Hydro Resources, Inc

Crownpoint Uranium Project
USNRC License
SUA-1580 Renewal
McKinley County, New Mexico

Consolidated Operations Plan

Revision 3.0

March 2013

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CORPORATE ENVIRONMENTAL POLICY

HRI, Inc.'s environmental policy reflects the Company's continual commitment to environmental stewardship in all aspects of its business activities. The Company strives to maintain high standards in its design, construction, operations, and restoration activities in order to consistently operate in a manner that protects the environment. Through a rigorous environmental compliance review procedure, the Company continuously evaluates all aspects of its operations to ensure that it is operating safely and in compliance with the multi-level state and federal regulations applicable to the in-situ uranium recovery (ISR) process.

This system includes a review of environmental regulations which impact the exploration, development, operation, and restoration/remediation activities of HRI; the development of safety and environmental procedures, and regular internal audits of these areas to assess compliance; the promotion of waste minimization techniques; the utilization of environmental benign choices in operating strategies; providing leadership in environmental awareness, and emphasizing employee involvement, and effectiveness in safety and environmental compliance on the job.

CORPORATE ALARA POLICY

HRI, Inc.'s ALARA policy reflects the same commitment stated in the Corporate Environmental Policy, with specific emphasis placed on maintaining occupational exposures to employees, contractors and visitors, from the radiological and toxic hazards of uranium, and its daughter products "as low as reasonably achievable".

The Company strives to maintain high ALARA standards through engineering design, hands on management, and employee training. It is recognized that a successful ALARA program is the responsibility of everyone in the production of uranium; including management, the Radiation Safety Officer (RSO), and all workers. The Company continually evaluates and provides the necessary resources and incentives to ensure ALARA goals will be met.

CROWNPOINT URANIUM PROJECT
CONSOLIDATED OPERATIONS PLAN

1.0 GENERAL DESCRIPTION

The Crownpoint Uranium Project (the CUP, as collectively described throughout this document) has been the subject of a number of applications, reports, submittals, correspondence, and various other documentation which has been submitted to the United States Nuclear Regulatory Commission (NRC). The general chronology of these submittals is specified in 1.2 below.

During the time of the current license review, the licensing of the CUP had taken a number of years and included several additional site locations with corresponding informational submittals. Then, NRC had expressed concern that the Application information has become disjointed for the purpose of "tiedown provisions" in the operating license. The purpose of the CONSOLIDATED OPERATIONS PLAN (COP) was to extract and combine the information in previously submitted documents into one consolidated specification report.

As described in Section 1.2 below, after the current CUP license was approved by NRC, the license and supporting record were challenged. The COP Revision 2.0 dated August 15, 1997 was a substantial component of this record. This COP Revision 3.0 contains the same specifications and representations which had been articulated to NRC in the past within COP Revision 2.0. HRI has carefully formatted COP Revision 3.0 to be the same as Revision 2.0 which was litigated and ultimately found to be acceptable by the Commission. In some instances updated NRC regulations and guidance have been incorporated into Revision 3.0. Also, HRI has incorporated NRC staff comments and suggestions from the pre-submission audit into Revision 3.0.

1.1 Project Identification

Hydro Resources, Inc. (HRI)[1], a wholly-owned subsidiary of Uranium Resources, Inc., proposes to develop in-situ recovery (ISR) operations in McKinley County, New Mexico (Fig 1.1-1). The

[1] Hydro Resources, Inc. is a Delaware Corporation licensed to do business in New Mexico. Because the name "Hydro Resources" was not available, the company operates as HRI, Inc. (also referred to as HRI). All references to Hydro Resources, Inc., and HRI should be considered interchangeable for the purposes of this report.

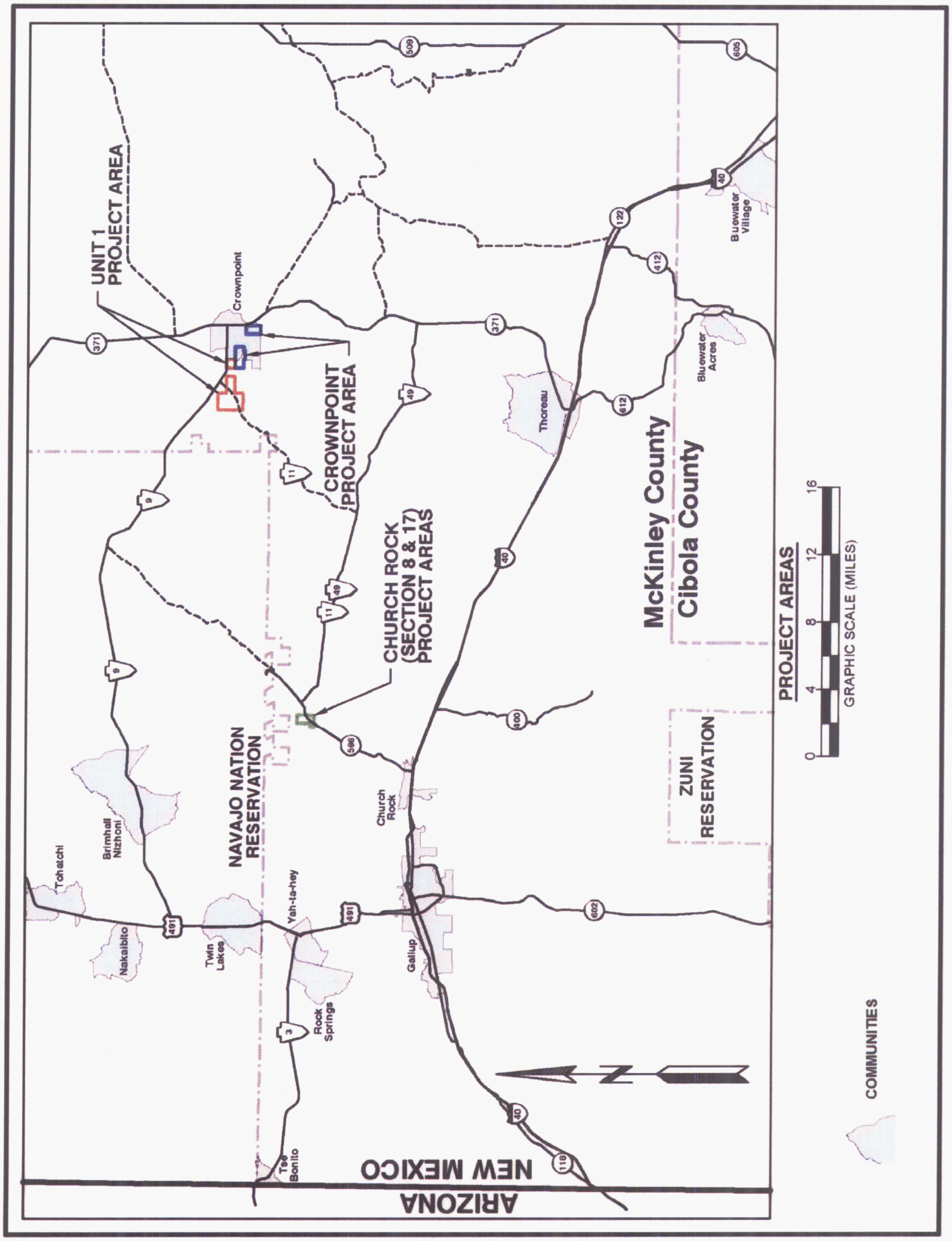


Figure 1.1-1. Regional Location Map of West-Central New Mexico and the Project Areas.

proposed project will consist of three separate satellite facilities: one at Churchrock, Crownpoint and Unit 1. The processing and drying facility will either be located at the Crownpoint Central Plant (CCP) or one of URI, Inc.'s licensed production facilities in Texas[2]. Each satellite will have a nominal design processing capacity of 4000 gpm, and production capacity of 1 million lbs. of uranium concentrate per year. Collectively, the CCP and satellite facilities are referred to as the CUP. The location of each is described separately below:

1.1.1 Churchrock

The Churchrock satellite will be located in the SE/4, SE/4 of Section 8, T16N, R16W.

ISR could be located on one or both of the parcels of land owned by or leased to HRI on Sections 8 and 17, T16N, R16W, as described below:

Section 8

SE/4 - 174.546 ac. Patent Mining Claims.

Section 17

200.0 acres being NE/4, and the SE/4 NW/4.

The location of the Churchrock property is illustrated with respect to the topography and cultural features on Figure 1.1-2.

1.1.2 Crownpoint

The Crownpoint Central Plant (CCP) will be located on the SE/4 of Section 24, Township 17 North, Range 13 West in McKinley County, New Mexico. ISR and processing activities are anticipated within the license boundary as described herein.

T17N, R12W:

Beginning at a point on the NW corner of the SW/4 of Section 19, go 1,320' East along the North line of the South half of Section 19 to a point at the NE corner of said tract of land;

THENCE South along the East line of said tract 2,640' parallel with the West line to the SE corner of said tract of land;

[2] URI, Inc. is a wholly owned subsidiary of Uranium Resources, Inc. and operated ISR operations under its NRC Agreement State License L03653.

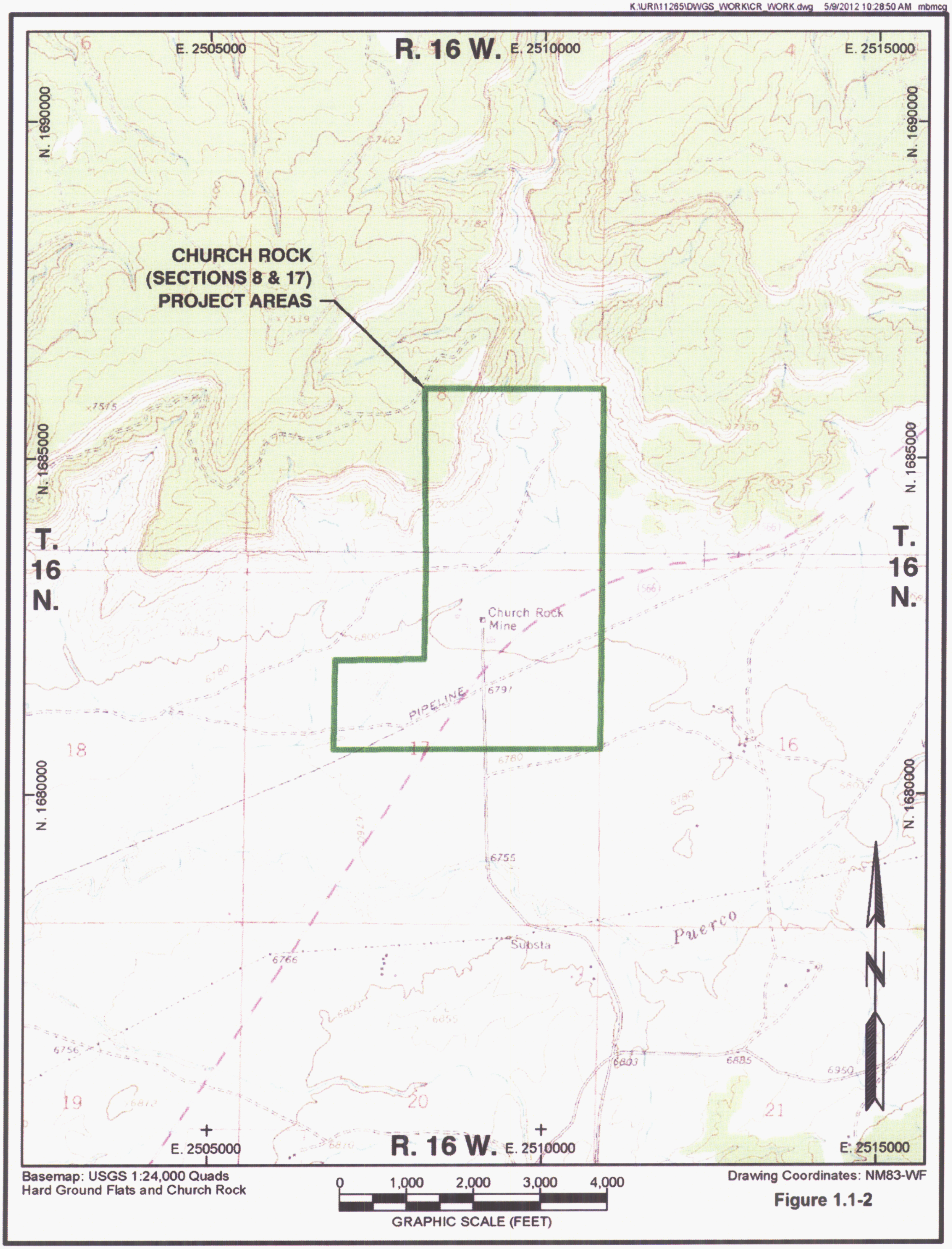

K:\URI\11265\DWGS_WORK\CR_WORK.dwg 5/9/2012 10:28:50 AM mbmcg
R. 16 W.
E. 2505000
E. 2510000
E. 2515000
N. 1690000
N. 1685000
N. 1680000
T. 16 N.
CHURCH ROCK (SECTIONS 8 & 17) PROJECT AREAS
Church Rock Mine
PIPELINE
Puerco
Substa
N
Basemap: USGS 1:24,000 Quads
Hard Ground Flats and Church Rock
0 1,000 2,000 3,000 4,000
GRAPHIC SCALE (FEET)
Drawing Coordinates: NM83-WF

Figure 1.1-2

THENCE West along the South line of said tract 1,320’ parallel with the North line of the SW corner of said tract of land;

THENCE North along the West line of said tract 2,640’ parallel to the East line to the point beginning for said tract of land located in Section 19.

Additionally,

Beginning at a point 650’ South of the NW quarter for a point of beginning for said tract of land located in the West half of Section 29, go 2,640’ East along the North line of said tract parallel to the South line of said W/2 of Section 29;

THENCE South along the East line of said tract 4,630’ parallel with the West line to the SE corner of said tract of land;

THENCE West along the South line of said tract 2,640’ parallel with the North line to the SW corner of said tract of land;

THENCE North along the West line of said tract 4,630’ parallel to the East line to the point of beginning for said tract of land located in Section 29.

T17N, R13W:

Beginning at a point on the NW corner of the SW/4 of Section 24, go 5,280’ East along the North line of the South half of Section 24 to a point at the NE corner of said tract of the SE/4;

THENCE South along the East line 2,640’ parallel with the West line to the SE corner of the SE/4 of said Section 24;

THENCE South along the East line 465’ parallel with the West line to a point on said East line which is the SE corner of said tract in Section 25;

THENCE West along the South line of said tract of land 2,640’ parallel with the North line of said tract;

THENCE North 465’ along the West line parallel with the East line to the NW corner of said tract of land located in Section 25;

THENCE West 2,640’ along the South line parallel with the North line to the SW/4 of Section of 24;

THENCE North along the West line 2,640’ parallel to the East line to the point of beginning.

The location of the Crownpoint site is illustrated with respect to topography, and cultural features on Figure 1.1-3.

1.1.3 Unit 1

The Unit 1 satellite will be located in the NE/4, SE/4 of Section 21, T17N, R13W. ISR could be located on any of the parcels of land leased to HRI as described below.

Sections 15, 16, 21, 22, 23, and 24, T17N, R13W:
Section 15; SW/4 - 160 acres.
Section 16; SE/4 - 160 acres.
Section 21; E/2 - 320 acres.
Section 22; W/2 NE/4 - 480 acres.
Section 23; NW/4 - 160 acres.
Section 24; NW/4 - 160 acres.

The location of the Unit 1 properties is illustrated with respect to topography and cultural features in Figure 1.1-3.

1.2 History and Permitting of the Project

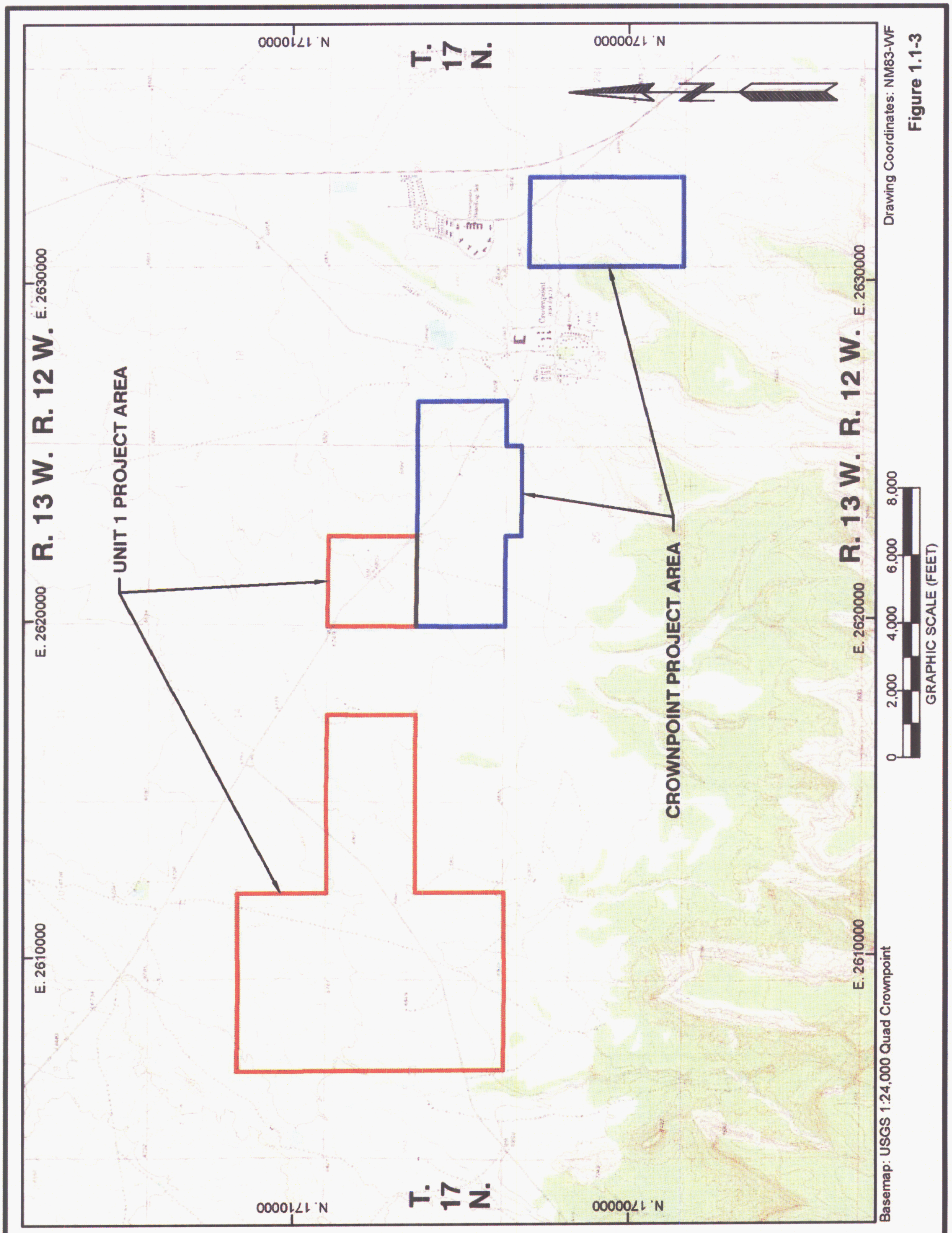
HRI initiated its License application in accordance with 10 CFR Part 51.45, by submitting an environmental report (ER) to the NRC by cover letter dated April 13, 1988.[30][3] The ER was also provided to the BIA, BLM, and others.

An application for a State of New Mexico discharge plan was submitted at the same time the NRC License was initiated. Subsequently, by letter dated April 25, 1988, HRI submitted an application to the NRC for a source material license to commercially produce uranium at its Churchrock ISR project, McKinley County, New Mexico.

On October 12, 1988, HRI announced that it had acquired existing conventional mine facilities in Crownpoint, formerly owned by Conoco and Westinghouse Corporations, and proposed to conduct uranium recovery processing there. By letter dated May 8, 1989, HRI submitted a Supplemental Environmental Report addressing this change. [32]

Discharge plan DP-558 which authorized ISR at the Churchrock Section 8 location was approved by the New Mexico Environment Improvement Division (now NMED) on November 2, 1989. [51] This approval was preceded by approval of an aquifer exemption by the US EPA on June 21, 1989. [69]

[3] [ID] Section 11.0 References


R. 13 W. R. 12 W.
UNIT 1 PROJECT AREA
CROWNPOINT PROJECT AREA
T. 17 N.
T. 17 N.
N. 171000
N. 170000
N. 171000
N. 170000
E. 2610000
E. 2620000
E. 2630000
E. 2610000
E. 2620000
E. 2630000
R. 13 W. R. 12 W.
0 2,000 4,000 6,000 8,000
GRAPHIC SCALE (FEET)
N
Basemap: USGS 1:24,000 Quad Crownpoint
Drawing Coordinates: NM83-WF
Figure 1.1-3

An application was submitted for water rights at the Churchrock property to the New Mexico State Engineer on February 14, 1991. This application was protested by the Navajo Nation on jurisdictional grounds. On February 13, 1992 the application was conditionally denied because of excessive project water consumption.

The proposed development plan was expanded when HRI applied for mineral interests involving leases on allotted lands which were designated Unit 1. HRI addressed adding these areas in a new ER dated January 1992, and submitted to the NRC on April 23, 1992. [33] Finally, the proposed project was again expanded to include mineral claims near the former Conoco/Westinghouse underground mine. The environmental report for this addition was submitted on July 31, 1992. [35]

An application was submitted to the New Mexico Environment Department on June 12, 1992, for authorization to conduct ISR operations on Section 24, and 19 of the Crownpoint Properties. [35] This application was subsequently withdrawn.

A UIC application was submitted to EPA on October 9, 1992 which would authorize ISR on Unit 1 properties. This application was subsequently withdrawn. [36]

In March of 1993, HRI submitted an application to amend DP-558 by adding the Section 17 property. [38] A public hearing was conducted in October of 1993 on the amendment. The hearing was convened, and continued from time to time thereafter. The amendment was approved by NMED on October 7, 1994. EPA did not issue the requisite aquifer exemption for the property because of a question over regulatory jurisdiction.

On January 27, 1993 HRI revised its water budget to be consistent with the rights of UNC as determined by the State Engineer and reapplied for a transfer of United Nuclear Corporation's water rights. The new water budget placed emphasis on the fact that rather than simple consumption of extracted water, the ISR process largely recirculates a known volume or "corpus" of groundwater over the life of a mine. The State Engineer conducted a hearing in March 1998 regarding the application for the transfer of the water rights. On October 19, 1999 the State approved the water rights application for HRI's Churchrock ISR project. HRI was granted rights of 400 ac-ft/yr. based on the diversion and recirculation of a corpus of water for ISR. [52] The approved appropriation provides sufficient water for the Churchrock ISR operational life.

On May 18th 2004 the State Engineer granted water rights not to exceed 650 acre-feet-annum for the Crownpoint Section 24 site. This followed HRI's application dated May 11, 2001 for the same.

In October, 1994 the Draft Environmental Impact Statement (DEIS) was released by an interagency review group consisting of the U.S. Nuclear Regulatory Commission (NRC), the U.S. Bureau of Land Management (BLM), and the U.S. Bureau of Indian Affairs (BIA). [100] The review group was assisted by input from the Navajo Nation, the State of New Mexico, and other interested parties.

In February, 1995, NRC conducted public hearings on the Draft EIS. Thereafter, NRC compiled public comments, and other questions, and posed these to HRI as requests for additional information by letter dated Jan. 11, 1996, February 9, 1996, and July 15, 1996. HRI's responses to these documents were forwarded on to NRC on February 20, April 1, and August 15 respectively. [39][40][41]

In July, 1996, HRI submitted a renewal application to NMED for DP-558. Also, in July, 1996, HRI submitted an application to NMED for a separate discharge plan for the Section 17 property. This bifurcation was designed to clearly distinguish between the two properties (Sections 8 & 17) for the purpose of providing flexibility in dealing with any future jurisdictional questions which might arise.

In August, 1996, HRI submitted an application for a discharge plan which would authorize ISR of the Crownpoint Property for the south half of Section 24. [43]

In November, 1996, HRI submitted an application for an EPA UIC permit which would authorize ISR of the Unit 1 Property.

In February, 1997, the Final Environmental Impact Statement (FEIS) was released by an interagency review group consisting of the U.S. Nuclear Regulatory Commission (NRC), the U.S. Bureau of Land Management (BLM), and the U.S. Bureau of Indian Affairs (BIA).

On August 15, 1997 HRI provided the NRC a final Consolidated Operations Plan that contained all the specifications and representations which had been articulated to NRC in the past, under one cover. On December 4, 1997 The Safety Evaluation Report was compiled pursuant to HRI's safety plan that was described in the Operations Plan. The Safety Evaluation Report and the FEIS provided the basis for NRC's decision to issue the Radioactive Materials License. In January 1998 the NRC issued a license in that would allow operations to begin in the Section 8 ISR site.

In mid-1998, the NRC determined that certain residents from the communities of Churchrock and Crownpoint and other environmental activists who requested a hearing had standing to raise certain objections to the license. The NRC Atomic Safety Licensing Board (ASLB) administrative law judge and his technical staff conducted a hearing in two Phases.

Phase I covered the Section 8 ISR portion of the license and was broken into 9 distinct briefing subjects including performance-based licensing, liquid waste disposal, surface water protection, cultural resource issues, air emissions issues, HRI qualifications in training and experience, groundwater protection, adequacy of financial assurance, EIS and environmental justice considerations. With regard to groundwater at the Section 8 ISR Site, on August 30, 1999the ASLB concluded that the risks of ISR at Churchrock will be minimal and on January 31, 2001 the Commission concurred with the technical, substantive and legal findings of the administrative law judge's that the project as planned safely protected groundwater resources. [97]

Phase II of the NRC Subpart L litigation followed. On July 20, 2005 the Presiding Officer ruled on groundwater issues and on August 21, 2006 the Presiding Officer upheld HRI license. [98][99] These rulings were subsequently appealed to the Commission and then on to the United States Court of Appeals for the 10th Circuit who on March 8, 2010 denied the petition by the Southwest Research and Information Center and other parties for review of HRI's NRC license and upheld the NRC's licensing decision in all respects. Next on May 21, 2010 the Court of Appeals denied a petition for a rehearing or en banc review of the court's previous decision. On September 15, 2010, attorneys on behalf of Southwest Research and Information Center petitioned the United States Supreme Court for review of the 10th Circuit Court of Appeals ruling that upheld the Company's NRC license. The petition was denied by the Supreme Court in November 2010, thereby ending the NRC litigation.

By letter to the U.S. NRC, dated October 18, 2010, HRI submitted, for NRC staff review, revisions to its NRC approved restoration action plans (RAPs). [46] The revisions were submitted pursuant to the changes required by the hearing process. NRC staff reviewed the information provided by HRI and on October 14, 2011 approved HRI's request to lift the prohibition on HRl's use of

NRC license SUA-1580, imposed by the Commission in CLI-00-08. The license currently is in timely renewal status.

Along the separate State of New Mexico UIC permitting path, on July 2, 1996, HRI submitted an Application to NMED for the Renewal of DP-558 that was issued in 1989. [44] On August 16, 1996 the Secretary of the NMED declared that HRI's renewal was timely within the meaning of Section 5101.G of the WQCC Regulations and that HRI was in full compliance with the approved discharge plan.

On July 14, 1997 United States Environmental Protection Agency (EPA) determined that the Section 8 land's status as Indian country under their regulations was "in dispute" and as such EPA not the State of New Mexico had authority to issue a UIC permit. This action effectively placed the State's renewal of HRI Discharge Plan in limbo. In December 1997, HRI and NMED appealed those determinations to the United States Court of Appeals for the Tenth Circuit. On January 6, 2000, the issue was remanded by the Court back to the EPA. In February 2007, the EPA reached a decision that Section 8 was Indian country, and therefore under its jurisdiction. URI appealed the decision to the Tenth Circuit Court in April 2009. By a 2-1 decision the court upheld the EPA's ruling. In August 2009, URI's petition for an en banc review was granted and oral arguments were held January 2010. Om June 5, 2010, thirteen years after the EPA's first determination, the United States Court of Appeals for the Tenth Circuit en banc held that the Section 8 ISR property was <u>not</u> Indian Country. The result of the ruling means the authority to issue a UIC permit to URI falls under the jurisdiction of the State of New Mexico, and not the EPA. On September 13, 2010 time expired for opposing parties to petition the United States Supreme Court to review the June 2010 United States Court of Appeals en banc ruling. No petitions were filed with the U.S. Supreme Court as of the September 13, 2010 deadline, ending the litigation.

In step with these court rulings, on July 29, 2010 NMED wrote URI acknowledging New Mexico jurisdiction over UIC permitting of the Section 8 ISR project and requested documentation that would allow the renewal process to proceed.

1.3 ISR Technique

ISR involves the use of a oxygen fortified groundwater solution (lixiviant) to extract the mineral of interest from the geologic formation in which it occurs. This is accomplished by injecting the lixiviant through injection wells completed in the zone of interest, dissolving the target minerals, then recovering the pregnant lixiviant or production fluid by pumping production wells. At HRI's properties, uranium will be extracted from roll front type deposits which contain an average ore grade of approximately 0.15 percent U_3O_8. The ore deposits are usually a few feet in thickness.

Various well patterns will be typically used for uranium ISR at the CUP. Each well field area consists of groups of these patterns which will be installed to correspond to the irregular geometry of the ore bodies.

At the CUP, the lixiviant consists of native groundwater to which gaseous carbon dioxide (or some form of sodium bicarbonate), and oxygen will be added. After injection of the lixiviant into injection wells, and recovery through production wells, it will be piped to the ion exchange facility where the uranium will be removed by circulating the pregnant lixiviant through ion exchange resin. The barren lixiviant will then be returned to the well field. At the satellite projects, ion exchange will be transported in appropriate closed trailers to a central processing facility where it will be further processed to its final form. Ion exchange resin will be returned to the IX system for further use after it has been stripped of uranium.

Once the economic recovery limit of a production area is reached, lixiviant injection will be stopped, and the affected ground water will be treated (restored) to return the water to a quality consistent with baseline as specified in Section 10, and/or as mandated by NRC, and other controlling regulatory authorities.

An extensive water monitoring program will be required for ISR at the CUP. Specifically designated wells will be monitored for water level, and sampled for certain water quality parameters on a regular basis to ensure that the injected lixiviant stays within the defined production zone.

The chief components of an in situ uranium recovery facility include:

a. **ISR process**, where a lixiviant stream is continuously recirculated from the recovery plant into injection wells, through the ore bearing strata, and a uranium-rich (pregnant) lixiviant is withdrawn (via production wells)and recirculated to the recovery plant;

b. The **recovery plant**, where uranium in the pregnant lixiviant is extracted, and the resulting barren lixiviant is recirculated through the well fields.

c. **Yellowcake precipitation**, and **concentration** in the form of uranium oxide or yellowcake which will be shipped as dry powder in drums.

d. The CUP will utilize a **yellowcake dryer** system to finish the dry product.

1.3.1 In Situ Mineral Extraction Preserves the Surface

Intergranular uranium mineralization makes up only a small portion of the total mass of uranium ore, therefore, after ISR the structural integrity of the host aquifer is maintained, and no land subsidence occurs. However, as part of HRI's site reclamation plan, the company will monitor if depressions appear at the surface due to subsurface collapse, and return the land surface to its general contour as part of the project's surface reclamation activities.

1.3.2 Restoration

Once the economic recovery limit of a CUP production area is reached, lixiviant injection will be stopped, and the affected ground water will be treated and restored to a quality which is consistent with baseline conditions, and/or as mandated by the controlling regulatory agencies.

1.3.3 Advantages of ISR

Uranium ISR is a proven technology that has been successfully demonstrated commercially in the states of Nebraska, Texas, and Wyoming. URI, HRI's affiliate, has extensive commercial experience in uranium ISR in the state of Texas from 1978 to the present. ISR of uranium is environmentally superior to conventional open pit uranium mining as evidenced by the following:

a. ISR results in significantly less surface disturbance. Mine pits, waste dumps, haul roads, and tailings ponds are not needed.

b. Compared to conventional mining, ISR reduces the short- and long-term exposure to the general population to the extremely low levels of radioactivity because almost all of the source term remains underground in its natural location. Very little residual radioactive waste is produced and there are no tailings. Land and water are returned to their original pre-ISR uses and quality.

c. ISR requires much less water than pit or underground mine dewatering, or conventional milling.

d. Minimal use of heavy equipment, combined with the lack of haul roads, waste dumps, etc., result in virtually no air quality degradation at ISR sites.

e. Following the initial construction activities fewer employees are needed at ISR sites, thereby reducing transportation and socioeconomic concerns.

f. Aquifers are not excavated, but remain intact during and after ISR so they remain available for future uses. Avoiding the creation of large excavations preserves the surrounding land for grazing or raising crops and other traditional uses.

g. The technology of recirculating groundwater through the ion exchange facility reduces the amount of solids to a negligible quantity, and tailings ponds are not used, thereby eliminating a major groundwater pollution concern.

1.4 Schedule for ISR Related Activities

Within the well field, individual wells will be shut down when they cease to be economically productive. When an entire segment of a well field has been depleted of uranium, restoration will be conducted by reverse osmosis treatment and brine concentration.

The projected general production and restoration schedule for the CUP is show on Figure 1.4-1. It should be emphasized that this schedule is projected and will ultimately be impacted by regulatory, and market influences. More detailed production and restoration schedules are described below.

1.4.1 Churchrock

The proposed ISR plan at Churchrock is summarized on Figures 1.4-2 through 1.4-5. The well field sequence listed on Figures 1.4-2 and 1.4-3 is generally illustrated on Figure 1.4-4 and 1.4-5 respectively. Production will proceed first on Section 8. Within the well field, individual wells will be shut down when they cease to be economically productive. When an entire segment of a well field has been depleted of uranium, restoration will be conducted via reverse osmosis treatment and brine concentration. The estimated productive/restoration life of the well fields at Churchrock Section 8 is approximately 6.5 years.

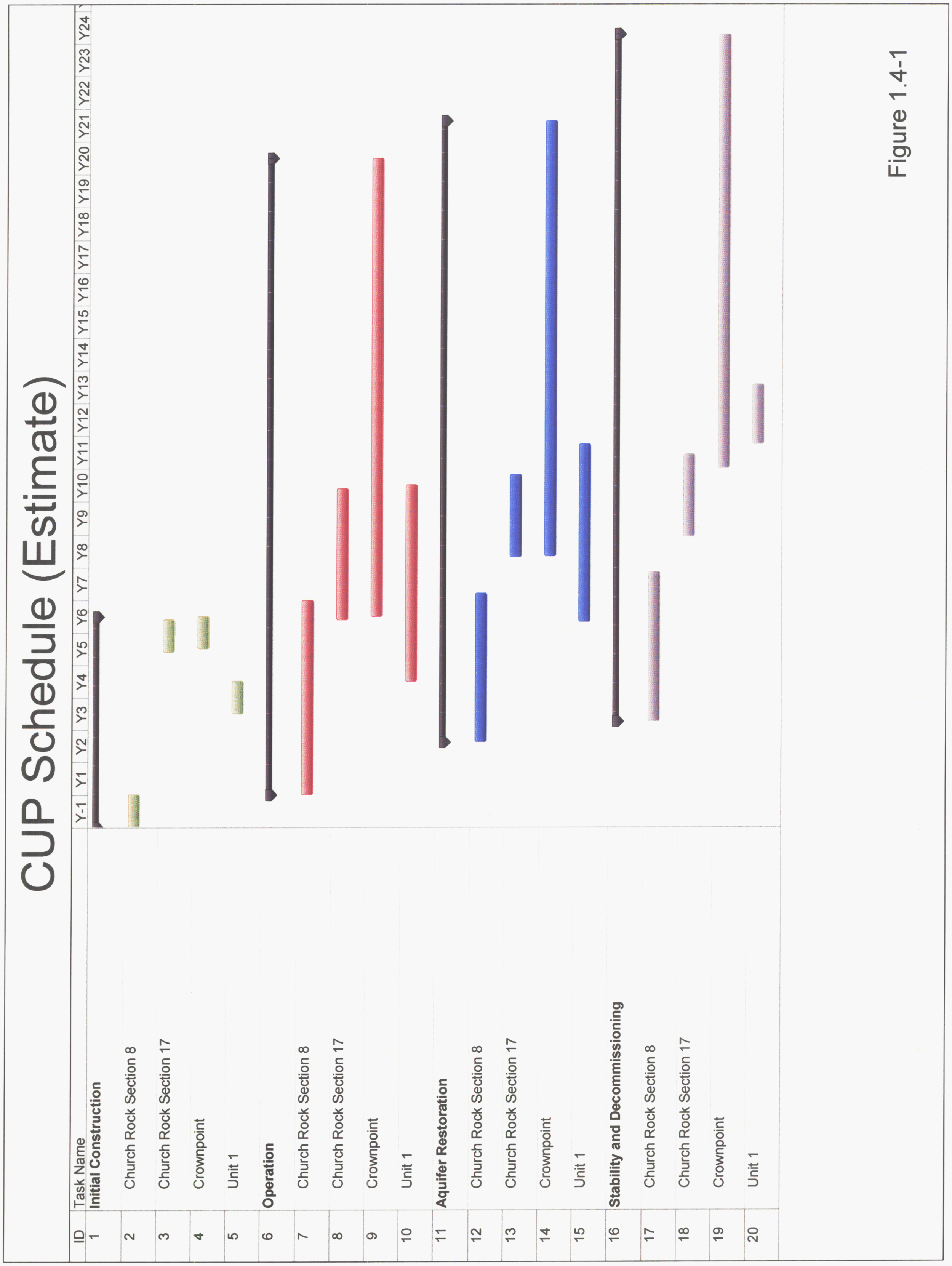

CUP Schedule (Estimate)
ID
Task Name
Y-1
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Y8
Y9
Y10
Y11
Y12
Y13
Y14
Y15
Y16
Y17
Y18
Y19
Y20
Y21
Y22
Y23
Y24
1 Initial Construction
2 Church Rock Section 8
3 Church Rock Section 17
4 Crownpoint
5 Unit 1
6 Operation
7 Church Rock Section 8
8 Church Rock Section 17
9 Crownpoint
10 Unit 1
11 Aquifer Restoration
12 Church Rock Section 8
13 Church Rock Section 17
14 Crownpoint
15 Unit 1
16 Stability and Decommissioning
17 Church Rock Section 8
18 Church Rock Section 17
19 Crownpoint
20 Unit 1

Figure 1.4-1

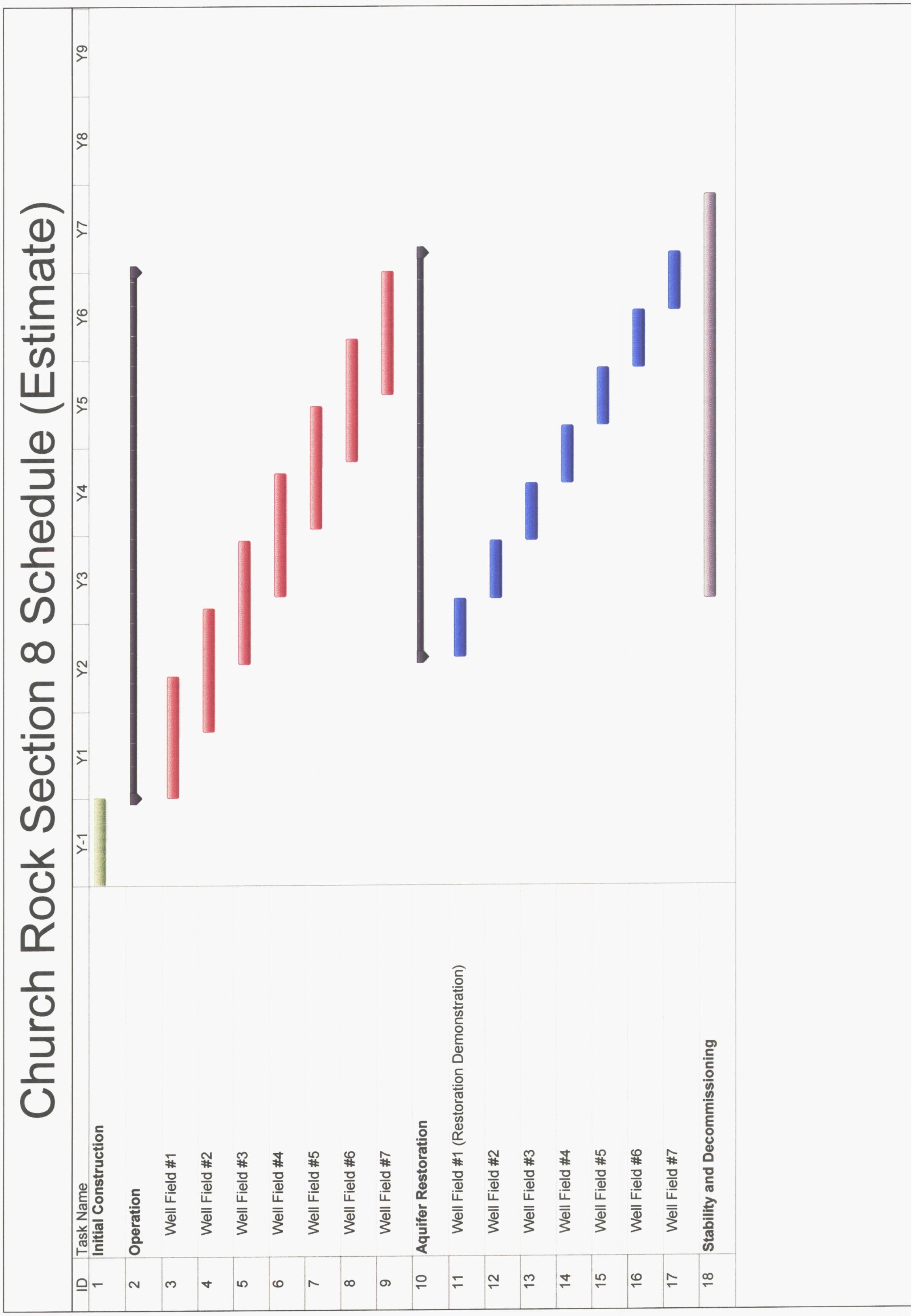

Church Rock Section 8 Schedule (Estimate)
ID
Task Name
Y-1
Y1
Y2
Y3
Y4
Y5
Y6
Y7
Y8
Y9
1 Initial Construction
2 Operation
3 Well Field #1
4 Well Field #2
5 Well Field #3
6 Well Field #4
7 Well Field #5
8 Well Field #6
9 Well Field #7
10 Aquifer Restoration
11 Well Field #1 (Restoration Demonstration)
12 Well Field #2
13 Well Field #3
14 Well Field #4
15 Well Field #5
16 Well Field #6
17 Well Field #7
18 Stability and Decommissioning

Figure 1.4-2

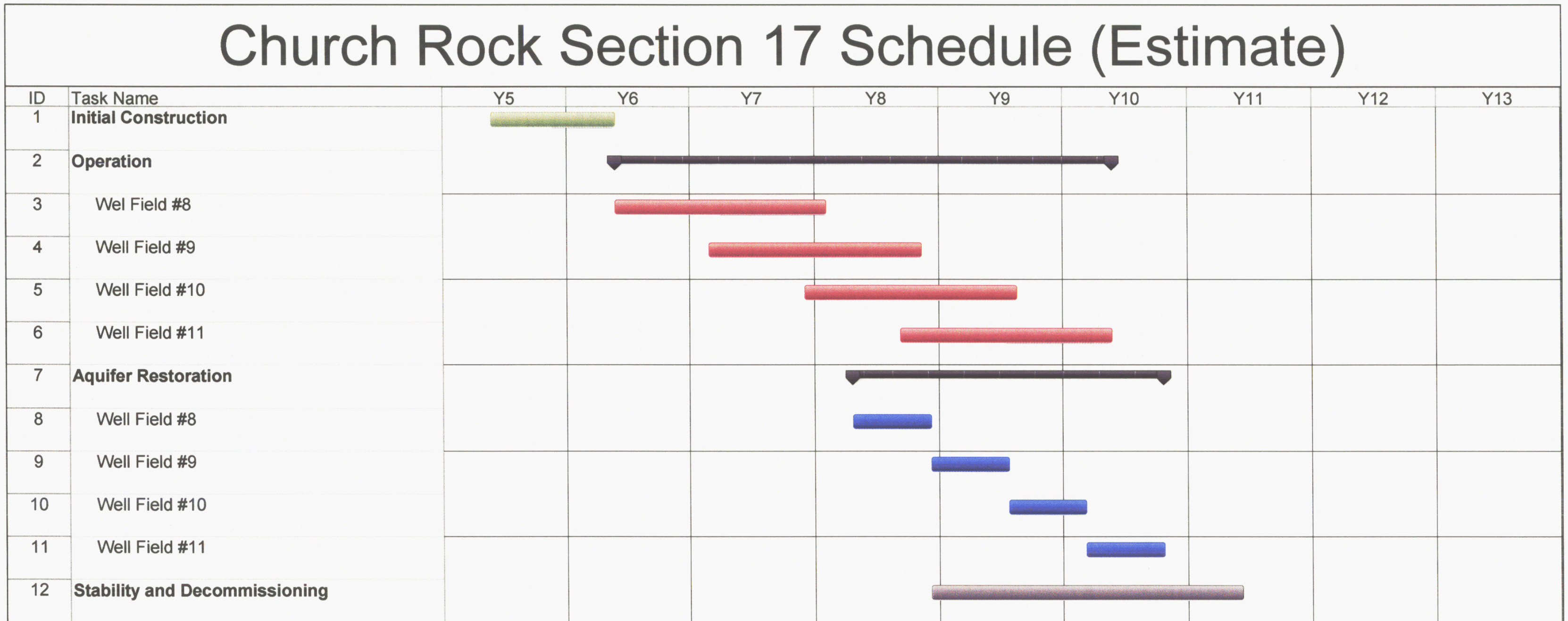

Church Rock Section 17 Schedule (Estimate)
ID
Task Name
Y5
Y6
Y7
Y8
Y9
Y10
Y11
Y12
Y13
1 Initial Construction
2 Operation
3 Wel Field #8
4 Well Field #9
5 Well Field #10
6 Well Field #11
7 Aquifer Restoration
8 Well Field #8
9 Well Field #9
10 Well Field #10
11 Well Field #11
12 Stability and Decommissioning

Figure 1.4-3

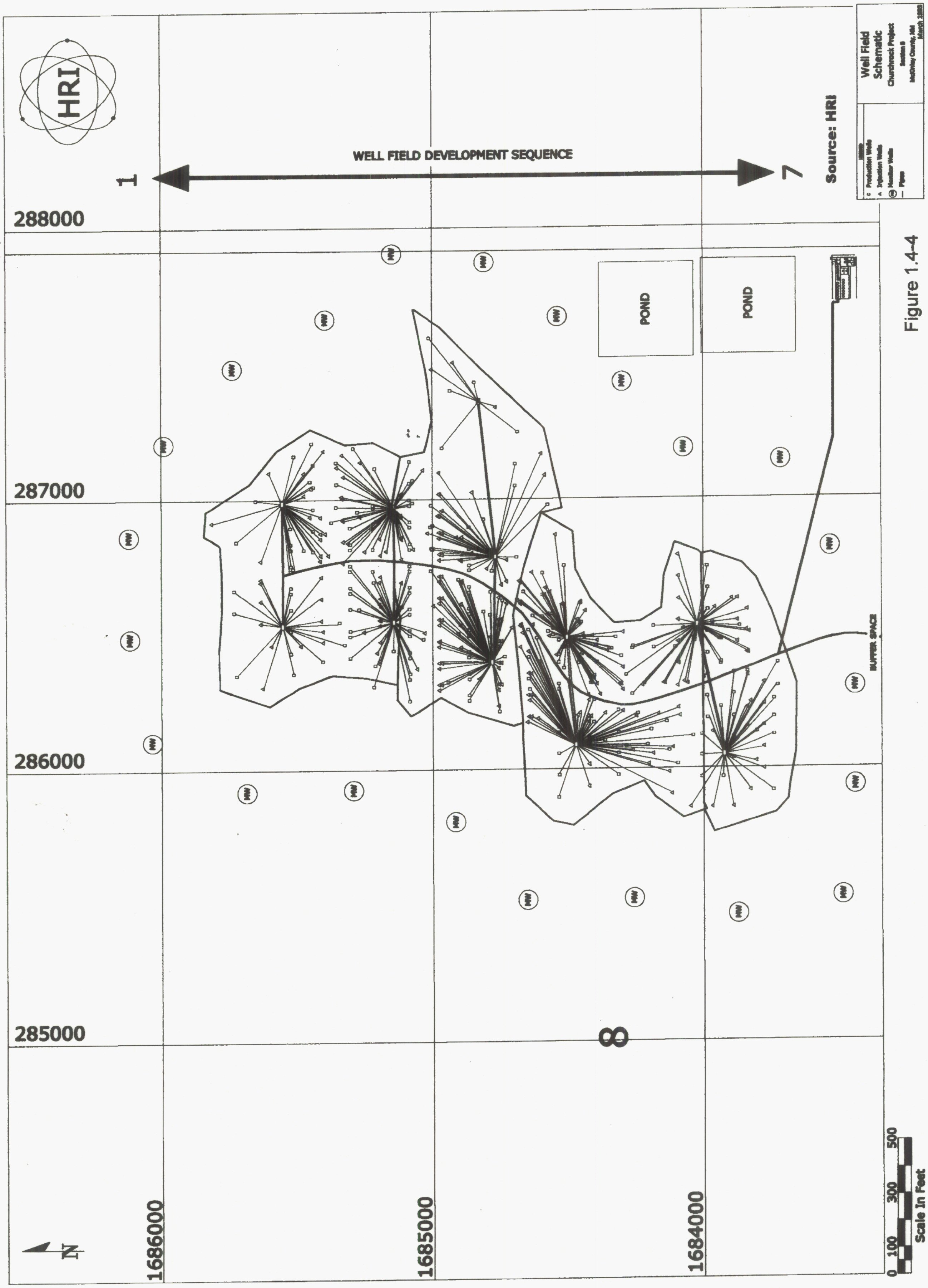

HRI
WELL FIELD DEVELOPMENT SEQUENCE
1
7
Source: HRI
Well Field
Schematic
288000
287000
286000
285000
1686000
1685000
1684000
POND
POND
BUFFER SPACE
MW
8
N
Scale In Feet
0
100
300
500

Figure 1.4-4

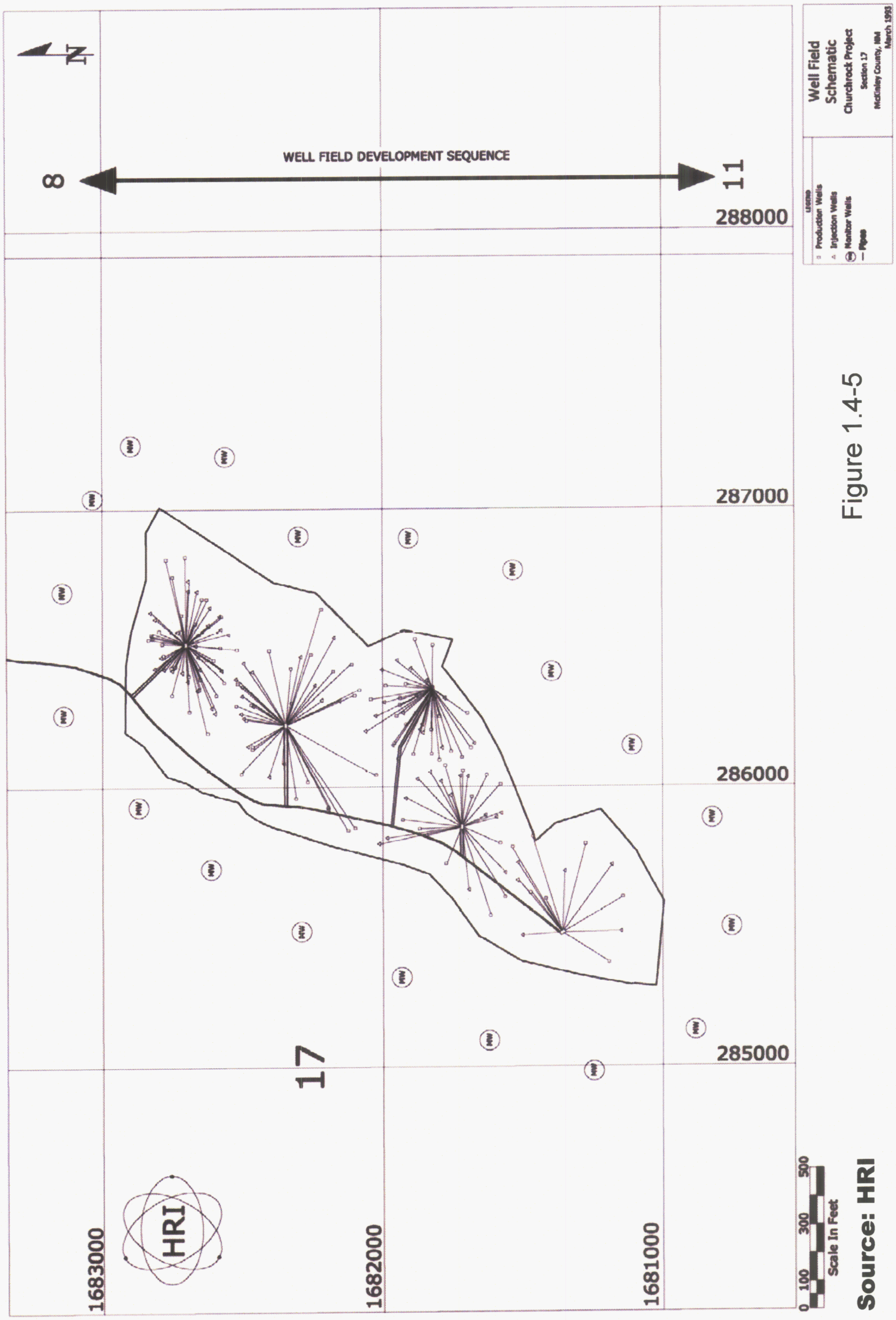


Figure 1.4-5

Source: HRI

Production is scheduled to begin on Section 17 when operations are in the final well field in Section 8 with the same production/restoration criteria stated above. The estimated production/restoration life of the well fields at Churchrock Section 17 is approximately 6 years, including final decommissioning on Section 8 at the end of the project. All timing is subject to discovery of additional reserves which will, by necessity, extend the duration of the uranium recovery and restoration period before final decommissioning.

1.4.2 Crownpoint

The proposed Crownpoint development plan is summarized on Figure 1.4-6. The estimated well field sequence listed on Figure 1.4-6 is generally illustrated on 1.4-7.

Prior to the injection of lixiviant at the Crownpoint site, HRI will replace the town of Crownpoint water supply wells NTUA-1, NTUA-2, BIA-3, BIA-5, and BIA-6. In addition, HRI will construct a water system pipeline and provide funds so that the Navajo Tribal Utility Authority (NTUA) and Bureau of Indian affairs (BIA) water supply systems can be connected. The wells, pumps, pipelines, and any other necessary changes to the existing water supply system will be made so the system can continue to provide the same quantity of water. The new wells will be located so that the water quality at each individual wellhead will not exceed EPA primary and secondary drinking water standards as a result of future ISR activities at the and Crownpoint site. HRI will coordinate with the appropriate agencies and regulatory authorities, including the BIA and the Navajo Nation Division of Water Resources, and the Navajo Nation Environmental Protection Agency (NNEPA) and the NTUA, to determine the appropriate placement of the new wells. Further, the existing wells will be abandoned and sealed in accordance with applicable guidelines.

Within the well field, individual wells will be shut down when they cease to be economically productive. When an entire segment of a well field has been depleted of uranium, restoration will be started via ground water sweep, and/or reverse osmosis treatment, and brine concentration. The estimated productive/restoration life of the well fields at Crownpoint is about 15 years. All timing is subject to discovery of additional reserves which will, by necessity, extend the duration of the uranium recovery and restoration period before final decommissioning.

1.4.3 Unit 1

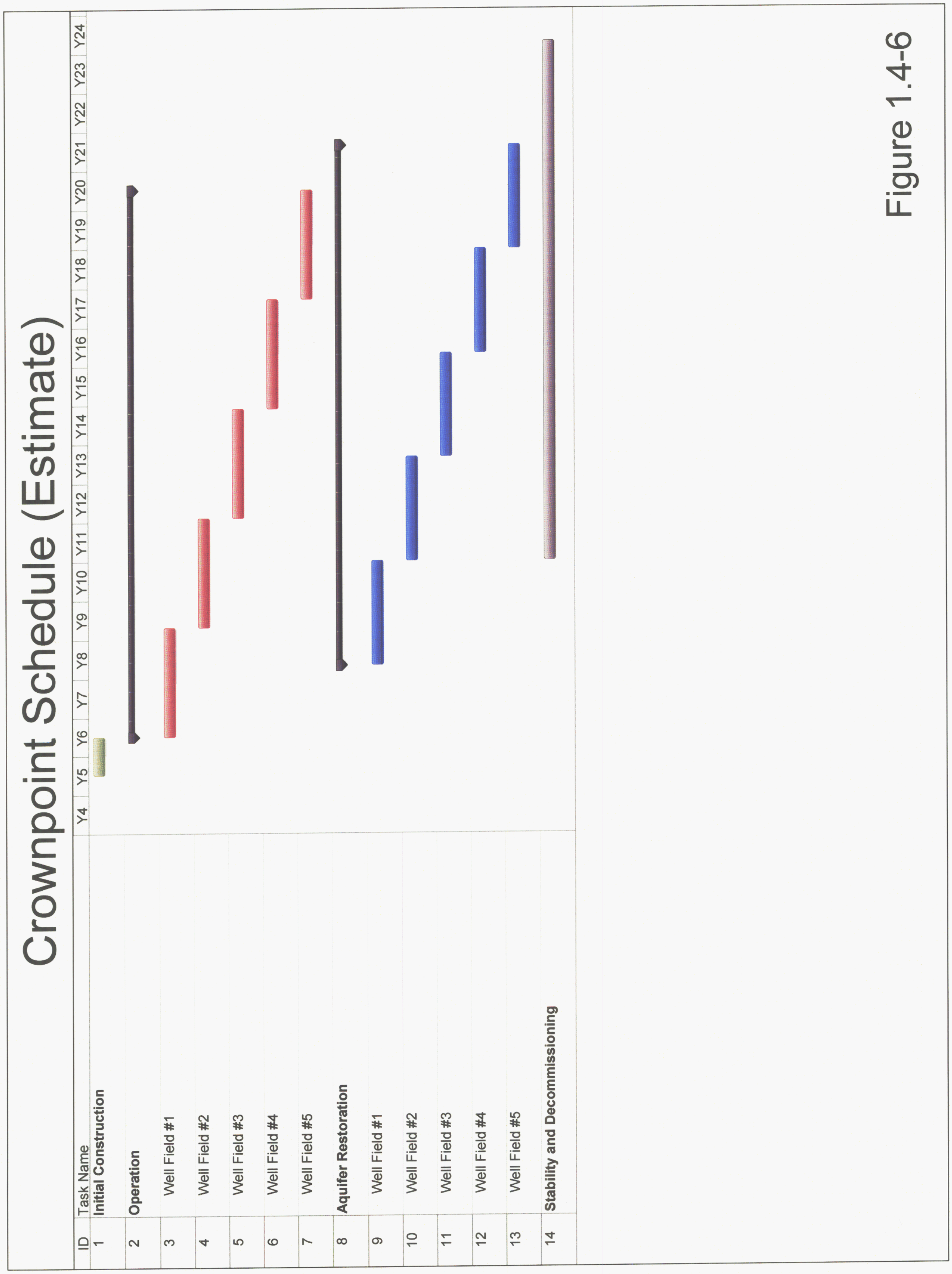
The proposed ISR plan at the Unit 1 area is summarized on Figures 1.4-8 and 1.4-9. Within the well field, individual wells will be shut down when they cease to be economically productive. When an entire segment of a well field has been depleted of uranium, restoration will be started via ground water sweep and/or reverse osmosis treatment, and brine concentration. The estimated productive/restoration life of Operating Area #1 is about 7 years. All timing is subject to discovery of additional reserves which will, by necessity, extend the duration of the uranium recovery and restoration period before final decommissioning.

1.5 Central Processing

Loaded ion exchange resin from the Church Rock, Unit 1 and/or Crownpoint sites will be processed at a common central processing plant. Plans call for the processing plant to be located at the Crownpoint site. An alternative approach is for loaded resin to be processed at one of HRI sister company's (URI, Inc.) two licensed process facilities in Texas according to the criteria outlines in NRC Regulatory Issue Summary 2012-06. [95] Processing resin in Texas will not affect operation of any of the three satellite facilities.

1.6 Waste Disposal

HRI will maintain an area within the restricted area boundary for storing contaminated materials prior to disposal. All contaminated pond residue and other waste will be disposed of at an NRC-or Agreement State-licensed waste disposal site. Prior to beginning operations, HRI will develop and maintain an agreement for the disposal of 11e(2) by-product material with a facility licensed by the NRC or an Agreement State to accept such material. Liquid wastes will be disposed of by deep disposal well, or evaporation.



Crownpoint Schedule (Estimate)
ID
Task Name
Y4
Y5
Y6
Y7
Y8
Y9
Y10
Y11
Y12
Y13
Y14
Y15
Y16
Y17
Y18
Y19
Y20
Y21
Y22
Y23
Y24
1
Initial Construction
2
Operation
3
Well Field #1
4
Well Field #2
5
Well Field #3
6
Well Field #4
7
Well Field #5
8
Aquifer Restoration
9
Well Field #1
10
Well Field #2
11
Well Field #3
12
Well Field #4
13
Well Field #5
14
Stability and Decommissioning

Figure 1.4-6

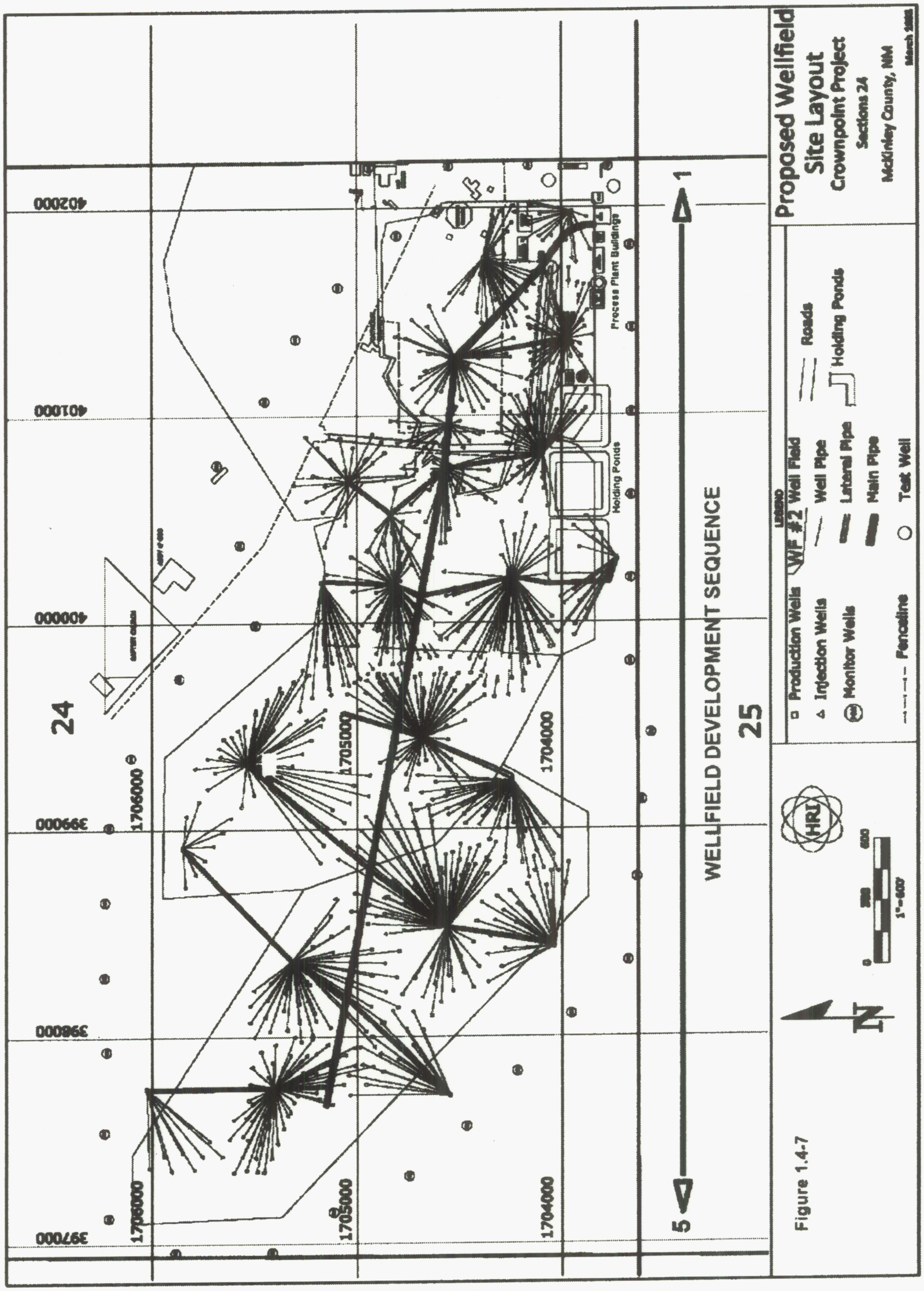

Proposed Wellfield
Site Layout
Crownpoint Project
Sections 24
McKinley County, NM
Production Wells
Injection Wells
Monitor Wells
Fenceline
LEGEND
WF #2 Well Field
Well Pipe
Lateral Pipe
Main Pipe
Test Well
Roads
Holding Ponds
HRI
WELLFIELD DEVELOPMENT SEQUENCE
5
1
24
25
Process Plant Buildings
Holding Ponds
397000
398000
399000
400000
401000
402000
1706000
1705000
1704000
N

Figure 1.4-7

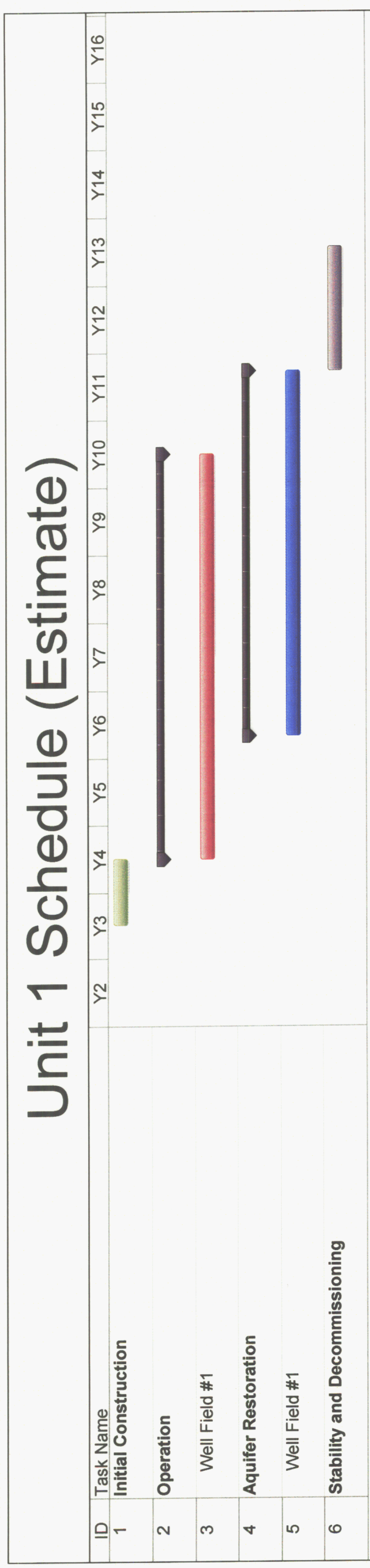
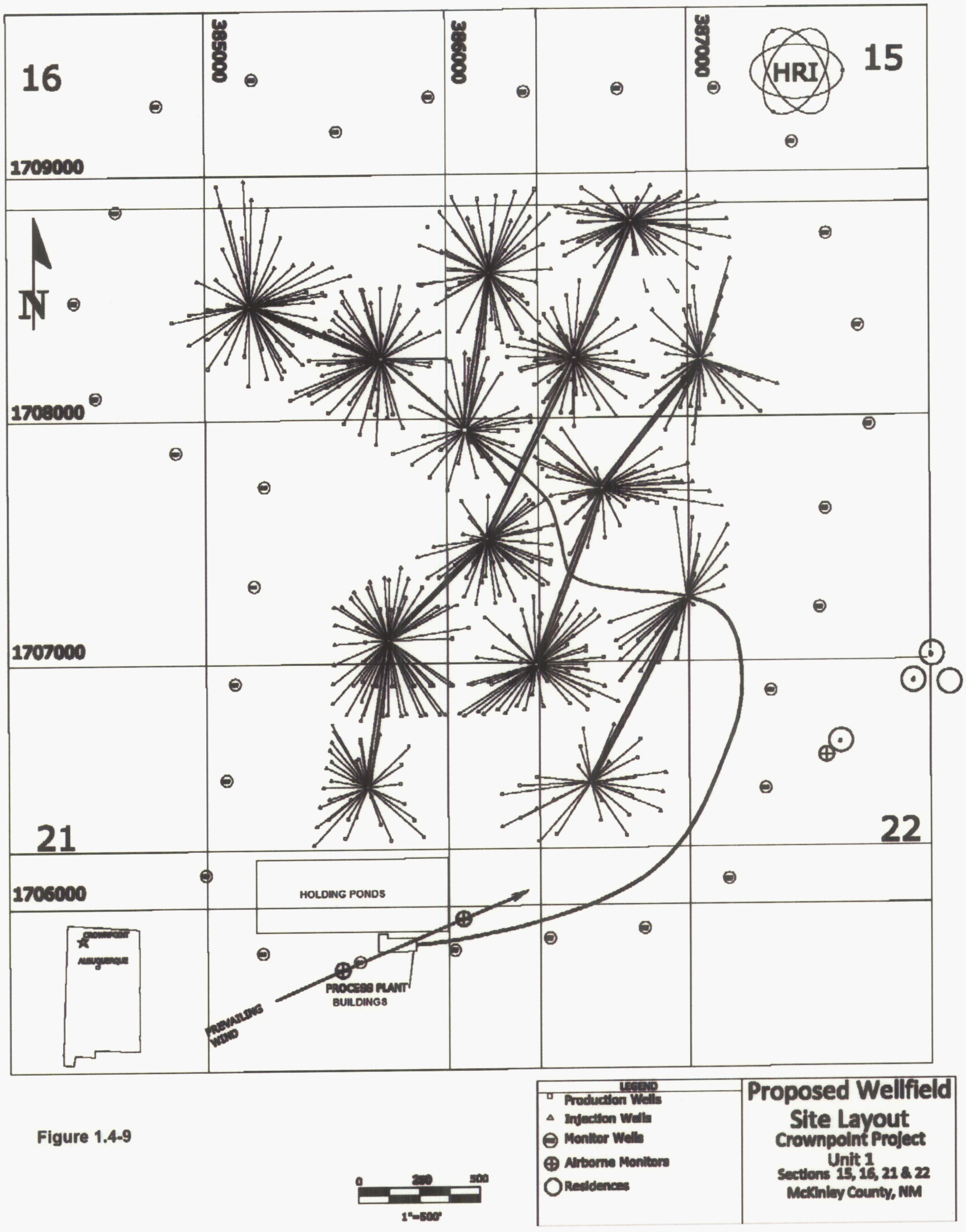

Unit 1 Schedule (Estimate)
ID
Task Name
1 Initial Construction
2 Operation
3 Well Field #1
4 Aquifer Restoration
5 Well Field #1
6 Stability and Decommissioning
Y2
Y3
Y4
Y5
Y6
Y7
Y8
Y9
Y10
Y11
Y12
Y13
Y14
Y15
Y16

Figure 1.4-8



16
15
HRI
385000
386000
387000
1709000
1708000
1707000
1706000
N
21
22
HOLDING PONDS
PROCESS PLANT
BUILDINGS
PREVAILING
WIND
LEGEND
Production Wells
Injection Wells
Monitor Wells
Airborne Monitors
Residences
Proposed Wellfield
Site Layout
Crownpoint Project
Unit 1
Sections 15, 16, 21 & 22
McKinley County, NM
1"=500'

Figure 1.4-9

1.7 Financial Assurance

HRI will provide financial Assurance (FA) for closure, including surface and subsurface restoration, and reclamation. The amount of the FA will be determined by the NRC based on cost estimates for completion of the approved reclamation plan by a third party in the event that HRI defaults. The FA will be reviewed annually by the NRC and adjusted to reflect expansions in operations, changes in engineering design, and inflation. The amount of FA will also be subject to NMED and/or EPA regulatory approval, and the form will meet the requirements of NMWQQC 5-210.B.17, and/or 40CFR144.63.

1.8 Cultural Resources Management

HRI will maintain and implement a final cultural resources management plan for all mineral operating lease areas and other land affected by licensed activities, pursuant to the National Historic Preservation Act Section 106 review and consultation process. The plan will provide specific procedures to implement HRI's policy of avoiding cultural resources. The plan will include archaeological and traditional cultural property surveys of all lease areas, identification of protection areas where human activity will be prohibited, archaeological testing (by an archaeologist contracted to HRI and holding permits from the Navajo Nation and the State of New Mexico as appropriate) before subsurface disturbance occurs at a specific location. Archaeological monitoring will be employed during all ground disturbing construction, drilling, and operation activities. In the event that previously unidentified cultural resources or human remains are discovered during project activities, the activity in the area will cease, appropriate protective action and consultation will be conducted, and if indicated, the artifacts or human remains will be evaluated for their significance.

1.9 NRC Performance Based Licensing (PBL)

Consistent with NRC licensing policy, HRI is planning operations to be consistent with PBL license format. Under the PBL format HRI will ensure the proper implementation of the Performance Based Condition. Under this format HRI can:

a. Make changes in the facility, or process, as presented in the COP.

b. Make changes in the procedures presented in the COP.

c. Conduct tests or experiments not presented in the COP without prior NRC approval, if HRI ensures that the following conditions are met:

1. The change, test, or experiment does not conflict with any requirement specifically stated in the license (excluding material referenced in the Performance Based License Condition) or impair HRI's ability to meet all applicable NRC regulations.

2. There will be no degradation in the essential safety or environmental commitments in the license.

3. The change, test, or experiment will be consistent with NRC's conclusions regarding actions analyzed, and selected in the Final Environmental Impact Statement.

If the provisions of 1.8 are not met, HRI is required to submit an application for a License Amendment to the NRC. HRI's determinations whether the above conditions are satisfied will be made by a Safety and Environmental Review Panel (SERP). The SERP will consist of a minimum of three individuals; one member of the SERP will have expertise in management, and will be responsible for managerial and financial approval changes; one member will have expertise in operations and/or construction and in implementation of any changes; and one will be the RSO. Additional members may be included in the SERP as appropriate to address technical aspects in several areas, such as health physics, ground water hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be outside consultants.

1.10 Maintaining Records

HRI will maintain records of any changes made pursuant to the Performance Based License Condition until license termination. The records will include written safety and environmental evaluations made by the SERP that provide the basis for the determination that the particular change is in compliance with the requirements referred to above. HRI will furnish an Annual SERP Report to NRC that describes such changes, tests, or experiments, including a summary of the safety and environmental evaluation of each. In addition, HRI will submit the results of the annual ALARA review in accordance with 10 CFR 20 Subparts Land M, and revise the COP of the License Application to reflect changes made under this condition. All such records will be retained for a minimum of five years.

2.0 SURFACE FACILITIES

The proposed CUP may consist of three separate satellite facilities including the Churchrock, Crownpoint and Unit 1 satellites, and the Crownpoint Central Plant (CCP). Each satellite will contain equipment used for production and restoration. The Crownpoint satellite and other two satellite plants will be similar except the Crownpoint satellite may also be combined with the CCP yellowcake processing equipment, dryer system, and yellowcake drum storage area.

2.1 Processing Plant Equipment

At each satellite site HRI will conduct uranium mineral extraction using down flow pressurized columns containing IX resin, vessels to store various solutions, piping, and pumps. The proposed process pumps lixiviant from the well field through these columns and returns it to the well field injection circuit. The IX system will be operated in a closed system under low but continuous pressure.

The CCP (Figure 2.1-1) and satellite processing plants (Figure 2.1-2) may contain various vessels to hold and process liquid solutions. The principal vessels may include the down flow pressurized IX columns described above and, at the CCP, elution columns and yellowcake precipitation tanks. Other tanks will hold barren eluant and yellowcake slurry. HRI's COP includes general specifications for all vessels and piping. The specifications cite applicable American Society for Testing and Materials (ASTM) standards for plastic and fiberglass components, and American Society of Metallurgical Engineers (ASME) guides for all steel vessels that will be operated under pressure. [13][2]

When uranium is removed from the resins the concentrated uranium solution will be stored, and processed in precipitation tanks. Precipitated uranium will be sent through the drying process where it will be partly dewatered, washed, dried, and packaged for storage and shipment.

The satellite facilities at Churchrock, Crownpoint, and Unit 1 will only produce resin loaded with uranyl carbonate complex, but the CCP will also include drying and packaging equipment. Access to the yellowcake production and storage area will be restricted. Other chemical storage tanks may be located on a concrete pad near the retention ponds.

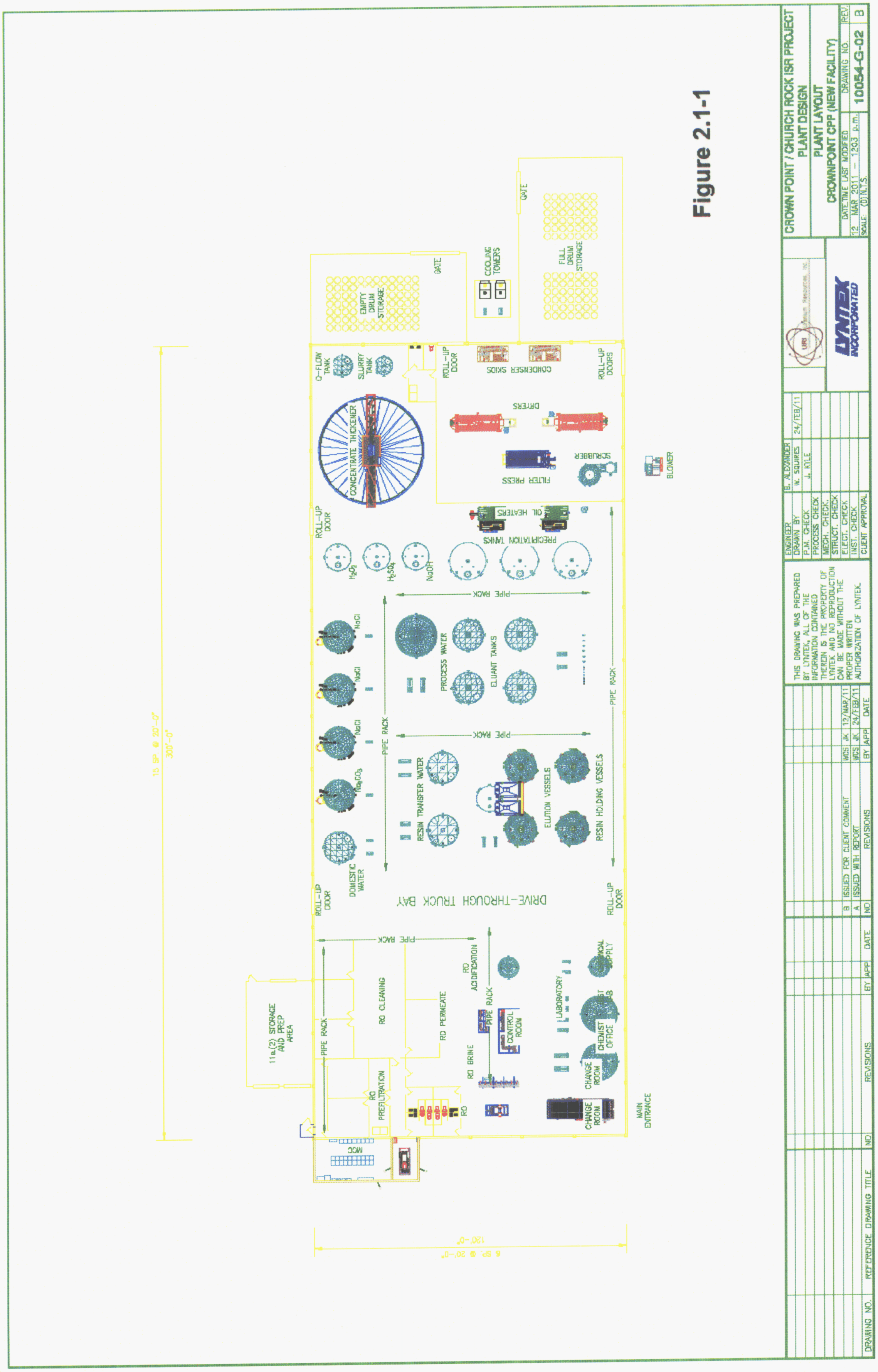

CROWN POINT / CHURCH ROCK ISR PROJECT
PLANT DESIGN
PLANT LAYOUT
CROWNPOINT CPP (NEW FACILITY)
DRAWING NO.
10054-G-02
REV
B
LYNTEK INCORPORATED
CONCENTRATE THICKENER
SLURRY TANK
DRYERS
CONDENSER SKIDS
FILTER PRESS
SCRUBBER
BLOWER
OIL HEATERS
PRECIPITATION TANKS
PIPE RACK
PROCESS WATER
ELUANT TANKS
RESIN TRANSFER WATER
ELUTION VESSELS
RESIN HOLDING VESSELS
DOMESTIC WATER
DRIVE-THROUGH TRUCK BAY
ROLL-UP DOOR
EMPTY DRUM STORAGE
FULL DRUM STORAGE
COOLING TOWERS
GATE
RO CLEANING
RO PERMEATE
RO BRINE
RO ACIDIFICATION
RO PREFILTRATION
LABORATORY
CONTROL ROOM
CHANGE ROOM
MAIN ENTRANCE
MCC

Figure 2.1-1

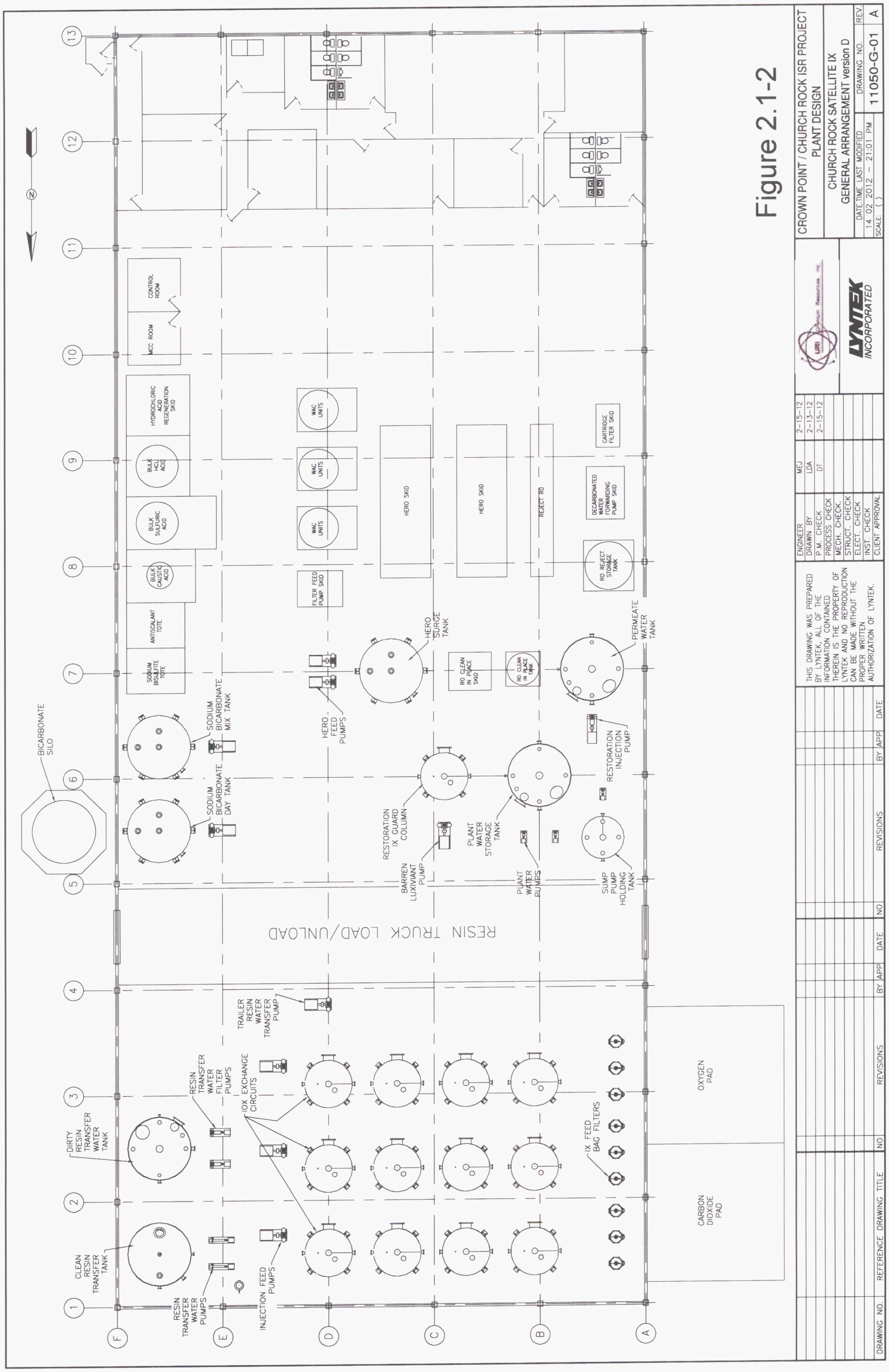

CROWN POINT / CHURCH ROCK ISR PROJECT
PLANT DESIGN
CHURCH ROCK SATELLITE IX
GENERAL ARRANGEMENT version D
11050-G-01
LYNTEK INCORPORATED
RESIN TRUCK LOAD/UNLOAD
BICARBONATE SILO
SODIUM BICARBONATE MIX TANK
SODIUM BICARBONATE DAY TANK
HERO SURGE TANK
HERO FEED PUMPS
PERMEATE WATER TANK
RESTORATION INJECTION PUMP
RESTORATION IX GUARD COLUMN
PLANT WATER STORAGE TANK
BARREN LUXIVIANT PUMP
PLANT WATER PUMPS
SUMP PUMP HOLDING TANK
DIRTY RESIN TRANSFER WATER TANK
CLEAN RESIN TRANSFER TANK
RESIN TRANSFER WATER PUMPS
RESIN TRANSFER WATER FILTER PUMPS
INJECTION FEED PUMPS
IOX EXCHANGE CIRCUITS
TRAILER RESIN WATER TRANSFER PUMP
IX FEED BAG FILTERS
OXYGEN PAD
CARBON DIOXIDE PAD
CONTROL ROOM
MCC ROOM
HERO SKID
REJECT RO
WAC UNITS
RO REJECT STORAGE TANK

Figure 2.1-2

Major structures to be provided at each facility initially may include, but are not limited to:

a. process pad, on which uranium ion exchange equipment will be located (Table 2.1-2);

b. waste retention ponds;

c. restoration treatment equipment also located in the processing plant;

d. office and service building (laboratory control room, workshops, etc.);

e. production chemical storage pad, and;

f. brine concentrator pad.

Table 2.1-2 CUP Processing Equipment.

Restoration Equipment	Processing Equipment
Chemical Tanks	Chemical Tanks
Cleaners	Sand Filters
Mix Tank	Down flow Pressurized IX Columns
RO Water Storage	Pumps
Final Filters	Barren Eluant Columns*
RO Units	Yellowcake Slurry Tanks*
RO Ion Exchange	Yellowcake Storage Tanks*
RO Sand Filters	Filter Press*
Brine Concentrator	Dryer system*

* CCP Only

2.2 Process Pad

The process pad will be made of concrete and provided with sumps, drains, and at least a 6 inch high curb at the periphery. The pad will be underlain by a synthetic liner that will capture potential leakage through cracks in the concrete. Thicker footers will be provided where heavy processing equipment and vessels will be located. The curb will be designed to confine and hold potential spills in the plant, and potentially contaminated runoff from the processing equipment area. The pad curb and sump will be adequate to contain the volume of the largest tank on the pad.

2.3 Retention Ponds

Where practical at the CUP, retention ponds will be constructed such that all retained fluid is below ground level. This will eliminate the potential for embankment failure, and the need for NRC Regulatory Guide 3.11 criteria. [88] Retention ponds will be added as needed to accommodate the fluid handling requirements of the operation.

The purpose of retention ponds will be to store waste, or restoration water until treatment, promote evaporative loss of water which cannot be discharged to the environment, and maintain control of source and byproduct material found in the liquid effluents from ISR. Initially, two or more retention ponds will be constructed at each site. These ponds will occupy up to 6 acres. If below ground level construction is found not to be possible, HRI commits to design and construct its pond embankments to meet specifications in NRC Regulatory Guide 3.11: *Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills.* [88]

Sixty days prior to beginning construction of wastewater retention ponds at any CUP production center, HRI will submit for NRC approval, detailed drawings and analysis/calculations for the pond embankment locations, diversion channels, and erosion protection design. Additionally, HRI will demonstrate through detailed engineering analyses that the ponds and diversion channels around the ponds will be stable under a probable maximum flood condition, in accordance with NRC Staff *Guidance*[4]. Included in this submittal will be HRI's planned SOP for inspecting and maintaining the pond liners and embankments, diversion channel, etc.

Standard provisions for the ponds will be two impermeable synthetic membrane liners: an inner 30 mil Hypalon liner or equivalent, and an outer liner 36 mils thick made of Hypalon, or equivalent (1 mil=0.001 inch). A space 4 to 5 inches thick between the two liners will contain sand or some other (granular) porous medium and a drainage network of open piping, forming an underdrain leak detection system. The (inner) liner will provide secondary containment for any leakage that may occur. The ponds

[4] NRC Regulatory Guide 3.11 recommends a 6 hour probable maximum precipitation (PMP) event to determine storage capacity and freeboard requirements (see page 12 of Regulatory Guide 3.11) as long as the ponds will be designed to contain only direct precipitation that falls on the pond area. In this scenario, there would be no external contributing drainage area to the ponds. As this is a regulatory guide, licensees or applicants can propose alternate design storms as long as adequate justification is provided. The staff's primary concern is that the licensee maintains control of byproduct material. If a licensee or applicant can make a case that an alternate design storm can provide the same control byproduct material, it could be acceptable to staff.

will be inspected daily for leakage. Fluid levels greater than six inches found in the leak detection system will be cause for immediate corrective action, including immediate notification of NRC by telephone.

2.3.1 Churchrock Pond Design Features

Based on results of surface hydrological engineering analysis which HRI performed for the Churchrock satellite process facility (Espey, Huston & Ass. Inc. 1993, 1996b), HRI concluded that the nearby unnamed arroyo tributary to the Puerco River and its overbanks do not affect the proposed satellite in the Probable Maximum Precipitation (PMP)/ Probable Maximum Flood (PMF) event. [23][25] The Puerco River was not considered a flood hazard to the satellite due to its extreme horizontal separation from the site, more than 1 mile to the south. The backwater effects of the Puerco River on the unnamed tributary leading to the site are not considered substantial enough to warrant an in-depth investigation. The study concluded that a riprap diversion channel will be sufficient to safely and efficiently route surface water away from the proposed site. Further detailing of the berm system will be dependent on the proposed site grading and will be part of the license condition.

2.3.2 Crownpoint Pond Design Features

In the event that HRI elects to maintain the existing on-site lined impoundments in their current location at Crownpoint , the channel and erosion protection improvements as described in the following analysis will be performed.

A surface hydrological engineering analysis was performed to determine the adequacy of the existing drainage channel and berms south and west of the three impoundment ponds (Espey, Huston & Ass. Inc., 1996a). [24] This channel was determined to be inadequately sized to carry a PMF event. A proposed solution was selected which is designed to prevent the PMF from overtopping the embankment, and to maintain effective erosion protection along its slope.

Initially, a surface water hydrologic analysis was performed for the site to determine a peak flow rate based on a PMP event. The selection of the PMP as a design storm based on NRC Staff Technical Position WM 8201 Hydrologic Criteria for Tailings Retention Systems. [[69] The particular PMP event selected is based on the criteria stated in Chapter 2: Design Flood Estimation from Methodologies for Evaluating Long-Term Stabilization Designs of Uranium Mill Tailings Impoundments prepared for the U.S. Nuclear Regulatory Commission, and HMR #49 Probable Maximum Precipitation Estimates, Colorado River, and Great Basin Drainages prepared by the National Weather Service. [50][29] From these sources a 6-hour drainage average depth local-storm PMP was determined to be the most conservative PMP for this analysis.

Using USGS topography maps along with on-site 1”=100’ scale topography maps, a 2.7 square mile drainage basin was determined for a design point approximately 3500 feet downstream of the existing facility site. This drainage basin was separated into drainage areas to determine how storm water runoff reaches portions of the site. Soil Conservation Service (SCS) methodology was used to determine Runoff Curve Numbers (CN) and Time of Concentration (T) values. [102] The CN values are conservatively estimated in the range of 87-88. The T values ranged from 20-45 minutes. This data was used in the U.S. Army Corps of Engineers (ACOE) HEC-1 Flood Hydrograph Computer Model, along with the calculated PMP, to calculate runoff hydrographs. [58] From these hydrographs, peak flow rates were selected for use in calculating the PMF. Three rates were selected along the channel, and occur at approximately 2.5 hours into the 6-hour PMP. This data is summarized in the Table 2.3-1.

Table 2.3-1 Hydrologic Summary Table

Location	Contributing Drainage Area	Peak Flow Rate for PMP
Upstream end of existing diversion channel (southeast corner of site)	1.37 mi^2	11,428 cfs
Confluence of existing diversion channel and arroyo (southwest corner of site)	1.75 mi^2	14,516 cfs
Approximately 3500 feet downstream of the end of the diversion channel	2.73 mi^2	19,599 cfs

To determine the PMF water surface profile and channel velocities, an ACOE HEC-2 Water Surface Profile Computer Model was prepared. [59] Supplemental information was determined using the ACOE HEC-RAS (River Analysis System) Computer Modeling Software.[59] Topographical information for the channel and its overbanks were determined using 1”=100’ scale on-site topography maps. Selection of other variables, such as surface roughness coefficients ('n' values), is based on a sensitivity analysis to determine the most conservative values.

Based on the existing conditions analysis, all three impoundment ponds would be inundated by the PMF. The flooding of the westernmost pond (containing drill mud) is due in part by the backwater effect of the road and culvert just to the northwest. However, the primary reason all three ponds would be inundated is that the drainage channel is not adequately sized to accommodate the PMF. The high flows also produce high velocities within the channel as determined by the HEC-2 computer model. These velocities would be sufficient to cause erosion of the existing embankment.

A proposed solution was selected that protects the two uppermost ponds and abandons the use of the lowest pond (containing drill mud). This proposed solution begins by lowering and widening the existing channel to a 40-foot bottom width with 3:1 side slopes. The limits of this improvement fall between where the two arroyos reach the channel at the southeast and southwest corners of the site. The channel will expand to the south so as not to encroach on the existing embankment between the channel, and impoundment ponds. It will also be lowered to eliminate the concrete pad washout at the southwest corner, and to reduce the elevation of the PMF. Its slope will be approximately 0.005 with several small drops lined with rock riprap. In addition, rock riprap will be laid on the embankment between the impoundment ponds and the channel to protect that slope from erosive velocities which still occur in this proposed condition, although at a reduced rate. Finally, the existing road and culvert will be demolished and converted to a low water crossing.

The riprap design for median rock size (D50) and layer thickness were determined by using methodologies described in Design of Erosion Protection Covers for Stabilization of Uranium Mill Tailings Sites prepared for the NRC.[79] Using the Safety Factors Method, a D50 size of approximately 16" has been preliminarily determined based on flow depth and channel slope. Additionally, the minimum thickness of the rock layer should be about three feet.

2.3.3 Unit 1 Pond Design Features

A qualitative description and assessment of the surface water drainage conditions was conducted for the Unit 1 satellite site(Espey, Huston & Ass. Inc., 1996c). [26] A portion of the Crownpoint, NM (USGS) quadrangle and an aerial photo of the site were used to conduct this qualitative analysis.

The Unit 1 satellite will be located approximately 3.5 miles west of Crownpoint. The proposed site lies on a high ridge between two existing shallow arroyos. These arroyos run from south to north, and begin on the north side of the access road to the site. The proposed site (building and ponds) will be no closer than 500 feet to either arroyo.

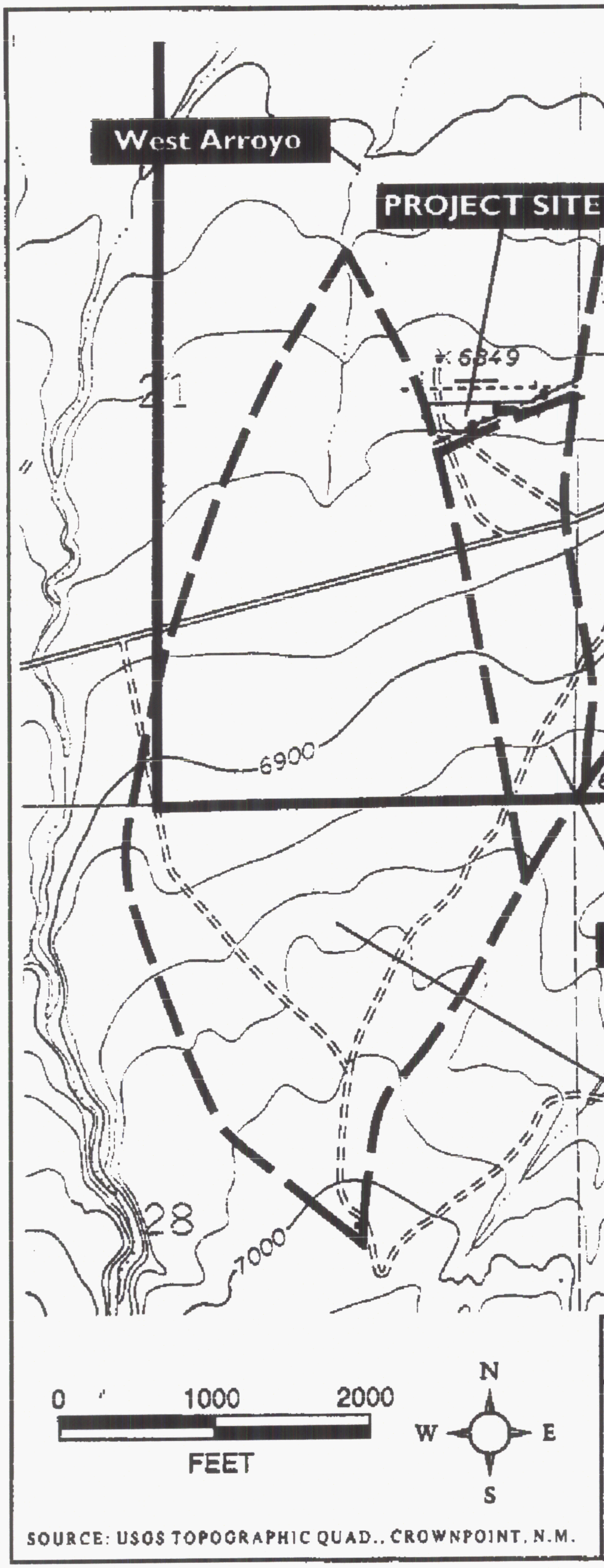
A Rational Method Calculation was performed to determine approximate flows reaching the arroyos in the vicinity of the project site during the Probable Maximum Precipitation (PMP) event. A full (100%) 1hr-1mi^2 PMP rainfall, adjusted for elevation, is approximately 8.9 inches. The rainfall depth is dependent on the rainfall duration for each drainage area. It was calculated by determining times of concentration (T_c) for the two small drainage areas leading to the arroyos, and using T_c as an approximate rainfall duration. The rainfall duration and depth were then used to determine rainfall intensity for each drainage area.

A possible solution to route Drainage Area 3 away from the proposed site is a diversion channel that directs flows toward the East Arroyo. Table 2.3-2 shows a breakdown of existing and proposed hydrologic characteristics of the Drainage Areas based on their delineations shown on Figure 2.3-1.

Using Manning's equation, routing Drainage Area 3 towards the East Arroyo could be handled by a trapezoidal channel 3' deep, 8' wide, with 5:1 side slopes, at an incline of 2%. The velocity in this proposed channel is about 10 feet per second (fps) but erosion should be of minor significance considering the horizontal separation from the proposed site. With both arroyos shown in Figure 2.3-1 beginning near the site, there is not much opportunity to accumulate significant flows or flooding elevations. With the flows listed above, overtopping of the arroyos will be likely to occur but the 500 foot separation between the arroyos and the site should be more than sufficient to avoid the PMF Floodplain. A more detailed look at arroyo flooding will be part of the license condition. Local on-site drainage and diversion will also be handled at a later date through the site development plans as part of the license condition.

Table 2.3-2 UNIT 1 SATELLITE HYDROLOGIC (RATIONAL METHOD) SUMMARY TABLE

	Drainage Area (A) (ac)	Time of Concentration (T_c) (min)	Intensity (I=rainfall depth/duration) (in/hr)	Runoff Coefficient (C) (-)	Peak PMP Flow Rate (Q=CIA) (cfs)
East Arroyo, Existing Conditions (DA1)	55	27	17.2	1.0	946
Drainage Area 3, Existing Conditions	45	33	14.6	1.0	657
East Arroyo, Proposed Conditions (DA1+DA3)	100	35	13.9	1.0	1390
West Arroyo, Existing and Proposed Conditions (DA2)	230	55	9.5	10.	2185



EH&A Espey, Huston & Associates, Inc.
Engineering & Environmental Consultants

FIGURE 2.3-1

SITE LOCATION AND
DRAINAGE AREA MAP
8/30/96

2.4 Tankage

2.4.1 Fiberglass Vessels

The standard utilized in the fabrication of fiberglass reinforced tanks conform to Voluntary Product Standard PS 15-69. [8] This voluntary standard, initiated by the Society of Plastics Industry, Inc. was developed under the Procedures for the Development of Voluntary Product Standards and is published by the Department of Commerce. The purpose of this product standard is to establish a national basis for standard sizes, dimensions, and significant quality requirements for commercially available, glass-fiber-reinforced, chemical-resistant process equipment. Nomenclature used in the industry comes from American Society for Testing and Materials (ASTM) Designation D883-69, Standard Nomenclature Relating to Plastics, and includes the following definitions: [14]

a. Glass Content - Glass content will be determined in accordance of ASTM Designation D2584-67T: Tentative Method of Test for Ignition Loss of Cured Reinforced Resins. [11]

b. Tensile Strength - Tensile strength will be determined in accordance with ASTM Designation D638-67T: Standard Method of Test for Tensile Properties of Plastics. [9]

c. Flexural Strength - Flexural strength will be determined in accordance with Procedure A, and Table 1 of ASTM Designation D790-66: Standard Method of Test for Flexural Properties of Plastics. [10]

d. Flexural Modulus - The tangent modulus of elasticity in flexure will be determined by ASTM Method D790-66. [10]

e. Hardness - The hardness will be determined in accordance with ASTM Designation D2583-67: Standard Methods of Test for Indentation Hardness of Plastics by Means of a Barcol Impressor. [4]

2.4.2 Vessel Design - Fiberglass

The design of vessel wall thickness will be predicated on using a safety factor of 10 to 1; using mechanical property data for Glass Content, Tensile Strength, Flexural Strength, Flexural Modulus, and Hardness; utilizing a liquid specific gravity of 1.2; and temperatures of 180 degrees Fahrenheit. Glass content, tensile strength, flexural strength, flexural modulus and hardness will be determined in accordance with the American Society for Testing Materials (ASTM). [4]

2.4.3 Choice of Fiberglass

When bidding fiberglass vessels to commercial fabricators, HRI always requests conformity to Voluntary Product Standard PS 15-69. This standard addresses the criteria used in manufacturing fiberglass flanges, vents, elbows, tees, crosses, eccentric reducers, and the compounds. Finally, the resin of choice for most applications within the recovery operation will be one that can stand up to acids and bases over a broad pH spectrum.

2.4.4 Steel Vessels

Filters and down flow ion exchange vessels will be fabricated from steel using the American Society of Metallurgical Engineers (ASME) guide of Section VIII, Division 1, for the design and fabrication of pressure vessels. [3] This design incorporates a safety factor of four times the design pressure at conditions specified by the end user. Pressure testing for at least one hour at 1.5 times maximum operating pressures is required to obtain ASME coding. HRI specifies all of its steel pressure vessels to be built to these standards.

2.4.5 Piping

Process piping within the plant facility will be made of steel, polyvinyl chloride (PVC), fiberglass, and high density polyethylene (HDPE) of varying diameters and wall thickness which follow ASTM standards. [16] Wherever applicable, the use of PVC and HDPE piping will be utilized because of their superior rating for chemical resistivity.

a. PVC Piping - ASTM standards for PVC pipe and fittings are divided among five groups. [17] These groups are: Group A, Plastic Pipe Specifications; Group B, Plastic Pipe Fittings Specifications; Group C, Plastic Piping Solvents, Cements, and Joints; Group D, Methods of Test; and Group E, Recommended Practices. In addition, Product Standards have been established for each grouping. [17] Type I and II PVC are defined by manufacturer's recommended standards, and these standards originated from Product and ASTM Standards.

Processing solutions will normally be transferred under load pressures (<150 psig) within the plant facility. According to PS 21-70, and ASTM 1785, the maximum working pressure at 73.4 degrees Fahrenheit for 8 inch, schedule 40 PVC is 160 psig. Most PVC piping within the extraction facility will range below 6 inches in diameter. Maximum working pressure for 6 inch diameter PVC is 180 psig. Schedule 80 PVC, which has a wall thickness slightly larger than schedule 40, can sustain maximum operating pressures at higher levels. For example, 6 inch diameter schedule 80 PVC pipe has a maximum operating pressure of 280 psig.

All process piping will be designed in accordance with generally accepted engineering standards according to the flow rate, required pressure, and the medium being processed. Process pumps will also be sized to minimize required discharge pressures to achieve transfer requirements as specified.

b. Steel Piping - The use of steel piping will be minimized within the water treatment facility. However, if steel pipe is specified for a particular application, then the rated operating pressure for that pipe will be used in the design specifications. The construction of line steel pipe conforms to ASTM A53 for standard plain end pipe. [18] For example, Grade A pipe of dimensions 8 inches, 10 inches, and 12 inches have maximum operating pressures of 1,300, 1,200, and 1,400 psig respectively. These safe operating pressures far exceed any that will be employed at either the central plant or satellite facilities.

HRI will employ all safety, and design features that have been successfully employed at its twin operations in Texas. The use of generally accepted engineering design will be utilized in the specification, and selection of piping, and tankage.

2.5 Yellowcake Dryer System at Crownpoint

Yellow-cake slurry at Crownpoint will be dried by a batch-type low temperature rotary vacuum dryer system. The drying and packaging will occur in the same area. Yellowcake drums awaiting shipment will be stored on a curbed concrete pad inside the restricted area. The system includes:

a. A drying chamber, approximately 4 ft. by 12 ft., equipped with an internal mixing auger and a mechanism for directly discharging the dried product into 55 gallon drums;

b. a bag filter to capture and return to the drying chamber the entrained solid particles present in the exiting vapor stream;

c. a water-cooled condensing unit to cool and liquefy water evaporated from the yellowcake slurry;

d. a vacuum pump, and;

e. a recirculating closed-loop hot oil heating system that uses a propane, natural gas-fired, or electric boiler to heat the oil.

2.5.1 Operation of the Vacuum Dryer System

A feed slurry containing approximately 50% water by volume, will be pumped into the drying chamber. Slurry transfer will be made by hydraulic transport through a pumping loop. A complete batch (approximately 2500 kg of yellow-cake) obtained from the filter press will be transferred to the dryer system and a record of the production inventory will be kept by weighing the yellow-cake drums. Drying will be achieved at about 100 degrees Celsius in a vacuum of 18 to 26 inches of mercury, with the hot oil recirculating around the drying chamber at about 230 degrees C. Drying progress will be monitored by the rise in level of condensed water in the condenser column. Drying time will be typically 9-14 hours per batch. Total cycle time including cooling, drum packaging, and refilling will be about 16 to 24 hours.

HRI will, during all periods of yellowcake drying operations, ensure that the manufacturer recommended vacuum pressure will be maintained in the drying chamber consistent with the provisions of 10 CFR 40 Appendix A Criterion 8 which requires that milling operations must be conducted so that all airborne effluent releases are reduced to levels as low as is reasonably achievable. The primary means of accomplishing this must be by means of emission controls.This will be accomplished by continuously monitoring differential pressure and installing instrumentation which will signal an audible alarm if air pressure differential falls below the manufacturers recommended levels. Yellowcake drying operations will be immediately suspended if any emission control equipment for the yellowcake drying or packaging areas will be not operating within the specifications for design performance. Manufacturer's recommendations for maintenance and operation of yellowcake dryers, and checking and logging requirements will be followed as specified in 10 CFR Part 40.

2.5.2 Dryer System Control of Particulates Emissions

The bag filter will be designed to recover 99.5% of the solids entrained in the water vapor, and any solids escaping this filter would be captured by the circulating sealant water within the vacuum pump. This water, which will be kept cool by passage through a cooling tower, will be periodically diverted to the production circuit to recover collected yellowcake particles, or will be diverted to the wastewater circuit. The vapor discharge line from the vacuum pump will be vented to the atmosphere.

2.5.3 Packaging

Dried yellowcake will be packaged in appropriately labeled, USDOT-approved, 55 gallon drums. Each drum in turn will be placed on a vibrating platform beneath the drying chamber, raised hydraulically, and secured at the rim to the dryer discharge chute. Drums will contain 650-1000 pounds of yellowcake. Filled drums will be lowered, covered, sealed, weighed, labeled, and moved to storage by means of forklift trucks or dollies specifically designed for this purpose.

2.5.4 Transportation of Chemicals and Reagents

HRI uses a number of reagents in the production of yellowcake. The primary reagents that will be transported are HCl, NaOH, $NaHCO_3$, H_2O_2, compressed liquid CO_2, liquid O_2, and NaCl. All transportation will be on paved roads except for a 9200 foot segment of unpaved, maintained road between Unit 1 and Navajo Highway #9 and a 1500 foot maintained segment of Church Road between Navajo #9, and the Crownpoint site.

2.5.5 Transportation To/From CCP

At the maximum production rate of 1 million lbs. per year for each satellite, it will be anticipated that up to 350 shipments of resin will be transported from each satellite facility to the processing facility per year. All transportation will be on paved roads except for a 9200 foot segment of unpaved, maintained road between the Unit 1 satellite and Navajo Highway #9, and a 1500 foot maintained segment of Church Road between Navajo #9, and the CCP. Additionally, HRI will utilize the Navajo #9 by-pass route so shipments of material will not pass through the town of Crownpoint. Transport of resin to Texas will be routed south on either SH 566 from the Church Rock site or SH 371 from the Unit 1 or Crownpoint sites to I-40. All delivery trucks used to transport project materials (resin, yellowcake, etc.) will carry the appropriate transport papers and all delivery truck drivers will hold appropriate licenses. The transportation route will be shown on Figure 2.5-1.

2.5.6 Transportation of Yellowcake to Conversion Plant

Following drying and packaging of the yellowcake product, the product will be sold to utilities. Yellowcake will be sold, and if transported from the CCP, handled with the same precautions defined in 2.5.5 except that the yellowcake will be shipped south on Highway 371 to Interstate 40 near Thoreau. Depending on production levels, twenty to sixty shipments a year are anticipated.

2.6 Well Fields

2.6.1 Churchrock

Well fields at the Churchrock satellite facility will be confined to T16N, R16W, Sections 8 & 17, as described in Section 1.1.2. The Churchrock satellite will consist of one production area which will be developed in two phases: the Section 8 phase, and the Section 17 phase. The production area (the area completely contained within the monitor well ring) will consist of approximately 200 acres with disturbances limited to approximately 133 acres.

The layout of the well field is shown on Figure 1.4-8. It is in the floor of the valley and will not be materially affected by the nearby escarpments. Injection, extraction and monitor wells will be constructed with sufficient setback from the arroyo that bisects the site to assure that erosion does not affect operations. Fully developed, it will consist of multiple injection and production wells which will feed into approximately 19 metering houses. All distribution lines from the individual wells to the meter house will be buried below frost depth. Main trunk lines will be on the surface or buried, and will lead from the meter houses to the satellite plant on Section 8.

2.6.2 Crownpoint

Well fields at the Crownpoint site will be confined to T17N, R12W & R13W, as described in Section 1.1.1. The initial operating area will consist of one production area on the south 1/2 of Section 24. The production area (the area completely contained within the monitor well ring) will consist of approximately 300 acres with disturbances limited to approximately 164 acres. The layout of the initial well field is shown on Figure 1.4-3. The

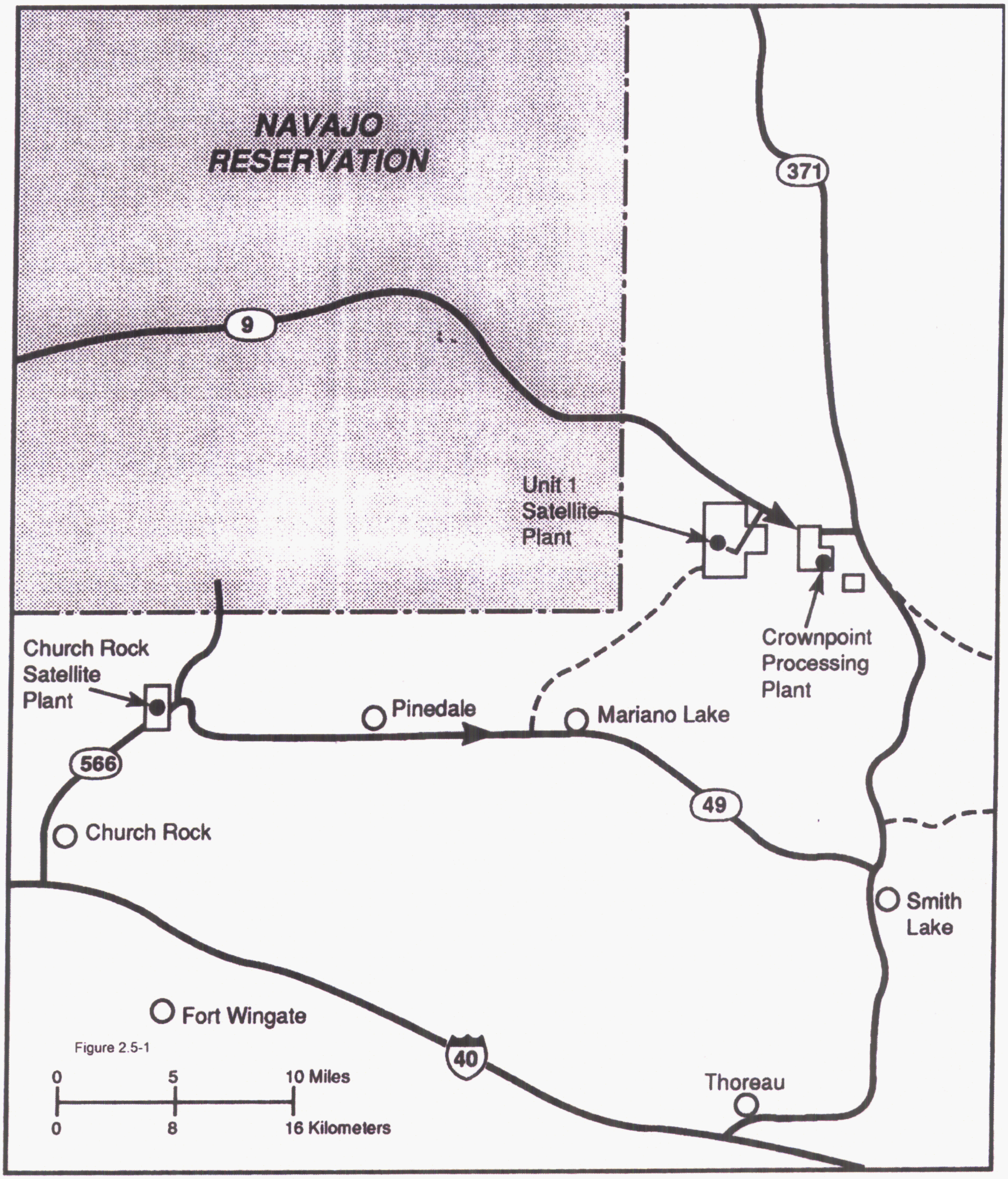

NAVAJO
RESERVATION
371
9
Unit 1
Satellite
Plant
Crownpoint
Processing
Plant
Church Rock
Satellite
Plant
Pinedale
Mariano Lake
566
49
Church Rock
Smith
Lake
Fort Wingate
Figure 2.5-1
0
5
10 Miles
0
8
16 Kilometers
40
Thoreau

Figure 2.5-1

well field will be located on flat terrain. When fully developed it will consist of multiple injection and production wells which will feed into approximately 25 metering houses. All distribution lines from the individual wells to the meter house will be buried below frost depth. Main trunk lines will be buried, and will lead from the meter house to the adjacent processing facility.

2.6.3 Unit 1

Well fields at the Unit 1 satellite will be confined to T17N, R13W as described in Section 1.1.3. The initial operating area will consist of one production area centered in the land block. The production area (the area completely contained within the monitor well ring) will consist of 750 acres when fully developed. The disturbance caused by the initial well field will be approximately 89 acres.

The layout of the initial well field is shown on Figure 1.4-5. It will consist of multiple injection and production wells which will feed into approximately 14 metering houses. All distribution lines from the individual wells to the meter house will be buried below frost depth. Main trunk lines will be buried, and will lead from the meter house to the satellite plant on Section 21.

3.0 OPERATIONAL PROCESSES

3.1 Introduction

At the CUP, the lixiviant will consist of native ground water to which gaseous oxygen and gaseous carbon dioxide and/or sodium bicarbonate have been added. After the lixiviant is injected into injection wells and recovered from production wells, it will be pumped to the processing plant where the uranium will be removed by passing the pregnant (uranium rich) lixiviant across ion exchange resin.

Loaded ion exchange resin will be periodically trucked to a process facility for processing into yellowcake. Yellowcake will be dried and then stored in drums for shipment to a purchaser at a UF_6 conversion or other nuclear fuel cycle facility.

3.2 Lixiviant Injection/Recovery

Uranium, present in the host ore in a reduced insoluble form, will be oxidized by the lixiviant solution injected into the ore zone. Once uranium is oxidized it complexes with bicarbonate anions in the groundwater and becomes mobile. ISR will proceed with the continuous recirculation of fortified groundwater solution through the uranium ore from the injection to the production wells. Uranium in the ore will react with the lixiviant to form a soluble uranyl dicarbonate complex.

$$2UO_2 + O_2 \rightarrow 2UO_3$$
$$UO_3 + 2NaHCO_3 \rightarrow NA_2UO_2(CO_3)_2 + H_2O$$

3.2.1 Lixiviant

The lixiviant, which will be comprised of native ground water fortified with sodium bicarbonate and/or gaseous carbon dioxide, and oxygen, will be injected into injection wells. After passing through the ore zone the pregnant lixiviant will be pumped from production wells to the satellite where the uranium will be extracted by ion exchange onto resin. The resulting uranium-depleted (barren) water will then be refortified with O_2 and re-injected into the well field to repeat the uranium recovery cycle. The lixiviant typically consists of the parameter concentrations shown in Table 3.2-1.

Table 3.2-1 Projected Lixiviant Chemistry
(mg/l unless otherwise noted)

Calcium	100 - 500
Magnesium	10 - 50
Sodium	500 - 1600
Potassium	25 - 250
Carbonate	0 - 500
Bicarbonate	800 - 1500
Sulfate	100 - 1700
Chloride	250 - 1800
Silica	25 - 50
Total Dissolved Solids	1500 - 5500
Uranium	50 - 250
226-Radium	100 or greater pCi/L
Conductivity	2500 - 7500 uS/cm
pH	6 - 9 standard units

3.2.2 Production Well Circulation

Injection and production well operations are described in Section 6.5.

Injection well and production well flow rates will be monitored to assess operational conditions and mineral royalties. The flow rate of each production and injection well will be determined by monitoring individual flow meters in each well field metering house.

The pressure of the injection trunk line will be determined daily in each well field metering house. The surface injection pressures will not exceed the maximum surface pressures posted in each metering house.

Data records for these monitoring activities will be maintained on-site.

3.3 Ion Exchange (IX)

The pregnant groundwater solution containing the uranyl dicarbonate complex will be received at the satellite through a network of well field piping, collection headers, and trunk pipelines, and will be pumped through the pressurized ion exchange columns, operated in series in a down flow mode. The entire system will be pressurized, precluding the elevation of gasses including radon in the process building and the environment. Uranium will be exchanged on the reacting sites of the resin for chloride ion (if the resin is in chloride form) according to the following reaction:

$$Na_2UO_2(CO_3)_2 + 2RCl \rightarrow R_2\ UO_2(CO_3)_2 + 2NaCl,$$

where R is a reacting site of the ion exchange resin.

When the ion exchange resin in a column has captured uranium to its optimum loading capacity, uranium breakthrough will occur. That is, uranium concentration in the barren water exiting the IX column will begin to rise. At this point, the column will be taken out of the operating circuit and another column with fresh ion exchange resin will be placed on-line.

After the uranium is removed by the ion exchange columns the process bleed will be removed from the lixiviant stream. The bleed may be treated by R.O., and if it is, the "product", or cleaned water will be returned to the lixiviant injection or to the formation outside the well field pattern, or disposed of by an approved method. The process bleed insures that more water is withdrawn than is injected, thereby keeping the lixiviant laterally within the production zone.

The only factor which could threaten a continued process bleed is loss of power. Since natural groundwater flow near the proposed well fields is on the order of only a few tens of feet per year (even when considering the pumping effects of Crownpoint town water wells), the flow outward from the well field during the period of short term power outage (2-3 days for example) will not be significant or measurable because of the exceedingly slow natural groundwater migration rate. Although it may not be necessary, HRI will have diesel generating capacity during Crownpoint facility ISR well field operations to maintain a cone of depression, and lighting in the event of power outage. HRI will continue a bleed at the CUP properties until the well fields have been declared fully restored to the required permit/regulatory limits.

After the bleed is removed from the lixiviant stream exiting the IX columns, the uranium-depleted (barren) water will be refortified with requisite chemicals and piped back to the well fields for reinjection.

Sodium bicarbonate and/or gaseous carbon dioxide will be added as needed to the lixiviant, while oxidant will be dissolved into the barren water prior to injection into the injection wells. The entire injection, production, ion exchange, and reinjection process will be effectively a closed system. This allows retention of residual carbon dioxide, and oxygen during recirculation of the lixiviant.

3.4 Elution and Precipitation

Once loaded with complexed uranyl dicarbonate, resin will be transported to a processing facility to be eluted. A brine and soda ash solution will be used to remove the uranium from the resin. The following chemical reaction occurs:

$$R_2UO_2(CO_3)_2 + 2NaCl + Na_2CO_3 \rightarrow Na_4UO_2(CO_3)_3 + 2RCl$$

In the first elution step, partially enriched eluant (from the second step of the previous elution) will be sent through the fully loaded ion exchange bed to yield a uranium-rich (pregnant) eluant, and will be stored separately in a tank. In the second step of the process, another partially enriched eluant will be passed through the partially denuded resin bed to remove the majority of the residual uranium present on the resin. The resulting partially enriched eluant will be stored in a recycle tank and used in the first step of the next elution cycle. In the third step of the elution process, a barren eluant will be passed through the mostly denuded resin bed and will then be used as the second stage of the next elution.

Uranium oxide will then be precipitated from the pregnant eluant. Carbon dioxide gas (CO_2) generated during acidification of the pregnant eluant with hydrochloric or sulfuric acid will be vented to the atmosphere. This breaks the carbonate complex from the uranium. Hydrogen peroxide will then be added to further oxidize the uranium and cause uranium oxide crystals to form and precipitate. The precipitate will be allowed to settle. The supernatant liquid (barren eluant) will be decanted and stored in two storage tanks, reconcentrated with salt (NaCl) and sodium carbonate, and reused in the uranium stripping circuit or discarded using appropriate disposal methods. A part of this stream will be discarded to the lined retention ponds periodically to keep accumulated impurities within limits.

3.5 Yellowcake Processing

As described in Section 3.4, pregnant eluant which contains uranyl d-, and tricarbonate will be acidified using hydrochloric acid (HCl) or sulfuric acid (H_2SO_4) to destroy the uranyl carbonate complex as shown below.

Hydrochloric Acid:

$$Na_4UO_2(CO_3)_3 + 6HCl \rightarrow UO_2Cl_2 + 4NaCl + 3CO_2 + 3H_2O$$

$$Na_2UO_2(CO_3)_2 + 4HCl \rightarrow UO_2Cl_2 + 2NaCl + 2CO_2 + 2H_2O$$

Sulfuric Acid:

$$Na_4UO_2(CO_3)_3 + 3H_2SO_4 \rightarrow UO_2SO_4 + 2Na_2SO_4 + 3CO_2 + 3H_2O$$

$$Na_2UO_2(CO_3)_3 + 2H_2SO_4 \rightarrow UO_2SO_4 + Na_2SO_4 + 2CO_2 + 2H_2O$$

In the next step hydrogen peroxide will be added to the solution to oxidize the uranium even further and cause it to precipitate according to one of the following reactions:

Hydrochloric Acid:

$$UO_2Cl_2 + H_2O_2 + xH_2O \rightarrow UO_4 \cdot xH_2O + 2HCl$$

Sulfuric Acid:

$$UO_2SO_4 + H_2O_2 + xH_2O \rightarrow UO_4 \cdot xH_2O + H_2SO_4$$

The crystalline uranyl peroxide slurry (UO_4 or yellowcake) may require pH adjustment, and then will be allowed to settle. The yellowcake will be further dewatered using a filter press. Finally, the yellowcake will be washed with a clean water to remove impurities such as sorbed chloride, and then dried at the CCP. Water left over from the dewatering and drying will either be reused in the elution circuit or sent to the waste pond. HRI's proposed operations at the CUP will result in a yearly production rate of approximately 3 million pounds of yellowcake.

3.6 Process Controls and Alarms

The potential for liquid leaks and spills will be minimized by adhering to SUA-1580 and NRC design criteria for uranium ISR recovery facilities, designing adequate spill containment and leak detection systems, training employees on monitoring procedures for process parameters and recognizing potential upset conditions before leaks or spills occur, training employees on inspection procedures for spill control BMPs in the SWPPP, frequently inspecting waste management systems and effluent control systems, and training employees in spill detection, containment and cleanup procedures.

Hazardous and nonhazardous chemicals will be used throughout the life of the project. Hazardous chemicals with the potential to affect radiological safety will be stored in a separate area of each processing facility. Hazardous chemicals also will be stored away from incompatible chemicals and away from areas frequented by workers to reduce the risk of injury during an accidental release. All hazardous chemicals at the project areas will be handled and stored in accordance with Federal, State and local regulations, including the CFR, OSHA, and EPA.

Process fluids will be contained in process vessels and pipes during operation. Instrumentation, controls, and alarms will monitor the flows, pressures, and tank levels to maintain parameters within prescribed limits. If a tank or process vessel fails the fluid will be contained in the process building. The fluid will be collected in the plant sumps and then pumped to other process vessels or a lined retention pond. After the fluids have been removed, the area will be washed down with plant water. The water will be collected in the plant sump system and pumped to a lined retention pond, thereby mitigating potential environmental impacts due to tank failures.

Secondary containment in the form of curbs and sumps will be installed around all chemical storage tanks, process vessels, and piping and equipment inside the processing buildings and chemical storage areas. The process pad at each processing facility will be made of concrete and underlain by a synthetic liner that will capture potential leakage through cracks in the concrete. Thicker footers will be provided where heavy equipment and vessels will be located. The pad curb and sump will be adequate to contain the volume of the largest tank on the pad.

Spills or leaks also could occur from piping or equipment outside of the processing facilities. In such an event, operational controls and alarms will signal an alarm (e.g., low pipeline pressure or water in a sump), the leak or spill will be contained, and fluids will be captured and transported to the lined retention ponds for disposal. All areas affected by such a failure or leak will be surveyed and any contaminated soils or material will be removed and disposed in accordance with NRC and State requirements.

In the event of a piping failure within the processing facilities, low pressure sensors will trigger alarms and the pump system will shut down, preventing any further release. Any liquid waste released in the processing facilities will be transported to the lined retention ponds for disposal.

Metering houses will be equipped with leak detection equipment that will signal alarms at the processing facilities. In addition, routine periodic inspections of metering houses and wellheads will be conducted by qualified personnel. Well field operators will visually inspect all piping and equipment within metering houses, wellheads, and valve vaults at least weekly. In the event of a leak, the affected soil will be surveyed for contamination and the area of the spill will be documented. If contamination is detected, the soil will be sampled and analyzed for the appropriate radionuclides. Contaminated soil will be removed and disposed in accordance with NRC and State requirements.

Flow monitoring and spill response procedures are expected to limit the impact of potential spills to surficial aquifers. In New Mexico, storm water runoff is controlled by a SWPPP issued by EPA.

4.0 CUP WASTE MANAGEMENT

4.1 General

The CUP and its associated facilities will generate different classes of waste materials: (1) domestic sewage; (2) AEA solid 11e.(2) byproduct material; (3) AEA liquid 11e.(2) byproduct material; (4) solid non-11e.(2) byproduct material; and (5) liquid non-11e.(2) byproduct material. In addition to the discussion below, HRI commits (as previously noted) that it will dispose of all AEA 11e.(2) byproduct material at properly licensed disposal facilities or using appropriate liquid disposal methods (e.g., evaporation). HRI also commits to dispose of all domestic sewage or non-11e.(2) byproduct material in accordance with appropriate disposal permits and procedures.

4.2 Domestic Sewage & Other Wastes

The CUP, like other licensed ISR projects, will generate liquid wastes that may be classified as domestic sewage or other similar wastes such as wastewater from restrooms, shower facilities, and miscellaneous sinks located throughout the office and change rooms. As discussed in HRI's initial license application, it remains the best management solution to employ a standard conventional septic tank/leach field system. As a result, HRI continues to commit to using this approach for its license renewal.

4.3 11e.(2) Byproduct Material

As is commonplace for all licensed ISR projects, the recovery of uranium from ores primarily for its source material content generates AEA-licensed 11e.(2) byproduct material. Consistent with the Commission's directive pursuant to 10 CFR Part 40, Appendix A, Criterion 2 and page 2-14 of HRI's CUP FEIS, HRI commits to no on-site disposal of solid 11e.(2) byproduct material at CUP project sites. [101] HRI also re-affirms its previous commitment to have a solid 11e.(2) byproduct material disposal agreement in place prior to commencement of licensed operations.

4.3.1 Liquid 11e.(2) Byproduct Material

During licensed uranium production, the major source of liquid 11e.(2) byproduct material will be the process bleed which has been estimated to be approximately one (1) percent of an IX flow rate. The process bleed will be managed in accordance with the requirements of HRI's current license to ensure that an adequate cone of depression is maintained throughout each well field both during initial operations and during concurrent operations and restoration. Liquid 11e.(2) byproduct material also may be present as wastewater resulting from plant decontamination wash-downs and other water treatment activities.

During groundwater/aquifer restoration, the primary source of liquid 11e.(2) byproduct material will be restoration fluids from restoration processes. Restoration fluids will be generated as a separate stream during HRI's initial Church Rock Section 8 demonstration project and during final well field restoration. In other instances, restoration fluids will be generated concurrently with uranium recovery operations in other well fields. Regardless of the timeframe, as determined by the Commission in 2000, restoration fluids are 11e. (2) byproduct material and will be disposed of in accordance with HRI's previous commitments, including but not limited to, brine concentration, evaporative waste retention ponds, and deep well disposal or a combination of these methods. As stated on Page 26 of HRI's CUP SER, current license conditions limit the usage of these options to "either surface discharge (with appropriate State or Federal permits/licenses), brine concentration, waste retention ponds, or a combination of the three options to dispose of such liquid 11e.(2) byproduct material." Surface discharge is no longer proposed. Other than that change, HRI concurs with NRC Staff's conclusions in Section 7.0 of the SER with respect to liquid 11e. (2) byproduct material disposal and does not propose to change any aspects of these approvals. In addition, HRI has no new information to demonstrate that any of these options, whether used singularly or in conjunction with one or more of the other approved options is not a viable liquid 11e.(2) byproduct material disposal solution.

4.3.1.1 Reverse Osmosis

Reverse osmosis is a water treatment process whereby the majority of dissolved "ions" are separated from the waste water and concentrated into a smaller concentrated brine volume. HRI is also evaluating the use of high-efficiency RO (HERO) units that would further reduce the brine volume requiring disposal. The resulting product water typically meets or exceeds drinking water standards, and during restoration activities is re-injected back into the well field further diluting the underground recovery solutions toward baseline quality. The concentrated brine system, representing 5-30% of the feed volume, must be disposed by either deep well disposal, surface evaporation, or further reduced in volume by brine concentration (a form of distillation).

Osmosis is a natural process that occurs in all living cells. With an appropriate semi-permeable membrane as a barrier to solutions of differing concentrations, naturally occurring osmotic pressure forces pure water from the dilute solution to pass through the membrane and dilute the more concentrated solution. This process will continue until an equilibrium exists between the two solutions.

Reverse osmosis (R.O.) is a reversal of the natural osmotic process. By confining a concentrated solution against a semi permeable membrane, and applying a reverse pressure on the concentrate greater than the naturally occurring osmotic pressure, water will move across the membrane ("product water"), and out of the original concentrate, resulting in an even more concentrated solution ("brine"). The membrane rejects the passage of the majority of the dissolved solids while permitting the passage of water.

HRI, Inc. will likely utilize spiral wound, polyamide, thin film composite membranes, or equivalent for the CUP. These membranes were selected primarily for their inherent rejection characteristics across the range of dissolved solids likely found at the CUP. Spiral wound membranes have a greater ability to flush particulates through to brine (i.e. non-fouling), unlike their predecessor hollow filament membranes which were easily plugged by precipitates and other micron-size debris.

The polyamide membrane composition can withstand a broad range of operating pH (1-12), whereas the cellulose diacetate membranes require a much narrower range of pH, near 5.5. This advantage translates into smoother and less troublesome operating control of the reverse osmosis unit because of its tolerance to pH changes occurring within the feed solution. Another benefit of the polyamide membranes is the elimination of needed pH adjustment of the product water. This condition occurs because the hydrogen ion (H) passes more readily through the membrane wall than its reciprocal hydroxyl ion, causing a lowering of the pH in the product water when compared to the feed solution.

However, one disadvantage of the polyamide membranes is their low tolerance of strong oxidants such as dissolved oxygen or residual chlorine (disinfectant) As a result, an oxygen scavenger such as sodium bisulfite might be added to R.O. feed water. The final product water will then be slightly on the reduced side electrochemically, thus aiding in the restoration of any oxidized ionic species.

Post-ISR solutions from a depleted well field will be directed to a surge tank in the plant area. If necessary, sodium bisulfite and an anti-scalent will be added at this point. If a high efficiency reverse osmosis system is used, then additional pretreatment may be necessary in order to raise the efficiency of the unit. The solution may next be bulk-filtered across sand filters to remove all solids greater than 30 microns. Filters will then filter out the remaining solids greater than 3 microns. The solution at this point will be ready for the reverse osmosis process.

To achieve reverse osmotic purification, the pretreated solution will be pressurized to approximately 235 pounds per square inch (psi) by a centrifugal pump. The pressurized solution will be directed to the first step of a two-stage reverse osmosis process. Approximately 50 percent of the total feed volume will be converted to product water in the first stage. The brine water of the first stage will then act as the feed for the second stage, which yields an overall product to brine ratio of 2-3:1 or more if a HERO system is used. The brine generated will be disposed of by evaporation and/or brine concentration and evaporation. The quality of the product water will be vastly superior to that of the Westwater Formation. It is expected that the product water will be mixed with post-ISR fluids before reinjection.

4.3.1.2 Deep Disposal Well

The most cost-effective method for disposal of waste water and brines from ISR operations is the use of a deep disposal well. Injection of waste water and brines into a deep geologic formation is used at URI’s ISR facilities in south Texas and is the preferred means of liquid waste disposal where technically feasible. Preferred geologic formations are repositories containing total dissolved solids (TDS) in excess of 10,000 ppm. Additionally, confinement from overlying and underlying fresh water aquifers must be demonstrated.

Wastes must be relatively neutral in the acid-base spectrum before being deep well injected. Calcium and iron scaling inhibitors are often added prior to injection of the water which is continuously monitored for pressures and flow rates.

Mobil/TVA drilled a test well at Crownpoint to establish the availability of deep seated confined aquifers containing water in excess of 10,000 ppm TDS, which also met the confinement criteria. Two zones meeting these criteria were determined: the Permian Abo and Yeso Formations. If HRI plans to use deep well injection it will require a that a Class I UIC Permit from the New Mexico Environmental Department of Environment (NMED), or US EPA.

4.3.1.3 Brine Concentrator

A brine concentrator may be used for disposal of liquid waste. Costs related to a brine concentrator make it less advantageous than a deep disposal well. Before brine concentration of wastewater will be employed, water will be pretreated by ion exchange for uranium removal. Then, the effluent will be processed by reverse osmosis to produce a product water that can be re-injected in a Class V well outside the production pattern, or back into the well field during the restoration cycle. The RO reject stream will be treated with brine concentrator and the resulting brine stream will be discharged to double-lined ponds for evaporation.

Brine concentration is a process that can literally process a waste stream into deionized water and a solids slurry. Many electrical utilities in the Four Corners area, and paper and pulp companies have employed this technology for decades to handle their waste streams. The principle behind the process is based on the ideal Carnot cycle. More simply explained, an initial fixed volume of concentrated brine is heated to boiling temperature. The steam vapor created is mechanically compressed, resulting in a secondary steam vapor whose temperature is elevated (15-20 degrees) by the work consumed during compression. Distilled water is condensed from the secondary steam vapor onto internal heat exchangers. The heat loss during condensation is transferred to the circulating brine on the opposite side of the heat exchanger. The brine's temperature is raised, maintaining the internal boiling environment. This source of heat sustains the creation of primary steam used to feed the compressor. The cycle is continuous so long as energy is added at the compressor stage. The electrical power consumed in compressing and elevating the temperature of the primary steam vapor produces a distilled product water. The resultant hyper-concentrated brine allows solid precipitate in the form of common salts as determined by the solution's limits for solubility. Systematic blow down of the solid slurry is directed to a waste disposal pond. Typically, for each 100 gallons of waste brine treated, 99 gallons of distilled water and 1 gallon of slurry solids would be formed.

This technology provide a system which utilizes no more than 1-2 gallons per minute of groundwater during recovery operations, and restoration, and which will generate a solid waste stream in the form of precipitated sludge. The sludge will be disposed as byproduct material.

4.3.1.4 Evaporation Ponds

This system is similar to brine concentration in that liquid wastes are evaporated' but unlike brine concentration the waters are not recondensed. Since the vapor pressures of high TDS solutions are low, resulting from the additional attractive ionic forces in the waters, the solar evaporation rates will be lower than for ordinary fresh water (2.5 gpm per acre). Therefore, to dispose of up to 150 to 250 gpm which will be maximum amount produced during restoration at a given location:

a. Up to 100 acres of double-lined ponds will be required.

b. If a spraying system was installed in the ponds, the aerial evaporative extent required will be up to 45 acres. As such, spraying systems will be a logical enhancement for evaporation at the project.

c. At the conclusion of recovery operations and restoration, the evaporative solids formed, and those solids blown into the ponds from the surrounding land, will be disposed appropriately.

Volume reduction by solar evaporation from ponds will generally be used for all waste streams. The use of HERO technology would greatly reduce the sizing of ponds.

4.3.2 Solid 11e.(2) Byproduct Material

Solid 11e.(2) byproduct material generated at the CUP will be spent or spilled resin as a result of normal operations and groundwater restoration, spilled yellowcake product, soils from well field or other facility spills, and site equipment and other materials resulting from well field and surface reclamation and from site decommissioning and decontamination. According to the criteria approved by NRC Staff in its initial license, HRI commits to characterizing solid 11e.(2) byproduct material wastes by scintillation probe and separated into unrestricted and restricted use categories. All contaminated equipment will be surveyed before the determination of its final disposition. The record of the survey will be completed on a form according to standard operating procedures. All equipment that does not meet the release requirements will be cleaned and resurveyed, or be disposed only in an NRC-licensed disposal facility, such as a licensed tailings impoundment. Any contaminated material accumulated at the site during operations or reclamation may be disposed as byproduct material. Alternatively, contaminated equipment can be sold or transferred to another source material license. This method will involve minimal decontamination and all shipments will be subject to U.S. Department of Transportation requirements. Restricted use contaminated equipment having no salvage value will be stored in a restricted area until it can be shipped to a licensed waste disposal facility. Materials that can be decontamination for unrestricted use can be sold or released offsite to the extent practicable. With respect to restricted use, as stated on Page 32 of the SER, HRI re-affirms its commitment to decontaminating to unrestricted release standards, or disposing of, all contaminated 11e.(2) byproduct material prior to final reclamation.

Materials that cannot be decontaminated to meet the unrestricted release standard will be disposed of at an appropriately licensed 11e.(2) byproduct material disposal facility. Currently in Texas, HRI's sister company maintains an 11e.(2) byproduct material disposal contract with Denison's White Mesa Mill and current assessments show that the amount of solid 11e.(2) byproduct material generated by the CUP will be within that facility's annual disposal limits. In the event that additional disposal capacity is required, HRI will pursue a supplementary contract with another available disposal facility. HRI continues to concur with its license condition on Page 31 of the SER regarding solid 11e.(2) byproduct material disposal.

4.4 Non-11e.(2) Byproduct Material

The CUP also will generate waste materials that do not qualify as 11e.(2) byproduct material under the AEA. These are materials that cannot be attributed directly to the processing of ores primarily for their source material uranium content. These materials are discussed below.

4.4.1 Liquid Non 11e.(2) Byproduct Material

Liquid non-11e.(2) byproduct material generated by the CUP will be confined to liquid wastes generated outside the scope of operations, groundwater restoration, and site decommissioning and decontamination. Such liquid wastes include, but are not limited to; water used during well field drilling and drill cleaning. These liquid wastes typically are confined to the site mud pits in a manner similar to drill cutting and other well drilling-related solid wastes. HRI re-affirms its commitment in its initial license application for handling of this material. Hazardous liquid waste such as used motor oil will be properly recycled or disposed of.

4.4.2 Solid Non 11e.(2) Byproduct Material

Waste generated during the pre-operational phase of the CUP, including but not limited to well field and CCP construction, will include well cuttings and other solid wastes from site construction. Such wastes will be confined to site mud pits and will be generated as minor, one-time, intermittent waste streams or will be stored and disposed of off-site pursuant to appropriate landfill requirements. As determined by NRC Staff on several previous occasions, these waste streams are determined to be non-11e.(2) byproduct material as TENORM and is not subject to off-site disposal requirements as 11e.(2) byproduct material. As a result, HRI adheres to its previous commitment that it will follow appropriate procedures to confine such waste streams to site mud pits and to contain any dispersion of any such materials.

The CUP also will generate solid non-11e.(2) byproduct material including office trash, boxes, miscellaneous wood packaging and products, steel, and pipes. As stated in its previous license application, HRI commits to obtain appropriate authorizations to dispose of such materials off-site.

5.0 AIRBORNE EFFLUENT CONTROL SYSTEMS

5.1 Non-Radioactive Airborne Effluents

Non-radioactive airborne effluents are limited to fugitive dust from well field access roads. In the event of significant fugitive dust from well field access roads, dust suppression of these areas may be utilized using either water or magnesium chloride.

5.2 Radioactive Airborne Effluents

Radioactive airborne effluents are regulated by the Nuclear Regulatory Commission (NRC) and regulatory limits are specified in Appendix B of Code of Federal Regulations Chapter 10 Part 20 (10 CFR 20). One of the most significant potential airborne radioactive effluent will be the release of 222-Rn gas, which is present in the ore zone and carried to the surface in the lixiviant. The second most significant potential airborne hazard is yellow cake which is natural uranium, and primarily a heavy metal toxic hazard as explicitly stated in 10 CFR 20.1201(e). Airborne hazard of uranium will primarily be focused during the time of packaging yellowcake into drums in the dryer system area, and will further be restricted to personnel packaging in the closed dryer system building, who will wear the required respiratory protection equipment.

5.2.1 Radon Gas

At various points in the uranium production process, radon gas may be vented to the atmosphere. These points of discharge will depend on the technology used at the plant and the need to minimize the doses received by workers and the public. The use of alternate technologies introduce different sources of possible exposure by radon. Examples of these possible points of discharge include: 1) Periodic radon release from pressurized down flow ion-exchange columns; 2) Radon release in waste water; and 3) Limited accidental release of radon and lixiviant from a leak in the pressurized system. HRI will vent the radon gas in such a way as to conform with the standards imposed by MILDOS calculations, and will take appropriate measures to monitor and abate radon exposure as required to protect both workers in the plant and the public at large. [63] HRI will use down flow IX columns and a pressurized system to abate radon exposure to ALARA limits, based on the best available technology. Moreover, where practible, all discharges will be into subsurface outlets to minimize the release of radon gas into the atmosphere.

Minor release from the plant will occur when individual pressurized IX columns are opened for resin transfer or elution. At this stage of the process, the contents of one IX column will be transferred to open eluant or precipitation vessels. Radon released will be limited to the fixed quantity of radon found dissolved in the water contained in one IX column. Radon escaping from the solution will be vented from the vessels through the ventilation system of processing buildings. In-plant monitoring will verify safe radon working levels are maintained in the plant.

The largest potential source of radon emissions from the proposed facilities will be waste water. Typically, radon dissolved in waste water will equilibrate with atmospheric pressure upon discharge into a retention pond. Enhanced with the turbulence caused by the pond discharge outlet, radon gas will come out of solution and escape to the atmosphere. If necessary, HRI proposes to reduce this radon source by partially removing it in intermediate holding tanks using a vacuum pump, compressing the gas and dissolving it in the lixiviant injection system.

The source term for radon gas (e.g. the quantity of gas that is released to the atmosphere from various locations within the in situ process) can be precisely measured by obtaining samples and then conducting same-time radon measurements in groundwater from the main trunkline on the pregnant side of the process facility ($Rn_{pregnant}$) and on the main trunkline of the barren side of the process facility (Rn_{barren}). The difference in the radon concentration ($Rn_{pregnant}$ - Rn_{barren}) has been released to the atmosphere and therefore becomes the source term which will be entered into the then current version of MILDOSE-AREA to determine compliance. The radon sampling schedule is stated in Table 9.5-1. Compliance will be demonstrated on an annual basis through modeling using measures radon release information from the previous year.

5.2.2 Airborne Yellowcake

HRI will use the low temperature vacuum dryer system described in Section 2.5 in its yellowcake drying and packaging system. The proposed vacuum dryer system will be designed to be a zero-emission device. Therefore, yellowcake emissions to the environment which may be of concern with open hearth type dryers will not be a concern at the CUP. Record keeping for the effluent control techniques will be sufficient to meet requirements in 10 CFR 20.2103(b)(4).

6.0 WELL DRILLING, INSTALLATION, COMPLETION, AND OPERATION

6.1 General

Several types of wells will be installed at the project site to facilitate the ISR process. Injection wells will be installed to allow the injection of the lixiviant. Production wells will be installed to allow the recovery (pumping) of the pregnant lixiviant (production fluid). Wells will be installed within the production zone to determine baseline water quality conditions, as well as monitor wells around the outside of the production zone (monitor well ring) to document the lateral control of the lixiviant. Monitor wells will be also installed in the first overlying aquifer above the production zone to ensure that the lixiviant does not migrate vertically from the production zone.

Production and injection wells will be constructed to assure that the well annulus is sufficiently cemented to prevent communication from the production zone to overlying aquifers penetrated by the well.

6.2 Production and Injection Wells

In the well field, injection wells will be arranged around production wells in patterns designed for optimum uranium recovery. The physical configuration of the mineralized ore zone, inferred from exploration geophysical logs, will determine production and injection well depths and the intervals from which uranium will be recovered. Typically, well patterns used for uranium ISR will include, but will not be limited to, alternating single line drive, staggered line drive, and five spot. Each well field area consists of groups of these patterns which will be installed to correspond with the irregular geometry of the ore bodies as determined from geological interpretation.

6.3 Monitor Wells

An extensive ground water monitoring program will be required for ISR and will be installed at the CUP for environmental monitoring. Selected wells will be monitored for water level and sampled for certain water quality parameters on a regular basis to ensure that the injected lixiviant stays within the defined production zone. Locations of monitor wells will be chosen to maximize detection of potential excursions of recovery solutions migration outside the production zone. Thus, with routine water quality determinations from monitor wells, early detection of this migration will be possible, allowing prompt remedial action and excursion prevention.

6.3.1 Production Zone Monitor Wells Spacing and Depth

Production zone monitor wells will be completed in the ore-bearing aquifer, encircling each well field at a distance of no more than 400 feet from the peripheral production or injection wells, and at spacing of not more than 400 feet apart. The angle formed by lines drawn from any production well to the two nearest monitor wells will not be greater than 75 degrees. The 400 foot spacing convention is widely used by the in situ industry throughout the United States. This spacing was originally determined through practical experience to locate monitor wells near enough to the operational areas to prevent broad areas of potential solution contamination, yet beyond the normal extent of the radially transported lixiviant.

In some areas of the proposed CUP sites, multiple ore horizons are vertically stacked within the Westwater Formation with no substantial confining layers between the ore bodies. In these areas, the perimeter production zone monitor wells would be screened across the full thickness of the stacked horizons and treated as a single production zone.

At the Churchrock site, monitor wells will be located by treating production mine workings like they were injection or production wells. Therefore, monitor wells will encircle each well field at a distance of 400 feet from the edge of the production, injection wells, and mine workings, and will be 400 feet apart. The angle formed by lines drawn from any production, injection well, or mine working to the two nearest monitor wells will not be greater than 75 degrees. This means that the detection of horizontal excursion will not be influenced by the presence of the mine workings.

6.3.2 Non-Production Zone Monitor Wells Spacing and Depth

Shallow monitor wells or non-production zone monitor wells will be completed in the aquifers overlying the ore zone. These wells will be located in the first overlying aquifer at a minimum of one well per every four acres of production wells. If a second overlying aquifer is identified, and evaluation of the thickness and integrity of the intervening aquitard will conservatively require its monitoring, then wells will be spaced in the second overlying aquifer at one well per eight acres of production wells.

6.4 Well Construction and Installation

All wells will be constructed so as to perform for the life expectancy of the well. All holes will be rotary-drilled with water well-type drill rigs which will be capable of circulating drilling fluids to the surface. The drill holes will be straight-drilled or directionally drilled depending upon the surface locations of obstacles such as cliffs or roads.

Each hole will be checked for deviation and logged. Spontaneous potential, resistivity and gamma ray logs will be obtained for all holes. This suite of logs is standard in the uranium industry. Where gamma logs indicate the presence of uranium mineralization, prompt fission neutron logging will be conducted. In the event that washouts are indicated, caliper logs will be called for to determine the cement quantities required for subsequent casing activities. Once a hole is drilled and logged, it can be determined if the location qualifies for commercial ISR activity and the hole will be cased.

Casings of injection, production and monitor wells will be either of threaded fiberglass or PVC, and perforated, under reamed or screened. A combination of fiberglass in the lower section of the hole and PVC in the upper hole will also be an option that may be used dependent on the site wells function (production, injection, and monitor wells) and the characteristics of the particular well field and the completion horizon. Fiberglass casing is preferred when differential drawdowns are expected to exceed 400 feet, fiberglass casing is capable of sustaining 1,400 feet of differential collapse pressure for 4" casing with a wall thickness of .150 inch. Besides its high resistance to collapse, fiberglass casing is acceptable for perforation since it will not shatter from the shock of perforation. Fiberglass and PVC casings are resistant to the oxidized conditions that are inherent uranium ISR.

PVC casing is a more economical alternative to fiberglass casing. PVC casing can sustain collapse pressures of over 400 feet for 6 inch SDR 17 casing. PVC is used widely in the uranium ISR business for its relatively good strength, low cost, availability, and resistance to the oxidized environment inherent in the ISR solutions. PVC casing is not as good for perforated completions because of its tendency to shatter, but techniques have been developed by HRI to use PVC casing and crossover to fiberglass casing to take full advantage of the properties of both casing types.

When considering the relative strength of casing materials with respect to operating conditions, one also needs to consider the additional strength provided by the cement sheath that exists in the annulus of the wellbore. This cement protects the casing by providing additional burst and collapse pressure resistance resulting from the relatively high compressive strength of the cement. This compressive strength increases the burst and collapse strength of the casing to approximately that of the cement. The physical properties of cement to be used follow:

Type:	ASTM Class I, API Class A
Density:	13.5 ppg
Additives:	2% bentonite gel
Compressive	2840 psig @ 80' F. & 72 hours
Strength:	3350 psig @ 1000 F. & 72 hours

(Source: Halliburton Cementing Tables) [27]

When the casing is run into the hole it will include centralizers with each being spaced between 150 to 200 feet along the total casing length.

Well Casing Specifications

	4″ PVC SCH 40	5″ PVC SCH 17	6″ PVC SDR 17	4″ FRP DHC 175	6″ FRP DHC 250
O.D. (inches)	4.500	5.563	6.625	4.680	6.900
I.D. (inches)	4.026	4.909	5.845	4.330	6.400
Wall Thickness (inches)	0.237	0.327	0.390	0.175	0.250
Casing Weight (lbs/foot)	2.030	3.450	4.890	2.100	4.750
Joint Length (feet)	21	21	21	30	30
Burst Strength (psig)	175	250	250	700	800
Collapse Strength (psig)	150	212	212	400	200
Material Specification	ASTM D-1785	ASTM D-2241	ASTM D-2241	API 15HR	API 15HR
Test Temperature (OF)	73.5	73.5	73.5	150	150
Test Temperature (OF)	73.5	73.5	73.5	150	150
Resistance to Lixiviant	Yes	Yes	Yes	Yes	Yes

ASTM D-1785: ASTM F480 Specs for PVC schedule 40, 80, and 120 pressures. [6][19]

ASTM D-2241: ASTM F480 Specs for PVC SDR rated pipe. [6][19]

Once the casing is run into a well, it will be cemented from bottom to top. The cement will consist of a slurry of Class A cement, approximately 2% bentonite gel, and water with a weight of approximately 13 ppg. The cement will be pumped through the casing and up the annular volume between the casing and borehole to the surface. The slurry volume will be sufficient to fill the annular volume, a portion of the lower casing volume, and to provide enough excess volume to fill any potential washouts with returns to the surface. After the entire slurry volume is pumped down the well, it will be displaced in the casing with water or a weighted fluid to a depth considered sufficient to ensure that enough cement remains in the casing to properly seal the annulus. The well will be sealed with the displacement fluid in the casing to prevent backflow and will be allowed to set for 48 hours to cure the cement. The properly designed displacement fluid will assure that the casing does not collapse prior to the curing of the cement.

The integral screen completion is typically used for shallower wells with very long completion intervals and satisfactory vertical isolation. The cement basket will be set in a confining shale above the completion interval and the screen will be suspended below the basket.

Perforated and under-reamed casing completion will be both used to open wells with casing placed across the target interval. The perforated casing completion utilizes hollow charge shots to punch holes through the casing, cement, and into the formation. The under-reamed casing completion uses a mechanical down hole tool to cut away the casing, cement, and the filter cake on the sand face. Both techniques would be very effective ways to open the well to the completion horizon. These completions provide very good vertical isolation of the interval due to cement remaining above and below the opening to seal the annulus of the casing.

The advantage of perforations is derived from the ability to operate them with a wire line unit at any depth. The advantage of under-reaming casing is that it allows the removal of the casing, cement, and filter cake from the completion interval. This creates a large diameter hole which allows for a very large surface area in the formation to be open to the wellbore. Historically, wells completed by under-reaming have demonstrated higher volumetric flow rates over those observed in perforated wells. The major disadvantage in under-reaming results from the limitations of the rotary rig and under-reaming tool. As the depths increase, the amount of weight resulting from the drill-string increases proportionally down hole on the blades of the cutter. HRI has a great deal of experience using under-reamers in deep wells, and with careful management of string weight and torque the under-reaming will be completed without major problems.

After the well completion, a set of cased hole geophysical logs will be run through the open interval and length of the casing. The single point resistivity and gamma ray logs may be run for this survey. The open interval and any potential casing leaks will be detected by the logs. After logging the well and opening the ore interval, the mechanical integrity of the casing will be tested.

6.4.1 Churchrock

Wells will be constructed at the Churchrock satellite to perform at depths averaging approximately 825 feet below the surface. At this depth the maximum injection pressure will be 137 psig (825 ft. x 0.167 psi/ft = 137 psig --- see Section 6.5.3). The maximum allowable wellhead injection pressure (MAWHIP) will be determined as in Section 6.5.3, and posted and monitored as described in section 6.6 to ensure that the formation fracture pressure will not be exceeded.

The casing will be constructed of either threaded fiberglass casing, solvent-welded PVC casing, or steel. The minimum casing design factors tabulated in Section 6.4 will be used for determining casing specifications.

6.4.2 Crownpoint/Unit 1

Wells will be constructed at the Crownpoint and Unit 1 satellites to perform at depths of approximately 2200 feet. At this depth the maximum injection pressure will be 367 psig (2200 ft. x 0.167 psi/ft. = 367 psig --- see Section 6.5.3). The MAWHIP will be determined as in Section 6.5.3, and posted, and monitored as described in section 6.6 to ensure that the formation fracture pressure will not be exceeded.

The casing for the upper wellbore will be constructed of either steel or threaded fiberglass casing, or a combination of each. The minimum casing design factors tabulated in Section 6.4 will be used for determining casing specifications.

6.4.3 Logging and Mechanical Integrity Testing

Subsequent to the well completion, certain cased-hole geophysical logs (single point, resistivity, gamma ray) may be used to survey the open interval and length of the casing. The open interval and possible casing leaks may be detected by the logs.

After the interval has been opened and cleaned (through air jetting, cross jetting, pumping, etc.), and the well casing has been logged, a mechanical integrity test (MIT) will be performed to further test the casing for possible leaks. An inflatable packer will be run into the well to a depth directly above the open interval. The packer will be inflated and the casing will be filled with water. The casing test pressure will vary with the maximum allowed injection pressure as described below. HRI will periodically retest the integrity of injection and production wells at an interval of every five years.

In all cases the well will be sealed, filled with water, and pressured up with air to at least 125% of the maximum allowable wellhead injection pressure (MAWHIP). The MAWHIP will be determined as in Section 6.5.3, and posted and monitored as described in section 6.6 to ensure that the formation fracture pressure is not exceeded. For example, at an average depth of 825 feet at Churchrock, the MAWHIP will equal 137 psig (825 ft. x 0.167 psi/ft), and for 2200 feet at Crownpoint, MAWHIP will equal 367 psig (2200 ft. x 0.167 psi/ft). Operating pressure will vary with the depth of the well and will be less than formation fracture pressure with a safety margin. After the test pressure is reached, the well will be sealed to hold pressure, and allowed to stand for 30 minutes. After 30 minutes, the well will be passed if less than 10% of the starting pressure is lost over the course of the test. If the pressure loss is greater than 10% and the well will fail the test, then action might be taken to locate and repair the leak, and the MIT re-run. The subsequent MIT will be passed before the well will be considered operational.

By determining MAWHIP by depth as described section 6.5.3, "in-line" injection pumps can be used at the wellhead (if desired) in order to increase the flow rate for selected wells where high rates may be necessary to "balance" to their extractors.

Records of mechanical integrity and construction details of the well will be recorded on a well completion report.

6.5 Well Operation

6.5.1 Production Flow Rates and Bleed

Each production well will be operated at the maximum continuous flow rate achievable for that pattern area. The primary consideration in determining maximum continuous flow rate will be to assure the well field is collectively balanced.

Generally, the overall injection flow rates into the well fields will be less than the total extraction flow rate by an amount known as "process bleed", resulting in a hydraulic pressure sink which causes native groundwater outside of the ore zone to migrate into the well field. This process bleed will be used to help protect the monitor wells against lixiviant excursion, and varies according ore geometry, well pattern and magnitude, and direction of the natural groundwater velocity. Since the process lixiviant is simply the natural groundwater recirculated continuously from the extraction wells through the surface IX facilities, into the injection wells, through the ore zone, and back to the extraction wells, the system can never be over injected, even with no process bleed. Groundwater velocity studies for the proposed CUP ISR sites indicate low natural groundwater velocities of 10 – 20 feet per year, which varies according to the natural hydraulic gradient and is site specific. As a result, the amount of process bleed used in any portion of HRI's well fields will also be site specific, incorporating effects of actual ore geometry and overall well field pattern, and operation. Since groundwater issues are strongly debated, and process bleed is considered a consumptive use of groundwater, process bleed will be minimized in all cases, yet will be sufficient to protect the monitor wells against excursion.

The process bleed, or excess water production from the well field, will be taken after uranium recovery and will form the primary liquid waste stream from the well field.

The net extraction of bleed will substantiate the 1/4 mile area of review as specified in NMWQCC 5-202.B.2 and 40CFR146.6.

6.5.2 Injection

The MAWHIP will be determined as described in Sections 6.5.3, 6.4.1.1, and 6.4.1.2. However, because the well casing is cemented into the bore hole, down hole pressures could substantially exceed the pressure rating of the well casing without adversely affecting the integrity of the well casing.

6.5.3 Formation Fracture Pressure

The terms "formation fracture pressure", as used throughout this COP, has the same definition and could be used interchangeably with the term "parting pressure". HRI will maintain down hole injection pressures less than the formation fracture pressure. To ensure that the formation fracture pressure will not be exceeded, the maximum wellhead surface injection pressure will be determined for each meter house and posted near the injection trunk line pressure gauge at each house.

The fracture pressure must be sufficient to lift the rock and water overlying the point of fracture, as well as overcome the adhesive property of the rock which resists "tearing". Rock Mechanics, as a field of study, has shown that hydraulically induced fractures will be formed approximately perpendicular to the least principal stress of the rock unit. Typically, this means that horizontal fractures will be formed for depths from surface to 1000 - 2000 feet, and vertical fractures below 1000 - 2000 feet.

The Oil & Gas industry has considerable experience in estimating formation fracturing gradient through the thousands of wells that have been cemented and/or purposefully fractured to enhance hydrocarbon production. Mathematical discussions of the fracture gradient have been presented (e.g., Hubbert and Willis in Underground Waste Management and Environmental Implications, AAPG Memoir 18, 1972), as well as empirical correlations developed by many of the Oil & Gas service companies (Halliburton, Dowell, EMCO). [47] One such correlation, EMCO Services' Fracture Gradient Chart 13 (EMCO 133-0778) for New Mexico, Oklahoma, and West Texas, indicates a fracture gradient of 0.645 psi per foot of depth (psi/ft) at 1,800 ft, and 0.655 psi/ft at 2,300 ft.[22] Using Hubbert and Willis, the fracture gradient in northwestern New Mexico is estimated at 0.64 to 0.70 psi/ft. To include a safety factor, a more conservative fracture gradient of 0.60 psi/ft was assumed for the fracture calculations shown here.

The hydraulic pressure at any point in the wellbore is the sum of the surface pressure plus the pressure caused by the weight of the fluids contained in the wellbore. This in turn equals the surface pressure plus the pressure gradient of the wellbore fluids times depth:

down hole psig = surface psig + (fluid gradient, psi/ft) (depth, ft)

Since ISR lixiviant essentially has a specific gravity of one, the wellbore fluid gradient equals that of water: 0.433 psi per foot depth (psi/ft). Thus, the estimated maximum allowable wellhead pressure (Max WHP) in northwestern New Mexico which will not exceed the formation parting pressure equals:

Max WHP = (fracture gradient - wellbore fluid gradient) x depth to open interval

Max WHP, psig = (0.60 psi/ft - 0.433 psi/ft) x (open interval depth, ft)

Max WHP, psig = (0.167 psi/ft) x (depth to open interval, feet)

This is conservative in that the New Mexico Oil Conservation Division (NMOCD) generally uses 0.2 psi/ft (approximately 20% higher than 0.167) for the parting pressure for the Cretaceous geologic system in the San Juan Basin absent any fracture tests. Using 0.167 psi/ft, the maximum allowable wellhead injection pressure (MAWHIP) can be determined as a function of the average depth to the open interval: MAWHIP at Churchrock for a depth of 825 feet will equal 137 psig, and for Crownpoint at 2200 feet, equals 367 psig.

Considering the fracture pressures in the Crownpoint area, a considerable safety margin will be included in the MAWHIP. As noted above, EMCO Services' Fracture Gradient Chart 13 (EMCO 133-0778) for New Mexico, Oklahoma, and West Texas indicates a fracture gradient of 0.645 psi/ft. at 1,800 ft., and 0.655 at 2,300 ft. [22] This translates into a 381 psig surface fracture pressure if the production zone were at 1,800 ft., and a 511 psig fracture pressure if the production zone were at 2,300 ft. Using HRI's proposed method of determining MAWHIP, injection pressure for the 1800 foot well will be 301 psig, and for the 2300 foot well will be 384 psig. A safety factor of 27%, and 33% at 1,800 ft., and 2,300 ft. respectively.

Consistent with regulatory requirements, prior to the injection of lixiviant HRI will conduct a Westwater Canyon aquifer step-rate injection test (fracture test)or acceptable equivalent within project site boundaries, but outside future well field areas at each of the three CUP sites. The parting pressure determined from these tests will be decreased by 25%, and used to determine the maximum allowable pressure gradient, and MAWHIP. They will be used in lieu of the estimates made above.

6.6 Well field Instrumentation

Injection, and production flow rates will be monitored in order that injection can be balanced with production across the entire well field, with the injection flow smaller than the production flow by the amount of the bleed rate. This information will also be used for assessing operational conditions and for determining mineral royalties.

A combination of meters will be used in the well field and the plant, with differing accuracy's dependent on their use. Because hundreds of flow meters will be in use at any particular time, and because no meter is 100% accurate, the overall summation of injection flows seldom ever exactly equals that of extraction. Yet, by the very nature of the closed ISR system, injection flow actually does exactly equal that of extraction, minus the bleed rate. As a result, injection flows will be prorated to that of extraction (or vice versa) after the bleed rate is subtracted. In addition, since ISR is a continuous operation across 24 hours a day for every day of the year, some meters will require repair and will give faulty readings until problems are identified and corrected. A major portion of operational maintenance will be spent in identifying, and repairing faulty flow meters. Thus, the procedure for determining final total flow rates will vary from time to time. Again, it is important to note that total injection flow rates can never actually be higher than total extraction in ISR because of the closed system.

Because elevations of the individual wells, depths to the open intervals, and distances from meter house to well (the frictional pressure loss) may vary considerably between injection wells, monitoring of MAWHIP will proceed in one of two ways:

a. The maximum allowable wellhead injection pressure (MAWHIP) will be determined for each injection well and posted in the meter house. For these injection wells, a pressure gauge will be placed on the wellheads or in the meter house, and pressure readings will be taken daily to ensure that the MAWHIP will not be exceeded.

b. A single maximum allowable injection pressure will be determined for the total meter house and posted in the meter house. The injection trunkline in the meter house will be fitted with a pressure gauge, and pressure readings will be taken of that gauge daily to ensure that maximum allowable trunkline injection pressure will not be exceeded.

Continuous monitoring pressure meters will be located in both production and injection main trunk lines. The meters will be installed in the manifolds at the plant pad. The meters will detect changes in line pressure indicative of a pipeline leak or rupture. A sudden change in line pressure will activate audible alarms in the plant building. Operators will immediately visually survey the well field pipeline system and, if a leak is detected, will follow procedures for spill notification and cleanup.

The well field operators will be responsible for visually monitoring the pipeline system for leaks. The operators will inspect the entire well field piping system at least twice every twelve hour shift. The inspection will include all wellheads, meter runs, branch lines to each well, lateral runs, and main trunk lines. Results of each inspection will be recorded by individual lateral on the daily well field shift notes. Detection of a leak or spill will be immediately followed by implementation of procedures for spill notification and cleanup.

Data records for these monitoring activities will be maintained on-site.

7.0 PIPELINE SPECIFICATIONS AND CONSTRUCTION

The fluids handling system in New Mexico encompasses various pumps, meters, pipelines, fittings and connections, and will generally consist of polyethylene, PVC, fiberglass, steel, and stainless steel materials, which are used universally in ISR . In materials technology, the ISR setting is considered both low pressure and low temperature, allowing use of "off the shelf" items and materials which will easily be available. In all cases, the components of this fluid handling system will be rated to withstand ambient temperatures and pressures of their environment, and the pressures and temperatures of the fluids with which they will be in contact, using published, generally accepted ratings. The materials will be chemically resistant, over their useful life to the fluids and solids with which they will be in contact. Specifications will be determined to maintain structural integrity throughout anticipated life of the component. As new materials become available, these same criteria will be used in determining their suitability. All well field piping systems and equipment will either be housed in containment buildings, placed on the surface, or buried.

All piping, including fittings, will be static pressure tested to 100% of its designed working pressure for 20 minutes. The pressure testing method will consist of filling the piping to be tested with water, pressured by an external pressure source, to the designed working pressure. The piping to be tested will then be isolated from the external pressure source with positive shut-off valves and held under pressure for twenty minutes. Piping that retains 90% of the original shut-in pressure after 20 minutes will be considered to be competent, and pressure leakage in excess of 10% will constitute a failure of test. The 10% leakage factor is to allow for material expansion under pressure with time and thermal expansion, if applicable. Any visible leakage of fluids within the test section of piping will constitute a failure of the pressure test. Any pipe that fails its pressure test will be replaced or repaired, and retested.

Pressure testing at 100% of the designed working pressure will make allowances for injection wellheads and associated piping on the occasional injection wells that require higher than normal injection pressures to maintain the designed injection rate. It will also account for changes in elevation along the path of the piping, since piping that changes elevation over distance will be tested to the maximum pressure that will be induced at the point of testing (the location where test pressures will be recorded) during operations. It follows, since the pressure at that point will be the maximum encountered at that point during operations, the pressure at every other point in the piping will be at the maximum to be encountered during operations, regardless of that point's elevation.

8.0 HYDROGEOLOGICAL ASSESSMENT OF WELL FIELDS[5]

Prior to well field development, it will be necessary to collect and assemble detailed information on geologic and hydrologic conditions, in order that ore zones can be defined, geologic and hydrologic parameters quantified, well fields planned, hydrologic monitoring programs developed, and baseline ground water quality sufficiently determined. To accomplish the above, HRI will conduct an intensive multi-step program consistent with the NRC License and NRC Guidance[6]. The following subsections contain a detailed description of the types of data which have been, and will be, collected for proposed well fields.

8.1 Overlying Zones

8.1.1 Churchrock

At the Churchrock property, the Brushy Basin Member of the Morrison Formation and the overlying Dakota Sandstone are water-bearing. Above the Dakota Sandstone is the continuous Mancos Shale that is present all the way to the surface. The Brushy Basin "B" Sand, as well as the Dakota Sandstone aquifer, will be monitored. Above the Dakota Sandstone there are no additional aquifers because it is continuous Mancos Shale to the surface. Upper monitor wells completed in the Brushy Basin "B" Sand will be located with a minimum of one well per every four acres of production area. Upper monitor wells completed in the Dakota Sandstone aquifer will be located with a minimum of one well per every eight acres of production area.

While mineralization stratigraphically above the Westwater is known to exist, HRI has not delineated the extent of this mineralization at this time. Therefore the feasibility of producing the Brushy Basin or the Dakota ore is presently

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[5] ISR Hydrologic Assessment of Well Fields, including groundwater background characterization and reclamation criteria, is regulated by both the Nuclear Regulatory Commission ("NRC") under 10CFR20 Criterion 5(B)(5) and the New Mexico Environment Department ("NMED") under NMAC 20.6.2.3103 & 20.6.2.5101 C.(2). The NMAC 20.6.2.3103 Standard is different from NRC 10CFR20 Criterion 5(B)(5)) because NRC restoration targets may be subsequently modified through the Alternate Contaminate Limit (ACL) process. Expected restoration result compared to the NMAC 20.6.2.3103 Standard for groundwater must be addressed in advance in determining the NMED Standard. HRI is committed to comply with both the groundwater background characterization and reclamation criteria of 10CFR20 Criterion 5(B)(5) and requirements under NMAC 20.6.2.3103 & 20.6.2.5101 C.(2).

[6] Phased ISR Data Collection is consistent with the Standard Review Plan for ISR Facilities, NUREG-1569. [88]

unknown. If HRI determines that production is feasible in either the Brushy Basin or the Dakota, the permitting of these intervals and environmental monitoring will proceed using the same program which has been described for ISR in the Westwater. Specifically, UIC permits or amendments of existing UIC permits will be obtained which will authorize this ISR activity. This will include the New Mexico discharge plan and federal EPA permit, and aquifer exemption, as necessary. Operationally, HRI will request that monitor wells be established in the sand being mined (Brushy, Dakota) at a spacing of 400 feet apart, and 400 feet from the closest injection/production well. The first overlying sand will be monitored at a density of one well per four acres, unless ISR is conducted in the Dakota, in which case there is no overlying zone.

HRI has conducted pump tests at the Churchrock property which demonstrated that the sands overlying the Westwater are hydraulically separated. Additional baseline water quality and hydrologic testing of production zone monitor wells and overlying monitor wells will be conducted after the operating monitor wells are installed, as will be described in Sections 8.5, and 8.6.

8.1.2 Crownpoint/Unit 1

In the vicinity of Crownpoint and Unit 1, the Brush Basin Member of the Morrison Formation is shale. This thick, contiguous shale overlays the production zone throughout the vicinity of the Crownpoint property. This is a regional shale which physically provides the aquitard between the Westwater and the Dakota.

Above the Brushy Basin is the Dakota Sandstone. Above the Dakota is 600-700 feet of Mancos Shale. Thereafter, to the surface are a number of sands form the Mesa Verde Group, the lowermost being the Gallup Sandstone.

As specified in Section 8.5 HRI, will run hydrological tests prior to ISR activities to confirm the previous project area pump tests and verify that additional drilling activities have not created any new avenues for leakage.

HRI proposes to monitor the Dakota Sandstone as the first overlying aquifer at both the Crownpoint and Unit 1 sites. Wells will be spaced at a density of one per four acres.

HRI does not propose to place monitor wells in sand of the Mesa Verde group for the following reasons:

a) These sands are separated from the production zone by the Dakota, which will be monitored.

b) The massive Mancos Shale, which separates the Dakota from the Mesa Verde Group, makes interformational transfer impossible.

c) Mechanical integrity test will assure that casing does not leak into shallow sands of the Mesa Verde Group.

d) Sands of the Mesa Verde Group are not substantial aquifers in the project area.

8.2 Underlying Zones

Underlying the host sand at Churchrock, Crownpoint, and Unit One, is the Recapture Member, and then the Cow Springs Member of the Morrison Formation. There is little site specific data on the thickness of the Recapture shale. However, the information which is available on drilling through the Recapture shale provide strong evidence of the shales quality as an aquitard. Specifically, the Recapture shale is 250 feet thick and is high quality shale. Given that the Recapture has been minimally penetrated, there is little potential for interformational transfer of recovery fluids which will affect the any underlying sand. The primary potential risk to any underlying water bearing sand will be deep drilling through the confining shale section which, if not properly abandoned, could provide a conduit for fluid migration.

HRI does not propose to monitor the Cow Springs aquifer. Prior to the injection of lixiviant at any of the three project sites, HRI will collect sufficient water quality data to generally characterize the water quality of the Cow Springs aquifer beneath the project sites, and will conduct sufficient hydrological confinement tests to determine that the Cow Springs aquifer beneath the sites is hydraulically isolated from the Westwater Canyon aquifer.

8.3 Effects of Old Mine Workings at Churchrock

The mine tunnels at the Old Churchrock underground mine site are opened into the Brushy Basin and the Westwater Canyon sands, both part of the Morrison formation. To the best of HRI's knowledge, the workings themselves do not extend up into the Dakota sand. However, the shaft does appear to be opened slightly into the Dakota, one to two feet at the very bottom of the sand. As evidenced by the mine workings in Section 17 of the Churchrock area, uranium mineralization occurs in the Brushy Basin sandstone, as well as the Westwater Canyon. In addition, geologic evaluation of this area shows that significant ISR uranium mineralization is contained in the Dakota Sandstone. If HRI's ongoing evaluation of the Churchrock geology indicate that uranium recovery in the sands overlying the Westwater is economically and technically feasible, applications for ISR in those zones will be made to all appropriate regulating entities, and proper authorizations will be received by HRI before and ISR occurs. HRI will monitor the aquifer immediately overlying any host sands with monitor wells spaced at one well per four acres. Thus, if ISR activity is taking place in the Brushy Basin sandstone, HRI will propose that the Dakota sand will have monitor wells placed at one well per four acres in the area above the ISR well fields. Although no aquifer has been identified above the Dakota sand in the Churchrock area, HRI will undertake such monitoring if a "first overlying sand" is determined at the time of actual ISR activity in that zone.

8.4 Exploration Holes

HRI, Inc. has exploration drill hole survey locations for every exploration hole at each of the three CUP properties (RAI #70 of Q1). [40] The status of plugging records will be detailed for each property below.

8.4.1 Churchrock Property

Hydrologic testing, simultaneous with well field development, will further confirm that the production zone is confined. If during operational testing individual holes become suspect, they can be found because their locations are surveyed and mapped, and corrective action (plugging) will be performed.

In addition to routine hydrological testing and corrective action, well field operations and the physical characteristics of the old exploration holes themselves prevent interformational communication.

8.4.1.1 Operational Controls

During operations, more water will be withdrawn than injected (well field bleed), which creates lower pressure within and around the well field area. Additionally, water levels in the zones overlying the production horizon will be monitored. Any movement of water out of the production zone and into the overlying intervals will be signaled by a water level in those formations higher than the original fluid level. In addition, the periodic samples taken from the monitor wells will be chemically tested for UCLs.

8.4.1.2 Borehole Characteristics

The weight of the abandonment fluid used in an exploration well is considerably heavier than water, and by itself will contain substantial pressure. A weight of about 9.5 ppg could be reasonably expected for the mud, but decreasing this even further to 9.2 ppg in the pressure calculation provides an additional level of confidence. The average depth to the top of the production horizon, using the four baseline wells completed into the Westwater Canyon, is 666 feet. Thus, the weight of the hole abandonment fluid, by itself, will generate a pressure of 30.1 psi.

The gel strength of a fluid is a measure of the shearing stress required to overcome the tendency of the fluid to remain static. The gel strength of the drilling mud left in a borehole requires that a certain pressure be reached before the mud will even move. This is in addition to total mud weight. The shear stress, in units of pressure, can be calculated from the following:

pressure, psi = 0.00333 x (GS) x h / D
Where GS = gel strength, lb/100ft^2.
h = length of fluid column, feet.
D = wellbore diameter, inches.

From: Davis, Ken. E., Factors Effecting the Area of Review for Hazardous Waste Disposal Wells, PROCEEDINGS OF THE INTERNATIONAL SYMPOSIUM ON SUBSURFACE INJECTION OF LIQUID WASTES, New Orleans, LA; March, 1986.[21]

Gel strength increases with time and can range from about 20 lb/100 ft^2 to hundreds after the mud has set in the borehole for years. Low gel strength muds are preferable in drilling but can be expensive to purchase, thus relatively high gel muds are common. A gel strength of 50 lb/100 ft^2 is felt to be conservative and was used in the pressure calculations. A wellbore diameter of 4.75 inches is typical of the size used for exploration wells. Using this, with 660 feet as average height of the fluid column noted above, the mud in exploration holes will require 23.3 psi [0.00333 x 50 x 666/4.75] of pressure to overcome the fluid's gel strength.

The formations, especially clays and shales, which have been penetrated by an exploration hole will slough into the well and will also naturally squeeze across the wellbore, closing it off. This trait is especially evident in drill holes left open for even a few days, when the borehole must be reamed again in order to get to the bottom. This plugging of the wellbore by swelling and stuffing of clays into the borehole has been such a problem in the past in the Churchrock area, that as early as the 1950's additives were mixed into the drilling mud to minimize the effect, a very unusual practice for that time.

The physical characteristics of an exploration hole that was drilled and abandoned years ago, make leakage out of our production zone very unlikely. But nevertheless, the monitoring system will be designed to alert the operator to a problem, including potential problems. This is the same monitoring system which will be in place even under the best conditions in which there were no old holes, or in which cement/bentonite gel had been used in their plugging. That is, unplugged holes will not affect our ability to detect and clean up any ISR solution outside of our well field.

Pump tests directly measure the integrity of the shales separating the production horizon from the overlying, and underlying sands. By itself, a pump test provides the best indication as to the continuity of the confining shales, and therefore, leakage potential of an aquifer. For this reason, a hydrologic test is considered necessary, even at a substantial cost to the company.

Pump tests provide a means of determining leakage potential, whether from unplugged wells or high permeability in the confining layers. A more detailed, theoretic analysis of a leaky system with the high permeability of the isolating clays is presented in the attachment: Popielak, R.S., and Sigel, J.;Economic, and Environmental Implications of Leakage Upon In-Situ Uranium Mining, Mining Engineering; August 1987, pp. 800-804. [56] Part of the results of that study is noted in the abstract to the paper: "The potential for environmental impacts appear to be minor".

8.4.2 Crownpoint Property

Drilling at Crownpoint property began in the late 1960's and early 1970's. Therefore, all plugging at the site was in compliance with the New Mexico State Engineers Regulation NMSA Section 69-3-6, which was promulgated in 1968.

HRI, Inc. has all of the plugging records which are available for the Crownpoint project.

Hydrologic testing that has been conducted at the Crownpoint property to date provides strong evidence that the production zone is confined from overlying zones. HRI, Inc. will conduct additional testing simultaneous with well field development. If former exploration boreholes become suspect during hydrologic testing, their locations will be surveyed and mapped so they can be readily located, and corrective action (plugging) will be performed.

8.4.3 UNIT 1 Property

Drilling at the UNIT 1 property began in the early 1970's by Mobil Oil. Therefore, all plugging at the site was in compliance with the New Mexico State Engineers Regulations NMSA Section 69-3-6, which promulgated in 1968.

HRI, Inc. has purchased Mobil's records which contain, to the best of our knowledge, all plugging reports.

Hydrologic testing that has been conducted at the UNIT 1 property by Mobil Oil provides additional strong evidence that the production zone is confined from overlying zones. HRI, Inc. will conduct additional testing simultaneous with well field development. As with other HRI properties, if individual holes become suspect during additional testing their location will be surveyed and mapped so they can be readily located, and corrective action (plugging) performed.

8.5 Hydrologic Testing Plan

HRI considers that the primary goal of pump testing in new production areas for ISR is to determine the degree of communication between the production zone and (1) the overlying zones, and (2), the production zone monitor wells. This will reflect the effects of hydraulic pathways, such as unplugged holes, and other pathways to the overlying zones, as well as ascertain the ability of production zone monitor wells to respond to changing flow conditions within the production area. The degree of communication at the production zone monitor wells surrounding the well fields will also directly indicate the magnitude of horizontal formation anisotropy. Of secondary importance is the determination of the physical flow parameters (transmissivity, storage, permeability) of the producing horizon, since they are of only very general utility to the ISR operator.

8.5.1 Single Well Test

Once a project area has been adequately assessed from a geologic and mineability standpoint, and the limits of the production area are determined so that it becomes a proposed production area, monitor wells (both overlying, and production zone) and baseline ISR wells will be installed. A hydrologic test will then be designed with the primary (hydraulic communication) and secondary goals in mind. Sufficient data preceding the pumping test will be collected for each of the monitor wells to assure that they are adequately reacting to barometric and/or antecedent conditions.

Initially, a single well relatively central to the proposed production area will be produced at a constant flow rate to allow for analysis of the formation flow parameters of transmissivity, storage, and permeability. Only a portion of the wells surrounding this first pumping well will be formally analyzed for these parameters, since they are of little value in the actual operation of a ISR well field. At least three wells, at appropriate angles to the pumping well, will be used to mathematically determine horizontal formation anisotropy. Isopleths, showing the piezometric surface near the time of maximum pressure drawdown across the area, will be drawn to graphically depict this same anisotropy. If other well fields are active in the area, they will be kept at flow rates as reasonably constant as possible during this segment of the hydrologic testing.

8.5.2 Multiple Well Tests

The pressure drawdown (cone-of-depression) caused by water production creates stress in the formation and any potential hydraulic boundaries or barriers, such as the overlying confining clays and possible non-sealing faults. If the proposed production area is sufficiently small, then the stress induced by pumping from a single well will adequately test potential barriers. Although the pressure drawdown decreases logarithmically with distance from the pumping well, the cone-of-depressions developed by multiple pumping wells would be additive across the production area, and can significantly increase the stress developed at any particular point. Since the ultimate goal of the hydrologic testing will be to determine the degree of communication of the production zone with the overlying and production zone monitor wells, the second phase of the investigation, if needed (as determined by the observed maximum drawdowns across the proposed production area developed by the single produced well), will involve producing multiple wells concurrently across the area and observing the composite effect of the resulting pressure drawdown on the various monitor wells. Plots of the water levels versus time of pumping will be made for the overlying monitor wells, and evaluated for pressure responses to pumping from the production zone. Maximum drawdowns will be tabulated for each of the production zone monitor wells to ensure that adequate response was achieved for those wells.

8.5.3 Production Area Hydrological Test Document

Following completion of the field data collection, data reduction, and data interpretation (in accordance with accepted scientific techniques and principles), the Production Area Hydrologic Test Document will be assembled and made available for regulatory review. In accordance with NRC requirements, the Production Area Hydrologic Test Document will be reviewed by the SERP to ensure that the results of the hydrologic testing and the planned ISR activities are consistent with technical requirements, and do not conflict with any requirement stated in the NRC license. A written report will be prepared by the SERP which evaluates safety and environmental concerns, and demonstrates compliance with applicable NRC license requirements. The written SERP report will be maintained at the site.

The Production Area Hydrologic Test Document contains the following:

a. A description of the proposed production area (location, extent, etc.);

b. a map(s) showing the locations of the baseline wells, and all monitor wells;

c. geologic cross-sections and cross section location maps;

d. isopach map of the overlying confining unit;

e. discussion of how the hydrologic test was performed, including well completion reports;

f. discussion of the results and conclusions of the hydrologic test including raw data for the pumping test(s), drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps, and when appropriate, directional transmissivity data and graphs;

g. sufficient information to show that wells in the monitor well ring will be in adequate communication with the production patterns; and

h. any other information pertinent to the area tested will be included, and discussed.

After appropriate review of Production Area Hydrologic Test Document, and subsequent authorization by the SERP, injection of lixiviant will begin in the new production area.

8.6 Baseline Water Quality Determination

8.6.1 General

The collection of baseline water quality data, and determination of baseline water quality conditions will be very important as the Upper Control Limits (UCL's) and ground water restoration objectives would be based on this data. HRI will collect three independent baseline water quality samples at a minimum of 14 days apart from each well.

8.6.2 Data Collection

Baseline water quality will be determined from water samples collected from wells installed in the various aquifers present as follows:

a. Monitor wells will be installed per the Production Area Hydrologic Test Document which will be reviewed, and approved by the SERP. At a minimum wells will be installed at the following density:

1. Production zone baseline wells - one per acre from select injection, and extraction wells which will be completed as well fields are developed;

2. production area monitor wells - spaced 400 feet apart, 400 feet from the well field patterns completed in the ore zone aquifer;

3. first overlying monitor wells - one per four acres completed in the first overlying aquifer in the well field patterns; and

4. second overlying monitor wells - one per eight acres completed in the second overlying aquifer in the well field patterns.

b. Water quality samples will be obtained and analyzed from the monitor wells described in **a** above. The sample well will be pumped during completion until water is free of mud and foreign material, and until conductivity and pH are reasonably constant in a natural range. As samples are taken during baseline sampling, the sampled well will be pumped for a sufficient amount of time to assure that sampled water is formation water. Sampling, preservation, analysis, and analytical quality control methods will be as defined in the current issues of Methods for Chemical Analysis of Water, and Wastes (EPA - Technology Transfer). Prior to sampling, regulatory authorities will be contacted in order that they can, if desired, collect split samples from the field sampling for comparative purposes.

The number of samples collected, and the parameters analyzed will be as follows:

a. Production Zone (Production Pattern) - Three sample sets collected and analyzed for the parameters listed in Table 8.6-1.

b. Production Area (Monitor Well Ring) - Three sample sets collected and analyzed for the parameters in Table 8.6-1.

c. Overlying Zones - Three sample sets for the parameters in Table 8.6-1.

8.6.3 Assessment of Baseline Water Quality Data

Baseline water quality will be determined by averaging the data collected for each parameter, from each well, for each zone that is to be monitored. This average will be used to determine the restoration criteria and UCL's. The variability of the data will also be calculated. Outliers will be determined using accepted methods such as those specified in Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Final Guidance (Chapter 8, A Discussion of Outliers). [68] Values determined to be high and low outliers will not be used in the baseline calculations.

Baseline conditions will be determined as follows:

a. Production Zone (Well field Pattern) Wells - Individual well data for each parameter will be averaged. The resulting average will generally be referred to as the production area average.

Table 8.6-1 Water Quality Parameters with Lower Levels of Detection (LLD)and Primary, and Secondary Restoration Goals.

	LLD[1]	Primary	Secondary[3]
Alkalinity	1	WF AVG.	WF AVG.
Ammonium	0.01	WF AVG.	10.0
Arsenic	0.001	WF AVG.	0.05
Barium	0.01	WF AVG.	1[2]
Bicarbonate	1	WF AVG.	WF AVG.
Boron	0.01	WF AVG.	WF AVG.
Cadmium	0.001	WF AVG.	0.01
Calcium	0.001	WF AVG.	WF AVG.
Carbonate	1	WF AVG.	WF AVG.
Chloride	1	WF AVG.	250
Chromium	0.001	WF AVG.	0.05
Copper	0.001	WF AVG.	1
Electrical Conductivity ~25 degrees C (micromho/cm)	1	WF AVG.	WF AVG.
Fluoride	0.1	WF AVG.	2[2]
Iron	0.01	WF AVG.	0.3
Lead	0.01	WF AVG.	0.05
Magnesium	0.001	WF AVG.	WF AVG.
Manganese	0.001	WF AVG.	0.05
Mercury	0.0001	WF AVG.	0.002
Molybdenum	0.01	WF AVG.	WF AVG.
Nickel	0.01	WF AVG.	0.1
Nitrate	0.01	WF AVG.	10
pH (s.u.)	°0-14	WF AVG.	6.5-8.5
Potassium	0.01	WF AVG.	WF AVG.
Radium-226 (pCi/l)	0.1	WF AVG.	5
Selenium	.001	WF AVG.	.05
Silica	.01	WF AVG.	WF AVG.
Silver	.001	WF AVG.	WF AVG.
Sodium	0.001	WF AVG.	WF AVG.
Sulfate	1	WF AVG.	250
TDS	1	WF AVG.	500
Uranium	0.001	WF AVG.	.03
Vanadium	0.1	WF AVG.	WF AVG.
Zinc	.001	WF AVG.	5

[1] mg/l unless otherwise noted. LLD may vary depending upon the laboratory that is used.
[2] NMWQCC 3-103 Standard.
[3] 40CFR141.62 or 143.3 unless otherwise noted.

b. Production Area (Monitor Well Ring) Wells - Individual monitor well data for each parameter will be averaged. The resulting average will generally be referred to as the production area average.

c. Overlying Zones - Individual monitor well data for each parameter will be averaged. The resulting average will generally be referred to as the non-production area average.

The standard industry practice is to use the arithmetic average to determine well field baseline. It is with the knowledge of standard industry practice that the NRC accepted procedure described above was developed. However, uranium geologists generally accept that redistributed uranium ore is log normally distributed. If so, an infinite amount of samples covering every portion of the ore would yield a lognormal distribution of uranium and uranium related-progeny. But in the real world the industry is forced to deal with a spaced sample well configuration such a one per acre[7].

HRI is committed to using the EPA's "Statistical Analysis of Ground-Water Monitoring Data at RCRA Facilities, Interim Guidance", for the treatment of outliers. However, as noted above, unlike RCRA facilities, with ISR uranium operations a known local anomaly is present in the rock (uranium mineralization which is lognormally distributed), a strong geochemical interface is known to be present and radionuclide constituents are logically present in the groundwater that is associated with this anomaly. Radionuclides are expected in a uranium ore body and it is not reasonable to extract them from the data if they fail the outlier test.

HRI believes the normal distribution should be validated with additional statistical analysis. To check reasonableness, HRI will utilize ProUCL 4.00.04[8], an EPA-sponsored statistical program which is ideally suited for this purpose. It is a comprehensive statistical software package equipped with statistical methods and graphical tools needed to address environmental sampling and statistical issues described in various CERCLA and RCRA guidance documents. ProUCL first determines if the data for a given constituent follows a normal,

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[7] Note that an acre is 43607 square feet or about 210 feet by 210 feet. A uranium ore front is commonly 100 to 200 feet wide. So even at a density of one well per acre it will be impossible to sample uniformly to get an accurate distribution across the ore.

[8] Singh, Anita, Maichle, R., Singh, A., Lee, S.E., and Armbya, N., 2009, ProUCL Version 4.00.04 User Guide, Draft, prepared for the U.S. Environmental Protection Agency, EPA/600/R-07/038 [70]

gamma, or logarithmic distribution. If the data follow one of these statistical distributions, a relevant UTL may be calculated. If the data follow no discernible distribution, a non-parametric UTL may be calculated. In the case of data with non-detects, the Kaplan-Meier non-parametric method may be used. With the Pro UCL analysis of data available, HRI will determine with regulatory authorities if baseline values such as those prescribed by a UTL calculation are appropriate for the purpose of establishing UCL's and the restoration table.

Consistent with the PBL format, HRI will develop a Standard Operating Procedure (SOP) which addresses the statistical assessment of baseline water quality data and the treatment of outlier data.

8.6.4 Upper Control Limits (UCL's)

8.6.4.1 General

As part of the detailed hydrogeological assessment, UCL's will be determined based on the baseline water quality data. The UCL parameters are chloride, bicarbonate, and conductivity.

8.6.4.2 Determination of Upper Control Limits

The UCL's will be based on the average baseline water quality data (i.e. production area average, or non-production area average), and determined as follows:

a. Chloride UCL - baseline average of all monitor wells in the horizon to be monitored plus five standard deviations.

b. Bicarbonate UCL - baseline average of all monitor wells in the horizon to be monitored plus five standard deviations.

c. Conductivity UCL - baseline average of all monitor wells in the horizon to be monitored plus five standard deviations.

To ensure that the UCL's determined from the baseline data are accurate, the monitoring data collected at the onset of the operational monitoring program (at least the first two samples) will be compared with the appropriate baseline data. In the event that the data collected at the onset of the operational monitoring program shows that the baseline water quality data is not consistent with previously determined baseline values, additional baseline water quality data will be collected and alternative UCL's will be proposed to the regulatory agencies.

Consistent with the PBLC format, HRI will develop a Standard Operating Procedure (SOP) which addresses the determination of UCL's, including the treatment of outlier data.

8.7 Operational Groundwater Monitoring Program

8.7.1 General

During production operations a carefully planned groundwater monitoring program will be utilized to ensure that production fluids are contained within the defined production zone. If production fluids exit the production zone, increases in concentration of the UCL parameters chloride, bicarbonate, and conductivity at the affected monitoring wells will occur. If this situation occurs and the concentration of the UCL parameters meets the criteria defined in Section 8.6, an excursion is present, and certain regulatory and operational procedures are followed.

8.7.1.1 Monitoring Frequency and Reporting

Monitor wells installed in the production zone monitor well ring, and those installed in the overlying and underlying aquifers (where applicable), will be sampled and analyzed for the UCL parameters every two weeks during production operations unless unable to do so because of uncontrollable events such as snowstorms or heavy rain.

Monitoring data for the UCL parameters will be retained on site for review by the NRC.

8.7.1.2 Water Quality Sampling and Analysis Procedures

Water quality samples will be obtained from the monitor wells with air lifts or submersible pumps. To assure that water within the well casing has been adequately displaced and formation water is sampled, wells will be pumped a certain amount of time, based on the particular well's performance. A minimum of one (1) casing volume of water will be removed from the well prior to sampling. Prior to sampling, the electrical conductivity and pH will be measured at periodic intervals and recorded on field data sheets to demonstrate that water quality conditions have stabilized, and ensure that formation water is sampled. All data for each well will be periodically reviewed to ensure that both sampling and analytical procedures are adequate.

Water quality samples will be analyzed for conductivity, chloride, and bicarbonate, usually within 48 hours of sampling, at the on-site laboratory. All analyses will be performed in accordance with accepted methods.

8.7.2 Excursions

HRI will adhere to NRC guidance which defines an excursion as occurring when two or more excursion indicators in a monitoring well exceed their upper control limits (UCLs). The NRC license conditions require that the licensee conduct biweekly sampling to detect excursions. If an excursion is detected, the licensee notifies the NRC and takes several steps to confirm the excursion through additional sampling. As described in NRC guidance (Section 5. 7. 8. 3), the licensee typically retrieve horizontal excursions by adjusting the flow rates of the nearby injection and production wells to increase process bleed in the excursion area. If an excursion is suspected in a groundwater monitoring well, the licensee is required to notify NMED and NRC within 24 hours, confirm the excursion and the well on excursion is required to be monitored every 7 days until concentrations of excursion indicators are at or below the respective UCLs. The licensee is required to provide a report to NRC within 60 days, describing the excursion, the corrective actions taken and the results. If an excursion cannot be corrected in 60 days, the licensee may be required to stop lixiviant injection or increase the surety to cover the costs of cleanup of the excursion (NRC, 2003a). [88]

Furthermore HRI commits to its more stringent excursion detection and corrective action criteria that was stated in the COP 2.0. There stated an excursion will be declared if any two excursion indicators in any monitor well exceed their respective upper control limits (UCLs), or a single excursion indicator exceeds its UCL by 20 percent. A verification sample will be taken within 24 hours after results of the first analyses are received. If the second sample does not indicate UCLs are exceeded, a third sample will be taken within 48 hours after the second sampling data is acquired. If neither the second nor third sample indicate UCLs are exceeded, the first sample will be considered in error. If the second or third sample contains the indicators above UCLs, an excursion will be confirmed.

Upon verification of an excursion, the EPA or NMED, and NRC will be verbally notified within 24 hours, and notified in writing within seven days. Corrective actions, such as changes in pumping, or injection rates, will be implemented as soon as possible. Corrective actions will continue until the excursion is mitigated. When excursion status is confirmed, corrective action will be required to return the water quality to the applicable upper control limit. During corrective action, sample frequency will be increased to weekly for the excursion indicators until the excursion is concluded.

In the event of a vertical excursion at the Crownpoint and Unit 1 properties, HRI will explore any significant aquifer above the Dakota Sandstone aquifer for vertical excursions, as opposed to just the deepest saturated sand of the Mesa Verde Group. The specific aquifers to be monitored in the event of a vertical excursion will be identified in HRI's 60-day excursion report as described in **a** below.

If an excursion has been confirmed, the following procedures will be applicable:

a. A written report describing the excursion event, corrective actions taken, and the corrective action results will be submitted to the NRC within 60 days of the excursion confirmation. The report will describe the excursion event, correction actions taken, and the results obtained. If wells are still on excursion at the time the report is submitted, the report will also contain a schedule for submittal of future reports to the NRC describing the excursion event, corrective actions taken, and the results obtained. In the case of a vertical excursion, the report will also contain a projected completion date when characterization of the extent of this vertical excursion will be completed.

b. In the event an excursion is not corrected within 60 days of confirmation, HRI will terminate injection of lixiviant in the vicinity of the monitor well within the well field on excursion until such time that aquifer cleanup is complete, or will provide an increase to the FA in an amount that is agreeable to NRC, which will cover the full cost of correcting and cleanup of the excursion. The FA increase will remain in force until the excursion has been corrected. The written 60-day excursion report will state and justify which course of action will be followed.

An excursion is corrected when all control parameters have been reduced to their upper control limit, or below. After the excursion is corrected, normal operations will be resumed.

Consistent with PBLC format, HRI will develop a standard Operating Procedure (SOP) which addresses regulatory agency reporting and corrective actions to be taken in the event of an excursion.

8.7.3 Well Field Development Documentation

Documentation of well field development will be maintained by the Radiation Safety Officer (RSO) and approved by the SERP.

8.7.3.1 Previous Mining

Planning for previous mining activities will be required only at the Churchrock Section 17 property.

As stated in Section 8.3, HRI has records of the locations of all previously mined workings. These workings were developed in the area of uranium mineralization, as will be all production patterns. Therefore, the production area monitor wells will be placed outside the physical location of mine workings. HRI will verify that the production area monitor wells will be outside the locations of workings by superimposing their surveyed locations on existing surveyed maps which illustrate the working locations.

The location of non-production zone monitor wells is discussed in Section 8.3.4. HRI will verify that non production monitor wells will be placed proximal to raises by superimposing their exact locations on existing surveyed maps which illustrate the raise locations.

Documents and maps showing the location of monitor wells will be maintained on site for inspection.

8.7.3.2 Geologic Data

The geology of an individual production area will be evaluated in conjunction with well field development to assure proper placement of monitor and production wells. The project geologist, and hydrologists will work together to compile the geologic/hydrologic data into a report. Included in this report will be:

a. A description of the proposed production area (location, extent, etc.);

b. a map(s) showing the locations of the baseline wells, and all monitor wells;

c. geologic cross-sections and cross section location maps;

d. isopach map of the overlying confining unit;

e. discussion of how the hydrologic test was performed, including well completion reports;

f. discussion of the results and conclusions of the hydrologic test including raw data for the pumping test(s), drawdown match curves, potentiometric surface maps and water level graphs;

g. sufficient information to show that wells in the monitor well ring will be in adequate communication with the production patterns; and

h. any other information pertinent to the area tested will be included, and discussed.

This information will be maintained on site for inspection.

8.7.3.3 Well Field Location

The license area location is described in Section 1.1.1 for the Crownpoint well fields, Section 1.1.2 for the Churchrock well fields, and Section 1.1.3 for the Unit 1 well fields. Property boundaries are generally well marked and HRI cannot legally encroach these boundaries. Additionally, all wells will be surveyed. These mapped locations will also contain boundaries, and cultural features.

These maps will be maintained on site for inspection.

8.7.3.4 Well Completion

Well location and completion will be performed as described in Section 6.0. Monitor well functionality will be verified through hydrological testing, and reported as described in Section 8.5.

Details of the construction, completion, and testing of each well will be maintained within a file for that well. This file will contain all geophysical logs associated with the well, field information, and the completion reports.

This information will be maintained on site for inspection.

8.7.3.5 Well Integrity Testing

Only wells that pass the mechanical integrity testing (MIT) requirements specified in Section 6.4.1.4 will be used at the CUP. MIT results will be recorded on the completion reports.

This information will be maintained on site for inspection.

8.7.3.6 Baseline Water Quality Data

Baseline water quality will be collected, analyzed, and evaluated according to the discussion set forth in Section 8.6. Statistical analysis, will be reviewed by the SERP, and the results documented and filed.

This information will be maintained on site for inspection.

8.7.3.7 Upper Control Limits

Baseline water quality will be collected, analyzed, and evaluated according to the discussion set forth in Section 8.6. Upper Control Limits (UCL's) analysis will be conducted according to the statistical procedures set out in Section 8.6.4. UCL results will be reviewed by the SERP, and the results documented and filed.

This information will be maintained on site for inspection.

8.7.3.8 Restoration Target Values

Baseline water quality will be collected, analyzed, and evaluated according to the discussion set forth in Section 8.6. Restoration Target analysis will be conducted according to the statistical procedures set out in Section 8.6.3, and will be reviewed by the SERP, the results documented, and filed.

This information will be maintained on site for inspection.

8.7.3.9 Location of Monitor Wells

Monitor wells will be located according to the discussion set forth in Sections 6.3.1, 6.3.2, and 8.6.2. Baseline water quality will be collected, analyzed, and evaluated according to the discussion set forth in Section 6.3.1, 6.3.2, and 8.6.2. Details of the construction, completion, and testing of each well will be maintained within a file for that well. This file will contain all geophysical logs associated with the well, field information, and the completion reports. Additionally, all wells will be surveyed, and mapped. These maps will also contain boundaries, and cultural features. Monitor well completion reports and location maps will be reviewed by the SERP.

Monitor well completion reports and location maps will be maintained on site for inspection.

8.7.3.10 Hydrological Tests of Confinement

Production area pumping tests will be performed and reported according to the methods and procedures set forth in Section 8.5. The Production Area Hydrologic Test Document will be reviewed by the SERP to ensure that the results of the hydrologic testing and the planned ISR activities are consistent with technical requirements.

The Production Area Hydrologic Test Document will be maintained on site for inspection.

8.7.3.11 Injection Pressures

Injection pressures of either individual wells or trunk lines will be determined daily at the injection well, or in each well field metering house. The surface wellhead pressures will not exceed the maximum surface pressures posted in each metering house.

Data records for these monitoring activities will be maintained on-site.

8.7.3.12 Pump Test Confirmation of Monitor Well Locations

Production area pump testing will be performed and reported according to the methods and procedures set forth in Section 8.5. The primary goal of the production area pump test will be to determine the degree of communication of the production zone with the overlying and production zone monitor wells. The primary results of the production area pump test will be recorded in the Production Area Hydrologic Test Document. The Production Area Hydrologic Test Document will be reviewed by the SERP to ensure that the results of the hydrologic testing and the planned ISR activities are consistent with technical requirements.

The Production Area Hydrologic Test Document will be maintained on site for inspection.

8.7.3.13 Hydrologic Parameters

Of secondary importance, will be the determination of the physical flow parameters (transmissivity, storage, permeability) of the producing horizon, since they will be of only very general utility to the ISR operator. Physical flow parameters will be calculated from the data that is obtained during the production area pump test. Physical flow parameters will be recorded in the Production Area Hydrologic Test Document. The Production Area Hydrologic Test Document will be reviewed by the SERP to ensure that the results of the hydrologic testing and the planned ISR activities are consistent with technical requirements.

The Production Area Hydrologic Test Document will be maintained on site for inspection.

9.0 RADIATION SAFETY

In accordance with 10 CFR 20.1101(b) and Regulatory Guides 8.10 and 8.31, HRI is committed to maintaining personnel occupational exposures to radioactive materials "as low as reasonably achievable”, or ALARA. [74][87] The following Radiation Safety Program is developed from operating experience at URI ISR facilities, gained from 1978 to the present.

9.1 Uranium Production Facilities

9.1.1 Conventional Mining

Underground mines pose significant inhalation hazards from airborne uranium and uranium decay progeny suspended in the mine air due to blasting or other mining operations. Additionally, the buildup of 222-Rn and its progeny can yield significant doses to the bronchial tissues of the lung, resulting in the most significant radiological doses in mining operations. The buildup of radon progeny in mining environments can result in air concentrations on the order of tens to hundreds of working levels, depending on emanation, ventilation, and other factors. The average exposure of all underground uranium miners in the U.S. in 1979 had an average exposure, for radon only, of about 3000 mrem per year, or 2.9 WLM (Working Level Months) [Cooper, W.E., 1981; O’Riordan, M.C., et.al., 1981; Johnson, J.R. et.al, 1981]. [20]

9.1.2 In Situ Recovery or ISR

ISR mineral extraction applies engineering controls and processes to insure the health and safety of personnel, the public, and the protection of the environment. Recovery solutions contain extracted soluble uranium circulated in a closed loop system through the processing plant and back to the ore zone, and thus there is no overall airborne hazard of uranium or uranium progeny. Unlike conventional mining which can use copious amount of water, ISR conserves consumption of water by continually circulating oxygenated groundwater back to the production zone. ISR extracts uranium while allowing the ore body to remain intact. This leaves the surrounding landscape open for grazing or raising crops. The final product is yellowcake, dried in a vacuum hopper with near zero emissions prior to shipment to an enrichment facility.

9.2 Product Material - Yellowcake

9.2.1 Chemical Form

Uranium in the ore body becomes soluble in the oxidized phase, and once oxidized, is mobilized by the bicarbonate (HCO_3^-) anion as a uranyl dicarbonate ($UO_2(CO_3)_2^{-2}$) anion. The solution is then pumped to the surface from the ore zone. The pressurized down flow ion-exchange (IX) resin columns in the processing plant acts in a manner very similar to a domestic water softener. Uranyl dicarbonate anions are exchanged onto the surface of the IX resin and displace two chloride ions (Cl^-). When fully charged, an NaCl brine solution is used to release the uranyl dicarbonate into an eluant, and to regenerate the IX resins. The eluant is then acidified with HCl, breaking the dicarbonate complex and forming UO_2Cl_2. This is precipitated with hydrogen peroxide (H_2O_2), forming hydrated UO_4 as described in section 3.7. The uranium peroxide is then dried and the product "yellowcake" is packaged for transport.

9.2.2 Uranium - Naturally Occurring Radioactive Material

Uranium is widely distributed around the world with an average concentration in the earth's crust of 4 PPM. Uranium is a heavy metal and is naturally radioactive. Natural uranium contains three isotopes: 238-U (99.3%), 235-U (0.7%), and 234-U (0.006%). 238-U constitutes one of the main primordial radioactive decay series and has a long radioactive decay half-life of 4.5 billion years.

238-U decays to 234-Th by alpha emission. Since 238-U has a long half-life and its immediate decay progeny (234-Th, 234-Pa, and 234-U) have relatively much shorter half-lives, these isotopes are in secular equilibrium with the 238-U decay. Because of 238-U's long half-life, the specific activity of natural uranium is unusually low (0.68 mCi/g 10 CFR 20 App. B Footnote 3). With a half-life of a quarter of a million years, 234-U will not decay to produce significant progeny for several thousand years.

In the decay from 238-U to 234-U, alpha, beta, and gamma radiations are emitted. Radioactive emission include two alphas of about 4 MeV of energy each, five different betas with E_{max} ranging from 0.1 to 2.3 MeV, and seven gamma rays all of either rare frequency or low energy of about 63 to 92 keV. A 55 gallon drum of yellowcake comes into secular equilibrium with 234-Th and 234-Pa within several months of production. Measurement at 30 cm from the surface of the drum will yield an external exposure rate of 2 mrem/hr.

9.2.3 Metabolism and Toxicity

Natural uranium is primarily an internal hazard, and the chemical toxicity far exceeds the radiological hazard as explicitly stated in 10 CFR 20.1201(e). Uranium metabolically behaves somewhat like calcium and will deposit on the bone surfaces. The three major organs which will receive the largest radiological dose from intake of uranium are the lungs, bone, and kidneys.

Table 9.2-1. Organ Dose Conversion Factors for Inhalation of Natural Uranium (Federal Guidance Report No.11 EPA-520/1-88-020 1988; secular equilibrium of 234-U with 238-U; class W)

Organ	Dose Conversion Factor (Sv/Bq)
gonad	7.11×10^{-9}
breast	7.13×10^{-9}
lung	1.51×10^{-5}
red marrow	2.04×10^{-7}
bone surface	3.12×10^{-6}
thyroid	7.12×10^{-9}
remainder	2.70×10^{-7}
Total:	1.87×10^{-5}

Most of the uranium is excreted out of the body, mostly contained in the feces, and a smaller fraction in the urine. The urinary clearance can vary widely depending on the solubility of the chemical form and whether the intake pathway is ingestion or inhalation. Soluble uranium will rapidly be eliminated while insoluble uranium will slowly convert to a soluble form in the body. Nephrons in the kidneys work hard to eliminate the heavy metal from the blood stream. Sufficient acute intakes of uranium will cause the kidneys to swell, with the potential risk of infection, and slightly higher intakes will cause permanent damage in the kidneys.

9.2.4 Solubility Class

All yellowcake at the CUP will be dried at a low temperature (less than 400° C) which will form the basis for using Class W throughout the entire process. In this form uranium forms a compound that can easily dissolve in the fluids in the lungs. The dust from this compound, when deposited in the lung, can cross through the lung tissue and enter the bloodstream. Most of it is then quickly filtered out by the kidneys and gradually excreted in the urine. The radiation dose to the kidneys is not as hazardous as the chemical action of the uranium on the kidney tissue.

9.3 Restricted and Controlled Areas

At the CUP, any area in which employees potentially will have access to yellowcake, i.e. product material, is a yellowcake work area and will be defined as a Restricted Area as defined in 10 CFR 20.1003. Offices, eating, drinking, and smoking areas will not be Restricted Areas, will not contain product material, nor will the employee(s) in these areas have access to yellowcake.

Areas which will potentially contain yellowcake and are candidates for designation as Restricted Areas are: the filter press area, elution area, IX, sand filters, RO unit area, dryer system area, YC drum waste storage. Engineering controls and surveys will help monitor and contain airborne yellowcake within these designated areas. Additionally, employees will be required to survey for alpha contamination before leaving the Restricted Area.

Other areas within the license boundary that are subject to ISR activity will be Controlled Areas as defined in 10 CFR 20.1003. HRI will limit access to these areas by fencing, building enclosures or any other method judged reasonable to limit access by the public.

Consistent with PBLC format, HRI will develop an SOP which describes the details of the areas which are designated Restricted Areas and Controlled Areas.

9.4 Instrumentation, Calibration, and Surveys

9.4.1 Instruments

Table 9.4-1 summarizes the types of radiation detection instruments which will be used at the CUP. Pursuant to NRC Regulatory Guide 8.30, all instruments used will have LLD’s less that 10% of applicable limits. [86] All radiation monitoring, sampling, and detection equipment will be calibrated at least annually, and after each repair. The calibration records will be maintained on site.

Detectors which will be used by HRI include ZnS scintillators, GM pancake probes, and NaI scintillators. Scintillation probes incorporate a photo multiplier tube (PMT). Filter air samples, and surface material swipes will be counted for alpha using a ZnS scintillator filter sample counter, and for alpha and beta using an end window GM detector. External exposure will be monitored using a NaI-PMT detector which has a high efficiency for detecting gamma.

In addition, passive detectors such as TLD's or electrolyte radon cups will be used in conjunction with the instruments below to monitor for maximum potential exposures. A few instruments most commonly used are listed in Table 9.4-1.

9.4.2 In Plant Surveys

The process areas described in Table 9.4-2 are subjected to the surveys listed in Table 9.4-3. These surveys are described in more detail throughout this Section.

9.5 Environmental Monitoring

Environmental monitoring will generally follow the schedule shown on Table 9.5-1. All environmental monitoring will begin at each station, for each media being sampled, three months before operations begin.

All effluent releases will be subject to release limits specified in 10 CFR Part 20. HRI will not inject lixiviant prior to NRC's review and approval of a SOP level detail environmental monitoring plan. The plan will indicate SOPs such as sampling methods and equipment, analytical procedures, and lower limits of detection. The plan will also indicate proposed environmental monitoring locations based on "as built" construction drawings, and provide the rational for their selection. The approved NRC monitoring plan will form the basis for HRI's operational SOP which will describe the details of the environmental monitoring program.

9.6 External Radiation Exposure Monitoring Program

9.6.1 External Radiation Monitoring Plan

All personnel will be issued dosimeters. TLD personnel badges measure the external exposure to the individual on site. On at least a quarterly basis, the badges will be read by the vendor, and reported on NRC Form 5, or equivalent. Issued TLDs will be of a design for measuring mixed beta and photon mixtures to accurately characterize the deep, eye, and shallow dose equivalents.

Table 9.4-1. Radiation Instrumentation Types, and General Specifications

1. Alpha Filter Sample Counter

·Scintillator: ZnS (Ag)
·Operating Voltage: 0.5-1.2 kV
·Weight: 1.9 kg
·Window: 0.4 mg/cm2
·Sample Holder: O-ring sealed stainless steel slide
·Sample Size: 2.54 cm diameter, 1.5 mm thick
·Tube Assembly: 3.8 cm diameter magnetically shielded photomultiplier tube
·Dynode String Resistance: 100 MW
·Compatibility: Model 177.

2. Pancake G-M Detector

·Window: 1.7 mg/cm2 mica, 15 cm2 active, 12 cm2 open
·Operating voltage: 0.9 kV
·Halogen quenched G-M
·Dead Time: 80 us
·Construction: Al housing, optional Pb shield
·Weight: 0.5 kg
·Compatibility: Models 3 and 177.

3. End Window G-M Detector

·Window: 1.7 mg/cm2 mica, 6 cm2 active, 5 cm2 open
·Operating voltage: 0.9 kV
·Halogen quenched G-M
·Dead Time: 200 us
·Construction: Al housing
·Weight: 0.5 kg
·Models 3 and 177.

4. Alpha Scintillator

·Scintillator: ZnS (Ag)
·Window: 0.8 mg/cm2 aluminized Mylar, 76 cm2 active, 50 cm2 open
·Tube Assembly: 3.8 cm diameter magnetically shielded photomultiplier
·Dynode String Resistance: 100 MW
·Operating Voltage: 0.5-1.2 kV
·Weight: 0.9 kg
·Compatibility: Model 177.

5. General Purpose Survey Meter - Model 3

·Compatible Detectors: G-M, scintillation
·Threshold: 30 mV
·Weight: 1.6 kg
·Meter Dial: 0-2 mR/hr or 0-5k cpm
·Multipliers: x0.1, x1, x10, x100
·High Voltage: Adjustable 0.2-1.5 kV

6. Alarm Rate meter - Model 177

·Compatible Detectors: G-M, scintillation
·Alarm Set: front panel with lock
·Reset: push-button to reset alarm
·Power: 120 VAC, 60 Hz single phase, <100 mA
·Battery: 6 V Pb-acid rechargeable, life of 50 hours in non-alarm condition
·Weight: 1.9 kg
·Meter Dial: 0-500 cpm, 0-1.5 kV
·Multipliers: x1, x10, x100, x1k
·Threshold: Adjustable 10-100 mV
·High Voltage: 0.2-1.5 kV
·Response: Fast - 4 seconds, Slow - 22 seconds
for 10% to 90% of final reading

***Instrument Manufacturer**

Ludlum Measurement
P.O. Box 810 - 501 Oak Street
Sweetwater, TX 79556

Table 9.4-2. Process Area Radioactivity Monitoring Location.

All Process Facilities

1. IX and Sand filters
Gamma - (TLDs) one between IX columns and sand filters
Radon Progeny - two at the IX and one at the sand filter.

2. RO Unit Area
Gamma - (TLDs) one between IX columns, one on the filter platform, one between the RO water storage tanks, one RO unit, and one between the cleaner tanks
Radon Progeny - one located by the IX columns

3. Chemical Storage Pad
Gamma - (TLDs) one located on the chemical storage pad

4. Exit Points
Alpha - thin window scintillator with an alarm rate meter

Areas only Concerning the Crownpoint Central Plant

5. Filter Press Area and YC Slurry Storage
Gamma - (TLDs)one on each yellowcake storage tank and one next to the filter press
Radon Progeny - one

6. Elution Area
Gamma - (TLDs) one at the base of barren eluant vessels and one between the eluant columns
Radon Progeny - one between the sand filters and the IX columns

7. Dryer System Area
Gamma - (TLDs) one in the office, the shower, and the dryer system room
Uranium - (low volume pump) continuous particulate filter sampling
Radon Progeny - one

8. YC Drum Storage
Gamma - (TLDs) one located central to the storage
Radon Progeny - one

**Additional monitoring will be conducted or eliminated at the RSO's discretion.*

TABLE 9.4-3

SUMMARY OF SURVEY FREQUENCIES

Type of Survey	Type of Area	Survey Frequency	Detection
1. Yellowcake	Filter press, special maintenance involving high airborne concentrations of yellowcake. Dryer building, downwind of dryer building.	Monthly grab samples. Extra breathing zone grab samples. Continuous.	1×10^{-11} µCi/ml
2. Radon Daughters	Scaffolding.	Monthly radon daughter grab samples as needed.	0.03 WL
3. External Gamma Radiation	Throughout process facility.	Quarterly.	.1 mrem/hr.
4. Surface Contamination	Yellowcake areas, eating rooms, change rooms, control rooms, offices.	Daily, monthly.	Visual 5,000 dpm alpha per 100 cm^2
5. Skin and Personal Clothing	Yellowcake workers who shower, non-yellowcake workers who do not shower.	Each day before leaving.	1,000 dpm alpha per 100 cm^2
6. Equipment to be released.	Equipment to be released that may be contaminated	Once before release.	5,000 dpm alpha per 100 cm^2

Table 9.5-1 Environmental Monitoring[9] for Church Rock, Crownpoint and Unit 1

Type of Sample	Number	Location	Method	Sample Frequency	Analysis Frequency	Type of Analysis
Air Radon Gas	Five	One upwind and two downwind of the plant or satellite site, one at the nearest residence or occupied structure within 10 km of the plant or satellite site, one control	Track Etch	Continuous	Quarterly	^{222}Rn
Process Fluids	Two	Lixiviant trunk lines in and out of process. 1 from lixiviant intake. 1 from lixiviant outlet.	Grab	Quarterly	Quarterly	^{222}Rn
Water Ground Water	One from each well	Potable, livestock, and irrigation water supply wells within 2 km license area.	Grab	Quarterly	Quarterly	Dissolved and suspended U- Nat., ^{226}Ra, ^{230}Th, ^{210}Pb, ^{210}Po, gross α and β
Water Monitor Wells	One from each well.	As designated in NRC License and NMED Discharge Plan.	Grab	Bi-monthly	Bi-monthly	Ec, Cl, Dissolved U-Nat, HCO_3
Water Surface Water	One from each impoundmen t and a minimum of two from each stream.	Permanent impoundments and upstream and downstream in surface waters passing through the license area; also adjacent impoundments subject to drainage from the license area.	Grab	Quarterly	Quarterly	Dissolves and Suspended U-Nat, total and soluble ^{226}Ra, ^{230}Th, ^{210}Po & ^{210}Pb
Soil Soil and Sediment	Same as surface water	At surface water sampling locations.	Grab	Quarterly	Quarterly	U-Nat, ^{226}Ra & ^{210}Pb
Vegetation Forage	Three	Grazing area near the facility in the direction of the highest predicted radionuclide values.	Grab	Three times during grazing season	Each sample	^{226}Ra & ^{210}Pb
Direct Radiation	Five	At radon gas sampling stations	TLD	Continuous	Quarterly	γ exposure rate
Soil	1	Septic system drain field	Grab	Once	Prior to requesting termination of license	U-Nat, ^{226}Ra & ^{210}Pb
Sludge	1	Septic tank	Grab	Once	Prior to sludge removal from tank and prior to requesting termination of the license.	U-Nat, ^{226}Ra & ^{210}Pb

[9] Modified for ISR with vacuum dryer from NRC RG 4.14. RG 4.14 explanatory footnotes apply.

Consistent with the PBL format, HRI will develop a Standard Operating Procedure (SOP) which addresses the methods which will be used to establish and record all doses to each employee from internal and external sources received at the CUP.

9.6.2 External Radiation Monitoring Surveys

Quarterly surveys will be performed at specified locations throughout the satellite buildings and CCP to assure that areas requiring posting as "Radiation Areas" will be identified, posted, and monitored to assess external radiation conditions. "Radiation Areas" will be those areas exhibiting 5 to 100 mrem per hour at a distance of 30 cm from the source.

9.7 Airborne Radiation Monitoring Program

HRI's Airborne Radiation Monitoring Program will generally contain the provisions of U.S. Nuclear Regulatory Commission Regulatory Guide 8.25, Revision 1, *Air Sampling in the Workplace* and U.S. Nuclear Regulatory Commission Regulatory Guide 8.30, *Health physics Surveys in Uranium Mills*. [81][86] The general components of the program are described below.

9.7.1 Airborne Uranium Particulate Monitoring

There will be no potential for exposure to ore dust at the CUP since the facility will be an *in situ* uranium mine. However, there will be the potential for exposure to yellowcake dust in certain areas of the CUP. All areas, including the filter press, drying, and packaging areas have a potential for exposure to yellowcake dust.

There will be a continuous monitoring of airborne uranium particulates at the drying and packaging areas. During periods of drying and packaging activity, the filters of the continuous air monitors will be changed and analyzed every several days as a decrease in airflow through the filter necessitates. At times when the dryer system is operated discontinuously, the airborne monitor will be operated and the filter analyzed for only the period of batch operation. During periods that drying and packaging activities are not occurring, the filters will be changed and analyzed on a weekly basis.

When non-routine work activities will be performed in an area or manner that could result in exposure to uranium particulates, area air samples or breathing zone samples will be utilized to determine airborne uranium particulate levels.

For all potential exposures, in the event that bioassay data is unavailable to quantify actual intakes, time studies and/or actual occupancy times will be used to estimate the employees' exposure.

Consistent with the PBL format, HRI will develop a Standard Operating Procedure (SOP) which addresses the methods which will be used to monitor air particulates in the dryer system area at the CUP.

9.7.2 Radon Daughter Monitoring

Radon progeny will be routinely monitored on a monthly basis at the satellites and the CCP.

Routine exposures to radon daughters will only be determined within the IX processing plant buildings. The method of analysis will be the modified Kusnetz method, or other commonly accepted method of measurement. Measurements will be made in locations and at times when there is a potential for the release of radon or radon progeny.

Consistent with the PBL format, HRI will develop a Standard Operating Procedure (SOP) which addresses the details of radon monitoring at the CUP.

9.7.3 Airborne Effluent Environmental Monitoring

To ensure compliance with l0 CFR 20.1301, 20.1302, and 20.1501, HRI will maintain a continuous air monitoring program at three separate locations: upwind of the CCP or satellite facilities, downwind from the CCP or satellite facilities at the restricted area boundary, and downwind at the nearest residence. These sampling locations contain passive gamma and radon monitoring devices that will be changed out on a quarterly basis.

In addition to the monitoring described above, continuous passive monitoring for gamma and radon will be performed at two locations (one upwind and one downwind) at the satellite facilities. These monitoring devices will be exchanged quarterly, and the results documented and maintained on site.

During operations, calculation estimates of individual exposures to radionuclides at the site boundary that meet the regulatory requirements in 10 CFR 20.1302(b0(2)(i) with regard to annual average concentrations in airborne effluents or the dose limits in 10 CFR 20.1301 will be maintained by the RSO.

9.8 Employee Exposure Records

Employee exposures at the CUP will be monitored in accordance with USNRC Regulatory Guide 8.34, Monitoring Criteria and Methods to Calculate Occupational Radiation Doses. [80] The employees will be monitored for internal exposure to yellowcake dust, see Section 9.9 "Bioassay Program", patterned after NUREG 8.22 Bioassay at Uranium Mills. [77] A bioassay program will be utilized as a means of ensuring the adequacy of the monitoring and respiratory protection programs for protection from airborne uranium dust, and from 222-Rn and its decay progeny. HRI will advise each worker of their annual dose pursuant to the provisions of 10CFR20.2106 and U.S. Nuclear Regulatory Commission Regulatory Guide 8.7, Revision 1, Instructions for Recording and Reporting Occupational Radiation Exposure Data.[90] A quarterly tabulation of annual dosage for all employees will be posted on a bulletin board in the central offices of the CCP and the satellites, along with all other regulatory postings. The table will contain all the provisions of NRC Form 5, or equivalent, for each employee.

According to the methods described in U.S. Nuclear Regulatory Commission Regulatory Guide 8.36, Radiation Dose to the Embryo/Fetus, declared pregnant women will have additional materials tabulated and posted stating the annual dose to the embryo-fetus. [82]

9.8.1 Time Period Airborne Exposure

In the event that bioassay data is unavailable to estimate actual intakes of yellowcake, employee exposure to airborne soluble uranium will be estimated for routine activities. The exposure estimates will be based on exposure times and the concentrations of airborne uranium as determined from routine air monitoring, or non-routine air monitoring (i.e. breathing zone monitoring or specific area air monitoring).

Routine exposures to uranium and radon daughters will be only determined only for workers routinely exposed to airborne radionuclides in concentrations which are likely to result in annual exposures in excess of 10% of the ALI without respiratory protection. Routine exposures will be estimated using exposure times generated from semiannual time studies.

Non-routine exposures to uranium will result from performing non-routine operational or maintenance tasks that have the potential for creating a significant exposure to airborne uranium. These types of exposures will be monitored utilizing a Radiation Work

Permit (RWP). The RWP will specify the types of radiological monitoring required for the task, and the protective equipment and clothing employees must wear while performing the task. The sampling results will be evaluated and documented. This data, together with the employee's time in the area, will be used to estimate the non-routine exposure. Each employee's routine and non-routine exposure to airborne uranium will be recorded weekly and summarized annually.

Routine employee exposure to radon daughters will be determined by measured working levels. Similar to non-routine uranium exposures, non-routine radon daughter exposures will be monitored utilizing an RWP. Routine exposure times will be determined by semi-annual time studies, or actual occupancy times. Each employee's routine and non-routine exposure to radon daughters will be recorded weekly, and summarized annually.

9.8.2 Airborne Uranium Exposure Calculation

The intake of uranium of soluble class W during the weekly or annual period being evaluated will be estimated using the following equation:

$$I_u = (S\ (c_i)(Dt_i)/(DAC))*(PF)$$

from i=1 to n

Where:

I_u - uranium intake (DAC-hours)
Dt_i - time worker is exposed to concentration (hours)
c_i - average concentration of uranium in the air (mCi/ml)
DAC - the derived air concentration value for soluble class W uranium from Appendix B of 10 CFR 20 (3E-10 mCi/ml per DAC)
PF - respirator protection factor from Appendix A of 10 CFR 20
n - number of exposures during the period of evaluation

9.8.3 Radon Progeny Exposure Calculation

As was discussed in Section 9.7.4, the modified Kusnetz or commonly acceptable method for determining exposure to radon daughters will be utilized at the HRI’s Crownpoint *in situ* uranium project and satellite facilities. From the monitoring data collected, the employees intake of radon progeny will be calculated using the following equation:

$$I_r = (S\ (WL_i)(Dt_i)/(DAC))*(PF)$$

from i=1 to n

Where:

I_r - radon daughter intake (DAC-hours)

Dt_i - time of exposure to concentration WL_i (hours)

WL_i - average number of working levels in the air

DAC - the derived air concentration value for radon daughters from Appendix B of 10 CFR 20 (0.33 WL per DAC)

PF - respirator protection factor

n - number of exposure periods during the year

9.8.4 Bioassay Intake Calculation

When urine bioassay data is available and the bioassay indicates significant uranium intake, worker airborne uranium intakes will be calculated by using an intake conversion factor (ICF) similar to NUREG 8.22 and standards in HPS ANSI Bioassay Programs for Uranium. [77] All uranium intake calculations will be based on a soluble class W. Calculations of chronic vs. acute intake will be determined at the discretion of the RSO. Subsequent bioassays may be necessary to confirm an intake, and will supersede an unconfirmed previous bioassay.

$$I_{u\ acute} = S\ C_{u,i} / ICF_{acute,i} \text{ and}$$

$$I_{u\ chronic} = S\ C_{u,i}\ Dt_i / ICF_{chronic,i} ,$$

from i=1 to n

Where:

$C_{u,i}$ - urine bioassay concentration (mg/L)

$I_{u\ acute}$ - uranium acute intake (mg)

$I_{u\ chronic}$ - uranium chronic intake (mg)

Dt_i- time duration of worker chronic for bioassay i (days)

$ICF_{acute,i}$ - acute intake conversion factor for bioassay i (/L)

$ICF_{chronic,i}$- chronic intake conversion factor for bioassay i (days/L)

n - number of intakes or bioassays during the period of evaluation

9.8.5 Action Levels Requiring Notification

Section 20.2203 of 10 CFR 20 requires that overexposure reports be made to the appropriate NRC Regional Office if the intake of uranium and/or radon exceeds the quantities specified in 10 CFR 20.1201. If the following exposure limits will be exceeded at the CUP, HRI will notify NRC.

a. Soluble Uranium - if an employee has an intake of more than 10 mg of soluble uranium in one week. This intake is in consideration of chemical toxicity.

b. Total Effective Dose Equivalent (TEDE) - if an employee exceeds the TEDE annual limit of 5 rem.

c. If an employee exceeds 4 WLM ^{222}Rn Progeny.

9.8.6 Administrative Action Levels

An administrative action level will be set at 3 mg of soluble uranium for a calendar week. An administrative action level will be set at 130 DAC-hours for exposure to insoluble uranium and/or radon daughters for any calendar quarter. If the action level is exceeded, the RSO will initiate an investigation into the cause of the occurrence, determine any corrective actions that will reduce future exposures, and document the corrective actions taken. Results of the investigation will be reported to management.

The results of the TLD badges will be evaluated on a quarterly basis and an administrative action level will be set at 300 mrem per quarter. If an employee's exposure exceeds this level, the RSO will investigate the reason for the exposure and initiate corrective measures to prevent a recurrence.

The results of the bioassay program also will be used to evaluate the adequacy of the respiratory protection program at the facility. An abnormally high urinalysis will be investigated both to determine the cause of the high result, and determine if the exposure records adequately reflected that such an exposure may have actually occurred.

9.8.7 Airborne Radioactivity Areas

Any area, room, or enclosure will be designated "Airborne Radioactivity Area" as defined in 10 CFR 20.1003, if at any time the uranium concentration exceeds 1 DAC (3E-10 mCi/ml). It is anticipated that only the yellowcake dryer system area will be posted as Airborne Radioactivity Areas as concentrations of soluble uranium may at times exceed 3E-10 mCi/ml. Because the predominant form of airborne uranium in these areas will be comprised of yellowcake dried at 100 degrees Celsius, the uranium DAC for solubility class W will be used (3E-10 mCi/ml).

Additionally, areas will be posted as "Airborne Radioactivity Areas" in the case that an individual present in the area without respiratory protection could exceed, during the hours an individual is present in a week, an intake of 10 percent of the ALI. Airborne radioactivity areas will be posted in accordance with 10 CFR 20.1902. HRI will avoid posting radiation hazard signs in areas that do not require them.

9.9 Bioassay Program

9.9.1 Persons to Be Monitored

Bioassays will be performed for all workers who are routinely exposed to airborne yellowcake or excessive levels of yellowcake, such as may occur when maintenance work is performed in yellowcake areas.

9.9.2 Type of Bioassay

Bioassays will be by means of urinalysis capable of detecting the uranium content of the urine with a sensitivity of at least 1 mg/L of urine. Results will be obtained within 20 days of the collection and corrected to standard urine specific gravity of 1.02.

$$C_{u\ corrected} = C_{u\ measured}\ (1.02 - 1)/(S_g - 1)$$

Where:

$C_{u\ corrected}$ - uranium concentration in urine corrected to standard specific gravity of 1.02 (mg/L)
$C_{u\ measured}$ - measured uranium concentration (mg/L)
S_g - measured specific gravity of the urine bioassay specimen

If an outside laboratory is used, results exceeding corrected concentration of 30 mg/L will be reported by telephone.

9.9.3 Frequency of Bioassay

Baseline bioassays will be initially obtained and thereafter will be conducted at least once each month for workers routinely exposed to yellowcake. This generally applies to individuals who will be assigned to the Restricted Area. Individuals who work within the restricted area but not in a yellowcake work area will not be subject to routine bioassay.

Declared pregnant workers will have bioassay conducted at a minimum of once per month regardless of job assignment.

9.9.4 Actions Based on Bioassay Results

A corrected value of 30 mg/L under equilibrium conditions will be considered the limiting value a worker may have for chemical toxicity. A value of 130 mg/L obtained within two weeks following a single intake of yellowcake indicates a value significantly large to cause kidney damage, according to the U.S. Nuclear Regulatory Commission. In view of this, the following actions will be taken:

a. **Less than 15 mg/L** - none

b. **15 to 30 mg/L** -

   1. Confirm results (repeat urinalysis).
   2. Attempt to identify cause of high exposure.
   3. Take corrective measures and/or limit worker exposure.

c. **Greater than 30 mg/L** -

   1. Take actions as given above for 15-30 mg/L.
   2. Notify the NRC in writing.
   3. Determine whether other workers could have been exposed and perform additional bioassay measurements on them.
   4. Consider work restrictions to assure the worker does not exceed a uranium concentration of 30 mg/L in urine.

d. **Greater than 30 mg/L for four consecutive bioassays or greater than 130 mg/L for any 1 test** -

   1. Take actions given in c.
   2. Have additional urine samples tested for albumin.

9.9.5 Prevention of Specimen Contamination

Specimens will normally be collected at the beginning of the work day before contamination in the workplace is possible. Clean, disposable containers will be used and the worker must wash his/her hands carefully prior to voiding, and then clearly print first and last name, date of specimen donation, and Social Security Number.

9.9.6 Quality Control

The bioassays will be processed along with known control specimens of 15, 30 mg/L, and one blank to provide a means of assuring accuracy of the tests. New employees will be required to donate a baseline urine specimen for analysis. A program which tests for proteins using a dip-stick indicator will be established under the RSO's discretion in the RSO's lab by a designee soon after receiving the specimen. Then, an appropriate method of preservation will be employed for specimens which will be stored for longer than one week according to ANSI Standards of urine uranium bioassay sample preservation (such as refrigeration or the addition of a small amount of HCl). The RSO has discretion in requesting a 24 hour urine specimen collection (1-2 L) for confirmatory analysis.

URI maintains a Standard Operating Procedure (SOP) which addresses current procedures for the bioassay program including recordkeeping protocol.

9.10 Contamination Control Program

The primary sources of potential surface contamination at the CUP will be associated with precipitation, drying, and packaging activities. The recovery and elution portions of the process will not present a significant surface contamination problem except for dried spills, or when special equipment maintenance is required. The primary method for control of surface contamination will be instruction in, and enforcement of, good housekeeping and personal hygiene practices. Any visible yellowcake or production fluid spills will be cleaned up as soon as possible to prevent drying and possible suspension into the air which could pose an inhalation hazard. Plant operators will be instructed in the proper use of equipment, and the prevention of spills and solution leaks at various stages of the process. Inadvertent contamination of designated clean areas will be controlled by instructing employees not to enter such areas with clothing or equipment contaminated with radioactive materials. If yellowcake is detected in a designated clean area, the RSO will be notified immediately, the area will be promptly cleaned, and an investigation into the source of the contamination will be performed.

To ensure these administrative controls will be effective in controlling surface contamination, alpha contamination surveys will be performed monthly in process areas and in designated clean areas.

Table 9.10-1 provides the limits for surface contamination.

9.10.1 Surface Contamination Control

Routine surveys in the CCP and satellite Facilities will consist of both a visual inspection for obvious signs of contamination and instrument surveys to determine total alpha contamination. If the total alpha survey indicates total contamination greater than 1000 dpm/100 cm^2, a smear survey will be performed to determine the removable contamination. Results will be documented on the survey data sheet.

Table 9.10-1 Limits for Release to Unrestricted Use

Nuclide	Average[a]	Maximum[b]	Removable[c]
U-nat	5,000 dpm/100 cm2	15,000 dpm/100 cm2	1,000 dpm/100 cm^2
226-Ra	100 dpm/100 cm2	300 dpm/100 cm^2	20 dpm/100 cm^2

a. Averaged over no more than 1 m^2.

b. Applies to an area of not more than 100 cm^2.

c. Determined by smearing with dry filter, or soft absorbent paper, applying moderate pressure and assessing the amount of radioactive material on the smear.

Source: Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," and "Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use, or Termination of License for Byproduct, Source, or Special Nuclear Material." [71]

In non-yellowcake work areas such as lunch rooms, offices, and change rooms, if the total alpha survey indicates contamination in excess of 1000 dpm/100 cm^2 (i.e. 20% of Table 9.10-1 removable limits) a smear test will be performed to assess the level of removable alpha activity. If smear test results indicate removable contamination greater than 200 dpm/100 cm^2, the area will be cleaned promptly, and resurveyed. The RSO will investigate the cause of the contamination and implement corrective action to minimize the potential for a recurrence.

Uranium processing equipment that must be removed for maintenance or repair will be thoroughly decontaminated to prevent the possibility of contamination in the maintenance shop. Any materials or equipment being released from the project site to an unrestricted area will be surveyed for contamination prior to release. Equipment and surfaces shall not be painted over or plated for the purpose of meeting release criteria. However, if painting over an area with contamination that cannot reasonably be removed is determined by the RSO to be ALARA, it may be allowed as long as the contamination on the article or surface is characterized and documented. The radioactivity of pipes, drain lines, pumps, or duct work where access can be difficult, will be determined by making measurements at a trap or similar access point. Adequate records will be maintained to ensure that the article or surface is not inadvertently released for unrestricted use. Should the survey indicate contamination in excess of the Table 9.10-1 limits, the equipment/material will be decontaminated and surveyed again. The survey results will be documented and maintained on site.

9.10.2 Personnel Contamination Control

Employees will maintain change rooms, showers, and lockers for clean clothing. An operable and appropriately calibrated alpha survey meter will be made available for employee use at the exit of the change room.

Employees will be instructed in the use of the survey meter, techniques for minimizing contamination, for maintaining good industrial hygiene, and in basic decontamination methods. Also, employees will be instructed on methods and procedures for good housekeeping practices within process areas to minimize the potential for contamination of personnel and equipment. The RSO or designee will perform unannounced spot check surveys for alpha contamination on workers leaving the Restricted Areas. These unannounced spot check surveys will be conducted on at least a quarterly basis.

Employees working in the precipitation, drying, and packaging areas, as well as those involved in process equipment maintenance or repair, will maintain appropriate protective clothing and equipment. Protective clothing will be laundered on site, or if a disposable type, will be disposed in a facility licensed to accept such wastes.

All employees with potential exposure to yellowcake or yellowcake dust may shower and change clothes each day prior to leaving the site. An employee who showers and changes clothes will be considered to be free of significant contamination. In lieu of showering, employees who work in the yellowcake work area will be required to survey their clothing, shoes, hands, face, and hair with an “frisk” alpha survey instrument prior to leaving the site. These surveys, and/or showers will be documented and records maintained on site. Additionally, prior to entering a designated clean area (e.g. lunchroom) from processing areas, employees will be required to wash their face and hands to ensure complete removal of possible contamination.

9.10.3 Transports and Shipments

Transport surveys will demonstrate that the exposure levels are below the regulatory limits, and the truck surfaces are free of radioactive material.

9.10.3.1 Yellowcake Drum Transport Survey

Packaged drums filled with dry yellowcake located on the storage pad will be smear surveyed using filter paper before shipment. The truck and trailer loaded with yellowcake drums will be surveyed for external exposure rate. The surface swipes and external exposure surveys will be recorded, and included as part of the YC drum shipment papers. Shipment papers will include measured contents of each drum, driver's agreement, bill of lading, and instructions in case of accident or spill.

Limits for Yellowcake Drum Transport

- removable alpha[1] 2,200 dpm/100 cm^2
- removable gamma/beta[1] 22,000 dpm/100 cm^2
- external exposure rate[2] at skin of trailer 2 mrem/hr

[1] 49CFR173.443, [2] 49CFR173.400

9.10.3.2 Yellowcake Drum Transport Labeling

Yellowcake is classified by the Department of Transportation as radioactive material of Low Specific Activity (LSA) according to 49 CFR 172-178. Each drum will be labeled on two sides with the drum number, net yellowcake weight, and radioactivity stickers including LSA, and Caution - Radioactive Material. Radioactive Material sticker is magenta against yellow background, and contains the following information:

Caution
Radioactive Material

Handle Carefully
No person will remain within 3 feet of this container unnecessarily
Principle radioactive contents: Natural Uranium (Oxide)
Activity of contents: 50 mCi (maximum)
Estimated radiation level at package surface
when packaged: 3.0 mrem/hr

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9.10.3.3 Resin Transports

Ion exchange resins are transported in specially designed trailers that are placarded according to DOT specifications. Resin transports are surveyed using a portable external exposure rate meters. Filter swipe(s) are taken and counted for alpha.

Administrative Limits for Slurry Transports

- fixed or removable alpha 1,000 dpm/100 cm^2
- external exposure rate 200 mrem/hr

Survey results are documented on a form and maintained on site for inspection.

9.10.3.4 Shipping and Receiving Packages

All outgoing yellowcake packages will be surveyed prior to commercial carrier shipment. The RSO will be notified of any anticipated package shipments. The package will be surveyed for external exposure rate, surface alpha and beta, by fixed and removable swipe surveys. All packages will be required to have the DOT labeling for packages containing radioactive material with the correct UN number, and a Radioactive White I, Yellow II, or Yellow III label which includes the radionuclide(s) and quantity. For packages containing yellowcake samples for an independent laboratory analysis, they will also be labeled Low Specific Activity (LSA). Packages received will be assessed for degradation or loss of containment integrity.

9.10.3.5 Trash Surveys

Office trash and other materials which are free of process contamination will be disposed of in a municipal land fill. Loads of trash will be surveyed for gamma and beta activity before leaving the site. No survey will exceed two times background at the surface of the trash trailer. Records will be maintained on site.

9.11 Respiratory Protection

9.11.1 Introduction and Policy Statement

In accordance with Subpart H, "Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas" of 10 CFR Part 20, "Standards for Protection Against Radiation", which permits licensees to make allowance for the use of respiratory protection in estimating exposures of individuals to airborne radioactive material, HRI will initiate a Respiratory Protection Program for the purpose of using the allowance similar to the U.S. Nuclear Regulatory Commission Regulatory Guide 8.15.[84]

Whenever practicable, HRI will utilize engineering controls, such as ventilation or process enclosure to preclude the use of respirators. However, when it is impracticable to apply process, or other engineering controls to limit concentrations of radioactive materials below those that define an airborne radioactivity area, other precautionary procedures, including increased surveillance and air sampling, limitation of work times in the area(s), and respiratory protective equipment, will be used to maintain the intake of radioactive materials ALARA.

Respirators will be routinely used for certain operations within the dryer system and packaging areas, as well as for certain maintenance activities in these areas. Radiation work permits for non-routine jobs and emergency situations may also require respirator usage. Employees will not enter areas where radioactive materials may exceed acceptable standards nor perform maintenance activities which may involve airborne releases until the RSO or designee has evaluated the potential exposure, and selected the proper respiratory equipment and other radiological protection controls.

9.11.2 Respiratory Protection Policies and Responsibilities

a. Respirators will be used only for operations where it is not feasible to prevent atmospheric contamination by effective engineering controls such as process enclosure or ventilation. However, respirator use will be no substitute for practicable engineering controls. Therefore, respirators will be used only while engineering controls are being evaluated/instituted, and during maintenance in tanks or other enclosures that routinely contain radioactive materials and/or other toxic materials. Only approved or certified respiratory equipment will be used.

b. Respirators will be used routinely for operations within the drying and packaging areas, and for certain other maintenance activities. Radiation work permits for special jobs and emergency situations may also require respirator use. Employees will not be allowed to enter areas where radioactive contaminants may exceed acceptable standards nor perform maintenance activities which may involve airborne releases until the RSO or designee has evaluated the potential exposure, selected the proper respiratory equipment, and implemented other health physics controls as may be appropriate for the situation.

c. Employees will leave an area where respiratory protection is required at any time for relief from respirator use in the event of equipment malfunction, physical or psychological distress, procedural or communication failure, significant deterioration of operating conditions, or any other condition that may require such relief.

d. Any individual required to wear a respirator to perform routine or non-routine tasks will also be required to have a shaven face where nothing interferes with the seal of tight-fitting face pieces against the skin.

9.11.3 Employee's Responsibilities

a. Employees will use the respirator in accordance with instruction and training provided by the RSO or designee. For some types of respirators providing protection for individuals wearing corrective glasses may be a serious problem. A proper seal cannot be established if the temple bars of the eye glasses extend through the sealing edge of the full face pieces. When a worker must wear corrective glasses as part of a face piece, the face piece and lenses will be fitted by a qualified individual to provide both good vision, comfort, and a gas-tight fit.

b. Informing his Supervisor of any personal health problem that could be aggravated by the use of respiratory protection equipment.

c. Not modifying or in any way altering the manufacturer's design of the respirator.

d. Pre-use inspection and reporting any observed or suspected malfunctioning respirator to the RSO or designee.

e. Using only those brands and types of equipment for which he has been trained to use, and can obtain a satisfactory fit.

f. Checking the seal of the respirator by appropriate means prior to entering a harmful atmosphere.

g. Notifying his supervisor, the RSO, or designee whenever it will be necessary to enter an area in which airborne radioactive contaminants may exceed acceptable standards, for the purpose of performing non-routine maintenance or activities for which a standard operating procedure does not exist.

h. Maintain respiratory equipment in serviceable condition.

9.11.4 Supervisor's Responsibilities

a. Notifying the RSO or designee whenever it will be necessary for an employee to enter an area in which airborne radioactive contaminants may exceed acceptable standards for the purpose of performing non-routine maintenance, or activities for which a standard operating procedure does not exist.

b. Enforcing the use of respirators in situations that require respiratory protection.

c. Consulting with the RSO or designee for evaluation of exposure hazards whenever it will be suspected that airborne radioactive or toxic contaminants could exceed acceptable standards.

d. Notifying the RSO or designee of any employee known to have an active medical work restriction, and obtain RSO clearance for such employee prior to assignment of any job requiring the use of respiratory protection.

9.11.5 The RSO or Designee Responsibilities

a. Providing necessary respiratory equipment to protect the health of the employee.

b. Random inspections to insure equipment maintained in serviceable condition.

c. The selection and fitting of employees with the proper respirator, as well as instructing them in the correct use and maintenance of the respirator.

d. Random inspections of respirator use.

e. Evaluating employee exposures and work conditions, including monitoring of airborne radioactive contaminant concentrations during the time the employees are working, and determining when a urinalysis will be required similar to NRC Regulatory Guide 8.22. [77]

f. Establishing and keeping records as required.

9.11.6 Respiratory Protective Equipment Selection

Several types of respiratory protection equipment will be available, and have been chosen to offer protection against potential airborne radioactive hazards to be encountered. The function of respirator type selection will be assigned to the RSO, designee, or the Director of Safety.

a. Several factors govern equipment selection. These include:

1. Nature and extent of the hazard.
2. Work requirements and conditions.
3. Respiratory equipment limitation.

b. The types of respirators that may be used at the CUP are those specified in Appendix A of 10CFR20.

c. Protection Factors. The overall protection given by a certain respirator is defined in terms of its protection factor (PF). These are outlined in Table I, US NRC Regulatory Guide 8.15, [84] and 10 CFR 20 Appendix A.

The PF is a measure of degree of protection afforded by a respirator defined as the ratio of the concentration of contaminants outside the face mask or hood to that inside the equipment under conditions of use. For example, an air purifying half-mask may be used for protection in atmospheres with a contaminant concentration up to 10 times the permissible exposure limit. In the case of employee-measured intake of airborne radioactive contaminants, the ambient concentration in the air will be divided by the protection factor to determine actual intake. The PFs are based on laboratory tests which show how much leakage can occur between face piece seal, and the face on a cross-section of different facial types and sizes after each wearer was properly fitted with various types of equipment. Therefore, the PFs may only be used on those people who are found to have a satisfactory fit with the device they will be wearing. (See NRC Regulatory Guide 8.15 [84], or 10CFR20 App. A for appropriate protection factors.)

d. Air-Purifying Respirators. Air-purifying respirators remove nonradioactive gases and vapors, or any Particulates from the ambient air to make it suitable for breathing. Air-purifying media consist of fiber filters, or sorbents used individually or in combination, and will be contained in a suitable protective casing that is designed for attachment to the respirator face piece or breathing tube. A filter is a fibrous medium used for the removal of airborne solid or liquid particulates from the air stream entering the respirator enclosure. They will be designed for a single type of particulate, or for various combinations of particulates such as dust, fumes, and mists. The protection factors apply for air-purifying respirators only when high efficiency particulate filters [above 99.97% removal efficiency by thermally generated 0.3 ppm dioctyl phthalate (DOP) test] will be used in atmospheres not deficient in oxygen, and not containing radioactive gas or vapor respiratory hazards.

Sorbents are used for chemically removing toxic gases and vapors from the airstream entering the respirator enclosure. The sorbents may be used singly, or in a mixture and multiple layers to give protection against a single gaseous contaminant, a class of contaminants (e.g., organic vapor, or acid gases), or combination of gases and vapors. They are not, of themselves, effective against particulates. They will not be approved for use for protection against radioactive gases or vapor unless their efficiency against the gas or vapor of interest has been well established.

9.11.7 Respiratory Training

Persons administering the Respiratory Protection Program (i.e. training, respirator selection, respiratory integrity testing, etc.) will have at least one year of work experience relevant to applied health physics, radiation protection, industrial hygiene (or related work), and respiratory protection. This experience will involve working with respiratory protective equipment, cleaning, maintenance, and fit testing (not strictly administrative). Additionally, a thorough understanding of the facilities' process and equipment, and the hazards generated, will be required. The RSO or designee will conduct respirator training. Every employee who needs to wear a respirator for health protection must be trained in the proper selection, maintenance, and use of the respirator, and its limitations. Respirator training will be documented on a respirator training completion form. Additionally, when respirators have been used in atmospheres containing airborne uranium, employees will participate in a bioassay program consisting of urinalyses similar to NRC Regulatory Guide 8.22. [77]

Training will consist of:

a. Fitting, which will be done by the RSO or trained designee.

b. Testing face piece-to-face seal under normal face/head movements that could cause leakage to ensure a proper fit.

The face-to-face piece seal will be tested using irritant smoke.

c. Learning how to wear, adjust, and test for proper fit before each wearing, including the positive and negative pressure fit checks.

d. Identifying the locations and times that respiratory protection is required.

e. Learning how to identify the various respirator cartridges, and types of contaminants that each cartridge is designed to protect against.

f. Learning the proper maintenance, inspection, and storage of respirator protection devices.

Any individual with an active work restriction (temporary or permanent) will consult with his supervisor, the RSO, or designee before using any respirator.

9.11.8 Medical Approval

Medical examination (approval) will be required for anyone who needs, or may have the need to wear a respirator. The medical examination will be required to determine that an individual is medically fit to use the respiratory equipment. The frequency of medical examinations will be determined by a physician prior to the initial fitting of respirators, and thereafter at a frequency determined by a physician. An examination will be given every 5 years up to age 35, every 2 years up to age 45, and annually thereafter. The approval will be documented by the tester on the respirator training.

9.11.9 Pre-Use Inspection Procedure

The respirator will be inspected before each use to ensure it is in good operating condition. Any damage or defective parts will be replaced before use. The following inspection procedure will be performed:

a. The face piece will be checked for cracks, tears, and dirt. The face piece, especially the face seal area, will be checked for distortions. The face seal area material will be pliable - not stiff.

b. All valves will be examined for signs of distortion, cracking, or tearing. Valve seats will be inspected for dirt or cracking.

b. The head straps will be intact and have good elasticity.

d. All plastic parts will be examined for signs of cracking or fatiguing. All the gaskets will be checked for proper seating.

e. The lens in the full face mask will be clear and free from cracking or crazing. It will be checked for embrittlement.

f. Full face respirators with gas mask type canister will require pre-inspection of the canister. The expiration date located on the side label will be checked. The respirator will not be used if the date has past. The respirator will not be used if the seal is missing over the bottom opening, or where it threads onto the face mask.

g. When using supplied air the air filtering system will be connected to the instrument airline. The filters in the air filtering system will be checked and replaced if necessary. The airline hose will be inspected for cracks; the rubber will be pliable, not stiff. Additionally, the hose connecting fittings will be checked to insure they are in good working order.

9.11.10 Assembly Instructions

Appropriate cartridges (high efficiency, organic vapor, or acid/gas or combination) will be attached securely to the face piece at the side inhalation openings.

9.11.11 Putting on the Full Face Respirator

The following will be performed for full face respirators in a non-contaminated area.

a. The head straps will be adjusted to their full extended position.

b. The face piece will be donned by grasping the head strap harness with the thumbs through the bands, spread outward.

c. The harness top will be pushed up the forehead, brushing hair upward from the face seal area. The donner will continue pushing up and over the head until the harness is centered at the rear of the head and the chin is fitted into the chin cup.

d. The face piece will be centered on the face, and the wearer will pull both lower (neck) head straps at the same time towards the rear.

e. The two upper (temple) head straps will be tightened.

f. The forehead head strap(s) will then be tightened.

9.11.12 Putting on the Half Mask Respirator

The following will be performed in a non-contaminated area.

a. The respirator will be placed over the mouth and nose. Then the head harness will be pulled over the crown of the head.

b. The bottom straps will be placed in back of the neck and hooked together.

c. Tightening will require pulling the ends of the head harness and the neck straps.

9.11.13 Fit Check

Before entering an area containing a hazardous atmosphere, the respirator wearer will be required to test the tightness of the seal of the respirator face piece to the face by performing a negative or positive pressure fit check. At the CUP, an random smoke fit test will be used as a spot check. These fit checks will be as follows:

a. Positive Pressure Fit Check - Place palm of hand over exhalation valve cover and exhale gently. If the face piece bulges slightly, and no leaks between the face and face piece are detected, a proper fit will be obtained. If air leakage is detected, reposition the respirator on the face and/or readjust the tension of the head-straps to eliminate the leakage. Repeat the above steps until a tight seal is obtained. If one cannot achieve a proper fit, do not enter the contaminated area.

b. Negative Pressure Fit Check - Place the palms of the hands (alternatively either pieces of cardboard or plastic) over the open area of the filter cartridge, inhale gently, and hold your breath for five to ten seconds. If the face piece collapses slightly, a proper fit has been obtained. If air leakage is detected, reposition the respirator on the face and/or readjust the tension of the head straps to eliminate the leakage. Repeat the above steps until a tight seal is obtained. If one cannot achieve a proper fit, do not enter the contaminated area. If a tight seal cannot be achieved contact the RSO or designee. DO NOT ENTER THE AREA WHERE THE RESPIRATOR IS REQUIRED.

To check the full face respirator with supplied air, the air is closed off and the wearer inhales gently. The wearer then holds their breath for 10 seconds. A good fit is indicated if the mask remains collapsed toward the face while holding ones breath.

Half mask respirators require fit testing EVERY time the respirator will be put on since it is more difficult to achieve and maintain an adequate fit with half masks than with other face pieces. At Crownpoint, a smoke fit test will be used as a spot check.

9.11.14 Respirator Maintenance

a. The primary purpose of the maintenance program will be to ensure that respiratory protective equipment will be kept ready for use. This part of the program will be very important to insure the safety of the wearer. Respirators will be cleaned and maintained under the direction of the RSO or designee. Each employee will be responsible for maintenance and cleaning of the respiratory equipment they will be using. The maintenance program will include the following.

1. Employee training in the approved methods for maintenance and cleaning of respiratory equipment.

2. The decontamination, cleaning, and disinfecting of respiratory protective equipment.

3. Inspection and testing of the respirator components for integrity and operability.

4. Replacement of defective components, when necessary.

5. Maintenance of auxiliary equipment.

6. Appropriate storage for respiratory protective equipment.

7. Spot checks by the RSO or designee for respirator contamination, proper respirator usage, respirator component integrity, correct cleaning practices, and proper respirator storage.

b. Respiratory Protective Equipment Cleaning, Sanitizing, and Maintenance - Hygienic procedures will be required for respirators being issued for use in environments containing airborne radionuclides, or other air contaminants. When operating in the dryer system and packaging areas, the respirator will require frequent cleaning, thereby avoiding the potential for radioactive material contaminating the inside of the face piece. The employee will be responsible for ensuring the respiratory equipment in use will be in good working order and the inside of the face piece will be contamination free. Emergency devices (SCBA) require cleaning after each use.

c. Placement of used respirators in a container designated for dirty/contaminated respirators, returning them to the Environmental Laboratory.

d. Removal of filter cartridges from respirators before washing.

e. Washing the respirator in a dish washer using liquid soap, such as LIQUI-NOX. Following the wash, all parts will be allowed to air dry at room temperature.

f. Inspection of all components for wear or deterioration, especially the inhalation and/or exhalation valves and seats.

g. Replacement of any worn components. Replacement parts will be kept in the Environmental/Radiation Safety Lab.

h. A random swipe survey to be performed by the RSO or designee with the results recorded on the respirator survey form. If any respirator survey indicates an alpha activity greater than 100 dpm/100 cm fixed alpha, the respirator will require re-cleaning and surveying again.

i. Storing of the respirator in a clean plastic bag. Bags will be found in the warehouse or the Environmental Radiation Safety Lab.

j. Random inspections by the RSO or designee of both respirator fit and conditions during periods of use by employees. Any employee found to have a poor fit and/or a respirator that will be unserviceable, will be removed from the area, the employee refitted and/or the respirator repaired. No protection factor will be used for the period of time the employee had an improper fit or, unserviceable respirator.

Consistent with the PBLC format, HRI will develop a Standard Operating Procedure (SOP) which addresses updated procedures for the respiratory program.

9.12 Quality Assurance

HRI will establish a Quality Assurance Program for all radiological and non-radiological effluent and environmental (including ground water) monitoring programs at the CUP. This Quality Assurance Program will address elements discussed in USNRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment." [91]

9.12.1 Program Objectives and Elements

Quality assurance comprises those planned and systematic actions which will be necessary to provide adequate confidence in the results of a monitoring program. Quality control will include those quality assurance actions that provide a means to control and measure the characteristics of measurement equipment and processes to established requirements. Therefore, quality assurance will include quality control.

The overall objectives of a Quality Assurance program are:

a. To identification of deficiencies in the sampling and measurement processes to those responsible for these operations so that corrective action can be taken.

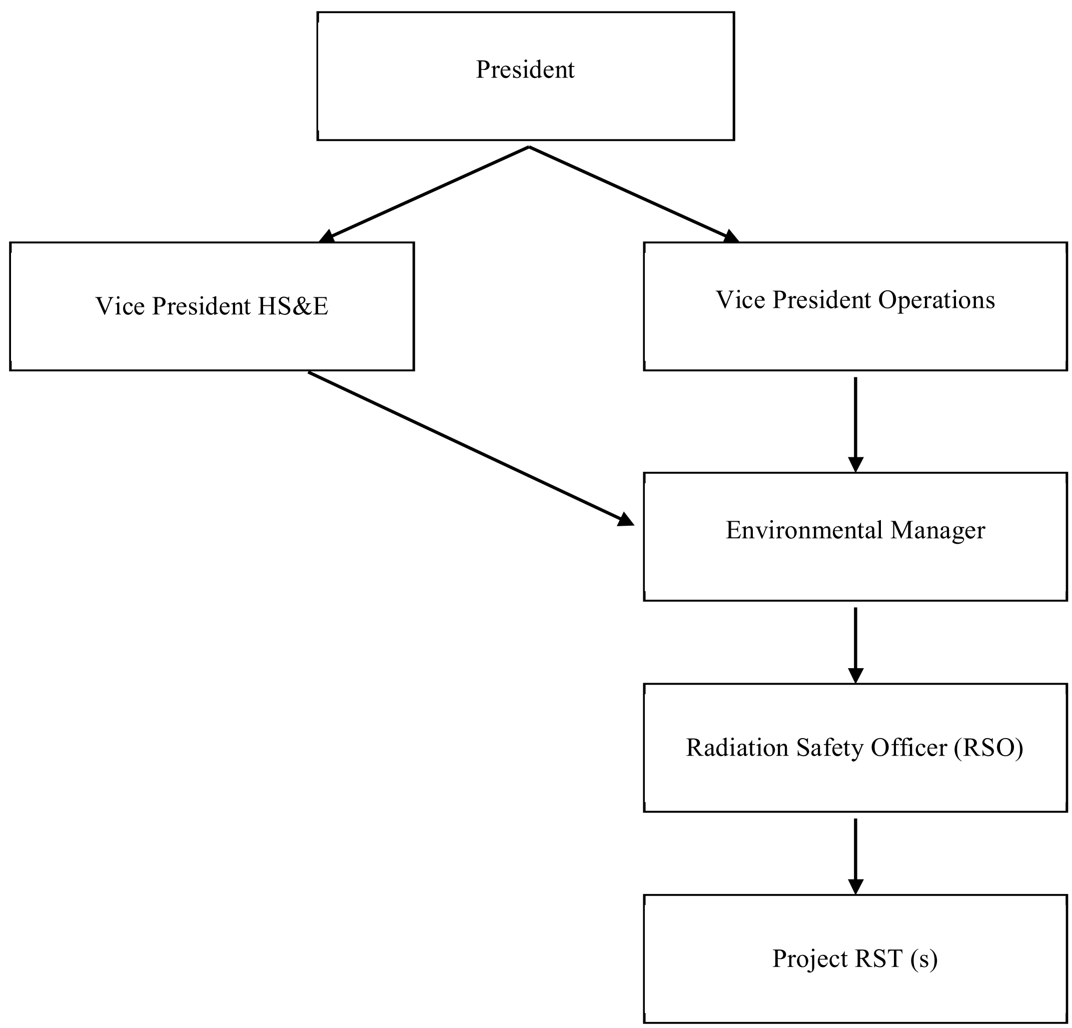
b. To obtain a measure of confidence in the results of the monitoring programs to assure regulatory agencies and the public that the results are valid.

To achieve these objectives, a Quality Assurance plan has been developed that includes elements recommended in USNRC Regulatory Guide 4.15. [91]

9.12.2 Organizational Structure and Responsibilities

Figure 9.12-1 shows the Environmental and Radiation Safety organization, and reporting responsibilities at the CUP. The responsibilities of those personnel involved in Quality Assurance will be follows:

Figure 9.12-1 CUP Organizational Structure



9.12.2.1 V.P. of Health, Safety and Environmental Affairs

The Vice President of Health, Safety, and Environmental Affairs (VPHSE) will have the ultimate responsibility and authority for the radiation safety, environmental compliance, and Quality

Assurance program at the CUP, in addition to off-site project development activities. The VPHSE will provide corporate audit input to the Environmental Manager and Radiation Safety Officer to ensure that all radiation safety, environmental compliance, and permitting/licensing programs will be conducted in a responsible manner, and in compliance with all applicable regulations and permit/license conditions. The VPHSE will report directly to the CEO of Uranium Resources, Inc.

9.12.2.2 V.P. Operations

The CUP Vice President of Operations (VPO) will be directly responsible for all operations, including, implementing industrial and radiation safety, and environmental protection. This includes all operating procedures, radiation safety programs, industrial safety programs, environmental, and ground water monitoring programs, associated quality assurance programs, and routine and non-routine maintenance activities. The VPO will be also responsible for compliance with all regulatory license conditions and regulations, and reporting requirements. The VPO will have the responsibility and authority to terminate immediately any activity that he determines to be a threat to employees, or public health, or the environment, as indicated in reports from the Environmental Manager or RSO. The VPO will be a member of the SERP and the ALARA Audit Team, and will report directly to the President of HRI.

9.12.2.3 Environmental Manager

The Environmental Manager (EM) will be based at the Albuquerque office or at a site office. He will be responsible for the development, administration, and enforcement of all radiation protection, environmental, and ground water monitoring programs at the CUP.

The EM will assist in the development, review, and approval of sampling and analysis procedures used at the CUP, and aid in the technical evaluation of laboratory data, as required. The EM will be also responsible for routine auditing of sampling quality assurance/quality control programs developed and used at the CUP.

The EM will develop and administer radiation protection programs to ensure that: (1) employees will be afforded the optimum practical protection against radiation hazards; (2) exposure of employees to radiation and radioactive materials will be maintained "As Low As Reasonably Achievable"; and (3) all applicable regulatory requirements will be met. The EM also will provide technical guidance and assistance to site personnel in the matter of radiation protection. The EM will have the authority to terminate immediately any activity that will be determined to be a threat to the employees, or public health, or the environment, as indicated in reports from the CUP RSO. The EM will be a member of the ALARA Audit team, and report directly to the President of HRI.

9.12.2.4 Radiation Safety Officer

The CUP Radiation Safety Officer (RSO) will be responsible for the daily supervision of the radiation safety and environmental programs at the CUP. Responsibilities will include the development and implementation of all radiation safety and environmental programs, ensuring that all records will be correctly maintained, and assist the VPO in ensuring compliance with NRC regulations and license conditions. The RSO will be designated as the Site QA Coordinator. The RSO will conduct training programs for the supervisors and employees with regard to the proper application of radiation protection and environmental control procedures. The RSO will personally inspect facilities to verify compliance with all applicable radiological health and safety requirements, and the Quality Assurance Program. The RSO will be a member of the SERP and assist management with the Annual ALARA Audit, and report directly to the EM.

9.12.2.5 Radiation Safety Technician

At least one RST will be present at each producing CUP location. The Crownpoint RST will conduct environmental and radiological surveys, collect air, water, soil, and vegetation samples, perform analyses, collect data for the radiation safety program, perform calculations of employee radiation exposures, keep records, and conduct various other activities associated with implementation of the environmental and radiation protection programs. The RST will report all radiation protection data directly to the RSO prior to submittal to the EM. The RST will assist management with the Annual ALARA Audit, and report directly to the RSO.

9.12.3 Qualifications and Training

Minimum technical qualifications and experience required for personnel who will be responsible for developing and administering the Crownpoint radiation and environmental protection programs, and the Quality Assurance Program, will be as follows:

9.12.3.1 V.P. of Health, Safety and Environmental Affairs

The VPHSE will require a Bachelor’s degree in Engineering or Science from an accredited college, or university, or equivalent work experience, plus a minimum of five years management experience in senior management of engineering and operations functions. A Master’s degree will qualify for two years work experience.

9.12.3.2 Vice President of Operations

The position of Vice President of Operations will require a Bachelor’s degree in Engineering or Science from an accredited college, or university, or equivalent work experience, plus a minimum of five years supervisory experience. A Master’s degree will qualify for two years work experience. Work experience will include industrial process/production experience and industrial process/ production management.

9.12.3.3 Environmental Manager

The position of EM will require a bachelor's degree in the physical or biological sciences, mathematics, or engineering from an accredited college or university, and at least three years of experience in applied health physics and radiation protection. Experience will be industry related. A Master’s degree will qualify for two years work experience.

9.12.3.4 Radiation Safety Officer

The position of RSO will require a Bachelor’s degree in the physical sciences, industrial hygiene, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium recovery facility radiation protection. Two years of relevant experience will be generally considered equivalent to 1 year of academic study. The RSO will possess at least 1 year of work experience relevant to uranium recovery operations in applied health physics, radiation protection, industrial hygiene, or similar work. This experience will involve actually working with radiation detection and measurement equipment, not strictly administrative or "desk" work. The RSO will have at least 4 weeks of specialized classroom training in health physics specifically applicable to uranium recovery. In addition, the RSO will attend refresher training on uranium recovery facility health physics every 2 years. The RSO will have a thorough knowledge of the proper application and use of all health physics equipment used in the uranium recovery facility, the chemical and analytical procedures used for radiological sampling and monitoring, methodologies used to calculate personnel exposure to uranium and its daughters, and a thorough understanding of the uranium recovery process and equipment used in the facility and how the hazards are generated and controlled during the uranium recovery process.

9.12.3.5 Radiation Safety Technician

The position of RST will require a minimum of a high school diploma, or alternatively, an equivalent combination of experience and training in uranium mill radiation protection. A Bachelor's degree in physical or biological sciences, engineering, or related discipline from an accredited college, or university with no experience will also be acceptable.

9.12.3.6 QA Training

Personnel performing quality related activities such as radiological sampling, water quality sampling and analysis, and environmental monitoring will be trained in the principles, and techniques of the activities performed. The majority of the personnel involved in these quality related activities will be experienced professionals. Training of the field personnel (e.g., RST, samplers) will be achieved by an on-the-job training (OJT) program that will be specific to the activities performed, and will be administered by experienced professionals. This OJT training will be documented and maintained on site. The training period will continue until the employee demonstrates proficiency as determined by observation of his/her working techniques, and by obtaining acceptable sampling and analytical results.

9.l2.3.7 Training Evaluation

At least annually, each individual who performs quality related activities will undergo a performance review by his immediate supervisor which will include an evaluation of the person's performance, adherence to written procedures, and knowledge of the nature and goals of the Quality Assurance Program. This evaluation will be documented and maintained on site.

9.12.4 Operating Procedures

HRI will establish Standard Operating Procedures (SOP's) for operational and non-operational activities involving radioactive materials including quality related activities. SOP’s will be reviewed annually by the RSO and, if necessary, changes will be recommended to the SERP. Prior to implementation of new or revised SOP's, they will be reviewed and approved by the SERP to ensure that proper safety and radiation safety principles and practices have been included. Additionally, the EM will perform a documented audit of all existing operating procedures that deal with radioactive materials on an annual basis.

9.12.5 Ground and Surface Water Quality Monitoring Program

Additionally consistent with PBL license requirements, HRI will develop specific SOP's detailing the procedures for collecting water samples and analyzing for the excursion parameters. Baseline water quality samples will be filtered and preserved on and/or off site, and transported to an EPA approved laboratory for analysis in accordance with accepted methods.

Periodically for monitor well samples a duplicate sample, and a spiked sample will be analyzed. The duplication begins with original sample aliquots and allows the analyst to determine the precision of the analytical result. Standard addition spikes consist of the addition of a known amount of analyze to a duplicate sample aliquot. These spiked samples will be useful in estimating the accuracy of an analytical result as well as identifying potential interferences.

The quarterly environmental ground and surface water samples described in Section 9.4.2 will be preserved on-site, and transported to an EPA certified laboratory for analysis. The samples will be preserved and analyzed in accordance with accepted methods.

9.12.6 Airborne Effluent and Environmental Sampling Program

The passive radon and gamma detectors will be analyzed by the manufacturer.

9.12.7 Radiological Monitoring Program

9.12.7.1 Monitoring Locations

Figures 2.1-1 and 2.1-2 of the COP illustrate the monitoring locations and the type of sampling performed at each location within the process areas at the CUP is described in Table 9.4-2.

9.12.7.2 Monitoring Equipment

Table 9.4-1 lists the specifications of typical radiation monitoring instruments that will be used at the CUP. A sufficient number of back up instruments will be available to insure that there will be operable instrumentation during calibration downtime, and in the event of maintenance problems.

9.12.7.3 Quality of Samples

Provisions will be made to ensure that representative samples are obtained by the use of proper sampling equipment, locations of sampling points, and sampling procedures.

Air samples may be composited for analysis if they are collected at the same location, and if they represent a sampling period of one calendar quarter or less. Air samples collected for analysis of 222-Rn and/or radon progeny will be analyzed using appropriate methods to minimize activity loss due to decay.

9.12.7.4 Lower Limit of Detection

The lower limit of detection for radiological and environmental samples will be determined similar to NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills"; Regulatory Guide 8.30, "Health Physics Surveys in Uranium Mills"; and NUREG - 5849, "Manual for Conducting Radiological Surveys in Support of License Termination", Section 5.2 "Instrument Detection Sensitivity". [75][56][96] In general, for radiological detection of a mass sample when the gross and background count times are equal, the Minimum Detectable Amount (MDA) is:

$$MDA = [2.71 + 4.65\ (R_b)^{0.5}] \ /\ [2.22\ E\ M\ (t_b)^{0.5}]$$

Where:

MDA - minimum detectable amount (pCi/g)
R_b - background count rate (cpm)
t_b - background count time (min)= gross count time
E - counter efficiency
M - sample mass (g)
2.22 - activity conversion factor (dpm/pCi)

9.12.7.5 Error Estimates

Whenever possible, results reported from the contract laboratory include estimates of uncertainty. The magnitude of the random error of the analysis to the 90% uncertainty level will be reported (2 standard deviations).

9.12.7.6 Calibration

Individual SOP's will be used for calibrating all sampling and measuring equipment (in conjunction with the use of qualified calibration services using appropriate procedures). Procedures and calibration methods used ensure that the equipment will operate with adequate accuracy and stability over the range of its intended use. Calibration procedures may be compilations of published standard practices, manufacturers' instructions, or procedures written in-house. To the extent possible, calibration of radiation measuring equipment will be performed using radionuclide standards traceable to the National Institute of Standards and Technology (NIST).

Calibrations will be performed on radiation detection instruments at annual intervals. Equipment will be recalibrated or replaced after any repairs, or whenever it is suspected of being out of adjustment, excessively worn, or otherwise damaged and not operating properly. Functional tests, i.e., routine checks performed to demonstrate that a given instrument is in working condition, will be performed using sources that are not traceable to the NIST. Radiation detection instruments will be function tested with a radiation check source before each day's use to ensure that they are responding to within +/- 20% of the reference reading for the check source. These function tests will be documented and maintained on site.

9.12.7.7 Quality of Results

A continuous program will be implemented for ensuring the quality of results and for keeping random and systematic uncertainties to a minimum. The procedure will ensure that samples and measurements will be obtained in a uniform manner, and that samples will not be changed prior to analysis because of handling or storage environment.

Procedures for computation of the concentration of radioactive materials include periodic independent verification of the results by a person other than the one performing the original calculation. The input data for computer calculations will be verified by a knowledgeable individual. All computer programs will be verified prior to initial use, and after each modification made by the manufacturer.

9.12.8 Field Sampling and Measurement Records

Field sampling and measurement records will be maintained at the Crownpoint Site. These records include:

a. Baseline Well Sampling Data Sheets;

b. Monitor Well Sampling Data Sheets;

c. Environmental Radiological Sampling Data Sheets;

d. Analytical Laboratory data sheets containing data on environmental samples, spikes, and duplicates;

e. Radiological measurement data sheets containing sampling, background measurement, and standardization data;

f. Instrument calibration records.

It will be the responsibility of the RSO to maintain all records pertaining to radiation measurement. The EM will be responsible for all records pertaining to baseline and excursion monitor well water quality sample collection and analysis.

A duplicate set of contract laboratories' analytical results will be maintained at an off-site location.

One copy of each annual ALARA/QA/QC audit report, as discussed in Section 9.12.12, will be kept at the site and it will be the responsibility of the RSO to maintain this file. A second copy will be filed at an off-site location.

All records will be maintained for five years, or until such time disposal is authorized by the USNRC if less than five years. All personnel radiation exposure files will be retained at the Corporate Office after CUP is closed.

9.12.9 Quality Assurance for Sampling

The quality assurance program for sampling can be broken down into the following areas:

a. Procedures used by the sampler which will define the details of sample location, sample frequency, number of samples, duration of sampling, sample volume, sample collection methods and holding times, equipment used for sample collection, sample containers, pre-treatment of containers, type and amount of preservative added, a replicate program, and chain of custody procedures.

b. SOP's will be prepared for calibration and maintenance of equipment used for field measurement. These procedures will provide details for the standardization, use, and maintenance of the instruments

c. Random control checks will be made by taking duplicate samples from specified points and submitting these to the contract analytical laboratory. These checks will allow for the evaluation of the performance of the contract laboratory, and to some extent, the validity of sampling procedures. In the event that the results of the duplicate samples will not agree within acceptable tolerances, an audit will be performed to determine if the cause is due to sampling, preservation and/or shipping methods, or the contract laboratory. Appropriate corrective action will be taken based on the results of the audit.

9.12.10 Quality Control in the Laboratory

9.12.10.1 Water Quality Laboratory

All baseline water quality samples will be sent to a contract EPA certified laboratory for analysis. HRI requires that the contract laboratory notify HRI should they no longer be EPA certified.

9.12.10.2 Radiochemical Laboratory

Environmental radio-chemical analysis will be conducted by an EPA certified contract laboratory. HRI will require that the contract lab notify HRI should they no longer be EPA certified.

9.12.10.3 Inter-Laboratory Analysis

As a further check on the Contract Laboratory, HRI will routinely submit duplicate samples to the laboratory, and a second EPA certified laboratory. If the results of the duplicate analyses are not within acceptable tolerances, the laboratory will be advised and must take the necessary corrective action to assure precise and consistent data. The corrective action taken by the laboratory will be reported in writing to HRI.

9.12.10.4 On Site Laboratory

The goal of the Quality Assurance program of the on-site laboratory will be to assure that data generated by the laboratory is scientifically valid, of known quality, and of sufficient quality to meet the regulatory agencies' requirements. The data must be reliable, defensible, and comparable to similar data generated by other laboratories. In order to meet this goal, the following plan will be implemented at the CUP laboratory:

a. All environmental samples received by the laboratory will be documented with the date received.

b. Records of field conductivity and pH will be compared with the values obtained by the laboratory. Significant discrepancies will be investigated promptly to determine if the field or laboratory measurements are in error. Appropriate corrective action will be taken based on the results of the investigation.

c. Checks will be made to ensure proper preservation and storage techniques have been implemented where applicable.

d. Chemical analysis procedures will be documented and maintained in the SOP manual.

e. Newly employed lab technicians will be fully trained, and their ability to accurately perform the analyses will be documented.

f. Sample analysis information such as volume of sample, volume of titrant, absorbance, etc., will be permanently recorded as well as the initials of the technician performing the analysis.

g. One spike and one duplicate analysis per 20 monitor well samples excursion will be performed, and the results evaluated.

h. Standards and blanks, if necessary, will be run and the results documented.

I. Results of the analyses will be entered on the proper forms and copies of the forms will be distributed according to a prescribed distribution list. The original form will be maintained by the laboratory.

j. All calibration, maintenance, and repair records of laboratory instrumentation will be documented and maintained on site.

9.12.11 Review and Analysis of Data

The radiological and water quality data received from the on-site and contract laboratories will be reviewed by the RSO, and/or the Environmental Manager or designee, who will be responsible for technically evaluating the data and distributing it to the appropriate files.

The criteria for the technical evaluation of the data will be discussed below.

9.12.11.1 Water Quality Data

Water quality data will be evaluated for reasonableness and agreement with previous analyses by the analyst, and the Environmental Manager in accordance with the procedure outlined in Section 9.12.11.3.

Cation-anion balance will be between 0.95 and 1.05.

The ratio of the measured total dissolved solids (TDS) at 180 degrees with the calculated TDS corrected for bicarbonate decomposition will be between 0.9 and 1.10.

9.12.11.2 Radiological Data

Radiological data received from the on-site or contract laboratories will be reviewed for reasonableness and agreement with previous analyses by the RSO, who will be responsible for technically evaluating the data and distributing it to the appropriate files.

The criterion for the technical evaluation is discussed below.

The reviewer will verify that the detection limits are 10% or less than the appropriate values listed within the Tables in 10CFR20 Appendix B.

The reviewer will determine whether the data indicates exceedences of applicable limits, or are trending upwards toward a problem.

9.12.11.3 Data Comparison

The data on a given sample or set of samples will be compared with the data from previous representative samples from the same population. If an individual result is within the precision and accuracy range of the method being utilized, and agrees with results obtained on previous samples, the result will be considered acceptable. If the result is outside of this range and does not agree with previous results, the data set will be evaluated for trends, other unusual distributions, or laboratory and/or sampling error. The laboratory will then be notified and asked to check calculations and quality control checks. If no discrepancies are found, a new analysis will be requested on the sample provided that the maximum holding time for the sample has not been exceeded. If the maximum holding time has been exceeded, a resample will be requested. If the resample verifies that a significant change in water quality or radiological conditions has occurred the cause of this change will be determined. The results of this investigation will be documented and reported to the Environmental Manager as soon as possible, and if necessary, corrective action initiated. If the data indicates that exceedences of applicable limits has taken place, appropriate reporting and documentation of corrective actions will be performed in accordance with NRC license and permit requirements.

9.12.12 Quality Assurance/Quality Control Audits

An annual audit of the water quality sampling and analysis program, radiological monitoring sampling, and Quality Assurance/Quality Control programs will be conducted in conjunction with the annual ALARA audit by the EM and the VPHSE. The EM may designate individuals qualified in chemistry and monitoring techniques who will not have direct responsibilities in the areas being audited to assist in the audit. Audit results will be reviewed with the RSO, the VPO, and the President of HRI. The results of the audit and corrective actions to be taken, if required, will be documented and maintained on site. An additional copy will be filed at the corporate office.

9.13 Security

HRI will minimize access and provides accountability for all persons entering the CUP Controlled Areas. Controlled Areas will include the CCP and individual satellites. The Controlled Area includes the facilities inside the fenced area of the CUP. This will include all buildings, ponds, well field patterns, and associated equipment. Access to this area will be through the main gate.

All non-employees entering the CUP will be required to log in at the main office after receiving visitor training as appropriate for the work they will be performing.

9.14 Contingency Plan for Transportation Accidents

9.14.1 Purpose

This section identifies the procedures to be followed in the event of a highway transportation accident of ion exchange resin between the Unit 1 satellite or Churchrock satellite, and the CCP/Crownpoint facility and material shipped from CCP which will be dried and then packaged according to Department of Transportation (DOT) requirements. The shipper utilized by HRI will be licensed to transport the yellowcake product in its dried form, and will have an approved accident contingency plan as part of the licensing process.

There are three major portions to the emergency response plan: immediate containment, accurate, and proper notification, and a conceptualized cleanup procedure with preplanned dedicated personnel, and equipment.

9.14.2 Shipments

To minimize the severity of an accident, the driver will be fully briefed on the nature of his load and the necessary safety precautions. The special instructions for accidents will be verbally presented to him and he will also carry written instructions with him accompanying the shipping papers. Additionally, a simple one page response letter will accompany the shipping papers detailing the nature of the problem. The letter will be used by persons encountering the accident, if the driver is unable to explain the nature of the material and the preliminary containment procedures. An example of the emergency response letter and the driver's manual accompanies this manual.

9.14.3 Initial Containment

The basic philosophy in spill containment will be to prevent the spread of the material, and to notify HRI personnel and civil authorities.

a. Containment - each transporter will be equipped with the proper shipping papers, response letter of identification and notification, driver's contingency manual, and the following equipment in a weatherproof box:

1. Polyethylene sheeting (2,000 square feet).
2. Shovels (2, short handle).
3. Disposable coveralls (3 pairs).
4. Rubber boots (3 pairs, mixed sizes).
5. Rubber gloves (4 pair).
6. Fiber tape (2 rolls).
7. Pocket knives (3).
8. Reflective warning signs, and polyethylene rope.
9. Respirators (3).

The drivers, or civil authorities immediately on the scene, will cover any spilled material with the sheeting. Sufficient protective clothing will be available for the work. The equipment and clothing will be wrapped in plastic after it is used (for future decontamination). The site will be secured from unauthorized personnel and all civil authorities will be notified and briefed on the situation. The initial notification and precautions will be enumerated in the response letter and the driver's manual.

The following are procedures, and containment:

1. Tank - not leaking

   a. Rope off area and restrain people from tampering with any material. Request the police for assistance in keeping people about 50 feet from the accident.

   b. Assure everyone that professional assistance and equipment are on the way, and there is no danger with a sealed tank.

2. Tank - Leaking

   a. Rope off area and caution everyone to stay away from the material. Use the police for assistance.

   b. Assure the police that there is no radiation danger, but potential dusts from the material is poisonous and should not be inhaled.

   c. Request to the civil authorities that the traffic be routed in such a fashion as to prevent tracking.

   d. If possible, prevent the material from running into streets, gutters, sewers, etc. A simple method is utilizing dirt ditches or dikes.

   e. Minimize dispersion and wear supplied respirators.

3. Fire Involved with Accident

   a. If necessary, isolate area from entry by using civil authorities.

   b. The material will not explode, but if possible, keep the fire away.

   c. If the tank is ruptured, use respirators to preclude material inhalation

b. Initial Notification - Initial notification will be from the driver, or the civil authorities who find the response letter and the driver's manual. The transport tractor will be equipped with a cellular telephone to provide for the telephone communications. The people to be notified (by collect calls) are as follows:

V.P. Operations	TBD	
Mark S. Pelizza	Dallas	214/683-8889 Cell
Salvador Chavez	Grants	505/786-5845 Off. 505/290-2356 Cell

As soon as one of these individuals is notified, a company notification system will be activated which will consist of management, clean-up team, and civil/regulatory notification. There will be duplication of notification in key areas to insure that notification is given. The basic system will be as follows:

X	**XX**	**XXX**
V.P. Operations will notify all:	V.P.H.S.& E. will notify all:	Plant Superintendent will notify all:
V.P.H.S.& E	V.P. Operations	V.P. Operations
Plant Superintendent	Plant Superintendent	V.P.H.S.& E
State Police	State Police	Clean-Up Team
Navajo Police	Navajo Police	Hospital
Clean-Up Team Leader	Clean-Up Team Leader	NRC
NRC	Clean-Up Team	Chemtrec

X. V.P.Operations Notifications

V.P.H.S.& E -	Mark S. Pelizza	214/683-8889 Cell
Plant Super. -	Salvador Chavez	505/786-5845 Off. 505/290-2356 Cell
State Police		505/827-3476
Navajo Police (if on Indian lands)		928/871-6581

(If not New Mexico, see civil/regulatory list for State Police) Clean-Up Team Leader (notifies clean-up crew) Hospital (if necessary).

XX. V.P.H.S.& E Notifications

V.P. Operations

Plant Super -	Salvador Chavez	505/786-5845 Off. 505/287-4165 Home
State Police		505/827-3476
Navajo Police		928/871-6581

(If not New Mexico, see civil/regulatory list for State Police)
Clean-up Team Assistant Leader (notifies clean-up team)
Regulatory Agencies (see list)

XXX. Plant Superintendent Notifications

V.P. Operations

V.P.H.S.& E -	Mark S. Pelizza	214/387-7777 Off. 214/618-5780 Home

Clean-up Team Leader (notifies clean-up team)

Hospital (if necessary)

Chemtrec	**One Call**	**800/424-9300**

Regulatory Agencies

New Mexico Environmental Department	(505) 219-6157
Navajo Environmental Protection Agency	(928) 871-7996
U.S. Nuclear Regulatory Commission	(301) 816-5100

9.14.4 Clean-Up Team Equipment

In order to effectively handle a uranium spill, the following equipment will be assembled, and stored in transportable containers for use by the clean-up team:

a. Coveralls - disposable (15 pair per size--medium large)
b. Gloves - rubber - long cuff (15 pairs)
c. Rubber boots - 15 pairs(3 size 9, 7 size 10, 5 size 12)
d. Shovels - (3 std. long handle, 3-scoop blade)
e. Plastic sheeting - 12 mil, 3200 square feet
f. Solvent glue for sheeting (3 cans/jars)
g. Hard hats (10)
h. Brooms (2) industrial floor
i. 55 gallon drum liners (50 bags)
j. Portable water sprayer (misting down powder)
k. Sample bottles (24)
l. Urine bottles (24)
m. Rope - 1-1/2 inch - 1000 feet
n. Warning signs - radioactive materials
o. Fiber tape - 6 rolls

p. Sump pump - 110 volt
q. Garden hose - 50 feet
r. Highway flashers
s. Respirators - 100 dust disposable

Additional Equipment from sites:

a. Calibrated beta, gamma, alpha survey meter
b. Hydrochloric acid, 55 gallon drum w/dispensing pump
c. Product storage drums(25),55gallons w/lids and bolts
d. Tools
e. Onan generator with fuel
f. Portable flood lights
g. Vacuum cleaner
h. Air compressor
i. Front end loader/back hoe
j. Radiotelephone, if possible
k. Camera with flash
l. Ore transport

9.14.5 Clean-Up Procedures

a. Set-up

1. Arrive at site, access situation, and assign team members to (1) collect/procure additional site specific equipment; (2) notify management of situation; and (3) brief civil authorities on procedures.

2. Issue protective clothing, and secure site from unauthorized entry.

3. Cover all spilled materials with plastic.

4. Set-up command post.

b. Protective Berming for spills

1. Cover exposed material with plastic sheeting.

2. Construct a protective berm completely around the whole area including the working or clean-up area.

3. If possible, construct a berm around the spilled material.

4. Construct a lined diked area for drum reloading, and contaminated equipment.

5. If possible, construct a lined area for trailer decontamination.

c. Clean-up - will proceed with the clean-up of the trailer cleaning, and removal of the product, and finally the spill site.

1. Trailer Clean-up

   a. Remove spilled material by shovels and/or vacuum cleaner into lined 55 gallon drum, and move to pad.

   b. Right trailer, if possible, and move off road surface to diked clean-up area.

   c. Clean exterior and interior, and remove to nearest fully controlled site (plant) for final decontamination.

   d. Test for contamination.

2. Pavement Clean-up

   a. If spill material has contacted the pavement, clean-up of this surface should be conducted next.

   b. Using scoop shovels, load lined barrels.

   c. Construct a two (2) foot wide plastic lined trench along the pavement edge.

   d. Rinse the surface with an acid solution, and direct the solution to the lined ditch for pick up by the sump pump.

   e. Continue until all signs of the materials are removed.

   f. Neutralize surface with water and collect final run-off for lab verification of clean-up.

3. Road Shoulder (soil) Clean-up

   a. Using shovels or loader, remove product to drum.

   b. Remove six inches of top soil and place in drums in area of direct spill.

   c. After trailer is removed and road is cleaned, begin to decontaminate plastic.

   d. Place plastic in drums.

   e. Place obviously contaminated soils in drums.

f. Remove trailer.

g. Remove majority of drums.

h. Begin final removal of all topsoil in affected area.

i. Conduct soil sampling in a grid fashion.

4. Final Clean-up

a. Do not remove outer protective berm (if constructed).

b. Review grid soil samples with regulatory agencies and get final clean-up approval.

c. Consult with highway department Re: reseeding program.

d. Remove protective berm after written verification is received from regulatory agencies.

e. Reseed area.

9.14.6 Personnel Protection

a. Identify everyone by name and address who came in contact with the material.

b. Secure a urine analysis from each of these individuals.

c. Report analysis to these individuals, and explain the results.

9.14.7 Response Letter

A letter containing the following information will be displayed in a prominent location within the cab of the transport vehicle, in the event an outside individual discovers a accident:

This vehicle is transporting uranium yellowcake or uranium ion exchange resin. The material is poisonous and should not be inhaled or ingested. It is not a radiation hazard, or an explosive. You should try to keep the material off your clothing and try not to track it about. The following steps will minimize spreading of the material:”

a. Notify the Department of Public Safety, County Sheriff, or Navajo Police and request their assistance in guarding the site.

b. Find the plastic sheeting in the vehicle and cover all spilled material.

c. The following people have the responsibility for handling the problem. <u>CALL COLLECT</u> if necessary or possible.

V.P. Operations

Mark S. Pelizza	Dallas	214/683-8889 Cell
Salvador Chavez	Grants	505/786-5845 Off. 505/290-2356 Cell

d. Inform any one of the above on the situation. Please give him your name, and address. These people are trained in handling this problem.

e. Request assistance in preventing people from handling the material, or removing it until Hydro Resources, Inc. (HRI) personnel are present.

f. Give this letter and all other shipping papers, and the driver's spill instructions manual to civil authorities.

9.14.8 Instructions to Driver

This section outline the type of instruction which will be maintained in the glove compartment of the transport for use by the driver in the case of an accident.

The material you are transporting is uranium concentrate or uranium bearing ion exchange resin.

a. Is not a radiation hazard in exposure of less than a few days;

b. Is poisonous and should not be breathed, swallowed, or put in the mouth;

c. It should be kept to a small area, and off clothing or body; and

d. Is not explosive.

<u>In Case of an Accident</u>

a. Cover any spilled material with the plastic sheeting provided in the transporter utilizing equipment supplied in emergency equipment box. The box contains the following equipment:

1. Polyethylene sheeting (2,000 square feet)
2. Shovels (2, short handle)
3. Disposable coveralls (3 pair)
4. Rubber boots (3 pair, mixed sizes)

5. Rubber gloves (4 pairs)
6. Respirators (3, use only for dry product spills)
7. Fiber tape (2 rolls)
8. Pocket knives (3)
9. Warning signs and guard rope (1/2 inch polyethylene)

After equipment is used, place under sheeting for later decontamination and prevention of theft.

b. Notify the civil authorities of the nature of the problem by:

1. Giving them the accompanying letter;

2. Telling them the nature of the problem; and

3. Requesting their help in securing the site from interference of bystanders, and notifying the HRI personnel listed below as soon as possible. Call collect and tell the operator that this is an emergency call. Call until one of the following individuals is notified.

Chemtrec	One Call	800/424-9300 Password: URI
V.P. Operations		
Mark S. Pelizza	Dallas	214/683-8889 Cell
Salvador Chavez	Grants	505/786-5845 Off. 505/290-2356 Cell

c. Initial containment prior to arrival of HRI:

1. Containers not leaking

a. Rope off area and restrain people from tampering with any material. Request the police assist in keeping people about 20-25 feet from the accident.

b. Assure everyone professional assistance and equipment are on the way, and there is no danger with closed uncontaminated containers.

2. Drums/Tank Leaking

a. Rope off area and caution everyone to stay away from the material. Use the police for assistance.

b. Assure the police that there is no radiation danger, but dusts from the material is poisonous and should not be inhaled.

c. Request to the civil authorities that the traffic be routed in such a fashion as to prevent tracking.

d. If possible, prevent the material from running into streets, gutters, sewers, etc. A simple method is utilizing dirt ditches, dikes, and tarps.

e. Minimize dispersion and wear your supplied respirators.

3. Fire involved with accident

a. If necessary, isolate area from entry by using civil authorities.

b. The material will not explode; but if possible, keep the fire away.

c. If the tank is ruptured, use respirators to preclude material inhalation.

9.14.9 Instructions to Civil Authorities

Detailed instruction to civil authorities will be maintained in the glove compartment of the transport. They will be prominently marked and contain the following information:

Hydro Resources, Inc. (HRI) has a fully trained and equipped Clean-Up Team for this type of hazardous material. A notification system has been developed and the following regulatory agencies have the responsibility for handling this problem. Hydro Resources <u>will</u> notify the responsible regulatory agencies. You may wish to call the Highway Patrol for assistance.

Regulatory Agencies

New Mexico Environmental Department	**(505)219-6157**
Navajo Environmental Protection Agency	**(928)871-7996**
U.S. Nuclear Regulatory Commission	**(301)816-5100**

9.14.10 Coordination With Local Emergency Services

To assess the local response, HRI has held meetings with officials of the Crownpoint Health Care Facility. The main focus of the meeting was to discuss the capability of the health care facility to respond to an accident, specifically one that might involve a person whose skin or clothing has product contamination. While discussing this topic the IHS officials expressed some concerns regarding the current lack of equipment and personnel training needed to effectively respond to this type of scenario. Three other points that were raised included: (1) the need for a separate room equipped for cleaning an injured person whose clothing or body might have surface contamination; (2) the need for on-going technical training because of the relatively high turnover in hospital staff, and (3) the need for hospital staff to feel comfortable with working in this situation.

HRI will, if allowed, provide proper survey equipment, on-going training for hospital staff, and a separate room equipped for decontamination. Additionally, HRI is proposing that a memorandum of understanding (MOU) be prepared which clearly outlines respective responsibilities.

One final, but equally important, topic of discussion included the suggestion that HRI hold a similar meeting with the hospital's Area Office and the EMT.

Consistent with PBLC Format, HRI will develop an action plan as part of a SOP which will provide for equipping and training Local Emergency Officials in the event an accident occurs involving source or byproduct material.

9.15 Incident Response and Reporting Procedures

HRI has established incident response and reporting procedures which will be put into effect in the event of any incident with potential significant radiological impacts and/or regulatory reporting requirements. This plan will be reviewed annually and revised as necessary to accurately reflect current operations. Up-to-date copies of the plan will be distributed to each supervisor and each major work location. Proper reporting will ensure that appropriate individuals and agencies are informed in a timely manner so that appropriate corrective actions can be taken. The initial incident review will center around the completion of 10 CFR Part 20 and 40 incident reporting requirements. The requirements of 10 CFR 21 and 71, and 49 CFR 172 and 173 will also be considered during the review to determine specific follow-up and reporting requirements.

Any unusual or unplanned event with potential significant radiological impact will be evaluated, documented, and appropriately reported. The nature of the event will determine the actions to be taken. All information, data and evaluations, along with the names and times of regulatory agencies contacted in relation to respective incidents will be properly documented, and retained on site.

9.16 Management Control and Administrative Procedures

All principal work assignments will be conducted in accordance with written operating procedures. Supervisory and management personnel will routinely observe their employees at work, and thus will be able to ensure adherence to the written procedures. If employees are found deviating from a procedure, they will be counseled by their supervisors and instructed to adhere to the written instructions. Follow up supervision will ensure the success of the counseling session. Such deviations and follow up counsel will be documented and the documentation maintained on file at the project site. All new operating procedures which will affect radiation safety will be reviewed by the SERP. Review of all operating procedures involving radioactive materials by the RSO will be performed at least annually to ensure that radiation exposures will be maintained as low as is reasonably achievable.

Non-routine work or maintenance activities which may result in significant personnel exposure to radioactive materials, and for which there is no SOP will be carried out in accordance with a Radiation Work Permit (RWP). These procedures include contacting the radiation safety staff prior to the start of work. The RSO or RST will survey the area for radiation and/or contamination levels, as appropriate, and conduct a discussion of precautions to be taken during the repair to keep personnel exposures as low as is reasonably achievable. Job supervisors will direct the work in such a manner as to minimize exposure to radiation or airborne radioactive materials. Air samples will be taken as necessary to evaluate the exposures of all involved personnel. Additionally, techniques such as the use of respirators will be used to reduce exposures.

9.17 Inspections, Compliance Audits and Records

The Crownpoint RSO or designee will conduct weekly inspections of all work, and storage areas. His/her findings pertaining to compliance with license requirements and radiation safety practices will be documented. The Crownpoint RSO or designated radiation safety technician will conduct a daily walk-through inspection of all work and storage areas of the CCP to insure proper implementation of good radiation safety procedures. The results of these inspections are documented and maintained on site.

Licensee management will conduct annual audits of the radiation protection and ALARA program, under the direction of the Environmental Manager and the VP Health, Safety and Environmental

Affairs. The Crownpoint RSO will accompany the audit team. The audit will address similar topics listed in Regulatory Guide 8.31, Section 2.3.3. The results of the audit will be reviewed and approved by the President prior to submittal to NRC.

HRI will maintain and retain through license termination all records required by 10 CFR 20 Subpart L. Such records will include records regarding receipt, transfer, and disposal of any source or byproduct material processed or produced by HRI; records of on-site radioactive disposal such as by deep well injection, or burial under 10 CFR 20.2002 and 20.2007; description of spills, excursions, contamination events or unusual occurrences; information on site characterization, residual soil contamination, hydrogeology, surface impoundments, ponds, lagoons, and well field aquifer anomalies; as-built drawings of structures, equipment, well fields, modifications; drawings of buried pipes or pipelines; preoperational background radiation levels; and, reports of spills, evaporation pond leaks, excursions of source, 11e.(2) or byproduct material.

HRI will maintain such records in a manner that can be provided to a new owner or new licensee or licensee in the event that the property or license is transferred or to NRC after license termination. Any such records received from a previous owner or licensee will be retained or turned over to NRC after license termination. Records will be maintained as hard copy originals, as copies on microfiche, or electronically protected.

An annual report will be submitted to the NRC that includes the ALARA audit report, land use survey, monitoring data, corrective action program report, one of the semiannual effluent and environmental monitoring reports, and any changes to the Safety and Environmental Review Panel (SERP) information.

9.18 Training

Appropriate levels of safety training will be provided to all individuals who are permitted to gain access into restricted portion of the location. The level of training will be dependent on the visitor/employment status of an individual, and the ability of each individual to access various locations within the licensed area. Training will cover some topics according to NUREG 1159, *Training Manual for Uranium Mill Workers on Health Protection from Uranium,* [73] with noted exception that the CUP will not be a mill, but an *in situ* uranium recovery facility. Additionally training will include the appropriate materials described in U.S. Nuclear Regulatory Commission Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure*, U.S. Nuclear Regulatory Commission Regulatory Guide 8.29, *Instructions Concerning Risks from Occupational Radiation Exposure*, and U.S.

Nuclear Regulatory Commission Regulatory Guide 8.31, Information Relevant to Ensuring that Occupational Radiation Exposures at Uranium Mills Will Be As Low As Is Reasonably Achievable.[85][83][87] Each anticipated training level is broken out below.

9.18.1 Initial Training

All new employees will provide a slip authorizing the Employer to request from previous employers all records relative to occupational exposures to ionizing radiation. This report is to be obtained from the former employer, if possible. This will become a permanent part of the employees' Radiation Exposure Record in the Applicants' files, and will be kept current and available at all times.

Training will be mandatory for all new employees in order for them to understand the potential problems of radiation exposure, and their own personal responsibility to adhere to all safety rules, for their own protection as well as others. Workers will be made knowledgeable of the procedures for making suggestions for better radiation protection and the importance of working together in order to lower radiation exposure.

New employees, for their own safety, will be made aware of the origin, location, and operation of job categories that require the strictest possible compliance with the Radiation Safety Program. New employees will be schooled in all aspects of Radiation Safety. This will ensure that all personnel can correctly apply Radiation Safety Protection as it relates to their primary duties, and to temporary placement in the plant area. A follow-up safety session will be to be conducted with each new employee during the first three months of employment, and a written record maintained. Thereafter, an annual test by the RSO of each employees' understanding of the Radiation Safety Program will be conducted and a record maintained on file.

9.18.2 Visitor Training

Visitor Training will be minimal, and visitors will be instructed as to the primary hazard at an *in situ* uranium mine, yellowcake ingestion. Visitors will be instructed to avoid contact with visible yellowcake in any location containing radioactive materials. Visitors will also be informed that HRI performs routine surveys of the radiation levels and surface contamination in any area which will be visited, and that safe conditions have been documented in each of these areas.

9.18.3 Clerical and Office Support Staff

Clerical, office support staff, and non-operations technical staff will be employees who typically work outside the "Work Area". Particularly, they will not require frisking before leaving the work area on a regular basis. Their training will be an abridged version of that given to the operation staff. Training and testing will be documented within the employee's files.

9.18.4 Operations Personnel

Operations Personnel will be provided Operations Personnel training. These individuals will typically be required to work with radioactive materials and therefore require more intense monitoring and frisking before leaving the work area.

In addition to classroom training, employees will receive continuous on-the-job training (OJT) from plant supervisors and the RSO. Plant employee's job performance with respect to radiation protection will be appraised using the calculated doses annually by his immediate supervisor and the RSO to determine if retraining is necessary. A training completion and Radiation Safety Rules will be signed by the RSO and the employee, and included in the employees' personnel file. The supervisor will be responsible for a continuous evaluation and OJT as necessary to ensure the employees' exposure is maintained "As Low As Reasonably Achievable".

9.18.5 Supervisory Personnel

Supervisors will receive all training received at Operations Personnel Level instruction, and additional training which will be appropriate for supervisors including: ALARA philosophy, contamination control, and work practices. Supervisors will be required to be fluent in certain surveys which may be required prior to releasing equipment in the absence of the RSO/RST, and will be able to provide specific job related training and evaluate their subordinates' performance.

9.18.6 Prenatal Training

Female employees will be given training operations or supervisory level depending on position of employment as above. Additionally, all female employees will be given instructions concerning prenatal radiation exposure and controlling radiation dose in the case of pregnancy, similar to U.S. NRC Regulatory Guide 8.13 Instruction Concerning Prenatal Radiation Exposure. [85]

9.18.7 Special Training for Yellowcake Transport Accidents

HRI will select and train capable personnel to prepare for a potential transport accident according to Section 9.14. A team will be supervised by the Production Manager, Environmental Manager and Plant Superintendent, and must contain members from the Radiation Safety Department and plant personnel. This team will have good background knowledge in radiation safety as per required in employee orientation. Further training in containment, recovery, decontamination, and the equipment needed to control such a spill will be given on an annual basis. In an event of any magnitude, the team will have been adequately trained and provided with the equipment to contain and decontaminate any accident site according to Section 9.14.

9.18.8 Training for the Radiation Safety Officer

Radiation Safety Officer training shall be on a biennial basis and include recognized schools or courses, if available, together with specialized topics such as the following:

a. Radiation measurement:
1. Detector types and operation.
2. Personnel monitoring methods.
3. Survey techniques and methods.
4. Quantitative and qualitative measurements.

b. Biological effects.

c. ALARA philosophy.

d. Audit techniques with respect to conformance with radiation practices and procedures by plant employees.

e. Rules and Regulations:
1. 10 CFR 19.
2. 10 CFR 20.
3. Regulatory guides.
4. Internal (administrative control) guides.
5. License conditions
6. Personnel monitoring.
7. Work practices.

f. Methods for controlling radiation dose:
1. Radiation control areas and posting requirements.
2. Personnel and area cleanup methods.

10.0 RECLAMATION PLAN

10.1 General

Reclamation at the project site will be comprised of four major activities which include the following:

- Radiological decontamination of buildings, process vessels, and other structures or affected areas.
- Removal and reclamation of the CCP, satellites, and auxiliary structures.
- Surface reclamation and revegetation of restored well fields.
- Ground water restoration within affected well fields, including production and monitor well plugging.

The preliminary schedule for ISR related activities and restoration has been discussed in Section 1 of this COP. Decommissioning and reclamation of the CCP and satellite sites will take place after operations are complete. Ground water restoration and well field decommissioning will be accomplished as well fields are completely mined out. Satellite facilities will also be decommissioned as soon as ground water restoration is complete and they are no longer needed.

Pursuant to regulatory requirements, HRI will submit a detailed reclamation plan to the NRC for review and approval at least 12 months prior to the planned final shutdown of ISR operations which included detailed QA/QC for all aspects of decommissioning. If depressions appear at the land surface due to subsurface collapse, HRI will return the land surface to its general contour as part of the project's surface reclamation activities. Before release of an area to unrestricted use, HRI will provide information to the NRC verifying that radionuclide concentrations meet applicable radiation standards.

Both the surface reclamation plan and ground water restoration plan are intended to return areas affected by ISR activities to a condition which supports the premining land use of sheep and cattle grazing and associated wildlife habitat.

10.2 Radiological Decontamination

All radiologically contaminated buildings, process vessels and other structures, and affected areas will be decontaminated prior to final reclamation to unrestricted release standards in accordance with NRC requirements, or removed to the appropriate disposal facilities. Decontamination will include acid and water wash-down of structures and concrete. The resulting waste water will be disposed by disposal well, brine concentration, and evaporation. Equipment which cannot be decontaminated will be dismantled and disposed in an U.S. NRC licensed waste disposal facility, or utilized at another NRC licensed uranium facility. All uncontaminated foundations will be removed or broken and buried in place.

10.3 Reclamation and Revegetation

The purpose of the reclamation program will be to stabilize the site with self-sustaining vegetative cover, and to restore all land disturbed by ISR operations and related activities to a productive condition for livestock grazing and wildlife habitat, consistent with the present and historical use of the area. Because of present overgrazing practices in the area, it is anticipated the reclamation program will substantially improve the project site. It is anticipated that future land use will be similar to current uses. Therefore, all revegetation treatments and plant species used will be selected for their desirability as cover and food for domestic and native fauna, soil stability, and surface and subsurface water conservation.

10.3.1 Well Field

During drilling operations, topsoil will be carefully removed from drill pit locations and separated from the subsoil. After the drilling is complete the subsoil will be replaced, followed by the topsoil. The drill site will then be graded and seeded as outlined in Section 10.3.4.

After ground water restoration is complete, all surface laterals and pipelines will be removed. Any vegetation which has been disrupted will be reseeded.

10.3.2 Plant Areas

Topsoil will be stockpiled as necessary in the location of all new plant facilities including buildings and ponds. Temporary grass will be established on these piles to prevent erosion.

After operations, all buildings, ponds and equipment will be demolished and removed from the CUP area. All contaminated material will be reused for licenses activities, decommissioned below release limits, and disposed of in an approved landfill, or disposed of in an appropriate byproduct disposal area.

Soil in the well fields and plant areas will be surveyed according to NUREG/CR-5849. [96] Topsoil will be placed in the location where it was removed and the area seeded as outlined in Section 10.3.4.

10.3.3 Wells

All production and injection wells will be permanently plugged and abandoned upon completion of ground water restoration, and stabilized in a manner which prevents interformational transfer of fluids. In particular, wells will be plugged to the surface with a cement design and procedure approved by the New Mexico State Engineer. The casing will be cut off three feet from the surface and the site seeded as outlined below.

10.3.4 Seeding Rates, Species, and Methods of Application

Species mixtures adapted to the climate and soil conditions existing on the properties, with forage characteristics of palatability, tolerance to grazing, and availability for year-round use, will be established. General species and treatments for revegetation will include varieties of species and species mixtures that have been tested.

The following mixture of native plants and rates of seeding are planned to be used for the various soil types that may occur on the disturbed areas. Normally, a maximum of three species of grass will be used in the planned mixture (Table 10.3-1).

TABLE 10.3-1 POUNDS OF PURE LIVE SEED PER ACRE (KG/HA)

	Clay Site	Loamy Site	Sandy Site
Arriba Western Wheatgrass	6.4(7.3)	4.8(5.4)	6.4(7.2)
Alkali Sacaton	.8(.9)	.7(.8)	.5(.6)
Vaughn Sideoats Gramma		2.0(2.2)	1.6(1.8)
Paloma Indian Ricegrass			2.4(2.7)
Bandera Rocky Mtn. Penstemon			.3(.3)
Pastura Little Bluestem	.3(.3)	.6(.7)	
Fourwing Saltbrush	1.2(1.3)		
Rabbit Brush			

When surface conditions and slopes permit, approved seed mixtures will be mechanically drilled with a drill suited to handling a variety of grass and legume seeds. If situations occur where slopes are too steep or rocky for seedling equipment, the mixture will be broadcast at approximately twice the recommended rate followed by harrowing, brush drag, or similar treatment to ensure seed coverage.

Mulch will be used in areas where water retention, soil temperature, or soil crusting are potential problems for seed germination and seedling growth. The mulch will be spread or blown uniformly over the area immediately after seeding. The mulch will consist of grass hay, straw, or woodchip applied at the rate of approximately 4.5 t/ha (2 ton/acre). It will be anchored mechanically with a mulch tiller, crimper, or if necessary with a chemical compound. Bark, wood chips and jute netting may be used for special situations.

The limiting factor in establishment of plants in the Crownpoint area will be available moisture. However, fertilizer can be applied with proper moisture to effectively establish seeded species. The need and benefit of fertilizer will be determined by site specific soil analysis and available moisture. When used, fertilizer will be placed near the drill row for maximum benefit. Broadcast application may be necessary in certain situations but will be less desirable than application with a drill because more fertilizer will be required.

Time of seeding under nonirrigated conditions will be very critical in New Mexico. The most desirable time for seeding is during the season of the highest expected precipitation. New Mexico's precipitation records show the greatest moisture comes in McKinley County in July, August, and September. The seeding project will be completed 45 to 60 days before expected long dry periods or freezing weather. Some species, e.g., Paloma Indian Ricegrass and Fourwing Saltbush, will germinate in late winter if sufficient moisture is available and good emergence of these species may occur from seeding in late fall or early winter.

Each CUP site will be fenced for the life of the operation. After reclamation, seeded areas will be protected by fencing, herding, or other approved animal control techniques until vegetation is established.

10.4 Ground Water Restoration[10]

Prior to conducting restoration operations, HRI will develop a updated groundwater restoration plan for the entire project. At a minimum, this plan will include a refined restoration schedule and a general description of updated methodology of restoration and post-restoration groundwater monitoring for the entire project.

10.4.1 Overview

Once the economic recovery limit of a well field is reached, lixiviant injection will be stopped and the affected ground water will be treated (restored) to return the quality of water to regulatory standards. HRI used historic experience and the regulatory combined criteria of both NMED and NRC with similar groundwater restoration operations in developing its groundwater restoration model.

The lixiviant utilized by HRI will be natural ground water fortified with oxygen, and will be benign compared to the acidic or ammonia bicarbonate leaching solution that were used in earlier in-situ operations. Early leach solutions had the common trait of introducing foreign substances to the ground water during uranium recovery, which ultimately caused restoration difficulties. The proposed lixiviant for this project simply changes the oxidation state of the host rock and utilizes natural ionic materials within the water as complexing agents. The pH remains neutral. The recovery process does not introduce new chemical species to the ground water system but does elevate certain species that are native to the host aquifer. Restoration will be centered on reducing naturally occurring constituents in ground water which become elevated as a result of the ISR process. Naturally occurring radioactive materials, especially uranium, which will be elevated during the ISR process are expected to be the most significant parameter limiting premining

[10] ISR Hydrologic Assessment of Well Fields, including groundwater background characterization and reclamation criteria, is regulated by both the Nuclear Regulatory Commission ("NRC") under 10CFR20 Criterion 5(B)(5) and the New Mexico Environment Department ("NMED") under NMAC 20.6.2.3103 & 20.6.2.5101 C.(2). The NMAC 20.6.2.3103 Standard is different from NRC 10CFR20 Criterion 5(B)(5)) because NRC restoration targets may be subsequently modified through the Alternate Contaminate Limit (ACL) process. Expected restoration result compared to the NMAC 20.6.2.3103 Standard for groundwater must be addressed in advance in determining the NMED Standard. HRI is committed to comply with both the groundwater background characterization and reclamation criteria of 10CFR20 Criterion 5(B)(5) and requirements under NMAC 20.6.2.3103 & 20.6.2.5101 C.(2).

use of the water, and will be subjected to the closest scrutiny during restoration.

10.4.2 Restoration Procedure

Restoration of the production zone may be achieved by a combination of groundwater sweep, reverse osmosis (RO) treatment and brine concentration. The restoration of ground water at the CUP ISR sites will have the benefit of a previously engineered array of injection and production wells that were initially installed in a configuration to maximize sweep efficiently throughout the uranium ore body, and maximize uranium recovery. The same engineering principals hold for maximum sweep efficiently during the restoration phase. In other words, ground water restoration will be performed uniformly throughout the production zone and verified statistically at individual sampling points. The engineering principle which assures restoration is sound.

With the reverse osmosis techniques, injection and extraction operations continue at the facility except produced water will be processed through a R.O. unit which produces a deionized fluid for reinjection. The injection solution passes through the pores of the aquifer formation and replaces the affected solutions which are pumped to the surface. The net effect will be that the resulting interstitial ground water quality becomes consistent with, and in many cases better than premining quality. The primary benefit of R.O. treatment will be that a large fraction of the total water extracted will be purified and reinjected resulting in less water consumption and less ground water drawdown in the area. R.O. technology has been widely utilized within the ISL industry and the resulting restoration history highly successful.

During reverse osmosis treatment of groundwater HRI is committing to the addition to a reductant such as sodium sulfide (Na_2S) as necessary to optimize the precipitation and minimize residual concentration of oxyanions in solution.

10.4.3 Restoration Demonstration

After production begins at the Section 8 ISR site, HRI will immediately begin work on a field restoration demonstration, outside of the actual production, yet inside the monitor well ring, and within the target ore zone. Key elements of the restoration demonstration will be as follows:

1. An isolated restoration demonstration pattern completed in the ore zone, constructed to the same basic configuration as the proposed production well field pattern and operated under the same conditions as the proposed ISR procedures.

2. The pattern will be run under commercial recovery activity conditions using fortified groundwater concentrations equal to or greater than concentrations expected to be required for production.

3. After the uranium recovery phase, a complete chemical description of the produced fluid will be obtained and a demonstration of a restoration will be initiated.

4. Restoration will be conducted using the same process that is described in Section 10.4.2. During restoration URI will test to quantify reduction of U(VI) under equilibrium conditions in the presence of sodium sulfide (Na_2S) at a dissolved concentration of 10 ppm or more as field conditions warrant necessary.

5. Sample analysis of key parameters and fluids will be completed at least every week during the restoration demonstration.

6. Restoration will continue until the ground water is restored to levels consistent with Criterion 5(B)(5) or other mandated regulatory standards.

7. Progress reports will be submitted monthly to the NRC and NMED. With each progress report, HRI will calculate and submit the volume of ground water affected, expressed in pore-volumes. Factors to be considered include: aerial extent, formation thickness and porosity. Upon the completion of the restoration demonstration, the data, analysis and conclusions will be compiled into a final report.

The demonstration will be conducted at a large enough scale to determine the number of pore-volumes that will be required to restore a production-scale well field. Specified below, FA for ground water restoration of these initial well fields will be based on nine pore-volumes. FA will be maintained at this level until HRI can demonstrate the number of pore-volumes required to restore a production-scale well field.

Consistent with PBLC format, HRI will develop a standard Operating Procedure (SOP) which addresses details of the restoration demonstration project.

10.4.4 Restoration Progress

Restoration rates will be monitored through analysis of waters produced from the formation. A sample will be taken weekly from the composite production line and analyzed for conductivity, chloride and uranium.

When this data indicates that restoration is at or near completion, each original baseline well will be sampled and analyzed for the parameters Ca, Na, HCO_3,SO_4, Cl, Ec, and U.

If the well field value for each chemical parameter is consistent with preexisting conditions, restoration will be considered to be complete and the stability period will begin. Stability will be determined by four sample sets taken at three-month intervals from the original baseline wells and analyzed for the parameters in Table 8.6-1.

10.4.5 Groundwater Restoration Criteria

HRI plans that groundwater restoration criteria be established on a parameter-by-parameter basis, with the primary goal of restoration to return all parameters to conditions that are consistent with baseline or other mandated regulatory standards and to satisfy Criterion 5(B)(5). To the extent that water quality parameters cannot be returned to the identical average baseline levels, the secondary goal will be to return water quality to the maximum concentration limits as specified in Section 20.6.2.3103 NMAC, or 40 CFR 141.62 or 143.3. These restoration goals are also required by HRI's NRC License and 10CFR40 Appendix A.

The following are the restoration targets:

a. Restoration results in a return to preexisting conditions for all indicators in all affected groundwater, and in all restoration water quality monitor wells.

b. Where the baseline concentration of a particular indicator is less than groundwater or drinking water standards, the appropriate established State and Federal criteria may be used to establish maximum permissible values for restoration purposes.

10.5 Plugging and Abandonment

All production and injection wells will be permanently plugged and abandoned upon completion of ground water restoration and stabilized in a manner which prevents interformational transfer of fluids. As such, USDWs will be permanently protected. In particular, wells will be plugged from TD to surface with a neat cement with a weight of approximately 12.5 ppg, cement slurry with 2% gel mixed with enough retarder (if necessary) to insure that the cement slurry's pumpability will be sufficient to properly circulate cement into the casing from the bottom to surface, or as otherwise determined by the New Mexico State Engineer. The casing will be cut off three feet from the surface and the site will be reclaimed.

This cement will be mixed either on site or at a remote location, as determined by an Engineer. It may be mixed by either a company-owned cement unit utilizing company personnel, or by a contractor-owned unit with contractor personnel. A tremie pipe consisting of one or more joints of PVC pipe followed by an appropriate amount of poly pipe (with depth markings clearly indicated) will be used. The PVC pipe will be included on the end to keep the poly pipe from hanging up on the walls or packer assembly while going into the wellbore. After identifying the holes that are scheduled to be plugged, the designated engineer will assemble information from completion information, logs or other available data necessary to determine volumes for the wellbore. The number of barrels of cement required to fill the casing and screen will be calculated with an "excess" factor of 120%.

In the field the engineer will provide technical supervision. The piping will be inserted into the hole to the bottom of the screen. Mixed cement will be circulated in cement slurry through piping using an excess factor of 120%. The engineer will check the cement density (which will be returning to surface) to verify that it is representative of the cement being pumped by taking a one cup sample of both the cement being pumped and the returns to verify that the cement is setting up properly.

The cement will be allowed to set for two days after which the cement samples will be checked to verify that the cement properly set up. Moreover, the cement in the casing will be tagged to see where it has fallen back to. The engineer will calculate how much additional cement will be required to fill cement to the surface and repeat step one to completely fill the wellbore.

A backhoe will be used to cut off casing to at least four feet below the original contours. The engineer will record that the hole has been successfully surface plugged. HRI will retain all records until five years after completion of any plugging and abandonment procedures.

10.6 Necessary Resources for Groundwater Restoration and Plugging

HRI will provide financial assurance (FA), updated annually, for plugging and abandonment of holes which are currently completed at the time of the annual update or are contemplated during the upcoming calendar year. The costs for each well will be calculated annually, using updated quotations and assumptions according to the model provided for in the site's Restoration Action Plan. [46] As described below, the individual parameters used within the plan will be updated before the injection of lixiviant at the site. The format of the FA to assure P & A of wells will be acceptable to the NMED/NRC.

Additionally, as a prerequisite to operating under HRI's NRC License, HRI must submit an approved FA arrangement to NRC to cover the estimated costs of groundwater restoration. This same document will be filed for approval with NMED as well. Generally, these financial assurance amounts shall be determined by the NRC and NMED based on cost estimates for a third party completing the work, in case the licensee defaults. FA for ground water restoration of the initial well fields will be based on nine pore-volume estimates. The nine pore-volume estimate is based on the data submitted to NRC. The initial estimate of 9 pore-volumes is evaluated in Section 4.3 of the FEIS. [101] Depending on the parameter and the test chosen, the pore-volumes required to achieve the lesser water quality of the secondary restoration goal, or background, ranged from less than one pore-volume to greater than 28 pore-volumes. However, plots of total dissolved solids and specific conductivity values (an indirect measure of TDS) show little improvement with continued pumping after eight to ten pore-volumes. The Mobil ground water demonstration is the largest restoration demonstration that has been conducted in the local area to date. During ground water restoration activities, after 6.9 and 9.7 pore-volumes, TDS concentrations were close to the TDS secondary restoration goal of 500 mg/l. Therefore, it was estimated by NRC that practical production scale ground water restoration activities will at most implement a nine pore-volume restoration effort. FA shall be maintained at this level until the number of pore-volumes required to restore the groundwater quality of a production-scale well field has been established by the restoration demonstration described in 2.54.5 a above. If at any time it becomes found that well field restoration requires greater pore-volumes or higher restoration costs, the value of the FA will be adjusted upwards.

Annual updates to the FA amount will be provided to the NRC and NMED at least 3 months prior to January 1 of each year. If the

NRC or NMED has not approved a proposed revision 30 days prior to the expiration date of the existing FA arrangement, HRI will extend the existing arrangement, prior to expiration, for 1 year. Along with each proposed revision or annual update of the FA, HRI will submit supporting documentation showing a breakdown of the costs and the basis for the cost estimates with adjustments for inflation (i.e., using the approved Urban Consumer Price Index), maintenance of a minimum 15 percent contingency, changes in engineering plans, activities performed, and any other conditions affecting estimated costs for site closure.

HRI will provide approved updated FA before undertaking any planned expansion or operational change which has not been included in the annual FA update. This FA update shall be provided to the NRC and NMED at least 90 days prior to the commencement of the planned expansion or operational change.

HRI commits to revising the surety arrangement within 3 months of NRC approval of a revised closure (decommissioning) plan if estimated costs exceed the amount of the existing financial surety and to provide NRC with copies of surety-related correspondence submitted to a state, a copy of the state's surety review, and the final approved surety arrangement. To the extent practible and consistent with New Mexico State criteria, reclamation/decommissioning plan cost estimates, and annual updates will follow the outline in Appendix C to the standard review plan.

10.7 Cost Reimbursement

When ground water restoration activities begin at the production-scale well field at either the Unit 1 or the Crownpoint sites, HRI will reimburse the Town of Crownpoint for increased pumping and well work-over costs.

As a conservative estimate of reimbursement amounts, HRI presents the worst case analysis of the most affected wells during operations in Table 10.7-1. Cost reimbursement will be ultimately based on actual affects.

Table 10.7.1

Conservative Case Showing Additonal Pumping Cost per Year Due to Lowered Water Levels at Crownpoint Town Water Wells Caused by ISL Mining & Restoration at Crownpoint / Unit 1

		Additional Cost Due to Crownpoint ISL Operation		Additional Cost Due to Unit 1 ISL Operation		Additional Cost Due to Crownpoint & Unit 1 ISL Operation	
Crownpoint Town Well	Average Summer Flowrate (gpm)	Drawdown (feet) [1]	Annual Cost ($)	Drawdown (feet) [3]	Annual Cost ($)	Drawdown (feet) [2]	Annual Cost ($)
BIA #3	79.4	53	$926	25	$437	78	$1,363
BIA #5	6.2	53	$72	25	$34	78	$106
BIA #6	100	51	$1,122	22	$484	73	$1,606
NTUA #1	27.7	55	$335	25	$152	80	$488
NTUA Conoco	58.7	44	$568	26	$336	70	$904

[1] Drawdown (feet) due to operation of HRI's Crownpoint ISL; estimated from figure shown as Attachment 60-1, HRI's response to NRC Q1 / 60.
[2] Drawdown (feet) due to operation of HRI's Crownpoint & Unit 1 ISL; estimated from figure shown as Attachment 60-2, HRI's response to NRC Q1 / 60.
[3] Drawdown (feet) due to operation of HRI's Unit 1 ISL; estimated by subtracting (1) from (2).

Typically, electrical amperage required by a submersible the pump is reasonably constant over a wide range of flowrates. However, conservatively assuming that amperage varies with hydraulic horsepower, the cost per year would be calculated as follows:

$$\frac{\$}{\text{year}} = \frac{(\text{gpm})\ (\text{head, feet})\ (0.746\ \text{kw/hp})\ (1440\ \text{min/day})\ (365\ \text{day/yr})\ (\$/\text{kw-hr})}{(3960)\ (60\ \text{min/hr})\ (\text{pump efficiency})\ (\text{motor efficiency})}$$

75% <-- Submersible pump efficiency (%).
75% <-- Motor efficiency (%).
$0.075 <-- Cost per Kw-hr ($).

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