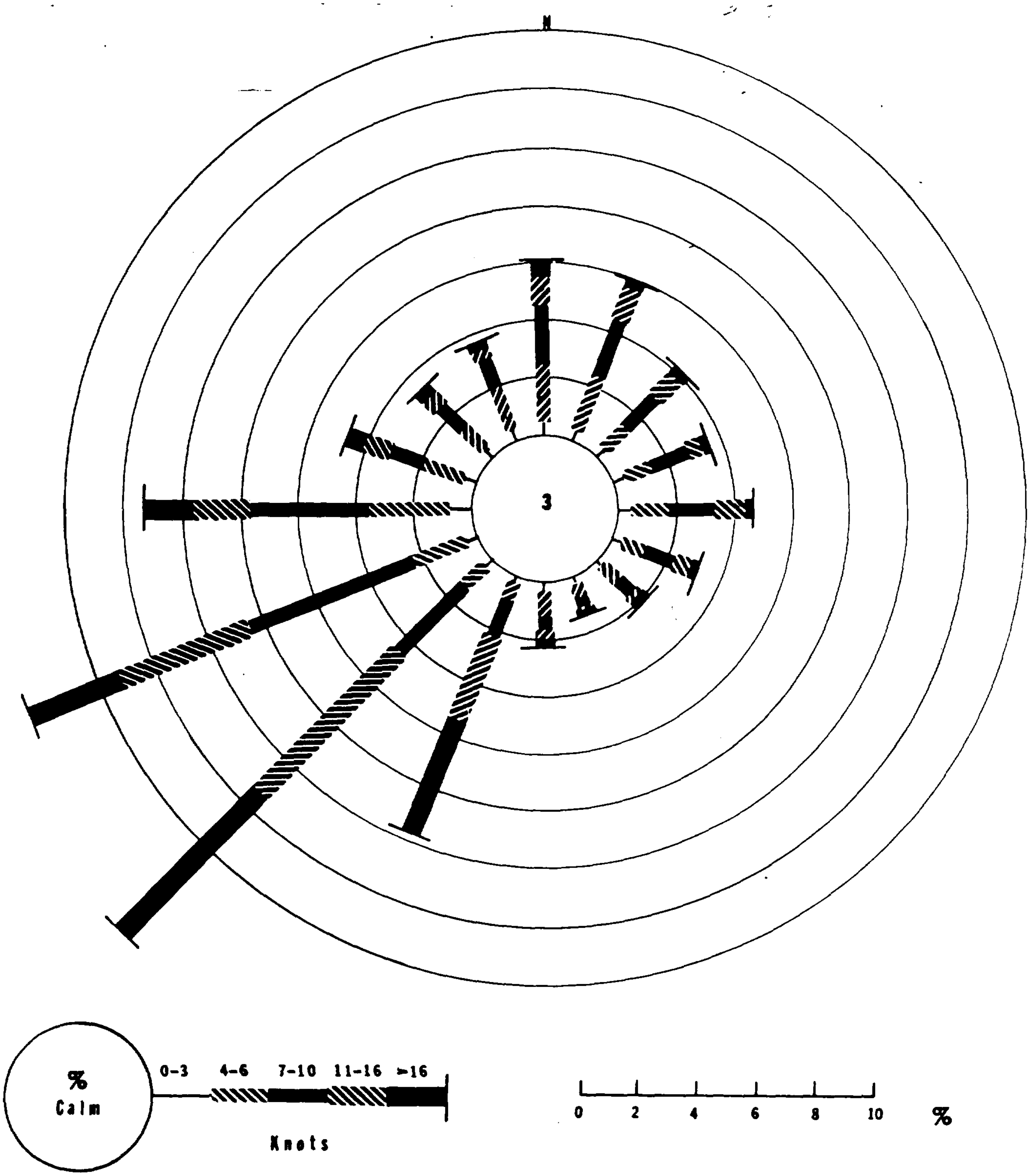
REVISIONS		
NO.	DATE	BY
1	3-28-88	wyl
2		
3		
4		
5		

ADJUDICATED WATER RIGHTS
IN OR WITHIN 3 MILES OF PERMIT AREA
SOUTH POWDER RIVER BASIN
CONVERSE COUNTY, WYOMING

SEQUOYAH FUELS CORP

Geology by	Scale 1" = 2 MILES	Sheet 1 of 1
Engineering by	Date NOV 1979	
Drafting by J.M.		FIGURE 2-3

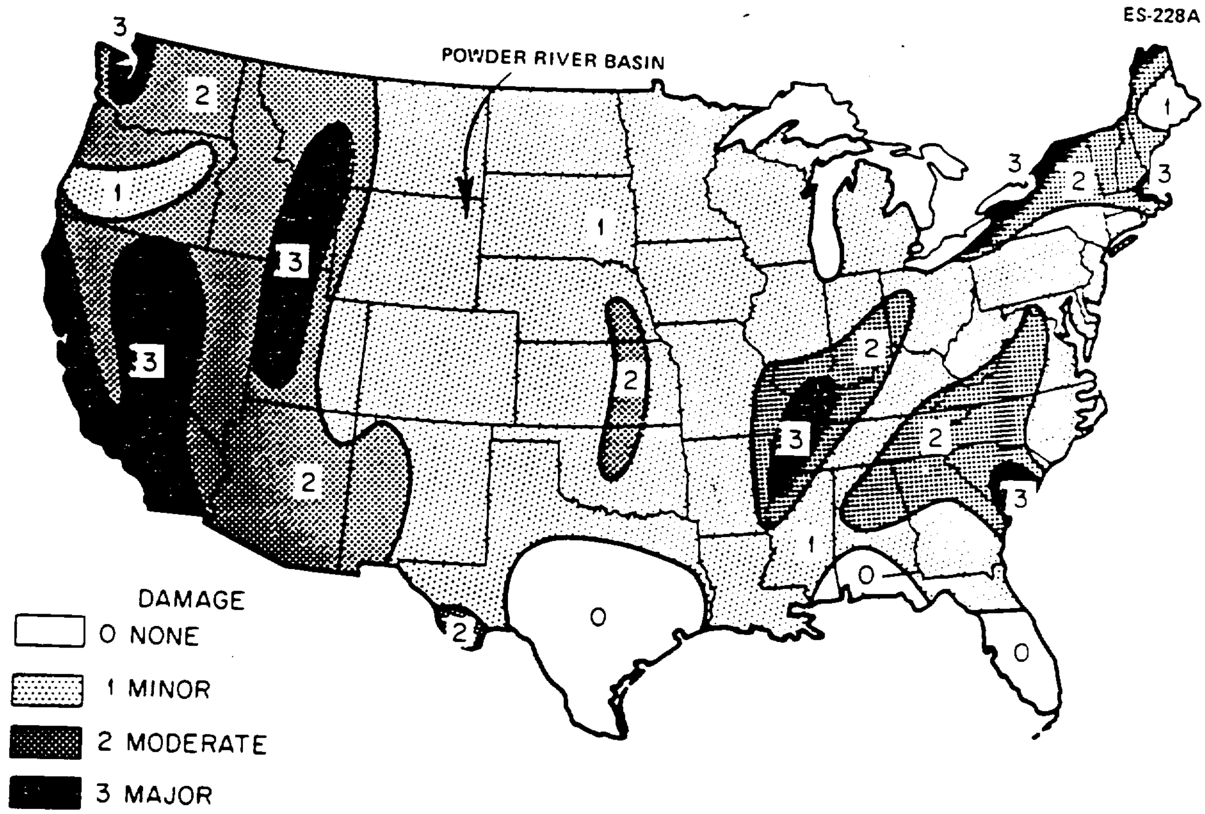
FIGURE 2-4



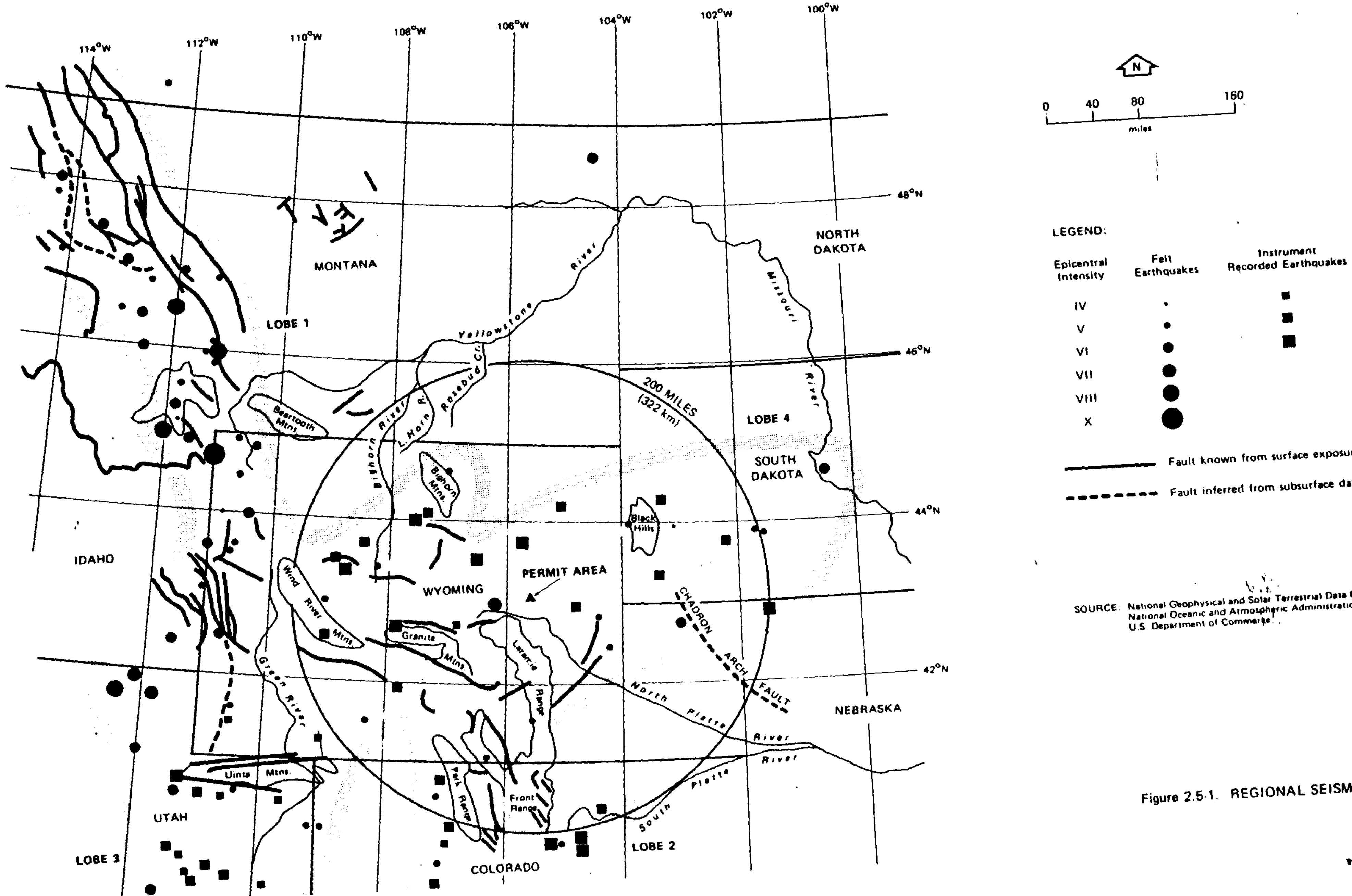
SOURCE: Based on the National Climatic Center's STAR program calculation for Casper (U.S. Department of Commerce, 1973).

Figure 2.7-1. ANNUAL WIND ROSE FOR CASPER, WYOMING (Period of Record, 1967 - 1971)

<u>FIGURE 2-5</u>



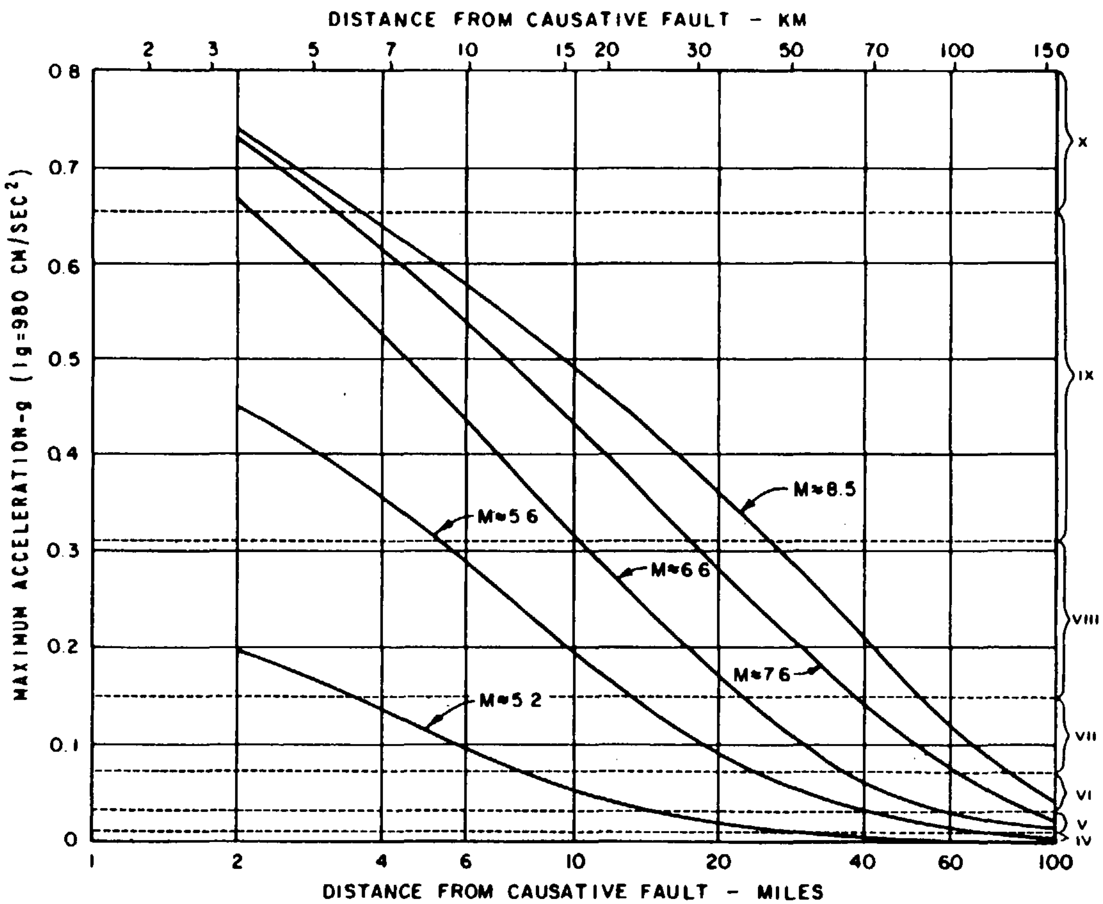
Seismic risk map of the United States. <u>Source</u>: S. T. Algermissen, *United States Earthquakes*, Fig. 2.4, U.S. Government Printing Office, Washington, D.C., 1968.



SOURCE: National Geophysical and Solar Terrestrial Data Center, National Oceanic and Atmospheric Administration, U.S. Department of Commerce.

Figure 2.5-1. REGIONAL SEISMICITY

FIGURE 2-6



Source: Schnabel and Seed, 1972.
Woodward-Clyde Consultants, 1977

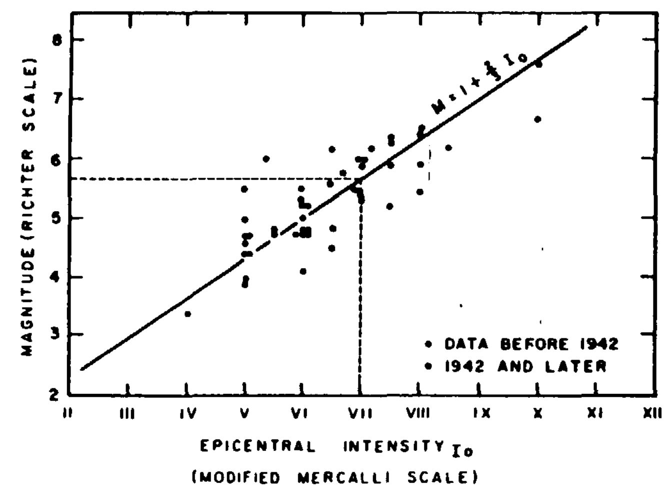


FIGURE 2-7

MAXIMUM ACCELERATION vs. DISTANCE CURVE : CURVE REPRESENTS THE RELATIONSHIP BETWEEN DISTANCE FROM THE CAUSATIVE FAULT AND THE MAXIMUM AVERAGE ANTICIPATED ACCELERATION FOR AN EARTHQUAKE OF GIVEN RICHTER MAGNITUDE (M) WHICH RANGES FROM 1 TO 9 TO DATE.

Figure 2.5-2. CORRELATING FACTORS FOR ESTIMATING EARTHQUAKES

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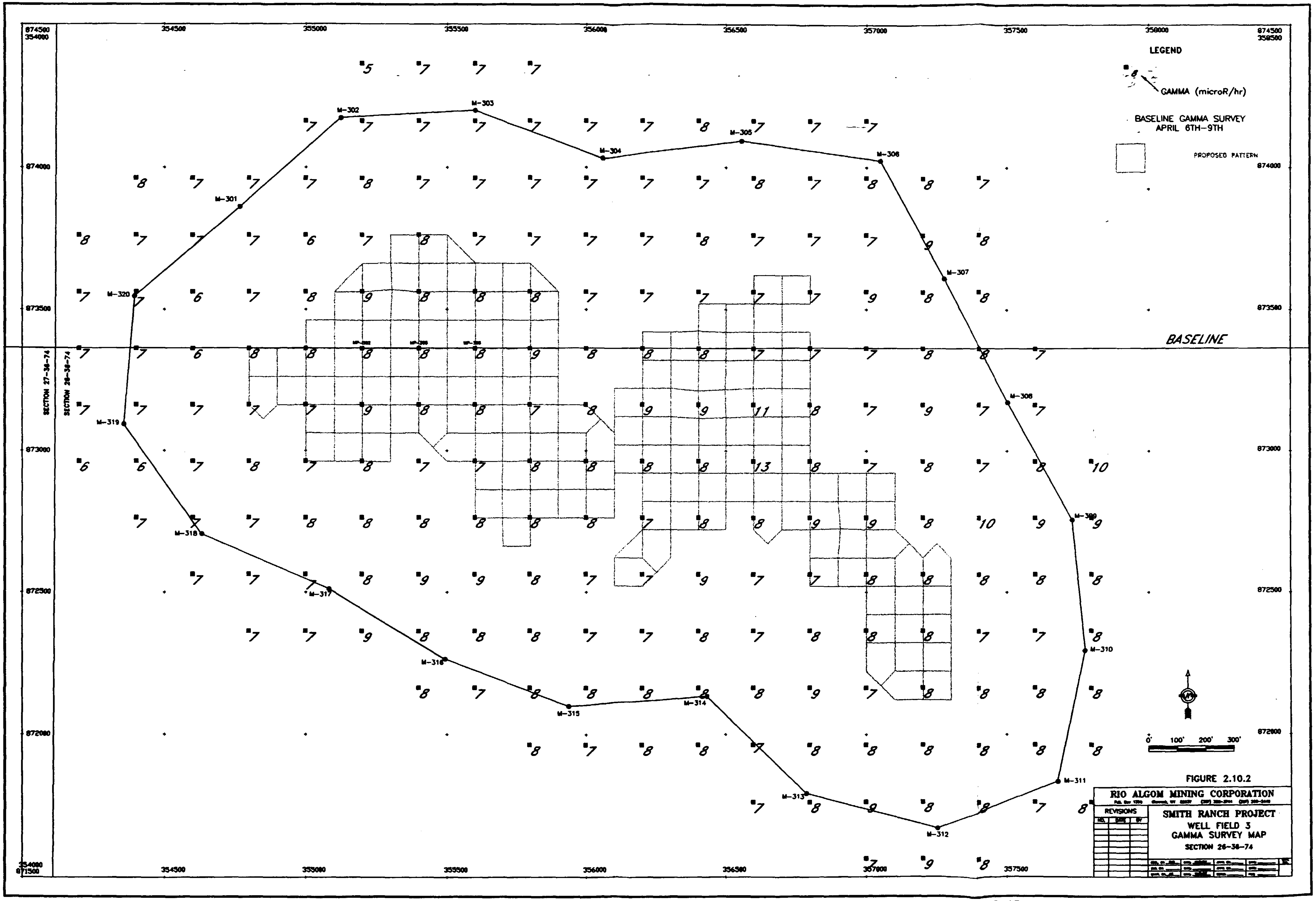

LEGEND
GAMMA (microR/hr)
BASELINE GAMMA SURVEY APRIL 6TH-9TH
PROPOSED PATTERN
BASELINE
SECTION 27-36-74
SECTION 26-36-74
M-301
M-302
M-303
M-304
M-305
M-306
M-307
M-308
M-309
M-310
M-311
M-312
M-313
M-314
M-315
M-316
M-317
M-318
M-319
M-320
0' 100' 200' 300'
FIGURE 2.10.2
RIO ALGOM MINING CORPORATION
REVISIONS
SMITH RANCH PROJECT
WELL FIELD 3
GAMMA SURVEY MAP
SECTION 26-36-74

OVERSIZE PAGE(S)

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CHAPTER 3

DESCRIPTION OF PROPOSED FACILITY

The permit area contains 16,200 acres. The total surface area to be affected by the proposed operation is within the permit area and will total approximately 700 acres.

The wellfields, the recovery plant and evaporation ponds are the significant surface features associated with the uranium solution mining operation.

The total well field area to be used for the injection and recovery of leach solution over the twenty year mine life will be approximately 400 acres. The recovery plant and related facilities will be located within the former Bill Smith Mine site. In addition to the facilities located at the mine site, satellite IX facilities will also be constructed away from the main site to facilitate the operation of wellfields located away from the central site. Solar evaporation ponds will consist of 5 to 15 acre cells to be constructed as needed. The total area of the initial evaporation ponds is expected to be approximately 20 acres lined with an impervious liner or other materials that would be acceptable to DEQ and NRC. Wastewater will also be disposed via deep injection wells constructed and completed as required by the appropriate regulatory agencies.

3.1 In Situ Leaching (ISL) Process

The ISL process will be conducted using a carbonate leaching solution made from varying concentrations and combinations of sodium carbonate, sodium bicarbonate, carbon dioxide, oxygen, and/or hydrogen peroxide added to the native groundwater. The combined carbonate/bicarbonate concentration in the injected solution will be maintained at less than five grams per liter and the hydrogen peroxide and/or oxygen concentration will be less than one gram per liter.

The leaching solution recovered from the wellfield will be pumped from the wellfield through buried pipelines to the uranium ion exchange facilities. At the ion exchange facilities, the uranium will be removed by solid resin ion exchange and chemicals, as specified above, will be added to the barren fluid to return it to the desired concentrations. The leaching solution will then be pumped back to the wellfield through buried pipelines, oxygen is added in the wellfield and injected in the production zone to recover additional uranium. Carbon dioxide may be added to the process stream as needed to control pH. Primary chemical reactions expected in the aquifer are provided in Figure 3-1. The production and injection rates for each well field will be metered and controlled to ensure a natural groundwater flow toward the solution mining area. A bleed rate of at least one-half percent will be maintained to provide this control. Figure 3-2 shows leaching solution flow balance for the Smith Ranch Project. During wellfield operations, injection pressures shall not exceed the mechanical integrity test pressures (see Section 3.1.4)at the injection wellheads. Not withstanding this restriction, the maximum injection operating wellhead pressures shall not exceed 90 % of the production zone fracture pressure or 95% of the ASTM maximum recommended operating pressure at 75°F for the well casing, whichever is lesser.

Figure 3-2 was clarified in April 1997 to add the deep disposal well injection for process wastewater.

This project will use processes and technology developed and demonstrated during Q-sand and O-sand R&D programs as well as techniques and processes developed at other ISL facilities that utilize best practices and industry experience.

3.1.1 Site Facilities Layout

The buildings to be utilized for housing the first ion exchange facility and the central processing plant will include the existing facilities at the Bill Smith Mine Site. No new surface disturbance will be required for these facilities as all buildings are located in the area previously disturbed by mining activities. Remote from the central processing plant, at least one satellite IX plant, for which approximately five (5) acres will be disturbed, will be constructed and used for IX operations. The resin from the satellite IX unit will be transferred by truck and eluted at the central processing plant.

The wellfield areas and the solar evaporation ponds will be installed on an as needed basis. The anticipated installation schedule for the wellfield area are discussed in a later section of this chapter and the evaporation ponds are discussed in Chapter 4. Figure 3-3 shows the approximate locations of the significant surface features within the permit area and in the general area. A plan view of the recovery plant is included in Figure 3-4.

As shown on Map E-1, Appendix E, most roads and associated culverts and crossings are existing. All new roads and crossings will be constructed in accordance with standards described in Chapter 3, Section 2(i) of the LQD Rules and Regulations. Crushed rock used for road construction will not exceed 1-1/2 inch in size. Topsoil will be stripped and stored in a manner consistent with that presented in

Section 6.2.3 of this permit, titled "Topsoil Handling and Replacement".

3.1.2 The Ore Deposits

The ore deposits in the project area generally occur at depths of 450 feet to 1,000 feet below the surface in long narrow trends varying from a few hundred to several thousand feet long and 20 to 300 feet wide. The depth depends on the local topography, the dip of the formation and stratigraphic horizon. The shallower ore deposits are contained within the Q-sand and the mineable ore in this sand occurs at depths of 450 to 500 feet. Most of the remaining uranium mineralization occurs in the O-sand formation at a depth of 700 to 900 feet. The Q-sand pilot and O-sand pilot were conducted at depths of approximately 500 feet and 750 feet respectively. The location of the pilots and the pilot recovery plant are shown on Figure 3-5.

A typical stratigraphic interval to be mined by the in situ mining method are shown by the geologic cross sections of the Q-sand and O-sand pilot areas, Figures 3-6 and 3-7. The designation of the intervals identified on the cross sections are Company designations. The production zone for an ISL wellfield is the geological interval host sands where leach solutions will be injected and recovered.

3.1.3 Wellfield Area

The wellfield areas will be developed as needed to meet production requirement in wellfields are generally about 50 acres each. Injection and recovery wells in a wellfield will be completed in the mineralized intervals of only one production zone at any one time. Injection and recovery wells will be completed as described later in Section 3.1.3.3

to isolate the open hole or screened ore bearing interval from all other aquifers. Production zone monitor wells will be located in a pattern around the wellfield units with the completion interval open to most of the production zone. One overlying and one underlying monitor well will also be completed in the aquifers immediately above and below the production zone. Overlying and underlying wells will be installed at a density of one for each four acres of wellfield area. However, spacing between overlying or underlying monitor wells in the same zone shall not exceed 1,000 feet.

When areas within a prospective wellfield are encountered which exhibit very thin or absent vertical confining layers, RAMC will evaluate the local stratigraphy and may adjust the monitoring and operating programs to account for such a situation. These adjustments may include placement of the overlying/underlying monitor wells in different stratigraphic horizons within the same wellfield, and perhaps in the same sandstone unit containing the mineralized intervals (at different horizons). Additional operational controls may also be instituted in the absence or breach of a confining layer, such as localized increased rates of over-recovery.

3.1.3.1 Wellfield Pattern

The wellfield development pattern to be utilized will be based on conventional five spot pattern which will be modified as needed to fit the characteristics of the orebody. The standard production cell for the five spot pattern contains four injection wells surrounding a centrally located recovery well. The cell dimensions will vary depending on the formation and the characteristics of the orebody. The injection wells in a normal pattern are expected to be between 75 feet and 150 feet apart. The recovery well for a production cell will be centrally located within the injection well pattern. All wells are expected to be completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations leaching solution will enter the formations through the injection wells and flow to the recovery wells. More water will be produced than injected to create an overall bleed and to reduce the pressure in the wellfield area. Under this pressure gradient the natural groundwater movement from the surrounding area will be toward the wellfield providing additional control of the leach solution.

It is expected that the minimum over production or bleed rates will be a nominal 0.5% of the wellfield production rate and the maximum bleed rate would be a nominal 1.5%. Over-production will be adjusted as necessary to maintain the perimeter ore zone monitor wells within the zone of control.

Perimeter ore zone monitor wells will be located in a uniform pattern around the wellfield approximately 500 feet from the outer limit of the wellfield pattern with a maximum spacing of 500 feet between wells. Monitor wells will also be completed in the aquifers directly overlying and underlying the production zone aquifer. The overlying and underlying aquifer monitor wells will be uniformly distributed over the wellfield area with one overlying and one underlying monitor well for each four (4) acres of wellfield area. However, spacing between overlying or underlying monitor wells in the same zone shall not exceed 1,000 feet.

Each injection well and recovery well will be connected to the respective injection or recovery manifold in a wellfield header building. The manifolds will route the leaching solutions to the pipelines carrying the solutions to and from the ion exchange facilities. Flow meters and control valves will be installed in the individual well lines to monitor and control the individual well flow rates and pressures. Wellfield piping is expected to be high density polyethylene (HDPE) pipe, PVC and/or steel. The wellfield piping will typically be designed for an operating pressure of 140 psig, and it will be operated at pressures equal to or less than the rated operating pressure of the pipe and other in-line equipment. The typical pressure rating for both non-metallic piping materials is 160 psig, (Sch. 40 PVC and SDR 11 HDPE). If a higher design pressure is needed, the pressure rating of the materials will be evaluated and if necessary, materials with a higher pressure rating will be used.

The individual well lines and the trunk lines to the ion exchange facilities will be buried to prevent freezing. The use of field header buildings and buried lines, has been proven an effective method of protecting the pipelines in the pilot programs which operated continuously through six years without freeze-ups or other significant weather related problems. A typical wellfield development pattern is illustrated in Figure 3-8. The O-Sand pilot leaching solution flow patterns shown in Figure 3-9 are expected to be typical for most of the wellfield areas.

3.1.3.2 Wellfields

The production areas have been divided into wellfields for scheduling development plans and for establishing baseline data, monitoring requirements, and restoration criteria. A wellfield will consist of a reserve block generally about 50 acres and will represent an area that is expected to be developed, produced and restored as a unit. Up to twenty such units will be required to develop the total project area. Four to six wellfields may be in production at any one time with additional units in various states of development and/or restoration. A wellfield will be dedicated to only one production zone and typically will have a flow rate in the 1000-4000 GPM range. Aquifer restoration of a wellfield will begin as soon as practical after mining in the unit is complete. If a mined out unit is adjacent to another unit being mined, restoration of a portion of the unit may be deferred to minimize interference with the mining operation. The wellfields as currently projected are shown in Figure 3-10, however the size and location of the wellfields will be modified as needed based on final delineations of the ore deposit, performance of the area and development requirements.

The projected mining schedule for each of the wellfields along with the anticipated groundwater restoration schedule is provided in Table 3-1. The schedule generally provides for one and one-half years for development of a wellfield, three years for uranium production, and three years for aquifer restoration. The three years provided for aquifer restoration include approximately one year for all or a portion of the wellfield to serve as a buffer area, one year for active restoration, and one year for stability monitoring following restoration. The status of the wellfields in the projected schedule are shown at two year and five year increments in Table 3-1. Figures 3-11 through 3-17 have been replaced with a single figure, Figure 3-11 which depicts the wellfield designations as currently projected for the life of the facility. Please note that the table and figure are generalized; i.e. if an area designated as undergoing restoration is directly adjacent to an area undergoing mining, all or a portion of the restoration unit could be serving as a buffer zone, or in stability monitoring.

During the development and construction of new mining areas, RAMC will protect and report any previously unknown archaeological sites encountered. Additionally, no surface disturbing activities shall take place within 100 feet of the boundaries of archaeological sites 48CO165, 1281, 1282, 1288, 1289, 1291, 1294, 1296 and 352 until the adverse affects of such disturbance has been mitigated under a plan approved by the State Historic Preservation Office, WDEQ/LQD and the BLM .

The development schedule provided in Table 3-1, and Figure 3-11, will be affected by various factors. These factors typically involve adjustments as necessary to meet production schedules and contractual agreements, longer (or shorter) than predicted mining or restoration times or delays in wellfield installations. To account for such changes, RAMC will include in the annual report to the WDEQ and NRC a map of the permit area showing the wellfields being developed, in production, in restoration, and areas where restoration has been completed. New areas where production or restoration is expected to begin in the subsequent year will also be identified in the annual report. With the production facility operating at a flow rate of 6000 GPM, approximately 800 injection and 400 production wells will be in operation. An updated schedule will be supplied with the annual report if the mining or restoration schedule varies from Table 3-1.

3.1.3.3 <u>Well Completion</u>

Monitor, production, and injection wells will be drilled to the top of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The well will then be cased and cemented to isolate the completion interval from all other aquifers. The cement will be placed by pumping it down the casing and forcing it out the bottom of the casing and back up the casing-drill hole annulus.

The well casing will be fiberglass or PVC. A typical fiberglass casing will be Centron's 2.1 pound per foot well casing with a 0.175 inch wall thickness or similar casing. The Centron casing has a standard joint length of 30 feet and is rated for 950 pounds per square inch operating pressure. A typical PVC casing would be Schedule 40 or stronger PVC well casing which has a nominal 5 inch diameter, 0.258 inch minimum wall thickness and is rated for 220 pounds per square inch operating pressure. The PVC casing joints normally have a length of approximately 20 feet each.

Three casing centralizers, located approximately 30 feet, 90 feet and 150 feet above the casing shoe, are normally run on the casing to ensure it is centered in the drill hole and that an effective cement seal is provided.

The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each of the wells is the calculated volume required to fill the annulus and return cement to the surface and in most cases cement returns to the surface initially. In some cases, however, the drilling may result in a larger annulus volume than anticipated and cement may not return to the surface. In these cases the upper portion of the annulus will be cemented from the surface. In the majority of cases where the cement has failed to return to the surface, the cause has been either a washout near the surface or a casing integrity problem. In the case of a casing problem, the well will not pass an MIT. In all cases, wells are required to pass an MIT test before being approved for operations. This will ensure that there is sufficient integrity to allow the well to receive or recover lixiviant.

After the cement has set, the well is drilled out and completed open hole. The well is then air lifted for about 30 minutes to remove any remaining drilling mud and/or cuttings. A small submersible pump is frequently run in the well for final clean-up and sampling. If sand production or hole stability problems are expected, a slotted liner, Johnson wire wrapped screen or similar device may be installed across the completion interval to minimize the problem.

Typical well completions are illustrated in Figures 3-18 and 3-19. Data on well elevations, depths, and water levels for the wells drilled for baseline data and pump tests are included in Table 3-2. Similar data for the other operating and monitor wells will be submitted to NRC and DEQ in the next annual report following the completion of the wells.

3.1.4 Well Casing Integrity

After a well has been completed and before it is made operational a mechanical integrity test (MIT) of the well casing will be conducted. In the integrity test, the bottom of the casing adjacent to or below the confining layer above the injection zone is sealed with a plug, downhole packer, or other suitable device. The top of the casing is then sealed in a similar manner or with a threaded cap, and a pressure gage is installed to monitor the pressure inside the casing. The pressure in the sealed casing is then increased to a specified test pressure and will maintain 95% of this pressure for 10 minutes to pass the test. If any well casing failing the test cannot be repaired, the well shall be plugged and abandoned. During well field operations, injection pressure shall not exceed the integrity test pressure at the injection well heads.

If there are obvious leaks or the pressure drops by more than five percent during the ten minute period, the seals and fittings will be reset and/or checked and another test is conducted. If the pressure drops less than five percent the well casing is considered to have demonstrated acceptable mechanical integrity.

If a well casing does not meet the mechanical integrity criteria, the casing will be repaired and the well re-tested. If a repaired well passes the MIT, it will be employed in its intended service. If the well defect occurs at depth, the well may be plugged back and re-completed for use in a shallower zone provided it passes the MIT. If an acceptable test cannot be obtained after repairs, the well will be plugged. The mechanical integrity test of a well will be documented to include the well designation, date of the test, test duration, beginning and ending pressures, and the signature of the individual responsible for conducting the test. Results of the well casing integrity tests shall be maintained on site and will be available for inspection by NRC and DEQ. A list of wells receiving and MIT, the dates of those MITs, and the designation of whether those wells passed or failed will be reported as part of the quarterly report to the DEQ. Mechanical integrity tests will be repeated once every five years for all wells used for active production or restoration operations.

If an injection well is cased with PVC or fiberglass, a new well casing integrity test will be conducted after any well repair using a downhole drill bit or under reaming tool. Any well with evidence of suspected subsurface damage will require a new MIT prior to the well being returned to service.

Monitor wells will be drilled and constructed in the same manner as production and injection wells and all three types of wells must pass MIT.

If necessary, after discussion between DEQ and RAMC, trend wells may be installed. These wells will be constructed, tested and monitored in the same manner, at the same frequency and for the same UCL parameters as monitoring wells. No baseline data for these wells will be required. If elevated constituents are detected in these wells, mitigating action will be taken. However, trend wells cannot trigger an excursion. Additionally, observation wells may be installed upon agreement between DEQ and RAMC. These wells are constructed in the same manner as monitor wells, except no baseline data is collected, nor are they sampled as monitor wells. Observation wells will be monitored for peziometric fluid level only on the same frequency as monitoring wells. Observation wells are used for the observation of fluid level changes in that well only, and will not trigger an excursion.

3.2 Ion Exchange and Central Processing Plant

The ion exchange and central processing plant for the project will use commercially available ion exchange resin for uranium removal and conventional designs for the elution and precipitation processes. Based from pilot test data, uranium concentrations of 40 to 100 ppm U_3O_8, are expected to be typical of the produced leaching solution. The pilot plant has demonstrated that standard ion exchange resins function well under these conditions and these resins are readily available for use in the extraction process. The first ion exchange facility will be located at the central processing plant. Subsequent ion exchange facilities will be located remotely, as needed, to allow satellite ion exchange operations to occur near the wellfields. These satellite ion exchange facilities are constructed and operated in the same manner as the ion exchange facility located at the central processing plant, and consists of the uranium loading ion exchange circuit only at this time. Rather than using direct resin transfer for elution operations, resin is transferred by truck transport from the satellite IX facility to the central processing plant for elution.

The combined ion exchange and central processing facility is organized into three sequential units: the resin loading and elution circuit, the precipitation circuit, and product drying/packaging area. The yellowcake will be dried in a vacuum dryer and packaged in 55 gallon steel drums for storage and shipment. The vacuum dryer is designed to minimize the potential for airborne contamination. The dryer circuit includes bag filtration and water scrubbing of the effluent gases. It is described in Section 4.2.3.

An ion exchange plant can process up to 5000 gpm of leaching solution. All of the resin may be eluted in the central processing plant or an option will be to elute the satellite resin in the field and transfer the rich eluate to the recovery plant for precipitation, drying and packaging. The product drying/packaging area can process 7,000 pounds U_3O_8 per day (2.5 million pounds per year); however, normal operations are expected to be about 80% of design. The uranium will be removed from the leaching solution by solid resin ion exchange units similar in design to those used in the pilot programs. Sodium carbonate, sodium bicarbonate, oxidants, and carbon dioxide will be added to the barren solution as required using techniques developed and tested in the pilot programs.

In addition, a satellite or the central ion exchange facility may contain equipment and facilities capable of treating up to 2,000 gpm of groundwater from wellfields which are in restoration.

3.2.1 Resin Loading/Elution Circuit

ISL mining of uranium requires the circulation of a solution that will oxidize the uranium to a soluble state and form stable uranium complexes that can be easily recovered from the ore body. The commercial project will use a carbonate leach solution consisting of varying concentrations and combinations of sodium carbonate (Na_2CO_3), sodium bicarbonate ($NaHCO_3$), oxygen, hydrogen peroxide (H_2O_2), and carbon dioxide (CO_2) added to the native groundwater. The carbonate/bicarbonate leaching solution is used because of its selectivity for uranium and minor reaction with the gangue minerals. The pilot tests were conducted using sodium bicarbonate, carbon dioxide, hydrogen peroxide, and oxygen in the leaching solutions. When the leaching solution is injected into the ore zone, the dissolved oxidant reacts with the uranium mineral and brings the uranium to the U^{+6} oxidation state. See Figure 3-1.

The uranium then complexes with some of the carbonates in the leaching solution to form an uranyldicarbonate ion $(UO_2\ (CO_3\ )_2\ )^{-2}$ and/or an uranyltricarbonate ion $(UO_2\ (CO_3)_3\ )^{-4}$, both of which are soluble and stable species in solution. When the uranium is removed by leaching, a small portion of the radium content will also be mobilized. Depending on site conditions, contaminants such as arsenic, selenium, and/or vanadium, may also be oxidized and mobilized. Results from the ISL pilot operations in the project area have shown elevated selenium values but no evidence of other trace elements being mobilized during leaching.

The dissolution and complexing of uranium occur as the lixiviant flows through the ore body from the injection wells to the production wells. Leaching solutions will continue to be circulated through a given area of the production zone as long as uranium recovery from that area is economically attractive.

The uranium-bearing solution or pregnant leaching solution pumped from the wellfield is piped to the ion exchange plant for extraction of the uranium by use of ion exchange units. As the solution passes through the recovery vessels, the ion exchange resin in the units preferentially remove the uranyldicarbonate or uranyltricarbonate from the solution. The barren solutions leaving the ion exchange units normally contain less than 5 ppm of uranium. After the resin in a vessel is essentially loaded and removing very little additional uranium, the vessel will be isolated from the normal process flow and the resin will be either eluted in-place or transferred to a special elution tank. For satellite IX facilities, this transfer will be performed by moving the loaded resin from the satellite to the central processing plant using truck transport. In the elution process the resin is contacted with a strong chloride (salt) solution which regenerates the resin in a process very similar to regenerating a conventional home water softener. The eluted resin is then placed back in service for additional uranium recovery. For satellite facilities, the eluted resin will be transferred from the central processing plant to the IX facility using truck transport.

After the barren solution leaves the ion exchange vessels, carbon dioxide and/or carbonate/bicarbonate will be added as necessary to return the carbonate/bicarbonate concentration to the desired operating level. The solution is then pumped back to the wellfield, with the oxidant (O_2 gas and/or H_2O_2) added either as it leaves plant site or just before is reinjected into the ore zone. Carbon dioxide will be added to the system as needed to control the pH and minimize calcium carbonate scale.

The piping and metering system for production and injection of the leaching solution will consist of buried trunk lines between the recovery plant and the operating wellfield areas with metering and distribution headers in the wellfield buildings. The individual well flows and pressures will be adjusted and controlled from the header buildings.

3.2.2 Precipitation Circuit

In the elution circuit, the uranyldicarbonate and uranyltricarbonate ions are removed from the loaded resin by a relatively small volume of strong chloride solution providing a solution (rich eluate) from which the uranium can be precipitated.

The rich eluate containing the uranium will be routed to a tank for temporary storage prior to entering a batch or small continuous precipitation circuit. To initiate the precipitation cycle hydrochloric or sulfuric acid will be added to the uranium bearing solution to breakdown the uranyl carbonate present in the solution. Hydrogen peroxide or ammonia will then be added to the eluate to effect precipitation of the uranium as uranyl peroxide or ammonium diuranate. The addition of hydrogen peroxide drives the pH of the solution down, and to optimize crystal growth and settling, a base, (e.g. sodium hydroxide or ammonia), will be added as a pH adjustment. The uranium precipitate will be allowed to settle and the uranium depleted supernate solution will be removed and stored for re-use in future elutions or disposed. Sodium chloride and sodium bicarbonate will be added to the lean eluate as needed for reconstitution.

Deep injection wells and/or lined evaporation ponds will be used to collect and dispose process wastewaters such as the excess eluant. The evaporation ponds may have multiple cells and each cell will be lined with a hypalon or similar membrane liner. A system of perforated pipes will be installed in a sand bed under the pond liner and will be monitored to ensure that if a leak were to occur, it would be quickly detected.

The precipitation cycle procedures and methods to be employed for this project have been used extensively in ISL programs and in conventional uranium milling operations.

3.2.3 Product Filtering, Drying and Packaging

After precipitation, the settled yellowcake is withdrawn for washing, filtering, drying and product packaging in a controlled area. The yellowcake (precipitated uranium) from the elution/precipitation circuit is washed to remove excess chlorides and other soluble contaminants and then de-watered to a thickened slurry. This slurry may be routed to holding tanks in the precipitation area prior to filtering and drying. The dried yellowcake will be packaged in 55 gallon steel drums for storage and shipping.

The yellowcake will be dried in a vacuum dryer and the off-gases during drying will be filtered and scrubbed to remove entrained particulates. The water sealed vacuum system will also provide ventilation while the dryer is being loaded and unloaded into drums. This type of dryer is expected to minimize air borne effluents. The drying system is described in more detail in Section 4.2.

Onsite inventory of U_3O_8 will typically be less than 200,000 lbs; however, in periods of inclement weather or other interruptions in product shipments all production will be stored on-site in designated storage areas.

The dried yellowcake product will be stored and shipped by exclusive use transport to another licensed facility for further processing. All yellowcake shipments will be made in compliance with applicable regulations.

The recovery plant used in the pilot programs will be retained in an operating condition as long as needed for use in conducting special tests to evaluate various leaching solution concentrations and optimizing procedures for processes such as resin loading and stripping. A flow diagram showing the major process components of the uranium recovery plant is included as Figure 3-2.

3.2.4 Major Process Equipment

Principal equipment used in the process consists of surge tanks (optional), ion exchange vessels, elution/precipitation tanks, vacuum drying system, and the piping, pumps and valves required to control and move the solutions among the various process components. The process equipment will be designed in modular units and the modules will be installed as needed to meet the required flow rates and production levels. The continuous flow portion of the circuit (the ion exchange circuit) will have instrumentation designed to monitor key fluid levels, flow rates and pressures. The elution precipitation portion of the recovery plant circuit will be designed based on a scale up of our experience with resin loading in the pilot operation.

The process plant is divided into functional areas to provide more efficient operations control as well as to maintain control in the event of an accident or major equipment failure. These functional areas within the plant area are: A) the ion exchange area where the uranium bearing solution from the wellfield is stripped of the uranium, B) the elution make-up and precipitation area where the stripped uranium is processed into a slurry, and C) the yellowcake filtering, drying and packaging area. During restoration, the additional ion exchange capacity and the restoration equipment will be added in the ion exchange area. Initially, yellowcake and chemicals may be stored in the process building, however, as operations increase to design levels, outside areas may be designated for yellowcake and chemical storage.

3.3 Instrumentation

Process plant monitoring and alarm instrumentation will be installed to provide centralized monitoring of key process components. Operator control of key elements will be maintained with a series of remotely controlled valves and power switches. When operating parameters move outside a specified normal operating range it will cause an alarm which will notify the operator to initiate corrective action to alleviate the problem. Excessively high or low levels or pressure alarms will initiate automatic shutdown of the related equipment. The system will be designed and installed to minimize the risk of uncontrolled releases of leaching solutions or other solutions and provide maximum safety and protection to the process plant operators and maintenance personnel.

Radiation detection instruments used to monitor the operation and the specifications on this equipment are included in the Health Physics

Manual. The location of monitoring points and monitoring frequency for in-plant radiation safety are discussed in Chapter 5.

TABLE 3-1

PROJECTED DEVELOPMENT SCHEDULE BY WELLFIELD

Wellfield Unit	Wellfield Acres
1	28
2	30
3	48
4	33
5	31
6	32
7	28
8	45
9	32
10	17
11	20
12	32
13	14
14	10
Total	400

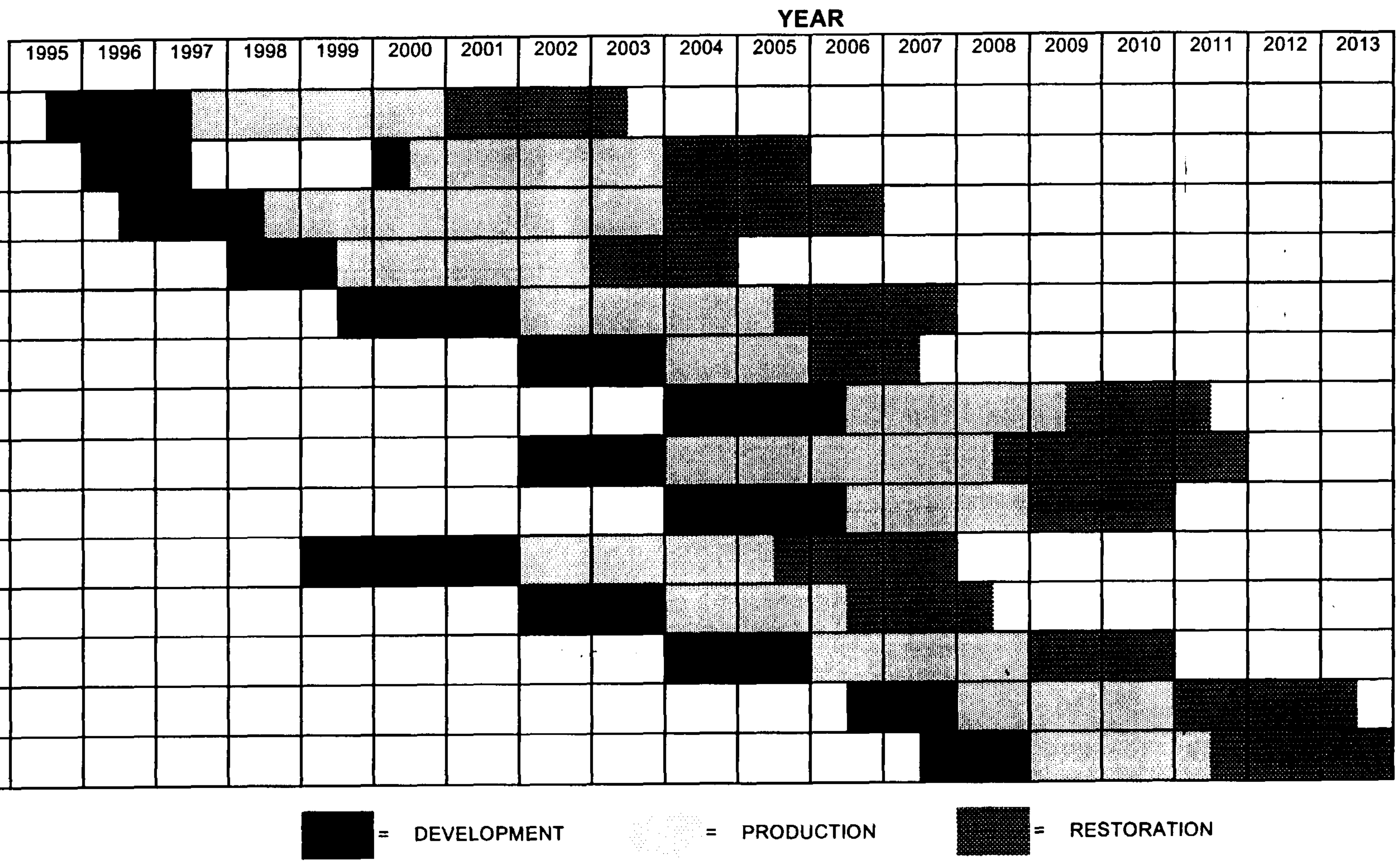

FIGURE 3-2
FLOW PROCESS SCHEMATIC

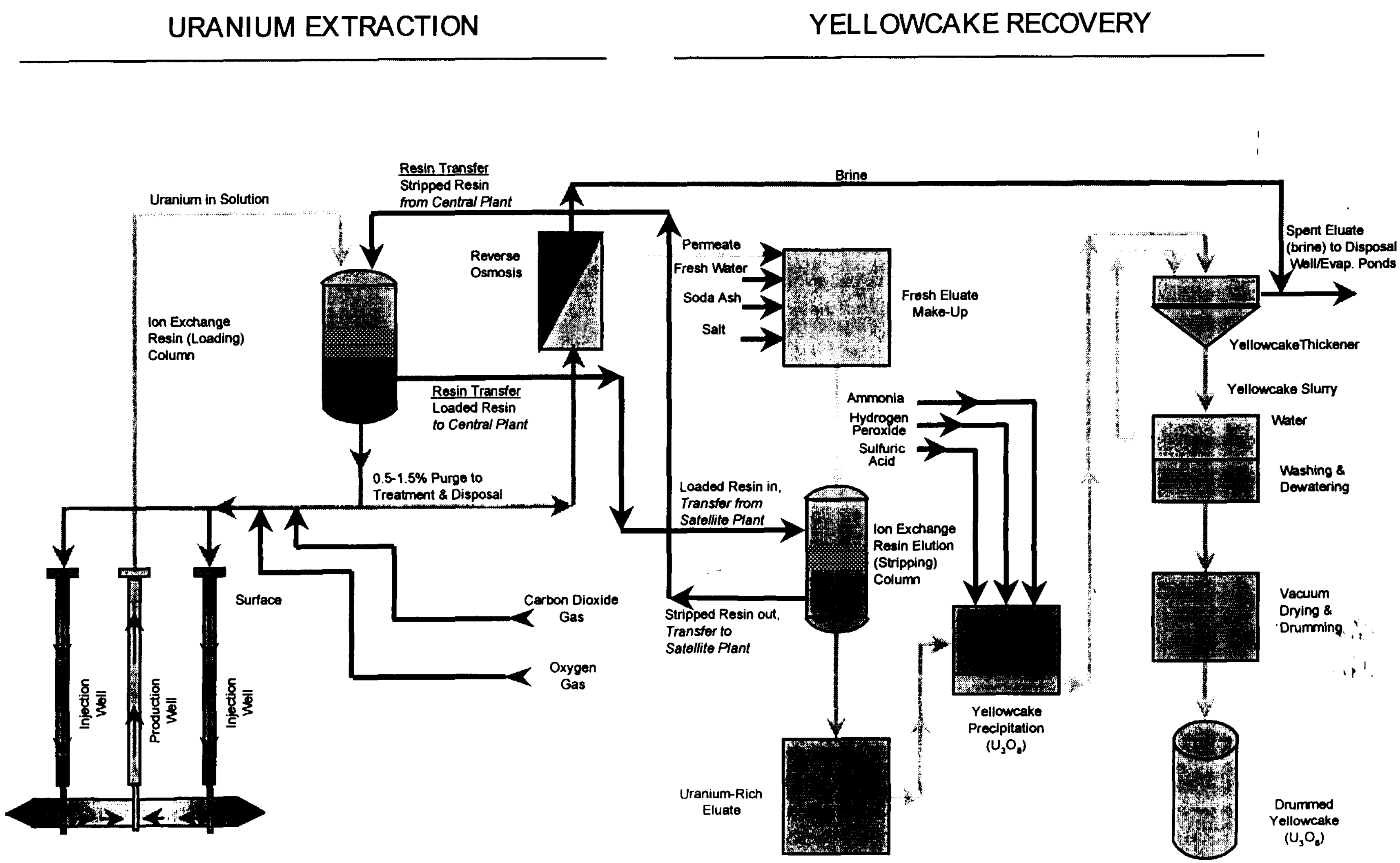

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FIGURE 3-18

TYPICAL WELL COMPLETIONS

(For Thinner Production Zones)

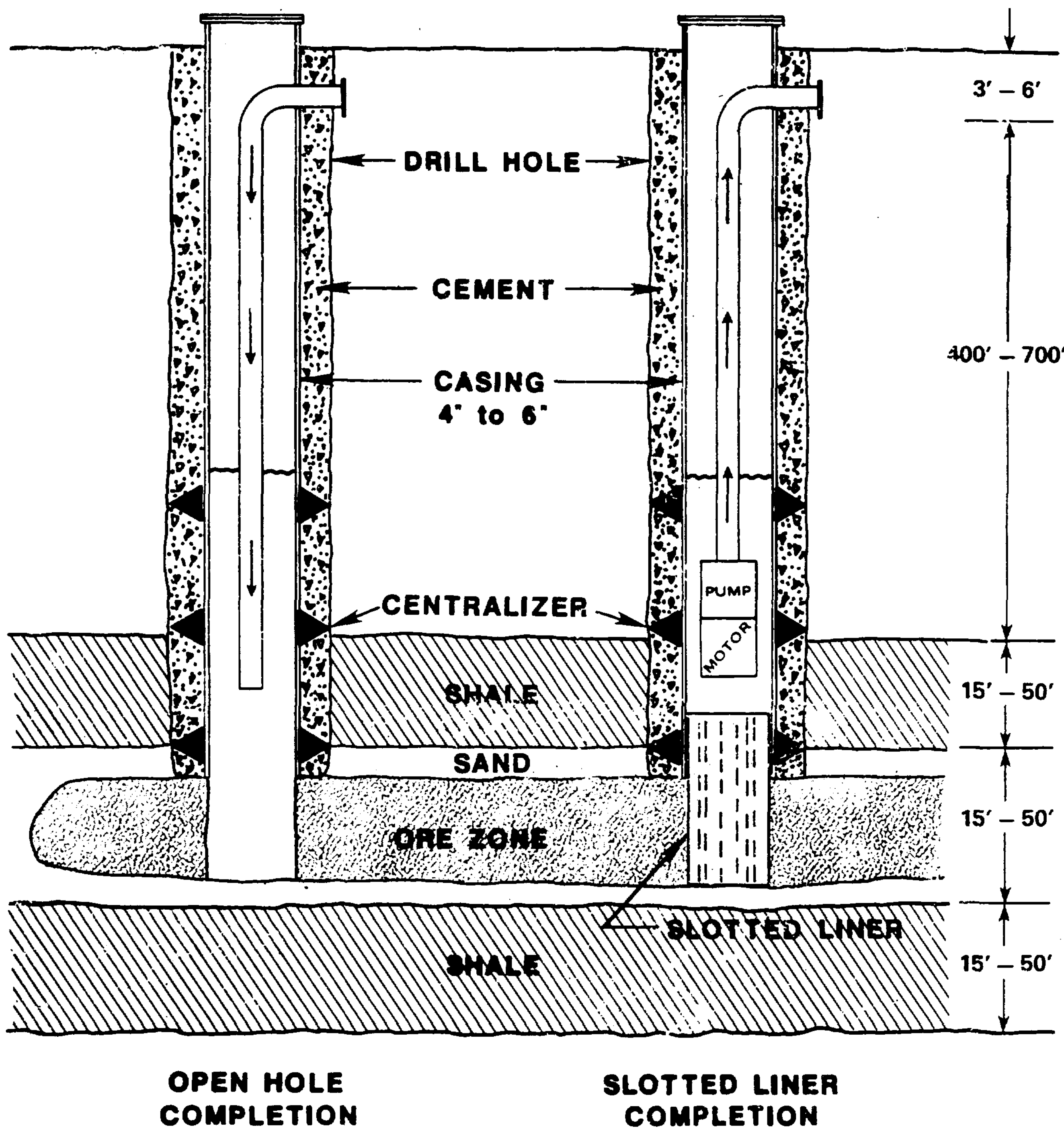
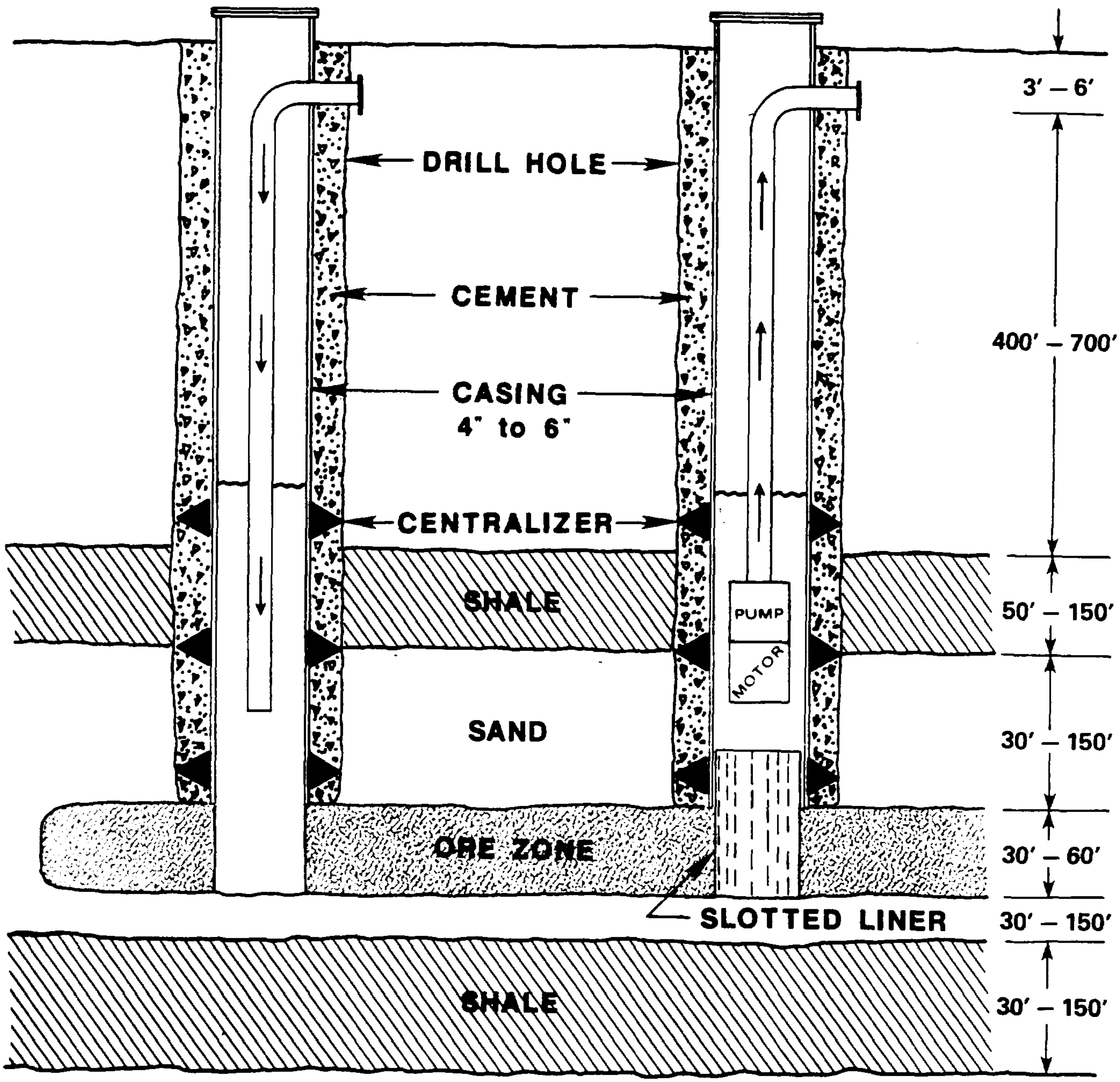


FIGURE 3-19

TYPICAL WELL COMPLETIONS

(For Thicker Production Zones)



OPEN HOLE COMPLETION

SLOTTED LINER COMPLETION

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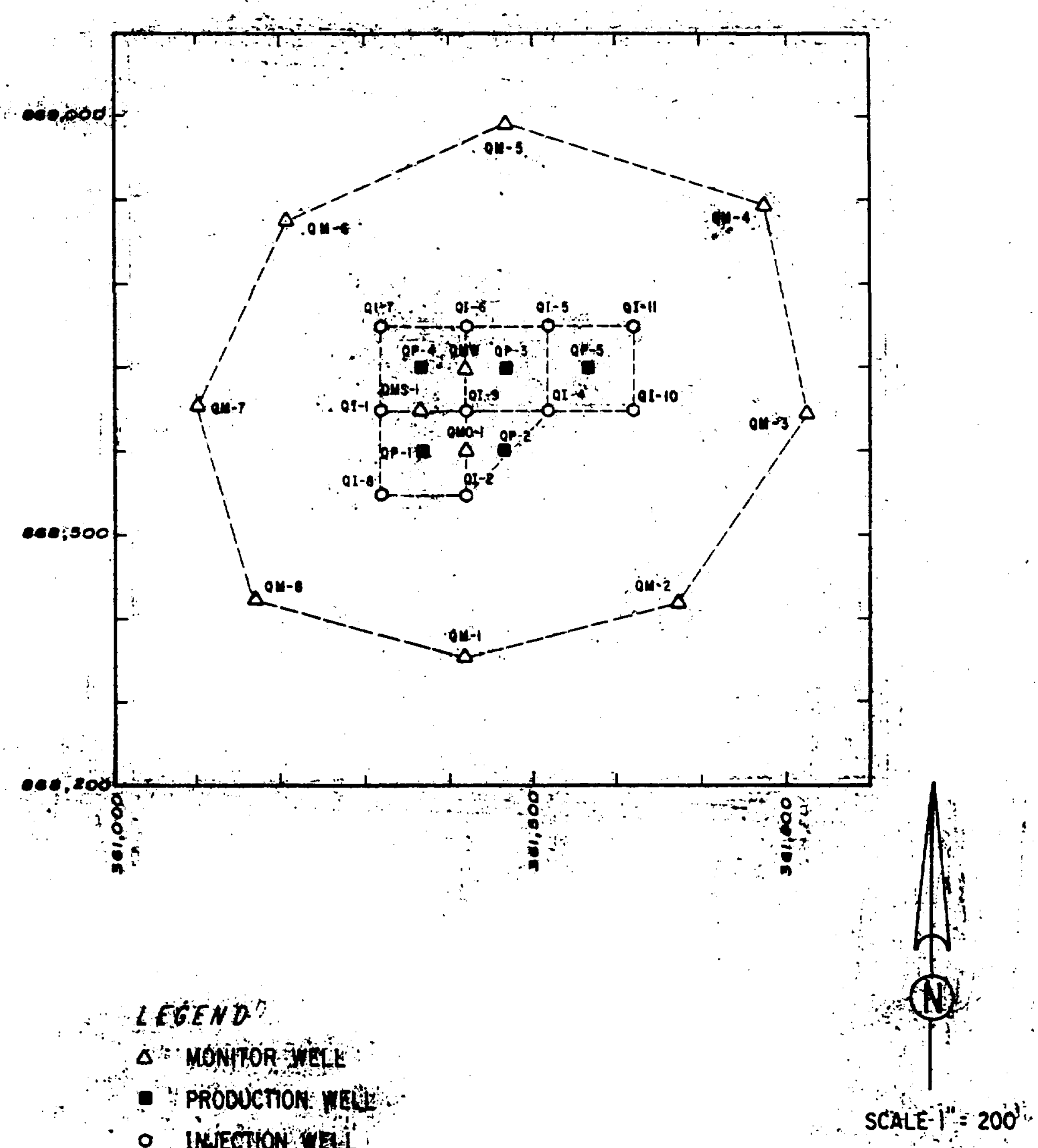
FIGURE 3-21

IN SITU R&D PROJECT WELL PATTERN
"Q" SAND DEPOSIT
SECTION 36-T36N, R74W
CONVERSE COUNTY, WYOMING

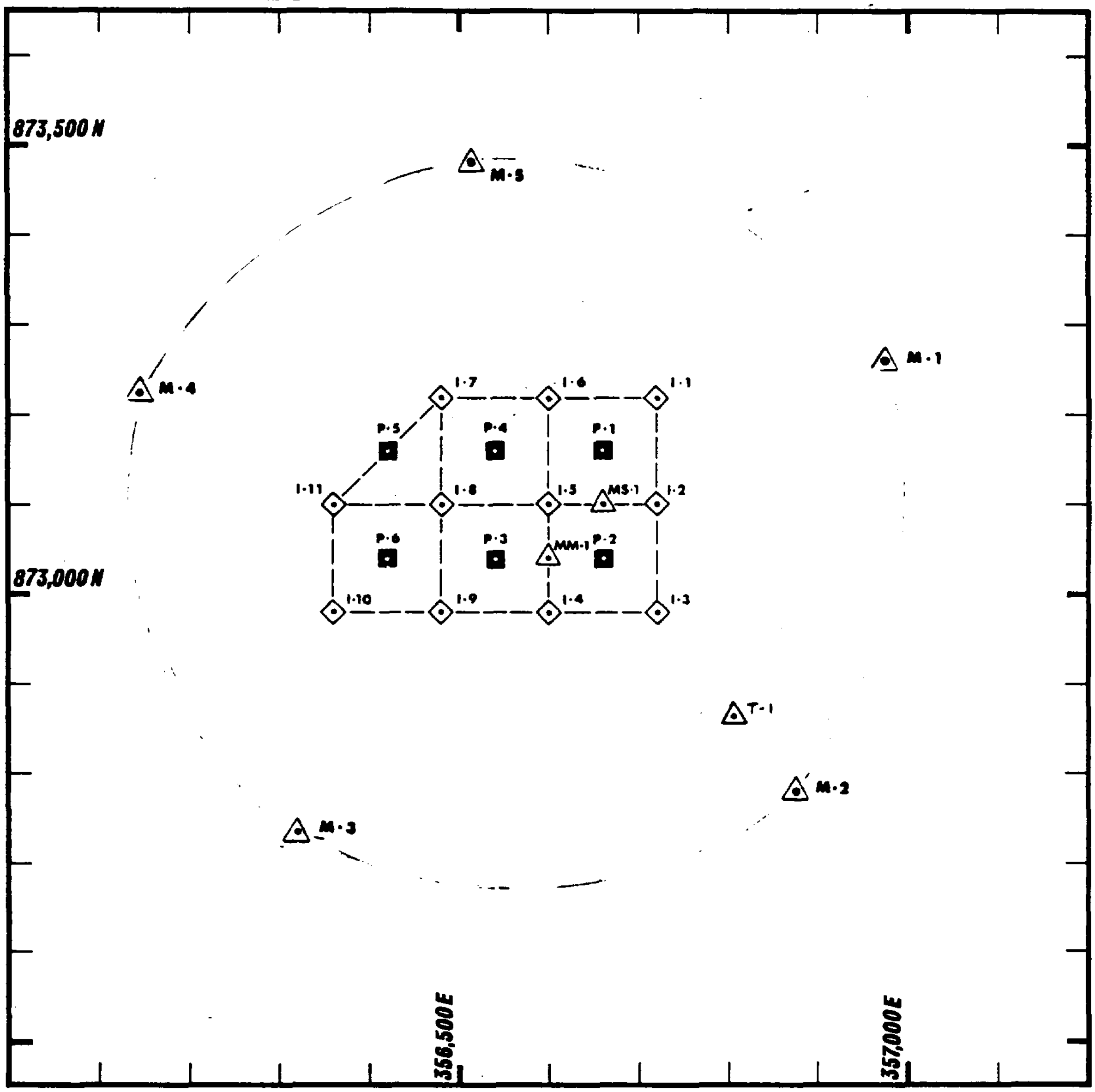


FEB. 1980
REV. JULY 1980

FIGURE 3-22

"O" SAND WELL PATTERN

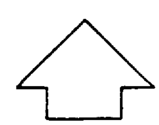
Section 26, T-36N; R-74W



Legend

- Monitor Well
- Production Well
- Injection Well
- MS-1 Upper Zone Monitor Well
- MM-1 Lower Zone Monitor Well

120 ft. Spacing Between Injection Wells



CHAPTER 4

EFFLUENT CONTROL SYSTEM

4.1 Dust

The general equipment arrangement in the process plant is designed to facilitate easy access, good air flow and separation of process function. As designed, no significant dust will be generated inside the process plant as limited dry product will be handled inside the buildings. The pilot operations have demonstrated that routine washdown procedures will keep the working areas clean of accumulating dust from operations or outside sources.

Yellowcake drying will have its own ventilation system, which is described in detail in section 4.2.3 of this chapter.

4.2 Gaseous Effluent

The principal radiological gas representing a potential radiological dose to man is radon-222 gas released to the atmosphere from the circulating leach solution and/or in the elution and precipitation circuit. Some carbon-dioxide gas and some acid fumes will evolve also from the elution/precipitation circuit, but these gases do not present a health problem at the anticipated concentrations. In order to alleviate potential discomfort or health problems due to the in-plant accumulation of gases and fumes, three ventilation systems will be installed. A ventilation system will be connected to all process vessels where significant radon-222 or process fumes could reasonably be expected to be released. For the general work areas in the recovery plant building, a forced air ventilation system will be installed for use when the buildings are normally closed due to weather or other factors.

A third ventilation system will be installed as a part of the yellowcake drying operation. See section 4.2.3 for a description of yellowcake drying process equipment.

4.2.1 Tank and Process Vessel Ventilation Systems

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks to exhaust fumes to the outside atmosphere. Air flow through any openings in the vessel will be from the process area into the vessel and into the ventilation system controlling any releases that occur inside the vessel. Where needed exhaust fans will pull the air from the top of the tanks and discharge the air with any gases and fumes to a vent placed on the outside of the building near the roof level. Separate ventilation systems will be used as needed for the functional areas within the recovery plant.

A tank ventilation system of this type was utilized in the pilot process plant and in-plant monitoring for radon concentrations has proven it to be an effective system for minimizing employee exposure as shown by data taken from the ALARA reports, Table 4-1.

4.2.2 Work Area Ventilation System

The work area ventilation system is designed to force air to circulate within the separate recovery plant process areas. The systems for the ion exchange area and for the precipitation area will include a minimum of two exhaust fans each. A third system will be provided for yellowcake drying and packaging area. The ventilation system exhausts will generally be located on the north or leeward side of the buildings. During favorable weather open doorways and the convection vents in the roof have provided satisfactory work area ventilation. Total radon-222 emissions from the pilot plant were minimal as demonstrated by a comparison of data from the upwind and downwind radon detectors for the plant, Table 4-2. The downwind detector is approximately 250 feet downwind from the ventilation system exhaust.

The maximum calculated annual radon release for the commercial ISL operations based on NRC procedures used in NUREG-0925 Appendix C assuming all produced fluids are in equilibrium. Using these basis, radon is released at the maximum rate of 6738 Ci/year during the period of maximum production and restoration flows of 11,000 gpm and 3,000 gpm respectively,(Table 4-3).

Other emissions to the air will be limited to exhaust and dust from limited vehicular traffic and small amounts of process chemicals such as ammonia, carbon dioxide, oxygen, hydrogen peroxide, sodium hydroxide, sulfuric acid and hydrochloric acid. There will be no significant combustion related emissions from the process facility as commercial electrical power is available at the site. Particulate emissions will also be minimal as the yellowcake will be dried in a proven vacuum drying system. This system is described in the following section.

4.2.3 Yellowcake Drying

The wet yellowcake from the precipitation circuit will be vacuum dried and packaged in fifty-five (55) gallon drums for shipment. The vacuum drying system is proven technology, which is being used successfully in several ISL sites where uranium oxide is being produced.

The vacuum drying system consists of the following:

1) Drying Chamber: A S.S. vessel is heated externally and is fitted with a mechanical agitator to stir the yellowcake.

The chamber has a top port for loading the wet cake and a bottom port unloading the dry powder. Additional ports are provided for venting of vapors during the drying procedure.

2) Bag House: This air and vapor filtration unit is mounted directly above the drying chamber so that any dry solids collected on the bag filter surfaces can be batch discharged back to the drying chamber. The bag house is heated to prevent condensation of water vapor during the drying cycle. It is kept under negative pressure by the vacuum system.

3) Condenser: This unit is located downstream of the bag house and is water cooled. It is used to remove the water vapor from the non-condensable gases coming from the drying chamber. The gases are moved through the condenser by the vacuum system. Dust passing through the bag filters is

wetted and entrained in the condensing moisture within this unit.

4) Vacuum Producer: The vacuum producer is a water sealed unit that provides a negative pressure on the entire system during the drying cycle. It is also used to provide ventilation during transfer of the dry powder from the drying chamber to fifty-five (55) gallon drums. The water seals captures entrained particulate matter remaining in the gas streams.

5) Packaging: The system is operated on a batch basis. When the yellowcake is dried sufficiently, it is discharged from the drying chamber through a bottom port into drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. As noted in 4) above, ventilation is provided by the vacuum pump when the powder is being transferred.

6) Heating: The heat for drying may be direct resistance heaters, steam or indirect heat by use of a heat transfer medium such as Dow-Therm or other suitable heat transfer materials. The drying is accomplished under 212° F and at pressures less than atmospheric.

7) Effluent Monitoring: Because of the low, intermittent air flow exiting the vacuum pump, isokinetic sampling of the effluent is not possible. The air flow from the vacuum pump associated with the yellowcake dryer will not exit the building. The water that is collected from the condenser will be recycled to the precipitation circuit or filtered and discharged with other process water. Room air will be

monitored routinely for airborne dust and radionuclides in accordance with Table 5-3.

8) Controls: The system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures.

4.3 Liquid Effluents

Liquid effluents from the operation include the production bleed stream, excess fluids from the elution and precipitation process, regeneration of the water softener system (calcium control), yellowcake rinse water, plant washdown water, restoration equipment (EDR/RO) waste, restoration bleed, analytical laboratory waste, and facility sanitary waste.

The net production bleed stream is expected to be about one half to one and one half percent of the production. The bleed will be taken after the ion exchange units have removed the uranium. The bleed stream and washdown water from satellite IX facilities is transferred to the central processing facility through a pipeline connecting the two facilities. If the water quality is acceptable, the water may then be routed through a separate radium removal and solids settling system prior to evaporation and/or land application (surface irrigation). Alternatively as shown in Figure 4.1 the water may be routed to a reverse osmosis unit. The resulting RO brine may be commingled with other plant water for disposal in a deep disposal injection well. The RO permeate effluent may be used as process water for chemical makeup or returned to the leaching circuit. WDEQ will be contacted to obtain the appropriate permits prior to use of land application.

Excess liquids from the elution and precipitation circuit and water softener regeneration are expected to average about 60 gallons per minute and will be routed to lined evaporation ponds or to a disposal injection well. Less than 2 gallons per minute of water will result from plant wash water. This water will be commingled with other plant waste water or may be used as process make-up water if it is of satisfactory quality.

During restoration two additional liquid waste streams are expected, Figure 4.2. The operation of electrodialysis (EDR) or reverse osmosis (RO) units will generate a stream in which most of the dissolved solids in the total EDR/RO stream are concentrated in 15% to 30% of the water volume. When operating full capacity this concentrated stream may be about 250 gallons per minute. This stream will be routed to a lined evaporation pond or to a disposal injection well. When water quality from restoration areas improve to the point that after uranium and radium removal it is suitable for discharge under the current NPDES permit it will be routed from the separate radium removal settling system to a water treatment system. When the recovery plant is operating at normal capacity it is expected that this stream could be more than 1000 gallons per minute. The use of excess water produced during restoration for irrigation of grassland as authorized by NRC and DEQ at Power Resources Inc. Highland Project, also in Converse County, will be evaluated. A projected water balance for the project operating at 6000 gpm with a one to one and one half percent production bleed is shown in Figure 4-2. Figure 4-3, Recovery Plant Flow Rates, provides additional detail on the individual streams of the water going to the deep disposal well. The production bleed stream water quality is expected to be similar to the bleed stream for the pilot plant operation. Assays of the pilot bleed stream are included in Table 4-4 and 4-5. A copy of the existing

NPDES permit for the Rio Algom Mining Corp. facility is included in Appendix F.

The lined evaporation ponds are expected to consist of several cells of five (5) to fifteen (15) acres each. Some waste streams may be routed to selected cells for additional treatment and/or processing. If treatment or processing can improve the water quality such that it meets Wyoming DEQ criteria for NPDES discharge or for irrigation and NRC radionuclide criteria for release to unrestricted areas, the water may be discharged through the water treatment plant or used for irrigation. Any such discharge or use of water from a lined evaporation pond will be metered and solutions in each pond will be sampled semi-annually and analyzed for bicarbonate, chloride, sodium, sulfate, uranium, arsenic, selenium and pH.

The composition of the water in the evaporation pond cells used to evaporate water with high total dissolved solids is expected to be similar to the quality of water in the evaporation ponds in the pilot program, Table 4-6 and 4-7. Sanitary wastes from the office building and change facilities will be disposed in approved septic tank drain field systems.

4.4 Solid Effluents

Based on the pilot operation, solid wastes generated by this project will consist of materials such as rags, trash, packing material, worn or replaced parts from equipment and piping, sediments removed from process pumps and vessels, and the solids remaining in the evaporation pond after the liquids have evaporated. The non-radioactive wastes, such as packing material, will be disposed in the site's existing solid waste disposal facility as authorized by the Wyoming DEQ. The on-site construction waste landfill site was originally permitted by Wyoming DEQ in 1978 and continues to operate disposing of construction and demolition materials. Public access to the disposal site is prohibited by the facility's fencing as only those materials generated by the facility or in association with its operation are allowed to be disposed at the site. No hazardous, sanitary, or contaminated wastes will be disposed onsite in the landfill. The landfill is not constructed into a source for groundwater.

The disposal facility is located directly behind the facility's Central Processing Plant near the top of a sandstone ridge to prevent run-on from snowmelt and precipitation. Prior to its original use, topsoil from the site was removed and stockpiled for future use. The disposal site(s) consist of a constructed trench approximately 10-14 feet deep surrounded on either side by litter control fencing. Materials placed within the site are periodically buried in placed with sand material originally excavated from the disposal pit or when construction materials primarily include such items as waste lumber, pallets, or cable spools maybe managed by a controlled burned through county burn permits. Any fugitive materials not managed by the litter fences are periodically collected and placed into the disposal site to assure the litter is appropriately controlled.

Radioactive solid waste that has a contamination level requiring controlled disposal will be isolated in drums or other suitable containers and will be disposed in a NRC licensed tailings facility or as otherwise approved by the NRC and Wyoming DEQ. Contaminated solid wastes from the pilot plant operation, excluding material removed during construction for the second pilot and evaporation pond solids were about six drums of material per year.

4.5 Solar Evaporation Pond

The solar evaporation ponds for the Smith Ranch Project will consist of a number of five to fifteen acre cells typically ten to twenty feet deep for holding process waste waters containing high total dissolved solids. A minimum of two cells will be constructed initially and the remaining cells will be constructed on an as-needed basis. The proposed evaporation ponds are expected to be located as shown on the attached Figure E-1, Appendix E. The initial cell will be approximately 550 ft x 1000 ft. (12.5 acres). The design plan and method of construction for the individual cells will be similar to that used for the pilot plant lined evaporation ponds. After all topsoil is removed from the area to be disturbed and stockpiled, the embankments will be constructed using the local clays and sandy clays. A preliminary subsurface study of potential evaporation pond sites was conducted by Chen & Associates of Casper, Wyoming. Eleven subsurface test holes drilled in the permit area encountered as much as 45 feet of clay and sandy clay material that would be suitable for use in constructing the pond embankment. A map of the area near the recovery plant, Figure 4-4, shows the general location of the subsoil test holes. Figures 4-5 through 4-17 and Table 4-8 through 4-10 provide additional information on the subsoil characteristics. No water was encountered in any of the test holes, which were typically 25 to 50 feet deep. The conclusions from Chen & Associates preliminary study are included in Table 4-11. The only test hole in the proposed area, hole SA23-1, indicates about one foot of clay material over a sandstone bedrock. Other tests in the general area, however, indicate the clay area will vary up to six feet in thickness. Material unsuitable for use in construction of soil liners will be identified, segregated and not employed for the construction of such liners.

The cells will be constructed from a combination of cuts and compacted subsoil embankments. Embankment slopes will be on the order of 3 horizontal to 1 vertical and the cells will have an eight foot wide or greater crest on all embankments. The material in the bottom of the cell and interior sides of embankments will be compacted to 90 to 95% of maximum standard Proctor density. A leak detection system consisting of perforated pipes placed in a sand layer and designed to drain to a common sump will be installed in each cell. The cell will then be lined with an impervious membrane material such as hypalon or high density polyethylene.

Sand for the leak detection system will probably be obtained from a sand borrow area located on a sandstone ridge outcrop approximately 1,000 feet from the existing Bill Smith mine buildings. This borrow area, identified on Map E-1 of Appendix E, has been used to obtain small quantities of sand for past mining activities. The use of this area will depend upon the quality of the available sand, and whether or not it will meet the geotechnical specifications necessary for the pond leak detection systems. It is expected that, if the sand is acceptable, the borrow area may be expanded to 10 acres or less to obtain the quantity of sand necessary for completion of the leak detection systems for all evaporation ponds planned (approximately 70 acres). Accordingly, Form UIC-1 has been revised to include the possibility of mining 10 acres of sand in addition to the primary mined mineral, uranium.

The final design and location of each cell will depend on site soils sampling and testing, however a typical design is provided in Figure 4-18. The embankments will be designed to divert natural run-off away from the pond and the ponds will be located away from significant surface drainage systems. The ponds will be fenced individually to exclude livestock and wildlife such as antelope. The fences around the evaporation ponds will be posted with warning signs for personnel protection. A Permit to Construct will be obtained from the Wyoming DEQ prior to beginning construction. The evaporation pond monitoring and sampling programs are discussed in Chapter 5.

TABLE 4-1

EMPLOYEE INTERNAL EXPOSURE SUMMARY
ALARA REVIEW REPORT
LICENSE SUA-1387

ALARA Report	Time-Weighted Exposure To Airborne Uranium - MPC Hours(1)				Exposure To(2) Radon Daughters WLM/Report Period	
	Operators Job		Maintenance Job			
	Monthly Avg.	Highest	Monthly Avg.	Highest	Avg.	Max.
1	16	24	2	6	(.08/mo)	
2	1.8	2.9	0.2	0.5	0.05	0.5
3	2.7	4.1	0.3	1.3	0.02	0.5
4	0.9	3.8	0.0	0.0	0.1	0.2
5	0.8	1.8	0.0	0.0	0.01	0.1
6	0.5	3.1	0.0	0.1	0.03	0.1
7	0.7	2.5	0.1	0.1	0.0	0.0
8	1.1	5.4	0.0	0.0	0.05	0.1
9	1.2	8.9	0.1	2.4	-	0.1
10	1.2	5.6	0.1	0.1	-	-
11	5.5	12.0	1.7	7.2	-	0.1

(1) Maximum allowable exposure is 520 MPC-hrs. per quarter or about 1,140 MPC-hrs. per ALARA report period.

(2) Maximum allowable exposure is 4 WLM per year or about 2 WLM per ALARA report period.

TABLE 4-2

BOUNDARY RADON-222 & GAMMA SURVEY DATA
Q-SAND AND O-SAND PILOT PLANT
CONVERSE COUNTY, WYOMING

	Average Radon-222 pCi/l (in Air)		Direct Gamma uR/Hr.	
	Upwind Location	Downwind Location	Upwind Location	Downwind Location
Baseline	1.1	1.3	-	-
1st Qtr. 1982	0.4	0.7	6	6
2nd Qtr. 1982	0.6	0.3	20	30
3rd Qtr. 1982	0.5	0.8	20	26
4th Qtr. 1982	1.5	2.1	20	25
1st Qtr. 1983	0.8	0.8	20	22
2nd Qtr. 1983	1.0	0.7	20	22
3rd Qtr. 1983	0.2	0.3	21	23
4th Qtr. 1983	0.2	0.2	21	25
1st Qtr. 1984	0.3	0.2	20	26
2nd Qtr. 1984	0.4	0.8	20	24
3rd Qtr. 1984	0.4	0.9	20	24
4th Qtr. 1984	0.5	0.6	16	19
1st Qtr. 1985	0.8	0.7	16	11
2nd Qtr. 1985	0.9	1.0	14	12
3rd Qtr. 1985	(1)	(1)	14	12
4th Qtr. 1985	(2)	0.7	11	14
1st Qtr. 1986	-	0.7	12	25
2nd Qtr. 1986	-	1.0	12	16
3rd Qtr. 1986	-	1.2	14	16
4th Qtr. 1986	-	0.5	20	20
1st Qtr. 1987	-	0.3	11	14
2nd Qtr. 1987	-	1.2	11	14

(1) Contractor terminated service; license amendment terminating requirement requested.

(2) Deleted per License Amendment No. 14

Table 4-3(a)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Wellfield 1. - Production

Operating Days = 360
Area = 1.05E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.05E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 8.5E7\ L$$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

$$(18903\ gal)(0.37)(3.785\ L/gal)\ (1/d) = 2.65E4\ L/d$$

Total Wastewater Purge Rate = 1.3% = 28.6 gpm

$$(28.6\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 1.56E5\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.05E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(8.5E7\ L) + (2.65E4\ L/d) + (1.56E5\ L/d)]}$$

$$= 6.16E5\ pCi/L$$

$$Rn_W = (3.65E\text{-}10\ Ci/pCi,d/yr)(6.16E5\ pCi/L)(1.56E5\ L/d) = 35\ Ci/yr$$

$$Rn_V = (3.65E10\ Ci/pCi,d/yr)(6.16E5\ pCi/L)(8.5E7\ L)(0.01/d) = 189\ Ci/yr$$

$$Rn_{IX} = (3.6E\text{-}10\ Ci/pCi,d/yr)(6.16E5\ pCi/L)(2.65E4\ L/d)(2200\ gpm/3000gpm) = 4.3\ Ci/yr$$

Table 4-3 (b)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 2. - Production

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.9E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.54E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 52 gpm

(52 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.83E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.9E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.54E8 L) + (2.65E4 L/d) + (2.83E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.83E5 L/d) = 63 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.54E8 L)(0.01/d) = 342 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(4000 gpm/3000gpm) = 7.8 Ci/yr

Table 4-3 (c)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 3. - Production

Operating Days = 360
Area = 1.71E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.71E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.39E8\ L$$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 46.8 gpm

(46.8 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.55E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.71E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.39E8\ L) + (2.65E4\ L/d) + (2.55E5\ L/d)]}$$

$$= 6.16E5\ pCi/L$$

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.55E5 L/d) = 57 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.39E8 L)(0.01/d) = 308 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3600 gpm/3000gpm) = 7.1 Ci/yr

Table 4-3 (d)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 4. - Production

Operating Days = 360
Area = 1.14E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.14E5 m2)(3 m)(0.27)(1E3 L/m3) = 9.23E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 31.2 gpm

(31.2 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.70E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.14E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(9.23E7 L) + (2.65E4 L/d) + (1.70E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.70E5 L/d) = 38 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(9.23E7 L)(0.01/d) = 205 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2400 gpm/3000gpm) = 4.7 Ci/yr

Table 4-3 (e)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 5. - Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

$$(18903\ gal)(0.37)(3.785\ L/gal)\ (1/d) = 2.65E4\ L/d$$

Total Wastewater Purge Rate = 1.3% = 39 gpm

$$(39\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 2.07E5\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.43E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.16E8\ L) + (2.65E4\ L/d) + (2.07E5\ L/d)]}$$

$$= 6.16E5\ pCi/L$$

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-3 (f)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 6. - Production

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.9E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.54E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 52 gpm

(52 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.83E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.9E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.54E8 L) + (2.65E4 L/d) + (2.83E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.83E5 L/d) = 63 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.54E8 L)(0.01/d) = 342 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(4000 gpm/3000gpm) = 7.8 Ci/yr

Table 4-3 (g)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 7. - Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.7E7\ L$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(28.6 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (2.65E4 L/d) + (1.42E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.7E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-3 (h)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 8. - Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (2.65E4 L/d) + (2.07E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-3 (i)

Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 9. - Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.43E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.16E8 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(1.43E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.16E8 L) + (2.65E4 L/d) + (2.07E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-3 (j)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Raneh Project (Cont.)

Wellfield 10. - Production

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 39 gpm

(39 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.07E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$C_{RN} = \dfrac{[(1E6)\ (574\ pCi/cm^3)(1.43E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.16E8\ L) + (2.65E4\ L/d) + (2.07E5\ L/d)]}$

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.07E5 L/d) = 46 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.16E8 L)(0.01/d) = 257 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(3000 gpm/3000gpm) = 5.9 Ci/yr

Table 4-3 (k)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 11. - Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.6E7\ L$$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

$$(18903\ gal)(0.37)(3.785\ L/gal)\ (1/d) = 2.65E4\ L/d$$

Total Wastewater Purge Rate = 1.3% = 26 gpm

$$(26\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 1.42E5\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(9.5E4\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(7.6E7\ L) + (2.65E4\ L/d) + (1.42E5\ L/d)]}$$

$$= 6.16E5\ pCi/L$$

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.6E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-3 (l)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 12. - Production

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$(1.9E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.54E8\ L$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 52 gpm

(52 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 2.83E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(1.9E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.54E8\ L) + (2.65E4\ L/d) + (2.83E5\ L/d)]}$$

$= 6.16E5$ pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.83E5 L/d) = 63 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.54E8 L)(0.01/d) = 342 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(4000 gpm/3000gpm) = 7.8 Ci/yr

Table 4-3 (m)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 13. - Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.6E7\ L$

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(26 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/cm^3)(9.5E4\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(7.6E7\ L) + (2.65E4\ L/d) + (1.42E5\ L/d)]}$$

$= 6.16E5$ pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.6E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-3 (n)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Wellfield 14. - Production

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.6E7 L

Capacity of Resin Column = 18903 gal. Fluid
Porosity 0.37
Unloading Rate = 1/d

IX Unloading Volume: based on 3000gpm

(18903 gal)(0.37)(3.785 L/gal) (1/d) = 2.65E4 L/d

Total Wastewater Purge Rate = 1.3% = 26 gpm

(26 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 1.42E5 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/cm^3)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.6E7 L) + (2.65E4 L/d) + (1.42E5 L/d)]

= 6.16E5 pCi/L

Rn_W = (3.65E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(1.42E5 L/d) = 31 Ci/yr

Rn_V = (3.65E10 Ci/pCi,d/yr)(6.16E5 pCi/L)(7.6E7 L)(0.01/d) = 169 Ci/yr

Rn_{IX} = (3.6E-10 Ci/pCi,d/yr)(6.16E5 pCi/L)(2.65E4 L/d)(2000 gpm/3000gpm) = 3.9 Ci/yr

Table 4-3 (o)

Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Wellfield 1. - Restoration

Operating Days = 360
Area = 1.05E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.05E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 8.5E7\ L$$

Restoration Removal Rate Maximum = 913 gpm

$$(913\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 4.98E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.05E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(8.5E7\ L) + (4.98E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(4.98E6\ L/d) = 853\ Ci/yr$$

Table 4-3 (p)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 2. - Restoration

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(1.9E5 m^2)(3 m)(0.27)(1E3 L/m^3) = 1.54E8 L

Restoration Removal Rate Maximum = 1660 gpm

(1660 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 9.05E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(1.9E5 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(1.54E8 L) + (9.05E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(9.05E6 L/d) = 1551 Ci/yr

Table 4-3 (q)

Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 3. - Restoration

Operating Days = 360
Area = 1.71E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.71E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.39E8\ L$$

Restoration Removal Rate Maximum = 1494 gpm

$$(1494\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 8.14E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.71E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.39E8\ L) + (8.14E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(8.14E6\ L/d) = 1394\ Ci/yr$$

Table 4-3 (r)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Wellfield 4. - Restoration

Operating Days = 360
Area = 1.14E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.14E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 9.2E7\ L$$

Restoration Removal Rate Maximum = 996 gpm

$$(996\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 5.43E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.14E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(9.2E7\ L) + (45.43E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(5.43E6\ L/d) = 931\ Ci/yr$$

Table 4-3 (s)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 5. - Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$$

Restoration Removal Rate Maximum = 1245 gpm

$$(1245\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 6.79E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = $\underline{[(1E6)\ (574\ pCi/g)(1.43E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}$
[0.181/d + 0.01/d)(1.16E8 L) + (6.79E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(6.79E6 L/d) = 1164 Ci/yr

Table 4-3 (t)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 6. - Restoration

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.9E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.54E8\ L$$

Restoration Removal Rate Maximum = 1660 gpm

$$(1660\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 9.05E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.9E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.54E8\ L) + (9.05E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(9.05E6\ L/d) = 1551\ Ci/yr$$

Table 4-3 (u)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 7. - Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.7E7\ L$$

Restoration Removal Rate Maximum = 830 gpm

(830 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.5E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (4.5E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-3 (v)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 8. - Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$$

Restoration Removal Rate Maximum = 1245 gpm

$$(1245\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 6.79E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.43E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.16E8\ L) + (6.79E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(6.79E6\ L/d) = 1164\ Ci/yr$$

Table 4-3 (w)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 9. - Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$$

Restoration Removal Rate Maximum = 1245 gpm

(1245 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 6.79E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.43E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.16E8\ L) + (6.79E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(6.79E6 L/d) = 1164 Ci/yr

Table 4-3 (x)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 10. - Restoration

Operating Days = 360
Area = 1.43E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.43E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.16E8\ L$$

Restoration Removal Rate Maximum = 1245 gpm

$$(1245\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 6.79E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.43E5\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.16E8\ L) + (6.79E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(6.79E6\ L/d) = 1164\ Ci/yr$$

Table 4-3 (y)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 11. - Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.7E7 L

Restoration Removal Rate Maximum = 830 gpm

(830 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.5E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (4.5E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-3 (z)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 12. - Restoration

Operating Days = 360
Area = 1.9E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(1.9E5\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 1.54E8\ L$$

Restoration Removal Rate Maximum = 1660 gpm

$$(1660\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d) = 9.05E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(1.9E5\ m^2)(3\ m)1.93\ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(1.54E8\ L) + (9.05E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

$$Rn_{Stack} = (3.65E\text{-}10\ Ci/pCi,d/yr)(4.76E5\ pCi/LL)(9.05E6\ L/d) = 1551\ Ci/yr$$

Table 4-3 (aa)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 13. - Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

$$(9.5E4\ m^2)(3\ m)(0.27)(1E3\ L/m^3) = 7.7E7\ L$$

Restoration Removal Rate Maximum = 830 gpm

$$(830\ gpm)(3.7\ 85\ L/gal)(60\ min/hr)(24\ hr/d\ ) = 4.5E6\ L/d$$

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

$$C_{RN} = \frac{[(1E6)\ (574\ pCi/g)(9.5E4\ m^2)(3\ \ m)1.93\ \ g/cm^3)(0.2)(0.181/d)0.8)]}{[0.181/d + 0.01/d)(7.7E7\ L) + (4.5E6\ L/d)]}$$

$$= 4.76E5\ pCi/L$$

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-3 (ab)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project (Cont.)

Wellfield 14. - Restoration

Operating Days = 360
Area = 9.5E4 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d

Flow Volume in Circulation:

(9.5E4 m^2)(3 m)(0.27)(1E3 L/m^3) = 7.7E7 L

Restoration Removal Rate Maximum = 830 gpm

(830 gpm)(3.7 85 L/gal)(60 min/hr)(24 hr/d) = 4.5E6 L/d

Fraction of Radon Carried in Circulating Volume = 0.8
Rate of Venting and Other Loss to System from Leaks and Spills = 0.01/d

C_{RN} = [(1E6) (574 pCi/g)(9.5E4 m^2)(3 m)1.93 g/cm^3)(0.2)(0.181/d)0.8)]
[0.181/d + 0.01/d)(7.7E7 L) + (4.5E6 L/d)]

= 4.76E5 pCi/L

Rn_{Stack} = (3.65E-10 Ci/pCi,d/yr)(4.76E5 pCi/LL)(4.5E6 L/d) = 771 Ci/yr

Table 4-3 (ac)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Wellfield 1. - New Wellfield Example

Operating Days = 360
Area = 1.05E5 m^2
Average Ore body Thickness = 3 m
Porosity = 0.27
Radium-226 in Ore = 574 pCi/g
Bulk Density of Ore = 1.93 g/cm^3
Radon Emanation Coefficient = 0.2
Radon Half-life = 0.181/d
110 Patterns Representing 330 Wells (3 unique wells per pattern)
1 mud pit per well
Drilled Well Diameter = 8"
Average Ore Material per Well in Grams:

$$(3.14)((8\ in/2)(2.54\ cm/in))^2(300\ cm)(1.93\ g/cm^3) = 1.88E5\ g/well$$

Total Ore in Mud Pit/yr = 1.88E5 g

Storage Time = 365 days/yr

Rnnw = 1E-12 Ci/pCi(0.2)(0.181/d)(574 pCi/g)(365 d/yr)(1.88E5 g/well)(330 wells/yr)

= 0.47 Ci/yr

Rn-222 flux = [(1E12 pCi/Ci)(0.47 Ci/yr)]/[1.05E5 m^2)(3.15E7 s/yr)]

= 0.14 $pCi/m^2/s$

Table 4-3 (Cont'd)
Calculations of Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Irrigation:

Numerous calculations have been performed for soil loading from irrigating with treated mine wastewater. The final concentrations of uranium and radium in the top soils are small and the source terms associated with the irrigation are small compared to other project source terms.

Irrigation water derived from restoration will be treated with barium chloride to reduce Ra-226 to 5 pCi/L. this will leave approximately 2.58E-1 pCi/g above background in the upper 15 cm of soils of the 500 acre irrigation site over the life of the mine.

Ra-226 = 0.258 pCi/g or approximately 0.258 pCi/m^2/s of radon flux

Uranium, treated to 1ppm, will leave approximately 12 pCi/g U238 distributed over the top 45 cm of soil throughout the irrigation area.

Table 4-3 (ad)
Calculations of Cumulative Average Annual Source Terms for Rio Algom Mining Corporation Smith Ranch Project

Central Processing Plant IX

ellfield		1997		1998		1999		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
1	Production		4000	4000	4000	4000	2000	2000																									
	Restoration								1000	1000	1000	1000																					
[redacted]																																	
	Production													4000	4000	4000	4000																
	Restoration																	1000	1000	1000													
[redacted]																																	
	Production																					2000	2000	2000	2000	2000	2000						
	Restoration																											1000	500	500	500	500	
[redacted]																																	
Total IX Flow			4,000	4,000	4,000	4,000	2,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	2,000	0	0	0	0	0
Total Restoration Flow			0	0	0	0	0	0	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000

Satellite IX #1

ellfield		1997		1998		1999		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
3	Production				3000	3000	2000	2000	2000	1000	1000	1000	1000																				
	Restoration													500	500	1000	500	500	500														
[redacted]																																	
	Production									1000	1000	3000	3000	2000	2000	2000																	
	Restoration																500	500	500	1000	1000												
[redacted]																																	
	Production													2000	2000	2000	3000	3000	3000	2000	2000	2000											
	Restoration																						1000	1000	500	500	500	500	1000				
[redacted]																																	
Total IX Flow			0	0	3,000	3,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	4,000	3,000	3,000	4,000	4,000	4,000	4,000	2,000	2,000	0	0	0	0	0	0	0	0	0
Total Restoration Flow			0	0	0	0	0	0	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	1,000	1,000	1,000	0	0	0	0

Satellite IX #2

ellfield		1997		1998		1999		2001		2002		2003		2004		2005		2006		2007		2008		2009		2010		2011		2012		2013	
		1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half	1st half	2nd half
9	Production																		3000	3000	3000	3000	3000										
	Restoration																							1000	1000	1000	1000						
[redacted]																																	
	Production													2000	2000	2000	2000	2000															
	Restoration																		500	500	500	1000											
[redacted]																																	
	Production																																
	Restoration																																
[redacted]																																	
Total IX Flow			0	0	0	0	0	0	0	3,000	3,000	3,000	3,000	4,000	4,000	4,000	2,000	2,000	3,000	3,000	3,000	3,000	3,000	0	0	0	0	0	0	0	0	0	0
Total Restoration Flow			0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	1,000	1,000	1,000	1,000	1,000	0	1,000	1,000	1,000	1,000	0	0	0	0	0	0
Cummulative Flow			2,000	2,000	5,000	7,000	6,000	8,000	8,000	11,000	11,000	11,000	11,000	12,000	12,000	12,000	9,000	9,000	11,000	11,000	11,000	11,000	9,000	6,000	4,000	4,000	4,000	2,000	0	0	0	0	0
Cummulative Restoration			0	0	0	0	0	0	1,000	1,000	1,000	2,000	1,000	2,000	2,000	2,000	3,000	3,000	3,000	3,000	2,000	1,000	1,000	3,000	3,000	3,000	3,000	2,000	2,000	1,000	1,000	1,000	1,000
Avg. Annual Flux Source Term Ci/				228.3		600.4			1573.25		2503.1		2759.9		5419.1		5343.4		6738.6		5109		2251		4774.3		5057.8		2808		1542		1156.5

TABLE 4-4

BLEED STREAM WATER ANALYSES
Q-SAND & O-SAND ISL PILOTS

DATE	HCO3	CO3	Cl	Na	SO4	TDS	U	Se	Ra-226	Th-230
	Grab Sample Analyses - mg/l except Ra & Th in pCi/l									
NPDES Limit	3000	NA	500	1000	NA	NA	NA	NA	NA	NA
12-09-81	1125	ND	89	212	254	1316	.23	.02	-	-
1-27-82	1093	ND	133	256	214	1336	.10	.03	-	-
2-10-82	922	ND	142	235	216	1478	.15	.02	-	-
3-11-82	1103	ND	166	265	220	1586	1.69	.02	-	-
4-08-82	1537	ND	199	280	280	2012	2.65	.03	-	-
5-07-82	869	ND	234	266	246	1260	.17	.02	-	-
6-10-82	647	ND	185	201	252	1342	.11	.03	-	-
7-26-82	1395	ND	317	301	317	2058	15.9	.03	-	-
8-19-82	1330	ND	310	315	290	1847	.32	.03	-	-
9-09-82	939	ND	460	321	270	1720	1.51	.06	-	-
10-22-82	1684	ND	302	337	390	2357	.67	.07	-	-
11-18-82	1586	ND	260	397	392	2393	.32	.04	1885*	5.4*
12-03-82	1537	ND	285	401	400	2367	2.25	.07	-	-
1-19-83	1159	ND	330	398	344	2050	.41	.03	-	-
2-24-83	1208	ND	268	371	432	2160	.64	.02	2680*	3.3*
3-24-83	1220	ND	272	369	408	2111	.70	.02	-	-
4-21-83	1098	ND	254	354	510	2035	.58	.02	-	-
5-12-83	1257	ND	273	392	428	2185	.75	.02	1055*	0.1*
6-23-83	1196	ND	286	348	402	2154	.28	.02	-	-
7-28-83	1220	ND	250	378	438	2121	.48	.02	-	-
8-23-83	854	ND	202	248	360	1558	.59	.01	5.3	1.0
9-22-83	1183	ND	247	364	450	2087	.29	.02	-	-
10-06-83	1147	ND	228	354	438	2025	.53	.02	-	-
11-03-83	1086	ND	261	345	414	1971	.51	.02	2.1	6.4*
12-08-83	927	ND	389	376	330	1873	1.31	.03	-	-

*Sampled upstream of bleed stream barium chloride treatment.

NA - Not Applicable

ND - Not Detected

TABLE 4-5

BLEED STREAM WATER ANALYSES
Q-SAND & O-SAND ISL PILOTS

Grab Sample Analyses - mg/l except Ra & Th in pCi/l

DATE	HCO3	CO3	Cl	Na	SO4	TDS	U	Se	Ra-226	Th-230
NPDES Limit	3000	NA	500	1000	NA	NA	NA	NA	NA	NA
1-27-84	1049	ND	253	338	410	1935	.28	.02	-	-
2-28-84	1049	ND	272	328	390	1864	.18	.02	2.1	1.3
3-16-84	1037	ND	292	328	342	1885	.23	.01	-	-
4-12-84	1061	ND	267	320	-	2007	.4	.01	-	-
5-10-84	939	ND	262	299	400	1834	.5	.02	13.7	.4
6-07-84	683	ND	154	212	354	1437	.6	.01	-	-
7-12-84	695	ND	214	234	368	1527	6.9	.01	-	-
8-09-84	647	ND	235	174	250	1363	.8	.01	4.1	1.2
9-06-84	830	ND	205	246	340	1717	1.3	.02	-	-
10-11-84	793	ND	235	270	362	1817	1.1	.02	-	-
11-27-84	854	ND	235	233	354	1716	1.3	.01	16.1	1.4
12-06-84	842	ND	235	234	348	1615	1.1	.03	-	-
1-16-85	695	ND	150	190	312	1339	.5	.01	-	-
2-14-85	659	ND	104	151	306	1736	.8	.09	247*	3.9*
3-14-85	598	ND	165	153	211	1157	.8	.01	-	-
4-10-85	587	ND	100	149	246	1301	.6	.01	-	-
5-17-85	542	ND	88	146	277	1011	.9	.04	1150*	0.3*
6-12-85	732	ND	90	131	350	1218	1.7	.04	-	-
7-30-85	561	ND	70	118	245	899	.3	.11	-	-
8-19-85	525	ND	138	141	247	1085	.5	.12	1260*	0.2*
9-13-85	476	ND	66	124	205	832	1.8	.12	-	-
10-16-85	427	ND	84	113	151	710	.3	.02	-	-
11-13-85	415	ND	42	102	157	642	.1	.07	830*	3.0*
12-18-85	500	ND	48	41	213	901	.2	.14	-	-
1-15-86	427	ND	38	85	189	735	.2	.10	-	-
2-13-86	390	ND	41	97	204	741	.6	.23	650*	0.3*
3-13-86	366	ND	20	79	218	733	.2	.09	-	-
4-16-86	371	ND	31	73	240	766	.1	.08	-	-
5-15-86	371	ND	31	64	288	830	.1	.15	780*	1.5*
6-11-86	283	ND	20	48	164	606	.4	.04	-	-
7-17-86	817	ND	118	119	567	1766	.5	.42	-	-
8-13-86	744	ND	86	102	553	1738	.7	.40	466*	4.6*
9-17-86	415	ND	41	65	264	1010	.3	.16	-	-
10-15-86	939	ND	108	156	617	2051	.5	.51	-	-
11-12-86	1684	ND	204	632	695	2991	6.9	.60	688*	8.1*
12-17-86	1098	ND	230	202	630	2384	.6	.60	-	-
1-16-87	1257	ND	180	224	600	2481	1.0	.71	-	-
2-18-87	1342	ND	165	274	767	2589	2.5	1.72	1267*	56*
3-18-87	695	ND	48	124	374	1261	1.5	0.58	-	-
4-16-87	586	ND	72	161	420	1255	1.3	0.25	-	-
5-13-87	1183	ND	155	296	720	2490	2.1	0.58	426*	5.7*
6-17-87	1135	ND	116	245	623	2034	3.4	0.68	-	-

*Sampled upstream of bleed stream barium chloride treatment.

NA - Not Applicable

ND - Not Detected

TABLE 4-6

EVAPORATION POND WATER ANALYSES
Q-SAND AND O-SAND ISL PILOTS

EAST CELL

	Cl[1]	Na	TDS	SO4	As	U	Alk	Ra-226
1st Qtr. 1982	20.8	11.2	35.1	0.4	.38	1100	35.5	2378
2nd Qtr. 1982	20.3	6.8	32.3	0.6	.96	784	26.8	456
3rd Qtr. 1982	51.7	6.2	36.9	0.6	.001	38	0.6	100
4th Qtr. 1982	16.2	4.4	27.6	0.5	.16	275	33.2	315
1st Qtr. 1983	0.6	0.3	1.0	.1	.008	4	2.0	86
2nd Qtr. 1983	6.7	4.3	13.8	0.3	.221	79	12.4	216
3rd Qtr. 1983	17.0	8.9	30.5	0.7	.03	13	2.6	108
4th Qtr. 1983	25.4	14.8	45.7	1.0	.06	103	7.6	483
1st Qtr. 1984	1.9	0.9	3.8	0.1	.001	22	4.3	42
2nd Qtr. 1984	7.1	4.0	12.2	0.3	.001	55	2.8	183
3rd Qtr. 1984	20.4	10.4	35.4	0.7	.025	105	3.9	21
4th Qtr. 1984	35.5	21.6	71.3	2.0	.003	141	17.4	5095
1st Qtr. 1985	26.3	14.9	49.4	1.5	.001	12	18.2	3030
2nd Qtr. 1985	25.0	12.7	45.5	1.3	.039	.20	12.2	643
3rd Qtr. 1985	49.5	29.7	81.9	2.1	.066	.23	9.6	510
4th Qtr. 1985	35.5	22.4	62.5	1.3	.003	.21	12.0	754
1st Qtr. 1986	26.5	20.4	52.3	1.4	.005	.33	134.9	184
2nd Qtr. 1986	39.0	26.5	70.1	2.5	.037	.25	17.0	1366
3rd Qtr. 1986	74.5	48.9	127.5	3.4	.007	.39	17.2	3253
4th Qtr. 1986	71.0	49.8	127.0	4.2	.009	.32	19.8	4
1st Qtr. 1987	51.5	33.7	98.1	3.3	.043	.24	28.4	772
2nd Qtr. 1987	57.3	38.8	103.9	3.3	.007	.25	21.2	1912

[1] Cl, Na, TDS and SO4 are in grams/liter; As & U mg/l; Alk Meq/l, Ra pCi/l.

TABLE 4-7

EVAPORATION POND WATER ANALYSES
Q-SAND AND O-SAND ISL PILOTS

WEST CELL

	Cl(1)	Na	TDS	SO4	As	U	Alk	Ra-226
1st Qtr. 1982	10.3	5.4	17.5	0.3	0.22	16	9.2	172
2nd Qtr. 1982	18.0	6.4	24.1	0.5	1.33	49	15.6	1804
3rd Qtr. 1982	36.9	8.5	51.7	0.4	.64	132	14.6	2119
4th Qtr. 1982	19.0	3.4	29.5	0.4	.56	131	11.6	1779
1st Qtr. 1983	0.3	0.2	0.5	.1	.011	2	0.4	22
2nd Qtr. 1983	0.5	0.2	1.0	-	.039	1	0.2	36
3rd Qtr. 1983	16.8	9.1	30.4	0.7	.03	14	3.8	44
4th Qtr. 1983	27.1	15.2	45.4	1.0	.09	100	7.8	553
1st Qtr. 1984	0.4	0.2	0.8	.1	.002	1	0.5	34
2nd Qtr. 1984	9.3	5.5	16.4	0.5	.002	121	7.0	224
3rd Qtr. 1984	20.8	10.5	36.1	0.8	.020	105	4.2	7
4th Qtr. 1984		------EMPTIED FOR REPAIR------						
1st Qtr. 1985		------EMPTIED FOR REPAIR------						
2nd Qtr. 1985	25.0	12.7	45.1	1.2	.042	.17	12.1	1149
3rd Qtr. 1985	47.0	28.5	81.6	2.2	.039	.23	9.2	490
4th Qtr. 1985	52.2	35.6	90.2	1.8	.002	.22	9.6	552
1st Qtr. 1986	44.0	28.8	77.9	1.8	.002	.14	8.4	423
2nd Qtr. 1986	43.5	31.2	87.0	2.8	.022	.20	9.4	923
3rd Qtr. 1986	75.5	49.3	128.8	3.9	.008	.38	16.2	2081
4th Qtr. 1986	75.5	49.2	132.2	4.1	.005	.27	17.2	41
1st Qtr. 1987	66.0	40.8	121.9	4.0	.125	.25	14.0	755
2nd Qtr. 1987	58.3	37.3	109.1	3.4	.011	.23	20.4	560

(1) Cl, Na, TDS and SO4 are in grams/liter; As & U mg/l; Alk meq/l, Ra pCi/l.

TABLE 4-8

SUMMARY OF LABORATORY PERMEABILITY TEST RESULTS

Test Hole	Depth (ft.)	Test Method	Permeability (cm/sec)	Soil Type
SA23-1	9.0	Undisturbed-Falling Head	2.0×10^{-4}	Sandstone Bedrock
SA25-2	4.0	Undisturbed-Falling Head	3.7×10^{-5}	Siltstone Bedrock
SA36-2	14.0	Undisturbed-Falling Head	1.8×10^{-7}	Very Clayey Sand
SA36-4	14.0	Undisturbed-Falling Head	6.0×10^{-8}	Very Sandy Clay-Silt
SA36-7	19.0	Undisturbed-Falling Head	1.0×10^{-8}	Very Silty-Clayey Sand

TABLE 4-9

SUMMARY OF FIELD PERMEABILITY TEST RESULTS

Test Hole	Depth (ft.)	Test Method	Permeability (cm/sec)	Soil Type
SA23-1	12 to 20	Packer	Less Than 10^{-6}	Claystone Bedrock
SA25-1	24 to 30.4	Packer	Less Than 10^{-6}	Claystone Bedrock
SA25-2	15 to 25	Packer	4.3×10^{-5}	Sandstone Bedrock
SA25-3	10 to 20	Packer	3.2×10^{-5}	Sandstone Bedrock
SA36-1	26 to 34	Packer	2.2×10^{-4}	Sandstone Bedrock
SA36-3	37 to 44	Packer	3.0×10^{-6}	Sandstone Bedrock
SA36-6	19 to 25	Packer	1.8×10^{-5}	Sandstone Bedrock
SA36-7	34 to 39.5	Packer	Less Than 10^{-6}	Sandstone Bedrock

NOTE: Permeabilities of less than 10^{-6} cm/sec indicate that no water take occurred during testing.

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TABLE 4-10

SUMMARY OF LABORATORY TEST RESULTS

HOLE	DEPTH (FEET)	NATURAL MOISTURE (%)	NATURAL DRY DENSITY (PCF)	ATTERBERG LIMITS		SPECIFIC GRAVITY	WATER SOLUBLE SULFATE (%)	GRADATION ANALYSIS			SOIL TYPE
				LIQUID LIMIT (%)	PLASTICITY INDEX (%)			+#4 (%)	-#4 +#200(%)	-#200 (%)	
SA23-1	9.0	2.8	115.8		NP			0	90	10	Sandstone Bedrock
SA25-1	14.0	4.6	98.4		NP			0	82	18	Silty Sand
SA25-2	1.0 - 15.0	9.3		27	5	2.69		0	16	84	Siltstone Bedrock
	4.0	6.3	105.9		NP			0	4	96	Siltstone Bedrock
SA25-3	4.0	10.0	87.9	25	5			0	42	58	Very Sandy Clay-Silt
SA36-1	0.0 - 20.0	7.3		26	9	2.67		0	53	47	Very Clayey Sand
	4.0	8.4	102.2								Very Clayey Sand
SA36-2	14.0	7.4	117.3	30	13			0	51	49	Very Clayey Sand
SA36-3	14.0	6.3	107.7		NP			0	78	22	Silty Sand
SA36-4	0.0 - 20.0	4.7		23	6	2.67		0	47	53	Very Sandy Clay-Silt
	14.0	7.6	116.7	33	19			0	25	75	Very Sandy Clay
SA36-5	9.0	14.3	111.3	42	21			0	16	84	Sandy Clay
SA36-6	9.0	12.3	122.5	48	25			0	13	87	Sandy Clay
SA36-7	19.0	5.6	108.8	24	5			0	58	42	Very Silty-Clayey San

TABLE 4-11

CONCLUSIONS

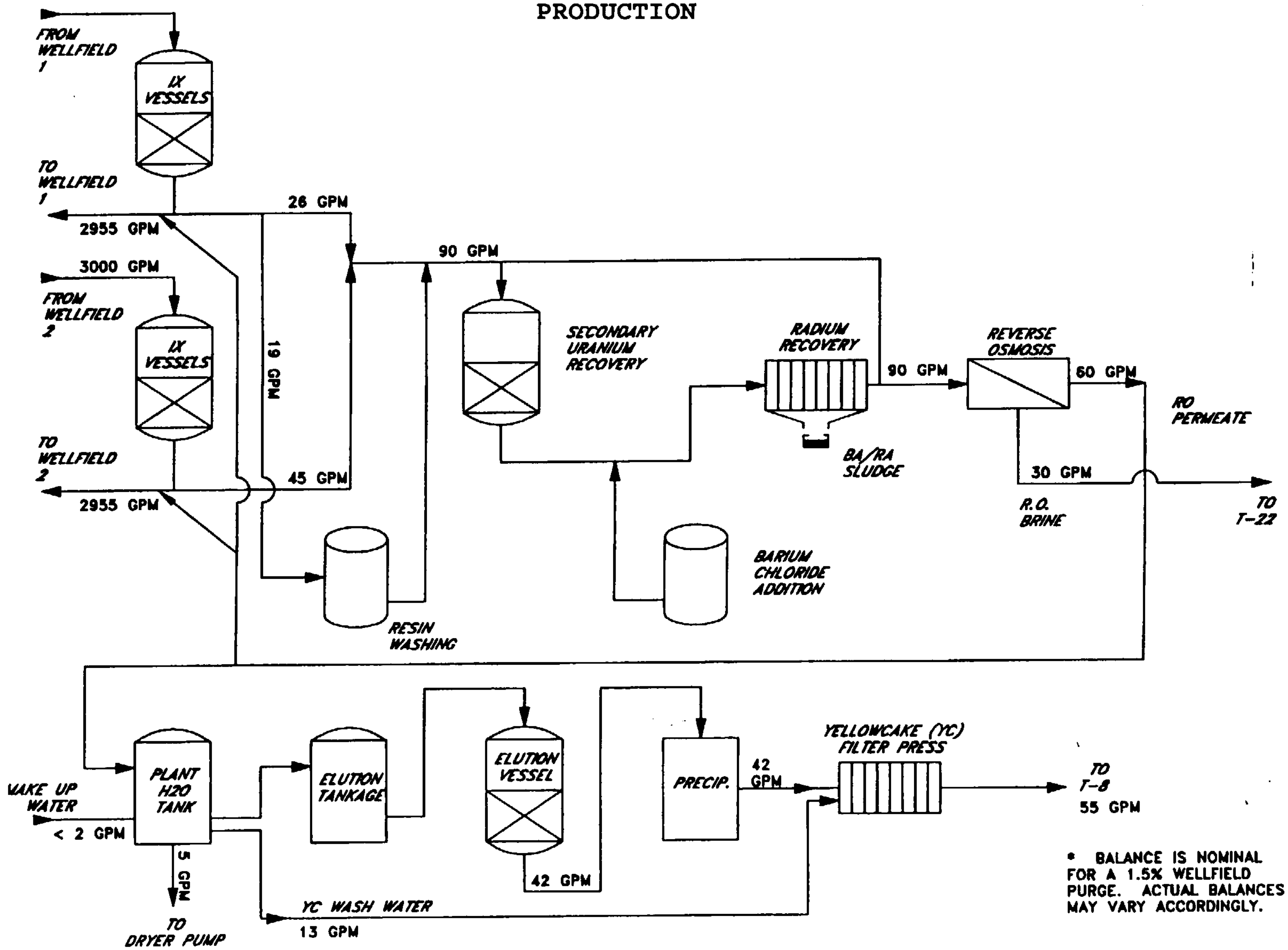
(1) All of the proposed locations studied are suitable for construction of the proposed evaporation ponds.

(2) All of the soils and bedrock encountered are suitable for use in construction of the proposed embankments.

(3) All of the soils and bedrock encountered with the exception of the sandstone bedrock are suitable for use in construction of the soil liners.

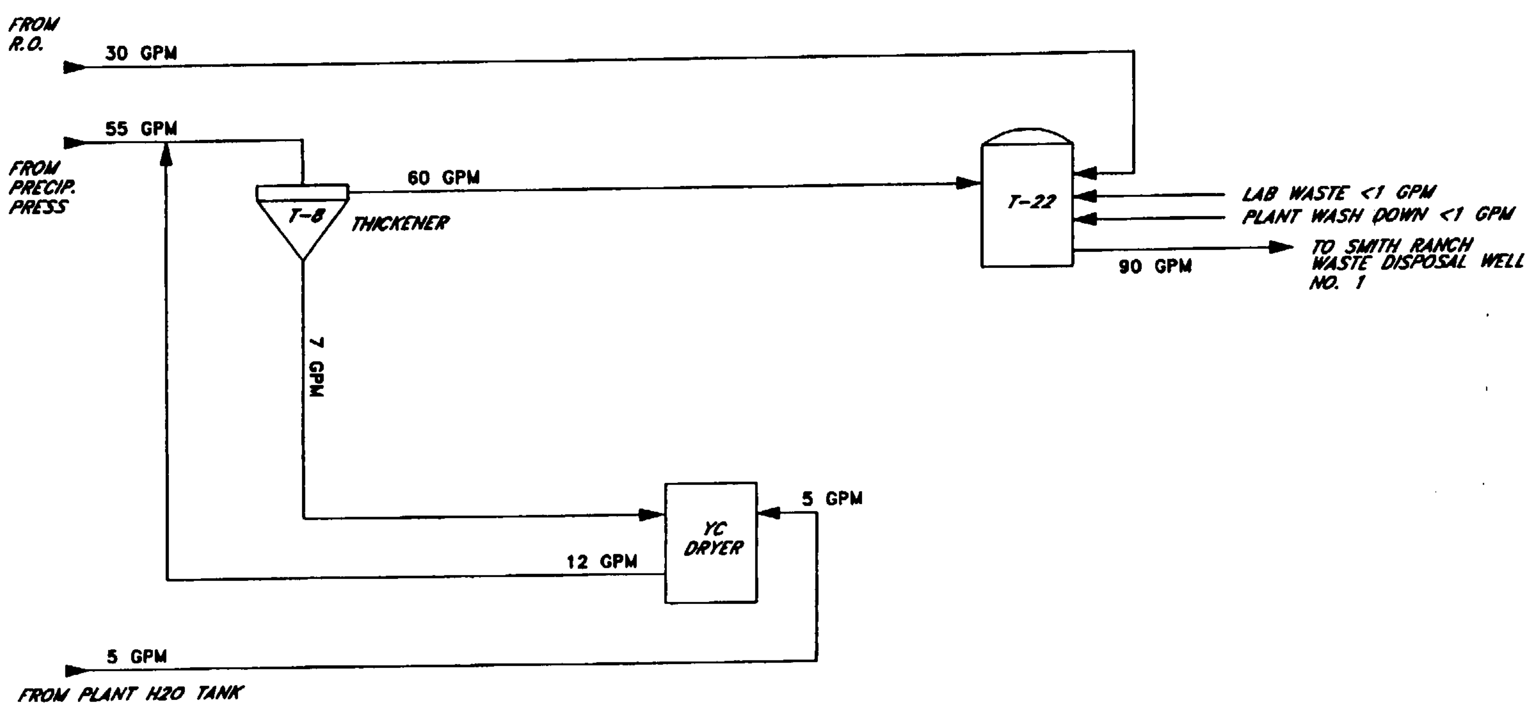
(4) Preliminary general design considerations are presented in the body of the report.

Figure 4-1
TYPICAL WATER BALANCE
FOR 1.5% PURGE AND FULL
PRODUCTION



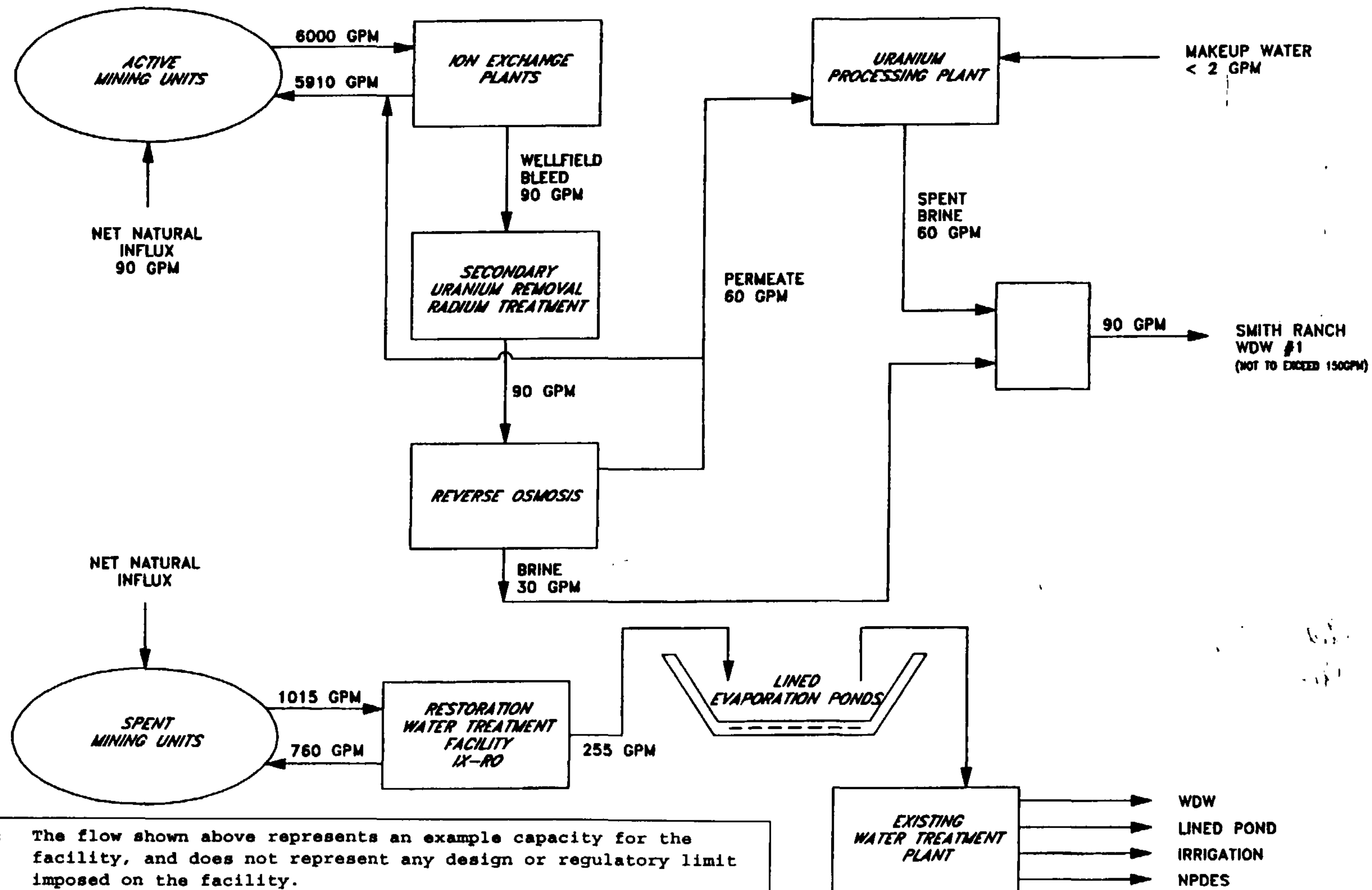
Note: The flow shown above represents an example capacity for the facility, and does not represent any design or regulatory limit imposed on the facility.

Figure 4-1(Cont'd)



Note:	The flow shown above represents an example capacity for the facility, and does not represent any design or regulatory limit imposed on the facility.

Figure 4-2
WATER BALANCE FOR SMITH RANCH PROJECT WELLFIELD OPERATIONS AT 6000 GPM WITH 90 GPM PURGE (1.5% BLEED)



Note: The flow shown above represents an example capacity for the facility, and does not represent any design or regulatory limit imposed on the facility.