3 DESCRIPTION OF FACILITY

Production of uranium by in-situ leach (ISL) mining techniques involves a mining step and a uranium recovery step. Mining is accomplished by installing a series of injection wells through which the leach solution is pumped into the ore body. Corresponding production wells and pumps promote flow through the ore body and allow for the collection of uranium-rich leach solution. Uranium is removed from the leach solution by ion exchange, and then from the ion exchange resin by elution. The leach solution can then be reused for mining purposes. The elution liquid containing the uranium (the "pregnant" eluant) is then processed by precipitation, dewatering, and drying to produce a transportable form of uranium.

The current Crow Butte ISL facility is capable of processing in excess of 5,000 gallons per minute (gpm) of leach solution. This 5,000 gpm flow does not include the restoration flow. On October 17, 2006, CBR submitted a request to the USNRC to increase the permitted flow to 9,000 gpm, excluding restoration flow. USNRC approval is pending.

The current facilities use a number of state of the art unit operations to recover uranium from the recovered leach solutions. These unit operations consist of:

- Ion exchange
- Uranium elution
- Uranium precipitation
- Uranium dewatering
- Uranium drying and packaging

3.1 SOLUTION MINING PROCESS AND EQUIPMENT

3.1.1 Ore Body

In the current Licensed Area, uranium is recovered by in-situ leaching from the Chadron Sandstone at a depth that varies from 400 feet to 800 feet. The overall width of the mineralized area varies from 1000 feet to 5000 feet. The ore body ranges in grade from less than 0.05 to greater than 0.5 percent U_3O_8, with an average grade estimated at 0.20 percent U_3O_8.

The Basal Chadron Sandstone in the area is approximately 40 feet thick. A detailed description of the geology can be found in **Section 2.6**, Geology and Seismology.

3.1.2 Well Construction and Integrity Testing

Three well construction methods and appropriate casing materials are used for the construction and installation of production and injection wells.

3.1.2.1 Well Materials of Construction

The well casing material used is polyvinyl chloride (PVC), which is 4.5 inch SDR-17 (or equivalent). The PVC casing joints normally have a length of approximately 20 feet each. With SDR-17 PVC casing, each joint is connected by a water tight o-ring seal which is located with a high strength nylon spline.

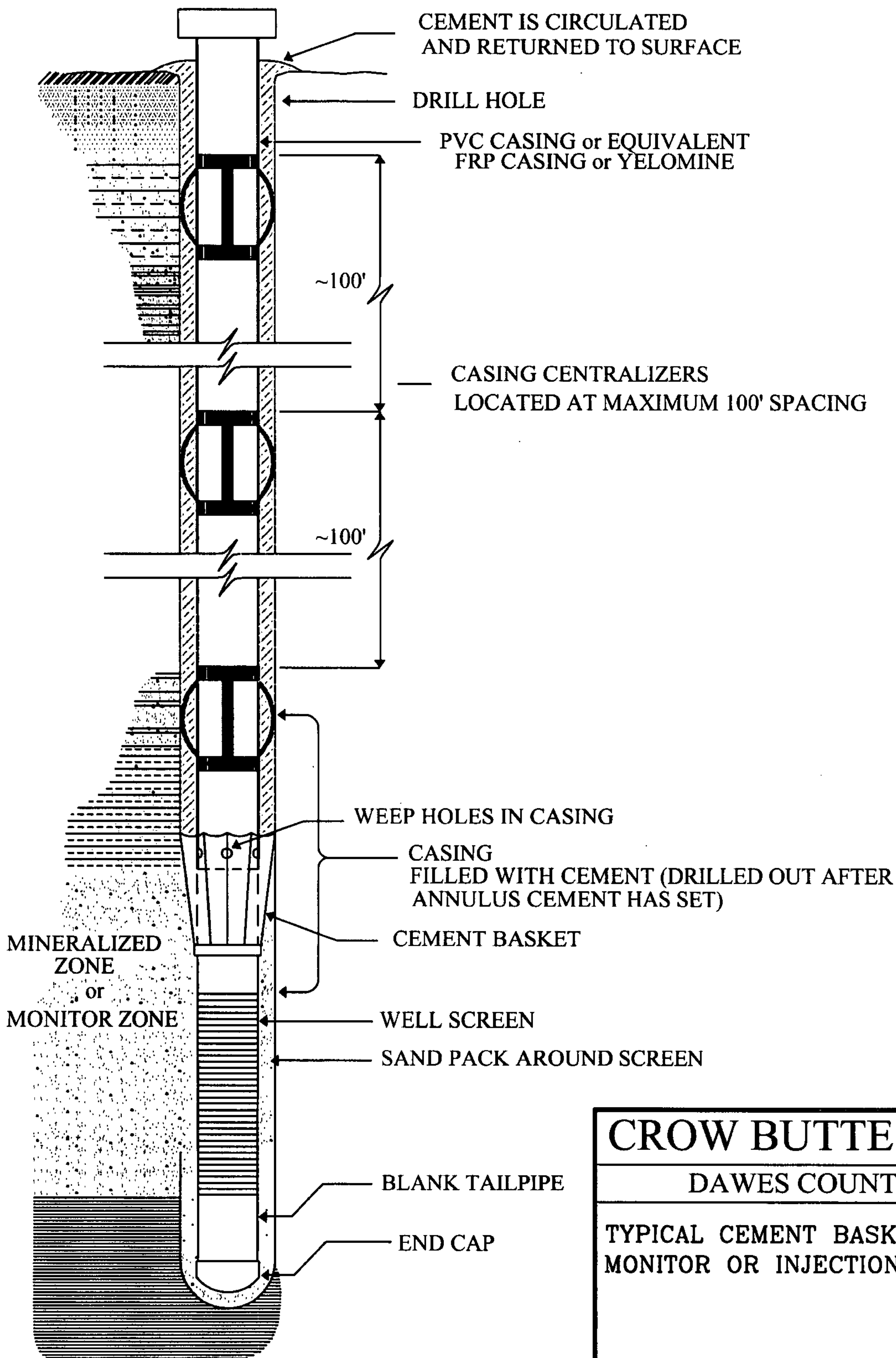
3.1.2.2 Well Construction Methods

Pilot holes for monitor, production, and injection wells are drilled to the top of the target completion interval with a small rotary drilling unit using native mud and a small amount of commercial drilling fluid additive for viscosity control. The hole is logged, reamed, casing set, and cemented to isolate the completion interval from all other aquifers. Three well construction methods are described and are not necessarily described in the order of their preferred use. Any of the methods are appropriate for monitor wells and has been approved by the NDEQ under the UIC Permit.

- **Method No. 1**, shown in **Figure 3.1-1**, involves the setting of an integral casing/screen string. The method consists of drilling a hole, geophysically logging the hole to define the desired screen interval, and reaming the hole, if necessary, to the desired depth and diameter. Next, a string of casing with the desired length of screen attached to the lower end is placed into the hole. A cement basket is attached to the blank casing just above the screen to prevent blinding of the screen interval during cementing. The cement is pumped down the inside of the casing to a plug set just below the cement basket. The cement passes out through weepholes in the casing and is directed by the cement basket back to the surface through the annulus between the casing and the drill hole. After the cement has cured sufficiently, the residual cement and plug are drilled out, and the well is developed by airlifting or pumping.
- **Method No. 2**, shown in **Figure 3.1-2**, uses a screen telescoped down inside the cemented casing. As in the first method, a hole is drilled and geophysically logged to locate the desired screen interval. The hole is then reamed if necessary only to the top of the desired screen interval. Next a string of casing with a plug at the lower end and weep holes just above the plug is set into the hole. Cement is then pumped down the casing and out the weep holes. It returns to the surface through the annulus. After the cement has cured, the residual cement in the casing and plug are drilled out, with the drilling continuing through the desired zone. The screen with a packer and/or shale traps is then telescoped through the casing and set in the desired interval. The packer and/or shale traps serve to hold the screen in the desired position while acting as a fluid seal. Well development is again accomplished by airlifting or pumping. Minor variations from these procedures may be used as conditions require.

Figure 3.1-1

Well Completion Method No. 1



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL CEMENT BASKET COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

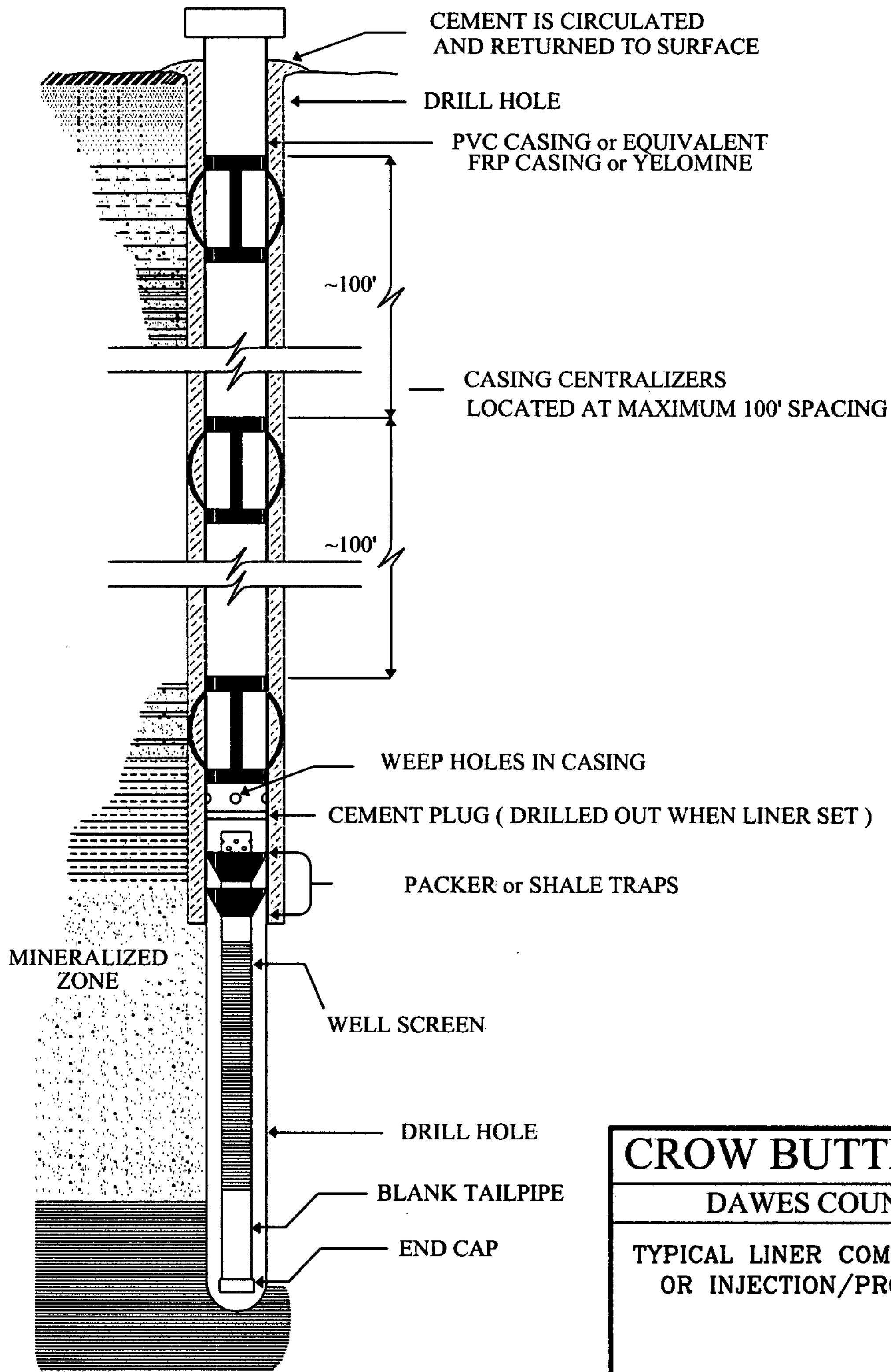
Prepared By : WB

Drawn By: WB

Date: 1/07

Figure 3.1-2

Well Completion Method No. 2



CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

TYPICAL LINER COMPLETION FOR MONITOR OR INJECTION/PRODUCTION WELLS

Prepared By : WB

Drawn By: WB

Date: 1/07

- **Method No. 3,** shown in **Figure 3.1-3**, is similar to methods one and two. The casing is cemented in place the entire length, and, after the cement grout has cured, the casing and grout are cut away to expose the interval to be mined or monitored. A screen is then telescoped into the open interval.

Casing centralizers, located at a maximum 100-foot spacing, are run on the casing to ensure it is centered in the drill hole and that an effective cement seal is provided. The purpose of the cement is to stabilize and strengthen the casing and plug the annulus of the hole to prevent vertical migration of solutions. The volume of cement used in each well is determined by estimating the volume required to fill the annulus and ensure cement returns to the surface. In almost all cement jobs, returns to the surface are observed. In rare instances, however, the drilling may result in a larger annulus volume than anticipated and cement may not return all the way to the surface. In these cases the upper portion of the annulus will be cemented from the surface to backfill as much of the well annulus as possible and stabilize the wellhead. This procedure is performed by placement of a tremie hose from the surface as far down into the annulus as possible. Cement is pumped into the annulus until return to the surface is observed.

A well completion report is completed on each well. This data is kept available on-site for review.

3.1.2.3 Well Development

Following well construction (and before baseline water quality samples are taken for restoration and monitoring wells), the wells must be developed to restore the natural hydraulic conductivity and geochemical equilibrium of the aquifer. All wells are initially developed immediately after construction using airlifting or other accepted development techniques. This process is necessary to allow representative samples of groundwater to be collected. Well development removes water and drilling fluids from the casing and borehole walls along the screened interval. The primary goal for well development is to allow formation water to enter the well screen.

The well is developed until the water produced is clear. This can be determined visually or with a turbidimeter. During the final stages of initial development, water samples will be collected in a transparent or translucent container and visually examined for turbidity (i.e., cloudiness and visual suspended solids). Development is continued until clear, sediment-free formation water is produced.

When the water begins to become clear, the development will be temporarily stopped and/or the flow rate will be varied. Sampling and examination for turbidity will be continued. When varying the development rate no longer causes the sample to become turbid, the initial development will be deemed complete.

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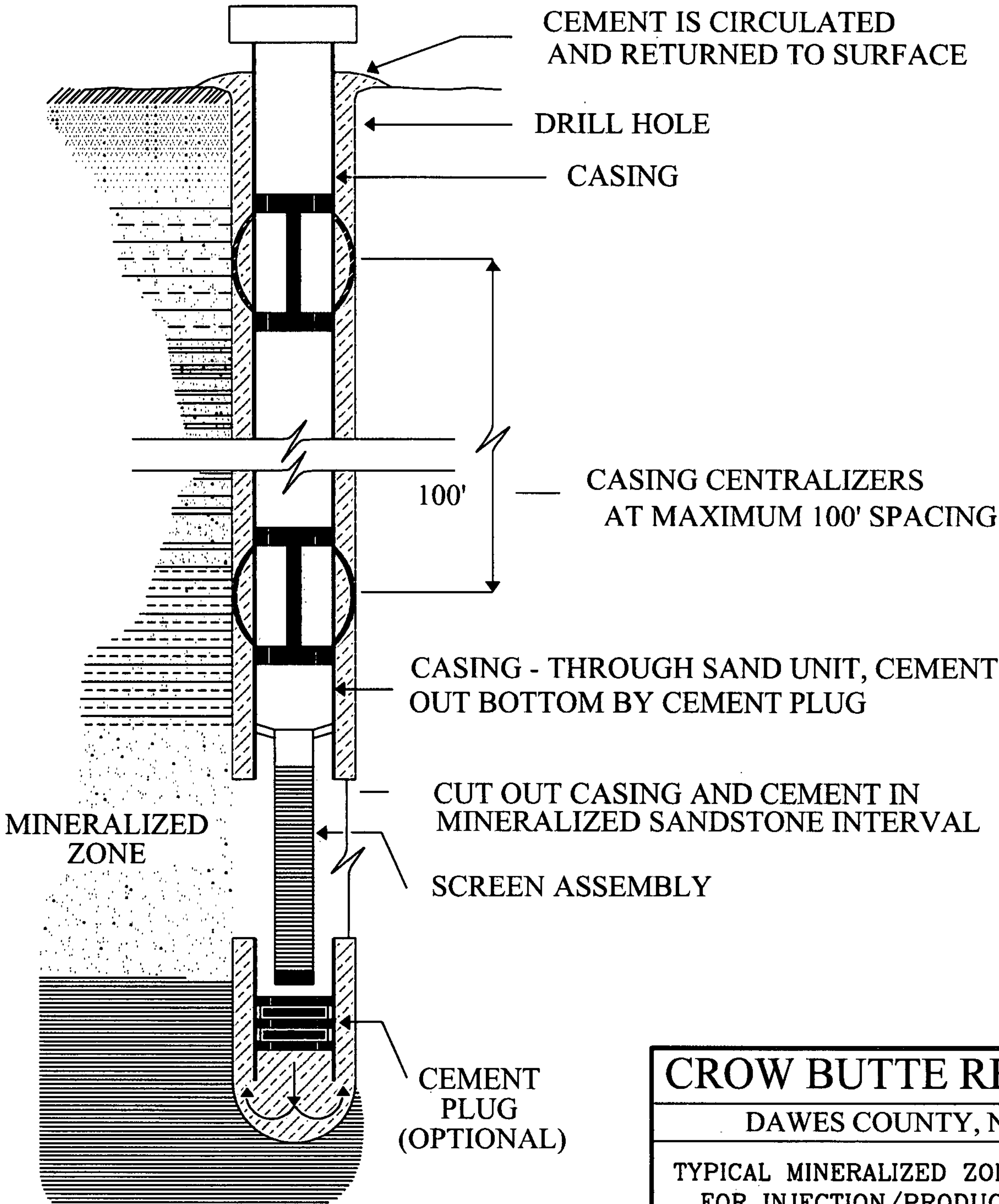
Figure 3.1-3

Well Completion Method No. 3



CROW BUTTE RESOURCES	
DAWES COUNTY, NEBRASKA	
TYPICAL MINERALIZED ZONE COMPLETION FOR INJECTION/PRODUCTION WELLS	
Prepared By : WB	
Drawn By: WB	Date: 1/07

Before obtaining baseline samples from monitor or restoration wells, the well must be further developed to ensure that representative formation water is available for sampling. Final development is performed by pumping the well or swabbing for an adequate period to ensure that stable formation water is present. Monitoring for pH and conductivity is performed during this process to ensure that development activities have been effective. The field parameters must be stable at representative formation values before baseline sampling will begin.

3.1.2.4 Well Integrity Testing

Field-testing of all (i.e., injection, production, and monitor) wells is performed to demonstrate the mechanical integrity of the well casing. This mechanical integrity test (MIT) is performed using pressure-packer tests. Every well will be tested after well construction is completed before it can be placed in service, after any workover with a drill rig or servicing with equipment or procedures that could damage the well casing, at least once every five years, and whenever there is any question of casing integrity. To assure the accuracy of the integrity tests, periodic comparisons are made between the field pressure gauges and a calibrated test gauge. The MIT procedures have been approved by the NDEQ and are currently contained in EHSMS Program Volume III, *Operating Manual.*

The following general MIT procedure is used:

- The test consists of placement of one or two packers within the casing. The bottom packer is set just above the well screen and the upper packer is set at the wellhead. The packers are inflated with nitrogen and the casing is pressurized with water to 125 percent of the maximum operating pressure (i.e., 125 psi).
- The well is then "closed in" and the pressure is monitored for a minimum of twenty minutes.
- If more than ten percent of the pressure is lost during this time period, the well has failed the integrity test. When possible, a well that fails the integrity testing will be repaired and the testing repeated. If the casing leakage cannot be repaired or corrected, the well is plugged and reclaimed as described in **Section 6.0**.

CBR submits all integrity testing records to the NDEQ for review after the initial construction of a mine unit or wellfield. Test results are also maintained on site for regulatory review.

3.1.3 Wellfield Design and Operation

The Crow Butte Mine Unit map, which shows the layout of the mine units and water well withdrawal points, is depicted in **Figure 3.1-4**. The mine schedule is shown in **Figure 1.7-2**. **Table 3.1-1** shows the history of mining operations to date. Each mine unit contains a number of wellfield houses where injection and recovery solutions from

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FIGURE 3.1-4

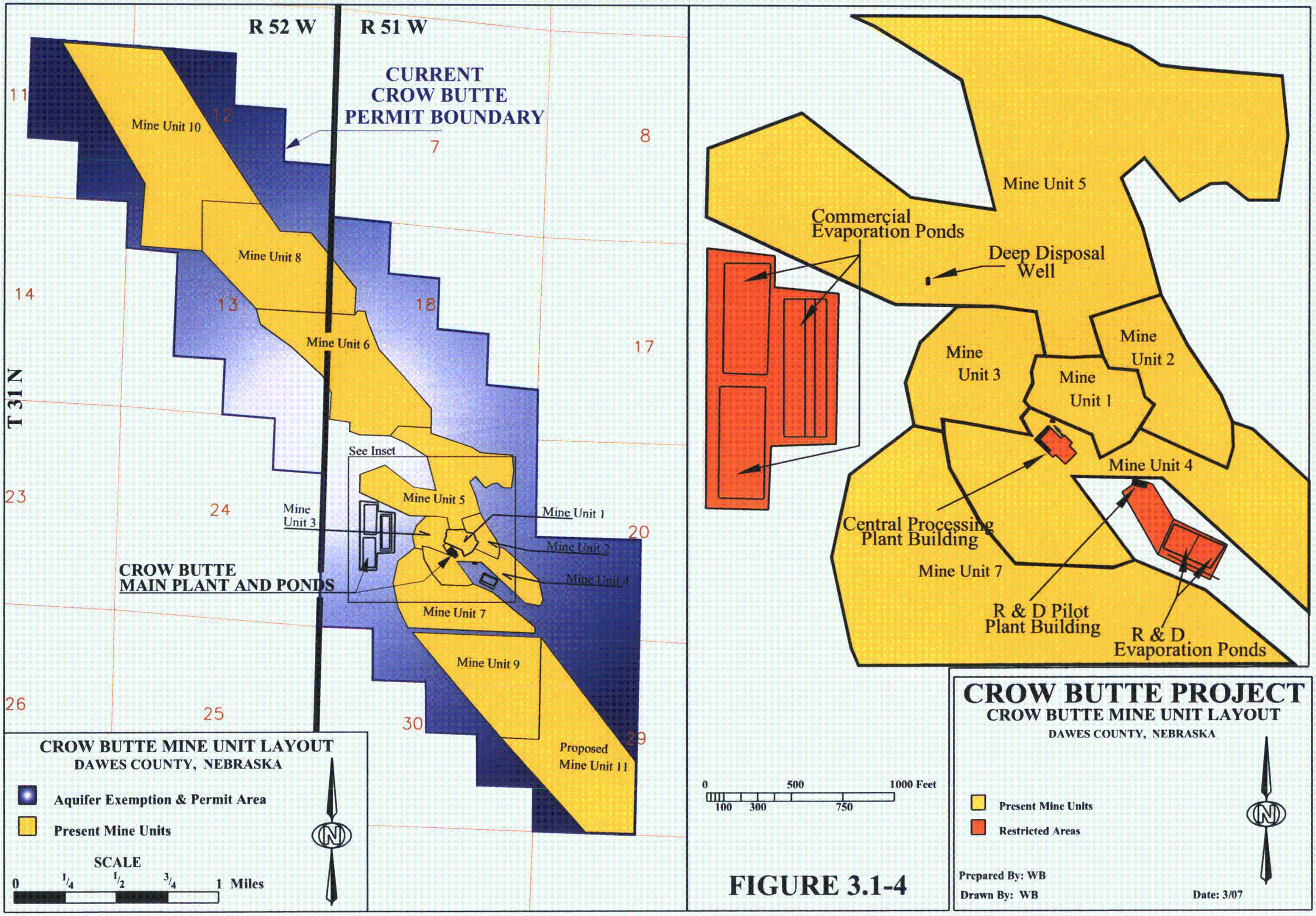


FIGURE 3.1-4

the process building are distributed to the individual wells. **Table 3.1-2** shows the current number of wellfield houses by Mine Unit. The injection and production manifold piping from the existing process facility to these wellfield houses is PVC, high-density polyethylene with butt welded joints or equivalent. In the wellfield house, injection pressure is monitored on the injection trunk lines. Oxygen is added to the injection stream in the wellfield house, and all injection lines off of the injection manifold are equipped with totalizing flowmeters that are monitored in the Control Room. Production solutions returning from the wells to the production manifold are also monitored with a totalizing flowmeter. All pipelines are leak tested and buried prior to production operations.

Table 3.1-1: Mine Unit Status

Mine Unit	Production Initiated	Current Status
Mine Unit 1	April 1991	Groundwater Restored; Reclamation Underway
Mine Unit 2	March 1992	Groundwater restoration
Mine Unit 3	January 1993	Groundwater restoration
Mine Unit 4	March 1994	Groundwater restoration
Mine Unit 5	January 1996	Groundwater restoration
Mine Unit 6	March 1998	Production
Mine Unit 7	July 1999	Production
Mine Unit 8	July 2002	Production
Mine Unit 9	October 2003	Production
Mine Unit 10	August 2007	Production
Mine Unit 11	Pending	Under construction

Table 3.1-2: Wellfield Houses by Mine Unit

Mine Unit	Wellfield Houses
Mine Unit 1	2
Mine Unit 2	3
Mine Unit 3	3
Mine Unit 4	5
Mine Unit 5	7
Mine Unit 6	7
Mine Unit 7	6
Mine Unit 8	8
Mine Unit 9	7
Mine Unit 10	9
Mine Unit 11	5

The wellfield injection/production pattern currently employed is based on a hexagonal seven spot pattern, which is modified as needed to fit the characteristics of the ore body. The standard production cell for the seven spot pattern contains six injection wells surrounding a centrally located recovery well.

The cell dimensions vary depending on the formation and the characteristics of the ore body. The injection wells in a normal pattern are expected to be between 65 feet and 150 feet apart. A typical wellfield layout is shown in **Figure 3.1-5**. The wellfield is a repeated seven spot design, with the spacing between production wells ranging from 65 to 150 feet. Other wellfield designs include alternating single line drives.

All wells are completed so they can be used as either injection or recovery wells, so that wellfield flow patterns can be changed as needed to improve uranium recovery and restore the groundwater in the most efficient manner. During operations, leaching solution enters the formations through the injection wells and flows to the recovery wells. Within each mine unit, more water is produced than injected to create an overall hydraulic cone of depression in the production zone. Under this pressure gradient the natural groundwater movement from the surrounding area is toward the wellfield providing additional control of the leaching solution movement. The difference between the amount of water produced and injected is the wellfield "bleed." The minimum over production or bleed rates will be a nominal 0.5 percent of the total wellfield production rate and the maximum bleed rate typically approaches 1.5 percent. Over-production is adjusted as necessary to ensure that the perimeter ore zone monitor wells are influenced by the cone of depression resulting from the wellfield production bleed.

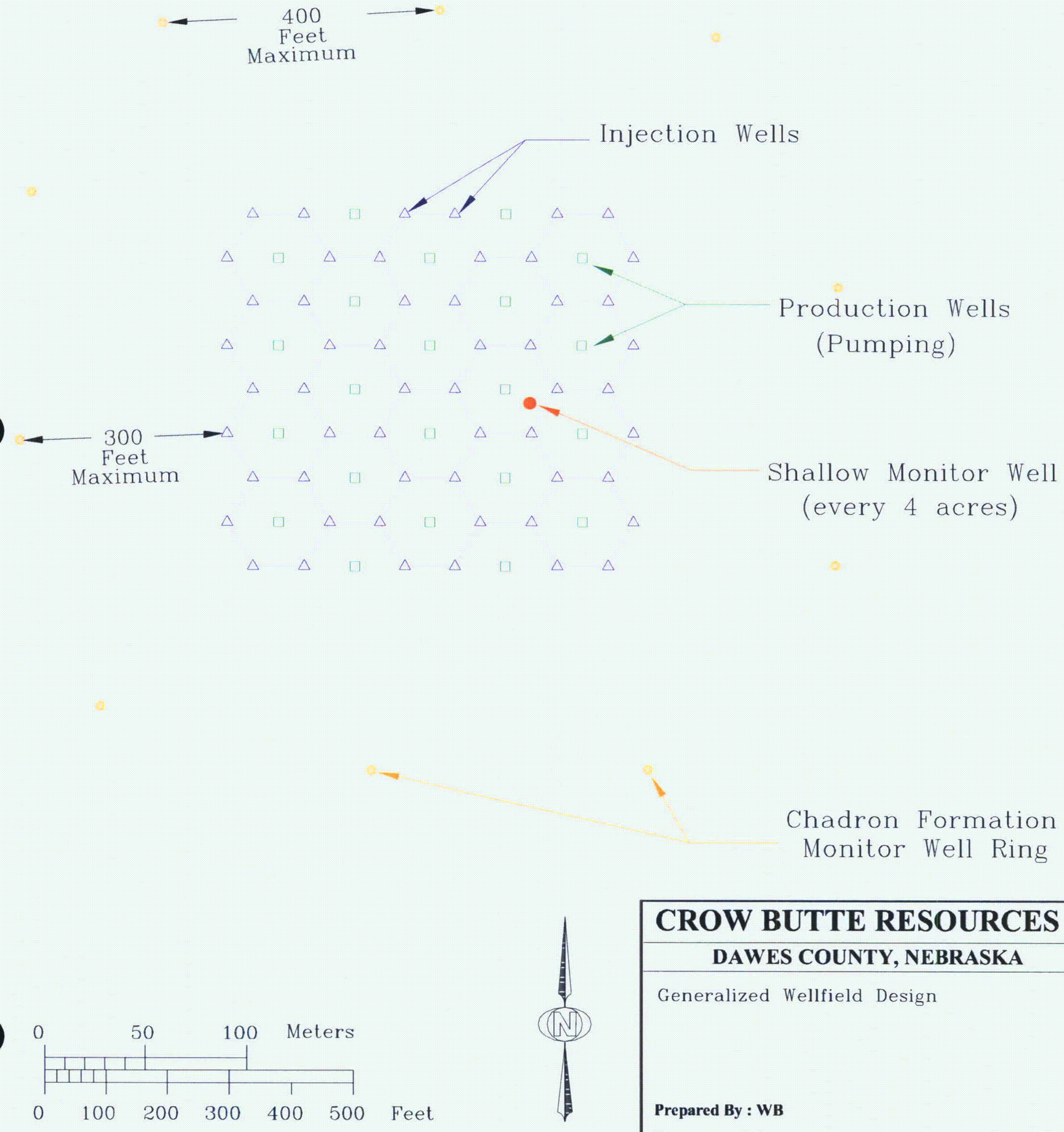
Monitor wells will be placed in the Chadron Formation and in the first significant water-bearing Brule sand above the Chadron Formation. All monitor wells will be completed by one of the three methods discussed above and developed prior to leach solution injection. The development process for monitor wells includes establishing baseline water quality before the initiation of mining operations.

Injection of solutions for mining will be at a rate of 9,000 gpm with a 0.5 percent to 1.0 percent production bleed stream. Production solutions returning from the wells to the production manifold will be monitored with a totalizing flowmeter. All pipelines and trunklines will be leak tested and buried prior to production operations.

A water balance for the current CBR Facility is shown on **Figure 3.1-6.** The liquid waste generated at the plant site will be primarily the production bleed which, at a maximum scenario, is estimated at 1.0 percent of the production flow. At 9,000 gpm, the volume of liquid waste would be 47,304,000 gallons per year. CBR adequately handles the liquid waste through the combination of deep disposal well injection and evaporation ponds.

FIGURE 3.1-5

Typical Wellfield Layout



CROW BUTTE RESOURCES

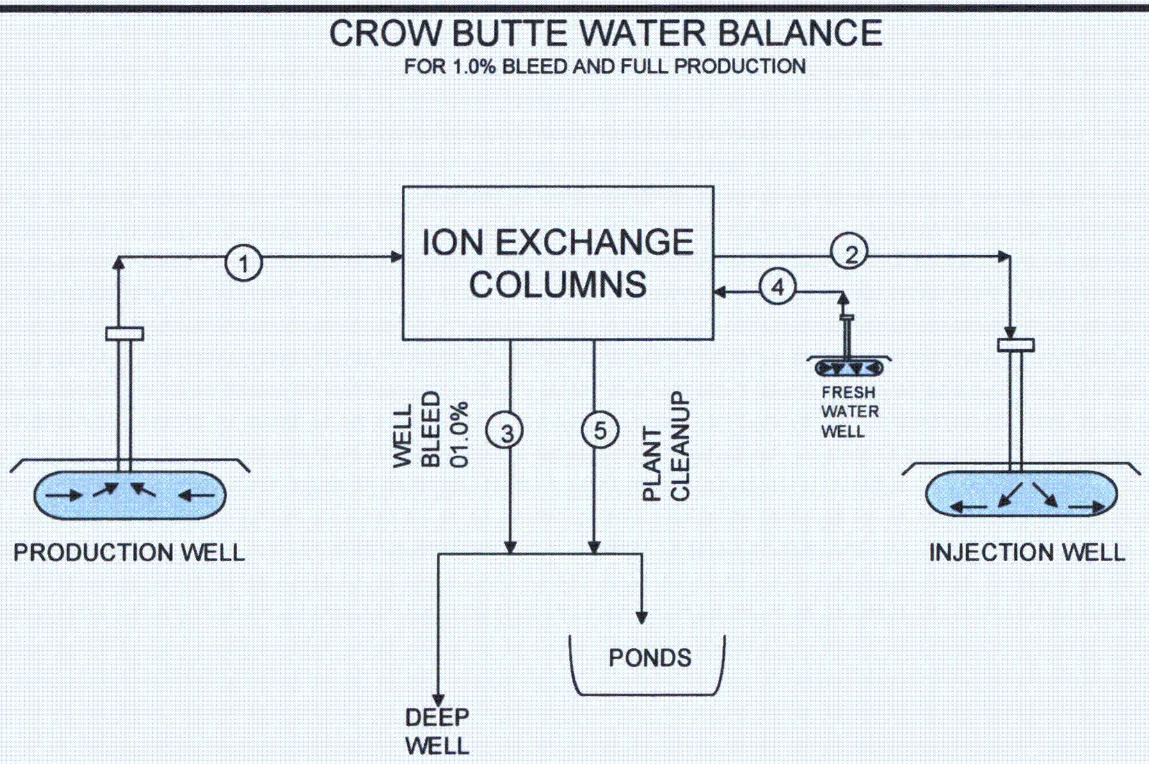
DAWES COUNTY, NEBRASKA

Generalized Wellfield Design

Prepared By : WB

Drawn By: WB **Date: 1/07**

Figure 3.1-6: Water Balance for Crow Butte Facility



STREAM #	1	2	3	4	5
SOLUTION GPM*	9000	8910	90	2	2

*BALANCE IS NOMINAL FOR A 1.0% BLEED. ACTUAL BALANCE MAY VARY ACCORDINGLY.

An Industrial Groundwater Use Permit application was submitted to NDEQ by Ferret Exploration of Nebraska (predecessor to CBR) in 1991. The application states that water levels in the City of Crawford (approximately three miles northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the Basal Chadron Sandstone during mining and restoration operations (based on a 20-year operational period). No impact to other users of groundwater is expected because (1) there is no documented existing use of the Basal Chadron in the CBR License Area, and (2) the potentiometric head of the Basal Chadron Sandstone in the CBR License Area ranges from approximately 10 to more than 50 feet above ground surface.

Because the Basal Chadron Sandstone (production zone) is a deep confined aquifer, surface water impacts are expected to be minimal. A detailed analysis of potential surface water impacts is provided in **Section 7.4**.

Further, the geologic and hydrologic data presented in **Sections 2.6** and **2.7**, respectively, demonstrate that (1) the occurrence of uranium mineralization is limited to the Basal Chadron Sandstone, and (2) the Basal Chadron is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the Basal Chadron Sandstone, and restoration operations will be conducted in the Basal Chadron following completion of mining. Groundwater is expected because (1) there is no documented existing use of the Basal Chadron in the License Area, and (2) the potentiometric head of the Basal Chadron Sandstone within the License Area ranges from approximately 10 to more than 50 feet below ground surface.

Based on a bleed of 0.5 percent to 1.5 percent which has been successfully applied in the current Licensed Area, the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 99 percent) of groundwater used in the mining process will be treated and re-injected (**Figure 3.1-6**). Potential impacts on groundwater quality due to consumptive use outside the License Area are expected to be negligible.

To generally quantify the potential impact of drawdown due to mining and restoration operations, the following assumptions were used:

- Mining/restoration life: 20 years
- Average net consumptive use: 112 gpm
- Location of pumping centroid: Center of Section 19
- Observation radius: 3.4 miles radially from centroid of pumping
- Formation transmissivity: 330 ft^2/d
- Formation thickness: 40 ft
- Formation hydraulic conductivity: 9.0 ft/d
- Formation storativity: 9.0×10^{-5}

The data were evaluated using a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent;
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping;
- The piezometric surface is horizontal prior to pumping;
- The well is pumped at a constant rate;
- No recharge to the aquifer occurs;
- The pumping well is fully penetrating; and,
- Well diameter is small, so well storage is negligible.

As discussed in **Section 5.8.8** of this application, an extensive water-sampling program will be conducted prior to, during and following mining operations at the Crow Butte facility to identify any potential impacts to water resources of the area.

The groundwater monitoring program will continue to be designed to establish baseline water quality prior to mining at each mine site; detect excursions of lixiviant either horizontally or vertically outside of the production zone; and determine when the production zone aquifer has been adequately restored following mining. The program will include sampling of monitoring wells and private wells within and surrounding the License Area to establish pre-mining baseline water quality. Water quality sampling will be continued throughout the operational phase of mining for detection of excursions. Water quality sampling will also be conducted during restoration, including stabilization monitoring at the end of restoration activities, to determine when baseline or otherwise acceptable water quality has been achieved.

During operation, the primary purpose of the wellfield monitoring program will continue to be to detect and correct conditions that could lead to an excursion of lixiviant or detect such an excursion, should one occur. The techniques employed to achieve this objective include monitoring of production and injection rates and volumes, wellhead pressure, water levels and water quality.

Monitoring of production (extraction) and injection rates and volumes enable an accurate assessment of water balance for the wellfields. A bleed system results in less leach solution being injected than the total volume of fluids (leach solution and native groundwater) being extracted. A bleed of 0.5 percent to 1.5 percent is maintained during production. Maintenance of the bleed will cause an inflow of groundwater into the production area and prevent loss of leach solution.

Wellhead pressure is monitored at all injection wells. Pressure gauges are installed at each injection wellhead or on the injection manifold and monitored at least daily.

Solutions resulting from the leaching of uranium underground is recovered through the production wells and piped to the processing plant for extraction. The uranium recovery process utilizes the following steps:

- Loading of uranium complexes onto an ion exchange resin;
- Reconstitution of the leach solution by addition of carbonate and an oxidizer;
- Elution of uranium complexes from the resin; and
- Drying and packaging of the uranium.

The process flow sheet for the above steps is shown in **Figure 3.1-7**.

3.1.4.1 Uranium Extraction

Recovery of uranium takes place in the ion exchange columns. The uranium bearing leach solution enters the column and as it passes through, the uranium complexes in solution are loaded onto the IX resin in the column. This loading process is represented by the following chemical reaction:

$$2\ R\ HCO_3 + UO_2(CO_3)_2^{-2} \dashrightarrow R_2UO_2(CO_3)_2 + 2HCO_3^{-1}$$

$$2\ RCl + UO_2(CO_3)_2^{-2} \dashrightarrow R_2UO_2(CO_3)_2 + 2Cl^{-}$$

$$R_2SO_4 + UO_2(CO_3)_2^{-2} \dashrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate or sulfate ions.

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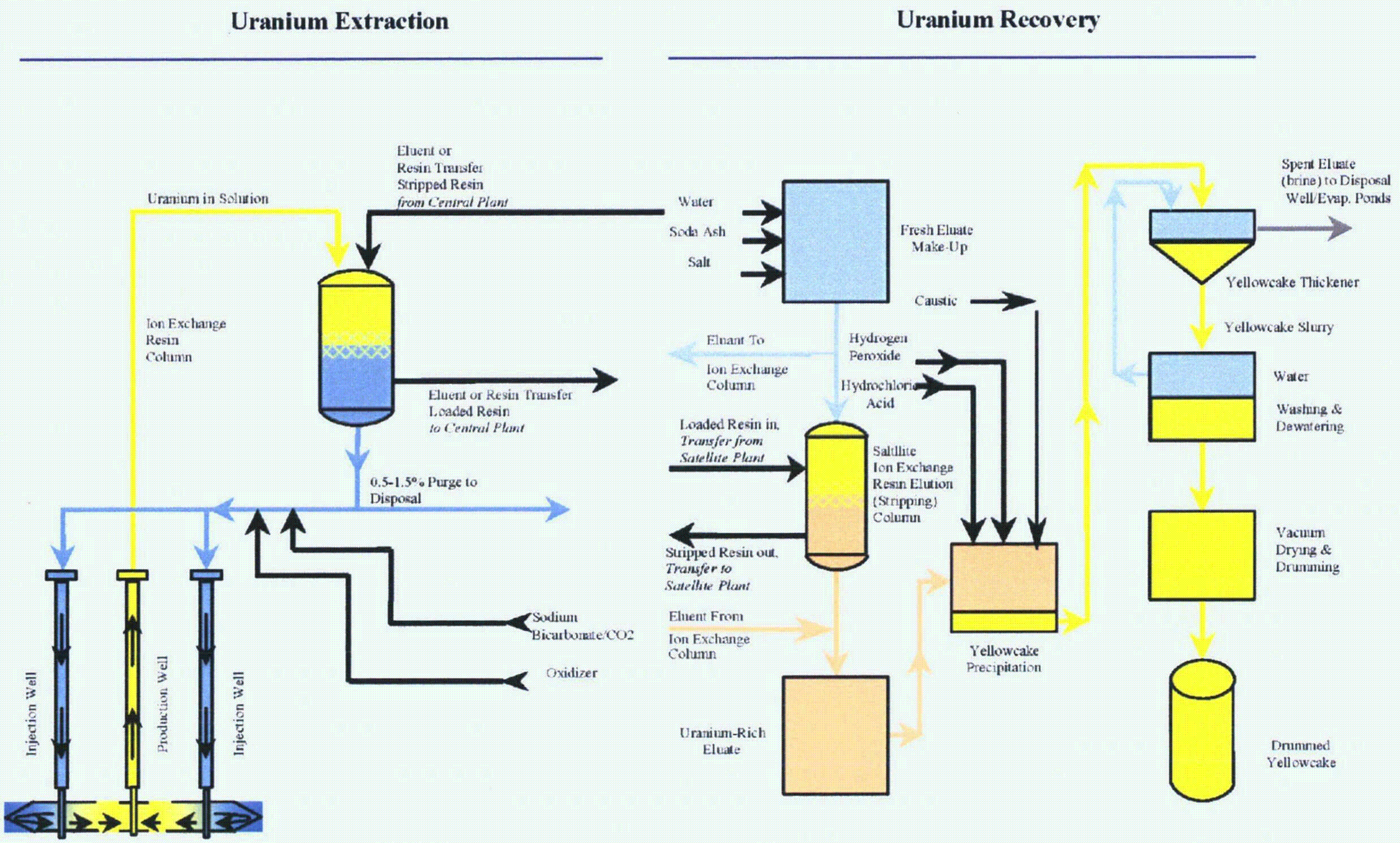
$$R_2SO_4 + UO_2(CO_3)_2^{-2} \dashrightarrow R_2UO_2(CO_3)_2 + SO_4^{-2}$$

As shown in the reaction, loading of the uranium complex results in simultaneous displacement of chloride, bicarbonate or sulfate ions.

Figure 3.1-7: Process Flow Sheet for Central Plant and/or Satellite Plant



The now barren leach solution passes from the IX columns to be reinjected into the formation. The solution is refortified with sodium and carbonate chemicals, as required, and pumped to the wellfield for reinjection into the formation. The typical lixiviant concentration and composition is shown in **Table 3.1-3.**

Table 3.1-3: Typical Lixivant Concentration and Composition

Species	Range	
	Low	High
Na	≤ 400	6000
Ca	≤ 20	500
Mg	≤ 3	100
K	≤ 15	300
CO_3	≤ 0.5	2500
HCO_3	≤ 400	5000
Cl	≤ 200	5000
SO_4	≤ 400	5000
U_3O_8	≤ 0.01	500
V_2O_5	≤ 0.01	100
TDS	≤ 1650	12000
pH	≤ 6.5	10.5

* All values in mg/L except pH (units).

Note: The above values represent the concentration ranges that could be found in barren lixiviant or pregnant lixiviant and would include the concentration normally found in "injection fluid".

3.1.4.2 Elution

Once the majority of the ion exchange sites on the resin in an IX column are filled with uranium, the column is taken off stream. (In the current main process plant, there are eight IX columns. In each train, leach solution passes sequentially through the columns). The loaded resin is then stripped of uranium in place through an elution process based on the following chemical reaction:

$$R_2UO_2(CO_3)_2 + 2Cl^- + CO_3^{-2} \dashrightarrow 2\ RCl + UO_2(CO_3)_2^{-2}$$

During the elution process, the pregnant eluant is transferred to the precipitation tank and intermediate eluant is stored in a tank for use during the next elution cycle.

After the uranium has been stripped from the resin, the resin is rinsed with a solution containing sodium bicarbonate. The rinse may also be performed with raw water or with water from another source. This rinse removes the high chloride eluant physically entrained in the resin and partially converts the resin to bicarbonate form. In this way, chloride ion buildup in the leach solution can be controlled.

3.1.4.3 Precipitation

When a sufficient volume of pregnant eluant is held in storage it is acidified to destroy the uranyl carbonate complex ion. The solution is agitated to assist in removal of the resulting CO_2. The decarbonization can be represented as follows:

$$UO_2(CO_3)_3^{-4} + 6H^+ \longrightarrow UO_2^{++} + 3\ CO_2\uparrow + 3H_2O$$

Sodium hydroxide (NaOH) is added to raise the pH to a level conducive for precipitating pure crystals. Hydrogen peroxide is then added to the solution to precipitate the uranium according to the following reaction:

$$UO_2^{++} + H_2O_2 + 2H_2O \longrightarrow UO_4 \bullet 2H_2O + 2H^+$$

The precipitated uranyl peroxide slurry is pH adjusted, allowed to settle, and the clear solution decanted. The decant solution is recirculated back to the barren makeup tank, sent to fresh salt brine makeup, or sent to waste. The thickened uranyl peroxide is further dewatered and washed. The solids discharge is either sent to the dryer for drying before shipping or is sent to storage for shipment as slurry to a licensed recovery or converting facility.

3.1.5 Process Wastes

The operation of the Crow Butte Facility has several sources of liquid and solid wastes. These sources, and associated methods of handling, are discussed in **Section 4** (Effluent Control Systems). A summary of major process waste streams is provided below.

3.1.5.1 Air Emissions

Airborne emissions from yellowcake drying are maintained at a minimum by a vacuum drying system. It is only radon gas that is mobilized during process operations and vented to the atmosphere.

3.1.5.2 Liquid Wastes

The operation of the process plant results in two primary sources of liquid waste, a production bleed and an eluant bleed. The production bleed stream is continuously withdrawn from the recovered lixiviant stream at a rate between 0.5 to 1.5 percent of the total volume of recovered lixiviant. The production bleed stream is taken following the recovery of the uranium by ion exchange and has the same chemical characteristics as the lixiviant. The eluant bleed stream is currently produced at a rate of approximately 5 to 10 gpm. The eluant bleed waste stream is managed by reuse in the plant or disposal in existing ponds and/or by deep well injection. The production bleed waste stream is managed by a combination of evaporation pond and deep disposal well injection.

3.1.5.3 Solid Waste

Solid waste generated at the CBR Facility consists primarily of spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste is segregated based on whether it is clean or has the potential for contamination with 11(e).2 byproduct materials.

Byproduct material generated at the CBR Facility consists of wastes such as filters, personal protective equipment (PPE), spent resin, piping, etc. All byproduct material is disposed of at a licensed facility approved for disposal of 11.e(2) byproduct material. All other non-byproduct solid waste is disposed of in an approved landfill. There is no on-site disposal of these materials.

Septic system solid waste is generated in a septic system. Solids generated during periodic cleanouts of the septic tank are disposed of by companies or individuals licensed by the State of Nebraska.

3.1.5.4 Hazardous Waste

To date, CBR has only generated universal hazardous waste such as waste oil and batteries. Waste oil is disposed of by a licensed waste oil recycler. The CBR Facility is currently classified as a Conditionally Exempt Small Quantity Generator (CESQG).

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3.2 CENTRAL PLANT, SATELLITE PLANT, WELLFIELDS, AND CHEMICAL STORAGE FACILITIES – EQUIPMENT USED AND MATERIAL PROCESSED

3.2.1 Process Plant Equipment

A general arrangement for the current main processing facility is presented in **Figure 3.2-1**. The recovery plant equipment can be placed in one of the following unit operations:

- Ion Exchange
- Filtration
- Lixiviant injection
- Elution/precipitation
- Dewatering/drying

The ion exchange system consists of eight up-flow and six down-flow ion exchange columns. The uranium loading process is continuous but the elution process is operated on a batch process. The loaded up-flow columns are eluted in place; the down-flow loaded resin is moved across a screen deck for washing before being eluted in a separate elution column.

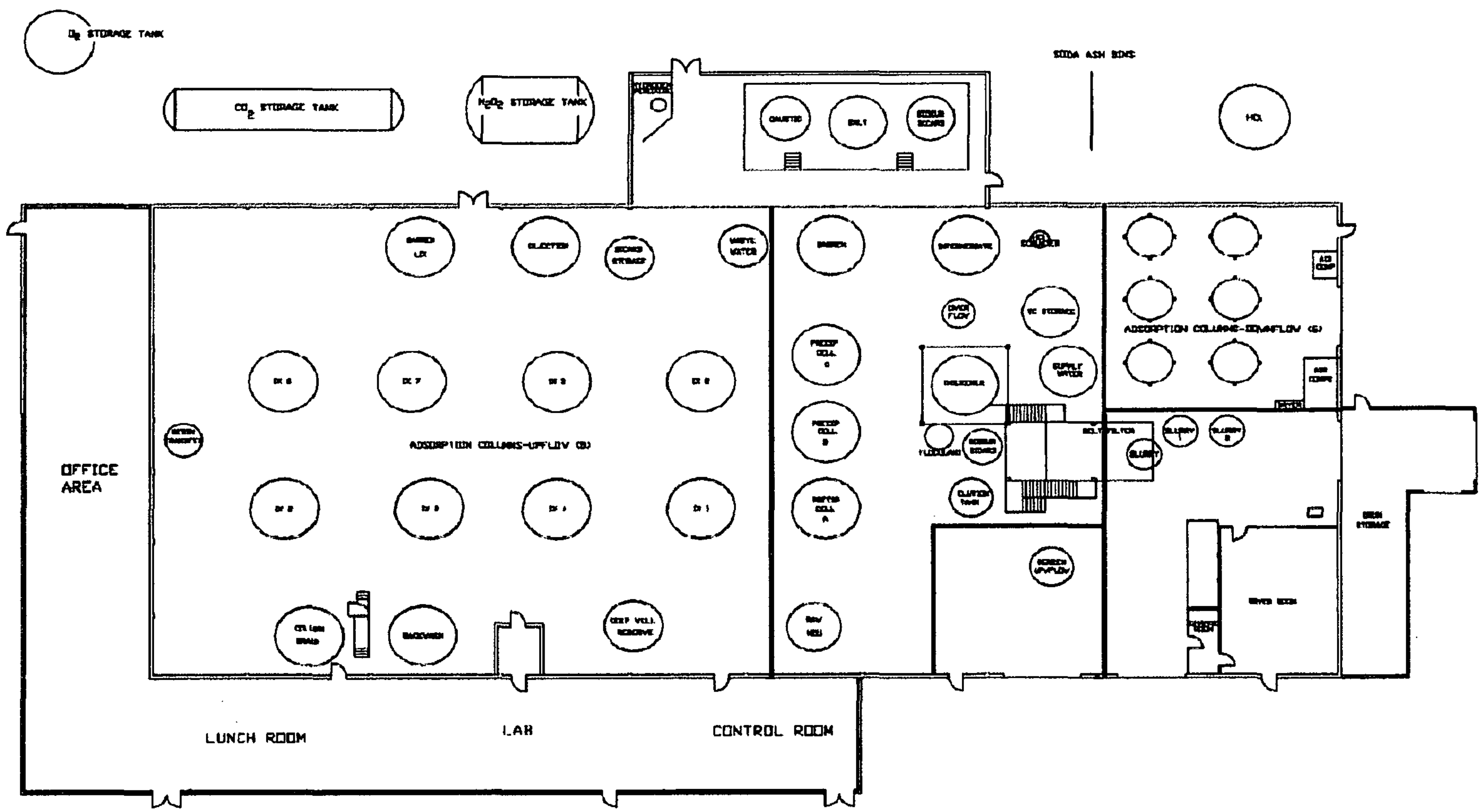
The up-flow injection filtration system consists of backwashable filters, with an option of installing polishing filters downstream. The down-flow system utilizes screens to prevent resin loss, and the resin itself acts as an injection filter, with an option of installing polishing filters downstream.

The up-flow lixiviant injection system consists of the injection surge tanks and the injection pumps. The tanks are fabricated out of FRP, and the injection pumps are centrifugal. The down-flow injection system depends on the down-hole submersible pumps to push through the sealed down-flow system and reinject the lixiviant. There is an option for in-line centrifugal booster pumps as needed to maintain pressures.

The elution/precipitation circuit consists of the barren eluant tanks and the acidizer/precipitator tanks. The barren eluant tanks and the precipitation tanks are constructed of FRP. The eluant is pumped from the barren eluant tanks to the ion exchange column that is in the elution mode. After the resin is eluted, the pregnant eluant is transferred to the acidizer/precipitator where the uranium is precipitated.

The areas in the processing plant where fumes or gases are generated are discussed in **Section 5.8**. Process tanks are vented for radon, O_2 and CO_2 removal. Building ventilation in the process equipment area is accomplished by the use of an exhaust system. This exhaust system draws fresh air in from ventilators and helps sweep radon, which can accumulate near the floor of the building, out to the atmosphere.

Figure 3.2-1: Central Processing Plant



3.2.2 Chemical Storage Facilities

Chemical storage facilities at the CBR Facility include both hazardous and non-hazardous material storage areas. Bulk hazardous materials, which have the potential to impact radiological safety, are stored outside and segregated from areas where licensed materials are stored. Other non-hazardous bulk process chemicals (e.g., sodium carbonate) that do not have the potential to impact radiological safety are stored in a designated area.

3.2.2.1 Process Related Chemicals

Process-related chemicals stored in bulk at the CBR Facility include carbon dioxide, oxygen, and or hydrogen peroxide. Sodium sulfide may also be stored for use as a reductant during groundwater restoration.

- **Carbon Dioxide** - Carbon dioxide is stored at the CBR Facility where it is added to the lixiviant.
- **Oxygen** - Oxygen is also typically stored at the plant, or within wellfield areas, where it is centrally located for addition to the injection stream in each wellhouse. Since oxygen readily supports combustion, fire and explosion are the principal hazards that must be controlled. The oxygen storage facility is located a safe distance from the CBR plant and other chemical storage areas for isolation. The storage facility has been designed to meet industry standards in NFPA-50 (NFPA 1996).

  Oxygen service pipelines and components must be clean of oil and grease since gaseous oxygen will cause these substances to burn with explosive violence if ignited. All components intended for use with the oxygen distribution system are properly cleaned using recommended methods in CGA G-4.1 (CGA 2000). The design and installation of oxygen distribution systems is based on CGA-4.4 (CGA 1993).

  The design locations of the carbon dioxide and oxygen storage tanks are shown on **Figure 3.2-1**.

- **Sodium Sulfide** - Hazardous materials typically used during ground water restoration activities include the addition of a chemical reductant (i.e., sodium sulfide or hydrogen sulfide gas). To minimize potential impacts to radiological safety, these materials are stored outside of process areas. Sodium sulfide is currently used as the chemical reductant during groundwater restoration at the current license area.

  The material consists of a dry flaked product and is typically purchased on pallets of 55-pound bags or super sacks of 1,000 pounds. The bulk inventory is stored outside of process areas in a cool, dry, clean environment to prevent contact with any acid, oxidizer, or other material that may react with the product. Hydrogen sulfide gas has never been used at the Crow Butte Project. In the event that CBR determines that use of hydrogen sulfide as a chemical reductant is necessary, proper safety precautions will be taken to minimize potential impacts to radiological and chemical safety.

As part of the EHSMS Program, a risk assessment was completed to recognize potential hazards and risks associated with chemical storage facilities (and other processes) and to mitigate those risks to acceptable levels. The risk assessment process identified hydrochloric acid as the most hazardous chemical with the greatest potential for impacts to chemical and radiological safety. The hydrochloric acid storage and distribution system at the Central Plant (**Figure 3.2-1**) has a maximum capacity of approximately 6,000 gallons. Strict unloading procedures are utilized to ensure that safety controls are in place during the transfer of hydrochloric acid. Process safety controls are also in place at the Central Plant where hydrochloric acid is added to the precipitation circuit. Since precipitation will not be performed at the satellite facility, the use and storage of concentrated hydrochloric acid will not be necessary in this area.

None of the hazardous chemicals used at the Crow Butte Project are covered under the USEPA's Risk Management Program (RMP) regulations. The RMP regulations require certain actions by covered facilities to prevent accidental releases of hazardous chemicals and minimize potential impacts to the public and environment. These actions include measures such as accidental release modeling, documentation of safety information, hazard reviews, operating procedures, safety training, and emergency response preparedness.

3.2.2.2 Non-Process Related Chemicals

Non-process related chemicals that are stored at the CBR Facility include petroleum (gasoline, diesel) and propane. Due to the flammable and/or combustible properties of these materials, all bulk quantities are stored outside of process areas at the satellite plant. All gasoline and diesel storage tanks are located above ground and within secondary containment structures to meet USEPA requirements.

3.3 INSTRUMENTATION AND CONTROL

The basic control system at the Crow Butte site is built around an Allen-Bradley PLC-5 6200 Series system. This system allows for extensive monitoring of all wellfield and recovery plant operations.

The Allen-Bradley system consists of a series of menus which allows the plant operator to monitor and control a variety of systems and parameters. In addition, each wellfield house contains its own processor, which allows it to operate independent of the main computer. All critical equipment is equipped with UPS systems in the event of a power failure.

Through this system, not only can the plant operators monitor and control every aspect of the operation on a real time basis, but management can review historical data to develop trend analysis for production operations. This not only ensures an efficient operation, but allows Crow Butte personnel to anticipate problem areas, and to remain in compliance with appropriate regulatory requirements.

Wellfield instrumentation is provided to measure total production and injection flow. In addition, instrumentation is provided to indicate the pressure that is being applied to the injection wells. Wellfield houses are equipped with wet alarms to detect the presence of liquids in the wellfield house sumps. The deep injection well is also equipped with a variety of sensors to monitor its status.

Instrumentation is provided to monitor the total flow into the plant, the total injection flow leaving the plant, and the total waste flow leaving the plant. Instrumentation is provided on the plant injection manifold to record an alarm in the event of any pressure loss that might indicate a leak or rupture in the injection system. The injection pumps are sized or equipped so that they are incapable of producing pressures high enough to exceed design pressure of the injection lines or the maximum pressure to be applied to the injection wells.

In the process areas, tank levels are measured in chemical storage tanks as well as process tanks. A number of different monitors are in place for the dryer system, and drum logging is automated.

3.3.1 References

Compressed Gas Association (CGA). 1993. CGA G-4.4, *Industrial Practices for Gaseous Oxygen Transmission and Distribution Piping Systems.*

Compressed Gas Association (CGA). 2000. CGA G-4.1, *Cleaning Equipment for Oxygen Service.*

National Fire Protection Association (NFPA). 1996. NFPA-50, *Standard for Bulk Oxygen Systems at Consumer Sites.*

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4 EFFLUENT CONTROL SYSTEMS

This section describes the effluent control systems used at the Crow Butte Project. The effluents of concern at ISL operations include the release or potential release of radon gas (radon-222), radionuclides in liquid process streams, and dried yellowcake. Yellowcake processing and drying operations are conducted at the Central Plant.

The yellowcake drying facilities at the Central Plant are comprised of one vacuum dryer. The current license allows for the addition of a second dryer. Yellowcake processing and drying is carried out using a vacuum dryer with a wet condenser system, thus there are no airborne effluents from this system. By design, vacuum dryers do not discharge any uranium when operating. Effluent controls for yellowcake drying at the Central Plant have been reviewed by USNRC and approved in the current license.

4.1 GASEOUS AND AIRBORNE PARTICULATES

The only radioactive airborne effluent at the Crow Butte facility is radon-222 gas.

4.1.1 Tank and Process Vessel Ventilation Systems

Radon-222 is contained in the pregnant lixiviant that comes from the wellfield into the plant. The majority of the radon-222 is released in the injection surge tanks and in the ion exchange columns. These vessels are covered and vented to the atmosphere. The vents from the individual vessels go into a manifold that is exhausted to atmosphere outside the plant building via an induced draft fan. Venting the radon-222 gas to atmosphere outside the plant minimizes employee exposure. Redundant exhaust fans direct collected gases to discharge piping that exhaust fumes to the outside atmosphere. The design of the fans is such that the system is capable of limiting employee exposures with the failure of a single fan. Discharge stacks are located away from building ventilation intakes to prevent introducing exhausted radon into the facility as recommended in Regulatory Guide 8.31 (USNRC 2002). Airflow through any openings in the vessels is from the process area into the vessel and into the ventilation system, controlling any releases that may occur inside the vessel.

Small amounts of radon-222 may be released via solution spills, filter changes, RO operation, and maintenance activities, but these are minimal releases on an infrequent basis. The exhaust system in the plant further reduces employee exposure. The air in the plant is sampled for radon daughters (**Section 5.0**) to assure that concentration levels of radon and radon daughters is maintained as low as reasonably achievable (ALARA).

The type of dryer used in the Crow Butte process facility is a vacuum dryer. With this dryer, the yellowcake is dried in a heating chamber that is maintained at negative pressure. Airflow in a vacuum dryer is minimal and is from the outside of the drying chamber into the chamber. Any particulate that may be released goes to a bag filter, with the moisture-laden air going to a closed loop condenser where the water condenses and entrains any remaining particulate, with the vacuum source being a liquid ring vacuum pump acting as a final filter against any particulate escape. The water is periodically transferred to the yellowcake thickener. With a vacuum dryer, there is no release of particulate by way of a stack since there is no positive airflow. During packaging, the drum is sealed via a gasket to the dryer discharge. As the dryer is operating under vacuum, any leaks around this gasket result in air being drawn into the drum during the packaging of yellowcake, thus no contaminants are released. The air that may enter the discharge to the drum is also routed to the condenser system described above.

If the yellowcake emission control equipment fails to operate within specifications established in standard operating procedures, the drying and packaging room is immediately closed and declared an airborne radiation area. Heating operations are switched to cooldown, or packaging operations are temporarily suspended.

4.1.2 Work Area Ventilation System

As discussed in **Section 4.1.1**, the work area ventilation system has been designed to force air to circulate within the plant process areas. The ventilation system exhausts outside the building, drawing fresh air in. The design of the ventilation system is adequate to ensure radon daughter concentrations in the facility are maintained below 25 percent of the derived air concentration (DAC) from 10 CFR Part 20.

Operational radiological in-plant monitoring for radon concentrations has proven that the facility's ventilation system has been an effective method for minimizing employee exposure.

Other emissions to the air are limited to exhaust and dust from limited vehicular traffic.

4.2 LIQUIDS AND SOLIDS

4.2.1 Liquid Waste Sources and Disposal

As a result of ISL mining process, there are three sources of water that are collected on the site.

4.2.1.1 Primary Water Sources

Water generated during well development

This water is recovered groundwater and has not been exposed to any mining process or chemicals. However, the water may contain elevated concentrations of naturally-occurring radioactive material if the development water is collected from the mineralized zone. The water is discharged directly to one of the solar evaporation ponds and silt, fines and other natural suspended matter collected during well development is settled out in the pond. Well development water may be treated with filtration and/or reverse osmosis and used as plant make-up water or disposed of in the deep disposal well.

Liquid process waste

The operation of the process plant results in two primary sources of liquid waste, an eluant bleed and a production bleed. These bleeds are routed to either the deep disposal well or an evaporation pond.

Aquifer restoration

Following mining operations, restoration of the affected aquifer commences which results in the production of wastewater. The current groundwater restoration plan consists of four activities: 1) Groundwater Transfer, 2) Groundwater Sweep, 3) Groundwater Treatment, and 4) Wellfield Circulation. Only the groundwater sweep and groundwater treatment activities will generate wastewater.

During groundwater sweep, water is extracted from the mining zone without injection, causing an influx of baseline quality water to sweep the affected mining area. The extracted water must be sent to the wastewater disposal system during this activity.

Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A reverse osmosis (RO) unit will be used to reduce the total dissolved solids (TDS) of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the waste disposal system. The brine is sent to the wastewater disposal system.

4.2.1.2 Secondary Water Sources

Stormwater Runoff

The design of the Crow Butte facilities and existing engineering controls is such that runoff is not considered to be a potential source of pollution. Therefore, this water is not specifically collected and routed to a pond for disposal.

Stormwater management is controlled under permits issued by the NDEQ. CBR is subject to stormwater National Pollutant Discharge Elimination System (NPDES) permitting requirements for industrial facilities and construction activities. The NDEQ NPDES regulatory program contained in Title 119 (NDEQ 2005) requires that procedural and engineering controls be implemented such that runoff will not pose a potential source of pollution.

Domestic Liquid Waste

Domestic liquid wastes from the restrooms and lunchrooms are disposed of in an approved septic system that meets the requirements of the State of Nebraska. These systems are in common use throughout the United States and the effect of the system on the environment is known to be minimal when the systems are designed, maintained, and operated properly. CBR currently maintains a Class V UIC Permit issued by the NDEQ for operation of the septic system at the current License Area.

4.2.1.3 Liquid Waste Disposal

Two methods of disposal are used for the Crowe Butte Central Plant:

- Deep disposal well injection; and
- Evaporation via evaporation ponds.

Deep Disposal Well Injection

CBR currently operates a non-hazardous Class I injection well in the current license area for disposal of wastewater. The well is permitted under NDEQ regulations in Title 122 (NDEQ 2002) and operated under a Class I UIC Permit. CBR has operated the deep disposal well at the current license area for over ten years with excellent results and no serious compliance issues. CBR has found that permanent deep disposal is preferable to evaporation in evaporation ponds.

Evaporation Pond

Evaporation pond design, installation and operation criteria are those found in USNRC Regulatory Guide 3.11 (USNRC 1977). CBR maintains three commercial and two R&D evaporation ponds in the current License Area. Each commercial pond is nominally 900 feet by 300 feet by 17 feet in depth. The ponds are constructed with a primary and secondary liner system. An underdrain system consisting of perforated piping between the primary and secondary liners is installed to monitor for leaks. The underdrain slopes gradually to the ends of the ponds where they are connected to a surface monitor pipe. Checking for an increase in measurable moisture inside the leak detection system and/or analyzing the water in the pipe can discover a leak in the pond liner.

Each of the ponds has the capability of being pumped to a water treatment plant prior to discharge under the NPDES permit. A variety of treatment options exist depending upon the specific chemical contaminants identified in the wastewater. In general, a combination of chemical precipitation and reverse osmosis is adequate to restore the water to a quality that falls well within the NPDES criteria.

The current pond inspection program is based on USNRC recommendations in Regulatory Guide 3.11.1 (USNRC 1980) and is approved in SUA-1534. Routine inspections are required as follows:

- Daily Inspections

  Daily inspections consist of checking the pond depth and visually inspecting the pond embankments for slumping, movement, or seepage. The pond depth measurements are checked against the freeboard requirements.

- Weekly Inspections

  Weekly inspections consist of checking the perimeter game-proof fence and restricted area signs, checking the pond inlet piping, making underdrain measurements, checking the pond enhanced evaporation system (if installed), visually inspecting the liner, and measuring the vertical depth of fluid in the pond underdrain standpipes. During periods of seismic activity, flooding, severe rainfall, or other event that could cause the pond to leak, underdrain measurements are taken daily and recorded.

- Monthly Inspections

  During monthly inspections, the waste piping from the plant building to the ponds is visually inspected for signs of seepage indicating a possible pipeline break. Diversion channels surrounding the ponds are examined for channel bank erosion, obstruction to flow, undesirable vegetation, or any other unusual conditions.

- Quarterly Inspections

  Quarterly inspections check for embankment settlement and for irregularities in alignment and variances from originally constructed slopes (i.e., sloughing, toe movement, surface cracking or erosion). Embankments are inspected for any evidence of seepage, erosion, and any changes to the upstream watershed areas that could affect runoff to the ponds. Emergency lines are inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

- Annual Inspection

  A technical evaluation of the pond system is done annually, which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments. A survey of the pond embankments is done on an annual basis and the survey results documented and incorporated into the annual inspection report. The survey is reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes. The technical evaluation is the result of an annual inspection and a review of the weekly, monthly, and quarterly inspection reports by a professional engineer registered in the State of Nebraska. Examination of the pond monitor well sampling data is also reviewed for signs of seepage in the embankments. The inspection report presents the results of the technical evaluation and the inspection data collected since the last report. The report is kept on file at the site for review by regulatory agencies. A copy is also submitted to the USNRC.

- Pond Leak Corrective Actions

  If six inches or more of fluid is present in the standpipes, the contents will be analyzed for specific conductance. If the water quality in the standpipe is degraded beyond the action level, the water will be further sampled for chloride, alkalinity, sodium, and sulfate. The action level is defined as a specific conductivity of the fluid of the standpipe that is 50 percent of the specific conductivity of the pond contents.

  If there is an abrupt increase in both the vertical fluid depth of a standpipe and the specific conductance of the fluid of the standpipe, the liner will be immediately inspected for liner damage. Abnormal increases of these two indicators confirm a potential liner leak and agency reporting (i.e., USNRC and NDEQ) will be required.

  Upon verification of a liner leak, the fluid level will be lowered by transferring the cell's contents to the other cell. Water quality in the affected standpipes will be analyzed for the five parameters listed above once every seven days during the leak period, and once every seven days for at least two weeks following repairs.

4.2.1.4 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the Crow Butte facility, existing regulatory requirements from the USNRC and NDEQ, and provisions of the CBR Environmental, Health and Safety Management System (EHSMS), have established a framework that significantly reduces the possibility of such an occurrence. Extensive training of all personnel is standard policy at the CBR facility. Frequent inspections of waste management facilities and systems are conducted. Detailed procedures are included in the CBR EHSMS Program. .

There are primarily six potential sources of pollution at the Crow Butte Project.

- Solar Evaporation Ponds
- Wellfield Buildings and Piping
- Process Building
- Piping
- Transportation Vehicles
- Spills

Solar Evaporation Ponds

The solar evaporation ponds could contribute to a pollution problem in several ways. First, a pond could fail, either in a catastrophic fashion or as a result of a slow leak. In addition, a pond could overflow due to excess production or restoration flow, as well as due to the addition of rainwater.

With respect to a pond failure, all ponds have been built to USNRC standards, and are equipped with leak detection systems. Standard operating procedures require a periodic inspection of all ponds, liners, and berms. In the event of a leak, the contents of the pond can be transferred to another pond while repairs are made.

With respect to pond overflow, operating procedures are such that no individual pond is allowed to fill to a point where overflow is considered a realistic possibility. The flow rate of liquids to the ponds is minimal, thus there is ample time to reroute the flow to another pond. Regarding the addition of rainwater, the freeboards of ponds considered "full" are sufficient to contain the addition of significant quantities of rainwater before an overflow would occur. The inclusion of the freeboard allowance also precludes over-washing of the walls during high winds.

Wellfield Buildings and Piping

Wellfield buildings are not considered to be a potential source of pollutants during normal operations, as there are no process chemicals or effluents stored within them. The only instance in which a wellfield building could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe failure. The possibility of such an occurrence is considered to be minimal, as the piping is leak checked before it is initially placed into service. Piping from the wellfields is generally buried, minimizing the possibility of an accident. In addition, the flows through the piping are monitored and are maintained at a relatively low pressure. Flow monitoring provides alarms in the event of a significant piping failure which allow flow to be stopped, preventing any significant migration of process fluids. Wellfield buildings also are equipped with wet alarms for early detection of leaks.

Process Building

The process building serves a central hub for most of the mining operations, thus has the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result due to a release of process chemicals from bulk storage tanks, piping failure, or a process storage tank failure.

The design of the building is such that any release of liquid waste would be contained within the structure. A concrete curb is built around the entire process building. This pad has been designed to contain the contents of the largest tank within the building in the event of a rupture. In the event of a piping failure, the pump system can be immediately shut down, limiting any release. Liquid inside the building, either from a spill or from washdown water, is drained through a sump and sent to the evaporation ponds.

Piping

As previously discussed, all piping is leak checked prior to operation. Piping from the wellfields is generally buried, minimizing the possibility of an accident. Large leaks in the pipe would quickly become apparent to the plant operators due to a decrease in flow and pressure, thus any release could be mitigated rapidly.

Transportation vehicles

The release of pollutants to the environment could occur due to accidents involving transportation vehicles. This could involve either vehicles delivering bulk chemical products, transport of radioactive contaminated waste from the site to an approved disposal site, or from vehicles carrying yellowcake slurry or dried yellowcake.

All chemicals and products delivered to or transported from the site are carried in DOT approved packaging. In the event of an accident, procedures are currently in place in the EHSMS Program Volume VIII, *Emergency Manual*, to insure a rapid response to the situation.

Spills can take two forms within an ISL facility; surface spills such as pond leaks, piping ruptures etc., and subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a release of waste solutions.

Engineering and administrative controls are in place to prevent when possible both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur.

Spills

Spills can take two forms within an in-situ facility. These are surface spills (such as pond leaks, piping ruptures etc.) and subsurface releases such as a well casing failure, or a pond liner leak resulting in a release of waste solutions.

Engineering and administrative controls are in place at the Central Plant to prevent both surface and subsurface releases to the environment, and to mitigate the effects should an accident occur. The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids from the process plant to the wellfield and back. With the current CBR monitoring system, these are generally small releases and are quickly discovered and mitigated.

In general, piping from the plant, to and within the wellfield is constructed of PVC, high-density polyethylene pipe (HDPE) with butt-welded joints or equivalent. All pipelines are pressure tested prior to final operation. It is unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines are protected from a major cause of potential failure, which is vehicles driving over the lines causing breaks. Typically, the only exposed pipes are at the process plant, the wellheads and in the control house in the wellfield. Trunkline flows and manifold pressures are monitored each shift for process control.

4.2.2 Solid Waste

Any facility or process with the potential to generate industrial wastewater should practice good housekeeping. This activity generally consists of keeping facilities, equipment, and process areas clean and free of industrial waste or other debris. Good housekeeping includes promptly cleaning any spillage or process residues that are on floors or other areas that could be spread and collecting solid wastes in designated containers or area until proper disposal.

Solid waste generated at the site consists of spent resin, resin fines, empty reagent containers, miscellaneous pipe and fittings, and domestic trash. The solid waste is segregated based on whether it is clean or has the potential for contamination with 11(e).2 byproduct materials.

4.2.2.1 Non-contaminated Solid Waste

Non-contaminated solid waste is waste which is not contaminated with 11(e).2 byproduct material or which can be decontaminated and re-classified as non-contaminated waste. This type of waste may include piping, valves, instrumentation, equipment and any other item which is not contaminated or which may be successfully decontaminated. Release of contaminated equipment and materials is discussed in further detail in **Section 5**.

CBR has recently estimated that the current licensed site produces approximately 1,055 cubic yards (yd^3) of non-contaminated solid waste per year. This estimate is based on the number of collection containers on site and the experience of the contract waste hauler. Non-contaminated solid waste is collected on the site in designated areas and disposed of in the nearest permitted sanitary landfill.

4.2.2.2 11(e).2 Byproduct Material

Solid 11(e).2 byproduct waste consists of solid waste contaminated with 11e.(2) byproduct material that cannot be decontaminated.

11(e).2 byproduct material generated at ISL facilities consists of filters, Personal Protective Equipment (PPE), spent resin, piping, etc. CBR has recently estimated that the current licensed site produces approximately 60 to 90 yd^3 of 11(e).2 byproduct material waste per year. This estimate is based on the historical number of shipments to the licensed disposal facilities. These materials are stored on site until such time that a full shipment can be sent to a licensed waste disposal site or licensed mill tailings facility. CBR currently maintains an agreement for waste disposal at a properly licensed facility as a License Condition requirement for SUA-1534. CBR is required to notify USNRC in writing within 7 days if the disposal agreement expires or is terminated, and to submit a new agreement for USNRC approval within 90 days of the expiration or termination.

If decontamination is possible, records of the surveys for residual surface contamination are made prior to releasing the material. Decontaminated materials have activity levels lower than those specified in USNRC guidance (USNRC 1987). An area is maintained inside the restricted area boundary for storage of contaminated materials prior to their disposal.

4.2.2.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms are disposed of in an approved septic system that meets the requirements of the State of Nebraska. Disposal of solid materials collected in septic systems must be performed by companies or individuals licensed by the State of Nebraska. NDEQ regulations for control of these systems are contained in Title 124 (USNRC 2005).

4.2.2.4 Hazardous Waste

The potential exists for any industrial facility to generate hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA). In the State of Nebraska, hazardous waste is governed by the regulations contained in Title 128 (NDEQ 2007). Based on waste determinations conducted by CBR as required in Title 128, CBR is a Conditionally Exempt Small Quantity Generator (CESQG). To date CBR only generates universal hazardous wastes such as used waste oil and batteries. CBR recently estimated that the current operation generates approximately 1,325 liters of waste oil per year. Waste oil is disposed of by a licensed waste oil recycler. CBR has management procedures in place in EHSMS Program Volume VI, *Environmental Manual,* to control and manage these types of wastes.

4.2.3 References

Nebraska Department of Environmental Quality (NDEQ). 2002. Title 122, Rules and Regulations for Underground Injection and Mineral Production Wells (April 2002).

NDEQ. 2005. Title 119, Rules and Regulations Pertaining to the Issuance of Permits under the National Pollutant Discharge Elimination System, (May 2005).

NDEQ. 2005. Title 124, Rules and Regulations for the Design, Operation, and Maintenance of On-site Wastewater Treatment Systems, (May 2005).

NDEQ. 2007. Title 128, Nebraska Hazardous Waste Regulations, (January 2007).

U. S. Nuclear Regulatory Commission (USNRC). 1977. Regulatory Guide 3.11, Design, Construction, and Inspection of Embankment Retention Systems for Uranium Mills (Revision 2, December 1977).

USNRC. 1980. Regulatory Guide 3.11.1, Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings (Revision 1, October 1980).

USNRC. 1987. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for By-Product, Source or Special Nuclear Material (May 1987).

USNRC. 2002. Regulatory Guide 8.31, Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable (Revision 1, May 2002).

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5 OPERATIONS

CBR operates a commercial-scale in-situ leach uranium mine (the Crow Butte Project) near Crawford, Nebraska. CBR maintains a headquarters in Denver, Colorado where site-licensing actions originate. All CBR operations, including the Crow Butte Project operations, are conducted in conformance with applicable laws, regulations, and requirements of the various regulatory agencies. The responsibilities described below have been designed to both ensure compliance and further implement CBR's policy for providing a safe working environment with cost-effective incorporation of the philosophy of maintaining radiation exposures as low as is reasonably achievable (ALARA).

5.1 CORPORATE ORGANIZATION/ADMINISTRATIVE PROCEDURES

CBR will maintain a performance-based approach to the management of the environment and employee health and safety including radiation safety. The Environmental, Health, and Safety Management System (EHSMS) Program encompasses licensing, compliance, environmental monitoring, industrial hygiene, and health physics programs under one umbrella, and it includes involvement for all employees from the individual worker to senior management. This EHSMS Program will allow CBR to operate efficiently and maintain an effective environment, health, and safety program.

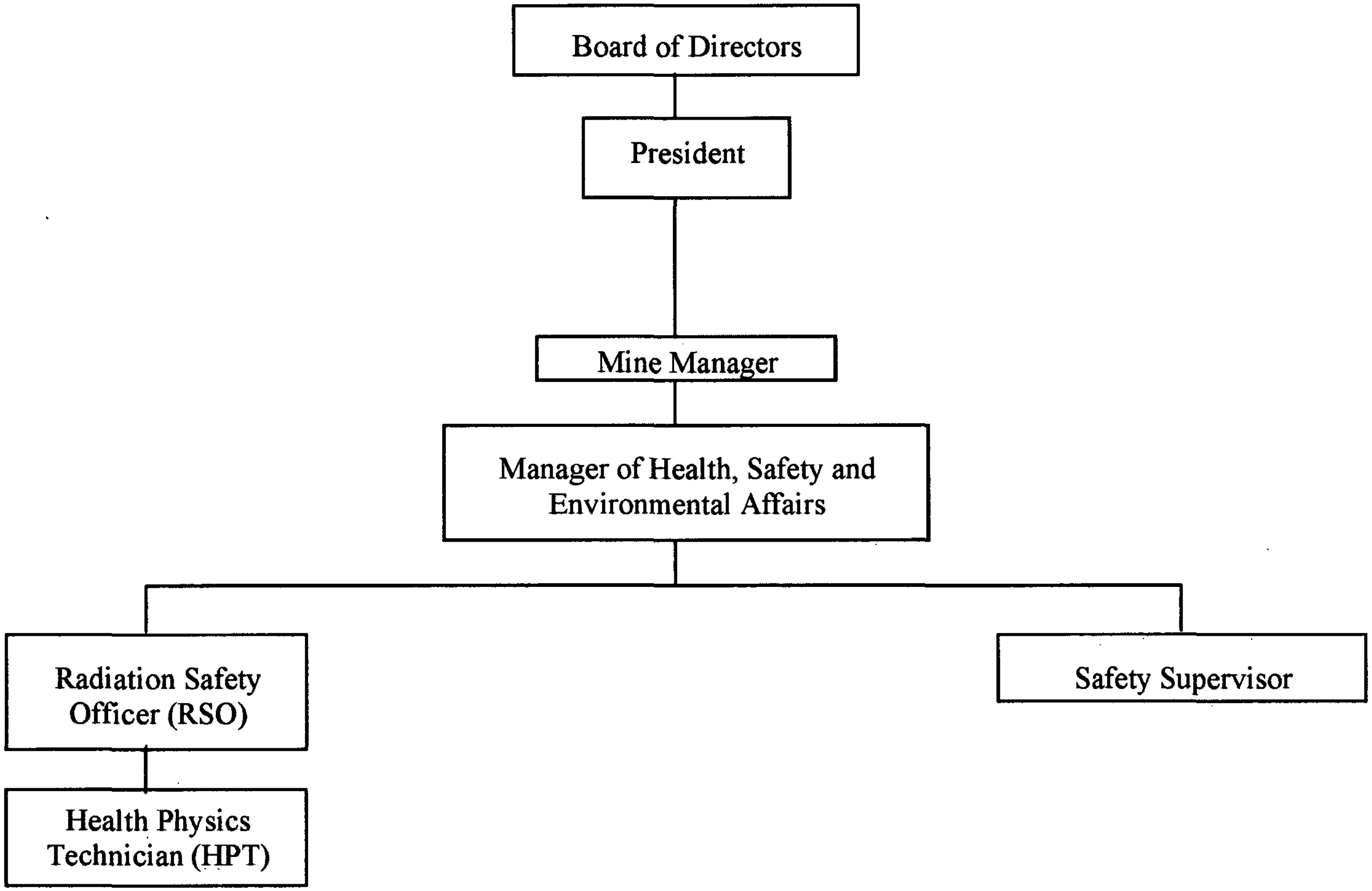
Figure 5.1-1 is a partial organization chart for CBR with respect to the operation of the Crow Butte Project and associated operations. This structure represents the management levels that play a key part in the EHSMS Program. The personnel identified are responsible for the development, review, approval, implementation, and adherence to operating procedures, radiation safety programs, environmental and groundwater monitoring programs, as well as routine and non-routine maintenance activities. These individuals may also serve a functional part of the Safety and Environmental Review Panel (SERP) described under **Section 5.3.3**.

Specific responsibilities of the organization are provided below.

5.1.1 Board of Directors

The CBR Board of Directors has the ultimate responsibility and authority for radiation safety and environmental compliance for CBR. The Board of Directors sets corporate policy and provides procedural guidance in these areas. The Board of Directors provides operational direction to the President of CBR.

Figure 5.1-1: Crow Butte Resources Organizational Chart



5.1.2 President

The President of CBR is responsible for interpreting and acting upon the CBR Board of Directors' policy and procedural decisions. The President is empowered by the Board of Directors to have the responsibility and authority for the radiation safety and environmental compliance programs at the Crow Butte Facility. The President is directly responsible for ensuring that CBR personnel comply with industrial safety, radiation safety, and environmental protection programs as established in the EHSMS Program. The President is also responsible for company compliance with all regulatory license conditions/stipulations, regulations, and reporting requirements. The President has the responsibility and authority to terminate immediately any activity that is determined to be a threat to employees or public health, the environment, or potentially a violation of state or federal regulations. The President is also responsible for license development and modifications.

5.1.3 Mine Manager

The CBR Mine Manager is responsible for all uranium production activity at the project site. All site operations, maintenance, construction, environmental health and safety, and support groups report directly to the Mine Manager. In addition to production activities, the Mine Manager is also responsible for implementing any industrial and radiation safety and environmental protection programs associated with operations. The Mine Manager is authorized to immediately implement any action to correct or prevent hazards. The Mine Manager has the responsibility and the authority to suspend, postpone, or modify, immediately if necessary, any activity that is determined to be a threat to employees, public health, the environment, or potentially a violation of state or federal regulations. The Mine Manager cannot unilaterally override a decision for suspension, postponement, or modification if that decision is made by the President and/or the Manager of Health, Safety, and Environmental Affairs. The Mine Manager reports directly to the President.

5.1.4 Manager of Health, Safety, and Environmental Affairs

The Manager of Health, Safety, and Environmental Affairs is responsible for all radiation protection, health and safety, and environmental programs as stated in the EHSMS Program and for ensuring that CBR complies with all applicable regulatory requirements. The Manager of Health, Safety, and Environmental Affairs reports directly to the Mine Manager and supervises the Radiation Safety Officer (RSO) to ensure that the radiation safety and environmental monitoring and protection programs are conducted in a manner consistent with regulatory requirements. This position assists in the development and review of radiological and environmental sampling and analysis procedures and is responsible for routine auditing of the programs. The Manager of Health, Safety, and Environmental Affairs has no production-related responsibilities. The Manager of Health, Safety, and Environmental Affairs also has the responsibility to advise the President on matters involving radiation safety and to implement changes and/or corrective actions involving radiation safety authorized by the President.

5.1.5 Radiation Safety Officer

The CBR RSO is responsible for the development, administration, and enforcement of all radiation safety programs. The RSO is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate radiation safety hazards and/or maintain regulatory compliance. The RSO is responsible for the implementation of all on-site environmental programs including emergency procedures. The RSO inspects facilities to verify compliance with all applicable requirements in the areas of radiological health and safety. The RSO works closely with all supervisory personnel to review and approve new equipment and changes in processes and procedures that may affect radiological safety and to ensure that established programs are maintained. The RSO is also responsible for the collection and interpretation of employee exposure-related monitoring including data from radiological safety. The RSO recommends improvements to any and all radiological safety-related controls. The RSO has no production-related responsibilities. The RSO reports directly to the Manager of Health, Safety, and Environmental Affairs.

5.1.6 Health Physics Technician

The CBR Health Physics Technician (HPT) assists the RSO with the implementation of the radiological and industrial safety programs. The HPT is responsible for the orderly collection and interpretation of all monitoring data, to include data from radiological safety and environmental programs. The HPT reports directly to the RSO.

5.1.7 Safety Supervisor

The CBR Safety Supervisor is responsible for the non-radiation-related health and safety programs. The Safety Supervisor is authorized to conduct inspections and to immediately order any change necessary to preclude or eliminate safety hazards and/or maintain regulatory compliance. The Safety Supervisor's responsibilities include the development and implementation of health and safety programs in compliance with Occupational Safety and Health Administration (OSHA) regulations. Responsibilities of the Safety Supervisor include development of industrial safety and health programs and procedures, coordination with the RSO where industrial and radiological safety concerns are interrelated, safety and health training of new and existing employees, and the maintenance of appropriate records to document compliance with regulations. The Safety Supervisor reports directly to the Manager of Health, Safety, and Environmental Affairs.

5.2 ALARA POLICY

The purpose of the ALARA (As Low As Reasonably Achievable) Policy is to keep exposures to all radioactive materials and other hazardous material as low as possible and to as few personnel as possible. The policy considers the state of technology and the economics of improvements related to benefits to the public health and safety, other societal and socioeconomic considerations, and the utilization of atomic energy in the public interest.

In order for an ALARA Policy to correctly function, all individuals, including management, supervisors, health physics staff, and workers, must take part in and share responsibility for keeping all exposures as low as reasonably achievable. This policy addresses this need and describes the responsibilities of each level in the organization.

5.2.1 Management Responsibilities

Consistent with Regulatory Guide 8.31 *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002), the licensee management is responsible for the development, implementation, and enforcement of applicable rules, policies, and procedures as directed by regulatory agencies and company policies. These shall include the following:

- The development of a strong commitment to and continuing support of the implementation and operations of the ALARA program;
- An Annual Audit Program which reviews radiation monitoring results, procedural, and operational methods;
- A continuing evaluation of the Health Physics Program including adequate staffing and support; and
- Proper training and discussions that address the ALARA program and its function to all facility employees and, when appropriate, to contractors and visitors.

5.2.2 Radiation Safety Officer Responsibility

The RSO shall be charged with ensuring the technical adequacy of the radiation protection program, implementation of proper radiation protection measures, and the overall surveillance and maintenance of the ALARA program. The RSO shall be assigned the following:

- The responsibility for the development and administration of the ALARA program;
- Sufficient authority to enforce regulations and administrative policies that affect any radiological aspect of the EHSMS Program;

- Assist with the review and approval of new equipment, process changes or operating procedures to ensure that the plans do not adversely affect the radiological aspects of the EHSMS Program;
- Maintain equipment and surveillance programs to assure continued implementation of the ALARA program;
- Assist with conducting an Annual ALARA Audit as discussed in **Section 0** to determine the effectiveness of the program and make any appropriate recommendations or changes as may be dictated by the ALARA philosophy;
- Review annually all existing operating procedures involving or potentially involving any handling, processing, or storing of radioactive materials to ensure the procedures are ALARA and do not violate any newly established or instituted radiation protection practices; and
- Conduct or designate daily inspections of pertinent facility areas to observe that general radiation control practices, hygiene, and housekeeping practices are in line with the ALARA principle.

5.2.3 Supervisor Responsibility

Supervisors shall be the front line for implementing the ALARA program. Each supervisor shall be trained and instructed in the general radiation safety practices and procedures. The supervisors responsibilities include:

- Receiving and providing adequate training to implement the general philosophy behind the ALARA program;
- Providing direction and guidance to subordinates in ways to adhere to the ALARA program;
- Enforcement of rules and policies as directed by the EHSMS Program, which implement the requirements of regulatory agencies and company management; and
- Seeking additional help from management and the RSO should radiological problems be deemed by the supervisor to be outside their sphere of training.

5.2.4 Worker Responsibility

Because success of both the radiation protection and ALARA programs are contingent upon the cooperation and adherence to those policies by the workers themselves, the facility employees must be responsible for certain aspects of the program in order for the program to accomplish its goal of keeping exposures as low as possible. Worker responsibilities include:

- Adherence to all rules, notices, and operating procedures as established by management and the RSO through the EHSMS Program;

- Making valid suggestions which might improve the radiation protection and ALARA programs;
- Reporting promptly, to immediate supervisor, any malfunction of equipment or violation of procedures which could result in an increased radiological hazard;
- Proper use of protective equipment; and
- Proper performance of required contamination surveys.

5.3 MANAGEMENT CONTROL PROGRAM

5.3.1 Environmental, Health, and Safety Management System

CBR's EHSMS Program formalizes CBR's approach to environmental, health, and safety management to ensure consistency across its operations. The EHSMS Program is a key element in assuring that all employees demonstrate "due diligence" in addressing environmental, health, and safety issues and describes how the operations of the facility will comply with the requirements of the CBR Environmental, Health, and Safety (EH&S) Policy and regulatory requirements.

The CBR EHSMS Program:

- Assures that sound management practices and processes are in place to ensure that strong environmental, health, and safety performance is sustainable;
- Clearly sets out and formalizes the expectations of management;
- Provides a systematic approach to the identification of issues and ensures that a system of risk identification and management is in place;
- Provides a framework for personal, site, and corporate responsibility and leadership;
- Provides a systematic approach for the attainment of CBR's objectives; and
- Ensures continued improvement of programs and performance.

The EHSMS Program has the following characteristics:

- The system is compatible with the ISO 14001 Environment Management System.
- The system is straightforward in design, is intended as an effective management tool for all types of activities and operations, and is capable of implementation at all levels of the organization.
- The system is supported by standards that clearly spell out CBR's expectations while leaving the means by which these are attained as a responsibility of line management.
- The system is readily auditable.
- The system is designed to provide a practical tool to assist the operations in identifying and achieving their objectives while satisfying CBR's governance requirements.

The EHSMS Program uses a series of standards that align with specific management processes and sets out the minimum expectations for performance. The standards consist of management processes that include assessment, planning, implementation (training, corrective actions, safe work programs, and emergency response), checking (auditing, incident investigation, compliance management, and reporting), and management review.

5.3.1.1 Operating Procedures

CBR has developed procedures consistent with the corporate policies and standards and local, state and federal regulatory requirements to implement these management controls. The EHSMS Program consists of the following standards and operating procedures contained in eight volumes:

Volume 1 – *Standards*

Volume 2 – *Management Procedures*

Volume 3 – *Operations Manual* (SOPs)

Volume 4 – *Health Physics Manual*

Volume 5 – *Industrial Safety Manual*

Volume 6 – *Environmental Manual*

Volume 7 – *Training Manual*

Volume 8 – *Emergency Manual*

Written operating procedures have been developed for all process activities including those involving radioactive materials for the Crow Butte Project. Where radioactive material handling is involved, pertinent radiation safety practices are incorporated into the operating procedure. Additionally, written operating procedures have been developed for non-process activities including environmental monitoring, health physics procedures, emergency procedures, and general safety.

The procedures enumerate pertinent radiation safety procedures to be followed. A copy of the written procedure will be kept in the area where it is used. All procedures involving radiation safety will be reviewed and approved in writing by the RSO or another individual with similar qualifications prior to being implemented. The RSO will also perform a documented annual review of the operating procedures.

5.3.1.2 Radiation Work Permits

In the case that employees are required to conduct activities of a non-routine nature where there is the potential for significant exposure to radioactive materials and for which there is no operating procedure, a Radiation Work Permit (RWP) will be required. The RWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The RWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

The RSO may also issue Standing Radiation Work Permits (SRWPs) for periodic tasks that require similar radiological protection measures (e.g., maintenance work on a specified plant system). The SRWP will describe the scope of the work, precautions necessary to maintain radiation exposures to ALARA, and any supplemental radiological monitoring and sampling to be conducted during the work. The SRWP shall be reviewed and approved in writing by the RSO (or qualified designee in the absence of the RSO) prior to initiation of the work.

5.3.2 Performance Based License Condition

This license application is the basis of the Performance-Based License (PBL) originally issued in 1998. Under that license, CBR may, without prior USUSNRC approval or the need to obtain a License Amendment:

- Make changes to the facility or process, as presented in the license application (as updated),
- Make changes in the procedures presented in the license application (as updated), and
- Conduct tests or experiments not presented in the license application (as updated).

A License Amendment and/or USNRC approval will be necessary prior to implementing a proposed change, test, or experiment if the change, test, or experiment would:

- Result in any appreciable increase in the frequency of occurrence of an accident previously evaluated in the license application (as updated);
- Result in any appreciable increase in the likelihood of occurrence of a malfunction of a structure, system, or component (SSC) important to safety previously evaluated in the license application (as updated);
- Result in any appreciable increase in the consequences of an accident previously evaluated in the license application (as updated);
- Result in any appreciable increase in the consequences of a malfunction of an SSC previously evaluated in the license application (as updated);
- Create a possibility for an accident of a different type than any previously evaluated in the license application (as updated);
- Create a possibility for a malfunction of an SSC with a different result than previously evaluated in the license application (as updated);
- Result in a departure from the method of evaluation described in the license application (as updated) used in establishing the final safety evaluation report (FSER), the environmental assessment (EA), technical evaluation reports (TERs), or other analysis and evaluations for license amendments.
- For purposes of this paragraph as applied to this license, SSC means any SSC that has been referenced in a staff SER, TER, EA, or environmental impact statement (EIS) and supplements and amendments thereof.

Additionally, CBR must obtain a license amendment unless the change, test, or experiment is consistent with the USNRC conclusions, or the basis of, or analysis leading to, the conclusions of actions, designs, or design configurations analyzed and selected in the site or facility SER, TERs, EIS, or EA. This would include all supplements, amendments, TERs, EAs, and EISs issued with amendments to this license.

5.3.3 Safety and Environmental Review Panel

A Safety and Environmental Review Panel (SERP) will determine compliance concerning the conditions discussed in **Section 5.3.2**. 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 for changes; one member will have expertise in operations and/or construction and will have expertise in implementation of any changes; and one member will be the RSO or equivalent. Other members of the SERP may be utilized as appropriate to address technical aspects of the change, experiment, or test in several areas such as health physics, groundwater hydrology, surface water hydrology, specific earth sciences, and others. Temporary members, or permanent members other than the three identified above, may be consultants.

The SERP is responsible for monitoring any proposed change in the facility or process, making changes in procedures, and conducting tests or experiments not contained in the current USNRC license. As such, they are responsible for ensuring that any such change results in no degradation in the essential safety or environmental commitments of CBR.

5.3.3.1 Safety and Environmental Review Panel Review Procedures

The CBR SERP will implement the following review procedures for the evaluation of all appropriate changes to the facility operations. The SERP may delegate any portion of these responsibilities to a committee of two or more members of the SERP. Any committees so constituted will report their findings to the full SERP for a determination of compliance with **Section 5.3.2** of this chapter. In their documented review of whether a potential change, test, or experiment (hereinafter called "the change") is allowed under the PBL (or Performance-Based License Condition [PBLC]) without a license amendment, the SERP shall consider the following.

<u>Current USNRC License Requirements</u>

The SERP will review the most current USNRC license conditions to assess which, if any, conditions will have an impact on or be impacted by the potential SERP action. If the SERP action will conflict with a specific license requirement, then a license amendment is necessary before initiating the change. This review includes information contained in the approved license application.

Ability to Meet USNRC Regulations

The SERP will determine if the change, test, or experiment conflicts with applicable USNRC regulations (example: 10 CFR Parts 20 and 40 requirements). If the SERP action conflicts with USNRC regulations, a license amendment is necessary.

Licensing Basis

The SERP will review whether the change, test, or experiment is consistent with USNRC's conclusions regarding actions analyzed and selected in the licensing basis. Documents that the SERP must review in conducting this evaluation include the SER and EA prepared in support of the 1997 LRA and any SERs, TERs, EAs, or EISs prepared to support amendments to the license. The RSO will maintain a current copy of all pertinent documents for review by the SERP during these evaluations.

Financial Surety

The SERP will review the proposed action to determine if any adjustment to financial surety arrangement or approved amount is required. If the proposed action will require an increase to the existing surety amount, the financial surety instrument must be increased accordingly before the change can be approved. The surety estimate must be updated either through a license amendment or through the course of the annual surety update to the USNRC. The USNRC incorporates the annual surety update by license amendment.

Essential Safety and Environmental Commitments

The SERP will assure that there is no degradation in the essential safety or environmental commitment in the license application, or as provided by the approved reclamation plan.

5.3.3.2 Documentation of SERP Review Process

findings, recommendations, and conclusions in a written report format. All members of the SERP shall sign concurrence on the final report. If the report concludes that the action meets the appropriate PBL or PBLC requirements and does not require a license amendment, the proposed action may then be implemented. If the report concludes that a license amendment is necessary before implementing the action, the report will document the reasons why and what course CBR plans to pursue. The SERP report shall include the following:

- A description of the proposed change, test, or experiment (proposed action);
- A listing of all SERP members conducting the review and their qualifications (if a consultant or other member was not previously qualified);
- The evaluation of the proposed action including all aspects of the SERP review procedures listed above;
- Conclusions and recommendations;

- Signatory approvals of the SERP members; and
- Any attachments such as all applicable technical, environmental, or safety evaluations, reports, or other relevant information including consultant reports.

All SERP reports and associated records of any changes made pursuant to the PBL or PBLC shall be maintained through termination of the USNRC license.

CBR will submit an annual report to the USNRC that describes all changes, tests, or experiments made pursuant to the PBL or PBLC. The report will include a summary of the SERP evaluation of each change. In addition, CBR will annually submit any pages of the license renewal application to reflect changes or supplementary information. Each replacement page shall include both a change indicator for the area of change, (e.g., bold marking vertically in the margin adjacent to the portion actually change) and a page change identification (date of change, change number, or both).

5.4 MANAGEMENT AUDIT AND INSPECTION PROGRAM

The following internal inspections, audits, and reports are performed for the Crow Butte Project operations:

5.4.1 Radiation Safety Inspections

5.4.1.1 Daily Inspections

The RSO, HPT or a qualified designated operator conducts a daily walkthrough inspection of the plant. The inspection entails a visual examination of compliance or other problems, which are reviewed with the Operations Superintendent.

5.4.1.2 Weekly RSO Inspections

The RSO and Operations Superintendent (or designees in their absence) will conduct a weekly inspection of all facility areas to observe general radiation control practices and review required changes in procedures and equipment.

5.4.1.3 Monthly RSO Reports

The RSO provides a written summary of the month's radiological activities at the Crow Butte Uranium Project facilities. The report includes a review of all monitoring and exposure data for the month, a summary of worker protection activities, a summary of all pertinent radiation survey records, a discussion of any trends in the ALARA program, and a review of adequacy of the implementation of the USNRC license conditions. Recommendations are made for any corrective actions or improvements in the process or safety programs.

5.4.2 Evaporation Pond Inspections

The inspection program developed by CBR for use on the ponds in the current production area is contained in EHSMS Program Volume VI, *Environmental Manual* and is based on the guidance in USNRC Regulatory Guide 3.11.1. The inspection program is summarized below.

5.4.2.1 Daily Inspections

- Pond Depth - The depth of water in each pond is measured and recorded.
- Pond Embankments - The pond embankments are visually inspected for signs of cracking, slumping, movement, or a concentration of seepage.

5.4.2.2 Weekly Inspections

- Perimeter Fence - The game-proof perimeter fence is inspected for holes that would allow animals to enter the pond area.

- Inlet Pipes – The pond inlet piping is inspected to verify that it is not clogged with ice, dirt, etc.
- Underdrain Measurements - The underdrains are measured, and the vertical depth of fluid in the standpipe is recorded.
- Pond Sprays - When in use, the enhanced evaporation systems should be checked at regular intervals.
- Pond Liner - The liner is visually inspected weekly for holes or other signs of distress.
- Leak Detection System - The leak detection pipes for all ponds are measured for fluid in the standpipes, and the vertical depth of the fluid shall be recorded on the Pond Inspection Forms.

5.4.2.3 Quarterly Inspections

- Embankment Settlement - The tops of the embankments and downstream toe area are examined for settlement or depressions.
- Embankment Slopes - Embankment slopes are examined for irregularities in alignment and variances from originally constructed slopes (sloughing, toe movement, surface cracking, or erosion).
- Seepage - Evidence of seepage in any areas surrounding the ponds (especially the downstream toes) is investigated and documented.
- Slope Protection - Vegetation on the outslopes of the pond is examined. Any evidence of rills or gullies forming is noted.
- Post-Construction Changes - Any changes to the upstream watershed areas that could affect runoff to the ponds is noted.
- Emergency lines are inspected to ensure that the rope has not deteriorated and the ropes reach to the pond water level.

5.4.2.4 Annual Inspection

A technical evaluation of the pond system which addresses the hydraulic and hydrologic capacities of the ponds and ditches and the structural stability of the embankments will be conducted annually. A survey of the pond embankments will be conducted annually and the survey results documented and incorporated into the annual inspection report. The survey is reviewed for evidence of embankment settlement, irregularities in embankment alignment, and any changes in the originally constructed slopes.

The technical evaluation will be the result of an annual inspection and a review of the weekly, monthly, and quarterly inspection reports by a professional engineer registered in the State of Nebraska. The pond monitor well sampling data will also be reviewed for signs of seepage in the embankments.

The inspection report will present the results of the technical evaluation and the analysis of inspection data collected since the last report. The report will be kept on file at the site for review by regulatory agencies. A copy is also submitted to the USNRC within 1 month of the annual inspection.

5.4.3 Annual ALARA Audits

CBR will conduct annual audits of the radiation safety and ALARA programs. The Manager of Health, Safety, and Environmental Affairs may conduct these audits. Alternatively, CBR may use qualified personnel from other uranium recovery facilities or an outside radiation protection auditing service to conduct these audits. The purpose of the audits is to provide assurance that all radiation health protection procedures and license condition requirements are being conducted properly at the Crow Butte Project facility. Any outside personnel used for this purpose will be qualified in radiation safety procedures as well as environmental aspects of solution mining operations. Whether conducted internally or through the use of an audit service, the auditor will meet the minimum qualifications for education and experience for the RSO as described in **Section 5.5.**

The audit of the radiation protection and ALARA program is conducted in accordance with the recommendations contained in USNRC Regulatory Guide 8.31. A written report of the results is submitted to corporate management. The RSO may accompany the auditor but may not contribute to the conclusions.

The annual ALARA audit report summarizes the following data:

- Employee exposure records;
- Bioassay results,
- Inspection log entries and summary reports of mine and process inspections,
- Documented training program activities,
- Applicable safety meeting reports,
- Radiological survey and sampling data,
- Reports on any overexposure of workers, and
- Operating procedures that were reviewed during this period.

The ALARA audit report specifically discusses the following:

- Trends in personnel exposures;
- Proper use, maintenance, and inspection of equipment used for exposure control; and
- Recommendations on ways to further reduce personnel exposures from uranium and its daughters.

The ALARA audit report is submitted to and reviewed by the CBR President and Mine Manager. Implementation of the recommendations to further reduce employee exposures, or improvements to the ALARA program, are discussed with the ALARA auditor.

An annual audit of the Quality Assurance/Quality Control (QA/QC) program is also conducted. An individual qualified in analytical and monitoring techniques who does not have direct responsibilities in the areas being audited performs the audit. The results of the QA/QC audit are documented with the ALARA Audit. The RSO has the primary responsibility for the implementation of the radiological QA/QC programs at the Crow Butte Project facilities.

5.5 HEALTH PHYSICS QUALIFICATIONS

CBR project staff are highly experienced in the management of uranium development, mining, and operations. The following are the minimum required personnel specifications and qualifications.

5.5.1 Radiation Safety Officer Qualifications

The minimum qualifications for the RSO are as follows:

- Education - A Bachelor's degree in the physical sciences, industrial hygiene, environmental technology, or engineering from an accredited college or university or an equivalent combination of training and relevant experience in uranium mill/solution mining radiation protection are required.
- Health Physics Experience - A minimum of 1 year of work experience relevant to uranium mill/solution mining operations in applied health physics, radiation protection, industrial hygiene or similar work is required.
- Specialized Training - A formalized, specialized course(s) in health physics specifically applicable to uranium milling/solution mining operations of at least 4 weeks' duration is required. The RSO attends refresher training on uranium mill health physics every 2 years.
- Specialized Knowledge - The RSO, through classroom training and on-the-job experience, possesses a thorough knowledge of the proper application and use of all health physics equipment used in the operation, the procedures used for radiological sampling and monitoring, methods used to calculate personnel exposures to uranium and its daughters, and a thorough understanding of the solution mining process and equipment used and how hazards are generated and controlled during the process.

5.5.2 Health Physics Technician Qualifications

The HPT will have one of the following combinations of education, training, and experience:

- Education - An Associate's degree or 2 years or more of study in the physical sciences, engineering, or a health-related field is required.

  Training - At least 4 weeks of generalized training in radiation health protection applicable to uranium mills/solution mining operations is required.

  Experience - One year of work experience using sampling and analytical laboratory procedures that involve health physics, industrial hygiene, or industrial safety measures to be applied in a uranium mill/solution mining operation is required.

- Education - A high school diploma is required.

  Training - At least 3 months of specialized training in radiation protection relevant to uranium mills, of which up to 1 month may be on-the-job training, is required.

- Experience - Two years of relevant work experience in applied radiation protection is required.

5.6 TRAINING

All site employees and contractor personnel at the Crow Butte Project are administered a training program based on the EHSMS Program covering radiation safety, radioactive material handling, and radiological emergency procedures. This training program is administered in keeping with standard radiological protection guidelines and the guidance provided in USNRC Regulatory Guide 8.29, *Instructions Concerning Risks From Occupational Radiation Exposure* (Revision 1, February 1996); Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002); and Regulatory Guide 8.13, *Instruction Concerning Prenatal Radiation Exposure* (Revision 3, June 1999). The technical content of the training program is under the direction of the RSO. The RSO or a qualified designee conducts all radiation safety training.

5.6.1 Training Program Content

5.6.1.1 Visitors

Visitors to the Crow Butte Project who have not received training are escorted by on-site personnel who are properly trained and familiar with the hazards of the facility. At a minimum, visitors are instructed specifically on what they should do to avoid possible hazards in the area of the facility that they are visiting.

5.6.1.2 Contractors

Any contractors having work assignments at the facility are given appropriate radiological safety training. Contract workers who will be performing work on heavily contaminated equipment receive the same training normally required of Crow Butte workers as discussed in **Section 5.6.1.3**.

5.6.1.3 Crow Butte Resources Employees

The CBR EHSMS Program Volume VII, *Training Manual*, incorporates the following topics recommended in USNRC Regulatory Guide 8.31, *Information Relevant to Ensuring That Occupational Radiation Exposures at Uranium Recovery Facilities Will Be As Low As Reasonably Achievable* (Revision 1, May 2002):

Fundamentals of Health Protection

- The radiological and toxic hazards of exposure to uranium and its daughters.
- How uranium and its daughters enter the body (inhalation, ingestion, and skin penetration), and
- Why exposures to uranium and its daughters should be kept as low as reasonably achievable (ALARA).

Personal Hygiene at Uranium Mines

- Wearing protective clothing;
- Using respirators when appropriate;
- Eating, drinking, and smoking only in designated areas; and
- Using proper methods for decontamination.

Facility-provided Protection

- Cleanliness of working spaces,
- Safety designed features for process equipment,
- Ventilation systems and effluent controls,
- Standard operating procedures, and
- Security and access control to designated areas.

Health Protection Measurements

- Measurements of airborne radioactive material,
- Bioassay to detect uranium (urinalysis and in vivo counting),
- Surveys to detect contamination of personnel and equipment, and
- Personnel dosimetry.

Radiation Protection Regulations

- Regulatory authority of USNRC, MSHA, and state;
- Employee rights in 10 CFR Part 19; and
- Radiation protection requirements in 10 CFR Part 20.

Emergency Procedures

All new workers, including supervisors, are given specialized instruction on the health and safety aspects of the specific jobs they will perform. This instruction is performed in the form of individualized on-the-job training. Retraining is conducted annually and documented. Every 2 months, all workers attend a general safety meeting.

5.6.2 Testing Requirements

A written test with questions directly relevant to the principals of radiation safety and health protection in the facility covered in the training course is given to each worker. The instructor reviews the test results with each worker and discusses incorrect answers to the questions with the worker until worker understanding is achieved. Workers who fail the exam are retested, and test results remain on file.

5.6.3 On-The-Job Training

5.6.3.1 Health Physics Technician

On-the-job training is provided to HPTs in radiation exposure monitoring and exposure determination programs, instrument calibration, plant inspections, posting requirements, respirator programs, and health physics procedures contained in the EHSMS Program Volume IV, *Health Physics Manual.*

5.6.4 Refresher Training

Following initial radiation safety training, all permanent employees and long-term contractors receive ongoing radiation safety training as part of the annual refresher training and, if determined necessary by the RSO, during monthly safety meetings. This ongoing training is used to discuss problems and questions that have arisen, any relevant information or regulations that have changed exposure trends, and other pertinent topics.

5.6.5 Training Records

Records of training are kept for 5 years for all employees trained as radiation workers (occupationally exposed employees).

5.7 SECURITY

CBR security measures for the current operation are specified in the Security Plan and Security Threat chapter in Volume VIII, *Emergency Manual.* CBR is committed to:

- Providing employees with a safe, healthy, and secure working environment;
- Maintaining control and security of USNRC licensed material;
- Ensuring the safe and secure handling and transportation of hazardous materials; and
- Managing records and documents that may contain sensitive and confidential information.

The USNRC requires licensees to maintain control over licensed material (i.e., natural uranium ["source material"] and byproduct material defined in 10 CFR §40.4). 10 CFR 20, Subpart I, *Storage and Control of Licensed Material,* requires the following:

§20.1801 Security of Stored Material

The licensee shall secure from unauthorized removal or access licensed materials that are stored in controlled or unrestricted areas.

§20.1802 Control of Material not in Storage

The licensee shall control and maintain constant surveillance of licensed material that is in a controlled or unrestricted area and that is not in storage.

Stored material at the Crow Butte Project would include uranium packaged for shipment from the facility or byproduct materials awaiting disposal. Examples of material not in storage would include yellowcake slurry or loaded ion exchange resin removed from the restricted area for transfer to other areas.

5.7.1 License Area and Plant Facility Security

5.7.1.1 Central Processing Facility Area

All Central Processing Facility areas where source or byproduct material is handled are fenced. The main access road is equipped with a locking gate. Strategically placed surveillance cameras monitor the access road and areas around the Central Processing facility. A 24-hour-per-day, 7-day-per-week staff is on duty in the Central Processing facility.

Central Plant operators perform an inspection to ensure the proper storage and security of licensed material at the beginning of each shift. The inspection determines whether all licensed material is properly stored in a restricted area or, if in controlled or unrestricted areas, is properly secured. In particular, operators ensure that loaded ion exchange resin, slurry, drummed yellowcake, and byproduct material are properly secured. If licensed material is found outside a restricted area, the operator will ensure that it is secured, locked, moved to a restricted area, or kept under constant surveillance by direct observation by site personnel or surveillance cameras. The results of this inspection will be properly documented.

5.7.1.2 Office Building

There is a reception area located at the main entrance into the office building. All other entrances are locked during off-shift hours. There is a limited number of traceable keys to the office, and they are given out to select employees. The main door and the door to the Central Plant Facility entrance are also equipped with an access keypad.

Visitors entering the office are greeted by the receptionist and announced to the receiving person. All visitors are required to sign the access log and indicate the purpose of their visit and the employee to be visited. The person being visited is responsible to supervise the visitors at all times when they are on site. Visitors are only allowed at the facility during regular working hours unless prior approval is obtained from the Mine Manager or the Manager of Health, Safety, and Environmental Affairs.

5.7.2 Transportation Security

CBR routinely receives, stores, uses, and ships hazardous materials as defined by the U.S. Department of Transportation (DOT). In addition to the packaging and shipping requirements contained in the DOT Hazardous Materials Regulations (HMR), 49 CFR 172, Subpart I, *Security Plans* requires that persons who offer for transportation or transport certain hazardous materials develop a Security Plan. Shipments may qualify for this DOT requirement under the following categories:

§172.800(b)(4) A shipment of a quantity of hazardous materials in a bulk package having a capacity equal to or greater than 13,248 L (3,500 gallons) for liquids or gases or more than 13.24 cubic meters (468 cubic feet) for solids;

§172.800(b)(5) A shipment in other than a bulk packaging of 2,268 kg (5,000 pounds) gross weight or more of one class of hazardous material for which placarding of a vehicle, rail car, or freight container is required for that class under the provisions of subpart F of this part;

§172.800(b)(7) A quantity of hazardous material that requires placarding under the provisions of subpart F of this part.

DOT requires that Security Plans assess the possible transportation security risks and evaluate appropriate measures to address those risks. All hazardous materials shippers and transporters subject to these standards must take measures to provide personnel security by screening applicable job applicants, prevent unauthorized access to the hazardous materials or vehicles being prepared for shipment, and provide for en route security. Companies must also train appropriate personnel in the elements of the Security Plan.

Transport of licensed/hazardous material by CBR employees will generally be restricted to transferring contaminated equipment between company facilities. This transport generally occurs over short distances through remote areas. Therefore, the potential for a security threat during transport by CBR vehicle is minimal. The goal of the driver, cargo, and equipment security measures is to ensure the safety of the driver and the security and integrity of the cargo from the point of origin to the final destination by:

- Clearly communicating general point-to-point security procedures and guidelines to all drivers and non-driving personnel;
- Providing the means and methods of protecting the drivers, vehicles, and customer's cargo while on the road; and
- Establishing consistent security guidelines and procedures that shall be observed by all personnel.

For the security of all tractors and trailers, the following procedures will be utilized:

- If material is stored in the vehicle, access must be secured at all openings with locks and/or tamper indicators.
- Off-site tractors will always be secured when left unattended with windows closed, doors locked, the engine shut off, and no keys or spare keys in or on the vehicle.
- The unit is to be kept visible by an employee at all times when left unattended outside a restricted area.

The security guidelines and procedures apply to all transport assignments. All drivers and non-driving personnel are expected to know and adhere to these guidelines and procedures when performing any load-related activity.

5.8 RADIATION SAFETY CONTROLS AND MONITORING

CBR has a strong corporate commitment to and support for the implementation of the radiological control program at the Crow Butte Project facility. This corporate commitment to maintaining personnel exposures as low as reasonably achievable has been incorporated into the radiation safety controls and monitoring programs described in the following sections. This license renewal application contains the results through 2006 of the radiological control program since 1990. Where the monitoring results indicate that the program should be modified, proposed changes in the program are also discussed.

Radiological surveys and sampling were conducted between 1994 and 2006 in accordance with the requirements of license SUA-1534.

The CBR radiological monitoring program is based principally on the recommendations contained in USNRC Regulatory Guide 8.30 and includes operational monitoring for airborne uranium, radon daughters, external radiation, and surface contamination. Environmental monitoring performed by CBR is based principally on the recommendations contained in USNRC Regulatory Guide 4.14 and includes monitoring environmental media surrounding the Crow Butte Project such as air, water, soil, and sediment.

5.8.1 Effluent Control Techniques

5.8.1.1 Gaseous and Airborne Particulate Effluents

Under routine operations, the only radioactive effluent at the Crow Butte facility is the release of radon-222 gas from the production solutions. A vacuum dryer is used for drying the yellowcake product. There is no airborne effluent from the vacuum dryer system.

The radon-222 is found in the pregnant lixiviant that comes from the wellfield into the plant. The production flow is directed to the process building for separation of the uranium. The uranium is separated by passing the recovery solution through fluidized bed upflow ion exchange units or pressurized downflow ion exchange units. Radon gas is released from the solution in the ion exchange columns and in the injection surge tanks. The vents from the individual vessels are connected to a manifold that is exhausted outside the plant building through the plant stacks.

Venting to the atmosphere outside of the plant building minimizes personnel exposure. Small amounts of radon-222 may be released in the plant building during solution spills, filter changes, and maintenance activities. The plant building is equipped with exhaust fans to remove any radon that may be released in the plant building. No significant personnel exposure to radon gas has been noted during operation of the Crow Butte facility. Results of radon daughter monitoring in the process areas are discussed in **Section 5.8.3**.

5.8.1.2 Liquid Effluents

The liquid effluents from the Crow Butte Project can be classified as follows:

- **Water generated during well development** - This water is recovered groundwater and has not been exposed to any mining process or chemicals. The water is discharged directly to one of the solar evaporation ponds and silt, fines and other natural suspended matter collected during well development is settled out.
- **Liquid process waste** - The operation of the process plant results in two primary sources of liquid waste, an eluant bleed and a production bleed.
- **Aquifer restoration** - Following mining operations, restoration of the affected aquifer commences which results in the production of wastewater. The current groundwater restoration plan consists of four activities: 1) Groundwater Transfer, 2) Groundwater Sweep, 3) Groundwater Treatment, and 4) Wellfield Circulation. Only the groundwater sweep and groundwater treatment activities will generate wastewater.

  During groundwater sweep, water is extracted from the mining zone without injection causing an influx of baseline quality water to sweep the affected mining area.

  Groundwater treatment activities involve the use of process equipment to lower the ion concentration of the groundwater in the affected mining area. A reverse osmosis (RO) unit may be used to reduce the total dissolved solids of the groundwater. The RO unit produces clean water (permeate) and brine. The permeate is either injected into the formation or disposed of in the waste disposal system. The brine is sent to the wastewater disposal system. The permeate may be further treated if necessary to meet the quality requirements of the NPDES permit for land application disposal.

The existing USNRC License allows CBR to dispose of wastewater by three methods:

- Evaporation from the evaporation ponds;
- Deep well injection; and
- Land application.

The design, installation, inspection and operation criteria for the solar evaporations ponds are those found to be applicable in USNRC Regulatory Guide 3.11, *Design, Construction and Inspection of Embankment Retention Systems for Uranium Mills* (Revision 2, December 1977). Each commercial pond is nominally 900 feet by 300 feet by 17 feet in depth. The ponds are membrane lined with a leak detection system under the membrane and are designed to allow the contents of any given pond to be transferred into another pond in the event of a pond problem.

Each of the ponds has the capability of being pumped for water treatment prior to discharge under the NPDES permit. A variety of treatment options exist depending upon the specific chemical contaminants identified in the wastewater. In general, a combination of chemical precipitation and reverse osmosis is adequate to restore the water to a quality that falls within the NPDES parameters.

5.8.1.3 Spill Contingency Plans

The RSO is charged with the responsibility to develop and implement appropriate procedures to handle potential spills of radioactive materials. Personnel representing the engineering and operations functions of the Crow Butte Project facility will assist the RSO in this effort. Basic responsibilities include:

- Assignment of resources and manpower.
- Responsibility for materials inventory.
- Responsibility for identifying potential spill sources.
- Establishment of spill reporting procedures and visual inspection programs.
- Review of past incidents of spills.
- Coordination of all departments in carrying out goals of containing potential spills.
- Establishment of employee emergency response training programs.
- Responsibility for program implementation and subsequent review and updating.
- Review of new construction and process changes relative to spill prevention and control.

Spills can take two forms within an in-situ uranium mining facility; surface spills such as pond leaks, piping ruptures, transportation accidents, etc., and subsurface releases such as a well excursion, in which process chemicals migrate beyond the wellfield, or a pond liner leak resulting in a release of waste solutions.

Engineering and administrative controls are in place to prevent both surface and subsurface releases to the environment and to mitigate the effects should a release occur.

> **Surface Releases** - The most common form of surface release from in-situ mining operations occurs from breaks, leaks, or separations within the piping that transfers mining fluids between the process plant and the wellfield. These are generally small releases due to engineering controls that detect pressure changes in the piping systems and alert the plant operators through system alarms.
>
> In general, piping from the plant to and within the wellfield is constructed of PVC, high-density polyethylene pipe with butt-welded joints or equivalent. All pipelines are pressure tested at operating pressures prior to operation. It is

unlikely that a break would occur in a buried section of line because no additional stress is placed on the pipes. In addition, underground pipelines are protected from a major cause of potential failure - that of vehicles driving over the lines causing breaks. The only exposed pipes are at the process plant, the wellheads, at temporary transfer lines and in the control house in the wellfield. Trunkline flows and wellhead pressures are monitored each shift for process control. One section of underground piping that passes beneath Squaw Creek is double contained for additional protection. Spill response is specifically addressed in the Radiological Emergencies and Emergency Reporting chapters of EHSMS Program Volume VIII, *Emergency Manual.*

CBR's spill control programs have been very effective at limiting surface releases from mining operations. CBR has never had a spill that was reportable under 10 CFR 20 reporting requirements. All spills are analyzed for root causes and contributing factors. Periodically, the CBR SERP meets to analyze recent spill events and to determine whether engineering or administrative improvements are indicated to reduce the frequency and magnitude of spills.

Transportation accidents - EHSMS Program Volume VIII, *Emergency Manual* provides the CBR emergency action plan for responding to a transportation accident involving a radioactive materials shipment. The Emergency Manual provides instructions for proper packaging, documentation, driver emergency and accident response procedures, and cleanup and recovery actions. Spill response is also addressed in EHSMS Program Volume VIII, *Emergency Manual.*

Sub-surface releases - Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring is to detect any mining solutions that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with in-situ mining.

At the Crow Butte Project site, an undetected excursion is highly unlikely. All wellfields are surrounded by a ring of monitor wells located no further than 300 feet from the wellfield and screened in the ore-bearing Chadron aquifer. Additionally, monitor wells are placed in the first overlying aquifer above each wellfield segment. Sampling of these wells is done on a biweekly basis. Past experience at in-situ leach mining facilities has shown that this monitoring system is effective in detecting leachate migration. The total effect of the close proximity of the monitor wells, the low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion extremely remote.

Migration of fluids to overlying aquifers has also been considered. Several controls are in place to prevent this. First, CBR has plugged all exploration holes to prevent co-mingling of Brule and Chadron aquifers and to isolate the mineralized zone. Successful plugging was tested by conducting four hydrologic tests prior to mining. Results indicated that no leakage or communication exists between the mineralized zone and overlying aquifers. In addition, prior to placing a well in service, a well mechanical integrity test (MIT) is performed. This requirement of the NDEQ UIC Program ensures that all wells are constructed properly and are capable of maintaining pressure without leakage. Finally, monitor wells completed in the overlying aquifer are also sampled on a regular basis for the presence of leach solution.

Seepage of solutions from the evaporation ponds into ground or surface water is also a potential pollution source. However, this has not been nor should it be a problem at the Crow Butte site. Construction and operational safeguards have been implemented to insure maximum competency of the synthetic liner and earthen embankments. The underdrain leak detection system allows sampling that would detect a leak. The pond soil foundation has low ambient moisture due to its elevation, soil type and preparation. In the unlikely event of pond fluids seeping into the compacted subsoil, the liquid would be quickly absorbed and would not migrate. Pond monitor wells are also located downstream of the evaporation ponds to detect leaks into the uppermost aquifer.

In addition to the spills described above, the accumulation of sediment or erosion of existing soils can lead to potential releases of pollutants. The likelihood of significant sediment or erosion problems is greatest during construction activities, which are completed at this time. Future construction activities could include additional wellfield development, or additional pond construction. During construction, there is a possibility that sediment load may increase in Squaw Creek. If rain, producing runoff, occurs during construction, a small amount of the fill may be carried into the creek. Significant precipitation during pond construction and plant facilities might also produce the same effect. Plant cover for erosion control will be established as soon as possible on exposed areas. Little additional suspendable material should be produced during mining operations and restoration activities. Site reclamation in the future with backfilling of ponds, grading the plant site, and replacing the topsoil will also expose unsecured soil for suspension in runoff waters. The increased sediment load as a result of precipitation during future construction or reclamation activities should not significantly affect the quality of Squaw Creek as the more sensitive areas of the stream are located upstream form the point of entry of the tributary.

Runoff from precipitation events should be controlled to minimize any exposure to pollutants on the site. At the Crow Butte Project site, runoff is not considered to be a major issue given the engineering design of the facilities, as well as the existing engineering and administrative controls. Rainwater entering a pond leading to a pond overflow would be the greatest item of concern. The design and operation of the ponds precludes a runoff-induced overflow as a realistic possibility. Should there be high runoff concurrent with a pipeline failure, some contamination could be spread depending upon the relative saturation of the soils beneath the leaking area. In any event, as only minimal releases of solutions would occur in the event of a pipeline failure and migration of pollutants due to runoff would still be minimal.

5.8.2 External Radiation Exposure Monitoring Program

5.8.2.1 Gamma Survey

Program Description

External gamma radiation surveys have been performed routinely at the Crow Butte Project. The required frequency is quarterly in designated Radiation Areas and semiannually in all other areas of the plant. Surveys are performed at specified locations in worker occupied stations and areas of potential gamma sources such as tanks and filters. CBR establishes a Radiation Area if the gamma survey exceeds the action level of 5.0 mR/hr for worker occupied stations. An investigation is performed to determine the probable source and survey frequency for areas exceeding 5.0 mR/hr are increased to quarterly. Records are maintained of each investigation and the corrective action taken. If the results of a gamma survey identifies areas where gamma radiation is in excess of levels that delineate a "radiation area", access to the area is restricted and the area is posted as required in 10 CFR §20.1902 (a).

External exposure at the Crow Butte Project is monitored using Optically-Stimulated Luminescent (OSL) dosimeters provided by Landauer Corp. Landauer is a NVLAP-certified vendor for the use of this technology for monitoring external exposures. Dosimeters are exchanged on a quarterly basis.

Historical Program Results

Routine gamma surveys have been performed as required at the Crow Butte Project. A Radiation Area has been established around the injection filter system since the beginning of commercial operations due to gamma levels above 5.0 mREM/hr. Radiation Areas have also been established around several other areas within the processing plant. These areas include the other process filter systems, around selected portions of the ion exchange piping, the waste demister box, the acid wash vat, and the reverse osmosis system. In addition, several of the wellhouses have been designated as Radiation Areas due to scale buildup in the injection manifold piping. Engineering controls such as lead sheeting and water block walls have been employed to maintain personnel exposures ALARA. Results of the gamma survey program are maintained at the Crow Butte Project site.

Proposed Beta and Gamma Survey Program

CBR proposes to continue with the same gamma exposure-monitoring program of worker occupied stations and areas likely to have significant gamma exposure rates at the Crow Butte Project that has been performed to date.

Gamma exposure rate surveys will be performed in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual*. Gamma survey instruments will be checked each day of use in accordance with the manufacturer's instructions.

Beta surveys of specific operations that involve direct handling of large quantities of aged yellowcake will be performed as discussed in USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Section 1.4. Beta evaluations may be substituted for surveys using radiation survey instruments. Surveys or evaluations will be performed whenever a change in equipment or procedures has occurred that may significantly affect worker exposures.

5.8.2.2 Personnel Dosimetry

Program Description

All employees working in the process facility or wellfield operations who have the potential to receive ten percent of the annual allowable dose limits have been issued dosimeters for determination of external gamma exposure. Dosimeters are provided by a vendor that is accredited by NVLAP of the National Institute of Standards and Technology as required in 10 CFR § 20.1501. The dosimeters have a range of 1 mR to 1000 R. Dosimeters are exchanged and read on a quarterly basis.

Historical Program Results

Figure 5.8.1 depicts the average and maximum external exposure levels for all employees at the Crow Butte Project from 1994 through 2006. The average annual exposures to gamma radiation have been well below the annual regulatory limit of 5 Rem and the CBR administrative limit of 1.25 Rem for this time period. The average external exposure for this 13-year period was 94 mREM, ranging from 33 to 165 mREM. The maximum external exposure for this time period ranged from 114 to 495 mREM.

For the years of 2000 through 2006, measurements indicated average external exposure levels of ranged from 81 to 129 mREM, with maximum exposures ranging from 238 to 448. The average and maximum exposure levels for 2006 (88 and 252 mREM, respectively) were lower than 2005 values (118 and 425, respectively) by approximately 24 percent and 41 percent, respectively.

As can be seen in **Figure 5.8-1**, there were noticeable elevations in the maximum exposure levels for the years 2001, 2002 and 2005. The most likely cause of these elevated maximum exposures in 2001 and 2002 was the requirement by CBR to store yellowcake during periods when the yellowcake dryer was unable to maintain production (CBR 2001, CBR 2002). The maximum exposure in 2005 (425 mREM) was received by a maintenance worker that was involved in several significant projects in areas with elevated gamma levels, including rebuilding one set of injection filters and installation of a new deep disposal well filtering system (CBR 2005).

Figure 5.8-1: Average and Maximum External Exposure Analysis

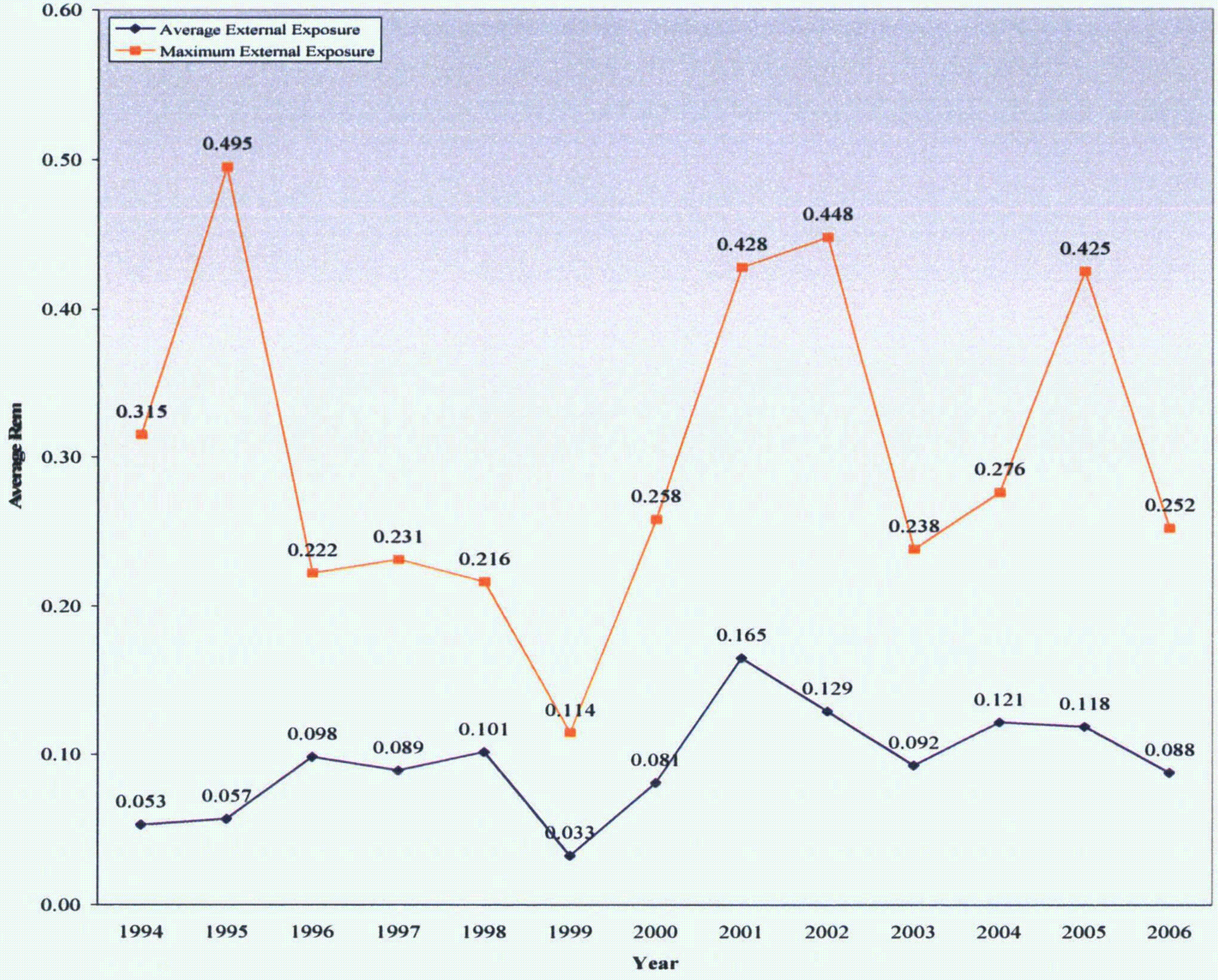


Figure 5.8-2 depicts the total Person-Rem due to external exposure for each year from 1994 through 2006. The results of the trend analysis indicate a significant decrease in the *combined external exposure* to gamma radiation from 2001/2002 to 2006 at the Crow Butte Project. As discussed above, once the yellowcake dryer was able to maintain production, the combined external exposure decreased from 5.28 Person-Rem in 2002, to 3.14 Person-Rem in 2003. The combined external exposure was further reduced from 3.44 Person-Rem in 2005 to 2.63 Person-Rem in 2006.

More detailed information as to the external exposure measurements are described in CBR's semi-annual and annual ALARA Review reports (1997 – 2006).

Personnel Dosimetry Program

10 CFR §20.1502 (a)(1) requires exposure monitoring for "Adults likely to receive, in 1 year from sources external to the body, a dose in excess of ten percent of the limits in §20.1201 (a)". Ten percent of the dose limit would correspond to a Deep Dose Equivalent (DDE) of 0.500 Rem. Maximum individual annual exposures at the Crow Butte Project facilities since 1987 have been well below ten percent of the limit. CBR believes that it is unlikely that any employee will exceed ten percent of the regulatory limit. Although monitoring of external exposure may not be required in accordance with §20.1201(a), CBR proposes to continue to issue dosimeters to all process and wellfield employees with the potential to receive ten percent of the annual allowable dose limits and exchange them on a quarterly basis. Results from dosimeter monitoring will be used to determine individual Deep Dose Equivalent (DDE) for use in determining Total Effective Dose Equivalent (TEDE) in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.*

5.8.3 In-Plant Airborne Radiation Monitoring Program

5.8.3.1 Airborne Uranium Particulate Monitoring

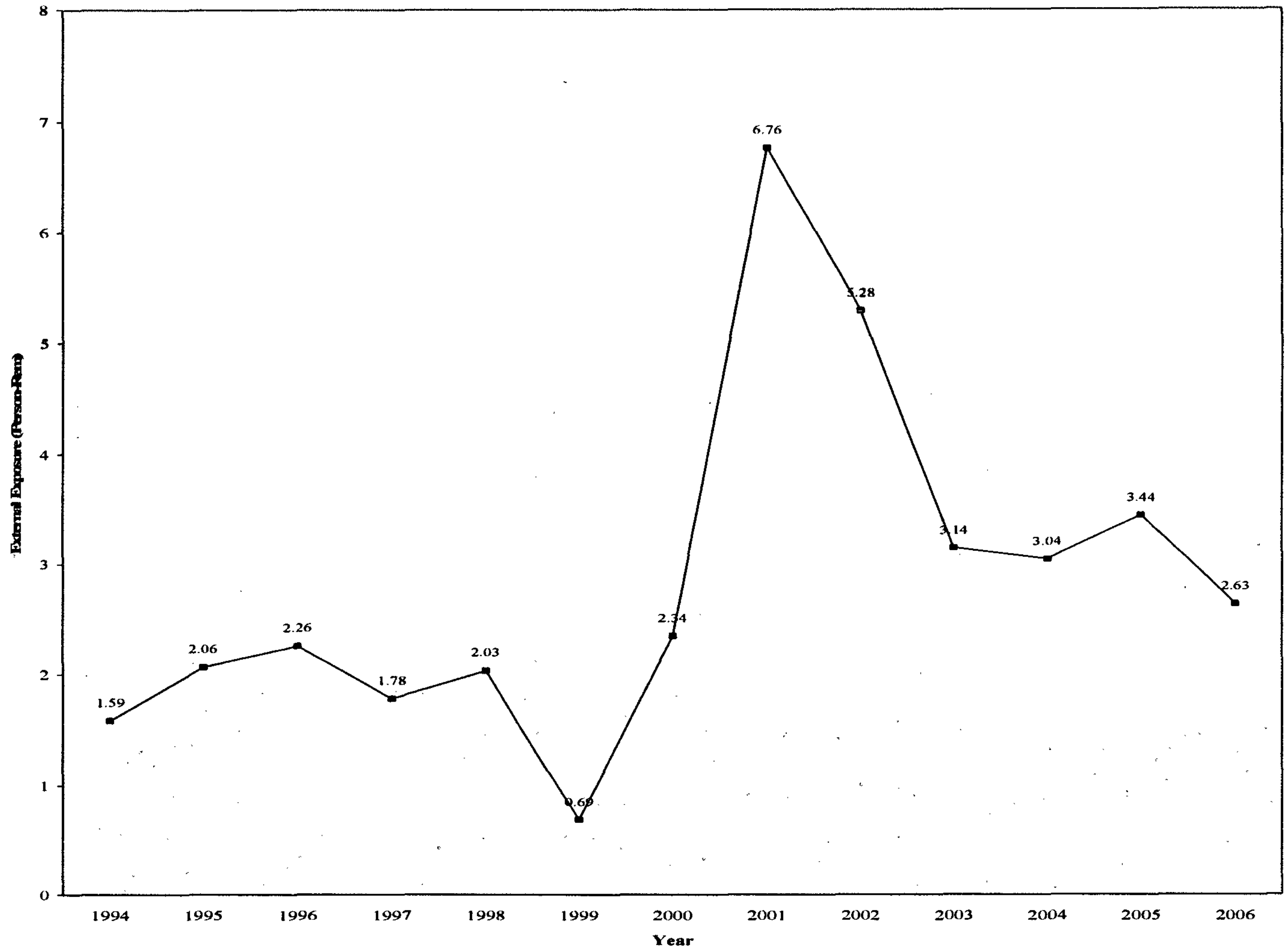
Program Description

Airborne particulate levels at solution mines which ship slurry yellowcake product are normally very low since the product is wet. Yellowcake drying operations began in 1993. Monitoring for airborne uranium has been performed routinely at Crow Butte Project through the use of area sampling and breathing zone sampling. The monitoring programs are described below.

Area Sampling

There are four required airborne uranium survey locations in the plant plus the dryer room. The monitoring frequency for the dryer room location is weekly, while the frequency for the other four locations is monthly. If a location meets the criteria for an Airborne Radioactivity Area as defined in 10 CFR §20.1003, the monitoring frequency increases to weekly. The only location at the Crow Butte Project that has met this criterion has been the dryer room during operation of the dryer.

Figure 5.8-2: Combined External Exposure Analysis



During operation of the dryer, the dryer room is isolated and posted as an Airborne Radioactivity Area. CBR limits access to personnel wearing the proper respiratory protective equipment. A breathing zone sample for the dryer operator is collected during packaging operations. An area air sample is also collected outside of the dryer room. When packaging is completed, the room is washed down and the dryer is reloaded. To open the room, an area air sample is collected inside the dryer room to verify that the airborne concentrations are low enough to remove the Airborne Radioactivity Area designation and allow access without respiratory protection. The breathing zone sample obtained during dryer operation is used to determine internal exposure for the dryer operator. The results of the area samples are used, along with monitoring results for the other four monitoring locations, to determine monthly plant average airborne uranium concentrations for routine exposure calculations. Airborne uranium samples are analyzed for gross alpha at the plant. The conservative assumption is made that all alpha activity on the samples is due to airborne uranium.

Area samples are taken in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.* Samples are taken with a glass fiber filter and a regulated air sampler such as an Eberline RAS-1 or equivalent. Sample volume is adequate to achieve the lower limits of detection (LLD) for uranium in air. Samplers are calibrated at the manufacturer's suggested interval or semiannually with a primary air flow calibrator. Sampler calibration is performed in accordance with the instructions currently in EHSMS Program Volume IV, *Health Physics Manual.*

Measurement of airborne uranium is performed by gross alpha counting of the air filters using an alpha scaler such as a Ludlum Model 2000 or equivalent. The Maximum Permissible Concentration (MPC) value for natural uranium of 1 E-10 μCi/ml from Appendix B to 10 CFR §§ 20.1 - 20.601 was applied to the gross alpha counting results. After implementation of the new 10 CFR 20 on January 1, 1994, the Derived Air Concentration (DAC) for soluble (D classification) natural uranium of 5 E-10 μCi/ml from Appendix B to 10 CFR §§20.1001 - 20.2401 was used. This is a conservative method because the gross alpha results include Uranium-238 and several of its daughters (notably Ra-226 and Th-230), which are alpha emitters. An action level of 25 percent of the MPC (DAC since 1994) for soluble natural uranium was established at the Crow Butte Project facilities. If an airborne uranium sample exceeded the MPC (DAC), an investigation was performed.

Historical Program Results

- Airborne Uranium Monitoring – Main Plant

Airborne Uranium monitoring has been performed at the Central Plant at the locations shown in **Figure 5.8-5** since 1994. **Table 5.8-1** provides the results of gross alpha monitoring for airborne uranium from the period of 1994 through 2006. The annual average and maximum monthly average airborne gross alpha activity for this period are reported. All activity levels were well below 25 percent of the Derived Air Concentration (DAC).

The results of the airborne uranium monitoring program are fairly consistent since operation of the dryer began in 1993. The annual average for the years 1994 through 2006 was 2.96 x E^{-12} µCi/ml (0.6 percent of DAC), with a range of 1.28 E^{-12} To 4.02 E^{-12} µCi/ml. The maximum average airborne activity values ranged from 3.70 E^{-12} to 2.33 E^{-11} µCi/ml (0.7 percent and 4.7 percent of the DAC, respectively). In 2005 and 2006, the average airborne activity was 3.80 E^{-12} µCi/ml (0.8 percent DAC) and 3.86 E^{-12} µCi/ml (0.8 percent DAC), respectively, with a maximum value of 5.03 E^{-12} µCi/ml (1.0 percent DAC) and 4.87 E^{-12} µCi/ml (1.0 percent DAC), respectively.

- Airborne Uranium Exposures

Exposure to airborne uranium is based upon the results obtained from air sampling discussed in Area Sampling above. Routine exposure is based upon the monthly average plant airborne uranium concentrations. For personnel assigned full-time to the plant, a conservative occupancy time of 100 percent is used to determine exposure. For all other personnel, actual time in the plant is used for exposure calculations. Exposures assigned during work performed under a Radiation Work Permit (RWP) or during routine dryer operations are based upon the results of specific monitoring and actual exposure times.

Table 5.8-1: In-plant Airborne Uranium Monitoring Results

Airborne Uranium Monitoring Period (Calendar Year)	Annual Average Airborne Activity µCi/Ml Gross α (% Dac)[1]	Maximum Monthly Average Airborne Activity µCi/Ml Gross α (%Dac)[1]
1994 (includes dryer room sample results)	3.22 E^{-12} (0.6% DAC)	6.07 E^{-12} (1.2% DAC)
1995	3.80e-^{12} (0.8%)	9.36e-^{12} (1.9%)
1996	1.28e-^{12} (0.3%)	4.71e-^{12} (0.9%)
1997	2.77 E^{-12} (0.5% DAC)	5.43 E^{-12} (1.1% DAC)
1998	3.06 E^{-12} (0.6% DAC)	5.36 E^{-12} (1.1% DAC)
1999	2.87 E^{-12} (0.6% DAC)	4.44 E^{-12} (0.9% DAC)
2000	2.63 E^{-12} (0.5% DAC)	5.84 E^{-12} 1.1% DAC)
2001	3.30 E^{-12} (0.7% DAC)	7.05 E^{-12} (1.4% DAC)
2002	2.25 E^{-12} 0.5% DAC)	3.70 E^{-12} (0.7% DAC)
2003	4.02 E^{-12} (0.8% DAC)	2.33 E^{-11} (4.7% DAC)
2004	1.65 E^{-12} (0.3% DAC)	5.99 E^{-12} 1.0% DAC)

Table 5.8-1: In-plant Airborne Uranium Monitoring Results

Airborne Uranium Monitoring Period (Calendar Year)	Annual Average Airborne Activity μCi/Ml Gross α (% Dac)[1]	Maximum Monthly Average Airborne Activity μCi/Ml Gross α (%Dac)[1]
2005	3.80 E^{-12} (0.8% DAC)	5.03 E^{-12} (1.0% DAC)
2006	3.86e-^{12} (0.8%)	4.87e-^{12} (1.0%)

Notes:

[1] Samples compared to the DAC where DAC=5 E-10 μCi/ml (10 CFR §§ 20.1001-2401 App B)

Uranium intakes for the time period 1994 through 2006 have been well below the annual regulatory limit of 1 μCi and the CBR administrative action level of 0.25 μCi. The average and maximum values over this period of time have been relatively consistent.

The maximum individual uranium intake for 2005 and 2006 was 1.94 x 10^{-2} μCi and 2.14 x 10^{-2} μCi, respectively, corresponding to a dose of 97 mREM (2 percent of the regulatory limit) and 107 mREM (2 percent of the regulatory limit), respectively. The average for all monitored employees in 2005 and 2006 was 5.87 x 10^{-3} μCi and 6.94 x 10^{-3} μCi, respectively, corresponding to a dose of 29 mREM (0.6 percent of the regulatory limit) and 35 mREM (0.7 percent of the regulatory limit), respectively. The combined uranium intake at the Crow Butte Uranium Project for 2005 was 0.170 μCi for the 29 employees that were monitored. This corresponds to a combined dose due to uranium intake of 0.85 Person-Rem. Uranium intake for 2006 was 0.208 μCi for 30 monitored employees, which corresponds to a combined dose due to uranium intake of 1.04 Person-Rem.

Figure 5.8-3 depicts the average and maximum exposure in Rem for each year from 1994 through 2006. The results of the exposure analysis indicate a noticeable increase in the both the average and maximum exposure to airborne uranium at the Crow Butte Project in 2005 and 2006. The average exposure increased by 9 mREM from 2004 (20 mREM) to 2005 (29 mREM) and 6 mREM from 2005 to 2006 (35 mREM). The maximum exposure more than doubled from 46 mREM in 2004 to 97 mREM in 2005, followed by an additional higher value of 107 mREM in 2006.

The maximum airborne uranium exposure in 2006 was due increased yellowcake handling during the year. In the last half of the year CBR began receiving yellowcake slurry from the Smith Ranch Project for drying. The yellowcake shipments were unloaded from slurry trailers and the yellowcake was dried and packaged. Fifteen shipments containing approximately 30,000 pounds of yellowcake slurry per shipment were received between September 15 and December 29, 2006. Packaging of the additional yellowcake increased the dose of the dryer operator.

The maximum airborne uranium exposure in 2006 was due to increased yellowcake handling during the year. In the last half of the year CBR began receiving yellowcake slurry from the Smith Ranch Project for drying. The yellowcake shipments were unloaded from slurry trailers and the yellowcake was dried and packaged. Fifteen shipments containing approximately 30,000 pounds of yellowcake slurry per shipment were received between September 15 and December 29, 2006. Packaging of the additional yellowcake increased the dose of the dryer operator.

Figure 5.8-4 plots the combined exposure due to airborne uranium exposure for each year from 1994 through 2006. The combined exposure increased from 0.470 Rem in 2004 to 0.851 Rem in 2005, followed by an additional increase to 1.041 Rem in 2006. This is an increase of approximately 45 percent from 2004 to 2006.

Average airborne uranium exposures for facility staff and maximum doses for individuals were found to be acceptably low, although trend review indicated an increase from 2004 through the years 2005 and 2006. These increases, even though well below permissible limits, were deemed to warrant some potential for minor ALARA reduction. ALARA opportunities to address these increases were identified in the site's calendar year 2005 and 2006 annual ALARA audits. One of the ALARA Opportunities identified during the 2006 audit was that during the remainder of 2007, new methods to reduce worker doses related to U_3O_8 airborne concentrations should be considered, and existing methods should be examined to determine whether improvements are feasible within ALARA constraints. Site personnel continue to examine the reasons for the 2005 and 2006 dose increases, with the objective to identify opportunities to reduce the impact of the primary contributors to airborne uranium exposure during 2005 and 2006.

Proposed In-Plant Airborne Uranium Monitoring Program

CBR proposes to continue with the same airborne uranium-monitoring program at the Crow Butte Project that has been performed to date with the following changes.

Airborne sampling will be performed on a monthly basis in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.* These procedures implement the guidance contained in USNRC Regulatory Guide 8.25, *Air Sampling in the Workplace.* Sampler calibration will be performed in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.*

5.8.3.2 In-Plant Radon Daughter Surveys

Program Description

There are 12 monitoring locations for radon daughter concentrations in the Central Plant, the RO Building, and the office areas. The required radon daughter monitoring frequency is monthly unless results are greater than 0.08 Working Levels (WL) (25 percent of the DAC). If this action level is exceeded, the monitoring frequency is increased to weekly until the levels are below the action level for 4 consecutive weeks.

Figure 5.8-3: Average and Maximum Airborne Uranium Exposure

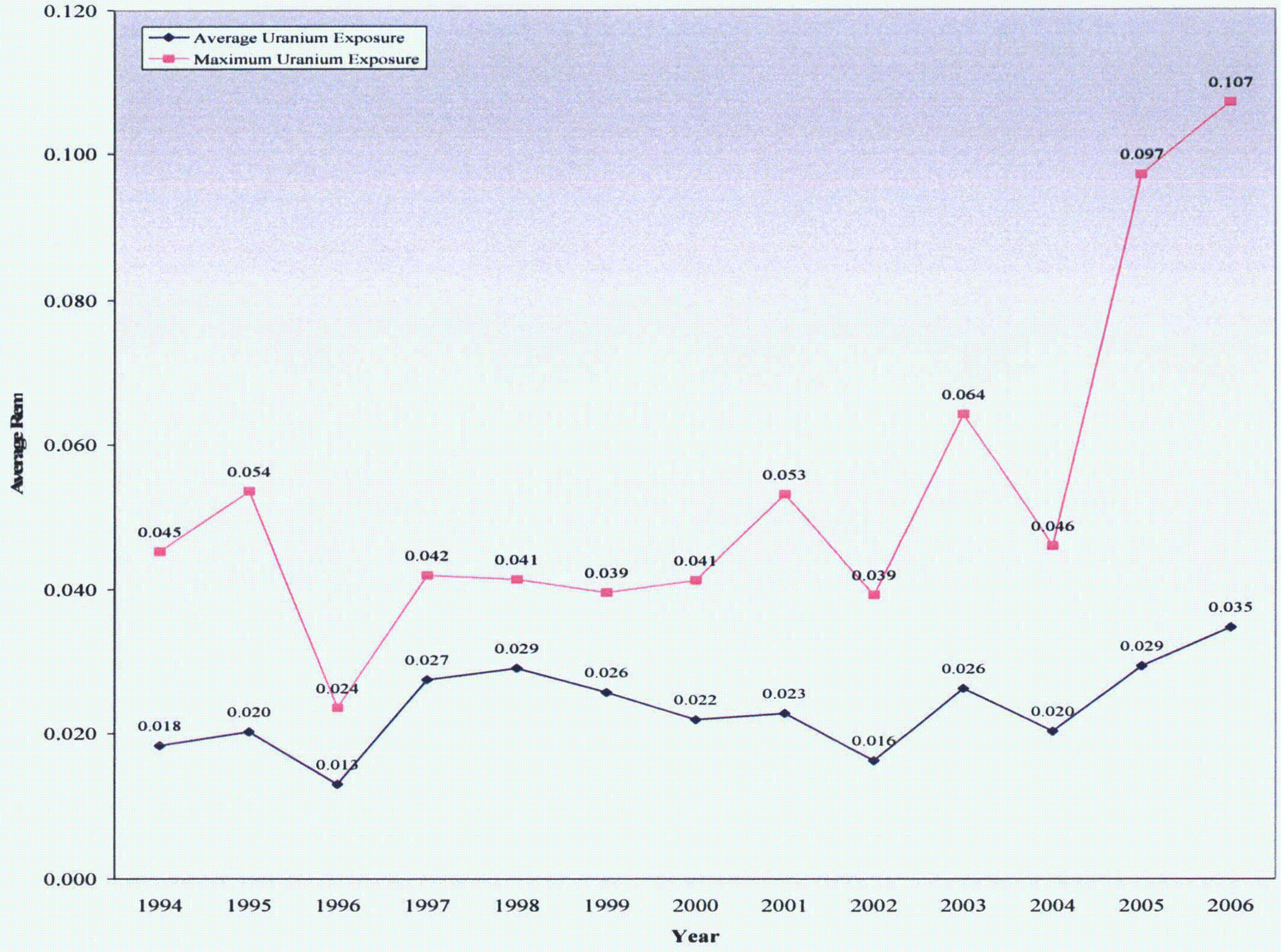


Figure 5.8-4: Combined Airborne Uranium Exposure Analysis

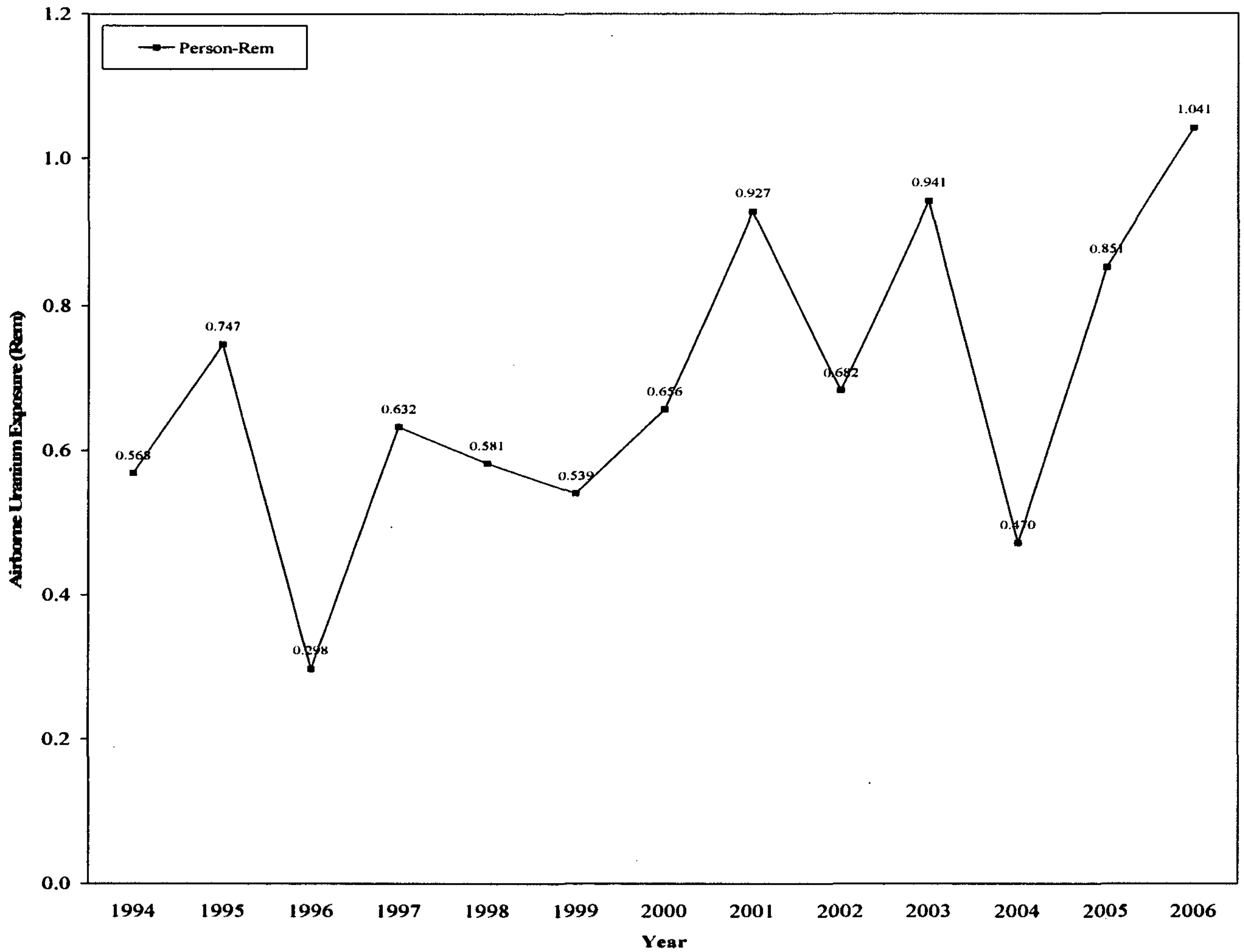
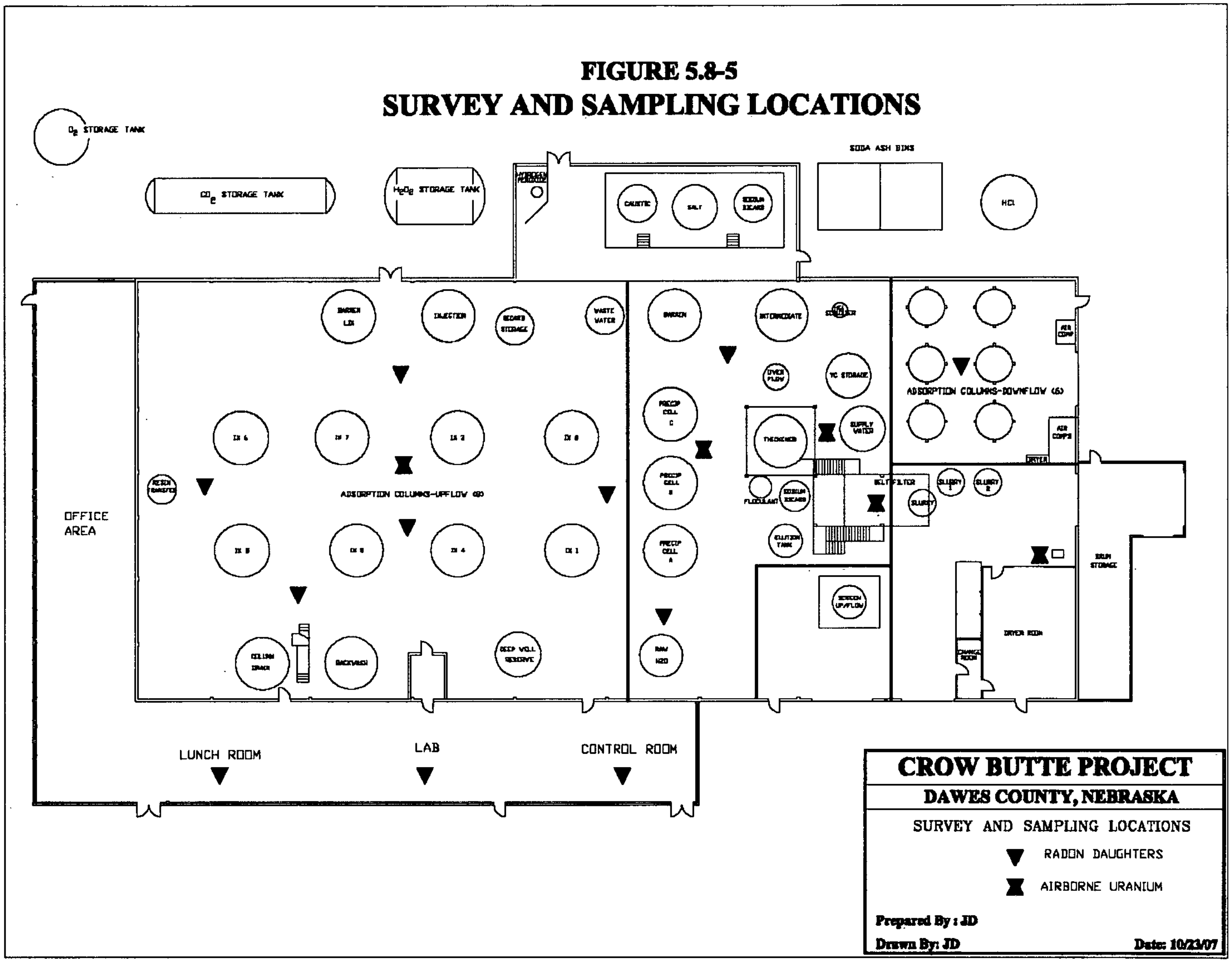


Figure 5.8-5: In-Plant Air-borne Uranium Air Sampling Location



Exposure calculations for radon daughters are based on the results of radon daughter sampling discussed below. Routine exposure is based on the monthly average of the plant radon daughter sampling. For personnel assigned full-time to the plant, a conservative occupancy time of 100 percent is used to determine exposure. For all other personnel, actual time in the plant is used for exposure calculations. Exposure received from work performed under a RWP is based on the results of monitoring performed during the work and the actual exposure times.

Samples are collected with a low-volume air pump and then analyzed with an alpha scaler using the Modified Kusnetz method described in ANSI-N13.8-1973. Air samplers are calibrated before each day's use.

Results of radon daughter sampling are expressed in WL where one WL is defined as any combination of short-lived radon-222 daughters in 1 liter of air without regard to equilibrium that emit 1.3×10^5 mega-electronvolt (MeV) of alpha energy. The DAC limit from Appendix B to 10 CFR §§ 20.1 - 20.601, as well as the current DAC limit from Appendix B to 10 CFR §§ 20.1001 - 20.2402, for radon-222 with daughters present is 0.33 WL. CBR has established an action level of 25 percent of the DAC or 0.08 WL. Radon daughter results in excess of the action level trigger an investigation of the cause and an increase in the sampling frequency to weekly until the radon daughter levels do not exceed the action level for 4 consecutive weeks.

Historical Program Results

Radon Daughter Monitoring - Main Plant

Table 5.8-2 provides the results of monitoring for radon daughters from the period of 1995 through 2006. The annual average and maximum values are presented. The data show that the average radon daughter activity concentration at Crow Butte Uranium Project was consistently less than 25 percent of the regulatory limit.

The monthly plant average radon daughter concentrations from 1994 through 2006 averaged 0.030 WL (9 percent of DAC of 0.33 WL) with a range of 0.015 to 0.048. The average for the same period of the maximum monthly average radon concentrations was 0.049 WL (15 percent of DAC) with a range of 0.026 to 0.070 WL (8 percent and 21 percent of DAC). In 2005 and 2006, the average radon daughter concentrations were 0.015 WL (4.5 percent of DAC) and 0.020 WL (8.0 percent of DAC), respectively, with a maximum value of 0.026 WL.

Table 5.8-2: In-plant Radon Daughter Monitoring Results

Radon Daughter Monitoring Period (Calendar Year)	Annual Average Radon Daughter Activity In WL (% DAC)[1]	Maximum Monthly Average Radon Daughter Activity In WL (%DAC)[1]
1994	0.032 (9.6% DAC)	0.046 (13.9% DAC)
1995	0.041 (12% DAC)	0.070 (21% DAC)
1996	0.038 (12% DAC)	.069 (21% DAC)
1997	0.048 (14.5% DAC)	0.068 (30.6% DAC)
1998	0.027 (8% DAC)	0.042 (12.7% DAC)
1999	0.041 (12% DAC)	0.065 (20% DAC)
2000	0.023 (7% DAC)	0.042 (13% DAC)
2001	0.032 (10% DAC)	0.049 (15% DAC)
2002	0.027 (8% DAC)	0.048 (15% DAC)
2003	0.030 (9% DAC)	0.045 (14% DAC)
2004	0.024 (7% DAC)	0.036 (11% DAC)
2005	0.015 (4.5% DAC)	0.026 (8% DAC)
2006	0.020 (6.1% DAC)	0.026 (7.9% DAC)

Note:
1 Samples compared to the DAC where DAC = 0.33 WL (10 CFR §§ 20.1001-2401 App B)

Radon Daughter Exposures

Individual exposures to radon daughters at the Crow Butte Uranium Project between 1994 and 2006 were well below the annual regulatory limit of 4 Working Level Months (WLM) and the CBR administrative action level of 1 WLM. The maximum individual radon daughter exposures for 2005 and 2006 were 0.213 WLM and 0.283 WLM, respectively, corresponding to a dose of 267 mREM (5 percent of the regulatory limit) and 350 mREM (7 percent of regulatory limit), respectively. The average exposure for all monitored employees was 0.101 WLM in 2005 and 0.161 WML in 2006, corresponding to a dose of 126 mREM (2.5 percent of the regulatory limit) and 200 mREM (4 percent of the regulatory limit), respectively. The combined radon daughter exposure at the Crow Butte Uranium Project for 2005 was 2.925 Person-WLM for the 29 monitored employees, corresponding to a dose of 3.656 Person-Rem. For 2006, the combined radon daughter exposure was 4.83 Person-WLM for the monitored employees, corresponding to a dose of 6.03 Person-Rem.

The results of the exposure analysis indicate a significant decrease in the individual average and maximum exposures to radon daughters at the Crow Butte Uranium Project in 2005 versus other years of operation. In 2005, there was also a significant decrease in the combined exposure in spite of an increase in the number of employees monitored for radon daughter exposure.

However, in 2006, there was an increase of 70 mREM for the average radon exposure and an increase of 80 mREM for the maximum radon exposure in 2006.

Figure 5.8-6 depicts the average and maximum radon exposures due to radon daughters for each year from 1994 through 2006. A comparison of these exposures indicates that individual average and maximum exposures in 2005 were at historic low levels for the project. The average radon exposure decreased almost 50 percent from 246 mREM in 2004 to 126 mREM in 2005. The maximum individual exposure also showed a significant decrease from 390 mREM in 2004 to 267 mREM in 2005. These exposure levels for radon daughters are the lowest recorded during the 12-year period. However, exposures increased from an average of 130 mREM in 2005 to an average of 200 mREM (70 mREM increase) in 2006 and an increase in the maximum exposures of 270 mREM in 2005 to 350 mREM in 2006 (80 mREM increase).

Figure 5.8-7 plots the combined exposure for all monitored employees for each year from 1994 through 2006. The combined exposure due to radon daughters in 2005 decreased from 5.67 Person-Rem in 2004 to 3.66 Person-Rem in 2005, which continues a downward trend from the last 4 years and is the lowest combined exposure in the 12-year period. This decrease occurred in spite of an increase in the number of employees monitored for radon daughter exposure, and was due to continued emphasis on effective engineering controls for radon. However, in 2006, the average radon daughter exposure increased from 3.66 Rem in 2005 to 6.03 Rem in 2006.

Even with the noted trend increases in radon exposures from 2005 to 2006 in **Figure 5.8-6** and **Figure 5.8-7**, average radon daughter exposures for facility staff and maximum doses for individuals, were found to be acceptably low. This increase, even though well below permissible limits, was deemed to warrant some potential for minor ALARA reduction. ALARA opportunities to address these increases were identified in the site's calendar year 2006 annual ALARA audits. One of the ALARA opportunities identified during the 2006 audit was that, during the remainder of 2007, new methods to reduce worker doses related to radon daughter concentrations should be considered, and existing methods should be examined to determine whether improvements are feasible within ALARA constraints. Site personnel continue to examine the reasons for the 2005/2006 dose increases, with the objective of identifying opportunities to reduce the impact of the primary contributors to radon exposures during 2005 and 2006.

Figure 5.8-6: Average and Maximum Radon Exposure

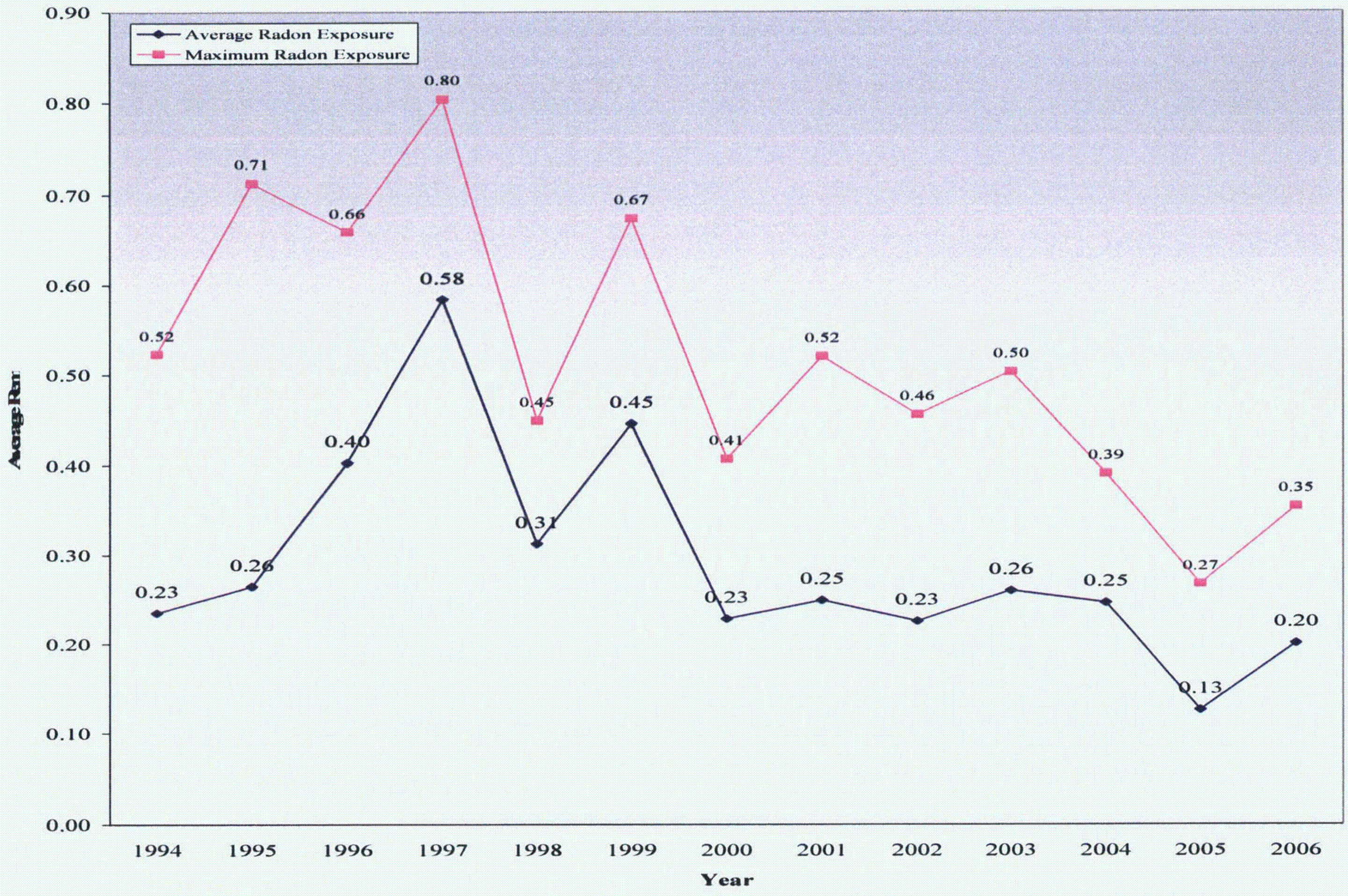
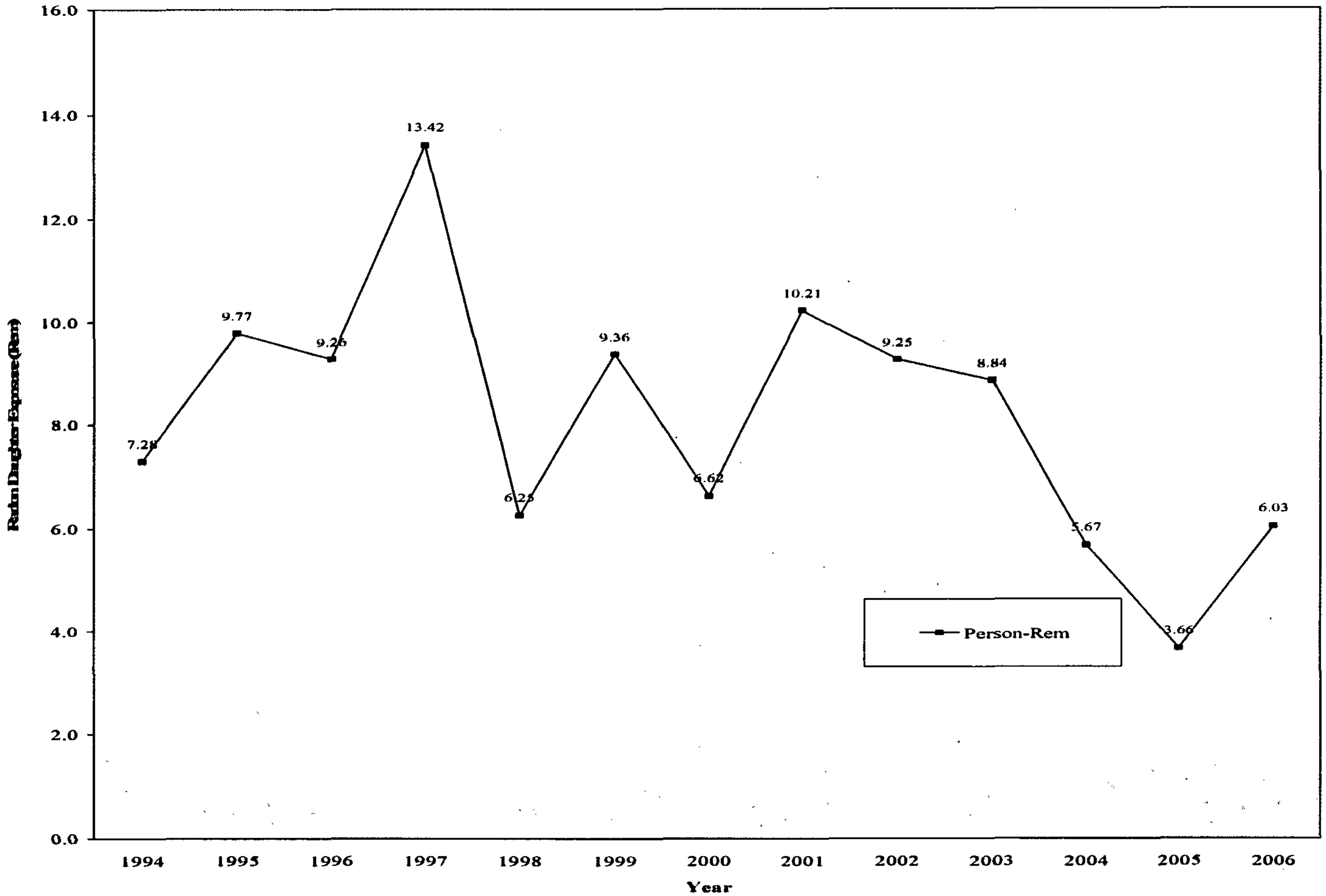


Figure 5.8-7: Combined Radon Daughter Exposure Trend Analysis



In-Plant Radon Daughter Monitoring Program

CBR proposes to continue with the same radon daughter monitoring program at the Crow Butte Project that has been performed to date with the following changes.

Based on operating experience, CBR proposes to continue radon daughter sampling at the locations shown in **Figure 5.8-5**. CBR believes that these locations provide accurate monitoring of plant radiological conditions.

Routine radon daughter monitoring will be performed monthly in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual*

Air samplers will be calibrated in accordance with the instructions contained in EHSMS Program Volume IV, *Health Physics Manual.*

5.8.3.3 Total Effective Dose Equivalent

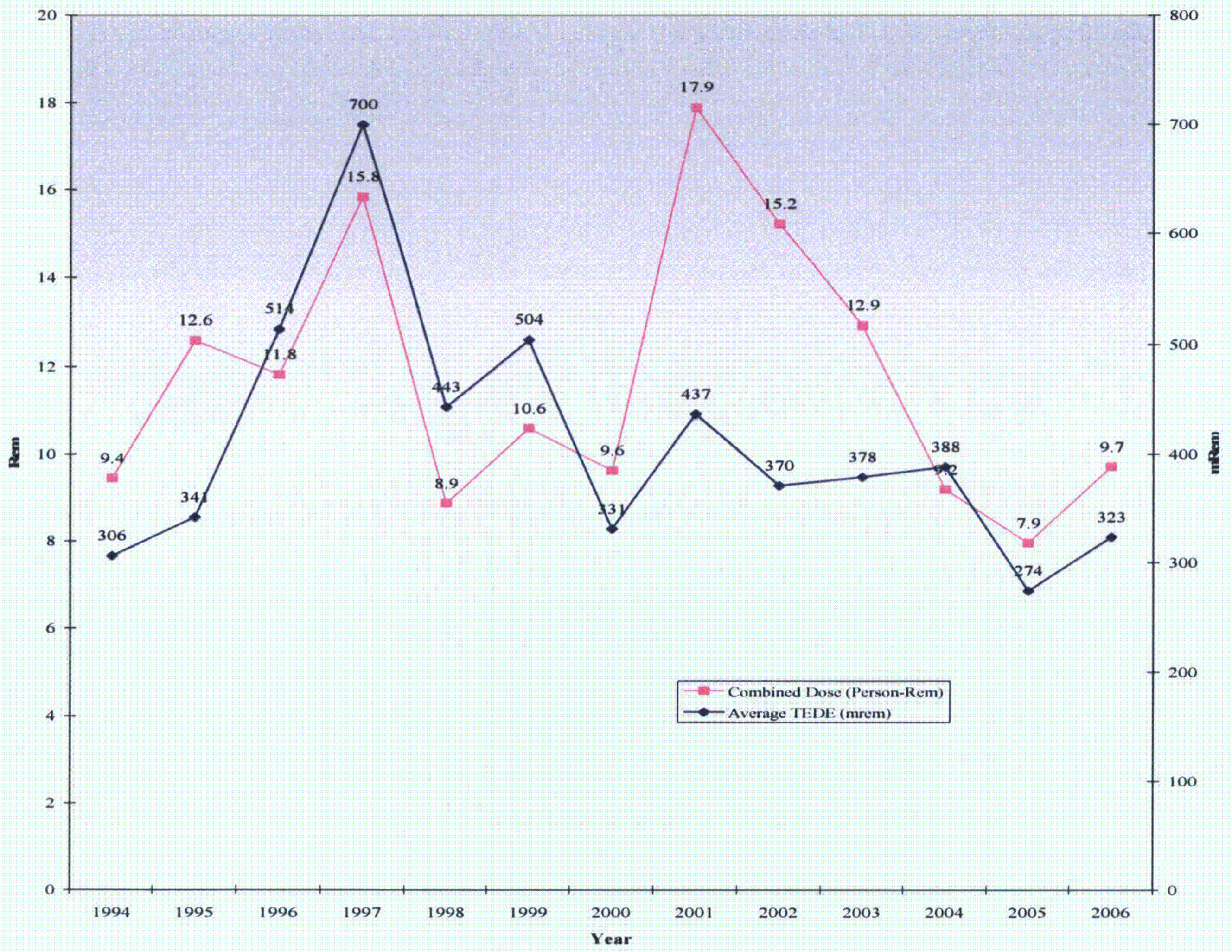
The TEDE for each monitored employee at the Crow Butte Project from 1994 through 2006 was well below the annual regulatory limit of 5 Rem. **Figure 5.8-8** depicts the combined and average TEDE for the project in Person-Rem and mREM, respectively, for each year from 1994 through 2006. The combined dose from 1994 through 1996 averaged 11.6 Person-Rem, with a range of 7.9 to 17.9 Person-Rem.

The maximum individual TEDE for 2005 and 2006 was 675 mREM (15 percent of regulatory limit) and 713 mREM (14.3 percent of regulatory limit), respectively, with an average TEDE for all monitored employees of 103 mREM (2 percent of regulatory limit) and 0.323 mREM (6.5 percent of regulatory limit), respectively. The combined TEDE at the CBR Project for 2005 and 2006 was 7.943 Person-Rem (29 employees) and 9.7 Person-Rem (30 employees) who are monitored for occupational exposure.

The average TEDE values showed only a slight increase for the years 2002, 2003, and 2204 (370, 378, and 388 mREM, respectively). The average TEDE was reduced significantly from 388 mREM in 2004 to 274 mREM in 2005, but the average TEDE increased to 323 Person–Rem in 2006 (15 percent increase). However, the 2006 value was lower than measurements for the years 1995 through 2004.

Figure 5.8-9 shows the total dose contributions of external exposure, radon daughter exposure, and airborne uranium exposure to the total effective dose from 1994 through 2006. The primary contributors to dose during 2006 were radon daughter exposures and external radiation exposures. External exposures have remained relatively constant during the past several years, and in fact were reduced significantly in 2006. Airborne uranium and radon daughter exposures, on the other hand, increased. ALARA actions being taken to address these increases are discussed in **Sections 5.8.3.1 and 5.8.3.2**.

Figure 5.8-8: Average and Combined Total Effective Dose Equivalent Analysis



5.8.3.4 Respiratory Protection Program

Respiratory protective equipment has been supplied by CBR for activities where engineering controls may not be adequate to maintain acceptable levels of airborne radioactive materials or toxic materials. Use of respiratory equipment at the Crow Butte Project is in accordance with the procedures currently set forth in the EHSMS Program Volume IV, *Health Physics Manual*

The respirator program is designed to implement the guidance contained in USNRC Regulatory Guide 8.15, *Acceptable Programs for Respiratory Protection.* The respirator program is administered by the RSO as the Respiratory Protection Program Administrator (RPPA).

5.8.4 Exposure Calculations

Employee internal exposure to airborne radioactive materials has been determined at the Crow Butte Project facility since commercial operations began in 1991. Since January 1, 1994, CBR has determined internal exposures based on the requirements of 10 CFR § 20.1204. Prior to January 1, 1994, internal exposure was calculated using the MPC-Hour method based on 10 CFR § 20.103. The following subsections present a discussion of the exposure calculation methods and results.

5.8.4.1 Natural Uranium Exposure

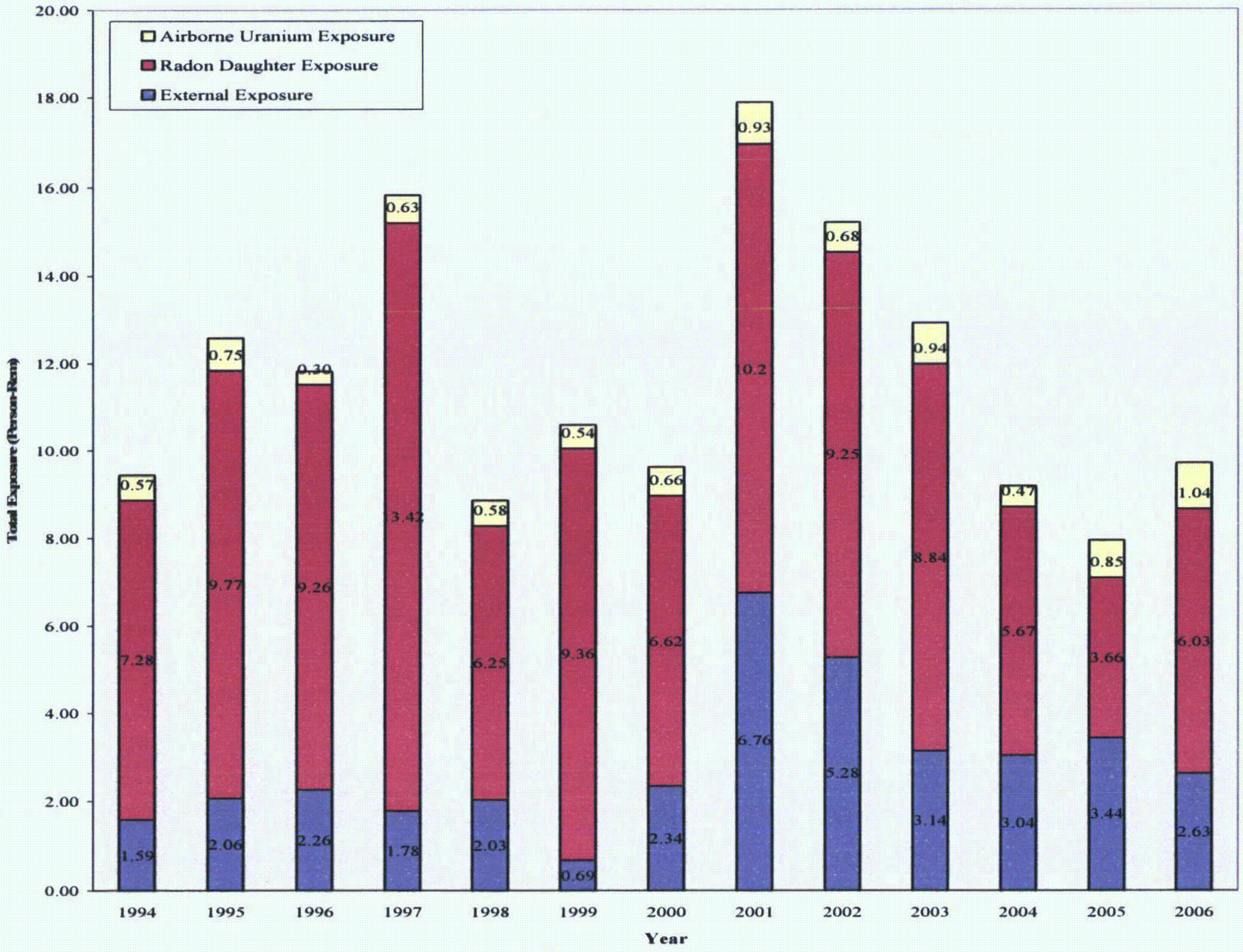
Exposure calculations for airborne natural uranium are carried out using the intake method from USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Revision 1, Section 2. The intake is calculated using the following equation:

$$I_u = b\sum_{i=1}^{n}\frac{X_i \times t_i}{PF}$$

where:

I_u	=	uranium intake, μg or μCi
t_i	=	time the worker is exposed to concentrations X_i (hr)
X_i	=	average concentration of uranium in breathing zone, μg/m^3, μCi/m^3
b	=	breathing rate, 1.2 m^3/hr
PF	=	respirator protection factor, if applicable
n	=	number of exposure periods during the week or quarter

Figure 5.8-9: Total Dose Contributions



The intake for uranium is calculated on Time Weighted Exposure (TWE) forms. The intakes are totaled and entered onto each employee's Occupational Exposure Record.

The data required to calculate internal exposure to airborne natural uranium are determined as follows.

Time of Exposure Determination

One hundred percent occupancy time is used to determine routine worker exposures. Exposures during non-routine work are always based on actual time.

Airborne Uranium Activity Determination

Airborne uranium activity is determined from surveys performed as described in **Section 5.8.3.1**.

Historical Program Results

Table 5.8-3 summarizes internal exposure results at Crow Butte Project from airborne uranium. The data show that internal exposure at Crow Butte Uranium Project has been maintained ALARA. The maximum individual internal exposure to airborne uranium during the period between 1994 and 2006 was significantly lower than the allowable regulatory limit of 1 μCi. For example, the average exposure level of 6.94 E^{-03} μCi in 2006 was 0.7 percent of the 1 μCi allowable, and the maximum exposure level of 2.14 E^{-02} μCi was 2.1 percent of the allowable level.

Table 5.8-3: Annual Airborne Uranium Exposure Results

Airborne Uranium Exposure Monitoring Period (Calendar Year)	Average Airborne Uranium Exposure (μCi)[1]	Maximum Airborne[1] Uranium Exposure (μCi)[1]
1994	3.66×10^{-3}	9.03×10^{-3}
1995	4.04×10^{-3}	1.07×10^{-2}
1996	2.59×10^{-3}	4.70×10^{-3}
1997	5.49×10^{-3}	8.37×10^{-3}
1998	5.81×10^{-3}	8.26×10^{-3}
1999	5.14×10^{-3}	7.89×10^{-3}
2000	4.38×10^{-3}	8.23×10^{-3}
2001	4.55×10^{-3}	$1,06 \times 10^{-2}$
2002	3.24×10^{-3}	7.82×10^{-3}
2003	5.24×10^{-3}	1.28×10^{-2}
2004	4.05×10^{-3}	9.17×10^{-3}
2005	5.87×10^{-3}	1.94×10^{-2}
2006	6.94×10^{-3}	2.14×10^{-2}

Note:
[1]The annual uranium intake limit for calendar years 1990 through 1993 was 0.252 μCi based on 10 CFR 20.103. In 1994, the annual limit on intake (ALI) was 1 μCi based upon "D" class natural uranium.

Proposed Airborne Uranium Exposure Monitoring Program

CBR proposes to institute the same internal airborne uranium exposure calculation methods at Crow Butte Project that have been used to date and which are currently contained in EHSMS Program Volume IV, *Health Physics Manual.* Exposures to airborne uranium will be compared to the DAC for the "D" solubility class for natural uranium from appendix B of 10 CFR §§20.1001 - 20.2401 (5 E-10 μCi/ml) for all areas of the plant.

5.8.4.2 Radon Daughter Exposure

Exposure calculations for airborne radon daughters are carried out using the intake method from USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Revision 1, Section 2. The radon daughter intake is calculated using the following equation:

$$I_r = \frac{1}{170} \sum_{i=1}^{n} \frac{Wi \times t_i}{PF}$$

where:

I_r	=	radon daughter intake, working-level months
t_i	=	time that the worker is exposed to concentrations W_i (hr)
W_i	=	average number of working levels in the air near the worker's breathing zone during the time (t_i)
170	=	number of hours in a working month
PF	=	the respirator protection factor, if applicable
n	=	the number of exposure periods during the year

The data required to calculate exposure to radon daughters are determined as follows.

Time of Exposure Determination

One hundred percent occupancy time is used to determine routine worker exposure times. Exposures during non-routine work are always based on actual time.

Radon Daughter Concentration Determination

Radon-222 daughter concentrations are determined from surveys performed as described in **Section 5.8.3.2**.

The working-level months for radon daughter exposure are calculated on the appropriate forms. The working-level months are totaled and entered onto each employee's Occupational Exposure Record.

Historical Program Results

Table 5.8-4 summarizes the results of radon daughter exposure calculations at Crow Butte Uranium Project between 1994 and 2006. The data show that internal exposure due to radon daughters at Crow Butte Uranium Project has been maintained ALARA, being significantly lower than the allowable level of 4.0 WLM. Since 1994, the average individual internal exposure to radon daughters was at its lowest in 2005 and 2006 (0.101 and 0.161 working-level months, respectively). These levels are approximately 3 percent and 4 percent, respectively, of the allowable regulatory limit of 4 working-level months. The maximum internal exposure to radon daughters was also at its lowest over this 13-year period at 0.213 in 2005 and 0.283 in 2006, (approximately 5 percent and 7 percent of the regulatory limit, respectively)

Table 5.8-4: Annual Radon Daughter Exposure Results

Radon Daughter Exposure Monitoring Period (Calendar Year)	Average Individual Exposure (Working-Level Months)[1]	Maximum Individual Exposure (Working-Level Months)[1]
1994	0.188	0.418
1995	0.212	0.570
1996	0.322	.0527
1997	0.467	0.643
1998	0.25	0.359
1999	0.356	0.539
2000	0.183	0.325
2001	0.199	0.416
2002	0.180	0.364
2003	0.208	0.402
2004	0.197	0.312
2005	0.101	0.213
2006	0.161	0.283

Note:
[1] The annual limit was 4 working-level months.

CBR proposes to institute the same internal radon daughter exposure calculation methods at Crow Butte Project that have been used to date and which are currently contained in EHSMS Program Volume IV, Health Physics Manual. Exposures to radon daughters will be compared to the DAC for radon daughters from Appendix B of 10 CFR §§20.1001 - 20.2401 (0.33 WL).

5.8.5 Bioassay Program

5.8.5.1 Program Description

CBR has implemented a urinalysis bioassay program at the Crow Butte Project facilities that meets the guidelines contained in USNRC Regulatory Guide 8.22, *Bioassay at Uranium Mills*, Revision 1. The primary purpose of the program is to detect uranium intake in employees who are regularly exposed to uranium. The bioassay program consists of the following elements:

1. Prior to assignment to the facility, all new employees are required to submit a baseline urinalysis sample. Upon termination, an exit bioassay is required. Additionally, bioassay samples are obtained annually from all employees.
2. During operations, urine samples are collected from workers whose routine work assignment requires them to enter areas where the potential for inhalation of yellowcake exists. Samples from these workers are collected quarterly. Workers who have the potential for exposure to dried yellowcake are sampled monthly. Samples are analyzed by an outside analytical laboratory for uranium content. Blank and spiked samples are also submitted to the laboratory with employee samples as part of the Quality Assurance program. The measurement sensitivity for the analytical laboratory is 5 micrograms per liter (μg/L).
3. Action levels for urinalysis are established based on Table 1 in USNRC Regulatory Guide 8.22, *Bioassay at Uranium Mills*, Revision 1.
4. *In vivo* measurements are performed in accordance with the recommendations contained in Regulatory Guide 8.22, *Bioassay in Uranium Mills*, Revision 1. Because CBR does not produce insoluble, high-fired yellowcake (defined as yellowcake dried at more than 400°C), no *in vivo* measurements have been required.

5.8.5.2 Historical Program Results

The following subsections summarize the results of the bioassay program since 1990, as reported in the ALARAs.

<u>1990 – Bioassay Results</u>

All bioassay samples were reported at lower than the 5 μg/L detection limit.

<u>1991 – Bioassay Results</u>

All bioassay samples were reported at lower than the 5 μg/L detection limit.

1992 – Bioassay Results

All bioassay samples were reported at lower than the 5 μg/L detection limit.

1993 – Bioassay Results

All bioassay samples were reported at lower than the 5 μg/L detection limit.

1994 – Bioassay Results

All bioassay samples were reported at or lower than the 5 μg/L detection limit with the exception of one sample which was 13.9 μg/L. Resamples of the individual that submitted this sample were lower than 5 μg/L.

1995 – Bioassay Results

All bioassay samples were reported at lower than the 5 μg/L detection limit.

1996 – Bioassay Results

All bioassay samples were reported at lower than the 5 μg/L detection limit.

1997 – Bioassay Results

All bioassay samples had results that were lower than the detection limit of 5 μg/L.

1998 – Bioassay Results

All bioassay samples taken during 1998 yielded results that were lower than the detection limit of 5 μg/L with the exception of three quarterly samples. The three samples that were higher than the detection limit were 5 μg/L, 9.0 μg/L, and 10.7 μg/L, which are below the 15 μg/L criterion for increased surveillance from USNRC Regulatory Guide 8.22. Subsequent samples obtained from these individuals immediately after receipt of the results were lower than the detection limit.

1999 – Bioassay Results

All bioassay samples taken during 1999 yielded results that were lower than the detection limit of 5 μg/L with the exception of one sample. The one sample that was higher than the detection limit was 81 μg/L, which is well above the 15 μg/L criterion for increased surveillance from USNRC Regulatory Guide 8.22. An operator submitted this sample after noticing a loose drum ring when moving yellowcake drums in the Dryer Room. This event occurred during a weekend shift. The operator obtained a bioassay sample approximately 1 hour after the incident. The CRSO was not notified of the incident until the following Monday. Additional samples were obtained following a 48-hour and 72-hour elapsed time after the incident. All three samples were submitted for analysis. The 48- and 72-hour samples were lower than the detection limit. CBR believes that the 1-hour sample was probably contaminated during collection. If the initial sample result of 81 μg/L had been correct, natural uranium above the detection limit would have also been detected in the 48- and 72-hour samples due to retention time in the body. Subsequent samples from the operator were also below the detection level.

Diagnostic samples were also necessary when a plant operator performed maintenance work on the yellowcake belt filter during a weekend shift. The work was performed without an RWP, and the CRSO was not notified until the following Monday. The bioassay samples obtained from the operator were lower than the detection limit. In response to this incident, the CRSO met with all operators to emphasize that work on yellowcake-related equipment must be cleared with the CRSO. The RWP SOP was also revised to specifically state what activities require the issuance of an RWP.

2000 – Bioassay Results

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2000:

- A diagnostic bioassay was obtained when a wellfield operator was sprayed in the face with injection water.
- Diagnostic bioassays were obtained when problems with yellowcake drum lid integrity resulted in a visible release of material.
- Diagnostic bioassays were obtained when a plant engineer and maintenance worker tore down the deep well feed pump for repairs without an RWP.
- Diagnostic bioassays were obtained when plant operators moved a drum of yellowcake with a hole in the lid without an RWP or respiratory protection.
- Diagnostic bioassays were obtained from personnel who were in the plant during the yellowcake dryer oil leak.

In most cases, diagnostic bioassays were necessary due to unforeseen situations where representative air sample results were not available. The diagnostic bioassay samples were all lower than the detection limit of 5 μg/L.

2001 – Bioassay Results

All routine bioassay samples taken during 2001 yielded results that were lower than the detection limit of 5 μg/L.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2001:

- Bioassays were obtained from five welding contractor employees after completion of repairs on the yellowcake dryer in conjunction with RWP 01-04.
- Diagnostic bioassays were obtained from a drum handler and a Health Physics technician after yellowcake leaked around the drum ring on a dry product drum that was being loaded for shipment.
- A diagnostic bioassay was obtained from a plant operator after performing work on the yellowcake belt filter without obtaining an RWP.
- Diagnostic bioassays were obtained from three individuals after the yellowcake dryer was overfilled, spilling product on the dryer room floor.
- Bioassays were obtained in conjunction with RWP 01-32 for changing filters in the yellowcake dryer baghouse.

In most cases, diagnostic bioassays were necessary due to unforeseen situations where representative air sample results were not available. The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2002 – Bioassay Results

With two exceptions, all routine bioassay samples taken during 2002 had results that were lower than the detection limit of 5 µg/L. In April, samples taken from a Plant Operator yielded a bioassay result of 6.2 µg/L. In June, samples taken from a Wellfield Operator yielded a bioassay result of 7.1 µg/L. Investigations conducted by the RSO did not identify any potential cause for the positive bioassay results for these two individuals. Subsequent bioassay samples were below the 5 µg/L detection level.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2002:

- Bioassays were obtained from Plant Operators after a yellowcake feed hose was disconnected, causing yellowcake to leak onto Precipitation Cell A.
- Diagnostic bioassays were obtained from two engineering personnel after working on the yellowcake packaging scale in the Dryer Room without an RWP.
- A bioassay was obtained from the welder working on replacing the belt filter room floor.
- Bioassays were collected from Plant Operators after the dryer heat was left on following a loss of vacuum and subsequent dryer emissions into the dryer room.
- A bioassay was collected from a Plant Operator after completion of support at Power Resources, Inc. for toll drying CBR product.

- Bioassays were collected on four occasions from personnel working under RWPs in conjunction with work on the Yellowcake Dryer.

In most cases, diagnostic bioassays were necessary due to unforeseen situations where representative air sample results were not available. The diagnostic bioassay samples were all lower than the detection limit of 5 μg/L.

2003 – Bioassay Results

With six exceptions, all routine bioassay samples taken during 2003 yielded results that were lower than the detection limit of 5 μg/L.

- In March, samples taken from a Plant Lead Operator yielded a bioassay result of 5.4 μg/L, which is slightly above the detection limit.
- In December, samples taken from two Plant Operators yielded bioassay results of 8.0 and 14.0 μg/L.
- In December, samples taken from three contractors working on installation of the new yellowcake dryer yielded bioassay results of 6.0, 6.0, and 10.0 μg/L.

Investigations conducted by the RSO did not identify any potential cause for the positive bioassay results for these individuals. No work was performed on heavily contaminated equipment, and all air sampling results were normal. It is possible that the empty bioassay bottles became cross-contaminated in the CBR Laboratory. The bottles were replaced and moved to a different storage location in early 2004.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2003:

- Bioassays were obtained from three Plant Operators cleaning yellowcake out of the old dryer under RWP 03-2.
- Bioassays were obtained on two occasions from two Plant Operators replacing bag filters in the yellowcake dryer baghouse under RWPs 03-4 and 03-14.
- A bioassay was obtained from one Plant Operator replacing the yellowcake dryer plug valve handle under RWP 03-6.
- A diagnostic bioassay was obtained from a Plant Operator after elevated air sample results were noted during a yellowcake transfer from a Precipitation Cell.
- A diagnostic bioassay was obtained from a Plant Operator who was sprayed with yellowcake during a slurry transfer after a feed line broke.

The diagnostic bioassay samples were all lower than the detection limit of 5 μg/L.

2004 – Bioassay Results

With two exceptions, all routine bioassay samples taken during 2004 yielded results that were less than the detection limit of 5 µg/L.

- In February, samples taken from a Plant Lead Operator yielded a bioassay result of 96 µg/L. Rechecks of this sample yielded 101 µg/L and 103 µg/L. The investigation by the RSO concluded that the most likely cause of this uranium level was contamination of the sample at CBR or at the analytical laboratory. Follow-up samples yielded concentrations that were below the detection limit. Using the guidance contained in USNRC Regulatory Guide 8.9, subsequent samples should have shown measurable levels of uranium if the original concentration was accurate.
- In November, samples taken from the Dryer Operator yielded a bioassay result of 17 µg/L. The investigation conducted by the RSO concluded that improper use of PPE and inadequate engineering design for transferring yellowcake to the dryer were the most likely causes of the elevated sample.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2004:

- Bioassays were obtained from three workers in February 2004 who were in the same area at the time the Pant Operator had the elevated bioassay noted above.
- Bioassays were obtained on two occasions in April from a maintenance worker involved in dryer maintenance.
- Bioassays were obtained on two occasions in November when breathing zone samples taken during dryer loading activities approached the DAC for soluble uranium.

The diagnostic bioassay samples were all lower than the detection limit of 5 µg/L.

2005 – Bioassay Results

With one exception, all routine bioassay samples taken during 2005 yielded results that were lower than the detection limit of 5 µg/L.

- In August, samples taken from the Dryer Operator yielded a bioassay result of 10 µg/L on a sample taken 5.5 hours after he relieved pressure from a drum of yellowcake. A follow-up 24-hour composite begun immediately after the 5.5-hour grab sample yielded 7.0 µg/L. A second 24-hour composite taken immediately after collection of the first yielded less than 5.0 µg/L.

In addition to routine bioassays, diagnostic samples were necessary on several instances during 2005:

- In April, samples were collected from employees involved in cleaning up yellowcake after the lower discharge valve was broken off of the yellowcake overflow tank.
- In July, samples were collected from employees working under RWP 05-12 to change the bags in the dryer baghouse.

The diagnostic bioassay samples were all lower than the detection limit of 5 μg/L.

<u>2006 – Bioassay Results</u>

All routine bioassay samples taken during 2006 yielded results that were lower than the detection limit of 5 μg/L. In addition to routine bioassays, the following bioassay samples were conducted:

- Diagnostic Bioassay. Employees who changed the bags in the baghouse of the yellowcake dryer were monitored for a 2-day period. All bioassay samples yielded concentrations that were lower than the detection limit of 5 μg/L.
- Bioassay Spike Agreement. A termination bioassay was conducted, resulting in a 10 to 20 μg/L spike that exceeded the Bioassay Spike Agreement range by 33 percent. All samples were rerun, and after the second run, the agreement range was 24 percent. The cause of the exceedance was an ELI analytical error made by the contract laboratory.

<u>Bioassay Quality Assurance Program Description and Historical Results</u>

Elements of the Quality Assurance requirements for the Bioassay Program are based on the guidelines contained in USNRC Regulatory Guide 8.22, *Bioassay in Uranium Mills*, Revision 1. These elements included the following:

- Each batch of samples submitted to the analytical laboratory is accompanied by two blind control samples. In mid-2005, the CBR facility began using control samples prepared from synthetic urine, rather than using urine from persons that were not occupationally exposed. The synthetic blind control samples are spiked to a uranium concentration of 10 mg/L to 20 mg/L and 40 mg/L to 60 mg/L. The results of analysis for these samples are required to be within ± 30 percent of the spiked value. CBR has tracked the results of the blind spike analysis since 1990. Historically, the majority of the samples have been within the ± 30 percent of the spiked value, with exceedances being rare. In 2006, there was only one exceedance and none haven been observed through the first three quarters of 2007. Past exceedances have been due to either occasional laboratory error or the facility's spike results were incorrect. When these infrequent errors were observed, the most recent batch of affected samples were rerun and steps taken to review, and as necessary correct, the procedures for spiking or the procedures for laboratory analysis. Actions taken in regard to investigating spiked sample value exceedances are recorded and maintained on file at the facility.

- The analytical laboratory spikes 10 percent to 30 percent of all samples received with known concentrations of uranium and the recovery fraction determined. Results are reported to CBR. All results have been within ± 30 percent.

Proposed Bioassay Program

CBR proposes to continue the Bioassay Program including urinalysis and *in vivo measurements as* described in this Section in accordance with the guidance contained in USNRC Regulatory Guide 8.22, *Bioassay in Uranium Mills*, Revision 1 and with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.*

5.8.6 Contamination Control Program

CBR's contamination control program at Crow Butte Project consists of the following elements.

5.8.6.1 Surveys for Surface Contamination

CBR performs surveys for surface contamination in operating and clean areas of the Crow Butte Project facilities in accordance with the guidelines contained in USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities*, Revision 1. Surveys for alpha contamination in clean areas, such as lunchrooms change rooms and offices, are conducted weekly. An action level of 25 percent of the limits from USNRC Regulatory Guide 8.30 is used for clean areas.

5.8.6.2 Surveys for Contamination of Skin and Personal Clothing

All personnel leaving the restricted area are required to perform and document alpha contamination monitoring. In addition, personnel who could come in contact with potentially contaminated solutions outside a restricted area, such as in the wellfields, are required to monitor themselves prior to leaving the area. All personnel receive training in the performance of surveys for skin and personal contamination. Personnel are also allowed to conduct contamination monitoring of small, hand-carried items as long as all surfaces can be reached with the instrument probe and the item is used in another process area. All other items are surveyed as described in the next section.

As recommended in USNRC Regulatory Guide 8.30, *Health Physics Surveys in Uranium Recovery Facilities* Revision 1, CBR conducts quarterly unannounced spot checks of personnel to verify the effectiveness of the surveys for personnel contamination. Employees assigned to the mine site are spot-checked, concentrating on plant operators and maintenance personnel. The purpose of the surveys is to ensure that employees are adequately surveying and decontaminating themselves prior to exiting the restricted areas.

5.8.6.3 Surveys of Equipment Prior to Release to an Unrestricted Area

The RSO, radiation safety staff, or properly trained employees survey all items from the restricted areas with the exception of small, hand-carried items described above. The release limits are set by *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses For Byproduct, Source, or Special Nuclear Materials*, USNRC, May 1987 ("Annex B"). Surveys are performed with the following equipment:

Total surface activity will be measured with an appropriate alpha survey meter. A Ludlum Model 2241 Scaler or a Ludlum Model 177 Ratemeter with a Model 43-65 or Model 43-5 alpha scintillation probe, or equivalent, will be used for the surveys.

1. Portable GM survey meter with a beta/gamma probe with an end window thickness of not more than 7 mg/cm^2, a Ludlum Model 3 survey meter with a Ludlum 44-38 probe or equivalent;
2. Swipes for removable contamination surveys as required;
3. Survey equipment is calibrated annually or at the manufacturer's recommended frequency, whichever is more frequent. Surface contamination instruments are checked daily when in use. Alpha survey meters for personnel surveys are response checked before each use with other checks performed weekly;
4. The contamination control program will continue in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual.*

5.8.6.4 Historical Program Results

The weekly contamination survey results indicate that the contamination control program at the Crow Butte Project is effective. The quarterly spot checks performed throughout the period show that the personnel contamination program is effective. Results of the contamination surveys, spot checks, and equipment release surveys are maintained at the Crow Butte Project site.

5.8.6.5 Contamination Control Program

CBR proposes to continue with the same contamination control program that is currently in use. The program has proven to be effective at controlling contamination of personnel and clean areas. The program is carried out in accordance with the instructions currently contained in EHSMS Program Volume IV, *Health Physics Manual*

5.8.7 Airborne Effluent and Environmental Monitoring Programs

5.8.7.1 Program Description and Historical Monitoring Results

The airborne effluent and environmental monitoring programs are designed to monitor the release of airborne radioactive effluents from the Crow Butte Project facilities. To evaluate the effectiveness of the effluent control systems, the results of the monitoring program are compared with the background levels and with regulatory limits. **Table 5.8-5** provides the sampling locations, types, frequency, methods, and parameters for the Crow Butte Project facilities.

5.8.7.2 Radon

The radon gas effluent released to the environment is monitored at seven locations (AM-1 through AM-6 and AM-8). Location AM-6 is considered the background location. Monitoring is performed using Track-Etch radon cups provided by Landauer Corporation. The cups are exchanged on a semi-annual basis in order to achieve the required LLD. The EHSMS Program Volume VI, *Environmental Manual* currently provides the instructions for radon gas monitoring. In addition to the manufacturer's Quality Assurance program, CBR exposes duplicate radon Track Etch cups for each monitoring period. The duplicate cups are identified as AB locations using the same number as the existing monitoring location (for example AB-3 is the duplicate cup at monitoring location AM-3). **Table 5.8-6** contains the results of radon monitoring for the Crow Butte Uranium Project facility between 1991 and 2007. **Figure 5.8-10** through **Figure 5.8-16** depict the trends for radon monitoring between 1991 and 2007 for each location. The total estimated radon release trend between 1991 and 2007 is shown in **Figure 5.8-17.**

As recommended in Regulatory Guide 8.37, a trend analysis of the radon monitoring results since commercial operations began in 1991 was performed. In 2003, three monitoring stations (AM-1, AM-2, and AM-8) exhibited significant spikes from historical radon concentrations in the second half. These sample locations are along the eastern and northern boundaries of the License Area and Section 19. In the 2003 ALARA Audit Review, CBR noted that the cause of the elevated radon-222 concentrations was not known. Radon release levels from the Crow Butte Project for the period are consistent with those since increased process flows were approved in 1998, so it did not appear that project releases were the source. Concentrations at the three locations ranged from 34 percent to 37 percent of the effluent concentration limit from 10 CFR Part 20, Appendix B Column 2, which is above normal concentrations at the environmental monitoring stations (generally less than 10 percent) but well below levels that are protective of the public.

Table 5.8-5: Operational Environmental and Effluent Monitoring Program

Sample Type	Location	Type	Number	Frequency	Analyses
Air (Radon)	Nearest residences and in the prevalent wind direction Environmental control station near Crawford, NE.	Continuous	6 1	Semiannual	Rn-222
Air (particulate)	Same locations as radon air monitoring	Continuous	7	A minimum of 2 weeks per month when dryer is in use	U-nat Ra-226 Pb-210
Surface Soil (top 5 cm)	Plant site before topsoil removal	Grab	2	Once	U-nat Ra-226
	Plant site after topsoil removal	Grab	2	Once	U-nat Ra-226
	Evaporation ponds before excavation	Grab	2	Once	U-nat Ra-226
	Air sampling stations	Grab	7	Once	U-nat Ra-226
Subsurface soil	Plant site	1/3 meter composites to one meter	1	Once	U-nat Ra-226
Groundwater	Water supply wells within 1 km of area wellfield	Grab	1	Quarterly	U-nat Ra-226
Surface water	Each stream passing through wellfield area (one upstream and one downstream)	Grab	2	Quarterly	U-nat Ra-226
	Each water impoundment in wellfield area	Grab	1	Quarterly	U-nat Ra-226
Direct Radiation	Air sampling stations	Continuous	7	Quarterly exchange of dosimeters	External gamma
Sediment	Each body of water where surface water sampling is performed	Grab upstream and downstream of wellfields	1 or 2	Annually	U-nat Ra-226 Pb-210

Table 5.8-6: Ambient Radon Gas Monitoring Results (pCi\L) (1991-2007)

Monitoring Period	Monitoring Location								
	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AB-3 (AM-3)	AB-6 (AM-6)
First Quarter, 1991	0.3	0.3	0.5	0.5	0.4	0.5	0.3	0.3	0.4
Second Quarter, 1991	0.3	0.3	0.3	0.5	0.3	0.3	0.3	0.3	0.3
Third Quarter, 1991	0.3	0.6	0.3	0.9	0.4	1.0	0.6	0.3	0.5
Fourth Quarter, 1991	0.3	0.5	0.6	0.9	0.7	0.3	0.4	0.4	0.6
First Quarter, 1992	0.5	0.5	0.5	0.7	0.7	0.6	< 0.3	0.5	0.7
Second Quarter, 1992	0.7	0.4	0.3	0.7	0.4	0.6	0.7	0.6	< 0.3
Third Quarter, 1992	< 0.3	0.3	< 0.3	0.5	0.4	< 0.3	0.5	< 0.3	< 0.3
Fourth Quarter, 1992	0.4	0.4	0.5	0.7	0.9	0.7	0.7	0.6	0.3
First Quarter, 1993	0.5	0.4	0.5	< 0.3	0.5	< 0.3	< 0.3	< 0.3	< 0.3
Second Quarter, 1993	0.4	0.6	< 0.3	0.4	0.5	0.4	0.6	< 0.3	< 0.3
Third Quarter, 1993	0.5	1.0	0.6	1.0	0.6	0.4	0.4	0.4	0.5
Fourth Quarter, 1993	0.7	0.9	0.6	0.6	1.1	0.7	0.8	0.6	0.7
First Quarter, 1994	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
Second Quarter, 1994	0.6	0.6	0.4	0.5	0.6	< 0.3	0.6	0.5	0.4
Third Quarter, 1994	0.9	0.7	0.9	0.7	0.8	0.8	0.8	0.5	0.7
Fourth Quarter, 1994	0.5	0.5	0.4	0.5	0.8	0.3	0.7	< 0.3	0.5
First Quarter, 1995	<0.3	0.5	<0.3	<0.3	<0.3	<0.3	0.4	<0.3	<0.3
Second Quarter, 1995	<0.3	0.5	<0.3	0.5	<0.3	<0.3	<0.3	0.6	<0.3
Third Quarter, 1995	<0.3	0.7	<0.3	<0.3	0.8	0.4	0.5	<0.3	0.6
Fourth Quarter, 1995	1.2	0.6	0.9	1.7	0.7	0.3	1.3	0.8	<0.3
First Quarter, 1996	<0.3	0.3	<0.3	0.4	<0.3	<0.3	<0.3	<0.3	<0.3
Second Quarter, 1996	0.5	<0.3	<0.3	0.5	<0.3	0.4	0.5	<0.3	<0.3
Third Quarter, 1996	0.7	0.7	0.5	0.6	1.1	0.8	0.9	0.5	1.0
Fourth Quarter, 1996	0.8	0.9	0.3	0.9	1.1	0.8	0.8	0.8	0.6
First Quarter, 1997	0.6 + 0.11	0.5+ 0.10	<0.3	<0.3	<0.3	<0.3	0.7+0.12	<0.3	0.5+0.11

Table 5.8-6: Ambient Radon Gas Monitoring Results (pCi\L) (1991-2007)

	Monitoring Location								
Monitoring Period	AM-1	AM-2	AM-3	AM-4	AM-5	AM-6	AM-8	AB-3 (AM-3)	AB-6 (AM-6)
Second Quarter, 1997	0.8+0.13	1.3+0.17	0.6+0.12	0.8+0.13	0.9+0.14	0.7+0.13	0.9+0.14	0.50.11	0.8+0.13
Third Quarter, 1997	0.6+0.11	0.9+0.14	1.0+0.15	1.2+0.17	1.5+0.19	0.9+0.14	1.2+0.16	0.8+0.13	1.0+0.15
Fourth Quarter, 1997	1.2+0.16	1.2+0.16	0.6+0.11	1.3+0.16	1.5+0.18	1.3+0.17	1.4+0.18	1.1+0.15	0.9+0.13
	Average Radon Concentration (x10^{-9} µCi/ml (Accuracy x 10^{-9} µCi/ml}								
First Half, 1998	0.2+0.03	0.7+0.08	0.4+0.06	0.4+0.06	0.7+0.08	<0.02	0.5+0.07	0.2+0.03	0.2+0.03
Second Half, 1998	0.4+0.05	0.7+0.07	0.6+0.07	0.6+0.07	0.9+0.08	0.4+0.05	0.7+0.07	0.4+0.05	0.4+0.05
First Half, 1999	0.2+0.03	0.5+0.07	0.2+0.04	0.3+0.05	0.4+0.06	0.2+0.04	0.4+0.06	0.3+0.05	0.4+0.06
Second Half, 1999	0.7+0.08	0.7+0.08	0.5+0.06	0.7+0.08	0.8+0.08	0.5+0.06	0.5+0.06	0.5+0.06	0.4+0.05
First Half, 2000	0.5+0.07	1.0+0.11	0.6+0.08	0.8+0.09	0.9+0.10	0.8+0.12	0.9+0.12	0.7+0.08	0.5+0.07
Second Half, 2000	1.2+0.14	1.1+0.11	0.8+0.09	1.2+0.11	1.6+0.14	0.9+0.09	1.1+0.11	1.0+0.10	1.1+0.11
First Half, 2001	0.4+0.06	0.9+0.10	0.3+0.05	0.5+0.08	0.4+0.05	0.4+0.05	0.6+0.08	0.5+0.08	0.5+0.06
Second Half, 2001	0.6+0.09	1.0+0.12	0.9+0.11	[a]	1.7+0.16	1.7+0.16	1.2+0.14	0.5+0.07	0.2+0.04
First Half, 2002	0.5+0.07	0.8+0.11	0.2+0.05	0.3+0.06	0.6+0.09	0.3+0.06	1.7+0.14	0.4+0.07	0.5+0.08
Second Half, 2002	0.5+0.07	0.6+0.08	0.2+0.04	0.2+0.04	0.4+0.06	0.5+0.08	0.8+0.10	0.2+0.04	0.2+0.04
First Half, 2003	0.4+0.07	0.9+0.12	0.4+0.07	0.7+0.10	0.9+0.12	0.9+0.12	1.0+0.12	0.7+0.10	0.5+0.08
Second Half, 2003	3.4+0.24	3.5+0.24	0.5+0.08	0.3+0.05	0.7+0.10	0.5+0.07	3.7+0.25	0.4+0.07	0.3+0.05
First Half, 2004	0.3+0.04	0.4+0.05	0.3+0.04	0.4+0.05	0.7+0.06	0.4+0.05	1.0+0.08	0.2+0.04	0.3+0.04
Second Half, 2004	0.3+0.04	0.5+0.05	0.2+0.03	0.2+0.03	0.6+0.06	0.2+0.04	0.3+0.04	0.2+0.04	0.2+0.2
								0.3+0.04[b]	0.6+0.06[d]
								0.4+0.05[c]	0.3+0.04[e]
First Half, 2005	0.4+0.05	0.6+0.06	0.3+0.04	0.4+0.04	0.7+0.06	0.3+0.04	0.6+0.06	0.2+0.04	0.2+0.03
								0.3+0.04[b]	0.8+0.07[d]
								0.6+0.06[c]	0.5+0.05[e]
Second Half, 2005	0.2+0.03	0.9+0.07	0.2+0.03	0.3+0.04	1.1+0.08	0.3+0.04	0.5+0.05	0.4+0.05	0.4+0.05
								0.4+0.05[b]	0.8+0.07[d]
								0.9+0.07[c]	0.6+0.06[e]

Table 5.8-6: Ambient Radon Gas Monitoring Results (pCi\L) (1991-2007)

	Monitoring Location								
Monitoring Period	**AM-1**	**AM-2**	**AM-3**	**AM-4**	**AM-5**	**AM-6**	**AM-8**	**AB-3 (AM-3)**	**AB-6 (AM-6)**
First half, 2006	0.5+0.05	0.6+0.06	0.3+0.04	0.5+0.05	0.8+0.07	0.5+0.05	0.7+0.06	0.3+0.04[b]	0.3+0.04
								0.8+0.07[c]	
Second Half, 2006	0.3+0.04	0.8+0.07	0.4+0.05	[a]	0.8+0.07	0.4+0.05	0.6+0.06	0.3+0.04[b]	0.4+0.05
								0.7+0.06[c]	
First half, 2007	0.3+0.04	0.3+0.04	0.3+0.04	0.3+0.04	0.7+0.06	0.4+0.05	0.6+0.06	0.5+0.05[b]	0.4+0.05
								0.7+0.06[c]	

Notes:

[a]Detector missing from cup – no data.

Monitoring Locations AB-3 and AB-6 are co-located with stations AM-3 and AM-6 (duplicate sampling locations modified beginning in the second half of 2004).

[b]AB-1 (AM-1 Duplicate)

[c]AB-2 (AM-2 Duplicate)

[d]AB-5 (AM-5 Duplicate)

[e]AB-8 (AM-8 Duplicate)

Figure 5.8-10: Radon Environmental Monitoring for AM-1 (1991 – 2007)

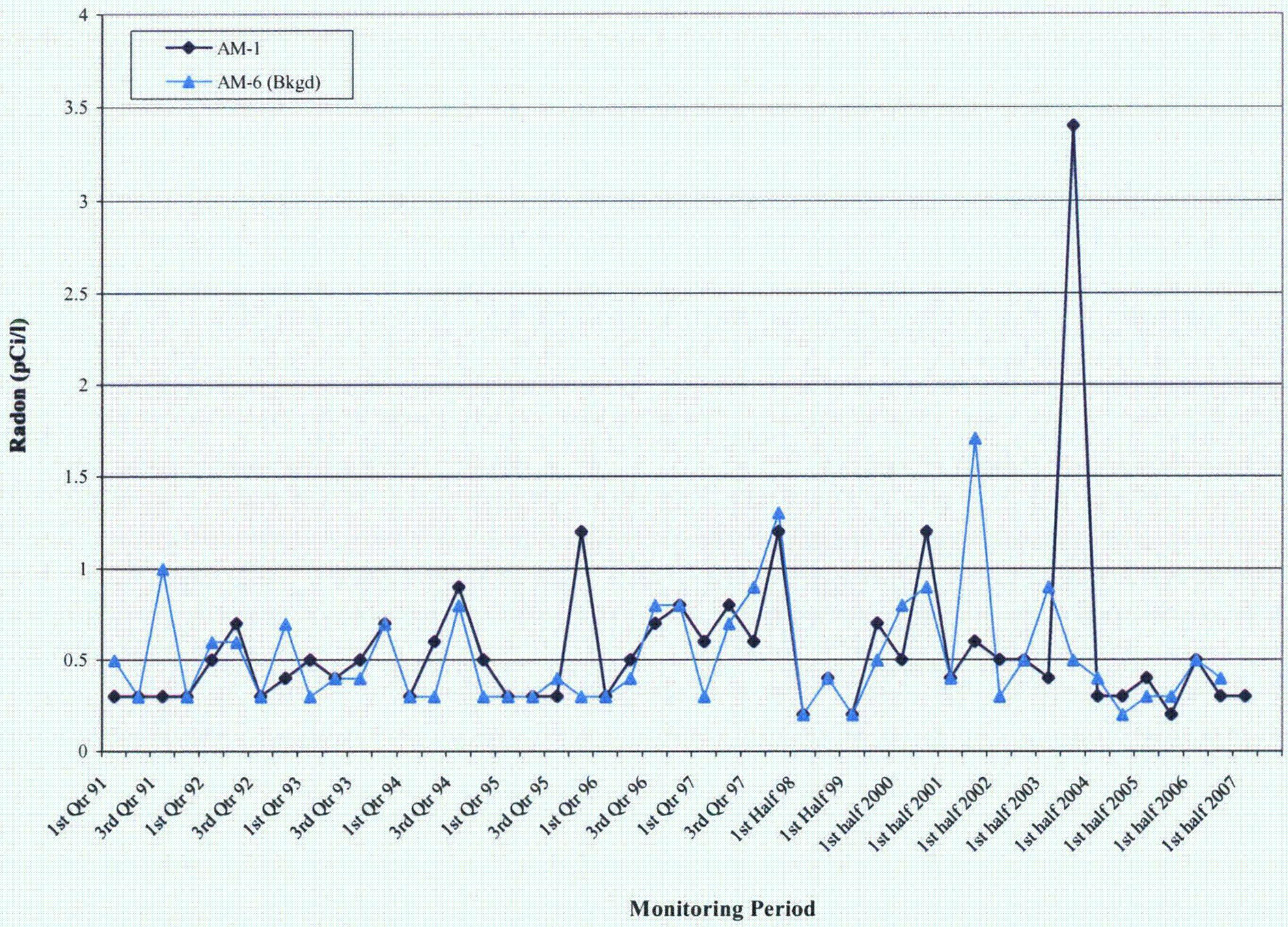


Figure 5.8-11: Radon Environmental Monitoring for AM-2 (1991 – 2007)

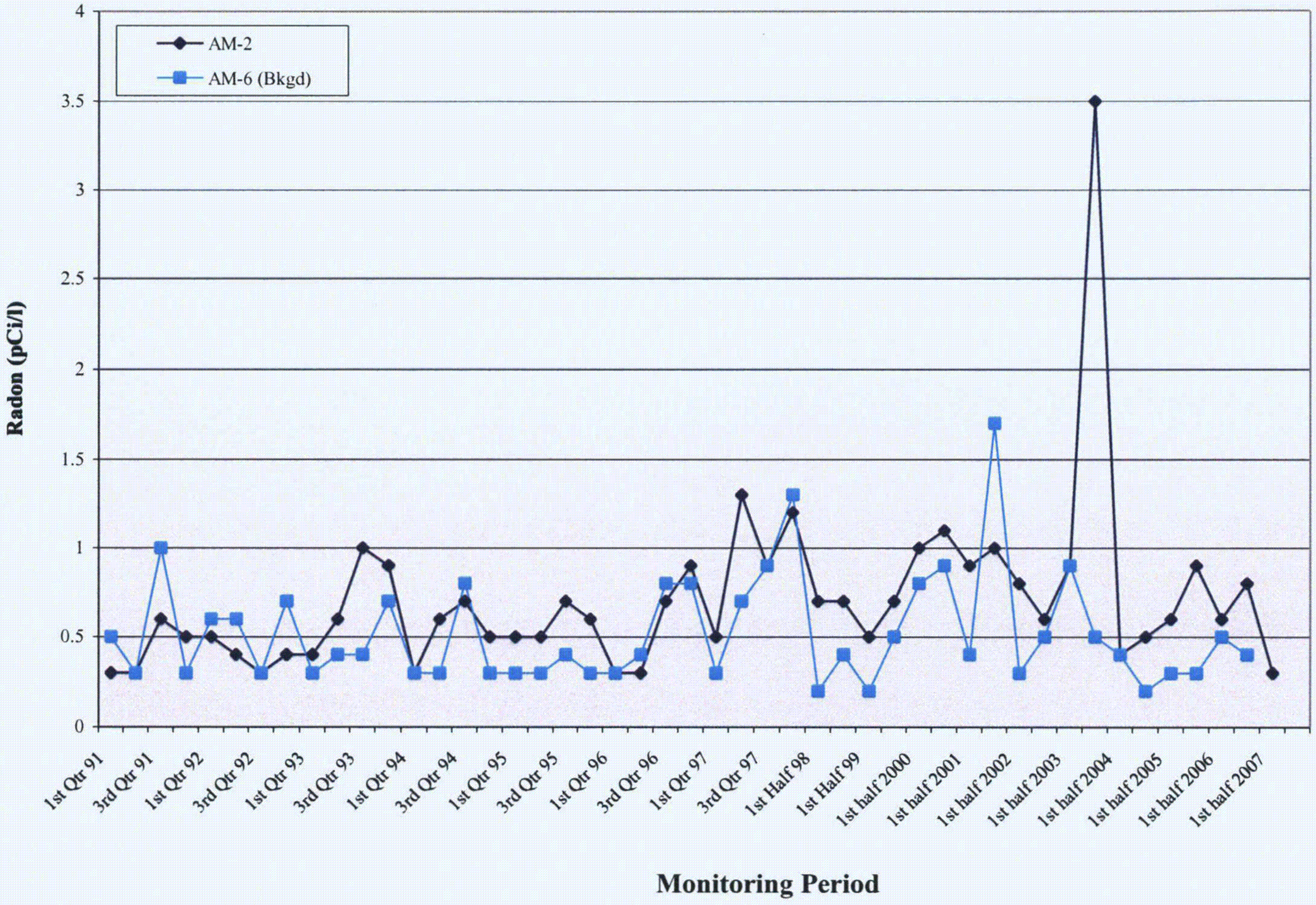


Figure 5.8-12: Radon Environmental Monitoring for AM-3 (1991 – 2007)

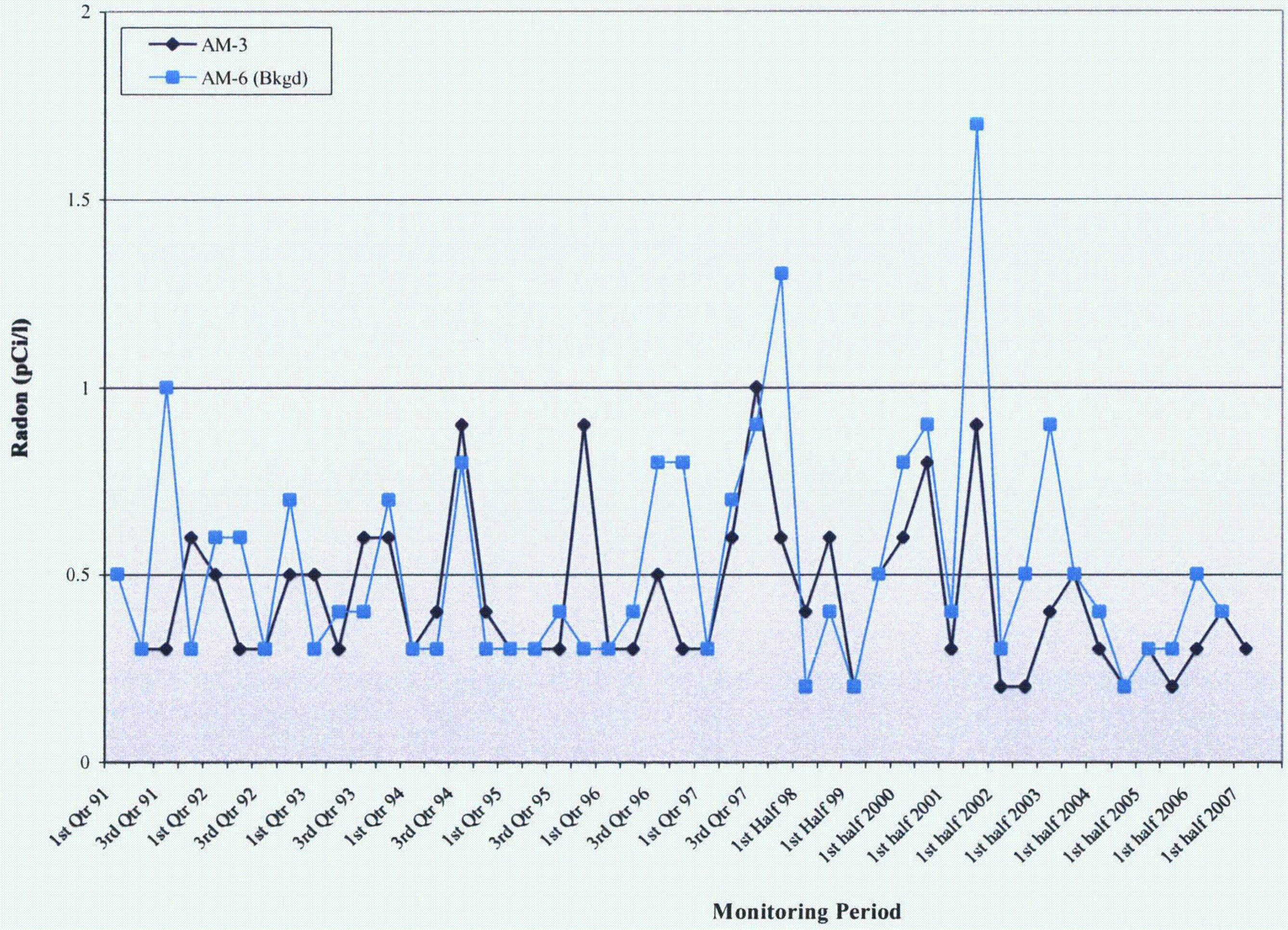


Figure 5.8-13: Radon Environmental Monitoring for AM-4 (1991 – 2007)

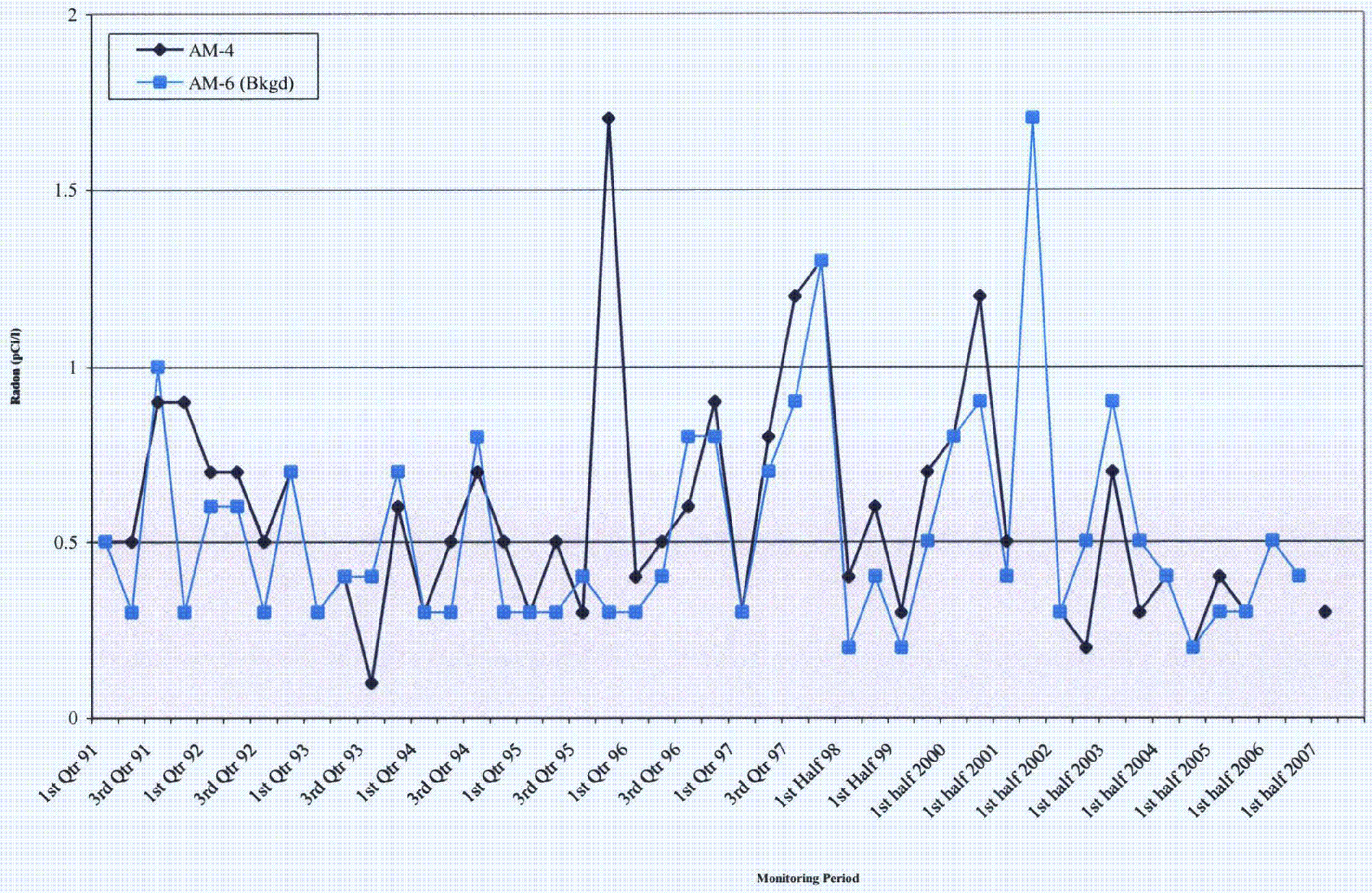


Figure 5.8-14: Radon Environmental Monitoring for AM-5 (1991 – 2007)

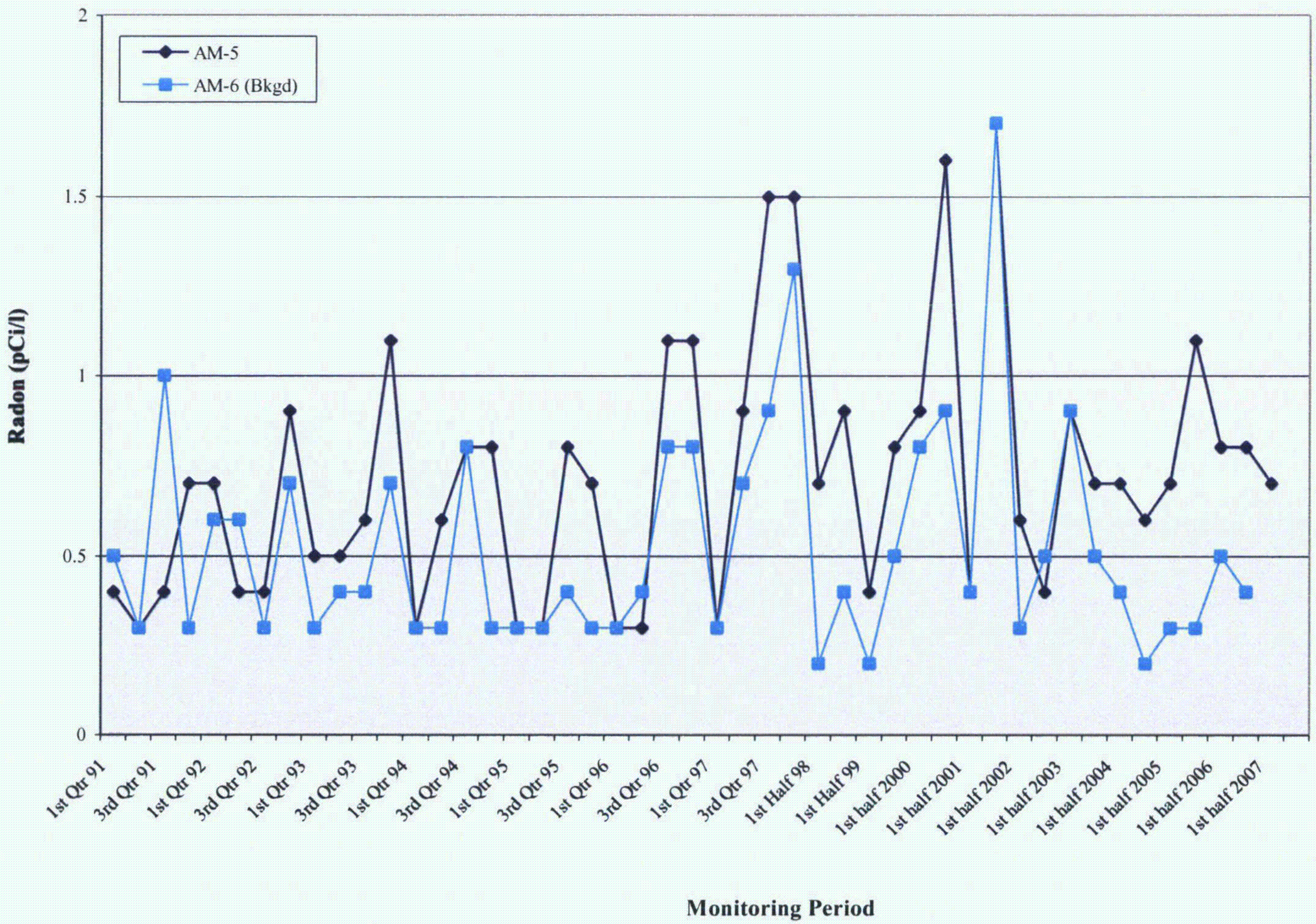


Figure 5.8-15: Radon Environmental Monitoring for AM-6 (1991 – 2007)

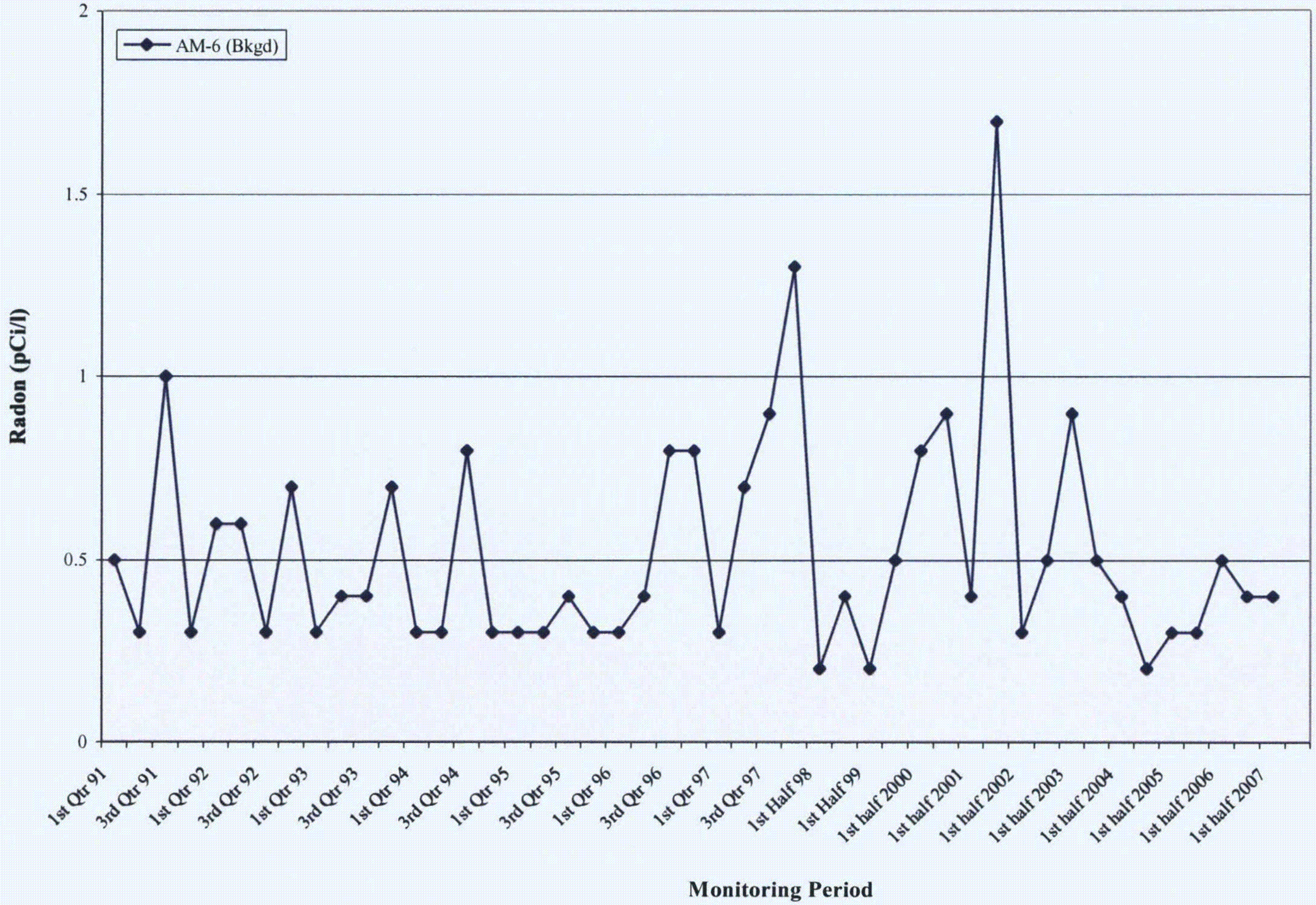


Figure 5.8-16: Radon Environmental Monitoring for AM-8 (1991 – 2007)

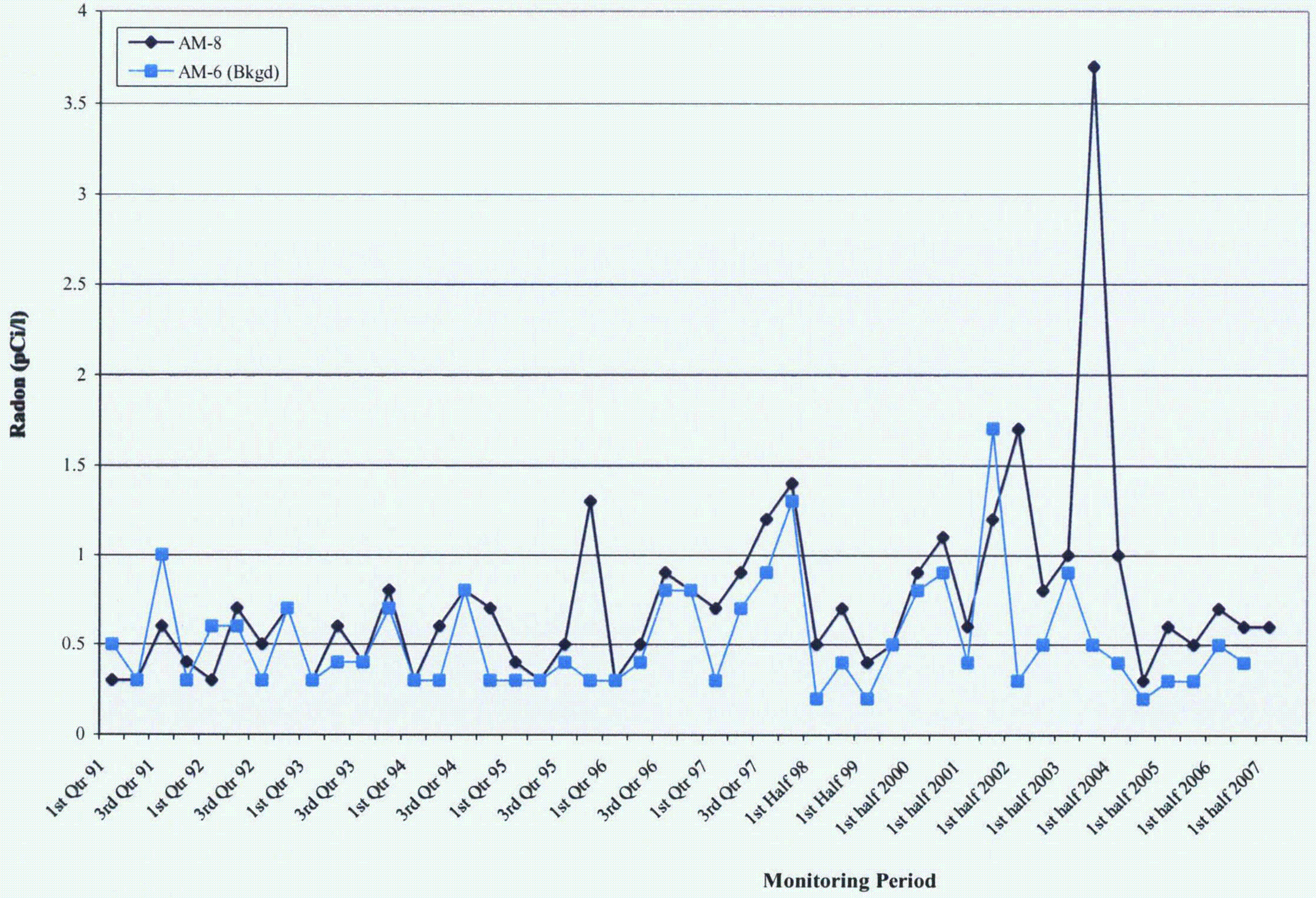
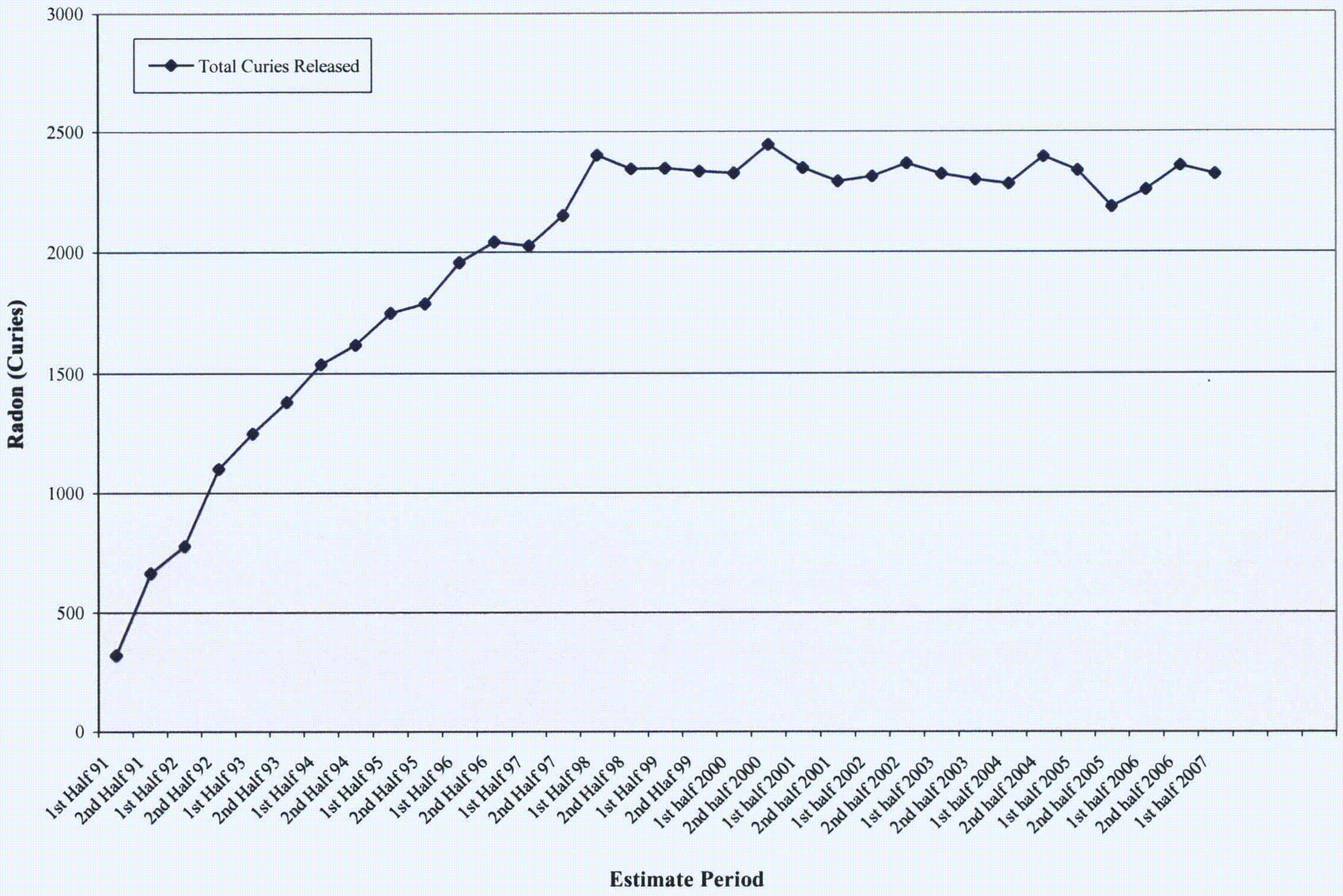


Figure 5.8-17: Total Estimated Radon Release (1991-2007)



In the 2003 ALARA Review, CBR noted that one possible cause for the anomalous results from the second half of 2003 was sampling or analytical error. The 2003 ALARA Audit conducted by Dr. Kenneth Baker recommended that duplicate monitors be deployed at the nearest residences. CBR deployed duplicate monitors at six stations for the second half of 2004 for comparison of results. In the initial analytical results provided by Landauer, Inc., the results from several stations were elevated and did not correlate well to the results from the duplicate monitors. CBR requested that Landauer reanalyze all monitors from the second half of 2004. The results of the reanalysis led to changes in reported values ranging from 0 percent to more than 120 percent. Landauer suggested that the variance in the reported values was due to a routine quarterly update of the background track density for manufacturing lots. The repeat analysis was performed after the background update and in all cases where the reanalysis resulted in a change. The reported values were lower and were consistent with historical concentrations. In the 2004 ALARA Audit Report, CBR reported that it was possible that a similar situation was the cause of the higher concentrations noted in the second half of 2003 and committed to place duplicate monitors at six stations through 2005 to determine the accuracy of the monitoring method.

Table 5.8-7 contains the results of the duplicate radon monitoring performed at the six selected monitoring locations for the second half of 2004 through the second half of 2005.

Table 5.8-7: Environmental Radon Duplicate Monitoring July 2004 to January 2006

Location	2nd half 2004		1st half 2005		2nd half 2005	
AM-1	0.3	0.3	0.4	0.3	0.2	0.4
AM-2	0.5	0.4	0.6	0.6	0.9	0.9
AM-3	0.2	0.2	0.3	0.2	0.2	0.4
AM-5	0.6	0.6	0.7	0.8	1.1	0.8
AM-6	0.2	0.2	0.3	0.2	0.3	0.4
AM-8	0.3	0.3	0.6	0.5	0.5	0.6

Notes: Units = x 10^{-9} µCi/ml
LLD = 0.2 x 10-9 µCi/ml

In addition to the environmental monitoring performed at the Crow Butte Project, release of radon from process operations is estimated and reported in the semi-annual reports required by 10 CFR § 40.65 and License SUA-1534 Condition Number 12.1. **Table 5.8-8** contains annual calculated radon releases from the Crow Butte Project Facility since 1994.

Table 5.8-8: Radon Release to the Environment (Curies)

	1995	1996	1997	1998	1999	2000
1st Quarter [Leaching]	856	896	899	1,061	1,148	1,100
2nd Quarter [Leaching]	890	882	917	1,150	1,114	1,073
Startup	2.6	11	10	18	2	11
Semi-Annual Total • Leaching • Restoration Total	 1,749 -- 1749	 1,789 -- 1789	 1,826 201 2,027	 2,229 170 2,399	 2,264 79 2,343	 2,184 139 2,323
3rd Quarter	895	926	951	1,100	1,105	1,110
4th Quarter	888	939	1,133	1,101	1,120	1,152
Startup	5	8	9	9	10	29
Semi-Annual Total • Leaching • Restoration Total	 1,788 -- 	 1,873 335 2,208	 2,093 55 2,148	 2,210 131 2,341	 2,235 96 2,331	 2,291 146 2,437
Annual Total	3,537	3,997	4,175	4,740	4,674	4,760
Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
1st Quarter [Leaching]	1,109	1,066	1,089	1,048	1,057	1,046
2nd Quarter [Leaching]	1,086	1,113	1,086	1,059	1,063	1,107
Startup	20	15	08	14	9	13
Semi-Annual Total • Leaching • Restoration Total	 2,215 129 2,344	 2,195 115 2,310	 2,183 136 2,319	 2,121 158 2,279	 2,129 205 2,334	 2,166 86 2,253
3rd Quarter	1,076	1,119	1,107	1,076	1,020	1,129
4th Quarter	1,082	1,098	1,083	1,094	1,036	1,110
Startup	7.6	20	21	17	16	09
Semi-Annual Total • Leaching • Restoration Total	 2,166 123 2,289	 2,237 128 2,365	 2,211 85 2,296	 2,187 205 2,392	 2,072 111 2,183	 2,248 106 2,354
Annual Total	4,633	4,675	4,615	4,671	4,517	4,607

5.8.7.3 Air Particulate

Composite airborne particulate samples for natural uranium, radium 226, and lead 210 are obtained quarterly from seven air monitoring locations. As recommended in USNRC Regulatory Guide 8.37, the results of airborne uranium monitoring performed since 1991 when commercial operations began were reviewed. There were no meaningful trends noted at any of the air monitoring locations. The results noted at these sampling stations indicate no significant impact on the environment or the public. **Figure 5.8-18** through **Figure 5.8-24** contain trend analysis graphs for airborne uranium at each air monitoring location between 1991 and 2006.

Figure 5.8-18: Airborne Uranium Environmental Monitoring AM-1 (1991 – 2007)

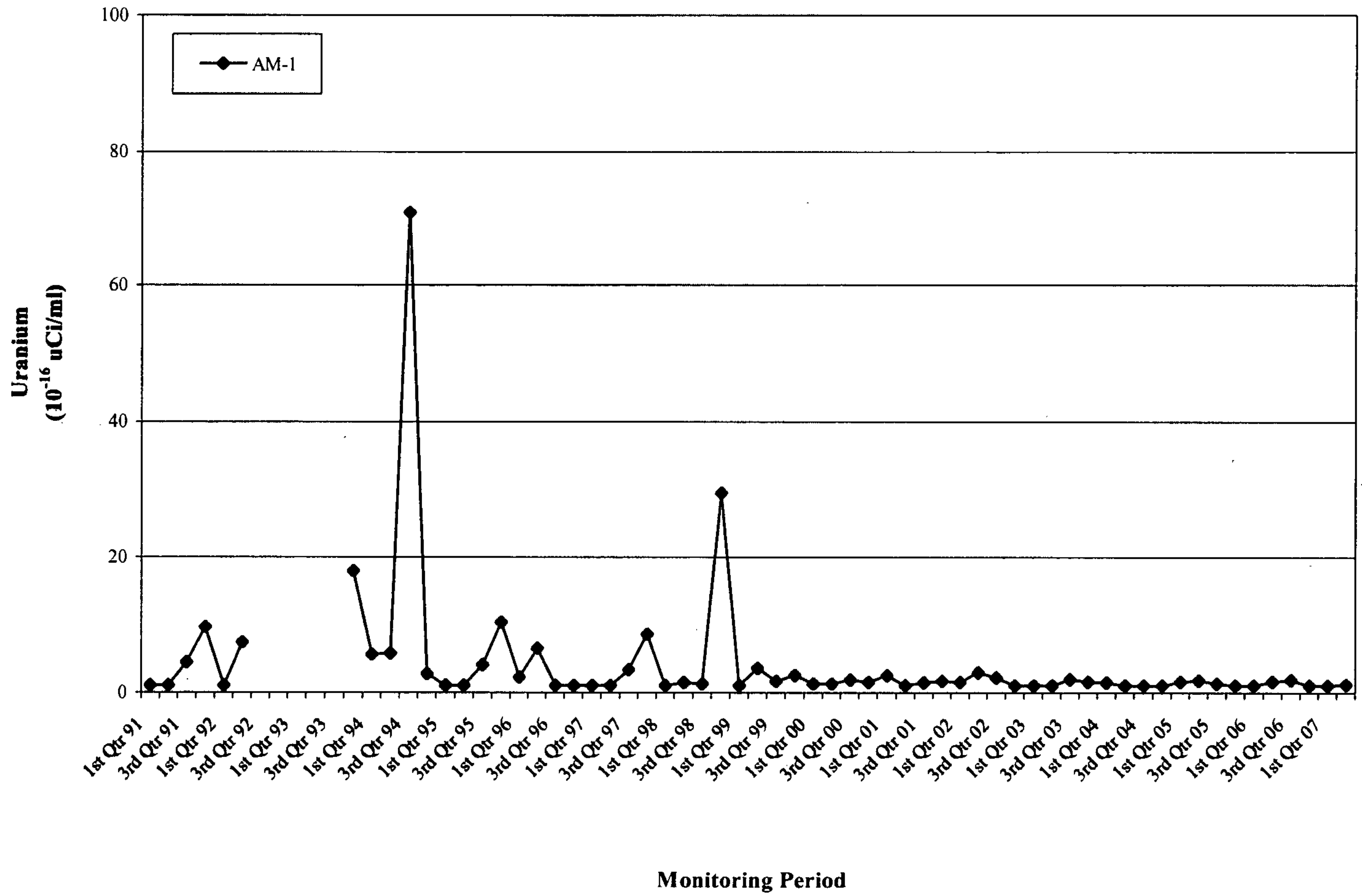


Figure 5.8-19: Airborne Uranium Environmental Monitoring AM-2 (1991 – 2007)

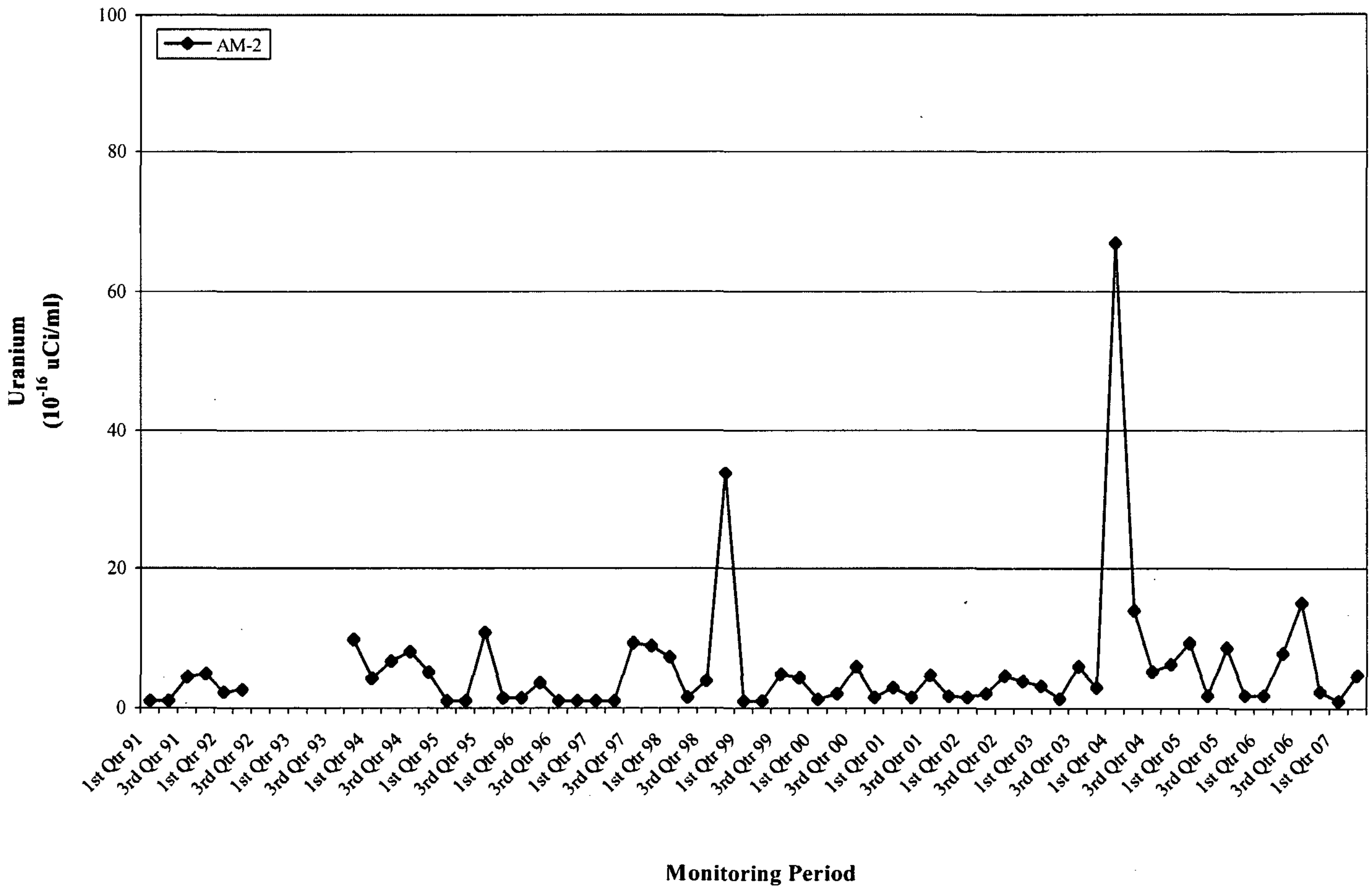


Figure 5.8-20: Airborne Uranium Environmental Monitoring AM-3 (1991 – 2007)

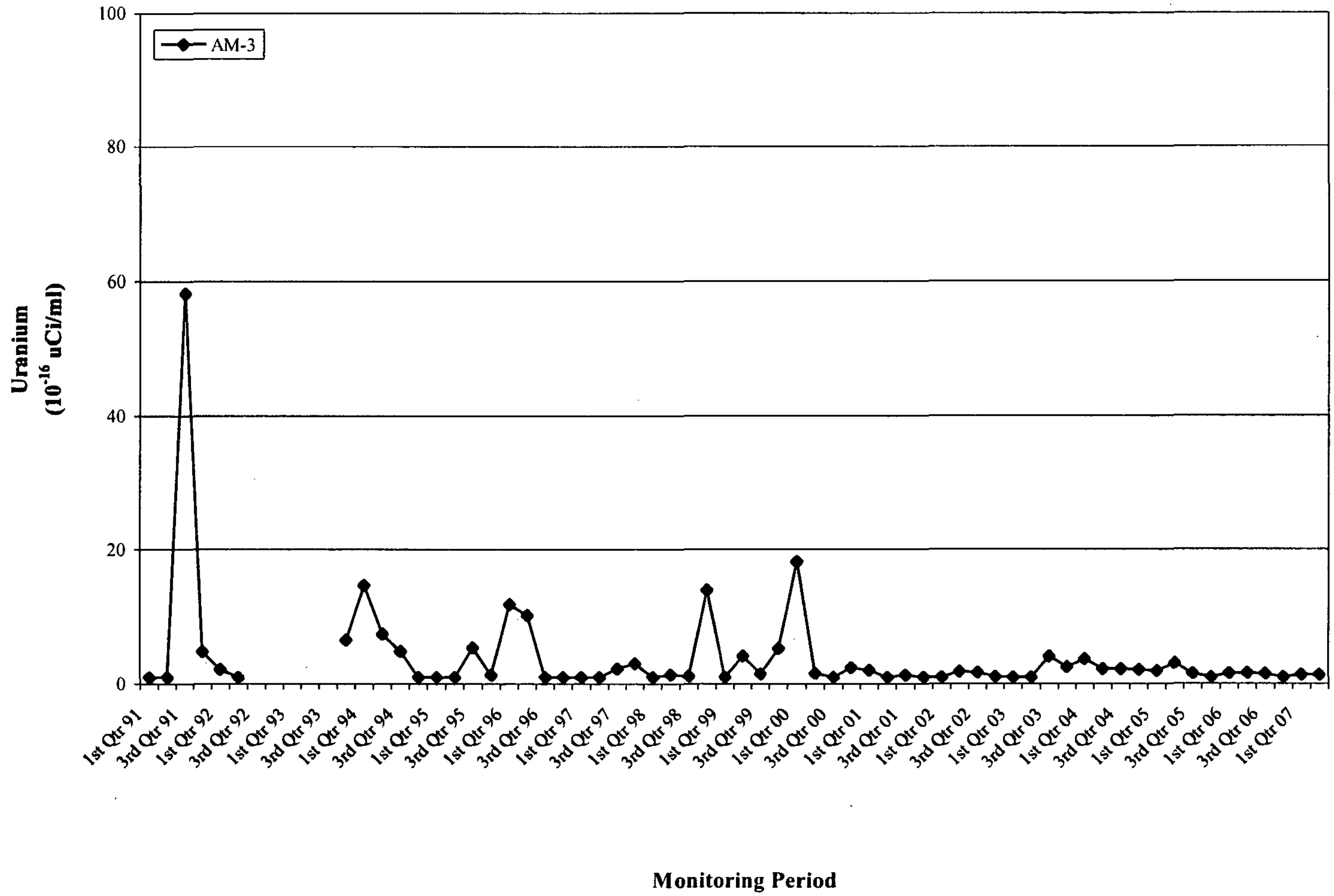


Figure 5.8-21: Airborne Uranium Environmental Monitoring AM-4 (1991 – 2007)

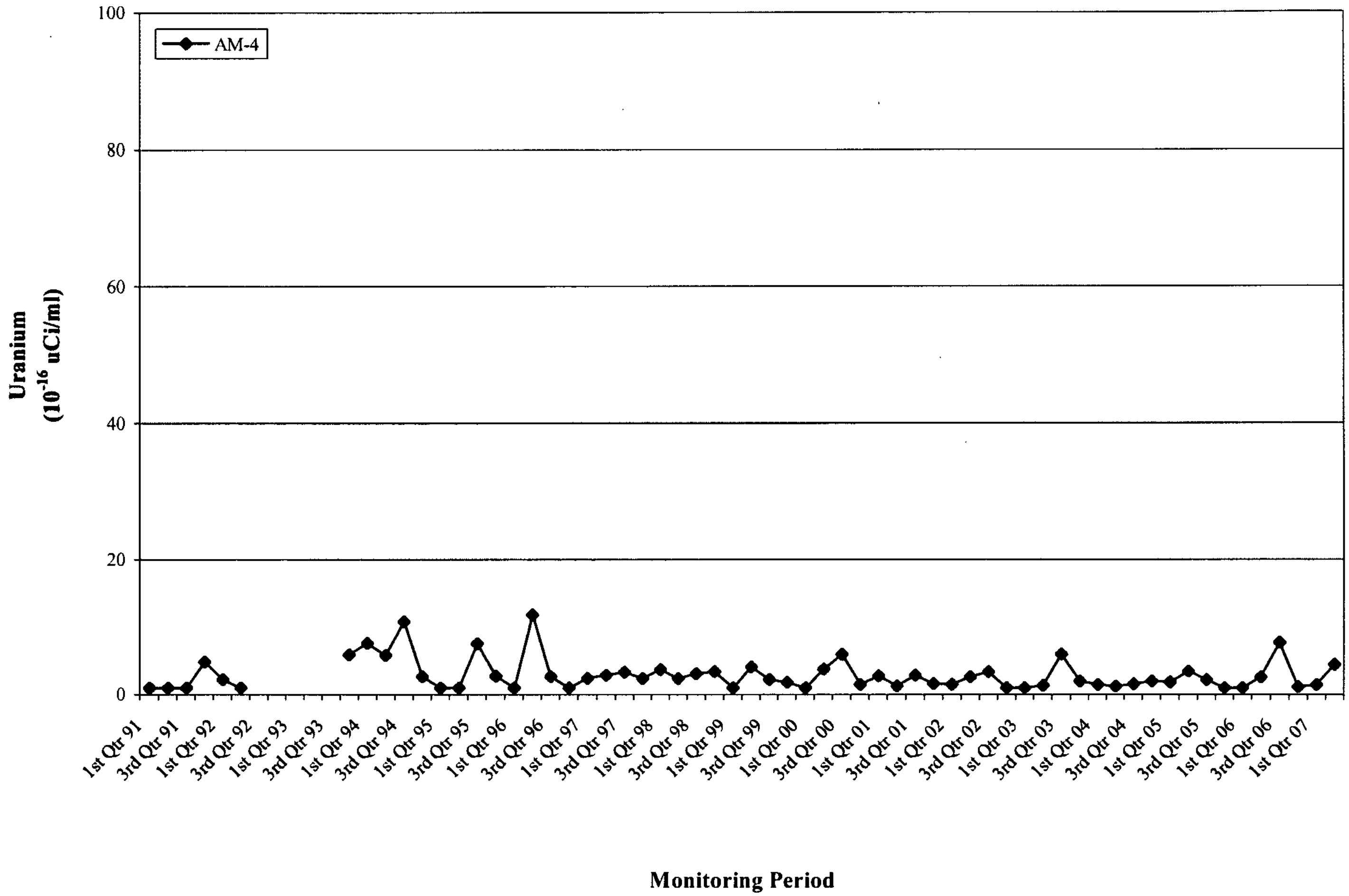


Figure 5.8-22: Airborne Uranium Environmental Monitoring AM-5 (1991 – 2007)

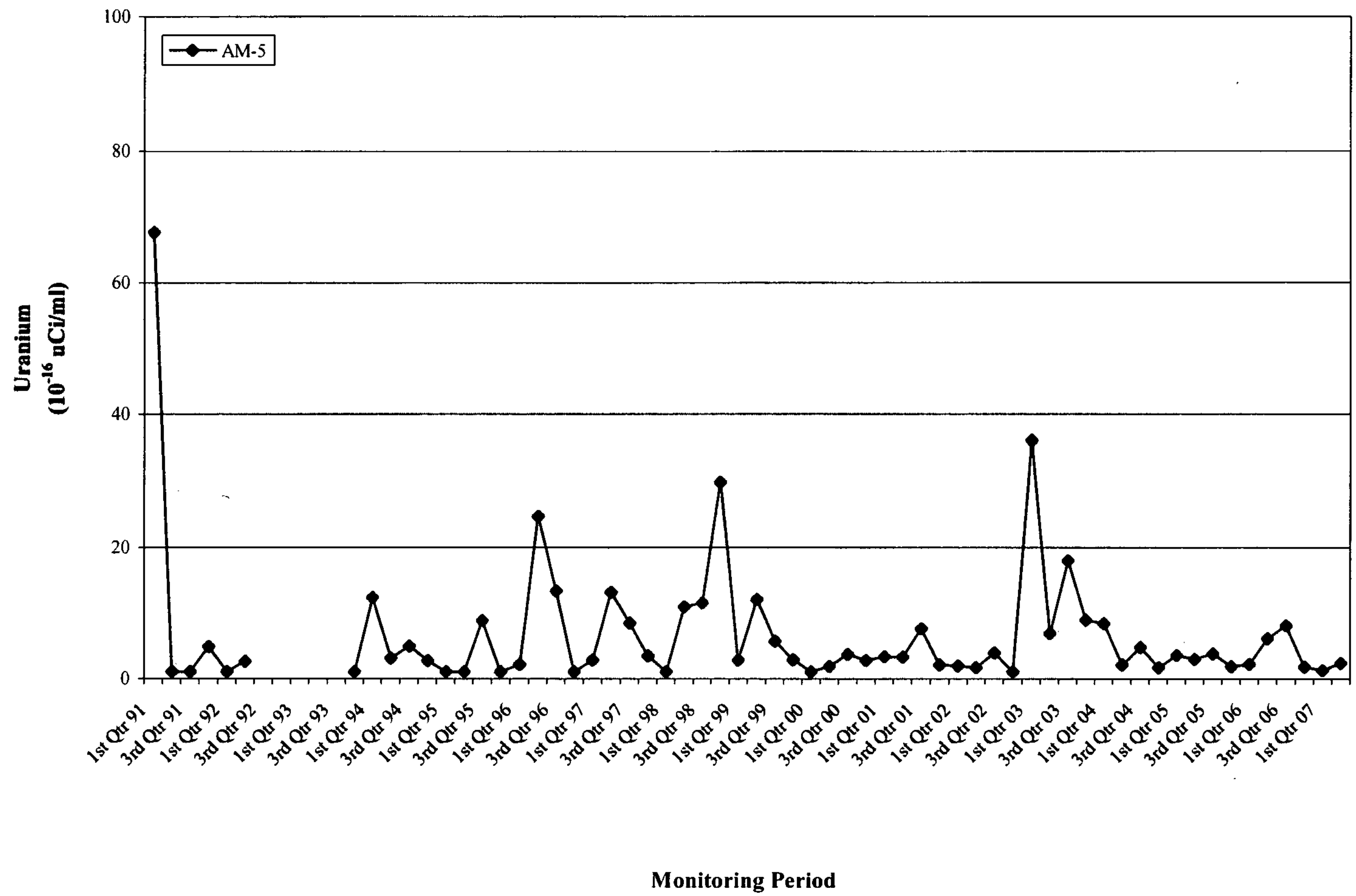


Figure 5.8-23: Airborne Uranium Environmental Monitoring AM-6 (1991 – 2007)

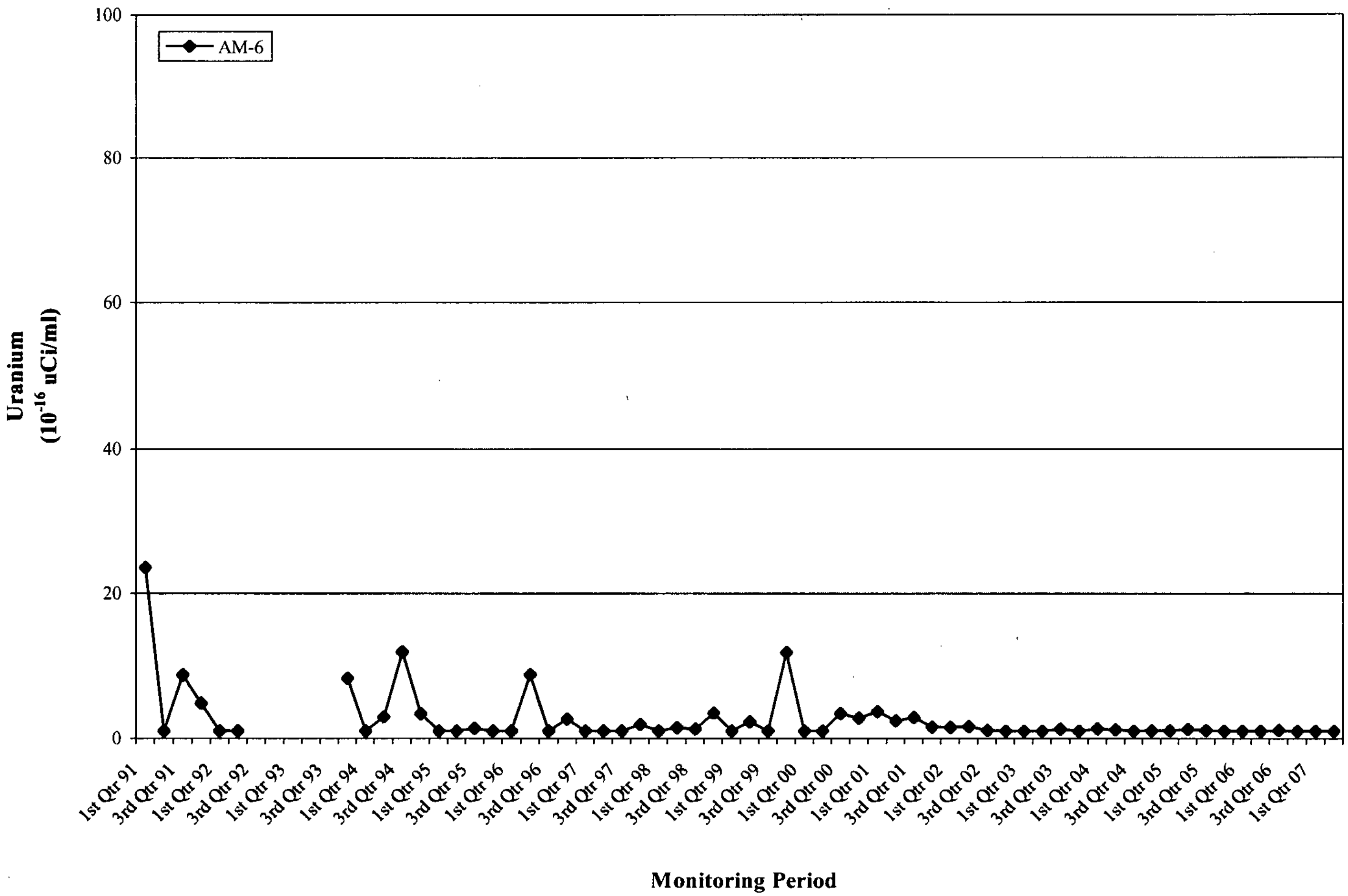
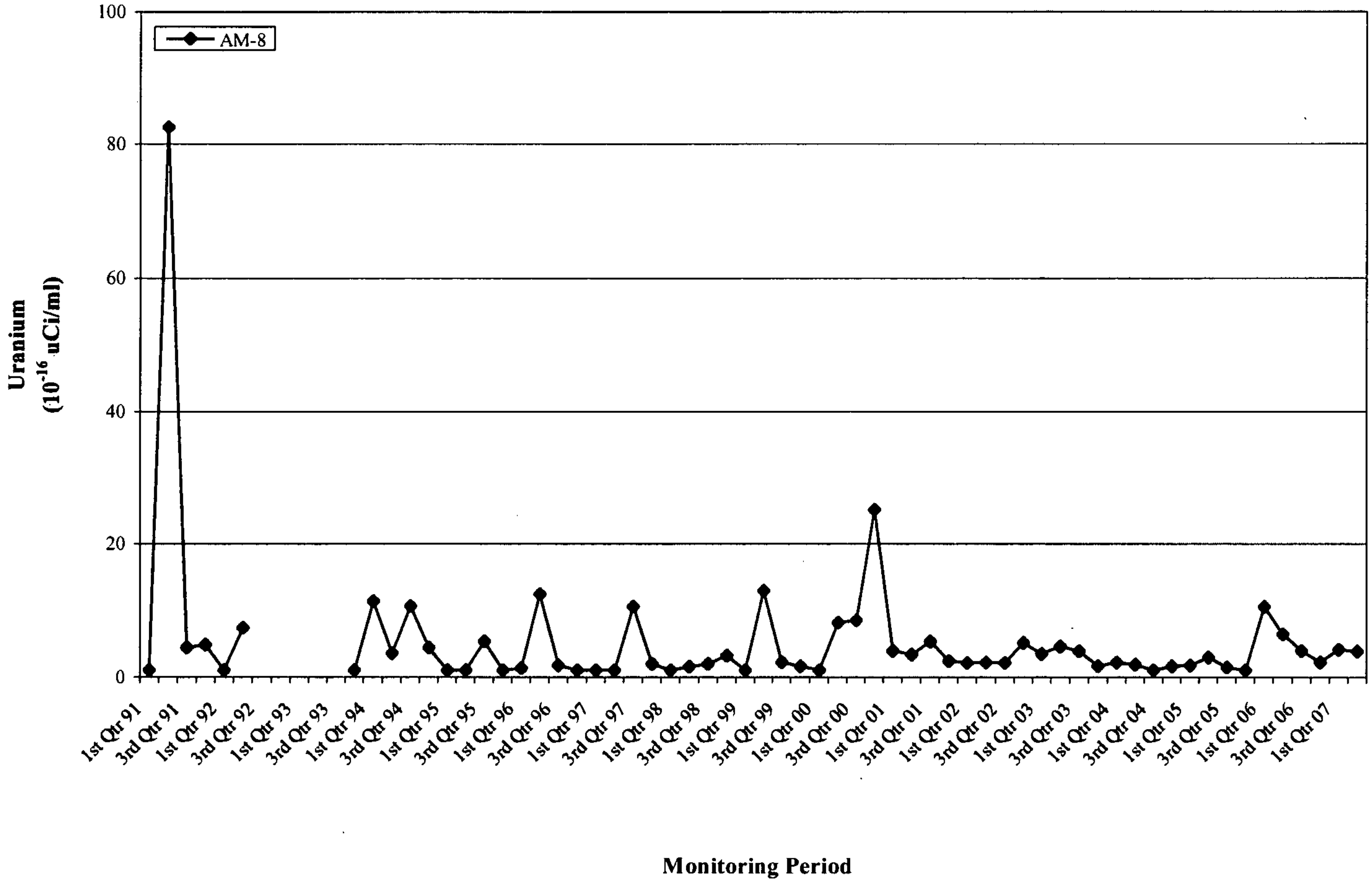


Figure 5.8-24: Airborne Uranium Environmental Monitoring AM-8 (1991 – 2007)



The 1997 LRA states that the environmental airborne particulate monitoring will be performed for 2 weeks of each month when the yellowcake dryer is in operation. CBR determined in early 2001 that increasing the sample frequency to continuously during dryer operation would provide monitoring data that would be more complete. Environmental air sampling has been performed continuously since 2001.

5.8.7.4 Surface Soil

Surface soil has been sampled as described in **Table 5.8-5**. Surface soil samples will be taken at the air monitoring locations following conclusion of operations and will be compared to the results of the preoperational monitoring program.

5.8.7.5 Subsurface Soil

Subsurface soil has been sampled at the plant as described in **Table 5.8-5.** Subsurface soil samples will be taken following conclusion of operations and will be compared to the results of the preoperational monitoring program.

5.8.7.6 Vegetation

Vegetation samples from Crow Butte Project were collected annually in animal grazing areas in the direction of the prevailing wind. Sampling was normally performed during the summer months. The samples were collected using the following procedures:

A minimum of 1 pound of vegetation was composited on three occasions during the grazing season. The materials collected were primarily the seed/flower head and leafy portions of grasses and forbes along with young shoots of shrubs. Vegetation was analyzed for natural uranium, radium-226, thorium-230, lead-210, and polonium-210. The results of annual vegetation sampling at the Crow Butte Project facility are presented in **Table 5.8-9**. Vegetation sampling was discontinued with the license renewal in 1998.

Table 5.8-9: Annual Vegetation Sampling Program Results*

Sample Date	U-Natural µCi/kg	Ra-226 µCi/kg	Th-230 µCi/kg	Pb-210 µCi/kg	Po-210 µCi/kg
6/9/92	2.90E-06	2.16E-06	< 1.00E-07	1.14E-04	6.44E-06
7/10/92	4.06E-06	9.67E-06	< 9.67E-08	5.98E-05	2.76E-06
8/13/92	1.47E-05	2.71E-06	9.34E-09	7.34E-05	9.43E-06
6/23/93	7.30E-06	1.80E-06	< 7.50E-08	2.30E-05	< 3.80E-07
7/20/93	3.90E-06	< 3.10E-08	< 3.10E-08	1.40E-05	< 1.60E-07
8/24/93	3.10E-06	1.80E-06	1.70E-08	8.30E-05	1.80E-05
6/1/94	1.60E-05	1.90E-05	< 8.00E-08	5.60E-05	5.20E-05
7/8/94	5.70E-06	1.10E-05	< 6.00E-08	2.80E-05	1.90E-05
8/1/94	1.30E-05	7.00E-07	< 4.30E-08	3.70E-05	4.40E-06

Table 5.8-9: Annual Vegetation Sampling Program Results*

Sample Date	U-Natural µCi/kg	Ra-226 µCi/kg	Th-230 µCi/kg	Pb-210 µCi/kg	Po-210 µCi/kg
6/21/95	4.60 E-6	6.00 E-6	<0.20 x E-7	33.0 E-6	3.80 E-6
7/21/95	4.01 E-6	1.02 E-05	<1,50 E-7	4.02 E-5	<7.3 E-7
8/23/95	1.6 E-5	53.0 E-7	30.0 E-7	50.0 E-6	18.0 E-6
6/19/96	9.9 E-6	3.2 E-6	1.29 E-6	10.0 E-6	<1.8 E-7
7/12/96	15 E-6	6.5 E-6	1.5 E-6	31.0 E-6	2.0 E-6
8/09/96	53.0 E-6	15.0 E-6	10.8 E-6	66.0 E-6	24.0 E-6
6/10/97	1.0 E-5	5.90 E-6	1.48 E-6	5.60 E-5	4.0 E-4
7/08/97	3.10 E-5	4.20 E-6	1.27 E-6	6.5- E-5	4.90 E-6
8/06/97	4.40 E-5	4.20 E-6	2.30 E-6	1.00 E-4	6.50 E-6

*Vegetation sampling discontinued with license renewal in 1998.

5.8.7.7 Direct Radiation

Environmental gamma radiation levels are monitored continuously at the seven air quality monitoring stations. Gamma radiation is monitored using dosimeters obtained from a qualified vendor. Environmental dosimeters are exchanged quarterly. Results of the annual gamma radiation monitoring are shown in **Table 5.8-10**. The trend data for environmental gamma monitoring between 1994 and 2007 are depicted in **Figure 5.8-25 through Figure 5.8-31**. There were elevated gamma radiation levels from 2001 through 2002 at the designated monitoring sites. However, since 2003, there were no meaningful trends noted at any of the air monitoring locations. The results noted at these sampling stations indicate no significant impact on the environment or the public.

5.8.7.8 Sediment

Sediment in Squaw and English Creeks and impoundments were sampled at upstream and downstream locations semiannually for 1 year prior to any construction in the area. Following construction, samples have been taken annually as described in **Table 5.8-5**. Samples are taken upstream and downstream of the Crow Butte Uranium Project site and analyzed for natural uranium, radium-226, thorium-230, and lead-210. The results of sediment sampling are shown in **Table 5.8-11. Figure 5.8-32** through **Figure 5.8-37** contain graphs of the results of the annual sediment analysis program between 1991 and 2006. These graphs plot the upstream and downstream locations for each creek and the inlet to the impoundments for each radioisotope.

There were no apparent trends for any sample location for any analyte. The concentrations of natural uranium in several English Creek samples were well above regional background levels. However, these elevated concentrations were noted in the English Creek drainage during preoperational monitoring, which would indicate that these levels are anomalous natural background concentrations. Composite samples obtained from E-1 and E-1 as part of the preoperational sampling program between

1982 and 1986 had average results with elevated natural uranium (3.4 pCi/g) and lead-210 (1.4 pCi/g) when compared with the other surface water sample locations. Samples obtained in 1998 before mining operations began in this area showed similar elevated uranium concentrations.

The sample locations are in a wetland are in the upper course of English Creek and downstream impoundments. The area has a large amount of organic matter and low water flows compared with the other surface water sampling locations for the project. CBR believes that the upper courses of English Creek are an area with reducing conditions that favor deposition of radionuclides. **Figure 5.8-35** is a trend graph for English Creek sediment sample points since 1998 that shows the elevated uranium concentrations noted in past sediment samples.

5.8.7.9 Proposed Airborne Effluent and Environmental Monitoring Program

CBR proposes to continue the Airborne Effluent and Environmental Monitoring Program described in this section.

5.8.8 Groundwater/Surface Water Monitoring Program

5.8.8.1 Program Description

During operations at the Crow Butte Project facilities, a detailed water sampling program is conducted to identify any potential impacts to water resources of the area. CBR's operational water monitoring program includes the evaluation of groundwater on a regional basis and groundwater within the permit or licensed area and surface water on a regional and site-specific basis. An overview of the groundwater and surface water monitoring programs at the Crow Butte Project can be found in **Table 5.8-5.**

5.8.8.2 Groundwater Monitoring

The groundwater excursion monitoring program is designed to detect excursions of lixiviant into the ore zone aquifer outside of the wellfield being leached and into the overlying water bearing strata. The Pierre Shale below the ore zone is more than 1,200 feet thick and contains no water-bearing strata. Therefore, it is not necessary to monitor any water-bearing strata below the ore zone.

Table 5.8-10: Annual Gamma Monitoring Results (mREM)

Date	1000 Cont	1001 AM-1	1002 AM-2	1003 AM-6	1005 R&D	1006 Well	1007 Well	1008 AM-8	1009 AM-3	1010 AM-4	1011 AM-5	1012 Comm
4/24/91	23.8	30.2	30.6	30	29.2	31.8	34	28	28.2	31.2	33	
7/11/91	27.6	29.4	27.6	26.6	28.6	32.2	31.6	27.4	30	30.2	28.2	30.6
10/10/91	23.8	30.8	27.2	25.8	29.6	34.4	31.4	23.2	30.8	30.2	29.2	29
1/14/92	36.2	43.2	43.4	46.6	44	41.4	54.8	41.6	45.2	41.8	46.6	40.4
4/16/92	26.6	30	31.8	30.6	29.8	34	34	41.8		34.2	35	32.2
7/9/92	34.6	30.4	29.6	31	32	33	32.4	29.8	32.6	30.2	33.2	31
10/14/92	35.8	31.4	32.6	30	31.2	30.4	33.4	27.4	36.2	31.6	30.6	33
1/13/93	36.4	28.2	33.4	32.6	35	35.4	39.8	35.4	33.6	30.4	35.6	31.2
4/16/93	42.6	38.4	34	33.6	37	35.8	40.6	33.2	32.4	36.8	36.8	33.6
7/13/93	43.6	29.2	31.6	30.8	29.8	34.4	34.4	31	31.6	25.8	33.6	30.8
10/11/93	39.8	29	27.2	27.6	31.6	29.8	32.8	26.4	31.4	30	28	26.4
1/14/94	49.4	35.8	32	34.2	34.4	38.4	33.8	32.2	33.2	29.8	32.2	44.4
4/15/94	46.8	33	32.6	42.2	32.2	27.2	40	36.2	40.2	16.4	39.4	35.4
7/19/94	59.2	35.8	37	36.8	38.6	42.6	45.8	36	38.2	43.2	40	41.2
10/14/94	57.2	29.8	29.4	39.6	38.8	16	32.8	32.2	36.8	35.8	39.2	37.2
4/03/95	46.4	34.2	31.2	33.8	34.8	36.8	36.6	30.6	30.2	34.4	32.2	33.0
7/05/95	43.2	30.0	29.8	27.8	28.0	32.4	32.2	23.4	21.4	25.8	27.0	25.4
10/02/95	49.4	40.0	34.8	33.2	30.0	39.4	33.8	37.4	35.6	37.8	34.6	37.0
1/02/96	40.8	24.6	24.6	25.0	12.0	26.4	28.0	24.6	25.4	23.2	26.2	24.2
4/01/96	44.8	29.2	28.2	32.2	29.4	30.4	30.2	29.2	30.4	32.2	31.8	25.8
7/01/96	46.2	35.0	31.2	33.0	33.2	36.8	35.8	30.6	34.2	30.6	31.2	32.2
10/01/96	35.2	35.4	36.0	34.2	32.8	37.4	36.2	30.8	33.2	35.4	37.4	32.4
1/02/97	51.8	32.6	31.4	32.6	28.6	40.6	0.0	31.6	30.0	33.6	30.0	34.2
4/01/97	45.0	28.2	28.2	31.2	26.0	30.8	31.6	26.8	27.4	18.2	29.4	29.2

Table 5.8-10: Annual Gamma Monitoring Results (mREM)

Date	1000 Cont	1001 AM-1	1002 AM-2	1003 AM-6	1005 R&D	1006 Well	1007 Well	1008 AM-8	1009 AM-3	1010 AM-4	1011 AM-5	1012 Comm
7/01/97	50.0	40.2	29.0	31.0	30.6	32.8	32.6	28.2	29.6	29.4	30.0	31.6
10/01/97	60.4	31.6	33.0	31.8	29.8	30,4	30.8	30.0	35.2	29.2	32.2	32.0
1/02/98	56.8	34.4	32.0	29.6	32.8	37.2	32.8	32.2	34.8	34.0	36.6	30.6
4//01/98	48.0	29.8	34.3	34.2	30.2	33.4	30.3	31.8	31.4	33.6	30.0	30.6
7/01/98	63.4	34.6	36.0	37.4	-	-	-	36.2	38.0	34.4	35.4	-
10/01/98	61.2	26.6	27.4	33.8	-	-	-	25.8	34.8	29.2	31.0	-
1/05/99	67.6	33.8	35.8	35.2	-	-	-	38.0	35.0	34.4	29.0	-
4/01/99	72.2	36.8	33.8	27.0	-	-	-	35.2	34.6	31.0	40.0	-
7/01/99	53.8	29.4	29.4	27.0	-	-	-	29.2	28.8	25.0	29.2	-
10/04/99	57.8	25.0	29.0	26.2	-	-	-	26.0	21.6	24.8	27.6	-
1/04/00	52.2	28.0	32.2	28.6	-	-	-	31.2	32.4	30.0	32.6	-
4/03/00	70.2	35.2	34.8	36.4	-	-	-	38.8	36.2	30.8	34.2	-
7/05/00	67.8	29.6	32.2	31.4	-	-	-	36.4	32.8	30.2	29.4	-
10/15/00	75.2	30.8	30.6	30.2	-	-	-	33.0	30.8	30.8	32.0	-
1/18/01	54.2	32.6	26.0	27.4	-	-	-	28.6	-	27.4	29.4	-
4/16/01	53.8	33.6	34.6	35.0	-	-	-	35.6	35.4	35.8	38.8	-
7/09/01	77.6	55.4	54.6	55.0	-	-	-	59.4	57.2	55.6	58.0	-
10/04/01	71.6	41.8	42.8	44.0	-	-	-	44.2	45.8	43.2	45.8	-
1/09/02	81.2	47.4	47.6	45.0	-	-	-	48.4	45.2	45.2	47.0	-
4/08/02	84.0	36.6	35.4	41.0	-	-	-	44.2	40.6	41.0	42.6	-
7/08/02	41.8	49.2	49.2	51.4	-	-	-	51.4	52.8	52.0	51.0	-
10-03/02	25.4	34.6	32.0	33.8	-	-	-	40.2	38.2	44.0	34.8	-
1/07/03	44.2	49.0	47.4	49.0	-	-	-	51.6	49.6	50.8	52.0	-
4/03/03	44.8	52.2	48.6	62.6	-	-	-	52.0	49.4	a	49.6	-

Table 5.8-10: Annual Gamma Monitoring Results (mREM)

Date	1000 Cont	1001 AM-1	1002 AM-2	1003 AM-6	1005 R&D	1006 Well	1007 Well	1008 AM-8	1009 AM-3	1010 AM-4	1011 AM-5	1012 Comm
7/11/03	37.4	42.0	43.0	44.2	-	-	-	46.8	45.0	43.8	47.0	-
10/03/03	33.8	43.6	44.0	39.0	-	-	-	45.0	44.0	43.2	45.4	-
1/08/04	40.6	51.0	49.6	46.4	-	-	-	51.0	49.0	48.6	48.2	-
4/05/04	40.8	45.8	44.6	48.0	-	-	-	49.4	45.8	48.6	48.8	-
7/13/04	34.2	42.2	42.6	43.0	-	-	-	43.8	41.4	43.8	45.4	-
10/05/04	35.0	45.0	42.8	45.2	-	-	-	44.8	46.0	43.2	43.8	-
1/06/05	40.0	52.4	49.0	49.0	-	-	-	49.8	49.0	49.2	51.2	-
4/05/05	44.2	53.8	53.6	52.4	-	-	-	55.6	55.0	53.0	53.0	-
7/08/05	25.6	36.4	33.4	40.6	-	-	-	36.4	36.6	36.4	39.4	-
10/06/05	35.6	40.6	41.4	40.6	-	-	-	42.4	41.4	37.8	32.0	-
1/06/06	33.6	41.6	40.0	b	-	-	-	40.6	41.2	42.2	42.4	-
4/06/06	31.6	36.4	37.8	36.4	-	-	-	39.2	41.0	39.2	39.8	-
7/05/06	28.4	35.0	35.2	35.8	-	-	-	36.8	38.0	32.0	35.8	-
10/05/06	20.2	25.8	27.0	25.2	-	-	-	28.8	28.0	27.6	26.8	-
1/05/07	27.2	34.8	31.8	33.0	-	-	-	35.0	35.0	32.6	35.4	-
4/05/07	33.0	39.0	48.0	38.4	-	-	-	41.0	39.0	38.8	39.0	-
7/06/07	24.0	29.0	29.6	30.2	-	-	-	29.0	28.8	28.4	27.2	-

Sample Locations: 1000: Control
1005: R&D Pond Gate
1006: Wellfield
1007: Wellfield
1012: Commercial Pond Gate

[a]Received damage by laboratory.
[b]Dosimeter not returned to laboratory.

Figure 5.8-25: Environmental Gamma Monitoring AM-1 (1991 – 2007)

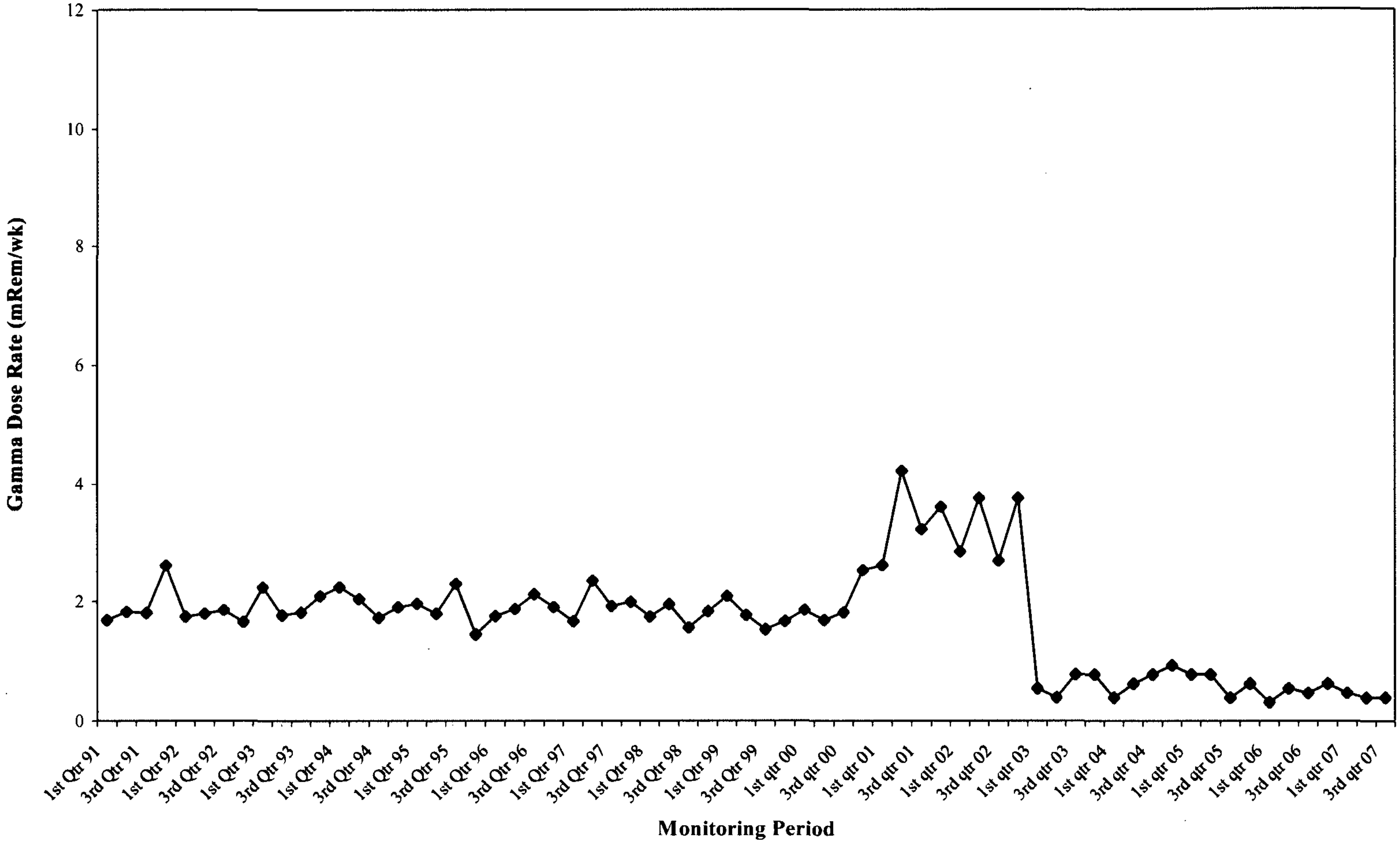


Figure 5.8-26: Environmental Gamma Monitoring AM-2 (1991 – 2007)

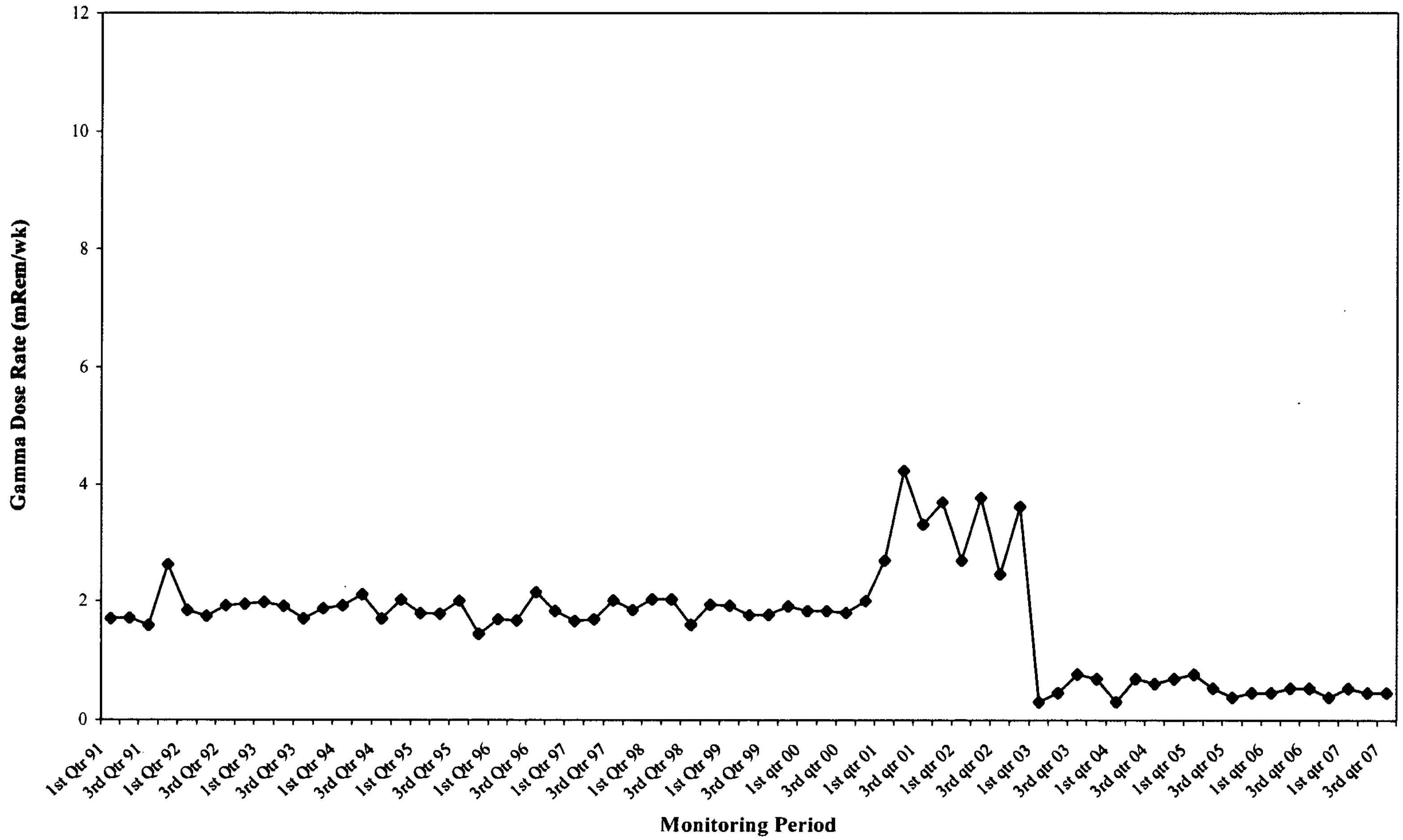


Figure 5.8-27: Environmental Gamma Monitoring AM-3 (1991 – 2007)

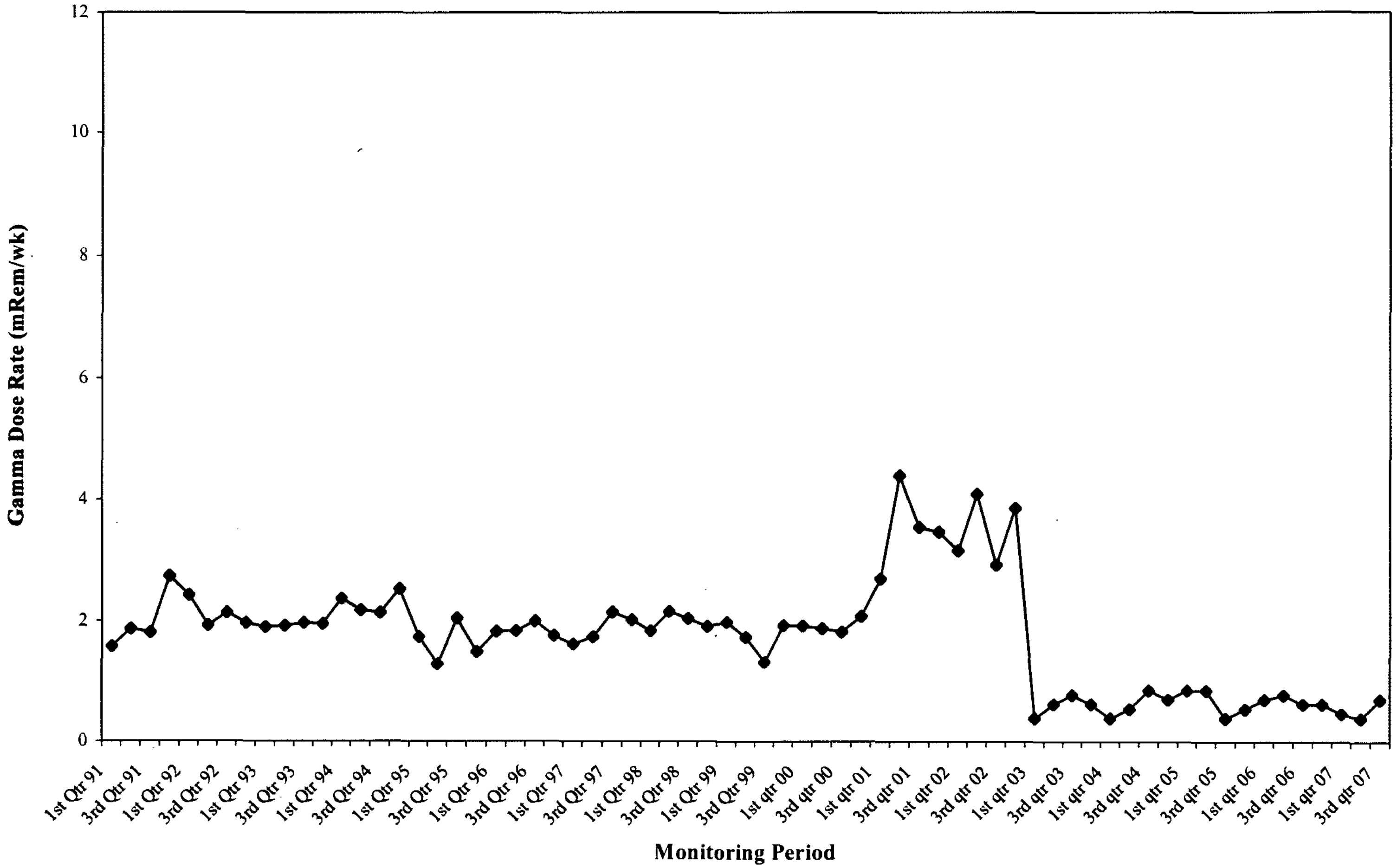


Figure 5.8-28: Environmental Gamma Monitoring AM-4 (1991 – 2007)

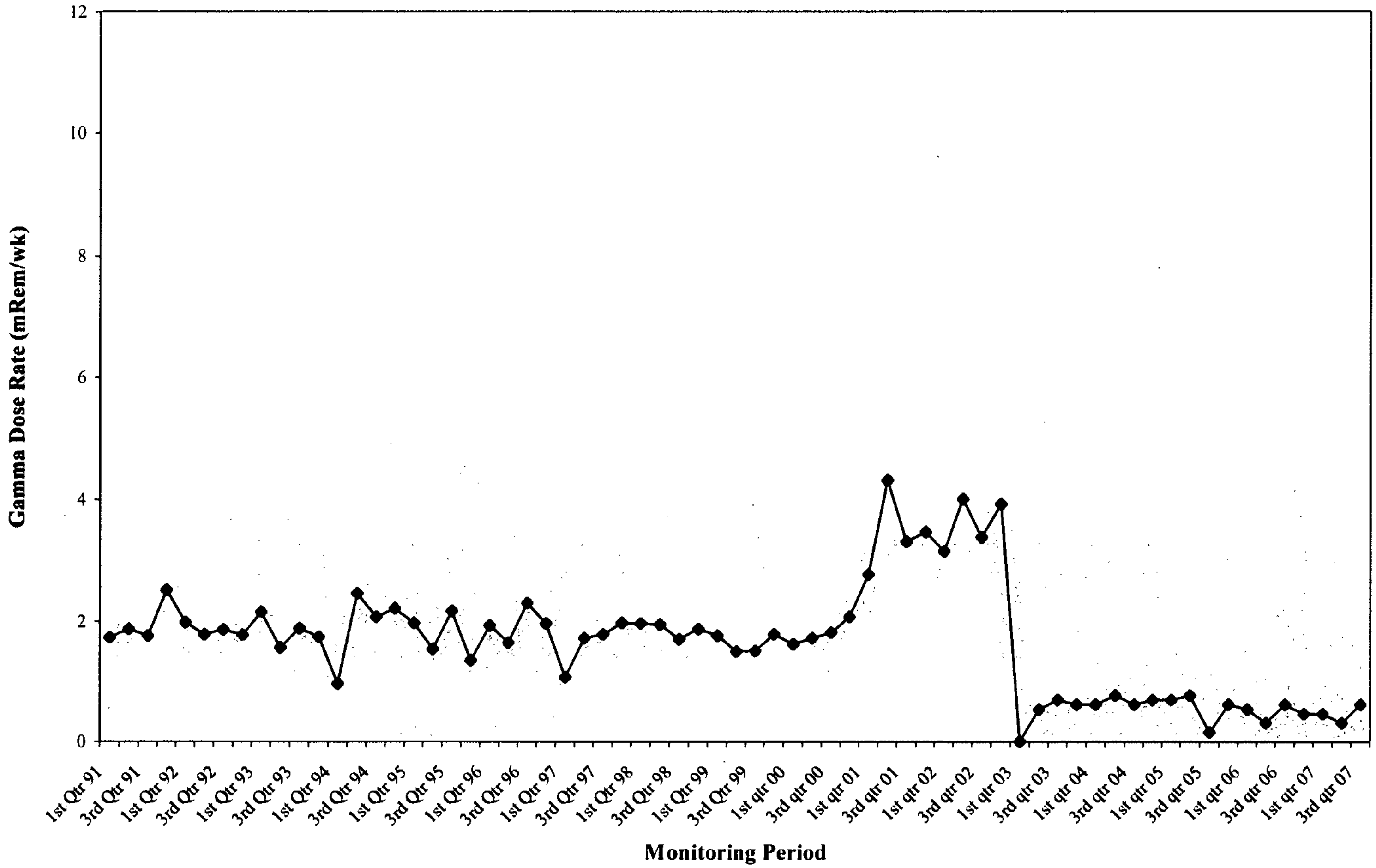


Figure 5.8-29: Environmental Gamma Monitoring AM-5 (1991 – 2007)

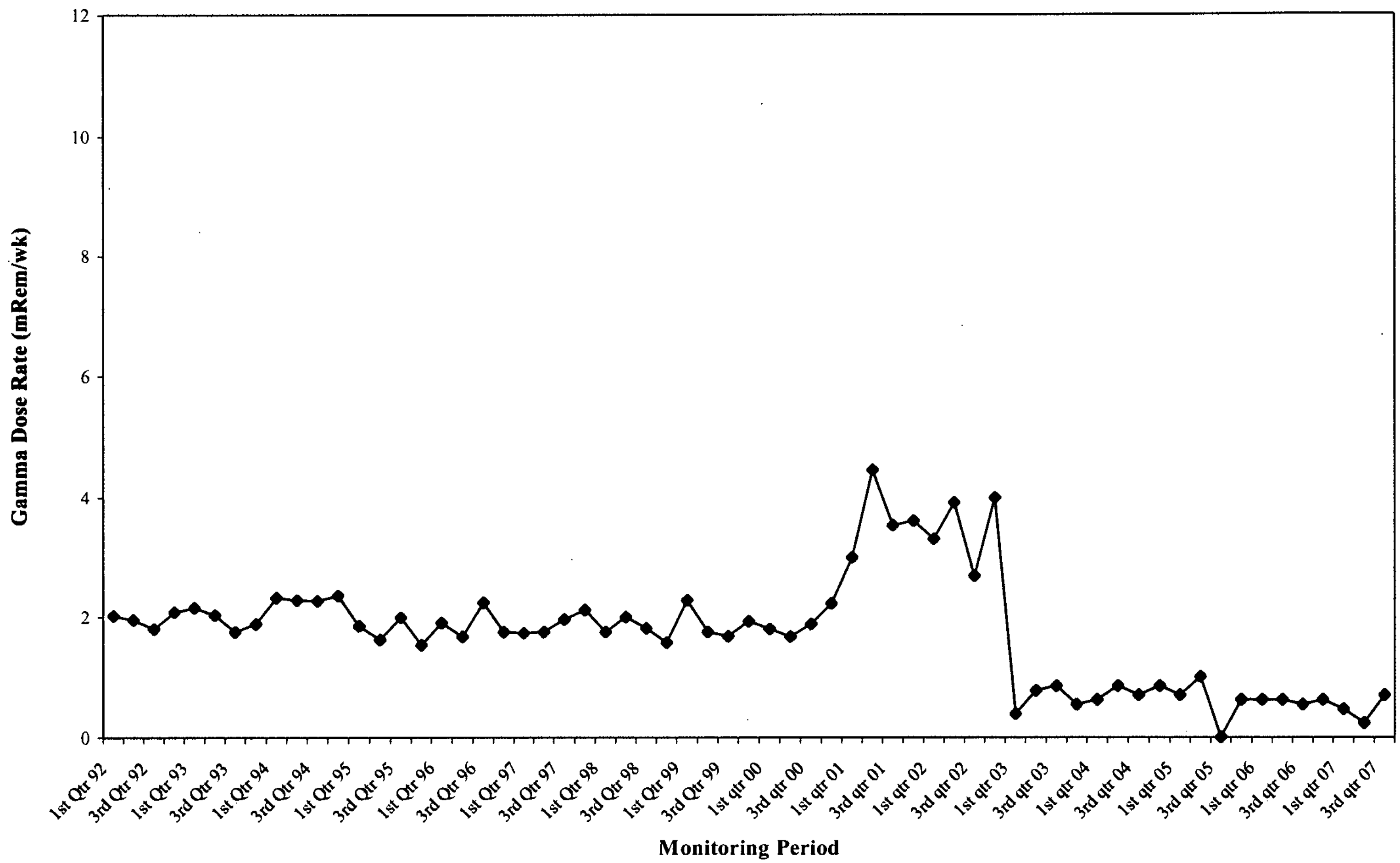


Figure 5.8-30: Environmental Gamma Monitoring AM-6 (1991 – 2007)

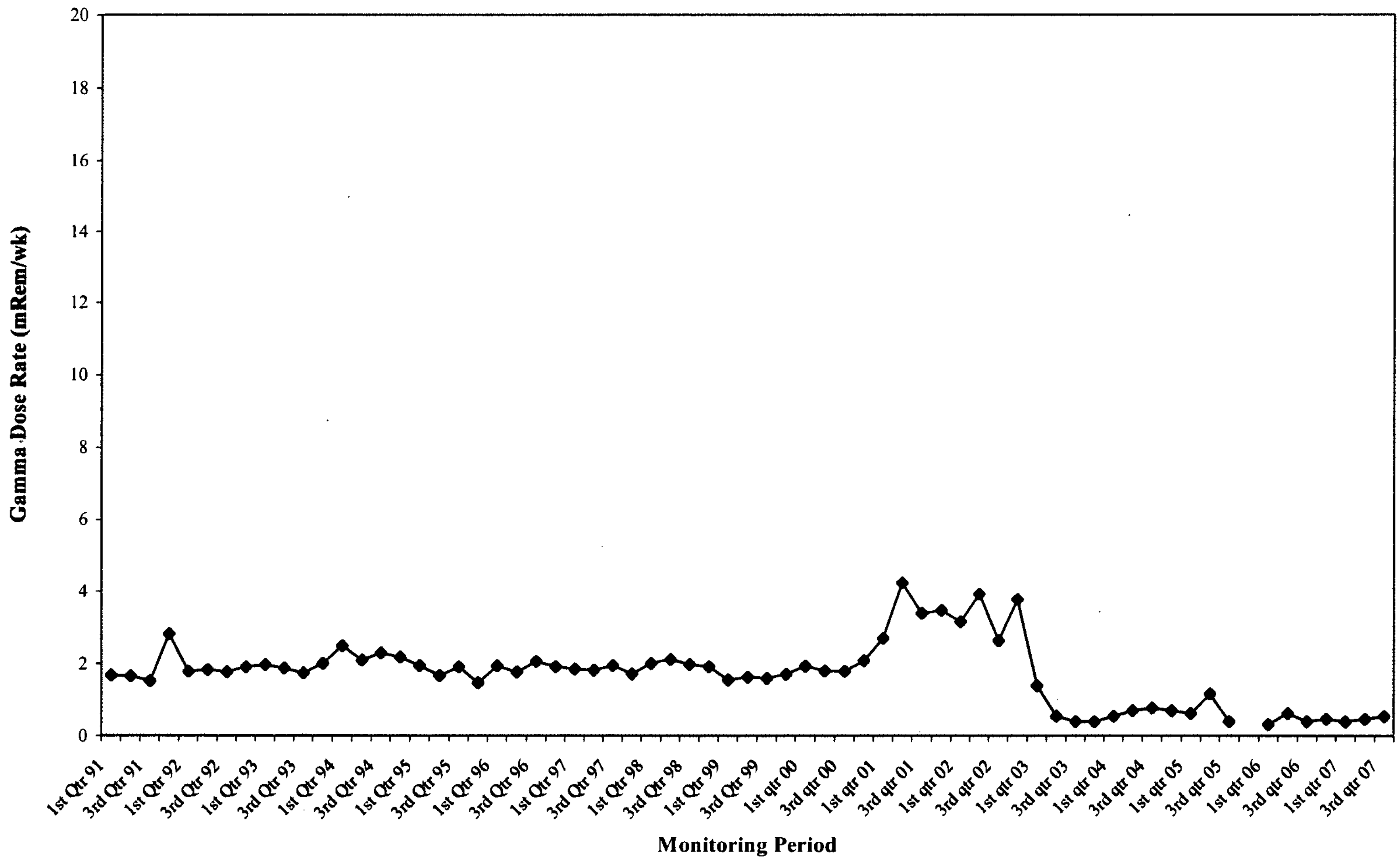


Figure 5.8-31: Environmental Gamma Monitoring AM-8 (1991 – 2007)

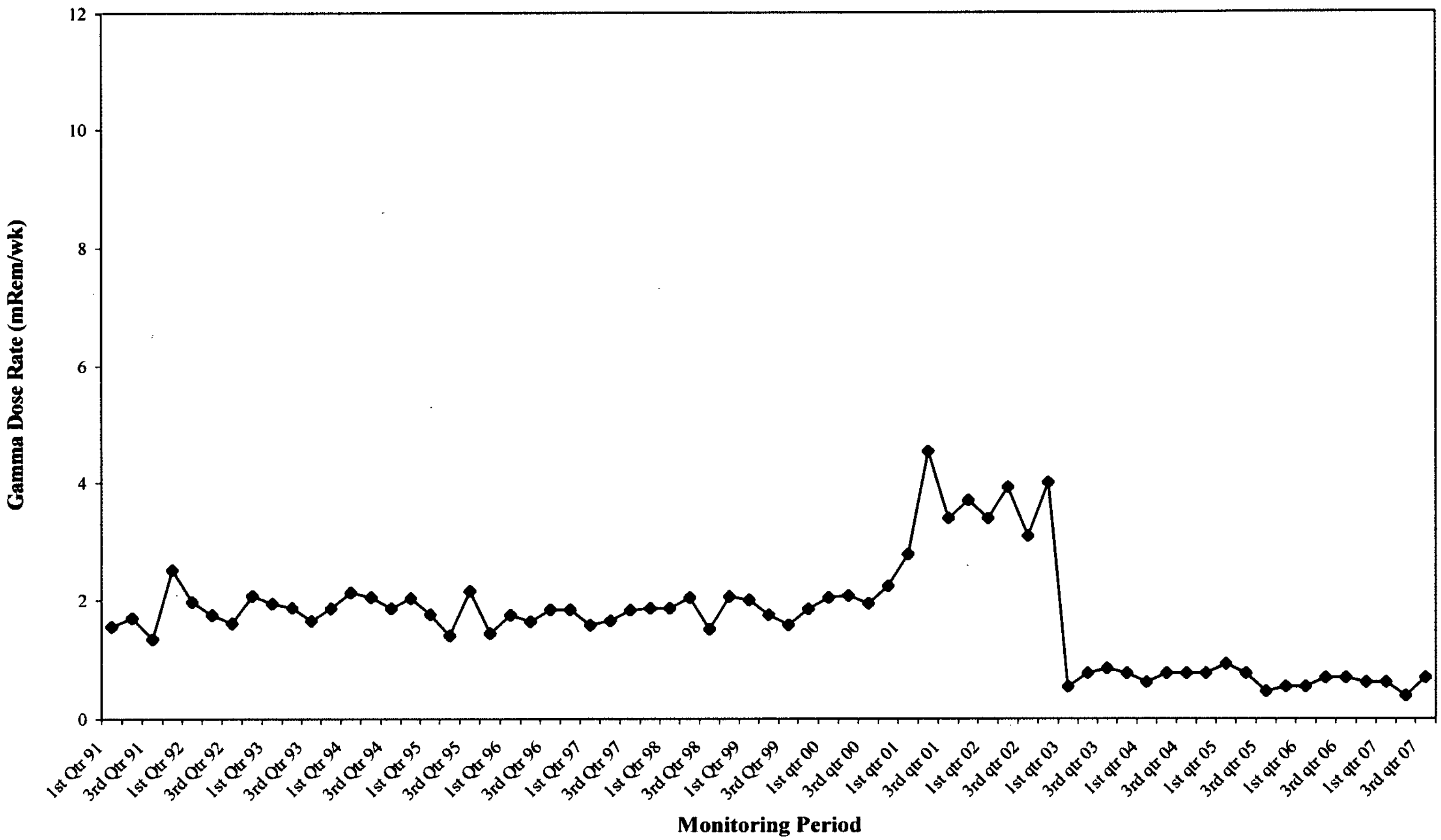


Table 5.8-11: Annual Sediment Sampling Results

Station	Date	U-Natural pCi/g	Radium-226 pCi/g	Th-230 pCi/g	Pb-210 pCi/g
S-1	10/20/99	0.48	0.37	-	<0.05
	10/30/00	0.38	0.31	-	<0.05
	10/17/01	0.44	0.61	-	0.87
	11/08/02	0.43	0.4	-	ND
	11/14/03	0.9	0.4	-	ND
	11/08/04	0.05	0.40	-	ND
	11/07/05	0.66	0.3	-	ND
	10/20/06	1.04	0.6	-	1.3
S-2	11/5/92	0.5	0.1		
	11/5/93	< 0.2	0.7	< 0.2	0.3
	10/13/94	0.5	0.4	0.4	1.9
	10/05/95	0.7	0.4	0.3	0.1
	10/10/96	0.4	0.4	0.2	<0.1
	10/16/97	0.48	0.4	0.22	0.7
	10/20/99	0.71	0.43	-	<0.05
	10/30/00	0.33	0.35	-	<0.05
	10/17/01	0.49	0.44	-	ND
	11/08/02	0.39	0.4	-	ND
	11/14/03	1.1	0.4	-	0.5
	11/08/04	0.03	0.40	-	ND
	11/07/05	0.49	0.6	-	ND
	10/20/06	0.57	0.5	-	0.3
S-3	11/5/92	0.3	0.1		
	11/5/93	0.1	0.4	< 0.2	0.3
	10/13/94	0.3	0.4	< 0.2	1.4
	10/05/95	0.5	0.8	0.2	<0.1
	10/10/96	1.1	0.6	0.3	0.7
	10/16/97	0.56	0.6	0.32	0.8
	10/30/00	0.31	0.37	-	<0/05
S-5	10/20/99	0.55	0.39	-	<0.05`
	10/17/01	0.45	0.51	-	0.48
	11/08/02	0.39	0.2	-	ND
	11/14/03	0.5	0.4	-	0.5
	11/08/04	0.03	0.40	-	ND
	11/07/05	0.47	0.6	-	ND
	10/20/06	0.24	0.3	-	ND
E-1 & E-2 Composite	10/20/99	3.70	0.85	-	1.40
	10/30/00	1.66	0.63	-	<0.05

Table 5.8-11: Annual Sediment Sampling Results

Station	Date	U-Natural pCi/g	Radium-226 pCi/g	Th-230 pCi/g	Pb-210 pCi/g
E-1	10/17/01	0.45	0.62	-	0.44
	11/08/02	2.11	0.70	-	ND
	11/14/03	5.5	0.60	-	ND
	11/08/04	0.13	0.09	-	ND
	11/07/05	2.94	0.80	-	ND
	10/23/06	1.81	0.90	-	0.40
E-4	10/20/99	6.30	0.64	-	1.32
	10/30/00	2.13	0.35	-	<0.05
	10/17 01	2.83	0.53	-	0.45
E-5	11/08/02	0.87	0.50	-	ND
	11/14/03	1.20	0.40	-	ND
	11/08/04	0.11	0.50	-	1.4
	11/07/05	1.64	0.7	-	1.4
	10/20/06	2.58	0.90	-	1.0
Impoundment I-3	11/08/02	1.09	0.70	-	ND
	11/14/03	1.70	0.60	-	ND
	11/08/04	0.13	0.50	-	ND
	11/07/05	6.25	0.1	-	ND
	10/20/06	5.85	1.0	-	1.6
Impoundment I-4	11/08/02	4.16	0.50	-	ND
	11/14/03	10.5	0.60	-	ND
	11/08/04	0.07	0.60	-	ND
	11/07/05	4.07	0.60	-	ND
	10/20/06	13.6	0.50	-	1.6

Notes:
- Denotes that no analysis was done for the listed parameter.
ND – Non-detect [0.2 pCi/g – dry]

Figure 5.8-32: Squaw Creek Sediment Uranium Concentration 1991 – 2006

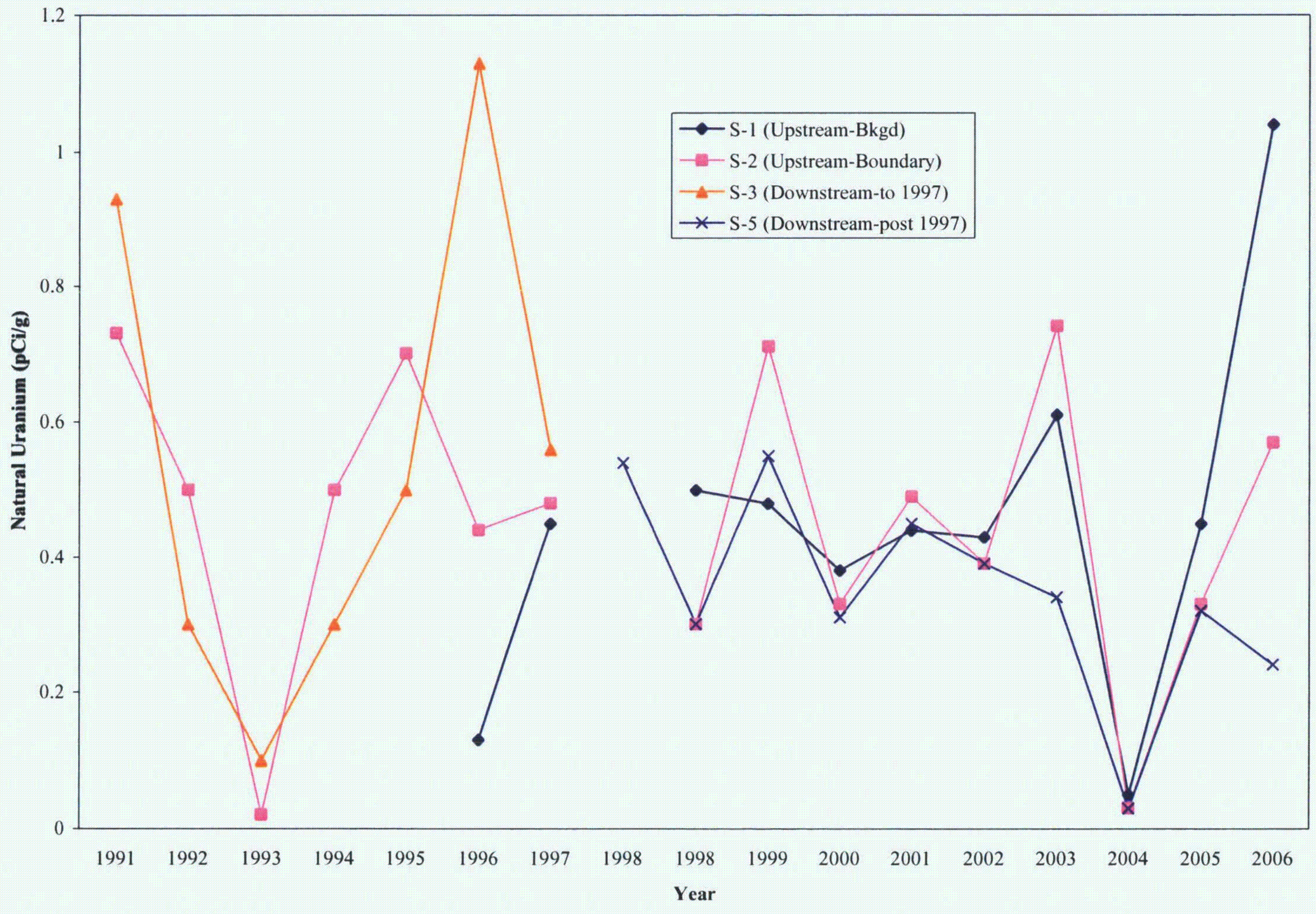


Figure 5.8-33: Squaw Creek Sediment Radium Concentration 1991 – 2006

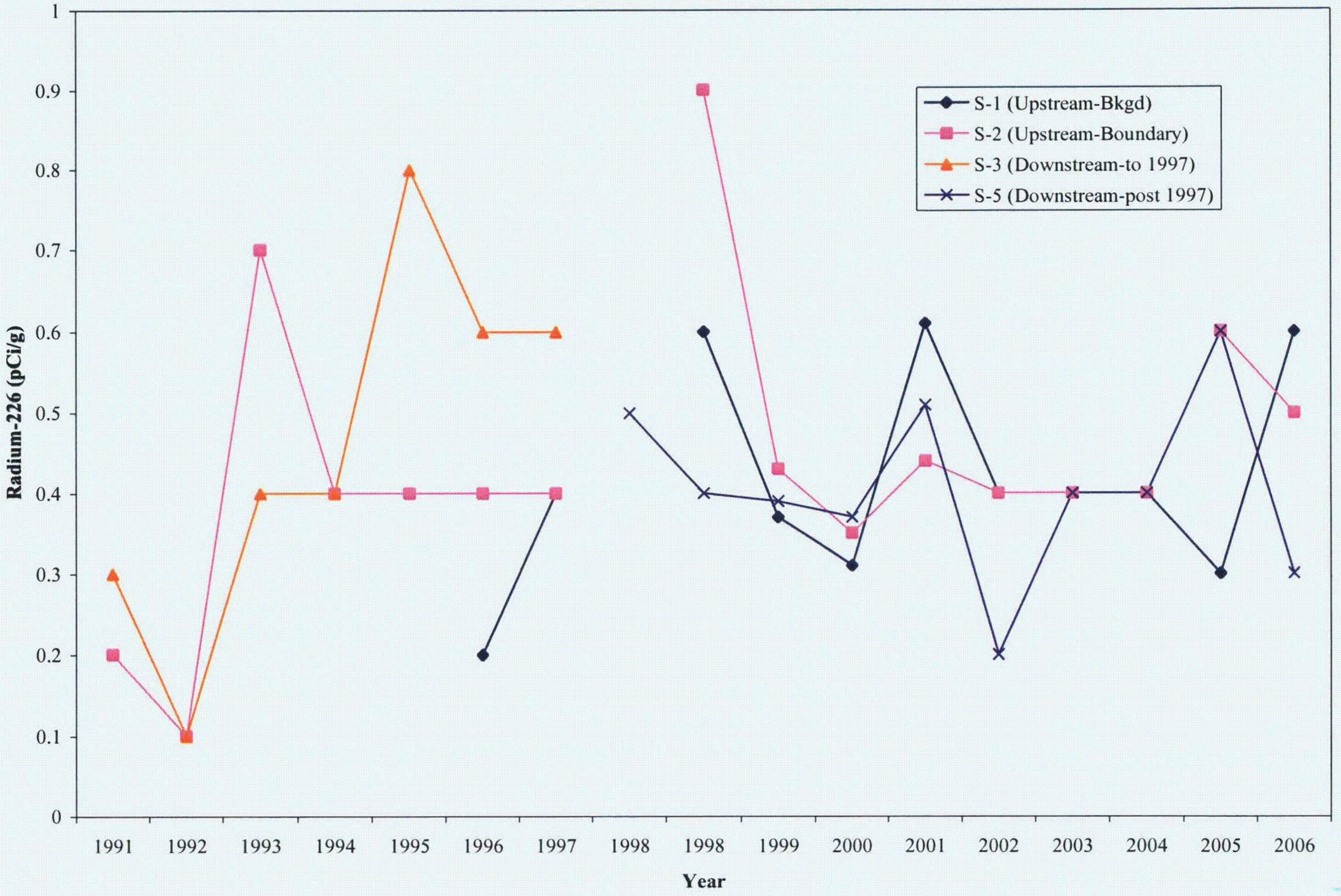


Figure 5.8-34: Squaw Creek Sediment Lead-210 Concentration 1991 – 2006

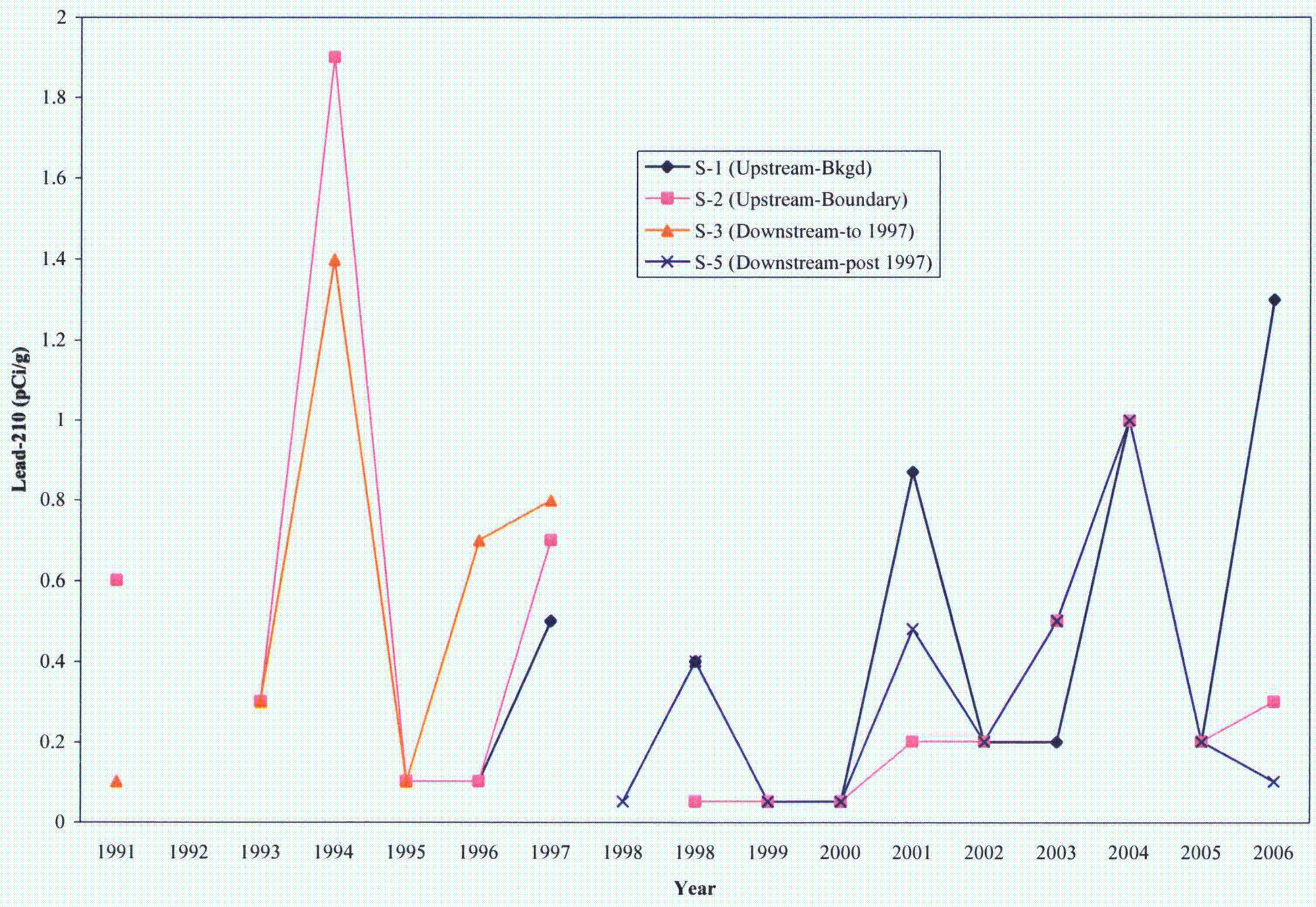


Figure 5.8-35: English Creek Sediment Uranium Concentration 1998 – 2006

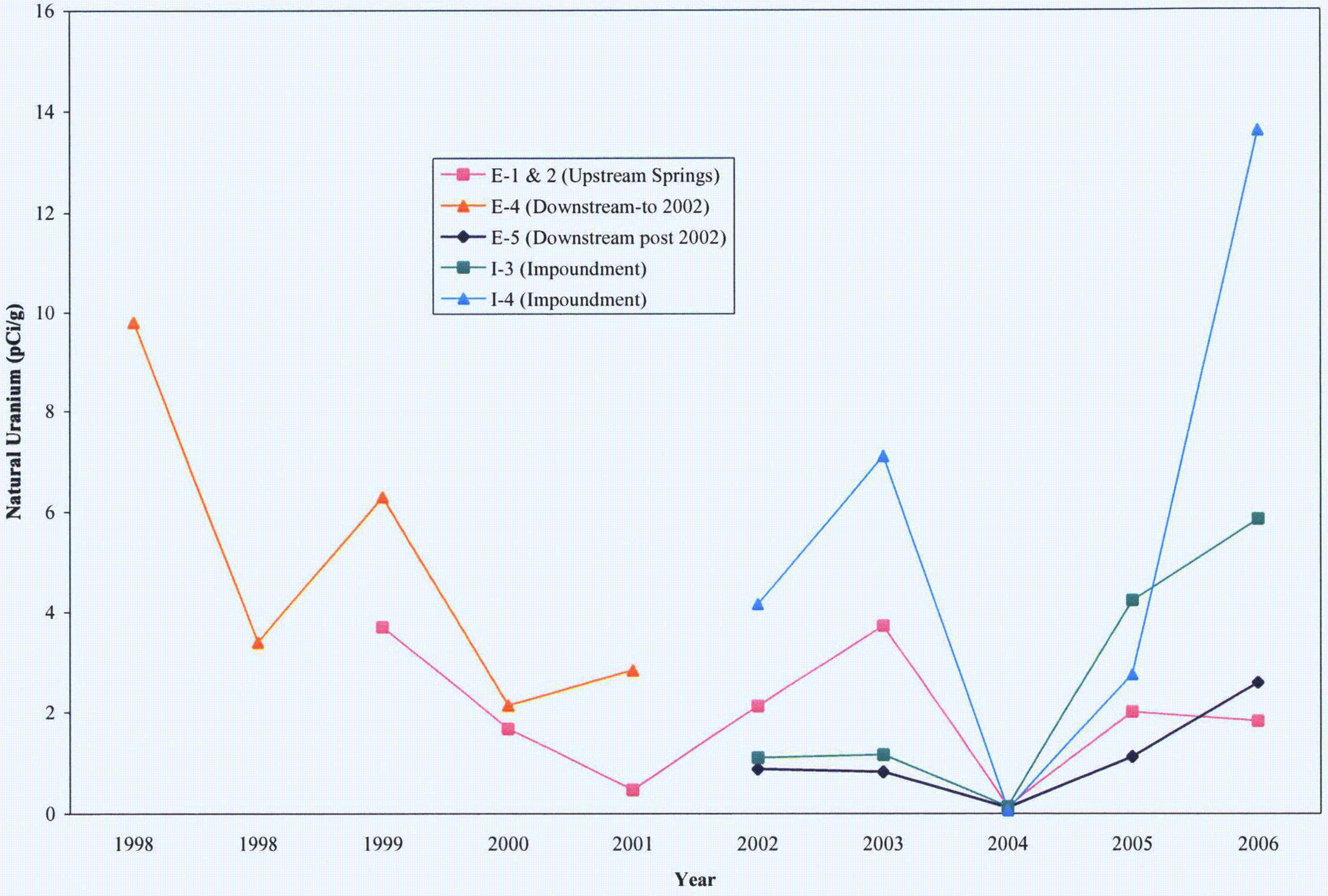


Figure 5.8-36: English Creek Sediment Radium Concentration 1998 – 2006

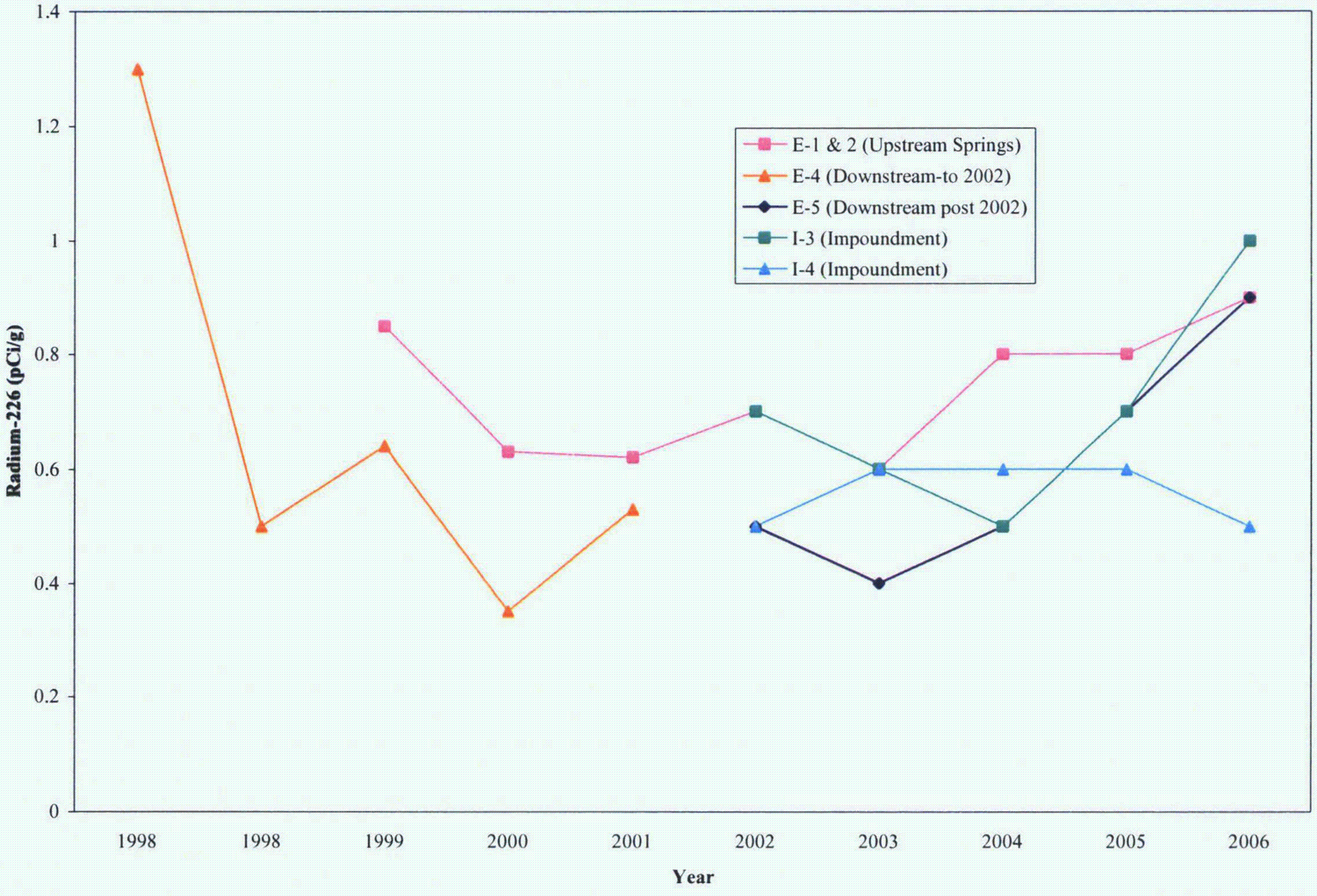
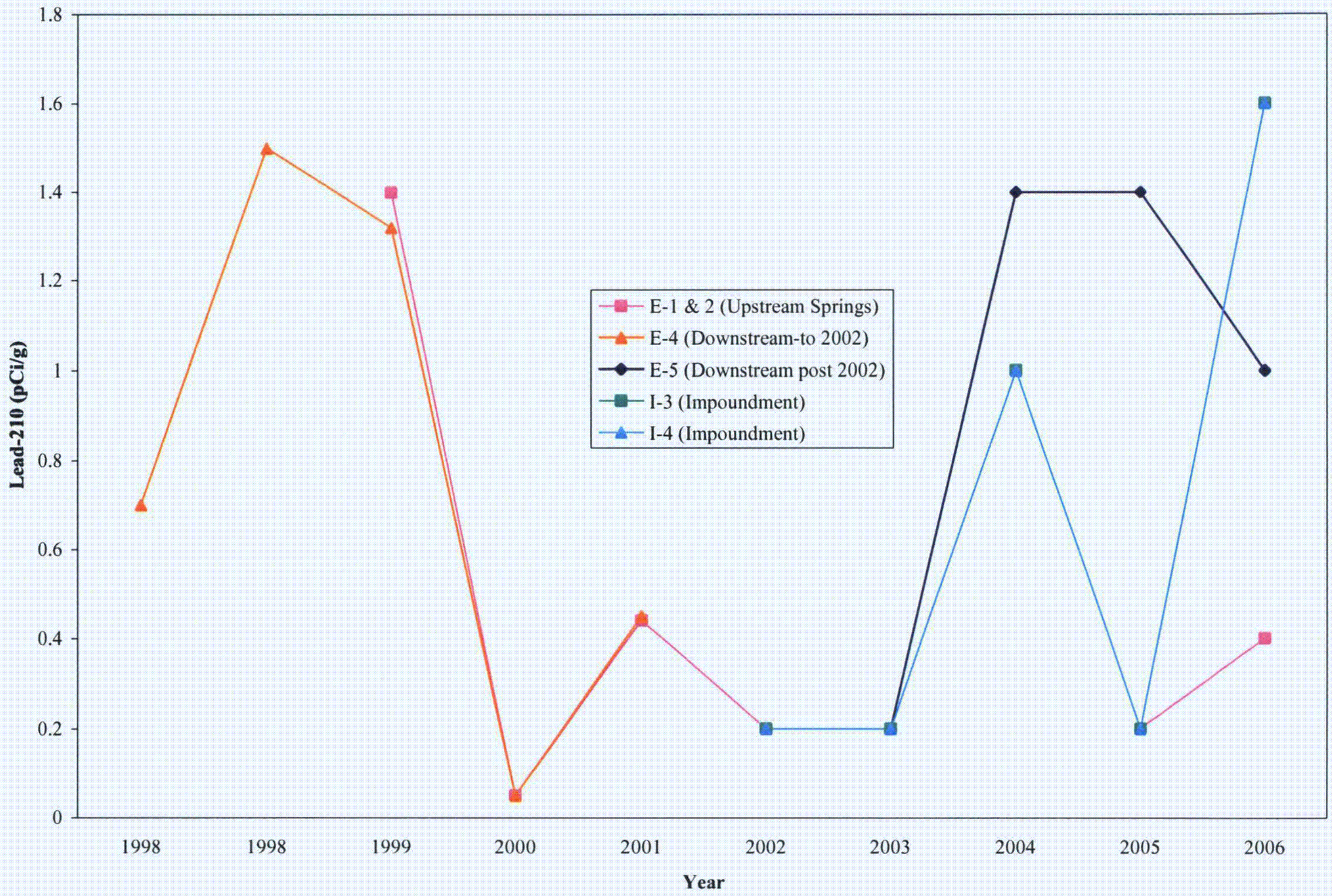


Figure 5.8-37: English Creek Sediment Lead-210 Concentration 1998 – 2006



Tables 5.8-12 through **5.8-15** summarizes all private wells and surface waters within 1 kilometer of the wellfield area boundary are sampled quarterly. Surface water samples are taken in accordance with the instructions contained in EHSMS Program Volume VI, *Environmental Manual*. Samples are analyzed for natural uranium and radium-226. The most current results of this sampling for uranium are shown in **Table 5.8-12** for private wells and **Table 5.8-14** for surface waters. The results for radium are shown in **Tables 5.8-13** for private wells and **5.8-15** for surface waters. The maximum allowable uranium and radium concentration as specified by Nebraska Department of Environmental Quality (NDEQ) Title 118 – Ground Water Quality Standards and Use Classification, are 5 piC/L and 0.030 mg/L respectively. All sampling results reported have been well below the maximum allowable concentrations for uranium and radium.

Monitor Well Baseline Water Quality

After delineation of the production unit boundaries, monitor wells are installed approximately 300 feet from the wellfield boundary. After completion, wells are washed out and developed (by air flushing or pumping) until water quality in terms of pH and specific conductivity appear stable and consistent with the anticipated quality of the area. After development, wells are sampled to obtain baseline water quality. For baseline sampling, all wells are purged until field parameters are stable. Quarterly monitor well results for uranium are shown in **Table 5.8-14** and for radium in **Table 5.8-15**. All monitor wells including ore zone and overlying monitor wells are sampled three times at least 14 days apart. The first, second, and third samples are analyzed for the excursion indicator parameters (chloride, conductivity, and alkalinity).

Results from the samples are averaged arithmetically to obtain a baseline value as well as an average value for determine upper control limits for excursion detection.

Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, upper control limits (UCLs) are set for certain chemical constituents that would indicate a migration of lixiviant from the well field. The parameters and constituents chosen for indicators of lixiviant migration and for which UCLs are set are chloride, conductivity, and total alkalinity. Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a highly mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion, as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, levels were not used as an excursion indicator. All wells are purged until field parameters are stable prior to collection of the sample. Upper control limits are set at 20 percent above the maximum baseline concentration for the excursion indicator. For excursion indicators with a baseline average below 50 mg/L, the UCL may be determined by adding 5 standard deviations or 15 mg/L to the baseline average for the indicator.

Operational monitoring consists of sampling the monitor wells no more than 14 days apart and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. In special circumstances, including inclement weather, wellhead mechanical failure, conditions which place an employee at risk while sampling, and conditions which could cause damage to the environment if sampling was performed, the sampling could be delayed by a period not to exceed 5 days. The circumstances requiring postponement of the sampling will be documented.

Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, or if one UCL value is exceeded by 20 percent, the well is resampled within 48 hours and analyzed for the excursion indicators. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second nor third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the USNRC Project Manager is notified by telephone within 48 hours and notified in writing within 30 days.

If an excursion is verified, the following methods of corrective action are instituted (not necessarily in the order given; depending on the circumstances):

- A preliminary investigation is completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well are adjusted as necessary to increase the net over recovery, thus forming a hydraulic gradient toward the production zone.
- Individual wells are pumped to enhance recovery of mining solutions.

Injection into the well field area adjacent to the monitor well may be suspended. Recovery operations continue, thus increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status is increased to weekly. An excursion is considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion for three consecutive 1-week samples.

Table 5.8-12: Private Wells Water Monitoring Results Uranium Analysis (mg/L)

Date Sampled	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #41	Well #63	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Drinking Water Well
Mar-91	-	-	-	-	0.0036	0.0045	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun-91	-	-	-	-	0.0140	0.0030	-	-	-	0.0030	0.0030	-	-	-	-	-	-	-	-
Sep-91	-	-	-	-	0.0049	0.0059	-	-	-	0.0059	0.0069	-	-	-	-	-	-	-	-
Dec-91	-	-	-	-	0.0041	0.0062	-	-	-	0.0021	0.0052	-	-	-	-	-	-	-	-
Mar-92	-	-	-	-	0.0050	0.0070	-	-	-	0.0050	0.0040	-	-	-	-	-	-	-	-
Jun-92	-	-	-	-	0.0040	0.0040	-	-	-	0.0040	0.0040	-	-	-	-	-	-	-	-
Sep-92	-	-	-	-	0.0080	0.0100	-	-	-	0.0100	0.0100	-	-	-	-	-	-	-	-
Dec-92	-	-	-	-	0.0200	0.0080	-	-	-	<0.0003	<0.0003	-	-	-	-	-	-	-	-
Mar-93	-	-	-	-	0.0100	<0.0003	-	-	-	<0.0003	0.0070	-	-	-	-	-	-	-	-
Jun-93	-	-	-	-	<0.0003	< 0.0003	-	-	-	<0.0003	<0.0003	-	-	-	-	-	-	-	-
Sep-93	-	-	-	-	0.0130	0.0020	-	-	-	0.0030	0.0020	-	-	-	-	-	-	-	-
Dec-93	-	-	-	-	0.0080	0.0120	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Mar-94	-	-	-	-	0.0250	0.0070	-	-	-	0.0070	0.0050	-	-	-	-	-	-	-	-
Jun-94	-	-	-	-	0.0050	0.0070	-	-	-	0.0050	0.0140	-	-	-	-	-	-	-	-
Sep-94	-	-	-	-	0.0030	0.0080	-	-	-	0.0050	0.0040	-	-	-	-	-	-	-	-
Dec-94	-	-	-	-	0.0050	0.0070	-	-	-	0.0060	0.0060	-	-	-	-	-	-	-	-
Mar-95	-	-	-	-	0.0100	0.0100	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Jun-95	-	0.0080	-	0.0050	0.0060	0.0090	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Sep-95	-	0.0088	-	0.0060	0.0058	0.0076	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Dec-95	-	0.0070	-	0.0050	0.0050	0.0090	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Mar-96	-	0.0091	-	0.0058	0.0058	0.0095	-	-	-	0.0067	0.0093	-	-	-	-	-	-	-	-
Jun-96	-	0.0074	-	0.0370	0.0037	0.0080	-	-	-	0.0064	0.0100	-	-	-	-	-	-	-	-
Sep-96	0.0200	0.0090	-	0.0060	0.0070	0.0100	-	-	-	0.0080	0.0100	-	-	-	-	-	-	-	-
Dec-96	0.0140	0.0040	-	0.0047	0.0052	0.0027	-	-	-	0.0063	0.0024	-	-	-	-	-	-	-	-
Mar-97	0.0100	0.0065	-	0.0016	0.0036	0.0073	-	-	-	0.0062	0.0018	-	-	-	-	-	-	-	-
Jun-97	0.0110	0.0071	-	0.0012	0.0031	0.0054	-	-	-	0.0030	0.0048	-	-	-	-	-	-	-	-
Sep-97	0.0190	0.0067	-	0.0052	0.0059	0.0078	-	-	-	0.0044	0.0067	-	-	-	-	-	-	-	-
Dec-97	0.0140	0.0078	-	0.0037	0.0040	0.0084	-	-	-	0.0058	0.0082	-	-	-	-	-	-	-	-
Mar-98	0.0139	0.0078	-	0.0041	0.5100	0.0076	-	-	-	0.0057	0.0076	-	-	-	-	-	-	-	-
Jun-98	0.0160	0.0086	-	0.0047	0.0057	0.0078	0.0068	0.0086	0.0127	0.0063	0.0081	-	-	-	-	-	-	-	-
Sep-98	0.0230	0.0100	-	0.0057	0.0062	0.0081	0.0073	0.0075	0.0140	0.0067	0.0100	-	-	-	-	-	-	-	-
Dec-98	0.0140	0.0085	-	0.0047	0.0057	0.0081	0.0064	0.0069	0.0133	0.0096	0.0067	-	-	-	-	-	-	-	-
Mar-99	0.0150	0.0085	-	0.0047	0.0054	0.0072	0.0063	0.0079	0.0130	0.0062	0.0099	-	-	-	-	-	-	-	-
Jun-99	0.0140	0.0086	-	0.0046	0.0061	0.0076	0.0067	0.0062	0.0120	0.0057	0.0085	-	-	-	-	-	-	-	-
Sep-99	0.0160	0.0087	-	0.0049	0.0057	0.0087	0.0075	0.0075	0.0110	0.0061	0.0086	-	-	-	-	-	-	-	0.0076
Dec-99	0.0043	0.0086	0.0042	0.0048	0.0057	0.0000	0.0071	0.0069	0.0130	0.0069	0.0089	-	-	-	-	-	-	-	0.0084
Mar-00	0.0200	0.0093	0.0039	0.0051	0.0062	0.0076	0.0000	0.0086	0.0150	0.0068	0.0094	-	-	-	-	-	-	-	0.0000
Jun-00	0.0160	0.0092	0.0037	0.0055	0.0068	0.0080	0.0000	0.0097	0.0160	0.0072	0.0093	-	-	-	-	-	-	-	0.0079
Sep-00	0.0170	0.0097	0.0047	0.0054	0.0057	0.0079	0.0066	0.0079	0.0140	0.0067	0.0100	-	-	-	-	-	-	-	0.0078
Dec-00	0.0200	0.0096	0.0044	0.0053	0.0061	0.0081	0.0000	0.0075	0.0130	0.0066	0.0090	-	-	-	-	-	-	-	0.0082

Table 5.8-12: Private Wells Water Monitoring Results Uranium Analysis (mg/L)

Date Sampled	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #41	Well #63	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Drinking Water Well
Mar-01	0.0162	0.0100	0.0042	0.0000	0.0067	0.0084	0.0082	0.0100	0.0160	0.0074	0.0100	-	-	-	-	-	-	-	0.0110
Jun-01	0.0190	0.0087	0.0033	0.0000	0.0056	0.0071	0.0068	0.0097	0.0190	0.0065	0.0076	-	-	-	-	-	-	-	0.0076
Sep-01	0.0166	0.0099	0.0029	0.0049	0.0058	0.0075	0.0068	0.0080	0.0155	0.0061	0.0081	-	-	-	-	-	-	-	0.0073
Dec-01	0.0170	0.0095	0.0047	0.0053	0.0058	0.0092	0.0073	0.0081	0.0154	0.0070	0.0090	-	-	-	-	-	-	-	0.0079
Mar-02	0.0163	0.0085	0.0044	0.0046	0.0054	0.0076	WI	0.0116	0.0174	0.0079	0.0086	0.0046	-	-	-	-	-	-	0.0079
Jun-02	0.0177	0.0098	WI	0.0051	0.0063	0.0078	WI	WI	0.0173	0.0078	0.0087	0.0053	-	-	-	-	-	-	0.0085
Sep-02	0.0159	0.0159	0.0024	0.0041	0.0045	0.0057	0.0052	0.0061	0.0120	0.0060	0.0065	0.0038	-	0.0125	-	-	-	-	0.0060
Dec-02	0.0155	0.0091	0.0045	0.0046	0.0053	0.0082	0.0066	0.0073	0.0142	0.0063	0.0078	0.0046	0.0087	0.0114	-	-	-	-	0.0074
Mar-03	0.0135	0.0092	0.0033	0.0045	0.0054	0.0066	0.0064	0.0072	0.0132	0.0073	0.0074	0.0045	0.0090	0.0103	0.0211	-	-	-	0.0071
Jun-03	0.0140	0.0091	0.0035	0.0048	0.0057	0.0068	0.0067	0.0088	0.0150	0.0072	0.0079	0.0049	0.0093	0.0100	0.0220	-	-	-	0.0077
Sep-03	0.0177	WI	0.0042	0.0053	0.0056	0.0076	0.0065	0.0078	0.0155	0.0061	0.0080	0.0050	0.0092	0.0100	0.0216	-	-	-	0.0071
Dec-03	0.0150	0.0090	0.0040	0.0050	0.0060	0.0090	0.0070	0.0070	0.0170	0.0060	0.0080	0.0050	0.0110	0.0120	0.0230	-	-	-	0.0070
Mar-04	0.0156	0.0089	0.0043	0.0046	0.0056	0.0077	WI	0.0072	0.0178	0.0072	0.0076	0.0046	0.0117	0.0107	0.0212	-	-	-	0.0078
Jun-04	0.0160	0.0086	0.0034	0.0047	0.0055	0.0069	WI	0.0081	0.0170	0.0073	0.0071	0.0047	0.0091	0.0099	0.0190	-	0.0190	-	0.0061
Sep-04	0.0132	0.0085	0.0036	0.0047	0.0053	0.0071	0.0057	WI	0.0164	0.0069	0.0073	0.0047	0.0085	0.0097	0.0174	0.0178	0.0096	-	0.0074
Dec-04	0.0120	0.0069	0.0035	0.0038	0.0045	0.0062	0.0054	WI	0.0150	0.0060	0.0071	0.0039	0.0076	0.0087	0.0170	0.0150	0.0091	-	0.0060
Mar-05	0.0100	0.0080	0.0030	0.0050	0.0050	0.0070	WI	WI	0.0200	0.0070	0.0080	0.0040	0.0080	0.0100	0.0200	0.0100	0.0100	-	0.0070
Jun-05	0.0100	WI	0.0040	0.0050	0.0060	0.0070	WI	WI	0.0200	0.0070	0.0070	0.0060	0.0090	0.0100	0.0200	0.0100	0.0100	-	0.0070
Sep-05	0.0160	WI	0.0043	0.0052	0.0056	0.0092	0.0067	0.0071	0.0189	0.0077	0.0075	0.0048	0.0093	0.0103	0.0183	0.0221	0.0111	-	0.0074
Dec-05	0.0150	0.0085	0.0043	0.0047	0.0054	0.0088	0.0050	WI	0.0170	0.0058	0.0065	0.0047	0.0091	0.0089	WI	0.0140	0.0111	-	0.0066
Mar-06	0.0140	0.0087	0.0032	0.0048	0.0055	0.0077	WI	WI	0.0170	0.0050	0.0063	0.0052	0.0084	0.0093	0.0180	0.0140	0.0096	-	0.0067
Jun-06	0.0150	0.0092	0.0042	0.0047	0.0055	0.0077	0.0063	WI	0.0180	0.0062	0.0071	0.0049	0.0090	0.0090	0.0170	0.0200	0.0110	-	0.0078
Sep-06	0.0150	WI	0.0044	0.0051	0.0057	0.0080	0.0067	0.0071	0.0180	0.0073	0.0075	0.0050	0.0093	0.0110	0.0190	0.0260	0.0111	-	0.0086
Dec-06	0.0170	WI	0.0049	0.0050	0.0056	0.0081	0.0066	0.0070	0.0180	0.0072	0.0077	0.0050	0.0094	0.0110	0.0180	0.0180	0.0111	-	0.0081
Mar-07	0.0160	0.0088	0.0035	WI	WI	0.0067	WI	0.0068	0.0170	0.0063	0.0075	0.0050	0.0092	0.0096	0.0180	0.0210	0.0000	0.0075	0.0078
Jun-07	0.0160	0.0091	0.0043	WI	WI	0.0065	0.0064	0.0075	0.0170	0.0069	0.0073	0.0061	0.0094	0.0090	0.0180	0.0210	0.0120	0.0083	0.0078

Notes:

WI = Well Inoperable

- = Sample not taken

Table 5.8-13: Private Wells Water Monitoring Results Radium Analysis (mg/L)

Date Sampled	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #41	Well #63	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Drinking Water Well
Mar-91	-	-	-	-	2.0000	3.2000	-	-	-	-	-	-	-	-	-	-	-	-	-
Jun-91	-	-	-	-	2.3000	0.5000	-	-	-	3.2000	1.8000	-	-	-	-	-	-	-	-
Sep-91	-	-	-	-	1.3000	0.9000	-	-	-	1.7000	0.9000	-	-	-	-	-	-	-	-
Dec-91	-	-	-	-	1.7000	0.5000	-	-	-	0.2000	0.7000	-	-	-	-	-	-	-	-
Mar-92	-	-	-	-	0.7000	0.5000	-	-	-	<0.2	1.0000	-	-	-	-	-	-	-	-
Jun-92	-	-	-	-	<0.2	0.4000	-	-	-	<0.2	<0.2	-	-	-	-	-	-	-	-
Sep-92	-	-	-	-	0.7000	1.6000	-	-	-	0.5000	0.9000	-	-	-	-	-	-	-	-
Dec-92	-	-	-	-	0.8000	0.6000	-	-	-	<0.2	0.4000	-	-	-	-	-	-	-	-
Mar-93	-	-	-	-	1.2000	0.8000	-	-	-	1.2000	0.9000	-	-	-	-	-	-	-	-
Jun-93	-	-	-	-	2.7000	0.6000	-	-	-	0.3000	<0.2	-	-	-	-	-	-	-	-
Sep-93	-	-	-	-	0.5000	0.4000	-	-	-	0.8000	0.8000	-	-	-	-	-	-	-	-
Dec-93	-	-	-	-	0.5000	1.9000	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Mar-94	-	-	-	-	0.3000	0.9000	-	-	-	3.4000	0.4000	-	-	-	-	-	-	-	-
Jun-94	-	-	-	-	0.2000	0.3000	-	-	-	<0.2	0.7000	-	-	-	-	-	-	-	-
Sep-94	-	-	-	-	1.5000	0.4000	-	-	-	0.4000	0.9000	-	-	-	-	-	-	-	-
Dec-94	-	-	-	-	<0.2	1.4000	-	-	-	0.3000	<0.2	-	-	-	-	-	-	-	-
Mar-95	-	-	-	-	<0.2	0.4000	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Jun-95	-	0.3000	-	0.9000	<0.2	1.2000	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Sep-95	-	1.0000	-	1.2000	1.5000	0.9000	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Dec-95	-	<0.2	-	<0.2	0.4000	0.2000	-	-	-	0.0000	0.0000	-	-	-	-	-	-	-	-
Mar-96	-	0.2000	-	0.2000	0.2000	0.3000	-	-	-	0.4000	0.4000	-	-	-	-	-	-	-	-
Jun-96	-	0.3000	-	0.2000	0.4000	0.9000	-	-	-	0.3000	4.3000	-	-	-	-	-	-	-	-
Sep-96	1.1000	<0.2	-	1.1000	0.9000	0.8000	-	-	-	<0.2	1.0000	-	-	-	-	-	-	-	-
Dec-96	0.4000	0.4000	-	1.9000	0.7000	0.7000	-	-	-	0.5000	<0.2	-	-	-	-	-	-	-	-
Mar-97	<0.2	<0.2	-	0.5000	<0.2	<0.2	-	-	-	<0.2	1.0000	-	-	-	-	-	-	-	-
Jun-97	<0.2	<0.2	-	<0.2	1.3000	<0.2	-	-	-	<0.2	<0.2	-	-	-	-	-	-	-	-
Sep-97	<0.2	<0.2	-	<0.2	1.9000	0.5000	-	-	-	<0.2	<0.2	-	-	-	-	-	-	-	-
Dec-97	<0.2	<0.2	-	<0.2	<0.2	<0.2	-	-	-	0.8000	<0.2	-	-	-	-	-	-	-	-
Mar-98	<0.2	<0.2	-	<0.2	<0.2	<0.2	-	-	-	<0.2	<0.2	-	-	-	-	-	-	-	-
Jun-98	1.0000	0.3000	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	-
Sep-98	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	-
Dec-98	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	-
Mar-99	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	-
Jun-99	<0.2	0.7000	-	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	4.2000	<0.2	-	-	-	-	-	-	-	-
Sep-99	<0.2	<0.2	-	<0.2	<0.2	<0.2	0.9000	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Dec-99	<0.2	<0.2	0.5000	<0.2	<0.2	0.0000	0.4000	<0.2	<0.2	0.3000	<0.2	-	-	-	-	-	-	-	<0.2
Mar-00	<0.2	0.7000	<0.2	<0.2	<0.2	<0.2	0.0000	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	0.0000

Table 5.8-13: Private Wells Water Monitoring Results Radium Analysis (mg/L)

Date Sampled	Well #8	Well #11	Well #12	Well #24	Well #25	Well # 26	Well #28	Well #41	Well #63	Well #125	Well #129	Well #131	Well #133	Well #134	Well #135	Well #138	Well #140	Well #435	Drinking Water Well
Jun-00	0.4000	<0.2	<0.2	<0.2	<0.2	<0.2	0.0000	<0.2	0.5000	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Sep-00	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Dec-00	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	0.0000	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Mar-01	0.5000	<0.2	<0.2	0.0000	<0.2	<0.2	<0.2	<0.2	0.6000	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Jun-01	0.4000	<0.2	<0.2	0.0000	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Sep-01	0.5000	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	-	-	-	-	-	-	-	<0.2
Dec-01	<0.2	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	-	-	-	-	-	-	ND
Mar-02	0.4000	ND	ND	ND	ND	ND	WI	ND	ND	ND	ND	ND	-	-	-	-	-	-	ND
Jun-02	ND	ND	0.0000	ND	ND	ND	WI	WI	ND	ND	ND	ND	-	-	-	-	-	-	ND
Sep-02	0.3000	0.3000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	0.5000	-	-	-	-	ND
Dec-02	0.7000	ND	0.3000	ND	ND	ND	0.3000	0.4000	ND	ND	ND	ND	ND	ND	-	-	-	-	ND
Mar-03	0.4000	ND	ND	ND	ND	ND	ND	ND	0.4000	ND	ND	ND	0.3000	ND	ND	-	-	-	ND
Jun-03	0.6000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.4000	-	-	-	ND
Sep-03	ND	0.0000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.3000	-	-	-	ND
Dec-03	ND	0.2000	ND	0.2000	0.3000	ND	ND	0.3000	0.6000	ND	ND	0.2000	0.6000	ND	0.3000	-	-	-	ND
Mar-04	ND	ND	ND	ND	ND	ND	WI	ND	ND	ND	ND	ND	ND	0.5000	ND	-	-	-	ND
Jun-04	0.4000	ND	ND	ND	ND	ND	WI	ND	ND	ND	ND	ND	ND	ND	ND	-	ND	-	ND
Sep-04	ND	ND	ND	ND	ND	ND	ND	WI	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND
Dec-04	0.4000	0.3000	0.4000	ND	0.3000	0.3000	0.4000	WI	0.2000	ND	ND	0.4000	0.4000	0.3000	ND	0.4000	0.3000	-	ND
Mar-05	ND	0.3000	ND	ND	ND	ND	WI	WI	0.4000	ND	ND	ND	ND	0.4000	0.2000	ND	ND	-	ND
Jun-05	0.3000	0.0000	0.3000	0.2000	0.3000	ND	WI	WI	0.2000	ND	ND	ND	0.5000	0.4000	0.4000	0.6000	0.4000	-	ND
Sep-05	0.2000	0.0000	ND	0.2000	ND	0.4000	ND	0.4000	0.8000	0.4000	ND	0.3000	ND	0.3000	0.4000	0.8000	ND	-	ND
Dec-05	ND	ND	ND	ND	ND	ND	ND	WI	0.8000	ND	ND	ND	ND	0.9000	WI	1.3000	1.3000	-	ND
Mar-06	ND	ND	ND	ND	ND	ND	WI	WI	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND
Jun-06	ND	ND	ND	ND	ND	ND	ND	WI	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND
Sep-06	1.4000	0.0000	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.7000	0.6000	ND	ND	ND	0.5900	-	ND
Dec-06	ND	0.0000	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	-	ND
Mar-07	0.6000	ND	ND	0.0000	WI	ND	WI	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0000	ND	ND
Jun-07	ND	ND	ND	0.0000	WI	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.8000	ND	ND	ND

Notes:

WI = Well Inoperable.

ND = Non Detect

- = Sample not taken

Table 5.8-14: Surface Water Monitoring Results Uranium Analysis (mg/L)

Date Sampled	Stream S-1	Stream S-2	Stream S-5	Stream E-1 & E-2	Stream E-5	Impoundment I-3	Impoundment I-4	Impoundment I-5
Mar-91	-	ND	-	-	-	-	-	-
Jun-91	-	0.002	-	-	-	-	-	-
Sep-91	-	0.002	-	-	-	-	-	-
Dec-91	-	0.0031	-	-	-	-	-	-
Mar-92	-	ND	-	-	-	-	-	-
Jun-92	-	0.001	-	-	-	-	-	-
Sep-92	-	0.005	-	-	-	-	-	-
Dec-92	-	<0.0003	-	-	-	-	-	-
Mar-93	-	ND	-	-	-	-	-	-
Jun-93	-	<0.0003	-	-	-	-	-	-
Sep-93	-	<0.0003	-	-	-	-	-	-
Dec-93	-	0.001	-	-	-	-	-	-
Mar-94	-	0.004	-	-	-	-	-	-
Jun-94	-	0.006	-	-	-	-	-	-
Sep-94	-	0.002	-	-	-	-	-	-
Dec-94	-	0.003	-	-	-	-	-	-
Mar-95	-	0.01	-	-	-	-	-	-
Jun-95	-	0.004	-	-	-	-	-	-
Sep-95	-	0.004	-	-	-	-	-	-
Dec-95	-	0.005	-	-	-	-	-	-
Mar-96	-	0.00525	-	-	-	-	-	-
Jun-96	-	0.0047	-	-	-	-	-	-
Sep-96	0.005	0.004	-	-	-	-	-	-
Dec-96	0.0018	0.0051	-	-	-	-	-	-
Mar-97	0.0012	0.0055	-	-	-	-	-	-
Jun-97	0.0024	0.0024	-	-	-	-	-	-
Sep-97	0.0047	0.0048	-	-	-	-	-	-
Dec-97	0.0026	0.0038	-	-	-	-	-	-
Mar-98	0.0047	0.0045	-	-	-	-	-	-
Jun-98	0.0052	0.005	0.0054	0.035	-	-	-	-
Sep-98	0.0043	0.004	0.0037	0.011	-	-	-	-

Table 5.8-14: Surface Water Monitoring Results Uranium Analysis (mg/L)

Date Sampled	Stream S-1	Stream S-2	Stream S-5	Stream E-1 & E-2	Stream E-5	Impoundment I-3	Impoundment I-4	Impoundment I-5
Dec-98	0.0043	0.0043	0.0061	ND	-	-	-	-
Mar-99	0.0048	0.0048	0.0042	0.02	-	-	-	-
Jun-99	0.0041	0.004	ND	0.0086	-	-	-	-
Sep-99	0.0036	ND	ND	ND	-	-	-	-
Dec-99	0.0043	0.0042	0.0047	0.018	-	-	-	-
Mar-00	0.0051	0.005	0.0055	0.015	-	-	-	-
Jun-00	0.0059	0.0056	0.0057	ND	-	-	-	-
Sep-00	0.0041	0.0041	ND	ND	-	-	-	-
Dec-00	0.0048	0.0046	0.0058	ND	-	-	-	-
Mar-01	0.0055	0.0054	0.0064	ND	-	-	-	-
Jun-01	0.0052	0.0049	0.0055	ND	-	-	-	-
Sep-01	0.0042	0.0044	0.0056	ND	-	-	-	-
Dec-01	0.0042	0.0044	0.0054	ND	-	-	-	-
Mar-02	0.0045	0.0052	0.008	ND	-	-	-	-
Jun-02	0.0052	0.0049	0.0061	ND	-	-	-	-
Sep-02	0.0032	Dry	Dry	ND	-	-	-	-
Dec-02	0.0043	0.0043	0.0064	ND	-	-	-	-
Mar-03	0.0047	Frozen	Frozen	ND	Frozen	Frozen	Frozen	-
Jun-03	0.0046	0.004	0.0045	ND	0.0077	0.0411	0.0334	-
Sep-03	0.004	Dry	Dry	ND	0.004	0.0009	0.0079	-
Dec-03	0.005	0.004	0.006	ND	0.01	0.116	0.024	-
Mar-04	0.00521	0.0051	0.00578	ND	0.0118	Frozen	Frozen	-
Jun-04	0.0044	0.0038	0.0049	ND	0.007	0.039	0.023	-
Sep-04	0.0034	0.0034	0.0044	ND	0.0024	0.0133	0.0091	-
Dec-04	0.0033	0.0033	0.0038	ND	0.0054	0.011	0.0097	-
Mar-05	0.004	0.005	0.005	v	0.009	0.03	0.03	-
Jun-05	0.004	0.0044	0.005	0.02	0.004	0.02	0.01	-
Sep-05	0.0041	0.0041	0.0051	0.0123	0.0039	0.0066	0.00914	-
Dec-05	0.0041	0.0042	0.0045	0.018	0.0066	0.074	0.015	-
Mar-06	0.0041	0.0041	0.0046	0.037	0.0082	0.0095	0.0083	-
Jun-06	0.014	0.0045	0.005	0.011	0.0017	0.004	0.015	-

Table 5.8-14: Surface Water Monitoring Results Uranium Analysis (mg/L)

Date Sampled	Stream S-1	Stream S-2	Stream S-5	Stream E-1 & E-2	Stream E-5	Impoundment I-3	Impoundment I-4	Impoundment I-5
Sep-06	0.0041	Dry	Dry	0.011	0.0072	Dry	0.027	-
Dec-06	0.0042	0.0044	Dry	0.055	0.0075	Dry	0.04	0.0095
Mar-07	0.0046	0.0046	0.0057	0.019	0.013	0.11	0.13	0.012
Jun-07	0.0043	0.0041	0.0045	0.011	0.0031	0.02	0.037	0.0048

Notes:

Dry = Surface water monitoring point was dry, no sample taken
Frozen = Surface water monitoring point was frozen, no sample taken
- = Sample not taken

Table 5.8-15: Surface Water Monitoring Results Radium Analysis (piC/L)

Date Sampled	Stream S-1	Stream S-2	Stream S-5	Stream E-1 & E-2	Stream E-5	Impoundment I-3	Impoundment I-4	Impoundment I-5
Mar-91	-	0.0000	-	-	-	-	-	-
Jun-91	-	<0.2	-	-	-	-	-	-
Sep-91	-	1.0000	-	-	-	-	-	-
Dec-91	-	0.2000	-	-	-	-	-	-
Mar-92	-	0.0000	-	-	-	-	-	-
Jun-92	-	<0.2	-	-	-	-	-	-
Sep-92	-	4.8000	-	-	-	-	-	-
Dec-92	-	0.8000	-	-	-	-	-	-
Mar-93	-	0.0000	-	-	-	-	-	-
Jun-93	-	<0.2	-	-	-	-	-	-
Sep-93	-	1.0000	-	-	-	-	-	-
Dec-93	-	0.5000	-	-	-	-	-	-
Mar-94	-	<0.2	-	-	-	-	-	-
Jun-94	-	0.5000	-	-	-	-	-	-
Sep-94	-	0.7000	-	-	-	-	-	-
Dec-94	-	<0.2	-	-	-	-	-	-
Mar-95	-	2.1000	-	-	-	-	-	-
Jun-95	-	0.3000	-	-	-	-	-	-
Sep-95	-	<0.2	-	-	-	-	-	-
Dec-95	-	0.3000	-	-	-	-	-	-
Mar-96	-	0.2000	-	-	-	-	-	-
Jun-96	-	5.6000	-	-	-	-	-	-
Sep-96	7.7000	3.3000	-	-	-	-	-	-
Dec-96	0.3000	<0.2	-	-	-	-	-	-
Mar-97	<0.2	<0.2	-	-	-	-	-	-
Jun-97	<0.2	<0.2	-	-	-	-	-	-
Sep-97	2.5000	1.4000	-	-	-	-	-	-
Dec-97	<0.2	<0.2	-	-	-	-	-	-
Mar-98	<0.2	<0.2	-	-	-	-	-	-
Jun-98	<0.2	<0.2	<0.2	<0.2	-	-	-	-
Sep-98	<0.2	<0.2	<0.2	<0.2	-	-	-	-
Dec-98	<0.2	<0.2	<0.2	0.0000	-	-	-	-
Mar-99	<0.2	<0.2	<0.2	<0.2	-	-	-	-
Jun-99	<0.2	<0.2	0.0000	<0.2	-	-	-	-
Sep-99	<0.2	0.0000	0.0000	0.0000	-	-	-	-
Dec-99	<0.2	<0.2	<0.2	<0.2	-	-	-	-

Table 5.8-15: Surface Water Monitoring Results Radium Analysis (piC/L)

Date Sampled	Stream S-1	Stream S-2	Stream S-5	Stream E-1 & E-2	Stream E-5	Impoundment I-3	Impoundment I-4	Impoundment I-5
Mar-00	<0.2	<0.2	<0.2	<0.2	-	-	-	-
Jun-00	<0.2	<0.2	2.6000	0.0000	-	-	-	-
Sep-00	<0.2	<0.2	0.0000	0.0000	-	-	-	-
Dec-00	<0.2	<0.2	<0.2	0.0000	-	-	-	-
Mar-01	<0.2	<0.2	<0.2	0.0000	-	-	-	-
Jun-01	<0.2	<0.2	<0.2	0.0000	-	-	-	-
Sep-01	<0.2	<0.2	<0.2	0.0000	-	-	-	-
Dec-01	ND	ND	ND	0.0000	-	-	-	-
Mar-02	ND	ND	ND	0.0000	-	-	-	-
Jun-02	ND	ND	ND	0.0000	-	-	-	-
Sep-02	ND	Dry	Dry	0.0000	-	-	-	-
Dec-02	ND	ND	ND	0.0000	-	-	-	-
Mar-03	ND	Frozen	Frozen	0.0000	Frozen	Frozen	Frozen	-
Jun-03	0.4000	ND	ND	0.0000	ND	ND	ND	-
Sep-03	ND	Dry	Dry	0.0000	ND	0.4000	0.5000	-
Dec-03	ND	ND	ND	0.0000	ND	0.2000	ND	-
Mar-04	ND	ND	ND	0.0000	ND	Frozen	Frozen	-
Jun-04	ND	ND	ND	0.0000	ND	ND	ND	-
Sep-04	ND	ND	ND	0.0000	ND	ND	ND	-
Dec-04	ND	ND	ND	0.0000	0.3000	ND	0.4000	-
Mar-05	ND	ND	ND	0.0000	ND	ND	ND	-
Jun-05	0.5000	0.5000	ND	0.3000	ND	ND	0.2000	-
Sep-05	ND	ND	ND	0.2000	ND	ND	ND	-
Dec-05	ND	ND	1.2000	ND	2.7000	1.0000	ND	-
Mar-06	ND	ND	ND	ND	ND	ND	ND	-
Jun-06	ND	ND	ND	ND	ND	ND	ND	-
Sep-06	ND	Dry	Dry	0.9800	0.6100	Dry	ND	-
Dec-06	ND	ND	Dry	ND	ND	Dry	ND	ND
Mar-07	ND	ND	ND	ND	ND	ND	ND	ND
Jun-07	ND	ND	ND	0.5000	ND	ND	ND	ND

Notes:

ND = Non Detect

Dry = Surface water monitoring point was dry, no sample taken

Frozen = Surface water monitoring point was frozen, no sample taken

- = Sample not taken

Baseline Water Quality Indicators include:

Physical Indicators

- Specific Conductivity
- Alkalinity
- Total Dissolved
- Temperature
- pH
- Solids

Common Constituents

- Ammonia
- Silica
- Sodium
- Nitrate
- Total Carbonate
- Potassium
- Chloride
- Magnesium
- Calcium
- Sulfate
- Nitrite

Trace and Minor Elements

- Arsenic
- Nickel
- Selenium
- Lead
- Cadmium
- Zinc
- Copper
- Fluoride
- Iron
- Barium
- Vanadium
- Manganese
- Mercury
- Molybdenum

Radionuclides

- Radium-226
- Uranium

5.8.8.3 Surface Water Monitoring

The pre-operational water quality monitoring program assessed water quality and quantity for Squaw Creek. CBR samples two surface water locations for Squaw Creek. The CBR SERP approved Mine Unit 6 on March 6, 1998. This expansion required that the downstream Squaw Creek monitoring location be relocated. The new sample point was designated as S-5. Sampling at the previous downstream location, S-3 was discontinued.

With the approval of Mine Unit 6, operational surface water sampling was also begun at the English Creek upstream and downstream locations. The upstream sample is a composite of the springs that are the sources of English Creek and were identified as E-1 and E-2 during the preoperational monitoring program. Preoperational monitoring location E-3 was not used for downstream monitoring because its location is well beyond the Mine Unit 6 wellfield. Instead, a new downstream location designated E-4 was chosen immediately outside the Mine Unit boundary and sampling was begun.

With the addition of Mine Unit 8, downstream sampling on English Creek was moved to location E-5. Additionally, the expansion to Mine Unit 8 requires sampling of the impoundments identified as I-3 and I-4 in the preoperational monitoring program when they are located within the wellfield. Samples from all locations are obtained quarterly. Surface monitoring results are submitted in the semi-annual activity and monitoring reports submitted to USNRC. A summary of the most recent regional surface water monitoring results can be found in **Table 5.8-14** and **Table 5.8-15**.

5.8.8.4 Evaporation Pond Leak Detection Monitoring

The evaporation ponds are lined and equipped with a leak detection system. During operations, the leak detection standpipes are checked for evidence of leakage. Visual inspection of the pond embankments, fences, and liners and the measurement of pond freeboard are also performed during normal operations. A minimum freeboard of 5 feet is allowed for the commercial ponds during normal operations. Anytime 6 inches or more of fluid is detected in a leak detection system standpipe, it is analyzed for specific conductivity. Should the analyses indicate that the liner is leaking (by comparison to chemical analyses of pond water), the following actions are taken.

- The USNRC Project Manager is notified by telephone within 48 hours of leak verification.
- Transferring its contents into an adjacent pond lowers the level of the leaking pond. While lowering the water level in the pond, the liner is inspected to determine the cause and location of the leakage. The area of investigation first centers on the pond area specific for the particular standpipe that contains fluid.
- Once the source of the leakage is found, the liner is repaired and water is reintroduced to the pond.
- A written report is submitted to the USNRC within 30 days of leak verification. The report includes analytical data and describes the cause of the leakage, corrective actions taken, and the results of those actions.

5.8.9 Quality Assurance Program

A quality assurance program is in place at Crow Butte Project for all relevant operational monitoring and analytical procedures. The objective of the program is to identify any deficiencies in the sampling techniques and measurement processes so that corrective action can be taken and to obtain a level of confidence in the results of the monitoring programs. The QA program provides assurance to both regulatory agencies and the public that the monitoring results are valid.

The QA program addresses the following:

- Formal delineation of organizational structure and management responsibilities. Responsibility for both review/approval of written procedures and monitoring data/reports is provided.

- Minimum qualifications and training programs for individuals performing radiological monitoring and those individuals associated with the QA program.
- Written procedures for QA activities. These procedures include activities involving sample analysis, calibration of instrumentation, calculation techniques, data evaluation, and data reporting.
- Quality control (QC) in the laboratory. Procedures cover statistical data evaluation, instrument calibration, and duplicate and spike sample programs. Outside laboratory QA/QC programs are included.
- Provisions for periodic management audits to verify that the QA program is effectively implemented, to verify compliance with applicable rules, regulations and license requirements, and to protect employees by maintaining effluent releases and exposures ALARA.

The EHSMS Program developed by CBR is a critical step to ensuring that quality assurance objectives are met. Current procedures exist for a variety of areas, including but not limited to:

1. Environmental monitoring procedures,
2. Testing procedures,
3. Exposure procedures,
4. Equipment operation and maintenance procedures,
5. Employee health and safety procedures,
6. Incident response procedures, and
7. Laboratory procedures.

5.8.10 Monitoring Program Summary

Section 5.8 of this renewal application has reviewed the radiological monitoring data produced at Crow Butte Project for the years 1990 through 2007. Each section has discussed the historical results of the data with an emphasis on regulatory compliance and trend analysis to determine whether CBR's ALARA goals are being met. Where the data indicated that some adjustments in the monitoring program were indicated, CBR has noted those changes in the "Proposed Program" portion of each Section. In order to aid the reviewer in comparing the elements of the current monitoring program with those of the proposed program, **Table 5.8-16** provides a tabular summary of both programs as well as the regulatory guidance provided in USNRC Regulatory Guide 8.30, *Health Physics Surveys In Uranium Recovery Facilities*, Revision 1.

Table 5.8-16: Radiological Monitoring Program Summary

Type of Survey	Type of Area	Current Frequency	Proposed Frequency	Reg. Guide 8.30 Recommended Frequency
Airborne uranium	• Airborne radioactivity areas • Other indoor process areas • Special maintenance involving high airborne concentrations of yellowcake	• Weekly grab samples[1] • Monthly grab samples • Extra breathing zone grab samples	• Weekly grab samples[1] • Monthly grab samples • Extra breathing zone grab samples	• Weekly grab samples • Monthly grab samples • Extra breathing zone grab samples
Radon daughters	• Areas that exceed 0.08WL • Areas that exceed 0.03WL • Areas below 0.03WL	• Weekly radon daughter grab samples • Monthly radon daughter grab samples • Quarterly radon daughter grab samples	• Weekly radon daughter grab samples • Monthly radon daughter grab samples • Quarterly radon daughter grab samples	• Weekly radon daughter grab samples • Monthly radon daughter grab samples • Quarterly radon daughter grab samples
External radiation: gamma	• Throughout mill • Radiation areas	• Semiannually • Quarterly	• Semiannually • Quarterly	• Semiannually • Quarterly
External radiation: beta	• Where workers are in close contact with yellowcake	• Survey by operation done once plus whenever procedures change	• Survey by operation done once plus whenever procedures change	• Survey by operation done once plus whenever procedures change
Surface contamination	• Yellowcake areas • Eating rooms, change rooms, control rooms, office	• Daily walkthrough • Weekly	• Daily walkthrough • Weekly	• Daily • Weekly
Skin and personal clothing	• Yellowcake workers who shower • Yellowcake workers who do not shower	• Each exit from controlled area[2] • Each exit from controlled area[2]	• Each exit from controlled area[2] • Each exit from controlled area[2]	• Quarterly • Each day before leaving
Equipment to be released	• Equipment to be released that may be contaminated	• Detailed survey before release	• Detailed survey before release	• Once before release
Packages containing yellowcake	• Packages	• Detailed survey before release	• Detailed survey before release	• Spot check before release
Ventilation	• All areas with airborne radioactivity	• Daily walkthrough	• Daily walkthrough	• Daily
Respirators	• Respirator face pieces and hoods	• Before reuse	• Before reuse	• Before reuse

Notes: 1 Increased sampling frequency based on administrative action level of 25 percent of the MPC or DAC; Sampling is performed in the dryer room during dryer operation.
2 All employees required to survey upon exit; Quarterly spot checks of >25 percent process staff are also conducted.

5.8.11 References

Crow Butte Resources, Inc. (CBR). 1998. ALARA Audit Report for the Year Ending December 31, 1998. USNRC License Number SUA-1534.

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Crow Butte Resources, Inc. (CBR). 2005. ALARA Audit Report for the Year Ending December 31, 2005. USNRC License Number SUA-1534.

Crow Butte Resources, Inc. (CBR). 2006. Prepared by Robert Meyer, Tetra Tech, Inc. Annual ALARA Audit. USNRC License Number SUA-1534. April 24, 2007.

6 GROUNDWATER QUALITY RESTORATION, SURFACE RECLAMATION, AND FACILITY DECOMMISSIONING

6.1 PLANS AND SCHEDULES FOR GROUNDWATER RESTORATION

The objective of the Restoration and Reclamation Plan is to return the affected ground water and land surface to conditions suitable for the uses for which they were suitable before mining. The methods to achieve this objective for both the affected ground water and the surface are described in the following sections. Before discussing restoration methodologies, a discussion of the ore body genesis and chemical and physical interactions between the ore body and the lixiviant is provided.

6.1.1 Ore Body Genesis

The uranium deposit in the License Area is a roll front deposit in a fluvial sandstone and is similar to those in the Wyoming basins such as the Gas Hills, Shirley Basin and the Powder River Basin. The origin of the uranium in the deposit could lie within the host rock itself either from the feldspar or volcanic ash content of the Chadron Sandstone. The source of the uranium could also be volcanic ash of the Chadron Formation which overlays the Chadron Sandstone. Regardless of the source of the uranium, it has precipitated in several long sinuous roll fronts. The individual roll fronts are developed within subunits of the Chadron Sandstone. The Chadron Sandstone is divided into local subunits by thin clay beds that confined the uranium bearing waters to several distinct hydrological subunits of the sandstone. These clay beds are laterally continuous for hundreds of feet but control the deposition of the uranium over greater distances as other clay beds exert vertical control when the locally controlling beds pinch out. Precipitation of the uranium resulted when the oxidizing water containing the uranium entered reducing conditions. These reducing agents are likely hydrogen sulfide (H_2S) and, to a lesser degree, organic matter and pyrite.

Solution mining of the deposit is accomplished by reversing the natural processes that deposited the uranium. Oxidizing solution is injected into the mineralized portion of the Chadron Sandstone to oxidize the reduced uranium and to complex it with bicarbonates. Pumping from recovery wells draws the uranium bearing solution through the mineralized portion of the sandstone. The presence of reducing agents will increase oxidant requirements over that necessary to only oxidize the uranium.

Since the deposition of the uranium was controlled between clay beds within the Chadron Sandstone, the mining solutions will be largely confined to this portion of the sandstone by selectively screening these intervals. This will limit the contamination and thus the required restoration of unmineralized portions of the sandstone.

6.1.2 Chemical and Physical Interactions of Lixiviant with the Ore Body

The following discussion is based on a range of lixiviant conditions from 0.5 to 3.0 grams per liter total carbonate and a pH from 6.5 to 9.0 standard units (S.U.). This represents the normal range of operating conditions for the Crow Butte License Area ISL operations.

6.1.2.1 Ion Exchange

The principal ion exchange reaction is the exchange of sodium from the lixiviant onto exchangeable sites on ore minerals with the release into solution of calcium, magnesium and potassium. This reaction can be shown as follows:

$$Ca_{clay} + 2\ Na^{+}_{solution} = 2\ Na_{clay} + Ca^{++}_{solution}$$

Similar reactions can be written for magnesium and potassium. Due to higher solubility of their sulfate and carbonate compounds and their low concentrations in Chadron Sandstone and the ore, magnesium and potassium in solution have no impact. The limited solubility of calcium carbonate ($CaCO_3$), and to a lesser degree, calcium sulfate, may lead to the potential for calcium precipitation.

Laboratory tests have indicated that the maximum calcium ion exchange capacity of the ore in a sodium lixiviant with 3.0 g/L total carbonate strength is 1.21 milliequivalents of calcium per 100 grams of ore. This equates roughly to 0.5 pound of calcium or about 1.2 pounds of calcium carbonate per ton of ore that could potentially precipitate. Not all of this calcium, however, will be realized since laboratory testing is run in such a way as to indicate the maximum amount of calcium that can be exchanged. Somewhat less than this amount will be released and only a portion of that precipitated. There is no way to directly control the buildup of calcium in the lixiviant circuit. In practice, the lixiviant carbonate concentration and the lixiviant pH is controlled. The formation characteristics dictate an equilibrium calcium concentration in the lixiviant system and ion exchange and/or precipitation will occur until the equilibrium is satisfied. The production bleed represents a departure from this equilibrium and as such has some effect on the amount of calcium exchanged. If the bleed is kept generally small, on the order of 0.5 percent, the effect of the bleed on the ion exchange is small.

6.1.2.2 Precipitation

In the presence of carbonate ions and bicarbonate ions in the lixiviant system, calcium ions will precipitate provided the limit of saturation has been reached. Calcium precipitation is a function of total carbonate, pH and temperature. For example, at 15° C, a pH of 7.5 S.U., and 1 g/L carbonate in lixiviant, the equilibrium solubility of calcium is approximately 40 to 100 ppm. Some uncertainty is seen in these numbers due to the effect of ionic strength and supersaturation considerations. However, these figures illustrate the effect of carbonate concentration and pH on the equilibrium solubility of calcium.

The amount of calcium produced depends on the ion exchange that is taking place, while the precipitation of calcium is a function of the lixiviant chemistry, and the degree of supersaturation that is observed in the system. As a first approximation, the proportion of calcium precipitation occurring above ground and underground will occur in the ratio of the residence times. In other words, if the residence time is much longer underground than it is above ground, as is the case for most in-situ leach operations including Crow Butte, then more of the calcium will precipitate underground than above ground. The calcium precipitation is a function of turbulence in the solution, changes in dissolved carbon dioxide (CO_2) partial pressure or pH, and the presence of surface area. The most likely places for calcium to precipitate are underground where the ore provides abundant surface area for precipitation, at or near the injection or production wellbore where changes in pressure, turbulence and CO_2 partial pressure are all observed, and on the surface in the filters, in pipes, and in tanks. If all the calcium were to precipitate (based on 1.2 pounds of $CaCO_3$ per ton of ore) the precipitate would occupy about 0.15 percent of the void space in that ton of ore.

Calcium may be removed from the system in two ways:

- Filters will be routinely backwashed to the evaporation ponds and periodically acid cleaned, if necessary, to remove precipitated calcium carbonate from the filter housing or filter media; and
- The solution bleed (approximately 0.5 to 1.0 percent) taken to create overproduction and a hydrologic sink in the mining area serves to eliminate some calcium from the system.

Should precipitation of calcium carbonate at or near the wellbore of the wellfield wells become a problem, these wells may be air lifted, surged, water jetted, or acidified to remove the precipitated calcium. Any water recovered from these wells containing dissolved calcium carbonate or particulate calcium carbonate is collected and placed into the waste disposal system. A liquid seal is maintained on any calcium carbonate in the evaporation ponds. Upon decommissioning, calcium carbonate from the plant equipment and pond residues will be disposed of in either a licensed tailings pond or a commercial disposal site.

The other possible precipitating species that has been identified is iron, which could precipitate as either the hydroxide or the carbonate, causing some fouling. Such fouling is usually evidenced by a reduction in the ion exchange capacity of the resin in the extraction circuit. Should this fouling become a serious problem, the resin can be washed and the wash solution disposed of in the waste disposal system. Due to the small amount of iron present in the Chadron Sandstone, iron precipitation has not been a problem in mining operations to date.

6.1.2.3 Hydrolysis

Hydrolysis reactions, which involve minerals and hydrogen or hydroxide ions, do not play an important role in the ore/lixiviant interaction. In the pH range of 6.5 to 9.0 S.U., the concentration of hydrogen and hydroxide ions is so small that these types of reactions do not occur to any great degree. The only potential impact would be a small increase in the dissolved silica content of the lixiviant system and a possible small increase in the cations associated with the siliceous minerals. The hydrolysis reaction does not have a significant effect on operations.

6.1.2.4 Oxidation

The oxidant consumers in the Chadron Sandstone are hydrogen sulfide in the groundwater, uranium, vanadium, iron pyrite, and other trace and heavy metals. The impact of these oxidant consumers on the operation of the plant is a general increase in the oxidant consumption over that which would be required for uranium alone. The second effect is a release of iron and sulfate into solution from the oxidation of pyrite. A third effect is an increase in the levels of some trace metals such as arsenic, vanadium and selenium into solution. As mentioned previously, the iron solubilized will most likely be precipitated as the hydroxide or carbonate, depending on its oxidation state. Any vanadium that is oxidized along with the uranium will be solubilized by the lixiviant, recovered with the uranium and could potentially contaminate the precipitated yellowcake product. Hydrogen peroxide precipitation of uranium is used to reduce the amount of vanadium precipitated in the product. Oxidation will also solubilize arsenic and selenium. The restoration program will return these substances to acceptable levels. A final potential oxidation reaction is the partial oxidation of sulfur species, increasing the concentrations of compounds such as polythionates, which can foul ion exchange resins. In in-situ operations with chemistries similar to Crow Butte, these sulfur species are completely oxidized to sulfate, which poses no problems.

6.1.2.5 Organics

Organic materials are generally not present in the CBR License Area ore body at levels greater than 0.1 to 0.2 percent. Where present organic materials effectively increase the oxidant consumption and reduce uranium leaching. On longer flow paths, organic material could potentially re-precipitate uranium should all of the oxidant be consumed and conditions become reducing. Another potential impact of mobilized organics could be the coloring and fouling of leach solutions. As the aquifer is maintained in the pH range of 6.5 to 9.0 S.U., mobilization of the organics and coloring of the leach solution is avoided.

6.1.3 Basis of Restoration Goals

The primary goal of the groundwater restoration program is to return groundwater affected by mining operations to pre-injection baseline values on a mine unit average as determined by the baseline water quality sampling program. This sampling program is performed for each mine unit before mining operations commence. Should restoration efforts be unable to achieve baseline conditions after diligent application of the best practicable technology (BPT) available, CBR commits, in accordance with the Nebraska Environmental Quality Act and NDEQ regulations, to return the groundwater to the restoration values set by the NDEQ in the Class III UIC Permit. These secondary restoration values ensure that the groundwater is returned to a quality consistent with the use, or uses, for which the water was suitable prior to ISL mining. These secondary restoration values are approved by the NDEQ in the individual Notice of Intent (NOI) for each mine unit based on the permit requirements and the results of the baseline monitoring program.

6.1.3.1 Establishment of Baseline Water Quality

Before mining in each mine unit, the baseline groundwater quality is determined. The data are established in each mine unit by assigning and evaluating groundwater quality in "baseline restoration wells". A minimum of one baseline restoration well for each four acres is sampled to establish the mine unit baseline water quality. A minimum of three samples is collected from each well. The samples are collected at least 14 days apart. The samples are analyzed for the parameters listed in **Table 6.1-1**.

Tables 6.1-2 through 6.1-11 contain the restoration information for Mine Units one through ten in the current commercial license area. These tables provide the baseline average and the range for all restoration parameters as well as the NDEQ restoration standard approved for that mine unit in the NOI.

6.1.3.2 Establishment of Restoration Goals

The baseline data are used to establish the restoration standards for each mine unit. As previously noted, the primary goal of restoration is to return the mine unit to preoperational water quality condition on a mine unit average. Since ISL operations alter the groundwater geochemistry, it is unlikely that restoration efforts will return the groundwater to the precise water quality that existed before operations.

Restoration goals are established by NDEQ to ensure that, if baseline water quality is not achievable after diligent application of best practicable technology (BPT), the groundwater is suitable for any use for which it was suitable before mining. USNRC considers these NDEQ restoration goals as the secondary goals. The NDEQ restoration values are established for each mine unit and are approved with the Notice of Intent to Operate submittals according to the following analysis:

- For parameters that have numerical groundwater standards established in Title 118 (NDEQ 2006), the restoration goal is based on the Title 118 maximum contaminant level (MCL).

Table 6.1-1: NDEQ Groundwater Restoration Standards

Parameter	NDEQ Title 118 Groundwater Standard	NDEQ Restoration Standard[1]
Ammonium (mg/L)	Not Listed	10.0
Arsenic (mg/L)	0.010	0.010
Barium (mg/L)	2.0	2.0
Cadmium (mg/L)	0.005	0.005
Chloride (mg/L)	250	250
Copper (mg/L)	1.3	1.3
Fluoride (mg/L)	4.0	4.0
Iron (mg/L)	0.3	0.3
Mercury (mg/L)	0.002	0.002
Manganese (mg/L)	0.05	0.05
Molybdenum (mg/L)	(Reserved)	1.0
Nickel (mg/L)	(Reserved)	0.15
Nitrate (mg/L)	10.0	10.0
Lead (mg/L)	0.015	0.015
Radium (pCi/L)	5.0	5.0
Selenium (mg/L)	0.05	0.05
Sodium (mg/L)	N/A	Note 2
Sulfate (mg/L)	250	250
Uranium (mg/L)	0.030	0.030
Vanadium (mg/L)	(Reserved)	0.2
Zinc (mg/L)	5.0	5.0
pH (Std. Units)	6.5 - 8.5	6.5 – 8.5
Calcium (mg/L)	N/A	Note 2
Total Carbonate (mg/L)	N/A	Note 3
Potassium (mg/L)	N/A	Note 2
Magnesium (mg/L)	N/A	Note 2
TDS (mg/L)	N/A	Note 4

1 NDEQ Restoration Standard based on groundwater standard (MCL) from Title 118. For parameters where the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.

2 One order of magnitude above baseline is used as the restoration value for some parameters due to the ability of some major ions to vary one order of magnitude depending on pH.

3 Total carbonate shall not exceed 50% of the total dissolved solids value.

4 The restoration value for Total Dissolved Solids (TDS) shall be the baseline mean plus one standard deviation.

Source: NDEQ Class III UIC Permit Number NE0122611

- If the baseline concentration exceeds the applicable MCL, the standard is set as the mine unit baseline average plus two standard deviations.
- If there is no MCL for an element (e.g., vanadium), the restoration value is based on BPT.
- The restoration values for the major cations (Ca, Mg, K, Na) allow the concentrations of these cations to vary by as much as one order of magnitude as long as the TDS restoration value is met. The total carbonate restoration criterion allows for the total carbonate to be less than 50 percent of the TDS. The TDS restoration value is set at the baseline mine unit average plus one standard deviation.

The current NDEQ restoration standards are listed in **Table 6.1-1**.

Under the provisions of the performance-based license, the CBR Safety and Environmental Review Panel (SERP) reviews and approves the establishment of restoration standards using the review procedures discussed in **Section 5**. **Table 6.1-1** lists the 27 parameters used at the Crow Butte project to determine groundwater quality. The current MCLs from Title 118 are listed as well as the restoration standards from the Class III UIC Permit. The restoration value for each mine unit is based on the current Title 118 standard at the time the Notice of Intent is approved by the NDEQ.

Mine Unit restoration values are contained in **Table 6.1-2** through **Table 6.1-11** as follows:

- Mine unit averages and secondary goals for Mine Units 1 through 5 are given in **Table 6.1-2** through **Table 6.1-6**. These restoration values were approved by USNRC based on submittals before operation of the Mine Unit.
- The mine unit average and NDEQ restoration values for Mine Unit 6 are given in **Table 6.1-7**. The CBR SERP determined these restoration values on March 4, 1998.
- The mine unit average and NDEQ restoration values for Mine Unit 7 are given in **Table 6.1-8**. The CBR SERP determined these restoration values on July 9, 1999.
- The mine unit average and NDEQ restoration values for Mine Unit 8 are given in **Table 6.1-9**. The CBR SERP determined these restoration values on July 10, 2002.
- The mine unit average and NDEQ restoration values for Mine Unit 9 are given in **Table 6.1-10**. The CBR SERP determined these restoration values on October 23, 2003.
- The mine unit average and NDEQ restoration values for Mine Unit 10 are given in **Table 6.1-11**. The CBR SERP determined these restoration values on April 10, 2007.

Table 6.1-2: Baseline and Restoration Values for Mine Unit 1

Parameter	Groundwater Standard	MU-1 Baseline	MU-1 Standard Deviation	MU-1 NDEQ Restoration Value
Ammonium (mg/L)	10.0	<0.372	N/A	10.0
Arsenic (mg/L)	0.05	<0.00214	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)[1]	0.01	<0.00644	N/A	0.005[1]
Chloride (mg/L)	250.0	203.9	38	250.0
Copper (mg/L)	1.0	<0.017	N/A	1.0
Fluoride (mg/L)	4.0	0.686	0.04	4.0
Iron (mg/L)	0.3	<0.0441	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.011	N/A	0.05
Molybdenum (mg/L)	1.0	<0.0689	N/A	1.0
Nickel (mg/L)	0.15	<0.0340	N/A	0.15
Nitrate (mg/L)	10.0	<0.050	N/A	10.0
Lead (mg/L)	0.05	0.0315	N/A	0.05
Radium (pCi/L)	5.0	229.7	177.1	584.0
Selenium (mg/L)	0.01	<0.00323	N/A	0.05
Sodium (mg/L)	N/A	412	19.2	4120
Sulfate (mg/L)	250.0	356.2	9.4	375
Uranium (mg/L)	5.0	0.0922	0.089	5.0
Vanadium (mg/L)	0.2	<0.0663	N/A	0.2
Zinc (mg/L)	5.0	<0.036	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.46	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	12.5	3.2	125.0
Total Carbonate (mg/L)	N/A	351	31.1	585
Potassium (mg/L)	N/A	12.5	1.5	125.0
Magnesium (mg/L)	N/A	3.2	0.8	32.0
TDS (mg/L)	N/A	1170.2	47.6	1170.2

[1] Standard for Cadmium lowered in modification to UIC permit dated March 9, 2001 following NDEQ approval of Mine Unit 1 restoration.

N/A = Not Applicable

Table 6.1-3: Baseline and Restoration Values for Mine Unit 2

Parameter	Groundwater Standard	MU-2 Baseline	MU-2 Standard Deviation	MU-2 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.37	0.07	10.0
Arsenic (mg/L)	0.05	<0.001	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)	0.005	<0.007	N/A	0.005
Chloride (mg/L)	250.0	208.6	30.8	250.0
Copper (mg/L)	1.0	<0.013	N/A	1.0
Fluoride (mg/L)	4.0	0.67	0.04	4.0
Iron (mg/L)	0.3	<0.045	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.073	N/A	1.0
Nickel (mg/L)	0.15	<0.037	N/A	0.15
Nitrate (mg/L)	10.0	<0.039	N/A	10.0
Lead (mg/L)	0.05	<0.035	N/A	0.05
Radium (pCi/L)	5.0	234.5	411.8	1058.0
Selenium (mg/L)	0.05	<0.001	N/A	0.05
Sodium (mg/L)	N/A	410.8	18.2	4108
Sulfate (mg/L)	250.0	348.2	10.3	369.0
Uranium (mg/L)	5.0	0.046	0.037	5.0
Vanadium (mg/L)	0.2	<0.07	N/A	0.2
Zinc (mg/L)	5.0	<0.026	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.32	0.2	6.5 – 8.5
Calcium (mg/L)	N/A	13.4	2.4	134.0
Total Carbonate (mg/L)	N/A	366.9	13.3	585.0
Potassium (mg/L)	N/A	12.6	2.5	126.0
Magnesium (mg/L)	N/A	3.5	0.4	35.0
TDS (mg/L)	N/A	1170.4	41	1170.4

Notes:
N/A = Not Applicable

Table 6.1-4: Baseline and Restoration Values for Mine Unit 3

Parameter	Groundwater Standard	MU-3 Baseline	MU-3 Standard Deviation	MU-3 NDEQ Restoration Value
Ammonium (mg/L)	10.0	<0.329	N/A	10.0
Arsenic (mg/L)	0.05	<0.001	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)	0.005	<0.01	N/A	0.005
Chloride (mg/L)	250.0	197.6	16.7	250.0
Copper (mg/L)	1.0	<0.0108	N/A	1.0
Fluoride (mg/L)	4.0	0.719	0.05	4.0
Iron (mg/L)	0.3	<0.05	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.1	N/A	1.0
Nickel (mg/L)	0.15	<0.05	N/A	0.15
Nitrate (mg/L)	10.0	<0.0728	N/A	10.0
Lead (mg/L)	0.05	<0.05	N/A	0.05
Radium (pCi/L)	5.0	165	222.5	611.0
Selenium (mg/L)	0.05	<0.00115	N/A	0.05
Sodium (mg/L)	N/A	428	27.6	4280
Sulfate (mg/L)	250.0	377.0	13.4	404.0
Uranium (mg/L)	5.0	0.115	0.158	5.0
Vanadium (mg/L)	0.2	<0.1	N/A	0.2
Zinc (mg/L)	5.0	<0.0131	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.37	0.3	6.5 – 8.5
Calcium (mg/L)	N/A	13.3	3.1	133.0
Total Carbonate (mg/L)	N/A	358.7	24.8	592.0
Potassium (mg/L)	N/A	13.9	4.0	139.0
Magnesium (mg/L)	N/A	3.5	0.9	35.0
TDS (mg/L)	N/A	1183.0	47.4	1183.0

Notes:
N/A = Not Applicable

Table 6.1-5: Baseline and Restoration Values for Mine Unit 4

Parameter	Groundwater Standard	MU-4 Baseline	MU-4 Standard Deviation	MU-4 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.288	0.08	10.0
Arsenic (mg/L)	0.05	<0.00209	N/A	0.05
Barium (mg/L)	1.0	<0.1	N/A	1.0
Cadmium (mg/L)	0.005	<0.01	N/A	0.005
Chloride (mg/L)	250.0	217.5	34.9	250.0
Copper (mg/L)	1.0	<0.0114	N/A	1.0
Fluoride (mg/L)	4.0	0.745	0.05	4.0
Iron (mg/L)	0.3	<0.0504	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.1	N/A	1.0
Nickel (mg/L)	0.15	<0.05	N/A	0.15
Nitrate (mg/L)	10.0	<0.114	N/A	10.0
Lead (mg/L)	0.05	<0.05	N/A	0.05
Radium (pCi/L)	5.0	154.3	171.5	496.0
Selenium (mg/L)	0.05	<0.00244	N/A	0.05
Sodium (mg/L)	N/A	416.6	27.8	4166
Sulfate (mg/L)	250.0	337.2	19.3	375.0
Uranium (mg/L)	5.0	<0.122	N/A	5.0
Vanadium (mg/L)	0.2	<0.0984	N/A	0.2
Zinc (mg/L)	5.0	<0.0143	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.68	0.3	6.5 – 9.28
Calcium (mg/L)	N/A	11.2	2.9	112.0
Total Carbonate (mg/L)	N/A	374.4	28	610.0
Potassium (mg/L)	N/A	16.7	4.7	167.0
Magnesium (mg/L)	N/A	2.8	0.8	28.0
TDS (mg/L)	N/A	1221.1	73.5	1221.1

Notes:
N/A = Not Applicable

Table 6.1-6: Baseline and Restoration Values for Mine Unit 5

Parameter	Groundwater Standard	MU-5 Baseline	MU-5 Standard Deviation	MU-5 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.28	0.05	10.0
Arsenic (mg/L)	0.05	<0.001	N/A	0.05
Barium (mg/L)	1.0	<0.10	N/A	1.0
Cadmium (mg/L)	0.005	<0.01	N/A	0.005
Chloride (mg/L)	250.0	191.9	7.9	250.0
Copper (mg/L)	1.0	<0.01	N/A	1.0
Fluoride (mg/L)	4.0	0.64	0.07	4.0
Iron (mg/L)	0.3	<0.05	N/A	0.3
Mercury (mg/L)	0.002	<0.001	N/A	0.002
Manganese (mg/L)	0.05	<0.01	N/A	0.05
Molybdenum (mg/L)	1.0	<0.10	N/A	1.0
Nickel (mg/L)	0.15	<0.05	N/A	0.15
Nitrate (mg/L)	10.0	<0.1	N/A	10.0
Lead (mg/L)	0.05	<0.05	N/A	0.05
Radium (pCi/L)	5.0	166.0	184.6	535.0
Selenium (mg/L)	0.05	<0.002	N/A	0.05
Sodium (mg/L)	N/A	397.6	14.4	3976
Sulfate (mg/L)	250.0	364.5	10.5	385.0
Uranium (mg/L)	5.0	0.072	0.056	5.0
Vanadium (mg/L)	0.2	<0.10	N/A	0.2
Zinc (mg/L)	5.0	<0.02	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.5	0.1	6.5 – 8.5
Calcium (mg/L)	N/A	12.6	1.8	126.0
Total Carbonate (mg/L)	N/A	372	13.0	590.0
Potassium (mg/L)	N/A	11.5	1.2	115.0
Magnesium (mg/L)	N/A	3.4	0.4	34.0
TDS (mg/L)	N/A	1179.5	22.5	1202.0

Notes:
N/A = Not Applicable

Table 6.1-7: Baseline and Restoration Values for Mine Unit 6

Parameter	Groundwater Standard	MU-6 Baseline	MU-6 Standard Deviation	MU-6 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.32	0.05	10.0
Arsenic (mg/L)	0.05	0.002	N/A	0.05
Barium (mg/L)	1.0	0.100	N/A	1.0
Cadmium (mg/L)	0.005	0.009	N/A	0.005
Chloride (mg/L)	250.0	206	15.4	250.0
Copper (mg/L)	1.0	0.012	N/A	1.0
Fluoride (mg/L)	4.0	0.65	0.03	4.0
Iron (mg/L)	0.3	0.050	N/A	0.3
Mercury (mg/L)	0.002	0.001	N/A	0.002
Manganese (mg/L)	0.05	0.010	N/A	0.05
Molybdenum (mg/L)	1.0	0.102	N/A	1.0
Nickel (mg/L)	0.15	0.050	N/A	0.15
Nitrate (mg/L)	10.0	0.1	N/A	10.0
Lead (mg/L)	0.05	0.050	N/A	0.05
Radium (pCi/L)	5.0	80.6	121.9	325
Selenium (mg/L)	0.05	0.001	N/A	0.05
Sodium (mg/L)	N/A	400	12.8	4000
Sulfate (mg/L)	250.0	361	14.6	390
Uranium (mg/L)	5.0	0.133	0.212	5.0
Vanadium (mg/L)	0.2	0.098	N/A	0.2
Zinc (mg/L)	5.0	0.011	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.2	6.5 – 9.0
Calcium (mg/L)	N/A	12.8	2.3	128
Total Carbonate (mg/L)	N/A	367.1	22.9	596
Potassium (mg/L)	N/A	11.9	1.7	119
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1192	28.1	1220

Notes:
N/A = Not Applicable

Table 6.1-8: Baseline and Restoration Values for Mine Unit 7

Parameter	Groundwater Standard	MU-7 Baseline	MU-7 Standard Deviation	MU-7 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.42	0.08	10.0
Arsenic (mg/L)	0.05	0.001	N/A	0.05
Barium (mg/L)	1.0	0.10	N/A	1.0
Cadmium (mg/L)	0.005	0.007	N/A	0.005
Chloride (mg/L)	250.0	198	22.6	250.0
Copper (mg/L)	1.0	0.01	N/A	1.0
Fluoride (mg/L)	4.0	0.70	0.05	4.0
Iron (mg/L)	0.30	0.05	N/A	0.30
Mercury (mg/L)	0.002	0.001	N/A	0.002
Manganese (mg/L)	0.05	0.01	N/A	0.05
Molybdenum (mg/L)	1.00	0.10	N/A	1.00
Nickel (mg/L)	0.15	0.05	N/A	0.15
Nitrate (mg/L)	10.0	0.1	N/A	10.0
Lead (mg/L)	0.05	0.05	N/A	0.05
Radium (pCi/L)	5.0	142	148.0	438
Selenium (mg/L)	0.05	0.004	N/A	0.05
Sodium (mg/L)	N/A	387	21.6	3,870
Sulfate (mg/L)	250.0	346	20.1	386
Uranium (mg/L)	5.0	0.110	0.138	5.0
Vanadium (mg/L)	0.2	0.10	N/A	0.2
Zinc (mg/L)	5.0	0.01	N/A	5.0
pH (Std. Units)	6.5 - 8.5	8.6	0.3	6.5 – 9.2
Calcium (mg/L)	N/A	12.2	2.6	122
Total Carbonate (mg/L)	N/A	356	N/A	588
Potassium (mg/L)	N/A	12.9	3.0	129
Magnesium (mg/L)	N/A	3.2	0.7	32
TDS (mg/L)	N/A	1,176	40.7	1,217

Notes:
N/A = Not Applicable

Table 6.1-9: Baseline and Restoration Values for Mine Unit 8

Parameter	Groundwater Standard	MU-8 Baseline	MU-8 Standard Deviation	MU-8 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.682	0.222	10.0
Arsenic (mg/L)	0.05	0.002	0.001	0.05
Barium (mg/L)	1.0	0.099	0.005	1.0
Cadmium (mg/L)	0.005	0.005	N/A	0.005
Chloride (mg/L)	250	196	53.8	250
Copper (mg/L)	1.0	0.01	N/A	1.0
Fluoride (mg/L)	4.0	0.638	0.048	4.0
Iron (mg/L)	0.30	0.135	0.086	0.30
Mercury (mg/L)	0.002	0.001	N/A	0.002
Manganese (mg/L)	0.05	0.01	N/A	0.05
Molybdenum (mg/L)	1.0	0.093	0.023	1.00
Nickel (mg/L)	0.15	0.049	0.003	0.15
Nitrate (mg/L)	10.0	0.2	N/A	10.0
Lead (mg/L)	0.05	0.049	0.003	0.05
Radium (pCi/L)	5.0	124.4	151.8	428
Selenium (mg/L)	0.05	0.004	N/A	0.05
Sodium (mg/L)	N/A	416.8	41.8	4,168
Sulfate (mg/L)	250	312	33	378
Uranium (mg/L)	5.0	0.188	0.140	5.0
Vanadium (mg/L)	0.2	0.127	0.122	0.2
Zinc (mg/L)	5.0	0.013	0.008	5.0
pH (Std. Units)	6.5 - 8.5	8.67	0.37	6.5 – 9.41
Calcium (mg/L)	N/A	12.3	3.5	123
Total Carbonate (mg/L)	N/A	377	15.6	569
Potassium (mg/L)	N/A	11.8	3.2	117.8
Magnesium (mg/L)	N/A	2.7	0.92	27.1
TDS (mg/L)	N/A	1,137	97.4	1,234

Notes:
N/A = Not Applicable

Table 6.1-10: Baseline and Restoration Values for Mine Unit 9

Parameter	Groundwater Standard	MU-9 Baseline	MU-9 Standard Deviation	MU-9 NDEQ Restoration Value
Ammonium (mg/L)	10.0	0.40	0.05	10.0
Arsenic (mg/L)	0.05	0.001	0.000	0.05
Barium (mg/L)	1.0	0.1	0.0	1.0
Cadmium (mg/L)	0.005	0.005	0.000	0.005
Chloride (mg/L)	250	203	13	250
Copper (mg/L)	1.0	0.01	0.00	1.0
Fluoride (mg/L)	4.0	0.8	0.0	4.0
Iron (mg/L)	0.3	0.04	0.01	0.3
Mercury (mg/L)	0.002	0.001	0.000	0.002
Manganese (mg/L)	0.05	0.01	0.00	0.05
Molybdenum (mg/L)	1.0	0.1	0.0	1.0
Nickel (mg/L)	0.15	0.05	0.00	0.15
Nitrate (mg/L)	10.0	0.06	0.01	10.0
Lead (mg/L)	0.05	0.05	0.00	0.05
Radium (pCi/L)	5.0	164	238	640
Selenium (mg/L)	0.05	0.003	0.001	0.05
Sodium (mg/L)	N/A	380	11	3,800
Sulfate (mg/L)	250	320	15	350
Uranium (mg/L)	5.0	0.1	0.24	5.0
Vanadium (mg/L)	0.2	0.1	0.0	0.2
Zinc (mg/L)	5.0	0.01	0.00	5.0
pH (Std. Units)	6.5 - 8.5	8.35	0.30	6.5 – 9.41
Calcium (mg/L)	N/A	13.6	4.6	136
Total Carbonate (mg/L)	N/A	383	14	595
Potassium (mg/L)	N/A	13.9	3.0	139
Magnesium (mg/L)	N/A	3.5	1.2	35.0
TDS (mg/L)	N/A	1,152	38	1,190

Notes:
N/A = Not Applicable

Table 6.1-11: Baseline Well Restoration Table Mine Unit 10

Parameter	Units	Groundwater Standard	Wellfield Average	Standard Deviation	NDEQ Restoration Value
Ammonia (NH_4 as N)	mg/L	10.0	0.34	0.07	10.0
Arsenic (As)	mg/L	0.010	0.001	0.001	0.010
Barium (Ba)	mg/L	2.0	0.1	0.0	2.0
Cadmium (Cd)	mg/L	0.005	0.005	0.000	0.005
Calcium (Ca)	mg/L	---	11.8	2.6	118.0
Chloride (Cl)	mg/L	250	185	14	250
Copper (Cu)	mg/L	1.3	0.01	0.01	1.3
Fluoride (F)	mg/L	4.0	0.72	0.10	4.0
Iron (Fe)	mg/L	0.3	0.03	0.01	0.3
Lead (Pb)	mg/L	0.015	0.001	0.0	0.015
Magnesium (Mg)	mg/L	---	3.4	0.7	34.0
Managanese (Mn)	mg/L	0.05	0.01	0.0	0.05
Mercury (Hg)	mg/L	0.002	0.001	0.0	0.002
Molybdenum (Mo)	mg/L	1.0	0.1	0.0	1.0
Nickel (Ni)	mg/L	0.15	0.05	0.0	0.15
Nitrite + Nitrate as N (NO_3 + NO_2)[1]	mg/L	10.0	0.1	0.0	10.0
pH	Std. Units	6.5 - 8.5	8.51	0.19	6.5 - 8.89
Potassium (K)	mg/L	---	10.1	1.6	101
Radium-226	pCi/L	5.0	87.3	161.0	409.3
Selenium (Se)	mg/L	0.05	0.003	0.002	0.05
Sodium (Na)	mg/L	---	388	12	3880
Sulfate (SO4)	mg/L	250.0	329	25	379
Total Carbonate (CO_3 + HCO_3)[2]	mg/L	---	394	15	550.5
Total Dissolved Solids	mg/L	---	1101	26	1127
Uranium (U)	mg/L	0.03	0.0378	0.0351	0.108
Vanadium (V)	mg/L	0.2	0.1	0.0	0.2
Zinc (Zn)	mg/L	5.0	0.01	0.01	5.0

1 Nitrate was reported by the lab as NO_3 + NO_2 instead of NO_3 as required in the permit. However, only two samples, well 4024 collected 6/09/06 and well CM8-6 collected 5/02/02, were above the detection limits. The restoration value is 10.0 mg/L while the average is 0.1 mg/L. Therefore, including NO_2 has no bearing on determining the restoration value. Nitrite, NO_2, was also analyzed for and all samples were below the detection limit of 0.10 mg/L.

2 Total carbonate = alkalinity as $CaCO_3$ x 1.2

Standard formulas were used to calculate the average and standard deviation but the true values, especially for the standard deviation, are most likely significantly smaller than shown. This results in a conservative estimate of the standard deviation.

--- = no NDEQ standard

NDEQ Permit Number NE0122611 requires that a Mine Unit be returned to a wellfield average of these restoration values. These concentrations were approved by the NDEQ with the Notice of Intent to Operate submittals. Post mining water quality for Mine Unit 1 can be found in **Table 6.1-12**.

CBR operated a R&D Pilot Facility starting in July 1986 and initiated restoration activities of its Wellfield No. 2 in February 1987. Wellfield No. 1 was incorporated into Mine Unit 1, thus no restoration took place in that area. The techniques used during that program are the basis for the commercial restoration program outlined in this section. CBR will utilize ion exchange columns, a reverse osmosis unit and reductant addition equipment similar to those used in the R&D restoration during commercial restoration operations.

6.1.4 Groundwater Restoration Methods

6.1.4.1 Introduction

Restoration activities in the current license area have proven that the groundwater can be restored to the appropriate standards following commercial mining activities. As shown in **Table 1.7-1**, Mine Units 2 through 5 are currently undergoing restoration, with Mine Unit 2 undergoing extended stability monitoring following active restoration. Mine Unit 1 groundwater restoration has been approved by the NDEQ and the USNRC. On February 12, 2003, the USNRC issued the final approval of groundwater restoration in Mine Unit 1 at Crow Butte. This approval was the culmination of three years of agency reviews including a license amendment to accept the NDEQ restoration standards as the approved secondary goals. Mine Unit 1 consisted of 40 patterns installed in 9.3 acres immediately adjacent to the Central Plant. Included within the boundaries of Mine Unit 1 were five wells that were originally mined beginning in 1986 as part of the R & D pilot plant operation. Commercial mining activities began in 1991 and were completed in 1994. Mine Unit 1 was successfully restored to the approved primary or secondary restoration standards for all parameters.

The commercial groundwater restoration program consists of two stages, the restoration stage and the stabilization stage. The restoration stage consists of four activities:

- Groundwater transfer
- Groundwater sweep
- Groundwater treatment
- Wellfield recirculation

A reductant may be added at anytime during the restoration stage to lower the oxidation potential of the mining zone. A sulfide or sulfite compound will be added to the injection stream in concentrations sufficient to reduce the mobilized species.

Table 6.1-12: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
Ca (mg/L)	87.9	87.1	80.8	87.9	87.6	93.9	89.4	89.6	89.9	85.4	86.7	98.3
Mg (mg/L)	22.6	20.6	22.7	23.8	21.4	23.9	22.5	23.1	24.8	23.2	23.1	23.8
Na (mg/L)	1154	942	1054	1144	1054	1174	1177	1182	1126	1144	1172	1083
K (mg/L)	32.7	26.3	30	30	27.2	31.3	30	31.3	32.7	30	30	28.6
CO_3 (mg/L)	0	0	0	0	0	0	0	0	0	0	0	0
HCO_3 (mg/L)	1099	900	972	981	1057	1086	1111	1207	1104	1170	1170	959
SO_4 (mg/L)	1109	959	1115	1240	1031	1209	1119	1112	1134	1115	1115	1283
Cl (mg/L)	598	455	586	594	544	598	594	619	607	603	603	590
NH_4 (mg/L)	0.33	0.67	0.14	0.33	0.44	0.07	< 0.05	< 0.05	0.33	0.27	0.15	0.49
NO_2 (mg/L)	< 0.01	0.02	0.09	< 0.01	0.11	< 0.01	< 0.01	< 0.01	0.04	0.05	< 0.01	0.05
NO_3 (mg/L)	1.06	< 0.1	0.97	0.99	1.29	0.74	0.86	1.3	1.25	1.46	1.6	0.46
F (mg/L)	0.37	0.26	0.54	0.45	0.45	0.37	0.38	0.45	0.43	0.43	0.4	0.35
SiO_2 (mg/L)	25.7	18.2	35.3	24.7	33.3	34.3	26.4	31.6	28.3	33.2	30	22.2
TDS (mg/L)	3694	3121	3756	3851	3515	3899	3751	3886	3873	3820	3807	3765
Conductivity (μmho/cm)	5843	4841	5590	5964	5445	6012	5807	6025	5916	5819	5940	5819
$CaCO_3$ (mg/L)	901	738	797	804	866	890	911	989	905	959	959	786
pH (Std. units)	7.65	6.87	6.85	7.28	7.16	7.35	7.65	7.81	7.37	7.46	7.78	6.92
Trace Metals												
Al (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.29
As (mg/L)	0.018	0.007	0.018	0.017	0.031	0.028	0.02	0.028	0.023	0.028	0.024	0.011
Ba (mg/L)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
B (mg/L)	1.17	1.44	1.09	1.36	1.06	1.26	1.13	1.19	1.15	1.23	1.25	1.17
Cd (mg/L)	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cr (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cu (mg/L)	< 0.01	< 0.01	0.05	< 0.01	0.02	< 0.01	< 0.01	< 1	< 0.01	< 0.01	< 0.01	< 0.01
Fe (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.38
Pb (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mn (mg/L)	0.02	0.11	0.05	0.04	0.14	0.15	0.08	0.06	0.06	0.02	< 0.01	0.16

Table 6.1-12: Post Mining Water Quality for Mine Unit 1 Restoration Well Sampling

	PM-1	PM-4	PM-5	PT-5	IJ-6	IJ-13	IJ-25	IJ-28	IJ-45	PR-8	PR-15	PR-19
Hg (mg/L)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Mo (mg/L)	0.6	0.2	0.42	0.53	0.47	0.5	0.56	0.54	0.53	0.59	0.53	0.37
Ni (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.12	0.12	0.12	< 0.05	< 0.05	< 0.05	< 0.05
Se (mg/L)	0.139	0.012	0.129	0.24	0.112	0.122	0.1	0.138	0.149	0.154	0.148	0.041
V (mg/L)	1	0.1	0.38	1.15	1.12	1.18	1.03	1.24	1.29	1.23	1.56	0.28
Zn (mg/L)	< 0.01	0.14	0.11	0.01	0.11	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Radionuclides												
U (mg/L)	8.63	6.29	54.52	9.3	13.9	9.31	9.9	2.52	14.83	5.24	5.18	6.78
Ra-226 (pCi/l)	370	126	329	1139	1113	1558	1258	1147	681	417	109	1182

The stabilization stage consists of monitoring the restoration wells for six months following successful completion of the restoration stage. Stabilization begins once restoration activities have returned the average concentration of restoration parameters to acceptable levels. Following the stabilization phase, CBR provides a restoration report to the appropriate regulatory agencies.

During mining and until restoration is complete, a hydrologic bleed will be maintained in each Mine Unit to prevent lateral migration of mining lixiviant. If a proper hydrologic bleed is not maintained, it is possible for water with chemistry similar to that in **Table 2.7-16** column "Typical Water Quality During Mining at CSA" to begin migrating toward the monitor well ring. The mobile ions such as chloride and carbonate would be detected at the monitor well ring and adjustments would be made to reverse the trend. The maintenance of a hydrologic bleed and the close proximity of the monitor well ring, less than 300 feet from the mining patterns, will ensure there is negligible migration of mining fluid. Vertical migration of fluids is less of a concern than lateral migration due to the underlying and overlying aquitards. The ubiquitous Chadron Formation clays, which cap the Lower Chadron Formation ore body, have hydraulic conductivities on the order of 10^{-11} cm/sec as outlined in **Section 2.7.2.2** of this application. Likewise, the underlying Pierre Shale is over 1,200 feet thick and acts as a significant aquitard. The vastly different piezometric heads between the Lower and Middle Chadron as well as the results of the pumping test support the conclusion that the Lower Chadron is vertically isolated.

6.1.4.2 Restoration Process

Restoration activities include four steps that are designed to optimize restoration equipment used in treating groundwater and to minimize the number of pore volumes circulated during the restoration stage. CBR will monitor the quality of selected wells during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary.

Groundwater Transfer

During the groundwater transfer step, water may be transferred between the mine unit commencing restoration and a mine unit commencing mining operations. Baseline quality water from the mine unit starting mining may be pumped and injected into the mine unit in restoration. The higher TDS water from the mine unit in restoration is recovered and injected into the mine unit commencing mining. The direct transfer of water will act to lower the TDS in the mine unit being restored by displacing water affected by the mining with baseline quality water.

The goal of the groundwater transfer step is to blend the water in the two mine units until they become similar in conductivity. The recovered water may be passed through ion exchange columns and filtration during this step if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

For the groundwater transfer step to occur, a newly constructed mine unit must be ready to commence mining. If a mine unit is not available to accept transferred water, groundwater sweep or other activity will be utilized as the first step of restoration. The advantage of using the groundwater transfer technique is that it reduces the amount of water that must ultimately be sent to the wastewater disposal system during restoration activities.

Groundwater Sweep

During groundwater sweep, water is pumped without injection from the wellfield, causing an influx of baseline quality water from the perimeter of the mining unit, which sweeps the affected portion of the aquifer. The cleaner baseline quality water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The affected water near the edge patterns of the wellfield is also drawn into the boundaries of the mine unit. The number of pore volumes transferred during groundwater sweep, if any, is dependent upon the presence of other active mine units along the mine unit boundary, the capacity of the wastewater disposal system, and the success of the groundwater transfer step in lowering TDS.

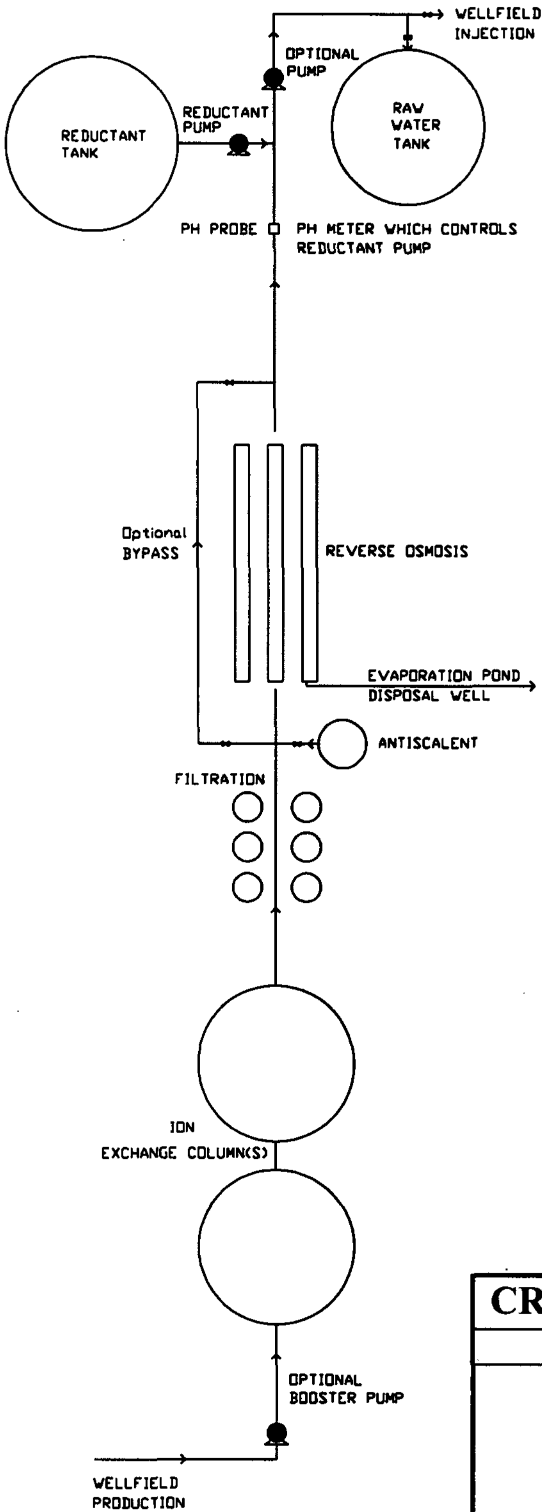
Groundwater Treatment

Following the groundwater sweep step, water will be pumped from production wells to treatment equipment and then re-injected into the wellfield. Ion exchange (IX), reverse osmosis (RO), and/or Electro Dialysis Reversal (EDR) treatment equipment is generally used during this stage as shown on the generalized restoration flow sheet on **Figure 6.1-1**.

Water recovered from restoration that contains a significant amount of uranium is passed through the IX system. The IX columns exchange the majority of the contained soluble uranium for chloride or sulfate. Once the solubilized uranium is removed, a small amount of reductant may be metered into the restoration wellfield injection to reduce any pre-oxidized minerals. The concentration of reductant injected into the formation is determined by the concentration and type of trace elements encountered. The goal of reductant addition is to reduce those minerals that are solubilized by carbonate complexes to prevent the buildup of dissolved solids, which would increase the time for restoration to be completed.

Another potential method for reducing the wellfield is through bioremediation. Bioremediation entails adding an organic electron donor, such as cheese whey, to the aquifer to stimulate native bacteria. As the bacteria feed on the organic media they generate a reducing environment which in turn causes most metals in solution to precipitate back to their original state. The concentration of native bacteria colonies returns to normal levels once the organic media is consumed. Crow Butte Resources, Inc. will see approval before initiating bioremediation.

FIGURE 6.1-1
Restoration Process Flow Diagram



CROW BUTTE RESOURCES	
DAWES COUNTY, NEBRASKA	
Restoration Process Flow Diagram	
Prepared By : JD	
Drawn By: JD	**Date: 3/30**

A portion of the restoration recovery water can be sent to the reverse osmosis (RO) unit. The use of a RO unit 1) reduces the total dissolved solids in the contaminated groundwater, 2) reduces the quantity of water that must be removed from the aquifer to meet restoration limits, 3) concentrates the dissolved contaminates in a smaller volume of brine to facilitate waste disposal, and 4) enhances the exchange of ions from the formation due to the large difference in ion concentration.

Before the water can be processed by the RO, soluble uranium can be removed by the IX system. The RO unit contains membranes that pass about 60 to 75 percent of the water through, leaving 60 to 90 percent of the dissolved salts in the water that will not pass the membranes. **Table 6.1-13** shows typical RO manufacturers specification data for removal of ion constituents. The clean water, called "permeate", will be re-injected, sent to storage for use in the mining process, or to the wastewater disposal system. The 25 to 40 percent of water that is rejected, called "brine", contains the majority of dissolved salts that contaminate the groundwater and is sent for disposal in the waste system. Make-up water may be added to the wellfield injection stream to control the amount of "bleed" in the restoration areas.

The reductant (either biological or chemical) added to the injection stream during the groundwater treatment stage will scavenge any oxygen and reduce the oxidation-reduction potential (Eh) of the aquifer. During mining operations, certain trace elements are oxidized. By adding a reductant, the Eh of the aquifer is lowered, thereby decreasing the solubility of these elements. Hydrogen sulfide (H_2S), sodium sulfide (Na_2S), or a similar compound will be added as a reductant. CBR typically uses sodium sulfide due to the chemical safety issues associated with proper handling of hydrogen sulfide. A comprehensive safety plan regarding reductant use is implemented.

The number of pore volumes treated and re-injected during the groundwater treatment stage will depend on the efficiency of the RO in removing TDS and the reductant in lowering the uranium and trace element concentrations.

Wellfield Recirculation

At the completion of the Groundwater Treatment Stage, wellfield recirculation may be initiated. In order to homogenize the aquifer, pumping from the production wells and re-injecting the recovered solution into injection wells may be performed to blend solutions.

The sequence of the activities will be determined by CBR based on operating experience and waste water system capacity. Not all phases of the restoration stage will be used if deemed unnecessary by CBR.

Once the restoration activities are completed, CBR will sample the restoration wells and determine if the mining unit has achieved the restoration values, on a mine unit average basis. If so, CBR will notify the regulatory agencies that it is initiating the Stabilization Stage and will submit supporting documentation that the restoration parameters are at or below the restoration standards. If at the end of restoration activities the parameters are not at or below the approved values, CBR will either re-initiate certain steps of the restoration plan or submit documentation to the agencies that the best practical technology has been used in restoration. The documentation will include a justification for alternate parameter value(s) including available water quality data and a narrative of the restoration techniques used.

Table 6.1-13: Typical Reverse Osmosis Membrane Rejection

Name	Symbol	Percent Rejection
Cations		
Aluminum	Al^{+3}	99+
Ammonium	NH_4^{+1}	88-95
Cadmium	Cd^{+2}	96-98
Calcium	Ca^{+2}	96-98
Copper	Cu^{+2}	98-99
Hardness	Ca and Mg	96-98
Iron	Fe^{+2}	98-99
Magnesium	Mg^{+2}	96-98
Manganese	Mn^{+2}	98-99
Mercury	Hg^{+2}	96-98
Nickel	Ni^{+2}	98-99
Potassium	K^{+1}	94-96
Silver	Ag^{+1}	94-96
Sodium	Na^{+}	94-96
Strontium	Sr^{+2}	96-99
Zinc	Zn^{+2}	98-99
Anions		
Bicarbonate	HCO_3^{-1}	95-96
Borate	$B_4O_7^{-2}$	35-70
Bromide	Br^{-1}	94-96
Chloride	Cl^{-1}	94-95
Chromate	CrO_4^{-2}	90-98
Cyanide	CN^{-1}	90-95
Ferrocyanide	$Fe(CN)_6^{-3}$	99+
Fluoride	F^{-1}	94-96
Nitrate	NO_3^{-1}	95
Phosphate	PO_4^{-3}	99+
Silicate	SiO_2^{-1}	80-95
Sulfate	SO_4^{-2}	99+
Sulfite	SO_3^{-2}	98-99
Thiosulfate	$S_7O_3^{-2}$	99+

Source: Osmonics, Inc.

6.1.5 Groundwater Stabilization

Upon completion of restoration, a groundwater stabilization monitoring program will begin in which the restoration wells and any monitor wells on excursion status during mining operations will be sampled and analyzed for the restoration parameters listed in **Table 6.1-1**. The sampling frequency will be one sample per month for a period of 6 months, and if the six samples show that the restoration values for all wells are maintained during the stabilization period with no significant increasing trends, restoration shall be deemed complete.

6.1.6 Groundwater Restoration Reporting

During the restoration process CBR will perform daily, weekly, and monthly analyses as needed to track restoration progress. These analyses will be summarized and discussed in the *Semiannual Radiological Effluent and Environmental Monitoring Report* submitted to USNRC. This information will also be included in the final report on restoration.

Upon completion of restoration activities and before stabilization, all designated restoration wells in the mine unit will be sampled for the constituents listed in **Table 6.1-1**. If restoration activities have returned the wellfield average of restoration parameters to concentrations at or below those approved by the USNRC and the NDEQ, CBR will proceed with the stabilization phase of restoration.

During stabilization, all designated restoration wells will be sampled monthly for the constituents listed in **Table 6.1-1**. At the end of a six-month stabilization period, CBR will compile all water quality data obtained during restoration and stabilization and submit a final report to the regulatory agencies. If the analytical results continue to meet the appropriate standards for the mine unit and do not exhibit significant increasing trends, CBR would request the mine unit be declared restored. Following agency approval, wellfield reclamation and plugging and abandonment of wells will be performed as described in **Section 6.2**.

6.2 PLANS FOR RECLAIMING DISTURBED LANDS

The following section addresses the final decommissioning methods of disturbed lands including wellfields, plant areas, evaporation ponds, and diversion ditches that will be used on the Crow Butte project sites. The section discusses general procedures to be used during final decommissioning as well as the decommissioning of a particular phase or production unit area.

Decommissioning of wellfields and process facilities, once their usefulness has been completed in an area, will be scheduled after agency approval of groundwater restoration and stability. Decommissioning will be accomplished in accordance with an approved decommissioning plan and the most current applicable NDEQ and USNRC rules and regulations, permit and license stipulations and amendments in effect at the time of the decommissioning activity.

The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in **Section 6.2.4**.
- Determination of appropriate cleanup criteria for structures (**Section 6.3**) and soils (**Section 6.4**).
- Radiological surveys and sampling of all facilities, process related equipment and materials on site to determine their degree of contamination and identify the potential for personnel exposure during decommissioning.
- Removal from the site of all contaminated equipment and materials to an approved licensed facility for disposal or reuse, or relocation to an operational portion of the mining operation as discussed in **Section 6.3**.
- Decontamination of items to be released for unrestricted use to levels consistent with the requirements of USNRC.
- Survey excavated areas for contamination and remove contaminated materials to a licensed disposal facility.
- Perform final site soil radiation surveys.
- Backfill and recontour all disturbed areas.
- Establish permanent revegetation on all disturbed areas.

The following sections describe in general terms the planned decommissioning activities and procedures for the Crow Butte facilities. CBR will submit to the USNRC and NDEQ a detailed Decommissioning Plan for their review and approval at least 12 months before planned commencement of final decommissioning.

6.2.1 General Surface Reclamation Procedures

The primary surface disturbances associated with solution mining are the sites containing the Central Processing Plant and associated facilities, Satellite Facilities, and evaporation ponds. Surface disturbances also occur during the well drilling program, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

The principal objective of the surface reclamation plan is to return disturbed lands to production compatible with the post mining land use of equal or better quality than the premining condition. For the License Area, the reclaimed lands should be capable of supporting livestock grazing and providing stable habitat for native wildlife species. Soils, vegetation, wildlife and radiological baseline data will be used as guidelines for the design, completion and evaluation of surface reclamation. Final surface reclamation will blend affected areas with adjacent undisturbed lands so as to re-establish original slope and topography and present a natural appearance. Surface reclamation efforts will strive to limit soil erosion by wind and water, sedimentation and re-establish natural trough drainage patterns.

The following sections provide procedural techniques for surface reclamation of all disturbances contained in the CBR mine plan. Provided are reclamation procedures for the facility sites, wellfield production units, evaporation ponds, and access and haul roads. Reclamation schedules for wellfield production units will be discussed separately because they are dependent upon the progress of mining and the successful completion of groundwater restoration. Cost estimates for bonding calculations are discussed in **Section 6.6** and include all activities that are anticipated to complete groundwater restoration, decontamination, decommissioning, and surface reclamation of wellfield and satellite plant facilities installed. These cost estimates are updated annually to cover work projected for the next year of mining activity.

6.2.1.1 Topsoil Handling and Replacement

In accordance with NDEQ requirements, topsoil is salvaged from building sites (including Satellite buildings) and pond areas. Conventional rubber-tired, scraper-type earth moving equipment is typically used to accomplish such topsoil salvage operations. The exact location of topsoil salvage operations is determined by wellfield pattern emplacement and designated wellfield access roads within the wellfields, which are determined during final wellfield construction activities.

As described in **Section 2.6**, topsoil thickness varies within the current License Area. Topsoil thickness is usually greatest in and along drainages where material has been deposited and deep soils have developed. Therefore, topsoil stripping depths may vary in depth, depending on location and the type of structure being constructed. In cases where it is necessary to strip topsoil in relatively large areas, such as a major road or building site, field mapping and Soil Conservation Service Soil Surveys will be utilized to determine approximate topsoil depths.

Salvaged topsoil is stored in designated topsoil stockpiles. These stockpiles are generally located on the leeward side of hills to minimize wind erosion. Stockpiles are not located in drainage channels. The perimeter of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles are seeded as soon as possible after construction with the permanent seed mix.

During mud pit excavation associated with well construction, exploration drilling and delineation drilling activities, topsoil is separated from subsoil with a backhoe. When use of the mud pit is complete, all subsoil is replaced and topsoil is applied. Mud pits generally remain open a short time. The success of revegetation efforts at the current site show that these procedures adequately protect topsoil and result in vigorous vegetation growth.

6.2.1.2 Contouring of Affected Areas

Due to the relatively minor nature of disturbances created by in-situ mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally speaking, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. The existing contours will only be interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post mining contour maps have been included in this application.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary, during the operating period. These changes will be caused by topsoil removal and storage along with the relocation of subsoil materials used for construction purposes. Restoration of the original land surface, which is consistent with the pre- and post-mining land use, the blending of affected areas with adjacent topography to approximate original contours and the reestablishment of drainage patterns will be accomplished by returning the earthen materials moved during construction to their approximate original locations.

Drainage channels that have been modified by the mine plan for operational purposes such as road crossings will be reestablished by removing fill materials, culverts and reshaping to as close to pre-operational conditions as practical. Surface drainage of disturbed areas that have been located on terrain with varying degrees of slope will be accomplished by final grading and contouring appropriate to each location so as to allow for controlled surface run off and eliminate depressions where water could accumulate.

6.2.1.3 Revegetation Practices

Revegetation practices are conducted in accordance with NDEQ requirements. During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield and pond areas, will be seeded with vegetation to minimize wind and water erosion. After placement of topsoil and contouring for final reclamation, an area will normally be seeded with a seed mixture developed in consultation with the Natural Resource Conservation Service as required by the NDEQ.

6.2.2 Process Facility Site Reclamation

Following removal of structures as discussed in **Section 6.3**, subsoil and stockpiled topsoil will be replaced on the disturbances from which they were removed during construction, within practical limits. Areas to be backfilled will be scarified or ripped prior to backfilling to create an uneven surface for application of backfill. This will provide a more cohesive surface to eliminate slipping and slumping. The less suitable subsoil and unsuitable topsoil, if any, will be backfilled first so as to place them in the deepest part of the excavation to be covered with more suitable reclamation materials. Subsoils will be replaced using paddle wheel scrapers, bulldozers or other appropriate equipment to transfer the earth from stockpile locations or areas of use and to spread it evenly on the ripped disturbances. Grader blades may be used to even the spread of backfill materials. Topsoil replacement will commence as soon as practical after a given disturbed surface has been prepared. Topsoil will be picked up from storage locations by paddle wheel scrapers or other appropriate equipment and distributed evenly over the disturbed areas. The final grading of topsoil materials will be done so as to establish adequate drainage and the final prepared surface will be left in a roughened condition.

6.2.3 Evaporation Pond Decommissioning

6.2.3.1 Disposal of Pond Water

The volume of water remaining in the lined evaporation ponds after restoration as well as its chemical and radiological characteristics will be considered to determine the most practical disposal program. Disposal options for the pond liquid include evaporation, treatment and disposal, or transportation to another licensed facility or disposal site. The pond water from the later stages of groundwater restoration may be treatable to within discharge limits. If this can be accomplished, the water will be treated and discharged under an appropriate NPDES permit. Evaporation of the remaining water may be enhanced by use of sprinkler systems, etc.

6.2.3.2 Pond Sludge and Sediments

Pond sludges and sediments will contain mining process chemicals and radionuclides. Wind blown sand grains and dust blown into the ponds during their active life also add to the bulk of sludges. This material will be contained within the pond bottom and kept in a dampened condition at all times, especially during handling and removal operation to prevent the spread of airborne contamination and potential worker exposure through inhalation. Dust abatement techniques will be used as necessary. The sludge will be removed from the ponds and loaded into roll off containers, dump trucks or drums and transported to a USNRC licensed disposal facility.

6.2.3.3 Disposal of Pond Liners and Leak Detection Systems

Pond liners will be kept washed down and intact as much as practical during sludge removal so as to confine sludges and sediments to the pond bottom. Pond liners will be cut into strips and transported to a USNRC licensed disposal facility or will be decontaminated for release to an unrestricted area. After removal of the pond liners, the pond leak detection system piping will be removed. Materials involved in the leak detection system will be surveyed and released for unrestricted use if not contaminated or transported to a USNRC licensed facility for disposal. The earthen material in the pond bottom and leak detection system trenches will be surveyed for soil contamination. Any contaminated soil in excess of the cleanup criteria discussed in **Section 6.4** will be removed and disposed at a USNRC licensed disposal facility.

Following the removal of all pond materials and the disposal of any contaminated soils, surface preparation will take place prior to reclamation.

6.2.3.4 On Site Burial

At the present time, on site burial of contaminants is not anticipated; however, depending upon the availability of a USNRC licensed disposal site at the time of decommissioning, on site burial may become a potential alternative. Should this occur, pond locations would be considered initially as the on site disposal locations for contaminated materials. Appropriate licensing with the regulatory agencies would be obtained prior to any on site disposal of contaminated wastes.

6.2.4 Wellfield Decommissioning

Surface reclamation in the wellfield production units will vary in accordance with the development sequence and the mining/reclamation timetable. Final surface reclamation of each wellfield production unit will be completed after approval of groundwater restoration stability and the completion of well abandonment activities discussed below. Surface preparation will be accomplished as needed so as to blend any disturbed areas into the contour of the surrounding landscape.

Wellfield decommissioning will consist of the following steps:

- The first step of the wellfield decommissioning process will involve the removal of surface equipment. Surface equipment primarily consists of the injection and production feed lines, wellhouses, electrical and control distribution systems, well boxes, and wellhead equipment. Wellhead equipment such as valves, meters or control fixtures will be salvaged.
- Removal of buried well field piping.
- Wells will be plugged and abandoned according to the procedures described below.

- The wellfield area may be recontoured, if necessary, and a final background gamma survey conducted over the entire wellfield area to identify any contaminated earthen materials requiring removal to disposal.
- Final revegetation of the wellfield areas will be conducted according to the revegetation plan.
- All piping, equipment, buildings, and wellhead equipment will be surveyed for contamination prior to release in accordance with the USNRC guidelines for decommissioning.

It is estimated that a significant portion of the equipment will meet release limits, which will allow disposal at an unrestricted area landfill. Other materials that are contaminated will be acid washed or decontaminated with other methods until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at a USNRC licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence at the License Area. Once a production unit has been mined out and groundwater restoration and stability have been accepted by the regulatory agencies, the wellfield will be scheduled for decommissioning and surface reclamation.

6.2.4.1 Well Plugging and Abandonment

All wells no longer useful to continue mining or restoration operations will be abandoned. These include all injection and production wells, monitor wells, and any other wells within the production unit used for the collection of hydrologic or water quality data or incidental monitoring purposes. The only known exception at this time may be a shallow well that could be transferred to the landowner for domestic or livestock use.

The objective of the Crow Butte well abandonment program is to seal and abandon all wells in such a manner as to assure the groundwater supply is protected and to eliminate any potential physical hazard.

The plugging method is approved by the NDEQ and is generally as follows:

- A mechanical plug may be placed above the screened interval.
- Thirty to fifty feet of coarse bentonite chips will be added to provide a grout seal.
- A plug gel or cement grout will be placed by tremie pipe from the chips to the top of the casing. The weight of the gel or grout plus the weight of the bentonite chips will be enough to exceed the local Chadron formation pressure plus the maximum injection pressure allowed (100 psi).
- The tremie pipe will be removed (when possible) and the casing will be filled to the surface.

- An approved hole plug will be installed.
- The well casing will be cut off below ground level, capped with cement, and the surface disturbance will be smoothed and contoured.
- The hole will be backfilled and the area revegetated.

Records of abandoned wells will be tabulated and reported to the appropriate agencies after decommissioning. CBR must submit a notarized affidavit to the NDEQ detailing the significant data and the procedure used in connection with each well plugged. The Nebraska Department of Natural Resources (NDNR) also requires filing a well abandonment notice for all registered wells.

6.2.4.2 Buried Trunklines, Pipes and Equipment

Buried process related piping such as injection and production lines will be removed from the mine unit undergoing decommissioning. Salvageable lines will be held for use in ongoing mining operations. Lines that are not reusable may either be assumed to be contaminated and disposed of at a licensed disposal site or may be surveyed and, if suitable for release to an unrestricted area, may be sent to a sanitary landfill.

6.3 REMOVAL AND DISPOSAL OF STRUCTURES, WASTE MATERIALS, AND EQUIPMENT

6.3.1 Preliminary Radiological Surveys and Contamination Control

Prior to process plant decommissioning, a preliminary radiological survey will be conducted to characterize the levels of contamination on structures and equipment and to identify any potential hazards. The survey will support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities. In general, the contamination control program used during mining operations (as discussed in **Section 5.8**) will be appropriate for use during decommissioning of structures.

Based on the results of the preliminary radiological surveys, gross decontamination techniques will be employed to remove loose contamination before decommissioning activities proceed. This gross decontamination will generally consist of washing all accessible surfaces with high-pressure water. In areas where contamination is not readily removed by high-pressure water, a decontamination solution (e.g., dilute acid) may be used.

6.3.2 Removal of Process Buildings and Equipment

The majority of the process equipment in the process building will be reusable, as well as the building itself. Alternatives for the disposition of the building and equipment are discussed in this section.

All process or potentially contaminated equipment and materials at the process facility including tanks, filters, pumps, piping, etc., will be inventoried, listed and designated for one of the following removal alternatives:

- Removal to a new location within the Crow Butte site for further use or storage;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other non-restricted use by others.

It is most likely that process buildings will be decontaminated, dismantled and released for use at another location. If decontamination efforts were unsuccessful, the material would be sent to a permanent licensed disposal facility. Cement foundation pads and footings will be broken up and trucked to a licensed disposal site or properly licensed facility if contaminated.

6.3.2.1 Building Materials, Equipment and Piping to be Released for Unrestricted Use

Salvageable building materials, equipment, pipe and other materials to be released for unrestricted use will be surveyed for alpha contamination in accordance with license conditions contained in SUA-1534 and applicable USNRC guidance.

The CBR release limits for alpha radiation are as follows:

- Removable of 1,000 dpm/100 cm^2
- Average total of 5,000 dpm/100 cm^2 over an area no greater than one square meter
- Maximum total of 15,000 dpm/100 cm^2 over an area no greater than 100 cm^2

Monitoring for beta contamination is a current license requirement. This requirement has been eliminated in subsequent ANSI standards, including ANSI/HPS N13.12 (ANSI 1999). In addition, CBR has routinely made these measurements but has never found them limiting.

Decontamination of surfaces will comply with CBR's ALARA policy, to reduce surface contamination as far below the limits as practical.

Non-salvageable contaminated equipment, materials, and dismantled structural sections will be sent to an USNRC-licensed facility for disposal. In most cases, the byproduct material will be shipped as Low Specific Activity (LSA-I) material, UN2912, pursuant to 49 CFR 173.427

6.3.2.2 Disposal at a Licensed Facility

If facilities or equipment are to be moved to a facility licensed for disposal of 11(e)2 byproduct material, the following procedures may be used.

- Flush inside of tanks, pumps, pipes, etc., with water or acid to reduce interior contamination as necessary for safe handling.
- The exterior surfaces of process equipment will be surveyed for contamination. If the surfaces are found to be contaminated the equipment will be washed down and decontaminated to permit safe handling.
- The equipment will be disassembled only to the degree necessary for transportation. All openings, pipe fittings, vents, etc., will be plugged or covered prior to moving equipment from the plant building.
- Equipment in the building, such as large tanks, may be transported on flatbed trailers. Smaller items, such as links of pipe and ducting material, may be placed in lined roll off containers or covered dump trucks or drummed in barrels for delivery to the receiving facility.
- Contaminated buried process trunk lines and sump drain lines will be excavated and removed for transportation to a licensed disposal facility.
- All other miscellaneous contaminated material will be transported to a licensed disposal facility.

6.3.2.3 Release for Unrestricted Use

If a piece of equipment or structure is to be released for unrestricted use, it will be appropriately surveyed before leaving the licensed area. Both interior and exterior surfaces will be surveyed to detect potential contamination. If the shape, size, or presence of inaccessible surfaces prevents an accurate and representative survey, the material will be assumed contaminated and properly disposed of. Appropriate decontamination procedures will be used to clean any contaminated areas and the equipment resurveyed and documentation of the final survey retained to show that unrestricted use criteria were met prior to releasing the equipment or materials from the site. The current release criteria are based on USNRC guidelines. The criteria to be used for release to unrestricted use will be the appropriate USNRC guidelines at that time. Release surveys will be based on the release methods discussed in **Section 5.8**.

If a process building is left on site for unrestricted use by a landowner, the following basic decontamination procedures will be used. Actual corrective procedures will be determined by field requirements as defined by radiological surveys.

After the building has been emptied, the interior floors, ceiling and walls of the building and exterior surfaces at vent and stack locations will be checked for contamination. Any remaining removable contamination will be removed by washing. Areas where contamination was noted will be resurveyed to ensure removal of all contamination to appropriate levels.

Process floor sumps and drains will be washed out and decontaminated using water and, if necessary, acid solutions. If the appropriate decontamination levels cannot be achieved, it may be necessary to remove portions of the sump and floor to disposal.

Excavations necessary to remove trunklines or drains will be surveyed for contaminated earthen material. Earthen material that is found to be contaminated will be removed to a licensed disposal facility prior to backfilling the excavated areas.

The parking and storage areas around the building will be surveyed for surface contamination after all equipment has been removed.

Decontamination of these areas will be conducted as necessary to meet the standards for unrestricted use.

6.3.3 Waste Transportation and Disposal

Materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed of at a disposal site licensed by the USNRC or an Agreement State to receive 11(e)2 byproduct material. CBR currently maintains agreements with two such facilities located in the states of Utah and Wyoming for disposal of 11(e)2 byproduct materials generated by mining operations. A contract for disposal at a minimum of one facility will be maintained current as required in SUA-1534.

Transportation of all contaminated waste materials and equipment from the site to the approved licensed disposal facility or other licensed sites will be handled in accordance with the Department of Transportation (DOT) Hazardous Materials Regulations (49 CFR Part 173) and the USNRC transportation regulations (10 CFR 71).

6.4 METHODOLOGIES FOR CONDUCTING POST-RECLAMATION AND DECOMMISSIONING RADIOLOGICAL SURVEYS

6.4.1 Cleanup Criteria

Surface soils will be cleaned up in accordance with the requirements of 10 CFR Part 40, Appendix A, including a consideration of ALARA goals and the chemical toxicity of uranium.

The proposed limits and ALARA goals for cleanup of soils are summarized in **Table 6.4-1** and described below.

Table 6.4-1: Soil Cleanup Criteria and Goals

Layer Depth	Radium-226 (pCi/gm)		Natural Uranium (pCi/gm)	
	Limit	**Goal**	**Limit**	**Goal**
Surface (0-15 cm)	5	5	230	150
Subsurface (15 cm layers)	15	10	230	230

The existing radium-226 criterion in 10 CFR Part 40, Appendix A, was used to derive a dose criterion (Benchmark Approach) for the cleanup of byproduct materials. The Benchmark Dose was modeled using the MILDOS. The results show that a concentration of 537 pCi/g for natural uranium in the top 15 cm layer of soil for the resident farmer scenario is equivalent to the Benchmark Dose derived from a concentration of 5 pCi/g of radium-226.

ALARA considerations require that an effort be made to reduce contaminants to as low as reasonably achievable levels. The ALARA goals are normally based on a cost-benefit analysis. For the cleanup of gamma-emitting radionuclides, the cost of cleanup becomes excessively high as soil concentrations and/or gamma emission rates become indistinguishable from background.

Cleanup of uranium mill sites has demonstrated that conservatively derived gamma action levels along with appropriate field survey and sampling procedures result in near background radium-226 concentrations for the site. In addition, the presence of a mixture of radium-226 and uranium will tend to drive the cleanup to even lower radium-226 concentrations. It is therefore believed that no specific ALARA goal is required for surface radium-226.

CBR proposes an ALARA goal of limiting the natural uranium concentration in the top 15 cm soil layer to 150 pCi/g, averaged over 100 m^2. According to the MILDOS runs shown in **Appendix A** the ratio of radium-226 dose rate per pCi/g to the uranium dose rate per pCi/g is 120. It is also shown by calculation that the ratio of radium-226 to uranium emission rates is 30. Therefore, if the action level for pure radium-226 results in cleanup of the site to less than 5 pCi/g, the action level should result in the cleanup of pure uranium to 30 times 5 or 150 pCi/g.

The uranium concentration should be limited to at most 230 pCi/g for all soil depths because of chemical toxicity concerns. Using the most conservative daily limit corresponding to the National Primary Drinking Water Standard, a soil limit of 230 pCi/g corresponds to the USEPA intake limit from drinking water with a uranium concentration of 0.06 mg/day.

CBR desires to reduce subsurface concentrations to a maximum of two-thirds of the proposed limit of 15 pCi/g radium-226. The subsurface uranium goal has not been reduced since it has not been demonstrated that these levels can be detected with readily available field instruments.

6.4.2 Excavation Control Monitoring

CBR will use 17,900 cpm as its gamma action level, as determined with a Ludlum Model 44-10/2221 NaI detection system or equivalent held at 18 inches above ground surface. The gamma action level, defined as the gamma count rate corresponding to the soil cleanup criterion, will be used in the interpretation of the data. This action level will be used with caution, or until a new action level is developed.

Hand-held and GPS-based gamma surveys will be used to guide soil remediation efforts.

Field personnel will monitor excavations with hand-held detection systems to guide the removal of contaminated material to the point where there is high probability that an area meets the cleanup criteria. Support will be provided by GPS-based gamma surveys periodically to more accurately assess the progress of excavation.

6.4.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to a few areas where there are known spills and, potentially, small spills near wellheads. Final GPS-based gamma surveys will be conducted in potentially contaminated areas, including 10 m buffer zones.

CBR will divide the area systematically into 100 m^2 grid blocks and sample all grid blocks containing gamma count rates exceeding the gamma action level. The samples will be five-point composites, and analyzed at an offsite laboratory for radium-226 and natural uranium.

CBR will sample the remaining grid blocks with average gamma count rates ranking in the top 10 percent.

If any grid blocks within the top 10 percent fail the cleanup criteria, CBR will sample the second ten percent of grid blocks. This will continue until all grid blocks pass within a 10 percent grouping. To meet the cleanup criterion, each of the sampled grid blocks must satisfy the following inequality,

$$\sum \frac{C_i}{Cc} < 1$$

where C_i is the concentration of the constituent and C_c is the concentration of the constituent that is equivalent to the Benchmark Dose.

CBR will remediate the grid blocks failing this inequality or propose alternatives consistent with Appendix A of 10 CFR 40.

After all sampled grids have met the inequality, an USEPA-recommended statistical test will be done to determine whether the mean of the equality defined above for all grid blocks is 1 or less at the 95 percent confidence level, using Equation 8-13 of draft NUREG/CR-5849 (USNRC 1992). If the mean of the sample concentrations is less than the criterion but the data fail the statistical test, CBR will follow procedures similar to those recommended in Section 8.6 of draft NUREG/CR-5849.

6.4.4 Subsurface Soil Cleanup Verification and Sampling Plan

For subsurfaces, CBR will adopt different survey and sample protocols, depending on the type and size of excavation. CBR will rely more on sampling and radium-226 and natural uranium analysis over surveying, to verify cleanup of subsurface excavations. The protocols are summarized in site procedures.

6.4.5 Temporary Ditches and Impoundments Cleanup Verification and Sampling Plan

CBR will adopt survey and sample protocols for temporary ditches and surface impoundments on a case-by-case basis. Ditches and impoundments can extend from the surface to the subsurface. For the purpose of decommissioning, the surfaces will be considered as part of adjacent soil surfaces. The subsurfaces will be surveyed and sampled systematically, based on their size and geometry. As with other subsurfaces, CBR will rely more on sampling and radium-226 and uranium analysis over surveying to verify cleanup of ditches and impoundments. Surveying is applicable in larger impoundments, however, wherein the effects of geometry are not as pronounced, particularly in areas not influenced by adjacent walls.

6.4.6 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of radium-226 and natural uranium. The criteria that CBR will use to select the commercial laboratory will follow the guidance published in the Multi-Agency Radiological Laboratory Analytical Protocols Manual (MARLAP) (USNRC 2004). The commercial laboratory will adhere to a well-defined quality assurance program that addresses the laboratory's organization and management, personal qualifications, physical facilities, equipment and instrumentation, reference materials, measurement traceability and calibration, analytical method validation, standard operating procedures (SOPs), sample receipt, handing, storage, records, and appropriate licenses.

The analytical work performed by the commercial laboratory will adhere to CBR-defined Data Quality Objectives (DQOs). Part of the DQO process is specific analytical sensitivities required by CBR. The minimum sensitivity required for each sample will be 0.5 pCi/g dry weight for each analyte, with an estimated overall error of $\pm$ 0.5 pCi/g.

CBR will expect the reporting equivalent of an USEPA Contract Laboratory Program Level 3 data package from the commercial laboratory.

CBR will maintain a laboratory QA file that will include, at a minimum, the laboratory's Quality Assurance Manual (QAM) and audit reports.

6.5 DECOMMISSIONING HEALTH PHYSICS AND RADIATION SAFETY

The health physics and radiation safety program for decommissioning will ensure that occupational radiation exposure levels are kept as low as reasonably achievable during decommissioning. The Radiation Safety Officer, Health Physics Technician or designee will be on site during any decommissioning activities where a potential radiation exposure hazard exists. In general, the radiation safety program discussed in **Section 5** will be used as the basis for development of the decommissioning health physics program. Health physics surveys conducted during decommissioning will be guided by applicable sections of Regulatory Guide 8.30 (USNRC 2002) or other applicable standards at the time.

6.5.1 Records and Reporting Procedures

At the conclusion of site decommissioning and surface reclamation, a report containing all applicable documentation will be submitted to the USNRC and NDEQ. Records of all contaminated materials transported to a licensed disposal site will be maintained for a period of five years or as otherwise required by applicable regulations at the time of decommissioning.

6.6 FINANCIAL ASSURANCE

6.6.1 Bond Calculations

Cost estimates for the purpose of bond calculations are made annually for the Crow Butte Project site. The cost assessment includes groundwater restoration, decontamination and decommissioning and surface reclamation costs for all areas to be affected by the installation and operation of the proposed mine plan. The detailed calculations utilized in determining the bonding requirements for the Crow Butte Project are submitted annually.

6.6.2 Financial Surety Arrangements

CBR maintains an USNRC-approved financial surety arrangement consistent with 10 CFR 40, Appendix A, Criterion 9 to cover the estimated costs of reclamation activities. Crow Butte maintains an Irrevocable Standby Letter of Credit issued by the Royal Bank of Canada (New York Branch) in favor of the State of Nebraska in the present (2007) amount of $22,980,913. The surety amount is revised annually in accordance with the requirements of SUA-1534.

6.6.3 References

American National Standards Institute (ANSI). 1999. ANSI/HPS N13.12, Surface and Volume Radioactivity Standards for Clearance.

Nebraska Department of Environmental Quality (NDEQ). 2006. Title 118 – Ground Water Quality Standards and Use Classification, March 27, 2006.

United States Nuclear Regulatory Commission (USNRC). 1992. NUREG/CR-5849, Manual for Conducting Radiological Surveys in Support of License Termination, Draft Report for Comment, June 1992.

USNRC. 2002. Regulatory Guide No. 8.30, Health Physics Surveys in Uranium Recovery Facilities, May 2002.

Nuclear Regulatory Commission et al. (USNRC). 2004. Multi-Agency Radiological Laboratory Analytical Protocols Manual. NUREG 1576. July, 2004.

7 ENVIRONMENTAL IMPACTS

The objective of the mining and environmental monitoring program is to conduct an operation that is economically viable and environmentally responsible. The environmental monitoring programs that are used to ensure that the potential sources of land, water and air pollution are controlled and monitored are presented in **Section 5.8**, Radiation Safety Controls and Monitoring.

This section discusses and describes the degree of unavoidable environmental impacts, the short and long-term impacts associated with operations and the consequences of possible accidents at the Crow Butte project.

Environmental impacts that have occurred since the approval of the Crow Butte Project 1997 LRA are summarized for well excursions and effluent releases as measured at groundwater monitoring, stream monitoring, air monitoring, and stream sediment sampling stations,

7.1 LAND USE IMPACTS

7.1.1 Land Surface Impacts

The primary surface disturbances associated with solution mining are the sites containing the processing plants and associated facilities including satellite facilities and evaporation ponds. Surface disturbances also occur during the well drilling program, pipeline installation, and road construction. These more superficial disturbances, however, involve relatively small areas or have short-term impacts.

Due to the relatively minor nature of disturbances created by in-situ mining, there are only a few areas disturbed to the extent to which subsoil and geologic materials are removed, causing significant topographic changes that need backfilling and recontouring. Generally speaking, solar evaporation pond construction results in redistribution of sufficient amounts of subsurface materials, which requires replacement and contour blending during reclamation. The existing contours have only been interrupted in small, localized areas. Because approximate original contours will be achieved during final surface reclamation, no post-mining contour maps have been included in this application.

Major facilities have already been constructed at the Crow Butte site. The site layout for the commercial operation currently includes:

- The original Research and Development Process building housing the Reverse Osmosis unit to be utilized for groundwater restoration activities. This area also includes two wellfields, two solar evaporation ponds and access roads.
- A nominal 120' by 300' process building which is used for uranium extraction, precipitation, drying and packaging, offices, laboratories and change rooms.
- Three commercial solar evaporation ponds.

- Deep well injection building located north of the main process facility.
- Commercial wellfields. Wellfield development includes a number of wellfield houses for each mine unit.
- Access roads.

Future site construction of the current licensed resource area may include the following:

- A satellite process facility and/or pumphouse located approximately one to three miles northwest of the existing process facility in response to the proposed increase in production capacity to 5,000 gpm. Initial estimates are that the satellite would be in the area of 5,000 square feet.
- Two solar evaporation ponds located in conjunction with the satellite facility. Two additional solar evaporation ponds adjacent to the commercial ponds.
- Expansion of the main process facility in response to the increase in production capacity to 9,000 gpm. Initial estimates are that this expansion may be in the area of 2,500 square feet.
- Additional access roads.

CBR has identified several additional resource areas in the region near the Crow Butte Central Plant that could conceivably be developed as satellite facilities. CBR submitted a request on May 30, 2007, for an amendment to Source Material License SUA-1534 for the development of additional uranium in situ recovery mining resources (North Trend Expansion Area). The proposed development area would be located approximately 1 mile northwest of the current License Area, and would be used as a satellite facility to the existing Central Plant. Commercial production at the Crow Butte Project, including the proposed North Trend Expansion Area, is expected to extend over the next ten years with depletion of uranium reserves at both areas by 2017. Environmental impacts associated with the proposed North Trend Expansion Area are addressed in the above-referenced license amendment and are not addressed in this document.

Development of additional satellite facilities is dependent upon further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR may submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area are depleted.

The total area impacted at any one time for the current License Area, not including access roads that will be reclaimed during the final stages of reclamation, is approximately 120 acres. All areas disturbed will be reclaimed either during the life of the mine or during final restoration and reclamation activities. Except for the wells, access roads, and possible satellite facility and/or pumphouses scattered throughout the License Area, the facilities are confined to approximately 40 acres within Section 19, T31N, R51W, Dawes County, Nebraska.

Changes in the surface configuration caused by construction and installation of operating facilities will be only temporary, during the operating period. These changes are due to topsoil removal and storage along with the relocation of subsoil materials used for construction purposes.

These surface impacts are unavoidable and will last for the duration of the project until final decommissioning. Mitigation measures for land surface impacts are discussed in **Section 6.2**.

7.1.2 Land Use Impacts

The principal land use for the License Area and the 3.62 km (2.25 mile) review area is livestock grazing on rangeland. Rangeland accounted for 55.7 percent of the land use in the License Area and the review area as discussed in **Section 2.2**. The secondary land use within this area is cropland, primarily for wheat, although a small proportion is used for alfalfa. Cropland accounted for 29.9 percent of the land use in the Crow Butte License Area and the review.

Land use impacts have occurred from existing Crow Butte facilities such as site preparation and construction activities included topsoil salvaging, pond excavation, building erection, road construction and completion of injection, production and monitor wells.

The unavoidable impact of site preparation, construction, and operation are the exclusion of cattle and crop production from the areas that are under development. The exclusion of agricultural activities from active mining areas is an unavoidable impact that will last for the duration of the project. Pastureland accounts for 43 percent of the nearly 50,000-acre License Area and surrounding 3.6 km (2.25 mile buffer). Cropland accounts for 29 percent of the total area. **Figure 2.2-1** depicts the License Area containing existing permitted facilities, and the current land use types within the CSA, which includes the License Area and a surrounding 2-mile buffer area.

As a result of site preparation and construction, cattle production has been excluded from the areas that are under development. The total estimated area that has been impacted during the course of the project is the 120 acres associated with the plant and wellfields. As discussed in **Section 2.2**, livestock and livestock products had a value of $28.81 per acre, indicating that livestock production on rangeland within the impacted wellfield area has a potential value of more than $7,770.

As a result of site preparation and construction, crop production has been excluded from the areas that are under development. The total estimated cropland area that has been impacted during the course of the project is the 1,041.7 acres associated with the plant and wellfields. In 2001 Dawes County had 77,000 acres harvested for 123,800 tons of hay and 33,700 acres harvested for 1,198,700 bushels of winter wheat. These harvests resulted in yields of 1.6 tons of hay and 35.6 bushels of wheat per acre harvested. Based on these yields, the lost annual crop production in the License Area would be up to 1,666 tons of hay and up to 37,085 bushels of wheat.

These impacts are considered temporary and reversible by returning the land to its former grazing use through post-mining surface reclamation. Mitigation measures for the loss of agricultural production over the course of the project are discussed in **Section 6.2**.

7.2 TRANSPORTATION IMPACTS

7.2.1 Access Road Construction Impacts

As noted in **Section 2.2.3**, Nebraska Highway 2/71 and U.S. Highway 20 converge at Crawford. The Crow Butte Project site is about 4.0 miles southeast of the City of Crawford via the unpaved Squaw Creek Road. Nebraska Highway 2/71 provides access to the License Area from points north and south of Crawford. U.S. Highway 20 provides access to Crawford and the License Area from points east and west.

The Burlington Northern Santa Fe (BNSF) Railroad runs in a northwesterly direction approximately 0.75 miles west of the license area. The BNSF rail line along the western boundary is used for combining local "pusher" engines with southbound trains to assist them in climbing the Pine Ridge south of Crawford. This rail line accommodates a significant amount of rail traffic, primarily from the coal mines in northeastern Wyoming.

The DM&E Railroad runs in a northeasterly direction, and forms a portion of the southeast boundary of the License Area. The junction of the two railroads is about 0.50 miles south of the License Area.

The continued operations of the project will have no impact on railroad operations in the area.

Main access roads have been designed to allow safe access from public roads by employees, contractors, and delivery vehicles. The annual average traffic counts for 2004 ranged between 1,195 south of Crawford and 540 north of Crawford on Nebraska Highway 2, and 1,795 on U.S. Highway 20 north of the License Area (Nebraska Department of Roads 2007). Traffic associated with the operation of the current facility has not adversely impacted existing traffic, and this trend is expected to continue with future planned operations.

7.2.2 Transportation of Materials

Transportation of materials to and from the Crow Butte Central Plant is discussed in the following sections:

7.2.2.1 Shipments of Construction Materials, Process Chemicals, and Fuel from Suppliers to the Site

Shipments of maintenance materials, process chemicals, and fuel from suppliers will continue to be received at the Crow Butte Plant. These shipments will continue to generate some additional noise in the area as discussed in **Section 7.7**. Since the site access roads are surfaced with gravel, the shipments will continue to generate additional dust. Air quality impacts and mitigation are discussed in **Section 7.6**.

Based on the current production schedule and material balance, it is estimated that approximately 150 bulk chemical and fuel deliveries per year will be made to the Crow

Butte Main Plant. This averages about one truck per working day for delivery of fuel and chemicals throughout the operational life of the project. Types of deliveries include carbon dioxide, oxygen, soda ash, propane, hydrochloric acid, sodium hydroxide, hydrogen peroxide, and motor vehicle fuel.

Additionally, wellfield construction materials will be received periodically throughout the operational phase of the project. These shipments are expected to occur at a frequency of once per month.

7.2.2.2 Shipment of U_3O_3, Loaded Ion Exchange Resin and 11(e)2 By-Product Material, Yellowcake, Resin From the Site to a Licensed Disposal Facility

Low level radioactive waste or unusable equipment contaminated with 11(e)2 by-product material will continue to be generated during operations and will be transported to a licensed disposal site. Because of the low volume of radioactive 11(e)2 by-product material generated, these shipments will be infrequent (averaging two per year if using roll off containers).

Shipments of natural uranium (U_3O_3), Ion Exchange Resin loaded with U_3O_3 and 11(e)2 by-product material shipments will continue to be handled as Low Specific Activity (LSA) material. All shipments will comply with all applicable DOT and USNRC regulations governing the transportation of this material.

7.2.3 Impacts to Public Roads

The additional traffic generated by the continued operation of the proposed Crow Butte Project may result in degradation of public road surfaces. In particular, the additional traffic may adversely impact local gravel roads maintained by Dawes County. These impacts have been, and are expected to continue to be, minimal since the additional traffic is not significant in comparison with current traffic levels.

7.3 GEOLOGY AND SOILS IMPACTS

7.3.1 Geologic Impacts

Geological impacts associated with operations are expected to be minimal, if any. No significant matrix compression or ground subsidence is expected, as the net withdrawal of fluid from the Basal Chadron Sandstone will be on the order of 1 percent or less, and the anticipated drawdown over the life of the project is expected to be on the order of 10 percent of the available head, or less. Further, once mining and restoration operations are completed and restoration approved, groundwater levels will return to near original conditions under a natural gradient.

7.3.2 Soil Impacts

Effects to soils have been more significant on approximately 30 fenced acres of the 1,310 acres that have been disturbed by construction of the Crow Butte Central Plant and associated facilities. Much of the remaining 1,280 acres devoted to wellfield production result in a much lower effects to soils.

The severity of soil impacts depend on the number of acres disturbed and the type of disturbance. Potential impacts include soil loss, sedimentation, compaction, salinity, loss of soil productivity, and soil contamination. Effects to soils at the Crow Butte site result from the clearing of vegetation, excavating, leveling, stockpiling, compacting, and redistributing soils during construction and reclamation. Disturbance related to the construction and operation of the Crow Butte site would be long-term, lasting for the duration of the project.

Wind erosion is a concern at the Crow Butte site. Various soils meet the criteria for severe wind erosion hazard (USDA 1977). These soils have one or more major constituents that are fine sand or sandy loam that can easily be picked up and spread by wind. Construction, as opposed to operation, presents the greatest threat to soils with potential for wind erosion. Wind erosion has been, and will continue to be, controlled by removing vegetation only where it has been necessary, avoiding clearing and grading on erosive areas, surfacing roads with gravel, and timely reclamation.

Water erosion is also a concern at the Crow Butte site. Various soils meet the criteria for severe water erosion hazard (USDA 1977). These soils have low permeability and high K-factors, making them susceptible to water erosion. The K-factor is used to describe a soil's erodibility; it represents both susceptibility of soil to erosion and the rate of runoff. It is calculated from soil texture, organic matter, and soil structure. Construction and operation increase soil loss through water erosion. Removal of vegetation for any activity exposes soils to increased erosion. Excavation could break down soil aggregates, increasing runoff and gully formation. Soil loss is reduced substantially by avoiding highly erosive areas such as badlands and steep drainages Roads will be located in areas where cuts and fills would not be required. Roads will be surfaced, drainage controls will be installed, disturbed areas will be reseeded, and water bars will be installed across reclaimed areas to minimize soil loss where possible.

Sedimentation in streams and rivers at the Crow Butte site could result from soil loss. Sedimentation could alter water quality and the fluvial characteristics of drainages in the area. Installation of appropriate erosion control measures as required by CBR's Construction Stormwater NPDES authorization (**Section 7.4.1**) and avoidance of erosive soils have aided, and will continue to aid, in reducing sedimentation.

Activity on the site has the potential to compact soils. While soils sensitive to compaction, such as clay loams, do not exist on the site, the intense volume and degree of activity at the Crow Butte site could damage soil properties and cause compaction. Compaction of the soils could decrease infiltration, promoting high runoff. If compaction occurs, reduced infiltration capacity could persist for over 50 years in some soils. Soil disturbance and traffic will continue to be minimized where possible, and soils will be loosened for reseeding during reclamation to control the effects of soil compaction.

Any soil on the site can be saline depending on site-specific soil conditions, such as permeability, clay content, quality of nearby surface waters, plant species, and drainage characteristics. Saline soils are extremely susceptible to soil loss caused by development. Soil erosion in areas with high salt content would contribute to salinity in the White River Basin. Reclamation of saline soils can be difficult, and no method that works in all situations has yet been found.

Facility development displace topsoil, which adversely affects the structure and microbial activity of the soil. Loss of vegetation expose soils and result in a loss of organic matter in the soil. Excavation could cause mixing of soil layers and breakdown of the soil structure. Removal and stockpiling of soils for reclamation could result in mixing of soil profiles and loss of soil structure. Compaction of the soil could decrease pore space and cause a loss of soil structure as well. This would result in a reduction of natural soil productivity.

A number of erosion and productivity problems resulting from the Crow Butte site may cause a long-term declining trend in soil resources. Long-term impacts to soil productivity and stability would occur as a result of large-scale surface grading and leveling, until successful reclamation would be accomplished. Reduction in soil fertility levels and reduced productivity would affect diversity of reestablished vegetative communities. Moisture infiltration would be reduced, creating soil drought conditions. Vegetation would undergo physiological drought reactions.

Surface spillage of hazardous materials could occur at the Crow Butte site. If not remediated quickly, these materials have the potential to adversely impact soil resources. In order to minimize potential impacts from spills, a Spill Prevention, Control, and Countermeasure (SPCC) Plan has been implemented. The SPCC plan includes accidental discharge reporting procedures, spill response, and cleanup measures.

7.4 WATER RESOURCES IMPACTS

7.4.1 Surface Water Impacts of Construction and Decommissioning

When stormwater drains off a construction site, it typically carries sediment and other pollutants that can harm lakes, streams and wetlands. USEPA estimates that 20 to 150 tons of soil per acre is lost every year to stormwater runoff from construction sites. For this reason, stormwater runoff is controlled by National Pollutant Discharge Elimination System (NPDES) regulations.

Construction activities at the Crow Butte Project to date have had a minimal impact on the local hydrological system. CBR conducts construction activities under NDEQ permitting regulations for control of construction stormwater discharges contained in Title 119. CBR is required by NDEQ General Construction Stormwater NPDES Permit NER 100000 to implement procedures that control runoff and the deposition of sediment in surface water features during construction activities. These procedures are contained in EHSMS Volume VI, *Environmental Manual,* and require active engineering measures, such as berms, and administrative measures, such as work activity sequencing to control runoff and sedimentation of surface water features. CBR must annually submit a construction plan for the coming year and obtain authorization from the NDEQ under the general permit.

The results of stream sediment sampling for most semiannual periods between 1998 and 2007 fall within the expected ranges, as shown in **Table 5.8-11** and **Figures 5.8-32** through **5.8-37**. In the second half of 2005, the concentrations of natural uranium in several English Creek samples were well above regional background levels. CBR has noted these elevated concentrations in the English Creek drainage during preoperational monitoring, which indicates that these levels are anomalous natural background concentrations.

7.4.2 Surface Water Impacts of Operations

7.4.2.1 Surface Water Impacts from Sedimentation

Protection of surface water from stormwater runoff during on-going wellfield construction related to operations is regulated by the NDEQ as discussed in **Section 7.4.1**.

7.4.2.2 Potential Surface Water Impacts from Accidents

Surface water quality could potentially be impacted by accidents such as an evaporation pond leakage or failure or an uncontrolled release of process liquids due to a wellfield accident. **Section 7.4.3.3** discusses the operation of the ponds and measures to prevent and control wellfield spills. An additional measure to protect surface water is that wellfield areas are installed with dikes or berms to prevent spilled process solutions from entering surface water features. Process buildings are constructed with secondary containment, and a regular program of inspections and preventive maintenance is in place. In addition to the administrative and engineering controls routinely implemented by CBR, it is expected that surface water impacts from potential accidents at the Crow Butte facilities will be minimal since there are no nearby surface water features.

7.4.3 Groundwater Impacts of Operations

Potential impacts to water resources from mining and restoration activities include the following.

7.4.3.1 Groundwater Consumption

As discussed in **Section 2.7**, a regional pump test has been conducted to assess the hydraulic characteristics of the Basal Chadron Sandstone, and overlying confining units. Pump tests are also performed for each mine unit to demonstrate hydraulic containment above the production zone, demonstrate communication between the production zone mining and exterior monitor wells, and to further evaluate the hydrologic properties of the Basal Chadron Sandstone.

A full and detailed analysis of the potential impacts of the mining operations at Crow Butte on surrounding water users have been provided in an Industrial Groundwater Use Permit application required by NDEQ. The permit application was submitted to NDEQ by Ferret Exploration of Nebraska (predecessor to Crow Butte Resources) in 1991. The application states that water levels in the City of Crawford (approximately three miles northwest of the mining area) could potentially be impacted by approximately 20 feet by consumptive withdrawal of water from the Basal Chadron Sandstone during mining and restoration operations (based on a 20-year operational period).

A similar order of magnitude impact (drawdown) likely exists for the Crow Butte operations. No impact to other users of groundwater has been observed, nor is expected during future operations because: (1) there is no documented existing use of the Basal Chadron in the License Area; and, (2) the potentiometric head of the Basal Chadron Sandstone in the License Area ranges from approximately 40 to 200 feet below ground surface.

Because the Basal Chadron Sandstone (production zone) is a deep confined aquifer, no surface water impacts are expected. Further, the geologic and hydrologic data presented in **Sections 2.6** and **2.7**, respectively, demonstrate that (1) the occurrence of uranium mineralization is limited to the Basal Chadron Sandstone; and, (2) the Basal Chadron is isolated from underlying and overlying sands. Hence, the mining operations are expected to impact water quality only in the Basal Chadron Sandstone, and restoration operations will be conducted in the Basal Chadron following completion of mining.

Based on a bleed of 0.5 percent to 1.5 percent, which has been successfully applied in the current licensed area, the potential impact from consumptive use of groundwater is expected to be minimal. In this regard, the vast majority (e.g., on the order of 99 percent) of groundwater used in the mining process will be treated and re-injected. Potential impacts on groundwater quality due to consumptive use outside the license area are expected to be negligible.

Because of the uncertainty regarding the impact of the White River structural feature on groundwater flow in the Basal Chadron Sandstone, strict quantification of the mining impacts is difficult until more detailed information related to this feature is available.

To generally quantify the potential impact of drawdown due to mining and restoration operations, the following assumptions were used:

• Mining/restoration life:	20 years
• Average net consumptive use:	5112 gpm
• Location of pumping centroid:	Center of Section 19
• Observation radius:	4 miles radially from centroid of pumping
• Formation transmissivity	330 ft^2/d
• Formation thickness	40 feet
• Formation hydraulic conductivity	9.0 ft/d
• Formation storativity	9.0×10^{-5}

The data was evaluated using a Theis semi-steady state analytical solution, which includes the following assumptions:

- The aquifer is confined and has apparent infinite extent;
- The aquifer is homogeneous and isotropic, and of uniform effective thickness over the area influenced by pumping;
- The piezometric surface is horizontal prior to pumping;
- The well is pumped at a constant rate;
- No recharge to the aquifer occurs;
- The pumping well is fully penetrating; and,
- Well diameter is small, so well storage is negligible.

Based on these assumptions and results from pumping tests, drawdown after 20 years of operation at a 4 mile radial distance from the centroid of pumping was calculated to be 23.6 feet. This amount of drawdown is approximately 4.5 percent of the available drawdown in the Basal Chadron Sandstone.

As discussed in **Section 5.8**, an extensive water-sampling program will be conducted prior to, during and following mining operations at the Crow Butte facility to identify any potential impacts to water resources of the area.

Water level measurements will be routinely performed in the production zone and overlying aquifer. Sudden changes in water levels within the production zone may indicate that the wellfield flow system is out of balance. Flow rates would be adjusted to correct this situation. Increases in water levels in the overlying aquifer may be an indication of fluid migration from the production zone. Adjustments to well flow rates or complete shut down of individual wells may be required to correct this situation. Increases in water levels in the overlying aquifer may also be an indication of casing failure in a production, injection or monitor well. Isolation and shut down of individual wells can be used to determine the well causing the water level increases.

To ensure the leach solutions are contained within the designated area of the aquifer being mined, the production zone and overlying aquifer monitor wells will be sampled once every two weeks as discussed in **Section 5.8**.

These impacts are unavoidable aspects of solution mining. No mitigative measures have been identified.

7.4.3.2 Impacts on Groundwater Quality

Solution mining of a mineral deposit is accomplished by reversing the natural processes that deposited the uranium. The native formation waters in the ore zones in the Basal Chadron aquifer are not recommended for human consumption because of naturally high levels of dissolved radioactive materials (uranium and Ra-226). In addition to uranium, other metals will mobilize by the mining process. This process affects the mining zone, which must be exempted from Clean Water Act protections by the NDEQ and the USEPA under the aquifer exemption provisions of the State and Federal UIC regulations.

Excursions represent a potential effect on the adjacent groundwater as a result of operations. During production, injection of the lixiviant into the wellfield results in a temporary degradation of water quality in the exempted aquifer compared to pre-mining conditions. Movement of this water out of the wellfield results in an excursion. Excursions of contaminated groundwater in a wellfield can result from an improper balance between injection and recovery rates, undetected high permeability strata or geologic faults, improperly abandoned exploration drill holes, discontinuity and unsuitability of the confining units which allow movement of the lixiviant out of the ore zone, poor well integrity, and hydrofracturing of the ore zone or surrounding units.

To date, there have been several confirmed horizontal excursions in the Chadron sandstone in the current license area. These excursions were quickly detected and recovered through overproduction in the immediate vicinity of the excursion. In all but one case, the reported vertical excursions were actually due to natural seasonal fluctuations in Brule groundwater quality and very stringent upper control limits (UCLs). In no case did the excursions threaten the water quality of an underground source of drinking water since the monitor wells are located well within the aquifer exemption area approved by the USEPA and the NDEQ. **Table 7.4-1** provides a summary of excursions reported for the License Area.

Table 7.4-1: Excursion Summary

Monitor Well ID	Date On Excursion	Date Off Excursion	Causal Factor(s)
CM6-6	July 1, 1999	September 23, 1999	Excursion of mining solutions
PR-15	January 13, 2000	March 23, 2000	Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM6-18	March 6, 2000	April 11, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
IJ-13	April 20, 2000		Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
SM7-23	April 27, 2000	January 13, 2004	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-28	May 25, 2000	June 22, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-13	May 25, 2000	July 20, 2000	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
SM6-12	September 8, 2000	November 20, 2000	Surface leak
SM6-13	March 1, 2001	April 12, 2001	Natural fluctuation of shallow groundwater quality (unrelated to mining activities)
CM5-11	September 10, 2002	May 6, 2003	Excursion of mining solutions
CM6-7	April 4, 2002	April 25, 2002	Excursion of mining solutions
PR-8	December 23, 2003		Mine Unit 1 interior monitor well affected by adjacent groundwater restoration (unrelated to mining activities)
CM5-19	May 2, 2005	July 26, 2005	Excursion of mining solutions
SM6-28	June 16, 2005	July 5, 2005	High water table due to heavy spring rains (unrelated to mining activities)
SM6-12	June 28, 2005	July 26, 2005	High water table due to heavy spring rains (unrelated to mining activities)
CM9-16	August 4, 2005	November 8, 2005	Excursion of mining solutions
CM8-21	January 18, 2006	April 7, 2006	Excursion of mining solutions
PR-15	September 26, 2006		See IJ-13 and PR-8

Notes:
Mitigative measures for impacts on groundwater quality are discussed in Section 5.3.

7.4.3.3 Potential Groundwater Impacts from Accidents

Groundwater quality could potentially be impacted during operations due to an accident such as evaporation pond leakage or failure, or an uncontrolled release of process liquids due to a wellfield accident. If there should be an uncontrolled pond leak or wellfield accident, potential contamination of the shallow aquifer (Brule), as well as surrounding soil, could occur. This could occur as a result of a slow leak or a catastrophic failure, a shallow excursion, an overflow due to excess production or restoration flow, or due to the addition of excessive rainwater or runoff.

To mitigate the likelihood of pond failure, all ponds at Crow Butte have been designed and built to USNRC standards using impermeable synthetic liners. A leak detection system was also installed, and all ponds are inspected on a regular basis. In the event that a problem is detected, the contents of any given pond can be transferred to another pond while repairs are made. The pond design and operation is discussed in greater detail in **Section 4.2.**

Over the course of the current licensed operation, CBR has experienced several leaks associated with the inner pond liner on the commercial evaporation ponds. These small leaks are virtually unavoidable since the liners are exposed to the elements. In each case these leaks were quickly discovered during routine inspections, primarily due to a response in the underdrain system. Corrective actions included lowering the pond level and locating the leak to allow repairs. In none of these situations was the shallow groundwater affected since the outer pond liner functioned as designed and prevented a release of the pond contents. All pond leaks, causes, and corrective actions are reported to the USNRC and the NDEQ.

With respect to potential overflow of a pond, current standard operating procedures require that pond levels be closely monitored as part of the daily inspection. Process flow to the ponds are minimal in comparison to the pond capacity, thus it can easily be diverted to another pond if necessary. In addition, sufficient freeboard is maintained on all ponds to allow for a significant addition of rainwater with no threat of overflow. Finally, the dikes and berms around the ponds channel runoff away from the ponds.

Another potential cause of groundwater impacts from accidents could be releases as a result of a spill of injection or production solutions from a wellfield building or associated piping. In order to control these types of releases, all piping is either PVC, high density polyethylene with butt welded joints, or equivalent. All piping is leak tested prior to production flow and following repairs or maintenance.

7.5 ECOLOGICAL RESOURCES IMPACTS

7.5.1 Effects of the Current Commercial Operation

Adverse impacts associated with development of the R&D operation and the current commercial operation included ground disturbing activities resulting from the construction of access roads, processing facility, active wells, and other project related needs. These disturbances have been less than 100 acres at any one time.

These disturbances have not significantly affected ecological resources because, as discussed in the baseline section, there is no critical habitat for any species within the CSA. Additionally, the small amount of project-disturbed land compared to the amount of similar habitat surrounding the area should not have affected populations of any species occurring there.

7.5.2 Impact Significance Criteria

The following criteria were used to determine the significance of construction and operation of the proposed project on wildlife and vegetation resources within the project area. These criteria were developed based on professional judgment, involvement in other USEPA projects throughout the West, and state and federal regulations.

- Removal of vegetation such that following reclamation, the disturbed area(s) would not have adequate cover (density) and species composition (diversity) to support pre-existing land uses, including wildlife habitat;
- Unauthorized discharge of dredged or fill materials into, or excavation of, waters of the U.S., including special aquatic sites, wetlands, and other areas subject to the Section 404 of the Clean Water Act, Executive Order 11988-flood plains, and Executive Order 11990 - wetlands and riparian zones;
- Reclamation is not accomplished in compliance with Executive Order 13112 (Invasive Species);
- Introduction and establishment of noxious or other undesirable invasive, non-native plant species to the degree that such establishment results in listed invasive, non-native species occupying any undisturbed rangeland outside of established disturbance areas or hampers successful revegetation of desirable species in disturbed areas;
- Whether or not a substantial increase in direct mortality of wildlife caused by road kills, harassment, or other causes would occur;
- Incidental take of a special-status species to the extent that such impact would threaten the viability of the local population;
- Whether or not an officially-designated critical wildlife habitat was eliminated, sustained a permanent reduction in size, or was otherwise rendered unsuitable;

- Whether or not any effect, direct or indirect, results in a long-term decline in recruitment and/or survival of a wildlife population; and
- Construction disturbance during the breeding season or impacts to reproductive success which could result in the incidental loss of fertile eggs or nestlings, or otherwise lead to nest abandonment in accordance with regulations prescribed by the Migratory Bird Treaty Act.

7.5.3 Vegetation

Direct impacts associated with project development and operations include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types) from soil disturbance and grading. Potential indirect impacts include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; and changes in visual aesthetics. Vegetation removal and soil handling associated with the construction and installation of wellfields, pipelines, access roads, and satellite facilities would affect vegetation resources both directly and indirectly. However, because most project-related infrastructure will be constructed within cultivated agricultural fields, vegetation impacts will be negligible. If the mixed-grass prairie vegetation community were to be developed, direct impacts would include the short-term loss of vegetation (modification of structure, species composition, and areal extent of cover types). Indirect impacts would include the short-term and long-term increased potential for non-native species invasion, establishment, and expansion; exposure of soils to accelerated erosion; shifts in species composition or changes in vegetative density; reduction of wildlife habitat; reduction in livestock forage; and changes in visual aesthetics.

During the anticipated life of the project (15 to 18 years), an estimated 1,041.7 acres of cultivated agricultural fields would be affected by surface-disturbing production facilities. The likelihood of impact is greatest for the primary vegetation cover types of cultivated fields, which occupies 62 percent of the total impacted area. As stated above, clearing of mixed-grass prairie vegetation community types is not anticipated.

Construction activities, increased soil disturbance, and higher traffic volumes could stimulate the introduction and spread of undesirable and invasive, non-native species within the project area. Non-native species invasion and establishment has become an increasingly important result of previous and current disturbance in western states. These species often out-compete desirable species, including special-status species, rendering an area less productive as a source of forage for livestock and wildlife. Additionally, sites dominated by invasive, non-native species often have a different visual character that may negatively contrast with surrounding undisturbed vegetation. Currently, the project area is relatively free of noxious and other unwanted invasive, non-native species.

In general, the duration of effects on cultivated agricultural land and mixed-grass prairie vegetation are significantly different. Cropland areas can be readily returned to production through fertilizer treatments and compaction relief. However, disturbed native prairie tracts require reclamation treatments and natural succession to return to predisturbance conditions of diversity (both species and structural). Reestablishment of mixed-grass prairie to predisturbance conditions would be influenced by climate (growing season, temperature, and precipitation patterns) and edaphic (physical, chemical, and biological) conditions in the soil.

Previously planted agricultural fields would be recontoured to approximate precontours and ripped to depths of 12 to 18 inches to relieve compaction. If mixed-grass prairie tracts were disturbed by surface activities, these areas would be completely reclaimed. Reclamation of mixed-grass prairie would generally include: (1) completing cleanup of the disturbed areas (wellfields and access roads); (2) restoring the disturbed areas to the approximate ground contour that existed before construction; (3) replacing topsoil, if removed, over all disturbed areas; (4) ripping disturbed areas to a depth of 12 to 18 inches; and (5) seeding recontoured areas with a locally adapted, certified weed-free seed mixture.

7.5.4 Surface Waters and Wetlands

Surface disturbances associated with the proposed facilities would not affect either Spring Creek or the White River. In addition, no wetlands have been identified within the project area. Therefore, impacts to wetlands and surface waters are not anticipated.

The Crow Butte License Area lies within the watershed of Squaw Creek and English Creek which are small tributaries to the major regional water course, the White River. Construction and operation impacts have had a minimal impact on the local hydrological system. Some additional sediment entered Squaw Creek from adjacent unnamed tributaries during construction earth moving activities of the Central Plant; however, this condition was temporary without any long-term impacts. The increased sediment load as a result of precipitation during construction, operations or reclamation should not significantly affect the quality of Squaw Creek since the more sensitive areas of the stream are located upstream from the point of entry of the tributary.

Although normal construction activities within the wellfields, process plant and along pipeline courses and roads may slightly increase the sediment yield of the areas disturbed, the relative size of such disturbances is minor compared to the size of the permitted areas and to the size of the watersheds. As wellfield decommissioning and reclamation activities will be on going throughout the life of the project, the area to be reclaimed at the conclusion of operations will be reduced, although a slight increase in sediment yields and total runoff can still be expected.

The results of stream sediment sampling for Squaw and English Creeks indicate that measured concentrations of radiological parameters (e.g., uranium) between 1998 and 2207 are consistent with preoperational monitoring, which indicates that these levels are anomalous natural background concentrations.

Wetlands and/or waterbodies (i.e., wet meadow, mixed prairie – riparian, wet meadow-riparian, deep marsh-riparian, riverine, and impoundment) make up only 3.17 percent (273.92 acres) of the habitat within the License Area. Although the potential for impacting such ecological systems is minor, efforts are made to avoid impacting such environments.

7.5.5 Wildlife and Fisheries

The effects on wildlife are associated with construction and operation of project facilities, which include displacement of some individuals of some wildlife species, loss of wildlife habitats, and an increase in the potential for collisions between wildlife and motor vehicles. Other potential effects include a rise in the potential for illegal kill, harassment, and disturbance of wildlife because of increased human presence primarily associated with increased vehicle traffic. The magnitude of impacts to wildlife resources would depend on a number of factors, including the time of year, type and duration of disturbance, and species of wildlife present.

7.5.6 Small Mammals and Birds

The direct disturbance of wildlife habitat in the project area likely would reduce the availability and effectiveness of habitat for a variety of common small mammals, birds, and their predators. The initial phases of surface disturbance and increased noise would result in some direct mortality to small mammals and would displace some bird species from disturbed areas. In addition, a slight increase in mortality from increased vehicle use of roads in the project area would be expected.

The temporary disturbances that occur during the construction period would tend to favor generalist wildlife species such as ground squirrels and horned larks, and would have more impact on specialist species such as western meadowlarks, lark buntings, and grasshopper sparrows. Overall, the long-term disturbance of 1,310 acres would have a low effect on common wildlife species. Songbirds that may be affected by the reduction in cultivated fields would be horned larks, sage sparrows, sage thrashers, and vesper sparrows. Although there is no way to accurately quantify these changes, the impact is likely to be low in the short term and be reduced over time as reclaimed areas begin to provide suitable habitats.

Because of the high reproductive potential of these species, they would rapidly repopulate reclaimed areas as habitats become suitable. Birds are highly mobile and would disperse into surrounding areas and utilize suitable habitats to the extent that they are available. The primary small mammals found on the project area include, but are not limited to, eastern cottontail, deer mice, thirteen-lined ground squirrel, white-footed mouse, meadow jumping mouse, and northern pocket mouse. The initial phases of surface disturbance would result in some direct mortality and displacement of small mammals from construction sites. Quantifying these changes is not possible because population data are lacking. However, the impact is likely to be low, and the high reproductive potential of these small mammals would enable populations to quickly repopulate the area once reclamation efforts are initiated.

7.5.7 Big Game Mammals

The principal wildlife impacts likely to be associated within the project area include: (1) a direct loss of certain wildlife habitat; (2) the displacement of some wildlife species; (3) an increase in the potential for collisions between wildlife and motor vehicles; and, (4) an increase in the potential for the illegal kill and harassment of wildlife.

In general, direct removal of habitat used by big game mammals is expected to be minimal, as the project area is predominantly used for agricultural production. Because a substantial proportion of the project area is used for seasonal crop production, only a small proportion of the available wildlife habitat in the project area would be affected. The capacity of the project area to support big game populations should remain essentially unchanged from current conditions.

In addition to the direct removal of habitat because of the development of wells and associated satellite facilities, disturbances from drilling activities and traffic would affect utilization of the habitat immediately adjacent to these areas; however, big game mammals are adaptable and may adjust to non-threatening, predictable human activity. It is envisioned that most big game mammal responses will consist of avoidance of areas proximal to the operational facilities, with most individuals carrying out normal activities of feeding and bedding within adjacent suitable habitats. In addition, the magnitude of displacement would decrease over time as: (1) the animals have more time to adjust to the operational circumstances; and, (2) the extent of the most intense activities such as drilling and road building diminishes and the wellfields are put into production. By the time the wellfields are under full production, construction will have ceased, and traffic and human activities in general would be greatly reduced. As a result, this impact would be minimal and it is unlikely that big game mammals would be significantly displaced under full field development. The level of big game mammal use of the project area is more likely to be determined by the quantity and quality of forage available.

The potential for vehicle collisions with big game mammals would increase as a result of increased vehicular traffic associated with the presence of construction crews and would continue (although at a reduced rate) throughout all phases of the wellfield operations. Development of new roads would allow greater access to more areas and may lead to an increased potential for poaching of big game animals; however, because of the proximity to Crawford and locations of farm residences in the project area, the incidence of vehicle collision impacts to big game mammals is anticipated to occur infrequently and no long-term adverse effects are expected.

Based on the foregoing, long-term adverse effects are not expected for any local big game mammal populations.

7.5.8 Upland Game Birds

The potential effects of the operation and maintenance of project facilities on upland game birds may include nest abandonment and reproductive failure caused by project-related disturbance and increased noise. Other potential effects involve increased public access and subsequent human disturbance that could result from new construction and production activities.

7.5.8.1 Sharp-tailed Grouse

No sharp-tailed grouse leks are known to occur within the project area. However, noise related to drilling and production activities may affect sharp-tailed grouse utilization of leks or reproductive success. Reduction of noise levels in areas near leks would minimize this potential impact. If leks are found, surface disturbance should be avoided within 0.25 miles of leks. If disturbance within the buffer areas is avoided, no impacts are expected.

Areas with large tracts of mixed-grass prairie would provide the best quality nesting habitat. To protect sharp-tailed grouse nesting habitats, construction should be limited within a 1-mile radius of an active lek between March 1 and June 30. Significant impacts to leks and subsequent reproductive success are not expected if these guidelines are implemented.

7.5.9 Raptors

Potential impacts to raptors within the project area include: (1) nest desertions or reproductive failure as a result of project activities and increased public access; (2) temporary reductions in prey populations; and, (3) mortality associated with roads.

The primary potential impact to raptors from project activities is disturbance during nesting that might result in reproductive failure. To minimize this potential, construction would not be allowed during the critical nesting season (Feb. 1 - July 31, depending on species) within 0.5 mile of an active nest of listed or sensitive raptor species, and 0.25 mile (depending on species or line of sight) of an active nest of other raptor species. The nature of the restrictions, exclusion dates, and the protection radii would vary, depending on activity status of nests, species involved, and natural topographic barriers, and line-of-sight distances should be developed in coordination within the Nebraska Game and Parks Commission (NGPC) or the U.S. Fish and Wildlife Service (USFWS).

Nests not used in 1 year, may potentially be used in subsequent years. Subsequent development within close proximity to these nests may preclude use of the nest in following years. Therefore, protection of nests that may potentially be used in the future may require limiting construction within 300 meters (depending on species or line of sight) to minimize impacts. If "take" of an inactive nest were unavoidable, development of artificial nesting structures would mitigate for the loss of the nest. In some instances, during the production phase when human activity is reduced, raptors may actually nest on artificial above-ground structures. Based on the foregoing, significant impacts to raptor nesting activities are not expected.

The development of proposed wellfield and satellite facilities would disturb an estimated 1,310 acres of potential habitat for several species of small mammals that serve as prey for raptors. This short-term impact would affect approximately 62 percent of the proposed license area, although this is not likely to limit raptor use within the project area. The small amount of short-term change in prey base populations created by construction is minimal in comparison to the overall status of the rodent and lagomorph populations. While prey populations on the project area would likely sustain some impact during the initial phase of the project, prey numbers would be expected to soon rebound to pre-disturbance levels following reclamation or active agricultural uses. Once reclaimed or in active agricultural uses, these areas would likely promote an increased density and biomass of small mammals that is comparable to those of undisturbed areas. For these reasons, implementation of the project is not expected to produce any appreciable long-term negative changes to the raptor prey base within the project area.

The creation of new roads would increase public access to areas within the project area. As use of the project area increases, the potential for encounters between raptors and humans would increase and could result in increased disturbance to nests and foraging areas. Closure of roads located near active raptor nests to public vehicle use would offset this potential impact. Some raptor species feed on road-killed carrion on and along the roads, while others (owls) may attempt to capture small rodents and insects that are illuminated in headlights. These raptor behaviors put them in the path of oncoming vehicles where they are in danger of being struck and killed. The potential for such collisions can be reduced by requiring drivers to follow all posted speed limits.

7.5.10 Fish and Macroinvertebrates

Suitable habitat for fish and macroinvertebrates exists within portions of Spring Creek and the White River. However, the construction, operation, and maintenance of the project are not expected to affect either of these habitats.

7.5.11 Threatened, Endangered and Candidate Species

The USFWS and NGPC have identified the following threatened, endangered and candidate species with the potential to occur in Dawes County: swift fox (state endangered), the bald eagle (state endangered), black-footed ferret (state/federal endangered), and whooping crane (state/federal endangered). However, as discussed in **Section 2.8**, the species with a reasonable possibility of occurring on or near the project site are the bald eagle and swift fox. The whooping crane, black-footed ferret and black-tailed prairie dog have not been observed on the project site.

7.5.11.1 Swift Fox (State Endangered)

The swift fox is closely associated with lagomorph populations, prairie dog colonies, ground squirrels, and other small mammals, which exist in varying densities and abundance throughout the License Area. High quality swift fox habitat is present in a grassland area immediately northwest of the project area, which would be expected to be a preferred habitat area over the existing License Area. Based on our analysis, the implementation of the project may affect the swift fox due to disturbance to habitats that may support preferred swift fox prey species. This minor indirect effect is not expected to affect the individual health of the swift fox or the status of the local swift fox population because of the availability and suitability of other undisturbed habitats in the License Area and adjacent areas.

7.5.11.2 Bald Eagle (State Threatened)

Based on our analysis of the effects of project implementation and the current and potential status of this species in northwestern Nebraska, we conclude that the proposed alternative will have no adverse effect on the bald eagle. This analysis is based on lack of observed bald eagle nests in the project area, no documentation of winter concentration areas or winter nighttime roosts (Fritz 2004), and lack of open water in which most bald eagle populations tend to maintain a close association

7.5.11.3 Black-footed Ferret (Federal and State Endangered)

There have been no observations or reports of the black-footed ferret in the project area, nor have there been any confirmed populations of the ferret observed in the state of Nebraska since 1959 (USFWS 1978). Black-footed ferret populations coincide closely with colonies of prairie dogs on which the ferret depends for food and habitat. Prairie dog colonies required for a successful ferret population are not found within the License Area. Based on our analysis of the effects of project implementation and the current and potential status of this species in northwestern Nebraska, we conclude that the proposed alternative will have no adverse effect on the black-footed ferret.

7.5.11.4 Whooping Crane (Federal and State Endangered)

There is a limited availability of highly suitable whooping crane habitat within the License Area, with the majority of sitings within Nebraska occurring in the Platte Valley that is located a considerable distance away in central Nebraska. Therefore, any presence of whooping cranes within the License Area and surrounding area would be expected to be infrequent and transient. Based on our analysis of the effects of project implementation and the current and potential status of this species in northwestern Nebraska, we conclude that the proposed alternative will have no adverse effect on the whooping crane.

7.5.11.5 Reptiles, Amphibians, and Fish

No threatened or endangered reptiles, amphibians, or fish species have been recorded in the project area, and none are expected to occur.

7.5.12 Cumulative Impacts

Cumulative impacts to ecological resources are not anticipated, as no substantive impairment of ecological stability or diminishing of biological diversity is expected within the project area.

7.6 AIR QUALITY IMPACTS

Any construction activities (e.g., new wellfields and Central Plant improvements) at the Crow Butte Project would cause minimal effects on local air quality. Effects to air quality would be increased suspended particulates from vehicular traffic on unpaved roads, in addition to existing fugitive dust caused by wind erosion, and diesel emissions from heavy equipment. As needed, the application of water to unpaved roads reduce the amount of fugitive dust to levels equal to or less than the existing condition. Diesel emissions from heavy equipment during operations (e.g., maintenance and new wellfield construction/development) are expected to be short term only.

Although there are no ambient air quality monitoring data for these non-radiological pollutants in the License Area, PM_{10} concentrations have been measured in Rapid City, South Dakota and Badlands National Park in South Dakota. Both locations are geographically similar to the License Area.

The Rapid City data were collected at the National Guard Camp Armory site about 2 miles west of the city. This area is classified as suburban. The Badlands data were collected in an area classified as rural. Because of the degree of urbanization, the air quality at the License Area would probably fall somewhere between the air quality at these two locations. These data were obtained from the USEPA air quality monitoring database (USEPA 2007), and are presented in **Table 7.6-1**.

Table 7.6-1: PM_{10} Monitoring Summary (micrograms per cubic meter)

	Maximum 24-hr Average		Annual Average	
Year	Black Hills, SD	Rapid City, SD	Black Hills, SD	Rapid City, SD
1998	-	87.4	-	30.7
1999	-	116.9	-	28.2
2000	38.5	97.4	12.0	31.3
2001	47.9	81.5	12.6	34.6
2002	26.0	104.7	9.9	34.9
2003	74.4	91.8	16.3	36.2
2004	24.0	72.0	10.0	30.0
2005	40.0	94.00	9.0	27.0
2006	30.0	124.0	10.0	29.0

The National Ambient Air Quality Standards (NAAQS) for PM_{10} are 150 micrograms per cubic meter (24-hour average), and 50 micrograms per cubic meter (annual average). All counties within the 80-km radius of the project are in attainment of NAAQS.

There will be an increase in the total suspended particulates (TSP) in the region as a result of the License Area. This increase in TSP will be greatest during the site preparation phase of the satellite facility. Revegetation will be performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. All areas disturbed during construction are revegetated with the exception of plant pad areas, roads, and areas covered by the pond liners. Of these, the only significant source of TSP is dust emissions from unpaved roads. The amount of dust can be estimated from the following equation taken from "Supplement No. 8 For Compilation of Air Pollutant Emission Factors" (USEPA 1978).

$$E = (0.81s)\frac{S}{30}\frac{365 - w}{w}$$

Where:

E	=	emission factor, lb per vehicle-mile
s	=	silt content of road surface material, 40%
S	=	average vehicle speed
w	=	mean number of days with 0.01 inches or more of rainfall, 85

Using the values stated above, the emission factor is equal to 0.25 lb/vehicle-mile. The distance from the facility to Highway 71 is 3 miles away traveling due west and 4.5 miles through Crawford. Assuming 35 employees, a five workday week and a 33 percent increase to allow for additional traffic (deliveries, etc.), the total mileage on dirt roads is 1000 miles/week. This corresponds to a dust emission of 6.5 tons/year as a result of the increased traffic on dirt roads. Traffic counts made by the Nebraska Department of Roads in 1987 indicated that there were 119 daily trips on the County Road that employees would take to Crawford (4.5 miles) from the plant. This results in over 2,000 miles per week at the present time. If the increased dust should present a problem, either due to current operations or due to possible future expansions, the emissions can be reduced through appropriate control procedures such as the use of dust control chemicals on the road surface.

All of the airborne emissions presented above will have a minimal impact of the environment. At no time during the life of the project it is anticipated that the ambient air quality standard of the State of Nebraska will be exceeded.

Other operational activities may have impacts on surrounding air quality. The only atmospheric emission from the production and process facilities will be radon gas, which is discussed at length in **Section 7.12.2**.

7.7 NOISE IMPACTS

The main noise impacts of the current Crow Butte uranium in situ operation were during construction of the main processing plant. Noise impacts at a distance of 2880 feet, the approximate location of the closest receptor from construction equipment located at the License Area, was calculated to be 49 dBA. Noise impacts were addressed in the 1998 LRA. The project area is bounded on the west by the Burlington Northern Santa Fe (BNSF) rail line. Therefore, the existing ambient noise in the immediate vicinity of the Project area is dominated by the trains on the BNSF rail line.

If a new satellite facility (e.g., North Trend Expansion Area) is constructed, then noise impacts would be comparable to those of the Central Plant construction. Noise impacts associated with the North Trend Satellite Plant are addressed in the North Trend application.

Construction associated with the current License Area has been, and will continue to be, minimal, e.g., heavy equipment used for periodic maintenance and construction of new wellfields. Such activities involve minimal equipment at any one time and are short-term impacts.

Noise sources during operation in the License Area have increased due to increased vehicle travel as increased numbers of employees traveling to and from Crawford for work at the Central Plant. In addition, there are some additional noise due to periodic truck deliveries an shipments associated with operations. Train usage has not increased as a result of operations. Processing equipment at the proposed satellite site would be minimal and is not expected to add to existing noise sources. Increases in noise levels due to operation are less than noise levels generated during construction. Therefore, noise levels during operation are expected to continue to be barely perceptible over the existing ambient noise that is dominated by vehicle noise from SH 2/71 and the BNSF railroad.

7.8 HISTORIC AND CULTURAL RESOURCES IMPACTS

As discussed in **Section 2.4**, an archaeological review area was surveyed for the presence of cultural resources that may be impacted by the Crow Butte Project. Field investigation in 1982 and 1987 identified twenty-one new archeological resource locations. These sites are represented by eight Native American components, twelve Euro-American locations and a buried deposit of undetermined cultural association. Six of these sites are considered to be potentially eligible for the National Register of Historic Places and would warrant further investigation if they were ever to be directly impacted. These resources however, have been avoided and not directly impacted as a result of construction activities. Any further construction activities will avoid these identified resources and coordination will be maintained with the Nebraska State Historical Society.

7.9 VISUAL/SCENIC RESOURCES IMPACTS

7.9.1 Environmental Consequences

The visible surface structures constructed in the Crow Butte License Area include the processing plant, office buildings, wellhead covers, wellhouses, and electrical distribution lines.

Each wellhead cover consists of a weatherproof structure placed over each well. Each structure is approximately 3 feet high and 2 feet in diameter. Each well house consists of a small shed. The plant building is approximately 100 feet by 130 feet in size. Electric distribution lines connect wellhouses to existing electric distribution lines. The distribution poles are approximately 20 feet high. The poles are wooden so that their natural color harmonizes with the landscape.

7.9.1.1 Short-term Effects

Temporary and short-term effects to the rural character of the landscape occurred from well construction, well drilling, and associated construction of ancillary facilities, such as access roads and electric distribution lines. Once installation of facilities was complete, temporary disturbance areas were reclaimed to pre-construction conditions. Only permanent disturbances associated with operations and maintenance of the facilities have remained following post-construction restoration.

7.9.1.2 Long-term Effects

Long-term effects for the project have resulted from the addition of structures to the landscape, such as the plant, wellhouses, wellhead covers, and associated access roads and electric distribution lines. Effects from long-term activities occur over the production life of the project.

Project development has altered the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree. However, these effects have been subordinate in scale to the existing landscape as viewed from sensitive viewing areas, which consist primarily of a small number of residences located outside of the License Area. The existing rural/agricultural landscape has been retained, but has been modified with a noticeable, but minor, industrial component. Line and textural contrasts of the well houses, the plant, administration buildings, and associated access roads and distribution lines are not visible from sensitive viewing areas. This is due to the License Area being isolated from locations where there are viewers with a concern for scenic landscapes, including recreation areas, major transportation routes, and residential areas.

7.10 SOCIOECONOMIC IMPACTS

Monetary benefits accrue to the community from the presence of the Crow Butte Project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the expected incremental economic impacts from the continued operation of the Crow Butte Project.

7.10.1 Tax Revenues

Future tax revenues are dependent on uranium prices, which cannot be forecast with any accuracy; however, these taxes are also somewhat dependent on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of around $80 per pound U_3O_8 in mid-August 2007), the increased production from the satellite plants should contribute to higher tax revenues as well.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The additional production from the satellite plants should be about 600,000 pounds per year. This additional production will eventually be offset by declining production from the original plant; however, the incremental contribution to taxes would be on the order of $1.0 million to $1.2 million per year in combined taxes.

7.10.2 Temporary and Permanent Jobs

7.10.2.1 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of future satellite plant(s) will provide approximately ten to fifteen temporary construction jobs for a period of up to one year for each satellite. It is likely that the majority of these jobs will be filled by skilled construction labor brought into the area by a construction contractor, although some positions could be filled by local hires. Permanent CBR employees will perform all other facility construction (e.g., wells and wellfields).

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than five percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of positions created by any future expansion will be filled with individuals from the local workforce and that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. In 2006, total unemployment in Dawes County was 137 individuals, or 2.9 percent of the total work force of 4,799. CBR expects that any new positions will be filled from this pool of available labor.

CBR projects that the current staffing level will increase by ten to twelve full-time CBR employees for each active satellite plant. These new employees will be needed for satellite plant and wellfield operator and maintenance positions. Contractor employees (i.e., drilling rigs) may also increase by four to seven employees depending on the desired production rate. The majority if not all of these new positions will be filled with local hires.

These additional positions should increase payroll by about $40,000 per month, or $400,000 to $480,000 per year.

7.10.3 Impact on the Local Economy

CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area. In 2006, these local purchases were estimated at $5,000,000. This level of business is expected to continue and should increase somewhat with the addition of expanded production from the satellite plant, although not in strict proportion to production. While there are some savings due to some fixed costs (Central Plant utilities for instance), there are additional expenses that are expected to be higher (wellfield development for the satellites is expected to be more expensive). Therefore, it can be estimated that the overall effect on local purchases will be proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3.65 to $4.35 million per year.

7.10.4 Economic Impact Summary

As discussed in this section, approval of this LRA would have a positive impact on the local economy as summarized in **Table 7.10-1**.

Table 7.10-1: Projected Economic Impact from Crow Butte License Area

	Estimated Economic Impact due to Crow Butte License Area
Employment	
Full Time Employees	+ 10 to 12
Full Time Contractor employees	+ 4 to 7
Part Time Employees and Short Term Contractors	+ 10 to 15 (Satellite Construction)
CBR Payroll	+ $400,000 to $480,000
Taxes	
Property Taxes	-
Sales and Use Taxes	-
Severance Taxes	-
Total Taxes	+ $1,000,000 to $1,200,000
Local Purchases	
Local Purchases, 2006	+ $3,650,000 to $4,350,000
Total Direct Economic Impacts	
	+ $5,050,000 to $6,030,000

7.11 ENVIRONMENTAL JUSTICE

The 2000 Census provides population characteristics for census tracts, which contain block groups that are further divided into blocks. The blocks are the smallest census area that contains the race characteristics of the population in Dawes County. The review area contains all or a portion of 68 blocks within Census Tract 9506. Block groups are the smallest census area that contains poverty level information. There is no poverty data for individual blocks within each block. There are three block groups that are located partially within the 2.25-mile review area; however, the block groups area includes most of the north portion of Dawes County.

The affected area selected for the Environmental Justice analysis includes the race characteristics of the population within the city of Crawford and the surrounding census tract blocks within the 3.62-km (2.25-mile) review area. The population with an annual income below the poverty level was determined from block group characteristics.

According to the 2000 Census, which is summarized in **Table 7.11-1**, the combined population of the city of Crawford and the surrounding census blocks within the review area was 1,265. Minority populations accounted for a small percentage of the total population. The majority of minority populations resided within Crawford.

The state of Nebraska was selected to be the geographic area to compare the demographic data for the population in the affected blocks. This determination was based on the need for a larger geographic area encompassing affected area block groups in which equivalent quantitative resource information is provided. The population characteristics of the review area are compared with Nebraska population characteristics to determine whether there are concentrations of minority or low-income populations in the review area relative to the state.

The data in **Table 7.11-1** shows that minority populations in the affected blocks account for considerably smaller proportion of the total review area population than the proportion of minority populations at the state level. No concentrations of minority populations were identified as residing near the proposed project facilities, as residents nearest to the Crow Butte License Area are rural populations, while most of the minority population lives in Crawford. There has been no disproportionate impact to minority population from the construction and implementation of the crow Butte Project.

With the exception of block group 3, the populations within the block groups have higher rates of people living below the poverty level than the state; however, lower income levels are characteristic of predominantly rural populations and small communities that serve as a local center of agricultural activity. No adverse environmental impacts would occur to the population within the review area from proposed project activities; therefore there would be no disproportionate adverse impact to populations living below the poverty level in these block groups.

Approval of this LRA may have a positive economic impact on the lower income and minority groups since the project will generate additional employment opportunities with compensation that compares favorably with other employment opportunities in the area.

Table 7.11-1: Race and Poverty Level Characteristics of the Population in the State of Nebraska, Dawes County, and the 2.25-mile Review Area

	Nebraska	Percent of Nebraska Pop.	Dawes County	Percent of Dawes County Pop.	Crawford City	Total Block Pop.	Crawford & Block Pop. (review area)	Percent of Crawford & Block Pop.	Block Group 1	Block Group 2	Block Group 3
Total Population	1,711,263	100.0	9,060	100.00	1,107	158	1,265	100.0	1,111	1,137	890
White alone	1,533,261	89.6	8,457	93.34	1,037	151	1,188	93.9		N/A	N/A
Black or African American	68,541	4.0	73	0.81	1	0	1	0.1	N/A	N/A	N/A
American Indian and Alaska Native	14,896	0.9	261	2.88	38	6	44	3.5	N/A	N/A	N/A
Asian alone	21,931	1.3	28	0.31	0	0	0	0.0	N/A	N/A	N/A
Native Hawaiian and Other Pacific Islander	836	0.0	5	0.06	0	0	0	0.0	N/A	N/A	N/A
Some other race	47,845	2.8	93	1.03	10	1	11	0.9	N/A	N/A	N/A
Two or more races	23,953	1.4	143	1.58	21	0	21	1.7	N/A	N/A	N/A
Hispanic or Latino	94,425	5.5	220	2.43	22	3	25	2.0	N/A	N/A	N/A
Percent below poverty level	9.4	N/A	17.1	N/A	14.4	N/A	N/A	N/A	21.3	14.0	8.3

N/A = Not Applicable
Source: Census 2000

7.12 PUBLIC AND OCCUPATIONAL HEALTH IMPACTS

7.12.1 Nonradiological Impacts

The in-situ solution mine is by design a self-contained mining circuit. Wastes generated by the facility are contained and eventually removed to disposal elsewhere. The potential non-radiological effects of the operation include the possibility of lixiviant excursion, evaporation pond leakage, and temporary disturbance of the land during site preparation, construction and operations. The effects of these possible occurrences are considered small as discussed in **Section 7**. The environmental monitoring programs given in **Section 5.8** are designed to quickly identify any adverse conditions that may result during operations. No long-term irreversible effects are anticipated.

7.12.1.1 Airborne Emissions

Hydrochloric acid is the main gaseous nonradiological effluent at Crow Butte. Hydrochloric acid that is kept on-site is stored in a tank twelve feet in diameter and ten feet tall. This tank is vented into a process tank to remove hydrogen chloride gas from the air passing from the vent. The only other possible gaseous effluent is carbon dioxide, which is also located on-site in a fifty-four ton tank. Very minor amounts of CO_2 could escape into the atmosphere when the tanks are charged.

To predict the concentration of hydrogen chloride in the region around the process facility, its rate of release must be estimated. The following assumptions were used in the estimate:

- Hydrogen chloride gas is emitted from the scrubber only during the process of filling the tank.
- The acid concentration is 32 percent with a temperature of 10° C (50° F) and a partial pressure of 11.8 mm Hg.
- One tank truck delivery is 1,497 kg (3,300 pounds) of acid and it requires one hour to fill the tank.
- The scrubber efficiency is 99 percent.
- Emissions occur from a scrubber vent 3.0 meters (9.8 feet) above the facility foundation. The vent has a diameter of 0.20 meters (8.0 inches) and a flow velocity of 0.2 meters/second (0.66 feet/second).

The estimate of hydrogen chloride gas released during tank filling process is 3.2 grams. Using this source term, atmospheric dispersion calculations, and the average meteorological condition, the highest concentration of hydrogen chloride is anticipated to be $2.5x10^{-2}$ $\mu g/m^3$ in the vicinity of the facility. The threshold limit for hydrogen chloride is 7,000 $\mu g/m^3$. This predicted concentration is very low and only occurs during the one hour required to fill the tank. It is estimated that this tank needs to be filled approximately 43 times per year. Even if the satellite process facility is built with a tank of similar capacity, the effect of this emission on the region surrounding the Crow Butte site will be insignificant.

There will be an increase in the total suspended particulates (TSP) in the region as a result of the Crow Butte project. This increase in TSP was greatest during the site preparation phase of the commercial facility. Revegetation has been performed where possible to mitigate the problems associated with the resuspension of dust and dirt from disturbed areas. Should new facilities be built, another transient increase in TSP can be expected, but it will not be as great as that experienced during the original construction phase. All areas disturbed during construction are revegetated with the exception of plant pad areas, roads, and areas covered by the pond liners. Of these, the only significant source of TSP is dust emissions from unpaved roads. The amount of dust can be estimated from the following equation taken from *Supplement No. 8 For Compilation of Air Pollutant Emission Factors* (USEPA 1978).

$$E = (0.81s)\frac{S}{30}\frac{365-w}{w}$$

Where:

E	=	emission factor, lb per vehicle-mile
s	=	silt content of road surface material, 40%
S	=	average vehicle speed
w	=	mean number of days with 0.01 inches or more of rainfall, 85

Using the values stated above, the emission factor is equal to 0.25 lb/vehicle-mile. The distance from the facility to Highway 71 is 3 miles away traveling due west and 4.5 miles through Crawford. Assuming 35 employees, a five workday week and a 33 percent increase to allow for additional traffic (deliveries, etc.), the total mileage on dirt roads is 1000 miles/week. This corresponds to a dust emission of 6.5 tons/year as a result of the increased traffic on dirt roads. Traffic counts made by the Nebraska Department of Roads in 1987 indicated that there were 119 daily trips on the County Road that employees would take to Crawford (4.5 miles) from the plant. This results in over 2,000 miles per week at the present time. If the increased dust should present a problem, either due to current operations or due to possible future expansions, the emissions can be reduced through appropriate control procedures such as the use of dust control chemicals on the road surface.

All of the airborne emissions presented above will have a minimal impact of the environment. At no time during the life of the project it is anticipated that the ambient air quality standard of the State of Nebraska will be exceeded.

7.12.1.2 Sediment Load

At the present time, there is little chance that the sediment load may increase due to precipitation and runoff, as erosion control and revegetation has occurred where possible.

Should additional construction take place, there is a possibility that sediment load may increase in Squaw Creek. If rain, producing runoff, occurs during construction a small amount of the fill may be carried into the creek. In addition, site reclamation with backfilling of the ponds, grading the plant site, and replacing topsoil will also expose unsecured soil for suspension in runoff waters. The increased sediment load as a result of precipitation during construction or reclamation should not significantly affect the quality of Squaw Creek since the more sensitive areas of the stream are located upstream from the point of entry of the tributary.

7.12.1.3 Water Levels

The effects of the production and restoration phases of the project on water levels in the Chadron aquifers has been evaluated, both at current production levels as well as the proposed 9,000 gpm production level. The potential impact of the mining operations on water users of the Chadron Aquifer near the project site relates only to a decrease in formation pressure (drawdown) of the aquifer. The in-situ leach operations will not impact the quality of the groundwater available to the well user. It should be noted that private wells completed in the Chadron Aquifer are relatively rare and only a few are regularly used for domestic purposes. To assess the pressure decrease associated with the Crow Butte project, it is necessary to establish the total consumptive water use of the mining operations from the primary leaching to the groundwater restoration phase. The method of calculation will then incorporate individual flow rates, along with the timing and spatial position of those flow rates.

Since groundwater is injected as well as extracted in the ISL process, the flow rates of interest in gauging the impact are the net flows, or extraction minus injection. These net withdrawals and their timing were estimated from the generalized production schedule shown in **Table 7.12-1**. The net groundwater loss from the Chadron Aquifer will be around 105 gpm by year three. However, this overall net loss is small and is comparable to an industrial well or irrigation well pumping at this same rate.

Three years was used as a representative length of time for production, and then restoration, of a typical wellfield unit. Since distance weakens the effects of pressure transients (caused by water production) dramatically, it is important to allocate withdrawal points, for calculation purposes, throughout the expected production area, especially as the area increases in size. As a result, withdrawal points were considered centered in multiple wellfield units across the Crow Butte License Area (**Figure 7.12-1**). The base of this figure has been updated to reflect the withdrawal points discussed above and the water wells completed in the Chadron Aquifer nearest to the Crow Butte ISL project. Withdrawal points are noted with letters (A, B, C, etc.) and correlate to the same letters shown in **Table 7.12-1**. Since the density of the Chadron Aquifer wells increase northwest from the Crow Butte project area toward Crawford, the tentative wellfield production schedule shown in **Table 7.12-1** provides an early and separate progression of the wellfield production away from the Crow Butte Central Plant area toward the Crawford area. This will maximize the effect of withdrawals on the Crawford area wells and provide a more conservative estimate of impact.

Table 7.12-1: Production Restoration Schedule Flow Projections

Year	Production			Restoration			Total Net Withdrawal
	Flow	Withdrawal Point	Net Withdrawal	Flow	Withdrawal Point	Net Withdrawal	
1	4000	B	20.0	450	A	36	56.0
2	4500	B	22.5	500	A	40	62.5
3	5000	B	25.0	1000	A	80	105.0
4	5000	C,D	25.0	1000	A	80	105.0
5	5000	C,D	25.0	1000	B	80	105.0
6	5000	C,D	25.0	1000	B	80	105.0
7	5000	D,E	25.0	1000	B	80	105.0
8	5000	E,F	25.0	1000	C,D	80	105.0
9	5000	E,F	25.0	1000	C,D	80	105.0
10	5000	F,G	25.0	1000	C,D	80	105.0
11-20+	5000		25.0	1000		80	105.0
+1	0	0	0	1000		80	80.0
+2	0	0	0	1000		80	80.0
+3	0	0	0	1000		80	80.0
+4	0	0	0	1000		80	80.0

Note:
A, B, etc. refer to wellfield withdrawal points, see **Figure 7.12-1** (Revised). All flow rates are in gpm.

The pressure drawdown calculations were made using the unsteady state solution to the exponential integral describing radial flow in a confined aquifer. The Principal of Superposition was used in the calculations to allow flow rates to a particular location to vary, as they normally would during production and restoration (start, stop, restart, etc.). The formation flow parameters employed in the computer model were 2725 gpd/ft for transmissivity and 1.04 x 10^{-4} for storage coefficient and are considered representative of the pumping tests conducted at the Crow Butte License Area.

Figures 7.12-2 through **Figure 7.12-5** show the estimated drawdowns over time for each of the Chadron Aquifer water wells (ww) outside of the Crow Butte License Area shown on **Figure 7.12-1**. As shown, the changes in formation pressures vary according to timing and location of water well withdrawals, with maximum drawdowns in this case of 26-27 feet reached at different times depending upon the location of the water well. After this, the formation water pressures will rise again as consumptive water use is decreased, then altogether stopped. Recharge of the Chadron Aquifer was ignored in these calculations, which resulted in larger, more conservative drawdowns. However, it can be expected that sometime during the mining operation, the cone of influence resulting from the net withdrawals will reach equilibrium as a result of recharge of the surrounding aquifer.

Table 7.12-2 shows the maximum projected drawdowns, without formation recharge, caused by Crow Butte mining operations to the surrounding Chadron water wells. It also includes an estimated maximum drawdown available in those water wells, assuming the wells were drilled to the bottom of the Chadron Aquifer, a sand thickness of 60 feet, and drawdown to the top of the Chadron. The ratio of maximum drawdown to available drawdown is then shown as a percentage. That ratio varies from 4.4 percent to 16.7 percent with an average of 9.0 percent. Generally, the relative impact of the Crow Butte project on the Chadron water well users is small. Chadron water has limited use as a groundwater supply because of its generally poor quality and high radionuclide content. If a user has his pump set just below the level, he may have to lower the pump by up to 25 feet to accommodate the drawdown.

In the Crawford area, several Chadron Aquifer water wells flow at the surface as a result of the elevation represented by the formation water pressure being higher than the ground-surface elevation. These wells are noted as having a positive Static Water Level in **Table 7.12-2**. Comparing the predicted drawdowns in the Crawford area to the static levels of **Table 7.12-2** indicates that some of the wells may no longer be flowing after some time. However, the water level will remain near the ground surface and submersible pumps can be installed to accommodate the well user. Later, as consumptive water use from mining operations is stopped, the formation pressures should recover so that these wells will again be flowing.

Figure 7.12-1

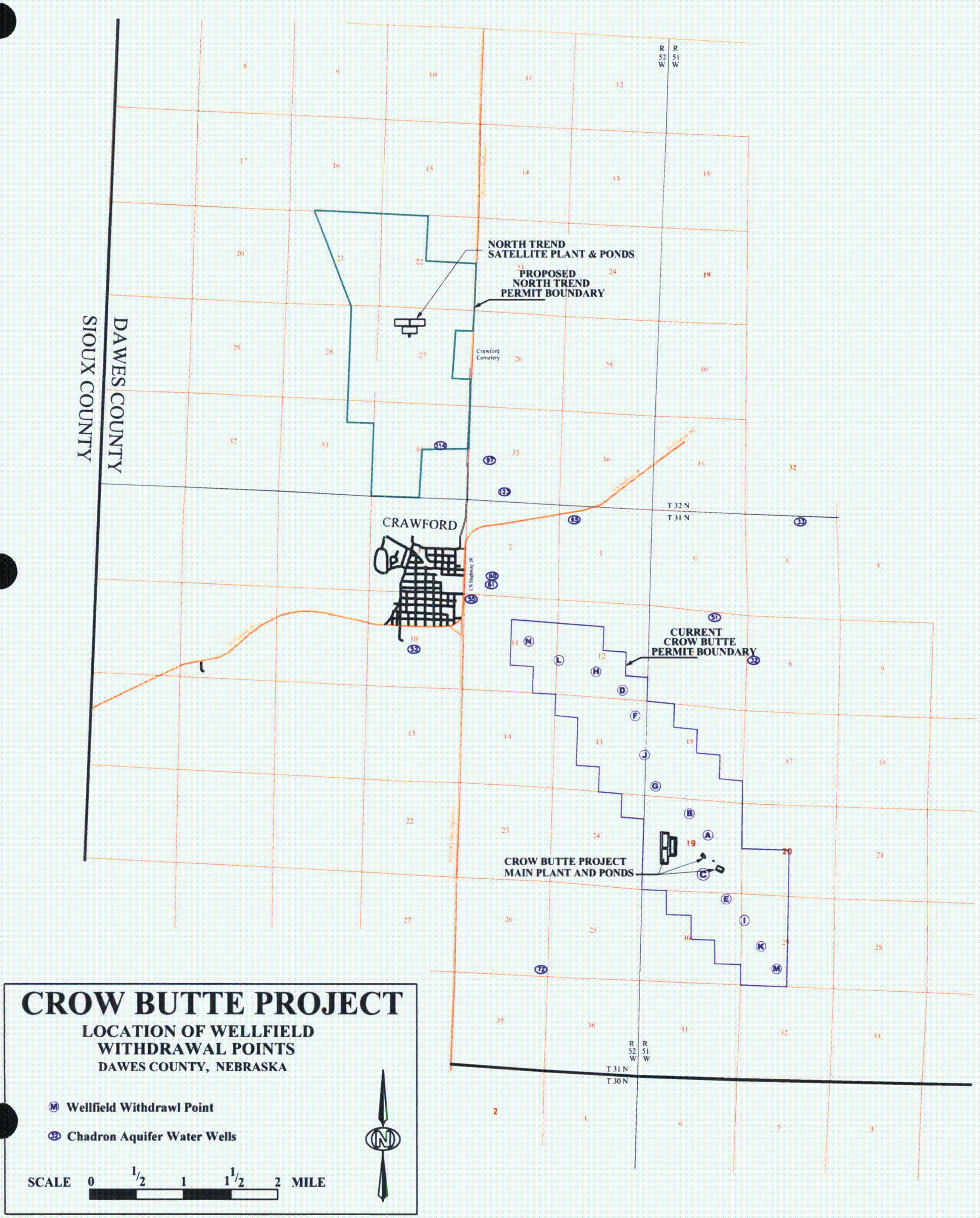

NORTH TREND
SATELLITE PLANT & PONDS
PROPOSED
NORTH TREND
PERMIT BOUNDARY
DAWES COUNTY
SIOUX COUNTY
Crawford Cemetery
CRAWFORD
T 32 N
T 31 N
CURRENT
CROW BUTTE
PERMIT BOUNDARY
CROW BUTTE PROJECT
MAIN PLANT AND PONDS
R 52 W
R 51 W
T 30 N
CROW BUTTE PROJECT
LOCATION OF WELLFIELD
WITHDRAWAL POINTS
DAWES COUNTY, NEBRASKA
Wellfield Withdrawl Point
Chadron Aquifer Water Wells
SCALE 0 1/2 1 1 1/2 2 MILE
N

Figure 7.12-2: Crow Butte Project Impact of Water Withdrawals

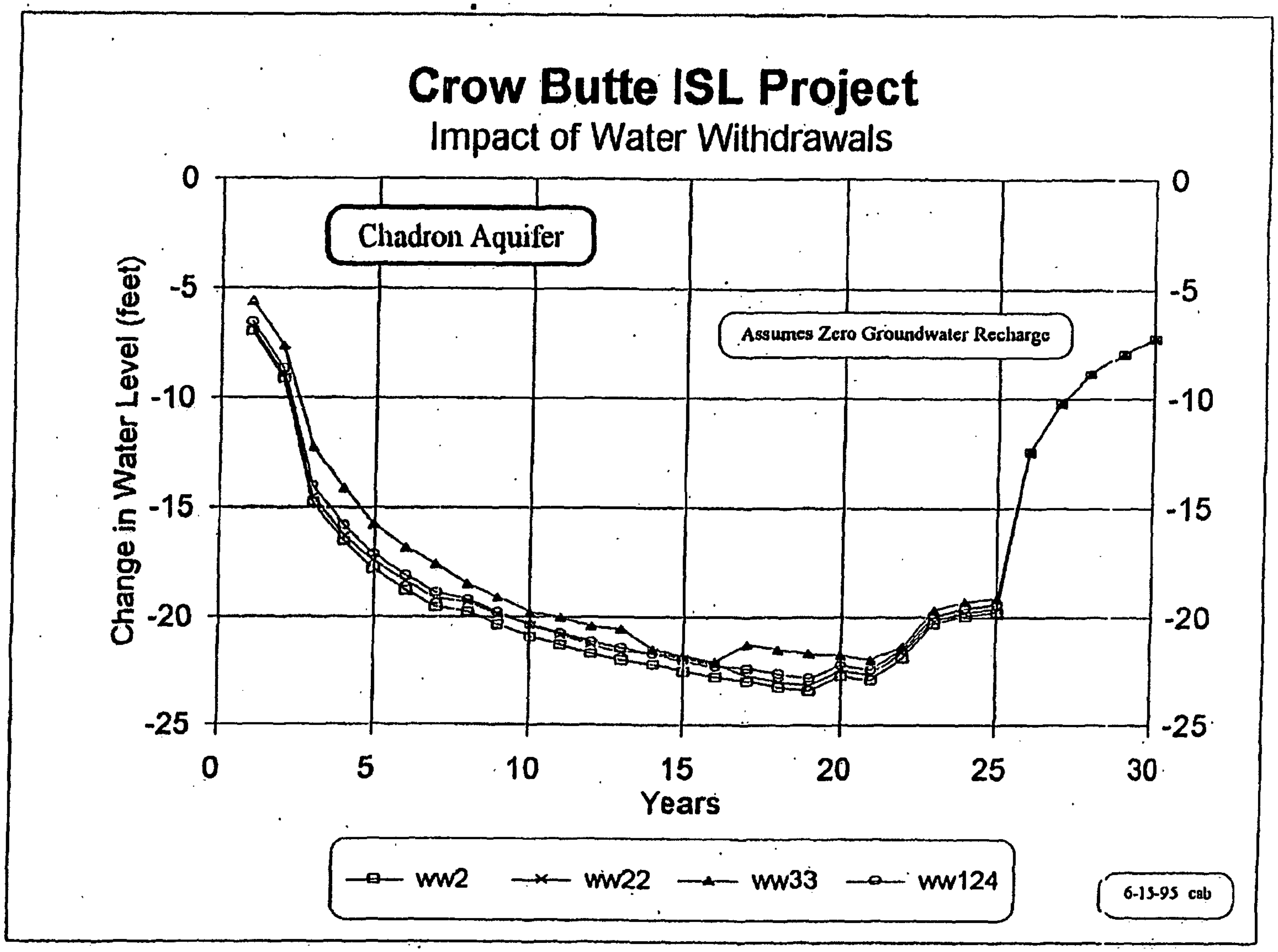


Figure 7.12-3: Crow Butte Project Impact of Water Withdrawals

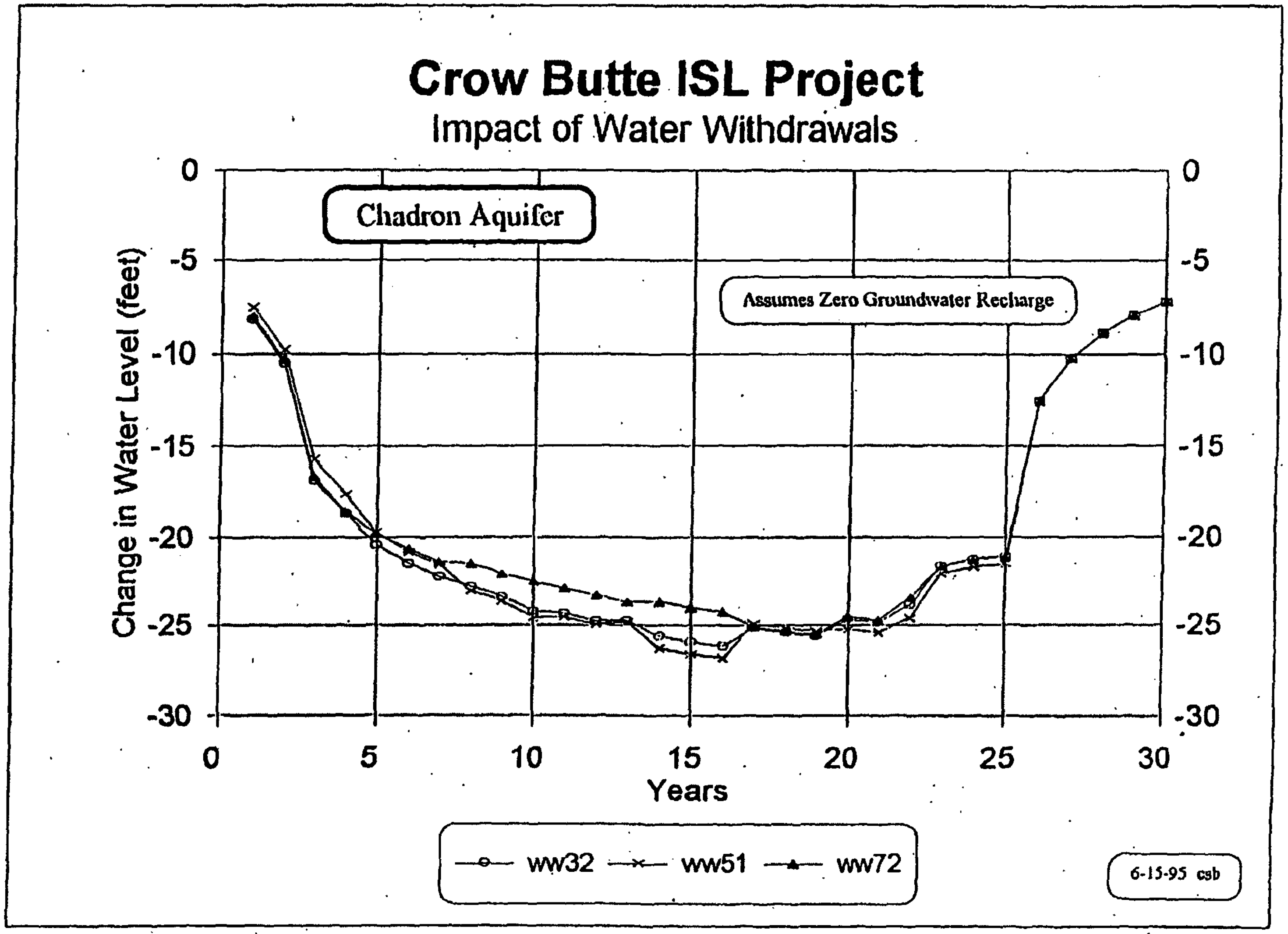


Figure 7.12-4: Crow Butte Project Impact of Water Withdrawals

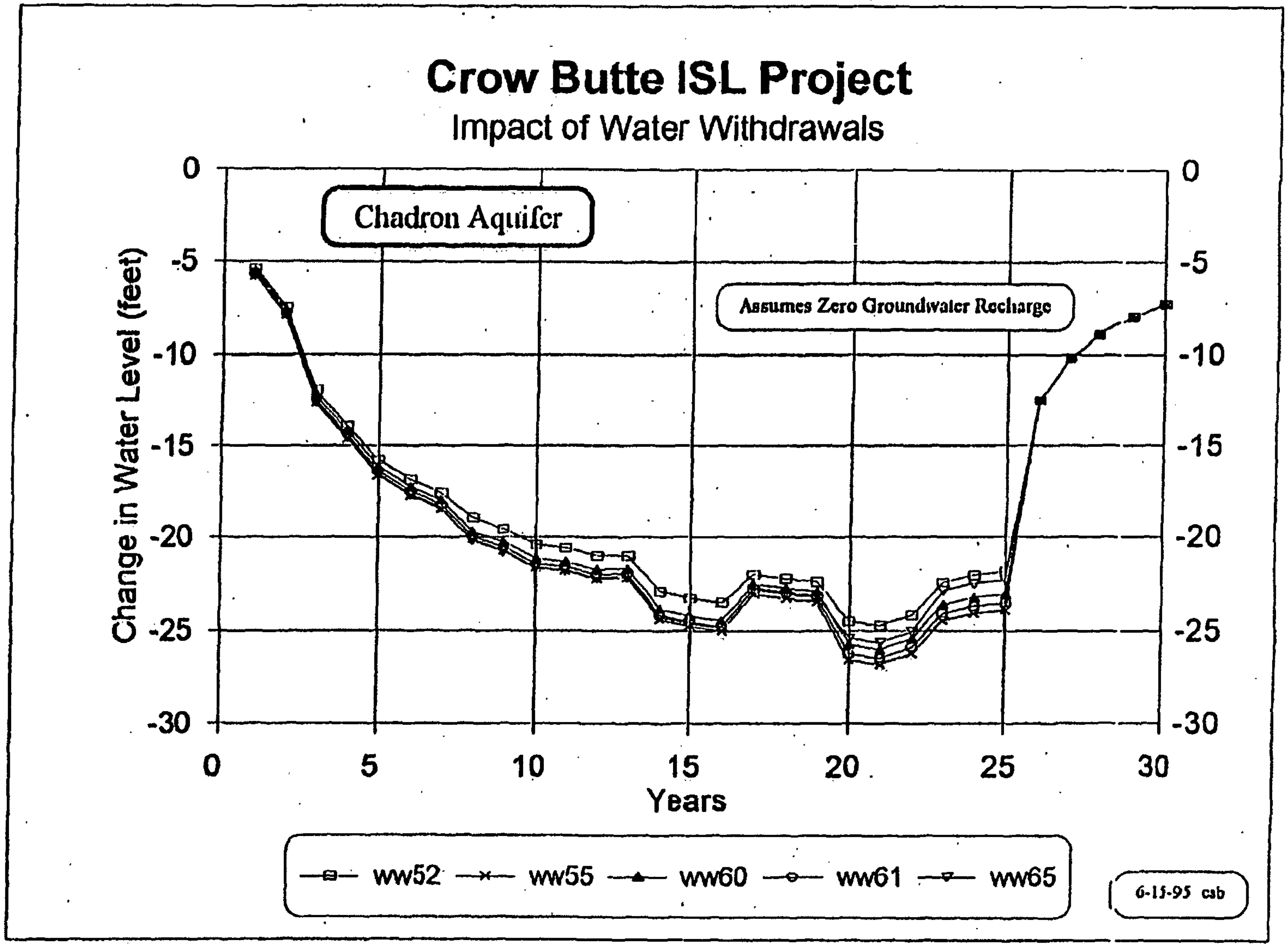
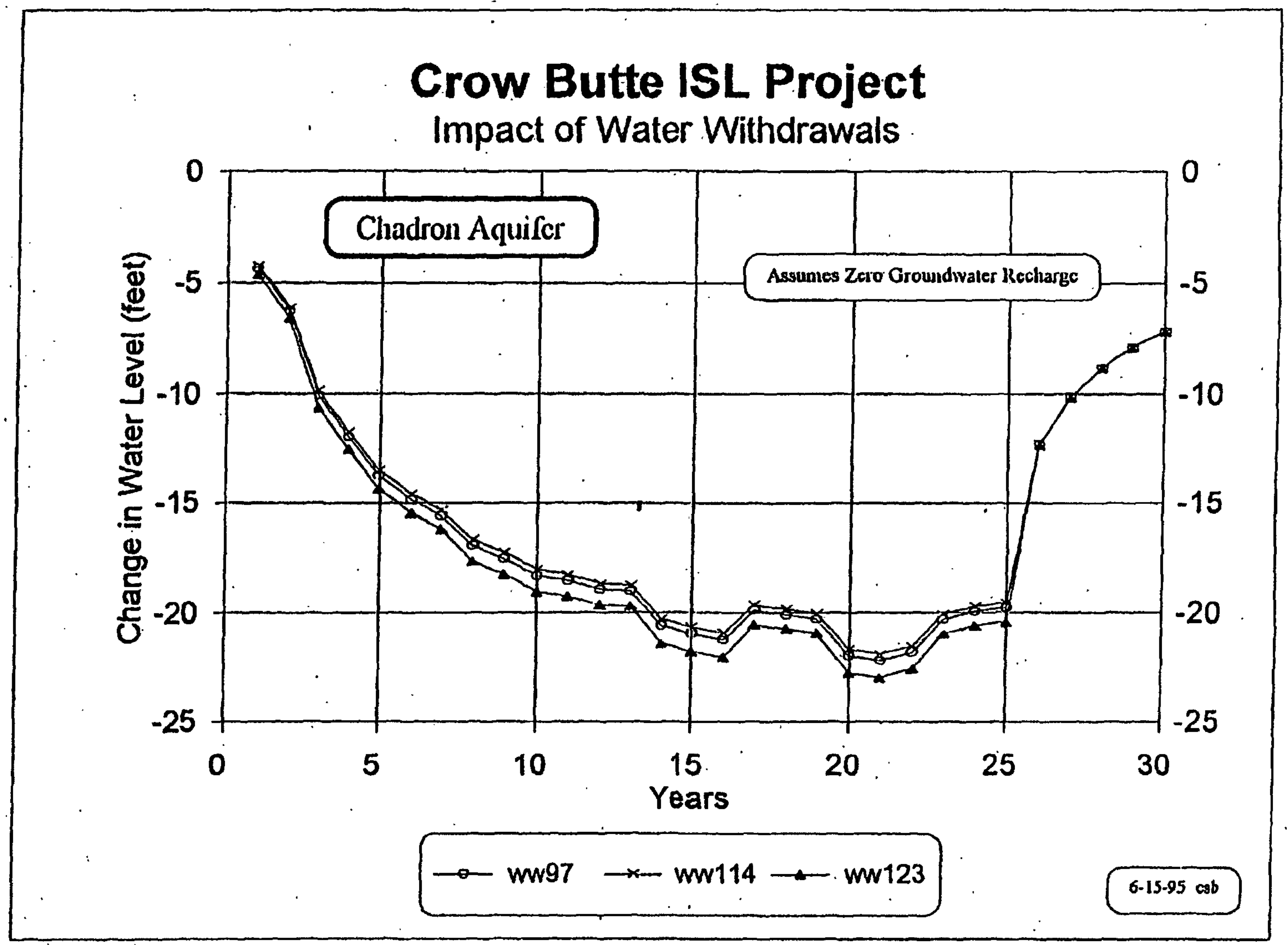


Figure 7.12-5: Crow Butte Project Impact of Water Withdrawals



7.12.2 Radiological Impacts

An assessment of the radiological effects of the Crow Butte Project must consider the types of emissions, the potential pathways present, and an evaluation of the potential radiological hazards associated with the emission and pathways. Since the project is an in-situ operation, most of the particulate emission sources normally associated with a conventional mill will not be present. A vacuum dryer is in use at the commercial operation. The vacuum dryer works on the principle that gases or particulates released into the system are collected in a liquid condenser and there is no release of particulates. The effluent collection efficiency for this dryer system is, therefore 100 percent. The routine radioactive emission will therefore, be radon-222 (radon) gas.

For purposes of this section, the proposed Crow Butte North Trend Expansion Area (new satellite facility), is included in the assessment of the total project radiological impacts. Radiological impacts associated with the proposed satellite facility are discussed in detail in a separate license amendment submitted to the USNRC In June, 2007. The satellite facility will not have precipitation equipment, with the loaded ion exchange resin being transported to the Crow Butte Main Plant for regeneration and stripping. The only source of planned radioactive emissions from the satellite will be radon gas, which is dissolved in the leaching solution.

Radon is present in the ore body and is formed from the decay of radium-226. The radon dissolves in the lixiviant as it travels through the ore body to a production well, when the solution is brought to the surface, the radon is released.

In order to assess the radiological effect of radon on the environment, an estimate of the quantity released during the operation must be made. Meteorological data and MILDOS-Area (Yuan et al. 1989) are used to predict the ground level air concentration at various points in the environment. The ingrowth of radon daughters is important and their concentration in the soil, vegetation and animals must be calculated. Finally, the impact on man from these concentrations of radionuclides in the environment must be determined.

In the following sections, the assumptions and methods used to arrive at an estimate of the radiological effects of the current Crow Butte Central Facility (average production flow rate of 9000 gpm) and the proposed North Trend Satellite Facility (average production flow rate of 4500 gpm) will be discussed briefly. The anticipated effects will be compared to naturally occurring background levels. This background radiation, arising from cosmic and terrestrial sources, as well as naturally occurring Radon, comprises the primary radiological impact to the environment in the region surrounding the Central Plant and proposed satellite facility.

Table 7.12-2: Estimated Percent Reduction in Available Drawdown in Chadron Aquifer Water Wells as a Result of the Crow Butte ISL Operations

Water Well Number	Static Water Level (feet)[1]	Total Depth of Well (feet)	Figure Number: Drawdown vs. Time	Projected Maximum Drawdown (feet)	Maximum Available Drawdown (feet)[2]	Reduction of Available Drawdown (percent)
2	-60 est.	650	4.12-2	-23.4	530	-4.4
22	-70 est.	400	4.12-2	-23.2	270	-8.6
33	-20 est.	212	4.12-2	-22.1	132	-16.7
124	-50 est.	520	4.12-2	-22.8	410	-5.6
32	-39.8	400	4.12-3	-26.2	300	-8.7
51	-30 est.	300	4.12-3	-26.8	210	-12.8
72	-82.2	450	4.12-3	.25.5	308	-8.3
52	4.62[3]	420	4.12-4	-24.7	365	-6.8
55	-6.25[3]	320	4.12-4	-26.8	254	-10.5
60	20 est.	312	4.12-4	-25.9	272	-9.5
61	19.64[3]	280	4.12-4	-26.4	240	-11.0
65	22.52[3]	260	4.12-4	-25.6	223	-11.5
97	57.75[3]	380	4.12-5	-22.2	378	-5.9
114	60 est.	470	4.12-5	-21.9	470	-4.7
123	21.37[3]	280	4.12-5	-23.0	241	-9.5
					Average =	-9.0

1 + = Above Ground Level; - = Below Ground Level

2 To the Top of the Chadron Sandstone; assumes 60 feet sand thickness

3 Measured 11/8

7.12.3 Exposure Pathways

7.12.3.1 Crow Butte Main Plant

The Crow Butte Project is an in-situ facility with a vacuum dryer and the only source of radioactive emissions from the facility is radon gas. Radon gas is dissolved in the leaching solution and may be released as the solution is brought to the surface and processed in the plant. Unplanned emissions from the site are possible as a result of accidents and engineered structure failure but are not addressed in the MILDOS-Area modeling. A human exposure pathway diagram addressing planned and unplanned radiological emissions is presented in **Figure 7.12-6**.

Currently, CBR has a license amendment request pending to increase the annual plant throughput from 5,000 gpm, exclusive of restoration flow to 9,000 gpm exclusive of restoration flow (i.e., 1000 gpm). The license amendment was submitted on October 17, 2006 and the MILDOS-Area simulation included in this license amendment application reflects the requested flow increase. Approval of this increase in the annual plant throughout is expected in the near-term.

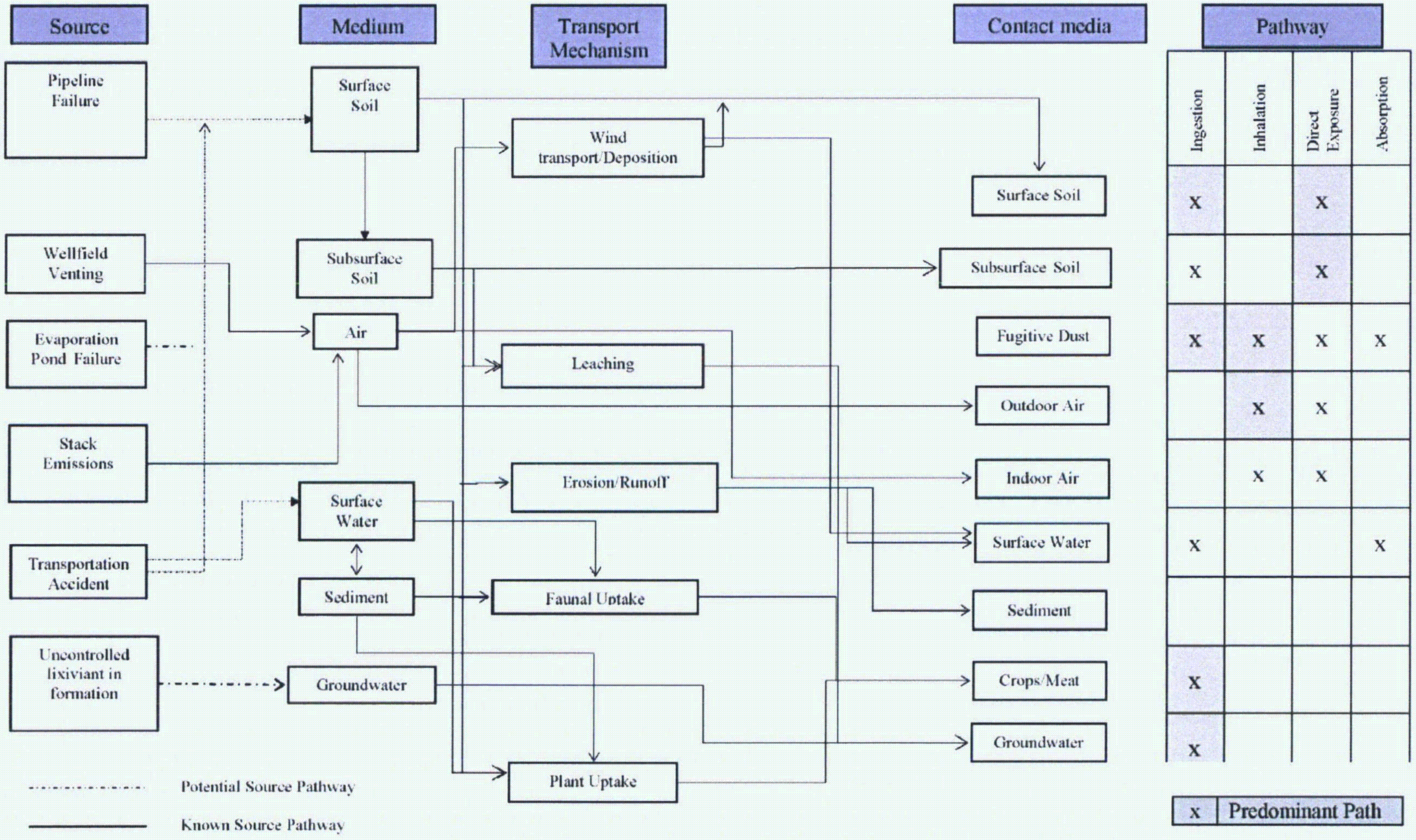
Approximately 5000 gpm of the process solution will be passed through upflow ion exchange columns which will vent the majority of the Radon into the exhaust manifold. From these columns, the solution will be transferred to an injection surge tank, where it will be refortified with chemicals before being pumped to the wellfield. This tank will be vented in a manner similar to the IX column and if any additional radon leaves the solution, it would be vented at this location.

Pressurized fixed bed downflow ion exchange columns will be used to process 4000 gpm of flow. The flow capacity of the existing facility is nominally 5000 gpm and it will require these additional downflow columns to increase the average production flow rate to 9000

With pressurized columns the radon will remain in solution and be returned to the formation and will not be released to the atmosphere. There will be minor releases of radon during the air blowdown prior to elution and during the filling of the columns after elution has been completed. The air blowdown and the gas released from the vent during column filling will be vented into the exhaust manifold and will be discharged via the main exhaust stack along with the radon from the upflow columns. It is estimated that less than 10 percent of the radon contained in the process solutions will be vented to atmosphere.

In the source term calculation CBR has adjusted the Radon release value to show that all of the contained Radon in the 5000 gpm flow processed by upflow IX will be released to the environment and that 10 percent of the contained Radon found in the 4000 gpm flow processed by pressurized downflow IX columns will be released to the environment during regeneration and venting.

Figure 7.12-6: Human Exposure Pathways for Known and Potential Sources from the Crow Butte License Area



7.12.3.2 Satellite Plant

The satellite plant would have 4500 gpm of production flow that would be processed by pressurized downflow ion exchange columns. The proposed satellite plant would consist of 8 to 10 pressurized downflow columns that would be operated with 2 columns in series and with either 4 or 5 sets of two operating in parallel. The columns will be nominally 8 feet in diameter and can process 500 to 750 gpm per set of two columns in series. Operation of these columns would only release a small fraction of the contained radon to the environment, with approximately 10 percent of the contained radon being released during resin transfer and venting.

After the IX resin is loaded the resin or eluate will be transferred to a trailer. It is anticipated that two resin or eluate shipments will be made per day. The trailer will transfer the resin or eluate to the main process facility for additional processing. The stripped and regenerated resin will be transferred to the trailer and returned to the satellite plant and be transferred into a process column.

The injection wells at the Central Plant and the proposed satellite facility will generally be closed and pressurized, but will be periodically vented. It was estimated that 25 percent of the radon will be released in the wellfields. The 25 percent released from the wellfields was assumed to be released from MU-4, MU-5, and the Raben Wellfield for mining with releases from MU-1, MU-2 and MU-3 for restoration.

In addition to releases from the wellfields, plant releases of radon will be from the main process facility through the plant vent and from the satellite facility (e.g., during resin transfer and venting) located in the McDowell Wellfield. The locations of the sources and receptors are in **Figure 7.12-7**. The height of the vent at the plant is 15.9 meters above the foundation of the facility.

The atmospheric emission of radon will lead to its presence in all quadrants of the region surrounding the current License Area and the proposed North Trend Satellite Facility. Due to the relatively short half-life of radon, the ingrowth of radon daughters during wind blown transportation must be considered. There exists an inhalation pathway as a result of the emission of radon gas. As the radon daughters' ingrow, deposition on the ground surface increases. A pathway also exists due to external radiation exposure arising from two sources. One source is radon and its daughters in the air, which is considered the cloud contribution. The other source is from radon daughters deposited on the ground, this source being termed the ground contribution.

A third pathway exists, which is the ingestion pathway. This results from direct foliar deposition and radionuclides in the soil being assimilated by the vegetation. The vegetation may represent a direct ingestion pathway to man if consumed, and a secondary pathway if fed to animals that are in turn consumed by man.

All of the above pathways are evaluated by MILDOS-Area.

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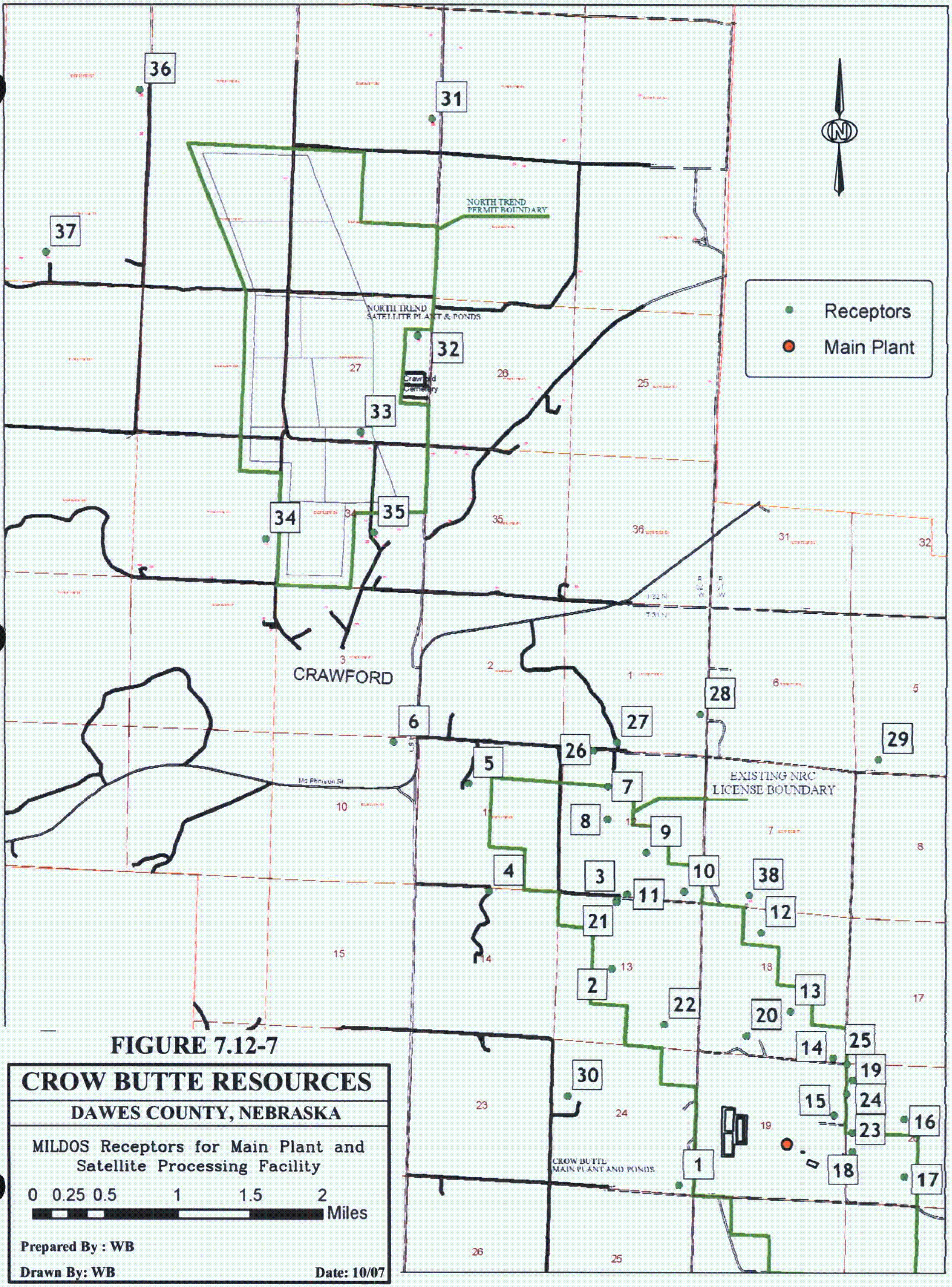

FIGURE 7.12-7

CROW BUTTE RESOURCES

DAWES COUNTY, NEBRASKA

MILDOS Receptors for Main Plant and Satellite Processing Facility

0 0.25 0.5 1 1.5 2 Miles

Prepared By : WB

Drawn By: WB **Date: 10/07**

7.12.4 Exposures from Water Pathways

7.12.4.1 Main Plant

The solutions in the zone to be mined are controlled and adequately monitored to insure that migration does not occur. The overlying aquifers are also be monitored.

Three commercial evaporation ponds located approximately 2000 feet from the plant building have been constructed for commercial operation. There are also two R&D evaporation ponds located approximately 1,000 feet from the plant building. The R&D ponds have a 34-mil Hypalon liner and a leak detection system. The commercial evaporation ponds are lined with double impermeable synthetic liners. The ponds, therefore, are not considered a source of liquid radioactive effluents. There is a leak detection system installed to provide a warning if the liner develops a leak. The ponds, therefore, are not considered a source of liquid radioactive effluents. The use of ponds to manage liquid waste was discussed in further detail in **Section 4**.

The Crow Butte Plant is located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment drain to a sump and are pumped to the ponds. The pad is of sufficient size to contain the contents of the largest tank in the event of its rupture.

The primary method of waste disposal at the Main Plant is by deep disposal well injection. The deep disposal well is completed at an approximate depth of 3,500 to 4,000 ft, isolated from any underground source of drinking water by approximately 2,500 feet of shale (Pierre and Graneros Shales). The well has been constructed under a Class I Underground Injection Control (UIC) Permit issued by the NDEQ and meets all requirements of the NDEQ UIC program. The use of a deep disposal well to manage liquid waste was discussed in further detail in **Section 4.**

Since there are no routine liquid discharges of process water from the Crow Butte Plant, there are no definable water related pathways.

7.12.4.2 Satellite Facility

The solutions in the zone to be mined will be controlled and adequately monitored to ensure that migration does not occur. The overlying aquifers will also be monitored.

The North Trend Satellite Facility will have evaporation ponds used to store waste solutions prior to deep well injection. The ponds will be double-lined with impermeable synthetic liners. A leak detection system will be installed to provide a warning if the liner develops a leak. The ponds, therefore, are not considered a source of liquid radioactive effluents. The use of ponds to manage liquid waste was discussed in further detail in **Section 4.**

The primary method of waste disposal at the North Trend Satellite Facility will be by deep disposal well injection. The deep disposal well will be completed at an approximate depth of 3,500 to 4,000 ft, isolated from any underground source of drinking water by approximately 2,500 feet of shale (Pierre and Graneros Shales). The well will be constructed under a Class I Underground Injection Control (UIC) Permit issued by the NDEQ and will meet all requirements of the NDEQ UIC program. The use of a deep disposal well to manage liquid waste was discussed in further detail in **Section 4**.

The North Trend Satellite Facility will be located on a curbed concrete pad to prevent any liquids from entering the environment. Solutions used to wash down equipment will drain to a sump and be pumped to the ponds. The pad will be of sufficient size to contain the contents of the largest tank if it ruptures.

Since no routine liquid discharges of process water are expected from the North Trend Satellite Facility, there are no definable water-related pathways.

7.12.5 Exposures from Air Pathways

The only source of radioactive emissions is radon released into the atmosphere through a vent system or from the wellfields. As shown in **Figure 7.12-6**, atmospheric releases of radon can result in radiation exposure via three pathways; inhalation, ingestion, and external exposure. The total effective dose equivalent (TEDE) to nearby residents in the region around the main processing plant and satellite facility was estimated by using the computer simulation, MILDOS-Area. The joint frequency data compiled from a site-specific meteorological station were used to define the atmospheric conditions in the project area.

Currently, CBR has a license amendment request pending to increase the annual plant throughput from 5,000 gpm, exclusive of restoration flow to 9,000 gpm, exclusive of restoration flow. The license amendment was submitted on October 17, 2006 and the MILDOS-Area simulation included in this license amendment application reflects the requested flow increase. To show compliance with the annual dose limit found in 10 CFR § 20.1301, CBR has demonstrated by calculation that the TEDE to the individual most likely to receive the highest dose from the mining processing plant and the North Trend Satellite operation is less than 100 mREM/yr. The results of the MILDOS-Area simulation are presented in **Table 7.12-3**, which shows the estimated TEDE from operation of the main Crow Butte Plant and the North Trend Satellite Plant. The coordinates of all receptors are listed in **Table 7.12-4**. The source values and the locations of the sources are presented in **Table 7.12-5**. Receptor locations and appropriate identifiers are shown on **Figure 7.12-7**.

No TEDE limits were exceeded. An evaluation of the TEDE follows:

- The maximum TEDE was 31.7 mREM/yr at Receptor #15, which is located approximately 0.25 mile northeast of the Central Plant site.
- Receptor #31 (NT-1) is the closest resident in the downwind direction for the North Trend Satellite Plant. The estimated TEDE at this location was 5.8 mREM/yr.

- The estimated TEDE at Receptor # 6, located on the east side of the town of Crawford, was 1.65 mREM/yr.
- The effect of the North Trend Satellite operation on the nearby residents of the existing Crow Butte facility is less than 1 mREM/yr.
- Since radon-222 is the only radionuclide emitted, public dose limits in 40 CFR 190 and the 10 mREM/yr constraint rule in 10 CFR §20.1101 are not applicable to the CBR facility.

Based on the site specific data (**Table 7.12-6**) and method of estimation of the source term presented in **Appendix A**, the modeled emission rate of Radon from the Crow Butte Project will be 7178 Ci/yr which consists of a flow of 5000 gpm in the upflow ion exchange columns in the existing plant along with the proposed 4000 gpm of flow treated in the pressurized down flow ion exchange columns.

Based on the site specific data (**Table 7.12-6**) and the method of estimation of the source term presented in **Appendix A**, the modeled annual emission rate of radon from the North Trend Satellite Facility is 1482 Ci/yr, which includes releases from ion exchange, production and restoration activities.

Additional discussions as to radon emissions from operations and restoration activities at the Central Plant and satellite facility are presented in **Section 5.8**.

Seven air monitoring stations are used to monitor radon gas effluent to the environment around the Crow Butte Plant. The applicant reviewed the Radon monitoring data obtained at these locations from 1991 through June of 2007 and these data are found in **Table 5.8-6** and **Figures 5.8-10** through **5.8-16.**

Table 7.12-3: Estimated Total Effective Dose Equivalent (TEDE) to Receptors Near the Crow Butte Uranium Processing Facility

Receptor #	Description	Distance from Main Plant (km)	TEDE* (mREM/y)
1	R1	1.29	6.64
2	R2	2.76	4.82
3	R3	3.30	6.14
4	R4	4.36	1.92
5	R5	5.35	1.98
6	Crawford	6.25	1.65
7	R7	4.43	4.87
8	R8	4.11	5.16
9	R9	3.59	8.12
10	R10	3.03	16.0
11	R11	3.29	7.34
12	R12	2.37	17.7
13	R13	1.49	28.1
14	R14	1.10	28.3
15	R15	0.62	31.7
16	R16	1.34	9.48
17	R17	1.35	6.06
18	Ehlers	0.73	15.5
19	Gibbons	1.03	24.9
20	Stetson	1.30	19.9
21	Knode	3.28	6.09
22	Brott	1.92	16.2
23	SP1	0.75	18.1
24	SP2	0.89	26.2
25	SP3	1.13	24.8
26	McDowell	4.87	4.24
27	Taggart	4.83	4.87
28	Franey	4.86	6.55
29	Bunch	4.39	7.54
30	Dyer	2.50	3.27
31	NT-1	12.01	5.84
32	NT-2	9.83	3.41
33	NT-3	9.19	3.09
34	NT-4	8.87	2.14
35	NT-5	8.18	2.42
36	NT-6	13.7	1.63
37	NT-7	12.86	1.04
38	NT-8	2.79	15.9

*No differences in TEDE between age classes were observed.

Table 7.12-4: Individual Receptor Location Data

Location	X (km)	Y (km)	Distance (km)
1. R1	-1.21	-0.44	1.29
2. R2	-1.95	1.95	2.76
3. R3	-1.89	2.71	3.30
4. R4	-3.34	2.80	4.36
5. R5	-3.57	3.99	5.35
6. CRAWFORD	-4.39	4.45	6.25
7. R7	-1.99	3.96	4.43
8. R8	-1.99	3.60	4.11
9. R9	-1.57	3.23	3.59
10. R10	-1.16	2.80	3.03
11. R11	-1.78	2.77	3.29
12. R12	-0.30	2.35	2.35
13. R13	0.03	1.49	1.49
14. R14	0.51	0.98	1.10
15. R15	0.52	0.34	0.62
16. R16	1.31	0.30	1.34
17. R17	1.31	-0.34	1.35
18. EHLERS	0.73	-0.06	0.73
19. GIBBONS	0.73	0.73	1.03
20. STETSON	-0.46	1.22	1.30
21. KNODE	-1.89	2.68	3.28
22. BROTT	-1.37	1.34	1.92
23. SP 1	0.73	0.15	0.75
24. SP 2	0.67	0.58	0.89
25. SP 3	0.67	0.91	1.13
26. McDOWELL	-2.16	4.36	4.87
27. TAGGART	-1.89	4.45	4.83
28. FRANEY	-0.98	4.76	4.86
29. BUNCH	1.01	4.27	4.39
30. DYER	-2.44	0.55	2.50
31. NT-1	-3.97	11.33	12.01
32. NT-2	-4.12	8.93	9.83
33. NT-3	-4.75	7.87	9.19
34. NT-4	-5.82	6.69	8.87
35. NT-5	-4.61	6.76	8.18
36. NT-6	-7.20	11.65	13.70
37. NT-7	-8.25	9.86	12.86
38. NT-8	-0.44	2.76	2.79

Table 7.12-5: Source Coordinates for Crow Butte Project and North Trend Satellite

Source	East (km)	North (km)	Rn-222 (Curies)
1. Plant Vent	0.00	0.00	4603
2. Satellite Plant Vent	-5.30	9.60	342
3. MU-2-4 (restoration)	-0.30	0.16	350
4. MU-5	0.0	0.74	454
5. MU-6&8	1.92	-1.20	908
6. MU 7&9	0.00	-0.74	908
7. North Trend Well field	-5.30	9.60	1320

Sources 2 and 7 are from the proposed North Trend Satellite Facility operating at 4500 gpm using upflow IX columns and 500 gpm restoration flow using downflow IX and reverse osmosis. Resin from the North Trend Satellite is transferred to the Crow Butte processing facility for elution and precipitation.

All other sources are from the existing Crow Butte processing facility operating at 5000 gpm production flow using downflow IX columns, 4000 gpm production flow using pressurized upflow IX columns, and a 1000 gpm restoration flow using downflow IX and reverse osmosis.

Table 7.12-6: Site Specific Information Crow Butte Project and North Trend Expansion Area

Parameter	Value
Average ore quality, U_3O_8, in ore body	0.27 percent
Ore radon activity, assuming equilibrium with U-238	761 pCi/g
Operating days per year (plant factor)	365 days
Dimensions of ore body	
Area per year to be mined	20 acres
Average thickness of body	5 ft
Average screened interval	15.1 ft
Average production flow rate (Satellite Facility)	4500 gpm
Average production flow rate (Main Facility)	9000 gpm
Formation porosity	29 percent
Process recovery	95 percent
Leaching efficiency	60 percent
Rock density	1.89 g/cm^3
Restoration flow rate (Satellite Facility)	500 gpm
Restoration flow rate (Main Facility)	1000 gpm
Restoration Residence time	35 days
Production cell parameters	
Residence time	7 days
Type of cell pattern	variable
Average cell area	10,000 ft^2
Average cell flow rate	121 lpm

Table 7.12-6: Site Specific Information Crow Butte Project and North Trend Expansion Area

Parameter	Value
Source stack description (Main)	
Stack height	15.9 m
Stack diameter	0.30 m
Stack velocity	11 m/sec
Source stack description (Satellite)	
Stack height	10 m
Stack diameter	0.2
Stack velocity	10 m/sec

ft/ft^2 = feet/square feet
g/cm^3 = grams per cubic centimeter
gpm = gallons per minute
lpm = liters per minute
m = meter
m2/sce = meters squared per second
pCi/g = picoCuries per gram

The results of the area ambient radon 222 concentrations and radionuclide concentrations for each monitoring site, and for TLD monitors at each site, fall within the expected ranges for all semi-annual reporting periods between the second half of 1998 through the first half of 2007 with the exception of results for the periods summarized below.

For the second half of 2003, the radon-222 results from three stations (AM-1, AM-2, and AM-8) were elevated above concentrations that are normally present. These sample locations are located along the eastern and northern boundaries of the License Area and Section 19. The cause of the elevated radon-222 concentrations is not known. Radon release levels from the Crow Butte project for the period are consistent with those since increased process flows were approved in 1998, so it does not appear that project releases are the source. CBR noted that there was no identifiable cause for these elevated concentrations from licensed operations. One possible cause for the anomalous results is sampling or analytical error. In order to monitor this possibility, CBR deployed duplicate monitors at the three stations for the second half of 2004 for comparison of results. . Even those these spikes in 2003 were above normal concentrations at the environmental monitoring stations (generally less than 10 percent), the levels were well below levels considered protective of the public.

In the initial analytical results, the results from several stations were elevated and did not correlate well to the results from the duplicate monitors; therefore all monitors were reanalyzed. The results of the reanalysis resulted in changes in reported values ranging from 0 percent to over 120 percent. The variance in the reported values was likely due to a routine quarterly update of the background track density for manufacturing lots. The repeat analysis was performed after the background update and in all cases where the reanalysis resulted in a change, the reported values were lower and were consistent with historical concentrations. It is possible that a similar situation was the cause of the higher concentrations noted in the second half of 2003. CBR will continue to place duplicate monitors at six stations through 2005 to determine the accuracy of the monitoring method.

7.12.6 Population Dose

The annual population dose commitment to the population in the region within 80 km of the Crow Butte Project is also predicted by the MILDOS-Area code. The results are listed in **Table 7.12-7**, where the dose to the bronchial epithelium is expressed in person-rem. For comparison, the dose to the population within 80 km of the facility due to natural background radiation is included in the table. These figures are based on the 1980 population and average radiation doses reported for the Western Great Plains.

The atmospheric release of radon also results in a dose to the population on the North American continent. This continental dose is calculated by comparison with a previous calculation based on a 1 kilocurie release near Casper, Wyoming, during the year 1978. The results of these calculations are included in **Table 7.12-7** and also combined with dose to the region within 80 km of the facility to arrive at the total radiological effects of one year of operation at the Crow Butte Project.

For comparison of the values listed in **Table 7.12-7**, the dose to the continental population as a result of natural background radiation has been estimated. This estimate is based on a North American population of 346 million and a dose to each person of 500 mREM/yr to the bronchial epithelium. The maximum radiological effect of the combined operation of the North Trend Satellite Plant and the Crow Butte Project would be to increase the dose to the bronchial epithelium of the continental population by 0.0023 percent.

Table 7.12-7: Dose to the Population Bronchial Epithelium and Increased Continental Dose from One Year's Operation at the Crow Butte Facility

Criteria	Dose (person-rem/yr)
Dose received by population within 80 km of the facility	171
Natural background by population within 80 km of the facility	24025
Dose received by population beyond 80 km of the facility	224
Total continental dose	394
Natural background for the continental population	$1.73 \times 10^{+8}$
Fraction increase in continental dose	2.27×10^{-6}

7.12.7 Exposure to Flora and Fauna

The exposure to flora and fauna was evaluated in Environmental Reports submitted in September of 1987 for the Central Plant, and in 2007 for the North Trend Satellite Plant, and the doses were found to be negligible. The proposed increase in process flow to 9,000 gpm at the Central Plant, and the addition of the North Trend Satellite Facility, is not expected to have any measurable impact on dose to flora and fauna.

7.13 WASTE MANAGEMENT IMPACTS

Liquid wastes generated from production and restoration activities are handled by one of three methods: solar evaporation ponds, deep well injection, or land application. All three methods are currently being employed at Crow Butte.

Alternative pond design and locations have been considered. The sites selected represent the best location considering proximity to the plant, size of drainage and suitable soils. The design is such that any seepage of toxic materials into the subsurface soils or hydrologic system would be prevented or minimized. The ponds have also been designed to protect the down-gradient are from surface flows and subsurface seepage in the event of dam failure.

All solid wastes are transported from the site for disposal. Non-contaminated waste is shipped to an approved sanitary landfill. Contaminated wastes are shipped to a USNRC approved facility for disposal. Should a USNRC licensed disposal facility not be available to CBR at the time of decommissioning, the alternative of on-site burial may be necessary. This alternative could incur long term monitoring requirements and more expensive reclamation costs, however, it may be the only alternative available to Crow Butte at that time.

7.14 EFFECTS OF ACCIDENTS

Accidents involving human safety associated with the in-situ uranium mining technology typically have far less severe consequences that accidents associated with underground and open pit mining methods. In-situ mining provides a higher level of safety for personnel and neighboring communities when compared to conventional mining methods or other energy related industries. Accidents that may occur would generally be quite minor when compared to other industries, such as an explosion at an oil refinery or chemical plant. Radiological accidents that might occur would typically manifest themselves slowly and are therefore easily detected and mitigated. The remote location of the facility and the low level of radioactivity associated with the process both decrease the potential hazard of an accident to the general public.

7.14.1 Tank Failure

Process fluids are contained in vessels and piping circuits within the process plant or in bermed outside storage tanks. The process plant has been designed to control and confine liquid spills should they occur. The plant building structure and concrete curb will contain the liquid spills from the leakage or rupture of a process vessel and will direct any spilled solution to a floor sump. The floor sump then pumps any spilled solutions back into the plant process circuit or to the waste disposal system.

All tanks inside the plant are constructed of fiberglass or steel. Instantaneous failure is thus highly unlikely. Tank failure would more likely occur as a small leak in the tank. In this case, the tank would be emptied to at least a level below the leaking area and repairs or replacement made as necessary. Standard Operating Procedures are in place to respond to any spill that may occur.

7.14.2 Pipe Failure

The rupture of a pipeline within the process plant is easily visible and can be repaired quickly. Spilled solution is contained and removed in the same fashion as for a tank failure.

The rupture of an injection or recovery line in a wellfield, or a trunkline between a wellfield and the process plant would result in either a release of barren or pregnant lixiviant solution that would contaminate the ground in the area of the break.

All piping from the plant, to and within the wellfield is buried for frost protection. Pipelines are constructed of PVC, high-density polyethylene with butt-welded joints or equivalent. All pipelines are pressure tested at operating pressures prior to final burial and production flow. As no additional stress is placed on a pipeline following burial, catastrophic failures are unlikely. The section of trunkline that flows under Squaw Creek has been double contained for additional safety.

Each wellfield has a number of wellfield houses, where injection and recovery lines are continuously monitored. Individual lines can each have high and low flow alarm limits set. All set points and alarms are monitored in the control room via the computer system. In addition, each wellfield building has a "wet" alarm to detect the presence of any liquids that may be present.

Small occasional leaks at pipe joints and fittings in the wellfield house or at the wellheads may occur from time to time. Until remedied, these leaks may drip some solution into the underlying soil. After repair, the soil will be surveyed for contamination and removed as appropriate. Preventative maintenance programs are in place to preclude this type of spill to the extent possible. In the event of a catastrophic pipe failure, solutions released would still be minimal as the pressure in the lines is not that great. In addition, all drainage to Squaw Creek has been diked and bermed to protect this water source.

7.14.3 Pond Failure

An accident involving a leak in a solar evaporation pond is detectable either from the regular visual inspections or via the leak detection system. The inspection program consists of daily, weekly, monthly and quarterly inspections in conjunction with an annual technical evaluation of the pond system. Any time six inches or more of fluid is detected in the standpipes, it is analyzed for specific conductance. If the water quality is degraded beyond the action level, it is sampled again and analyzed for chloride, alkalinity, sodium, and sulfate.

In the event of a leak, the contents of any one pond can be transferred to the other ponds while repairs are made. Freeboard requirements may be waived during this period. Catastrophic failure of a berm is also unlikely given the design requirements of the pond and the freeboard that is maintained. The pond soil foundation is compacted and has low ambient moisture, thus leaking solutions would not tend to migrate. Contingency plans are in place to address situations that may occur.

7.14.4 Lixiviant Excursion

Mining fluids are normally maintained in the production aquifer within the immediate vicinity of the wellfield. The function of the encircling monitor well ring, which is installed prior to any production activity, is to detect any lixiviant that may migrate away from the production area due to fluid pressure imbalance. This system has been proven to function satisfactorily over many years of operating experience with in-situ mining.

For the Crow Butte Project, monitor wells are located no further than 300 feet from the wellfields and screened in the ore-bearing Chadron Aquifer. Additionally, monitor wells are placed in the first overlaying aquifer above each wellfield segment. Sampling on these wells occurs on a regular basis as described in **Section 5.8**. The total effect of close proximity of the monitor wells, low flow rate from the well patterns, and over-production of leach fluids (production bleed) makes the likelihood of an undetected excursion remote.

7.14.5 Transportation Accidents

Transportation of materials to and from Crow Butte can be classified as follows:

- Shipments of yellowcake
- Shipments of process chemicals or fuel from suppliers to the site.
- Shipment of radioactive waste from the site to a licensed disposal facility.
- If the satellite plant is built, shipments of uranium-laden resin from the satellite plant to the main process facility.
- If the satellite plant is built, shipments of barren eluted resin or eluate from the main processing facility back to the satellite plant.

Accidents involving these transportation occurrences are discussed below. It is assumed that all transports will be made with contracted vehicles and licensed drivers, with the exception of the on-site transfers between the satellite plant and main facility should the satellite be built. In all likelihood, these transfer vehicles would be operated by a Crow Butte employee.

7.14.5.1 Accidents Involving Yellowcake Shipments

Accidents involving yellowcake shipment can take two forms. The first would involve a shipment of dried yellowcake product being shipped from the Crow Butte facility after processing. The second would involve the shipment of uranium oxide or yellowcake slurry. The slurry could be enroute from Crow Butte to another facility for processing, or it could be a shipment being sent to Crow Butte for processing. Slurry would generally be shipped from Crow Butte only if the dryer were not operational. Regarding slurry shipments to Crow Butte, there are currently no contracts or plans that would anticipate such a situation.

The dried yellowcake that is produced at Crow Butte is generally packaged in fifty-five gallon 18 gauge drums holding an average of 364 kg (800 pounds), classified by the Department of Transportation as Type A packaging (49 CFR Parts 171-189 and 10 CFR Part 71). An average truck shipment contains approximately 55 drums, or 17.5 tons of yellowcake. At the current production levels, approximately two shipments per month are made. At the proposed production level, it is expected that approximately three to four shipments per month would be necessary. If it becomes necessary to transport slurry, it will be transported in either a trailer-mounted tank vessel or in lined drums.

All vehicles and shipments are surveyed prior to leaving the site. The driver is provided with copies of all documents in the shipping packet. The shipping packet contains current copies of the shipping papers containing an exclusive use statement, the bill of lading, the Form 741, the contamination survey results, copies of the emergency telephone numbers, the emergency procedures, a list of materials in the spill control kit, and the driver responsibility statement.

In the accident analysis of the Sand Rock Mill Project, a transportation accident involving yellowcake was assumed for which an environmental release fraction of 9 x 10^{-3} of fractional probability of occurrence was calculated. This represents the initial airborne material released at an accident site carried by a five meter/second (10 mph) wind for a twenty-four hour period. Assuming a population density of sixty-two people per square kilometer, a fifty-year dose commitment to the lungs in the general population was estimated at between 0.9 and 13 man-rem, depending upon the severity of the spill. This value was considered small when compared with the estimated fifty year integrated lung dose of 1427 man-rem from natural background (USNRC, 1982). The relatively low activity of the product combined with the low population density in Northwest Nebraska and Wyoming would produce even lower dose commitments than the above estimates in the event of an accident.

7.14.5.2 Accidents Involving Shipments of Process Chemicals

Based on the current production schedule and material balance, it is estimated that approximately 272 bulk chemical deliveries per year will be made to the site. This averages about one truck per working day for delivery of chemicals throughout the life of the project. The proposed increase in production capacity would increase this number somewhat. Types of deliveries include carbon dioxide, hydrochloric acid, sodium chloride, hydrogen peroxide, oxygen, and soda ash. Since no unusual or hazardous driving conditions are known to exist in the northwest part of Nebraska, the accident rate should be that of the overall chemical trucking industry. Based on published accident statistics the probability of a truck accident is in the range of 1.0 to 1.6 x 10^{-6}/km. (1.6 to 2.6 x 10^{-6}/mile). Truck accident statistics include three categories of events:

- **Collisions**- between the transport vehicle and other objects, whether moving vehicles or fixed objects.
- **Noncollisions**- accidents involving only one vehicle, such as when it leaves the road and rolls over.
- **Other events**- include personal injuries suffered on the vehicle, persons falling from or being thrown against a standing vehicle, cases of stolen vehicles, and fires occurring in a standing vehicle.

The likelihood of a truck shipment of chemicals or product from the Crow Butte Project being involved in an accident of any type in the Crawford area during a one-year period is approximately 1 percent.

7.14.5.3 Accidents Involving Radioactive Wastes

Low level radioactive solid byproduct material or unusable contaminated equipment generated during operations are transported to a licensed disposal site as needed. Because of the low levels of radioactive concentration involved, these shipments are considered to have minimal potential impact in the event of an accident. Emergency response procedures are the same as for yellowcake shipments.

7.14.5.4 Accidents Involving Resin Transfers

One of the potential impacts of a satellite plant is the transfer of the uranium-loaded resin or eluate from the satellite to the main process facility.

Resin will be transported to and from the Crow Butte satellite plant in a specially designed, low-profile, 400 cubic foot (3,000 gallon) capacity tanker trailer. It is currently anticipated that two loads of uranium laden resin will be transported to the Crow Butte recovery facility for elution, and two loads of barren eluted resin will be returned to the Crow Butte satellite plant on a daily basis. The transfer of resin between the two sites will occur on county and private roads within the License Area.

Resin or eluate shipments shall be treated similarly to yellowcake shipments in regards to Department of Transportation (DOT) and USNRC regulations. Shipments will be handled as Low Specific Activity (LSA) material, for both uranium laden and barren eluted resin. Pertinent procedures, which Crow Butte will follow for a resin shipment, including emergency procedures in the event of an accident, are discussed n detail in the North Trend Amendment Expansion Area Technical Report

Currently, CBR intends to treat the eluted resin the same as the uranium loaded resin. It is possible that the eluted resin may be clean enough to be transported as non-radioactive material, as defined by DOT regulations. Operating experience will aid in the determination of the most practical and efficient way of dealing with the shipment of barren resin. Regardless, compliance with all applicable DOT and USNRC regulations will be the primary determining factor.

7.14.6 Other Accidents

Other potential accidents involving non-radiological materials are associated with the various chemical and fuel storage tanks maintained outside the process facilities. Each of the liquid chemical storage tanks is located on curbed concrete pads to contain any spills. The oxygen and carbon dioxide, which are stored as liquefied gases, do not require a curbed concrete pad for containment since these chemicals will convert to gaseous form and vent to the atmosphere if a leak occurred. These tanks are stored away from the processing building and yellowcake storage area.

Accidents involving personnel are also a possibility, although with a small work force, not considered to be likely. Personnel are trained in safety and emergency procedures in accordance with Mine Safety and Health Administration regulations. Initial and refresher training include occupational safety, first aid, radiation safety and fire procedures.

8 ALTERNATIVES TO PROPOSED ACTION

8.1 NO-ACTION ALTERNATIVE

8.1.1 Summary of Current Activity

CBR currently operates the Crow Butte Project; a commercial ISL uranium mining operation located approximately 4.0 miles southeast of Crawford in Dawes County, Nebraska. Operation is allowed under USNRC Source Materials License SUA-1534.

An R&D facility was operated on the property in 1986 and 1987. Construction of the commercial process facility began in 1988, with production beginning in April of 1991. The total original License Area occupies 3,300 acres, and the surface area to be affected by the current commercial project will be approximately 1,100 acres. Facilities include the R&D facility, the commercial process facility and office building, solar evaporation ponds, parking, access roads, and wellfields.

In the current License Area, uranium is recovered by ISL from the Chadron Sandstone at a depth that varies from 400 feet to 800 feet. The overall width of the mineralized area varies from 1,000 feet to 5,000 feet. The ore body ranges in grade from less than 0.05 percent to greater than 0.5 percent U_3O_8, with an average grade estimated at 0.27 percent U_3O_8. Production is currently in progress in Mine Units 10 and 11. Groundwater restoration has been completed and received regulatory approval in Mine Unit 1. Groundwater restoration is currently underway in Mine Units 2 through 4.

The current extraction plant is operating with a licensed process flow rate of 5,000 gpm exclusive of restoration flow. Maximum allowable throughput from the plant under SUA-1534 is currently 2,000,000 pounds (lb) of U_3O_8 per year. On October 16, 2006, CBR submitted a request to the USNRC for a license amendment to increase the plant throughput from 5,000 to 9,000 gpm. USNRC approval is pending.

8.1.2 Impacts of the No-Action Alternative

The no-action alternative would allow CBR to continue mining operations in the current License Area until the USNRC formally denied the renewal of the license application. As long as CBR submits a source material renewal application to the USNRC at least thirty days before the expiration date of the existing license (February 28, 2008), the license would not expire until the USNRC determined the final disposition of the renewal application and advised CBR of its decision. If the license renewal was not approved by the USNRC, restoration and reclamation activities would then become the primary activities.

If renewal of the current source material license was not approved, all activities at the Crow Butte site that are not associated with groundwater restoration and decommissioning would be completed, resulting in the loss of a significant portion of the total employment at the site. At the completion of decommissioning activities, all employment opportunities at the mine would be terminated.

In addition to the loss of significant employment opportunities in Crawford and Dawes Counties, the premature closing of the Crow Butte Project before commercially viable resources had been recovered would adversely affect the economic base of Dawes County. As discussed in further detail in **Section 7.10** and shown in **Table 8.1-1**, the Crow Butte Project currently provides a significant economic impact to the local Dawes County economy.

Table 8.1-1: Current Economic Impact of Crow Butte Project

	Current Crow Butte Operation Annual Economic Impact
Employment	
Full-Time Employees	52
Full-Time Contractor Employees	20
Part-Time Employees and Short Term Contractors	7
CBR Payroll, 2006	\$3,400,000
Taxes	
Property Taxes	\$627,000
Sales and Use Taxes	\$238,000
Severance Taxes	\$545,000
Total Taxes	\$1,410,000
Local Purchases	
Local Purchases, 2006	\$6,800,000
Total Direct Economic Impacts	
	\$11,610,000

A decision to not renew SUA-1534 for mining in the Crow Butte License Area would leave a large resource unavailable for energy production supplies. In 2006, total domestic U.S. uranium production was approximately 4 million pounds U_3O_8, of which more than 700,000 pounds (or approximately 18 percent) were produced at the Crow Butte Project. During the same year, domestic U.S. uranium consumption was approximately 67 million pounds of U_3O_8 with approximately 16 percent supplied by domestic producers (EIA 2007). The Crow Butte Project represents an important source of domestic uranium supplies that are essential in providing a continuing source of fuel to power generation facilities. The current limited supplies of fuel for nuclear power plants may negatively impact the renewed and growing interest in nuclear energy in the U.S. and other nations (MIT 2007).

In addition to leaving a large deposit of valuable mineral resources untapped, a denial of this license renewal would result in the loss of a large investment in time and money made by CBR for the rights to and development of these valuable deposits. Denial of this license renewal would also have an adverse economic impact on the individuals who have surface leases with CBR and own the mineral rights within the License Area.

8.2 PROPOSED ACTION

With USNRC approval of Source Material License SUA-1534, CRB would continue to operate the Crow Butte Project ILR operation as discussed in **Section 5** of this LRA. Amendments to the license may be sought as needed in order to recover the uranium resources, for which CBR holds valid claims, in the most effective manner.

8.3 REASONABLE ALTERNATIVES

8.3.1 Process Alternatives

8.3.1.1 Lixiviant Chemistry

CBR is using a sodium bicarbonate lixiviant that is an alkaline solution. Where the groundwater contains carbonate, as it does at CBR, an alkaline lixiviant will mobilize fewer hazardous elements from the ore body and will require less chemical addition than an acidic lixiviant. Also, test results at other projects indicate only limited success with acidic lixiviants, while the sodium bicarbonate has proven highly successful on the CBR R&D project and on commercial mining operations to date. Alternate leach solutions include ammonium carbonate solutions and acidic leach solutions. These solutions have been used in solution mining programs in other locations; however, operators have experienced difficulty in restoring and stabilizing the aquifer. Therefore, these solutions were excluded from consideration.

8.3.1.2 Groundwater Restoration

The restoration of the R&D project, the successful completion of restoration in Mine Unit 1, and the current restoration activities in Mine Units 2 through 4 at the current License Area exhibit the effectiveness of the restoration methods, in which groundwater sweep, permeate/reductant injection, and aquifer recirculation restored the groundwater to pre-mining quality. No feasible alternative groundwater restoration method is currently available for the Crow Butte project. The USNRC and NDEQ consider the method currently employed as the BPT available.

8.3.1.3 Waste Management

Liquid wastes generated from production and restoration activities are handled by one of three methods: solar evaporation ponds, deep disposal well injection, or land application. All three methods are permitted at the current operation; however, only solar evaporation ponds and deep disposal have been implemented. The use of deep waste disposal wells in conjunction with storage/evaporation ponds to dispose of the high total dissolved solids (TDS) liquid wastes that primarily result from the yellowcake processing and drying facilities is considered the best alternative to dispose of these types of wastes.

All solid wastes are transported from the site for disposal. Non-contaminated waste is shipped to an approved sanitary landfill. Radioactive-contaminated wastes are shipped to an USNRC-approved facility for disposal. Should an USNRC (or Agreement State) licensed disposal facility not be available to CBR at the time of decommissioning, the alternative of on-site burial may be necessary. This alternative could incur long-term monitoring requirements and more expensive reclamation costs.

8.4 ALTERNATIVES CONSIDERED BUT ELIMINATED

Several mining alternatives were considered as a part of the alternatives analysis conducted by CBR for the original 1987 permit application. Due to the significant environmental impacts and cost associated with these mining alternatives, they were eliminated from further consideration.

8.4.1 Mining Alternatives

Underground and open pit mining represent the two currently available alternatives to solution mining for the uranium deposits within the License Area. Neither of these methods is economically viable for producing the Crow Butte reserves at this time. These alternative methods are not economically feasible for several reasons including the spatial characteristics of the mineral deposit and environmental factors. The depth of the deposit and subsequent overburden ratio make surface mining impractical. Surface mining is commonly undertaken on large, shallow (less than 300 feet) ore deposits. Within the License Area, uranium is recovered from depths ranging from 400 to 800 feet.

In addition, the physical characteristics of the deposit and the overlying materials make underground mining infeasible for the Crow Butte Project. The costs of mine development, including surface facilities, shaft, subsurface stations, ventilation systems, and drifting, would decrease the economic efficiency of the project.

From an environmental perspective, open pit mining or underground mining and the associated milling process involve higher risks to employees, the public, and the environment. Radiological exposure to the personnel in these processes is increased, not only from the mining process, but also from milling and the resultant mill tailings. The personnel injury rate is traditionally much higher in open pit and underground mines than has been the experience at ISL solution mining operations.

Both open pit and underground mining methods would require substantial de-watering to depress the potentiometric surface of the local aquifers to provide access to the ore. The groundwater does contain naturally high levels of radium-226 that would have to be removed prior to discharge, resulting in additional radioactive solids that would require disposal. For conventional mining, a mill tailings pond that could contain 5 to 10 million tons of solid tailings waste from the uranium mill would also be required. Reclaiming mill tailings ponds typically requires dewatering/treatment of contaminated fluids, extensive in-place reclamation, and long-term monitoring.

In a comparison of the overall impacts of ISL of uranium compared with conventional mining, an USNRC evaluation concluded that environmental and socioeconomic advantages of ISL include the following: U.S. Nuclear Regulatory Commission, *Draft Environmental Statement Related to the Operation of the Teton Project*, NUREG-0925, June 1982 Para. 2.3.5.

- Significantly less surface area is disturbed than in surface mining, and the degree of disruption is much lower.
- No mill tailings are produced, and the volume of solid wastes is reduced significantly. The gross quantity of solid wastes produced by ISL is generally less than 1 percent of that produced by conventional milling methods (more than 2,090 lbs of tailings usually result from processing each metric ton 2,200 lbs of ore).
- Because no ore and overburden stockpiles or tailings pile(s) are created, and the crushing and grinding ore-processing operations are not needed, the air pollution problems caused by windblown dusts from these sources are eliminated.
- The tailings produced by conventional mills contain essentially all of the radium-226 originally present in the ore. By comparison, less than 5 percent of the radium in an ore body is brought to the surface when ISL methods are used. Consequently, operating personnel are not exposed to the radionuclides present in and emanating from the ore and tailings, and the potential for radiation exposure is significantly lower than that associated with conventional mining and milling.
- By removing the solid wastes from the site to a licensed waste disposal site and otherwise restricting them from contaminating the surface and subsurface environment, the entire mine site can be returned to unrestricted use within a relatively short time.
- Solution mining results in significantly less water consumption than conventional mining and milling.
- The socioeconomic advantages of ISL include:
    - The ability to mine a lower grade ore,
    - A lower capital investment,
    - Less risk to the miner,
    - Shorter lead time before production begins, and
    - Lower manpower requirements.

Finally, and perhaps most importantly, because Crow Butte is now an established commercial solution mining site, there are no viable alternative mining methods at this time. The current market price of uranium makes an established solution mining operation the most economically viable method of mining uranium.

8.5 CUMULATIVE EFFECTS

8.5.1 Cumulative Radiological Impacts

The USNRC website provides the location of all fuel cycle facilities in the United States, including source material facilities (e.g., uranium mills). The website was reviewed to identify the location of fuel cycle facilities within an 80-km (50-mile) radius of the CBR ISL facility (USNRC 2007).

The CBR operation is currently the only nuclear fuel cycle facility located in the state of Nebraska. There are no other fuel cycle facilities (including conventional uranium mills and in situ recovery facilities) located within 80 km of the CBR License Area. The nearest uranium in-situ recovery plant is the Highland Mines/Smith Ranch facility in Campbell County, Wyoming, which is currently the only producing facility in Wyoming. This facility is located approximately 100 miles west-northwest of the CBR facility. The White Mesa Mill located in southeastern Utah is currently the only fully licensed, operating conventional uranium mill in the U.S.

Other fuel cycle facilities that are nearest the CBR facility, but well beyond the 80-km radius, include the following: Honeywell International, Inc. Uranium Hexafluoride Production (Conversion) Facility, Metropolis, Illinois (currently the only active conversion plant in U.S.); AREVA NP, Inc. Uranium Fuel Fabrication Facility, Richland, Washington; Louisiana Energy Services Gas Centrifuge Enrichment Facility (under construction), Hobbs, New Mexico; and the U.S. Enrichment Corporation Gas Centrifuge Enrichment Facility, in Paducah.

There are two operating nuclear reactors located in the state of Nebraska beyond the 80-km radius: Cooper Boiling Water Reactor, 23 miles south of Nebraska City; and the Ft. Calhoun Pressurizes Water Reactor, 19 miles north of Omaha, Nebraska.

Potential impacts associated with the cumulative impacts associated with other existing radiological sources are considered to be *de minimus*. This is due primarily to the fact there are no nuclear fuel cycle facilities located within a 80-km radius of the CBR facility, there have been no cumulative impacts observed during the operating life of the CBR facility (16 years), and the CBR facility has operated for approximately 16 years with no observable significant adverse impacts associated with its operations (e.g., environmental).

8.5.2 Future Development

CBR has identified several additional resource areas in the region near the Crow Butte Central Plant that could conceivably be developed as satellite facilities. CBR submitted a request on May 30, 2007 for an amendment to Source Material License SUA-1534 for the development of additional uranium ISL mining resources called the North Trend Expansion Area. The proposed development area would be located approximately 1.0 mile northwest of the current License Area and would be used as a satellite facility to the existing Central Plant. Commercial production at the Crow Butte Project, including the proposed North Trend Expansion Area, is expected to extend over the next 10 years with depletion of uranium reserves at both areas by 2017.

Development of additional satellite facilities depends on further site investigations by CBR and the future of the uranium market. If conditions warrant, CBR may submit additional license amendment requests to permit development of these additional resources. However, CBR currently projects that development of these areas would be primarily intended to maintain production allowed under the current license as reserves in the current licensed area are depleted.

CBR believes that the only environmental impact from approval of the increased flow rate at the current operation would be a corresponding increase in the emission of radon-222 from the current operation. The amendment request estimated a 22 percent increase in the maximum public dose. CBR estimated that the maximum public dose would remain well below the public dose limit found in 10 CFR § 20.1301.

8.5.2.1 Other Fuel Cycle Facility Development

With the increase in worldwide demand for uranium, and the resulting increase in the price of uranium, additional fuel cycle facilities such as uranium milling (e.g., conventional uranium milling and in situ recovery facilities) are in the planning and development stages in the U.S., including Wyoming and South Dakota (USNRC 2007). The addition of any new fuel cycle facilities in close proximity to the CBR facility could result in cumulative impacts, with impacts depending upon the type of fuel cycle facilities. Any such future cumulative impacts associated with new fuel cycle facilities would have to be assessed once future plans for any such facilities are better understood.

Today, ISL has evolved to the point where it has been demonstrated to be both an economic and environmentally acceptable method for extracting uranium (IAEA 2005). The primary environmental consideration with ISL is typically the risk of groundwater contamination. Any future cumulative environmental impacts associated with ISL development in the area would be expected to be associated primarily with groundwater. Historically, groundwater contamination associated with ISL facilities using strict environmental controls, has been demonstrated to be controllable, safe and environmentally sound.

Cumulative impacts associated with local and regional socioeconomic issues would also be important considerations associated with significant future uranium development in the area of the existing CBR uranium operations.

8.6 COMPARISON OF THE PREDICTED ENVIRONMENTAL IMPACTS

Table 8.6-1 summarizes the environmental impacts for the no-action alternative, the preferred alternative, and the process alternatives discussed above. The predicted impacts for the mining alternatives are not included for comparison because these alternatives were rejected due to significant environmental and economic impacts. Environmental impacts are discussed in greater detail in **Section 7** of this LRA.

Table 8.6-1: Comparison of Predicted Environmental Impacts

			Process Alternatives	
Impacts of Operation	**No-Action Alternative**	**Preferred Alternative**	**Alternate Lixiviant Chemistry**	**Alternate Waste Management**
Land Surface Impacts	None	Minimal temporary impacts in wellfield areas; Significant surface and subsurface disturbance confined to a portion of the 30-acre satellite plant site.	Same as Preferred Alternative.	Same as Preferred Alternative. Potential additional impacts from land application of treated waste water.
Land Use Impacts	None	Loss of crop and cattle production in 1,310-acre impacted area for duration of project.	Same as Preferred Alternative.	Same as Preferred Alternative plus a potential long-term land use impact from on-site disposal of 11(e)2 byproduct material.
Transportation Impacts	None	Minimal impact on current traffic levels. Estimated additional heavy truck traffic of 500 trips per year; additional 6 to 8 VTPD light duty trucks.	Same as Preferred Alternative.	Same as Preferred Alternative.
Geology and Soil Impacts	None	None	None	None
Surface Water Impacts	None	None	None	None
Groundwater Impacts	None	Consumption of Chadron groundwater for control of mining solutions and restoration (estimated at 50 gpm average).	Same as Preferred Alternative. Increased difficulty with groundwater restoration and stabilization.	Same as Preferred Alternative.
Ecological Impacts	None	No substantive impairment of ecological stability or diminishing of biological diversity.	Same as Preferred Alternative.	Same as Preferred Alternative.

Table 8.6-1: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives: Alternate Lixiviant Chemistry	Process Alternatives: Alternate Waste Management
Air Quality Impacts	None	Additional 14.5 tons per year total dust emissions due to vehicle traffic on gravel roads.	Same as Preferred Alternative.	Same as Preferred Alternative.
Noise Impacts	None	Barely perceptible increase over background noise levels in the area.	Same as Preferred Alternative.	Same as Preferred Alternative.
Historic and Cultural Impacts	None	None	None	None
Visual/Scenic Impacts	None	Moderate impact; noticeable minor industrial component in sensitive viewing areas.	Same as Preferred Alternative.	Same as Preferred Alternative plus possible long-term visual and scenic impacts from on-site disposal cell for 11(e)2 byproduct material.
Socioeconomic Impacts	Eventual loss over the next 5 to 10 years of positive economic impact of $8.95M to the local area as reserves deplete in the current licensed operation.	Extension of the current annual direct economic impact of $8.95M plus the addition of between $5.05M and $6.03M annual direct economic impact to the local area.	Same as Preferred Alternative.	Same as Preferred Alternative.
Nonradiological Health Impacts	None	None	None	None
Radiological Health Impacts	None	12 percent increase in estimated maximum dose from additional radon gas released at Crow Butte.	Same as Preferred Alternative.	Same as Preferred Alternative.
Waste Management Impacts	None	Generation of additional liquid and solid waste for proper disposal.	Same as Preferred Alternative. Mobilization of additional hazardous elements in lixiviant requiring disposal.	Same as Preferred Alternative. Potential additional long-term impact from on-site disposal of 11(e)2 byproduct material.

Table 8.6-1: Comparison of Predicted Environmental Impacts

Impacts of Operation	No-Action Alternative	Preferred Alternative	Process Alternatives: Alternate Lixiviant Chemistry	Process Alternatives: Alternate Waste Management
Mineral Resource Recovery Impacts	Loss of a valuable domestic energy resource. CBR estimated reserves are under development but the current estimated recoverable resource is 2.0 million pounds with a current spot market value of $160 million.	Recovery and use of a domestic energy resource.	Same as Preferred Alternative.	Same as Preferred Alternative.

8.6.1 References

Energy Information Administration. 2005. *Uranium Market Annual Report.* [Web Page] Located at: http://www.eia.doe.gov/cneaf/nuclear/umar/umar.html. Accessed on February 22, 2007.

International Atomic Energy Agency (IAEA). 2005. *Guidebook on environmental impact assessment for in situ leach mining projects*, IAEA-TECDOC-1428. 170 pages.

United States Nuclear Regulatory Commission (USNRC). 2007. Locations of Fuel Cycle Facilities. [Web Page] Located at: http://www.nrc.gov/info-finder/materials/fuel-cycle/. Accessed on August 8, 2007.

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9 COST-BENEFIT ANALYSIS

9.1 GENERAL

The general need for production of uranium is assumed in the operation of nuclear power reactors. In reactor licensing evaluations, the benefits of the energy produced are weighed against environmental costs including a prorated share of the environmental costs of the uranium fuel cycle. The incremental impacts of typical mining and milling operation required for the fuel cycle are justified in terms of the benefits of energy generation to the society in general. However, the specific site-related benefits and costs of an individual fuel-cycle facility such as the Crow Butte Project must be reasonable as compared to that typical operation.

9.2 ECONOMIC IMPACTS

Monetary benefits accrue to the community from the presence of the Crow Butte Project, such as local expenditures of operating funds and the federal, state and local taxes paid by the project. Against these monetary benefits are the monetary costs to the communities involved, such as those for new or expanded schools and other community services. While it is not possible to arrive at an exact numerical balance between these benefits and costs for any one community, or for the project, because of the ability of the community and possibly the project to alter the benefits and costs, this section summarizes the economic impact of the project to date.

9.2.1 Tax Revenues

Table 9.2-1 summarizes the tax revenues from the Crow Butte Project.

Table 9.2-1: Tax Revenues for the Crow Butte Project

	2006	2005	2004	2003
Property Taxes	627,000	351,000	144,000	65,000
Sales and Use Taxes	238,000	185,000	161,000	153,000
Severance Taxes	545,000	338,000	180,000	73,000
Total	**1,410,000**	**874,000**	**485,000**	**291,000**

Future tax revenues are dependent on uranium prices which cannot be forecast with any accuracy; however, these taxes are also somewhat dependent on the number of pounds of uranium produced by CBR. To the extent that uranium prices remain at current levels (spot market of around $80 per pound U_3O_8 in mid-March 2007), the increased production from the satellite plants should contribute to higher tax revenues as well.

The present taxes are based on a relatively consistent production rate of 800,000 pounds per year. The contribution to taxes is on the order of $1.4 million per year.

9.2.2 Temporary and Permanent Jobs

9.2.2.1 Current Staffing Levels

CBR currently employs approximately 52 employees and 20 contractors on a full-time basis. Short-term contractors and part-time employees are also used for specific projects and/or during the summer months and may add up to 10 percent to the total staffing. This level of employment is significant to the local economies. The private employment in Dawes County in 2006 was 2,189 out of a total labor force of 3,401. Based on these statistics, CBR currently provides approximately 2.3 percent of the private employment in Dawes County. In 2006, CBR's total payroll was over $2,543,000. Of the total Dawes County wage and salary payments of $76,006,000 in 2006, the CBR payroll represented about 3.4 percent.

Total CBR payroll for the past four years was:

2003:	$2,102,000
2004:	$2,213,000
2005:	$2,382,000
2006:	$2,543,000

The average annual wage for all workers in Dawes County was $22,350 for 2006. By way of comparison, the average wage for CBR was about $51,000. Entry-level workers for CBR earn a minimum of $15.53 per hour or $32,300 per year, not including bonus or benefits.

9.2.2.2 Projected Short-Term and Long-Term Staffing Levels

CBR expects that construction of future satellite plant(s) will provide approximately ten to fifteen temporary construction jobs for a period of up to one year for each satellite. It is likely that the majority of these jobs will be filled by skilled construction labor brought into the area by a construction contractor, although some positions could be filled by local hires. Permanent CBR employees will perform all other facility construction (e.g., wells and wellfields).

CBR actively pursues a policy of hiring and training local residents to fill all possible positions. Due to the technical skills required for some positions, a small percentage of the current mine staff (less than five percent) have been hired elsewhere and relocated to the area. Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that the types of positions required at the current facility and those that will be created by any future expansion will be filled with individuals from the local workforce and that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. In 2006, total unemployment in Dawes County was 137 individuals, or 2.9 percent of the total work force of 4,799. CBR expects that many new positions will be filled from this pool of available labor.

CBR projects that the current staffing level will increase by ten to twelve full-time CBR employees for each active satellite plant. These new employees will be needed for satellite plant and wellfield operator and maintenance positions. Contractor employees (i.e., drilling rigs) may also increase by four to seven employees depending on the desired production rate. The majority, if not all, of these new positions will be filled with local hires.

These additional positions should increase payroll by about $40,000 per month, or $400,000 to $480,000 per year.

9.2.3 Impact on the Local Economy

In addition to providing a significant number of well-paid jobs in the local communities of Crawford, Harrison, and Chadron, Nebraska, CBR actively supports the local economies through purchasing procedures that emphasize obtaining all possible supplies and services that are available in the local area.

Total CBR payments made to Nebraska businesses for the past four years were:

2003: $3,602,000
2004: $3,597,000
2005: $4,570,000
2006: $6,800,000

The vast majority of these purchases were made in Crawford and Dawes County.

This level of business is expected to continue and should increase somewhat with the addition of expanded production from the satellite plant, although not in strict proportion to production. While there are some savings due to some fixed costs (Central Plant utilities for instance), there are additional expenses that are expected to be higher (well-field development for the satellites is expected to be more expensive). Therefore, it can be assumed that the overall effect on local purchases will be proportional to the number of pounds produced. In addition, mineral royalty payments accrue to local landowners. This should translate to additional purchases of $3.65 to $4.35 million per year.

9.2.4 Economic Impact Summary

The Crow Butte Project currently provides a significant economic impact to the local Dawes County economy. Approval of this LRA would have a positive impact on the local economy as summarized in **Table 9.2-2**.

Table 9.2-2: Current Economic Impact of Crow Butte Project

	Current Crow Butte Operation
Employment	
Full Time Employees	52
Full Time Contractor employees	20
Part Time Employees and Short Term Contractors	7
CBR Payroll, 2006	$3,400,000
Taxes	
Property Taxes	$627,000
Sales and Use Taxes	$238,000
Severance Taxes	$545,000
Total Taxes	$1,410,000
Local Purchases	
Local Purchases, 2006	$6,800,000
	$11,610,000

9.2.5 Short-Term External Costs

9.2.5.1 Housing Impacts

The available housing resources should be adequate to support the short-term needs during facility construction. According to the Nebraska Department of Economic Development, in 2000 a total of 492 housing units were vacant in Dawes County out of a total housing base of 4,004 units. Of the vacant units, 176 were available for rent. In addition to this availability of rental housing units, there are two small motels in Crawford that generally have vacancies and routinely provide units for itinerant workers such as railroad crews.

9.2.5.2 Noise and Congestion

No short-term increases in noise or congestion are anticipated at the current License Area; however, the addition of satellite facilities may increase the noise and congestion in the immediate vicinity during initial construction of the facility. This will include heavy truck and equipment traffic and access to the jobsite by construction workers. These impacts will be most noticeable to residents in the immediate vicinity of the facility and will be temporary in nature. The increase in noise should be considered in light of the project location, which is bounded on the west by the Burlington Northern Santa Fe rail line and on the east by Nebraska State Highway 2/71. The rail line along the western boundary is used for combining local "pusher" engines with south bound trains to assist them in climbing the Pine Ridge south of Crawford. As a result, there is a significant amount of noise generated by this activity including trains parked for extended periods. Dust from construction activities will be controlled using standard dust suppression techniques used in the construction industry.

9.2.5.3 Local Services

As previously noted, CBR actively recruits and trains local residents for positions at the mine. CBR expects that the majority of and open permanent positions would be filled with local hires. As a result of using the local workforce, the impact on local services should be minimal. In many cases these services (e.g., schools) are underutilized due to population trends in the area.

9.2.6 Long-Term External Costs

9.2.6.1 Housing and Services

Because of the small number of people who have needed to move into the area to support this project, the impact on the community in terms of expanded services has been minimal. CBR expects that any increase in long-term positions would be filled with individuals from the local workforce and that there will be no significant impact on services and resources such as housing, schools, hospitals, recreational facilities, or other public facilities. In 2006, total unemployment in Dawes County was 137 individuals, or

2.9 percent of the total work force of 4,799. CBR expects that any new positions would be filled from this pool of available labor.

9.2.6.2 Noise and Congestion

No long-term increases in noise or congestion are anticipated at the current License Area; however, the addition of satellite facilities may increase the noise and congestion in the immediate vicinity during initial construction of the facility. Most of this will consist of increased traffic from employees commuting to and from the work site and performing work in the wellfields. Some increase in heavy truck traffic will occur due to deliveries of process chemicals such as oxygen and the shipment of ion exchange resin from the satellite facility to the Central Processing facility. Delivery and ion exchange shipments should average two per day. These impacts will be most noticeable to residents in the immediate vicinity of the facility. As noted in **Section 9.2.5.2**, there is significant existing noise in the immediate area generated by the adjacent rail line and highway.

In the area around Crawford, the increased traffic will be unnoticeable due to the presence of U.S. Highway 20 and Nebraska Highway 2/71, which are both significant transport routes. The annual average 24-hour total and heavy vehicle count for U.S. Highway 20 at the eastern approach to Crawford for 2004 was 1,795 and 235, respectively. The limited additional traffic related to potential new satellite operations will not significantly affect these main routes.

9.2.6.3 Aesthetic Impacts

No additional aesthetic impacts are anticipated at the existing License Area; however, impacts to aesthetic resources resulting from the construction of new satellite facilities may occur. The potential visible surface structures at a satellite facility may include wellhead covers, wellhouses, electrical distribution lines, and one processing plant. The project would use existing and new roads to access each wellhouse and the satellite plant. Project development would alter the physical setting and visual quality of portions of the landscape, which would affect the overall landscape to some degree, as viewed from sensitive viewing areas. The proposed facilities would introduce new elements into the landscape and would alter the existing form, line, color, and texture, which characterize the existing landscape. The project would primarily affect croplands.

In foreground-middleground views, the satellite plant, wellhouses, and associated access road clearings would be the most obvious features of development. Clearings and access roads would be visible as light-tan exposed soils in geometrically-shaped areas with straight, linear edges that provide some textural and color contrasts with the surrounding cropland. The satellite plant, wellhouses, and wellhead covers would be painted to harmonize with the surrounding soil and vegetation cover. These facilities may be visible from area travel ways such as SH 2/71 and viewing areas such as the Crawford Cemetery, but would be subordinate to the rural landscape.

The electric distribution line poles would be an estimated 20 feet tall, and would be located throughout the project area to connect wellhouses with existing lines. The distribution lines are similar in appearance to those typical of the rural landscape, but would occur at a higher density than on adjacent lands. The lines would be obvious to viewers at the viewing areas, but would not change the rural character of the existing landscape.

Wellhead covers would be difficult to discern in the landscape from any sensitive viewing area. The form and textural contrast would be very weak because the relatively low profile (3 feet high) and small size of the facilities would disappear into the surrounding textures of soil and vegetation. Generally, color contrasts are most likely to be visible in foreground-middleground distance zone; however, the wellhead covers would be painted a tan color that would harmonize with the surrounding vegetation and soil colors. Therefore, contrast of line, form, texture, and color would be low. The facilities would not be noticeable to the casual observer. Wellhead covers would be visually subordinate to the landscape in foreground-middleground distance zone.

9.2.6.4 Land Access Restrictions

Property owners of land located within the immediate wellfield and plant boundaries will lose access and free use of these areas during mining and reclamation. The areas impacted are all used for agricultural purposes and the owners will lose the ability to use the areas for production purposes. Offsetting these land use restrictions are the surface lease and mineral royalty payments to the landowners.

9.3 THE BENEFIT COST SUMMARY

The benefit-cost summary for a fuel-cycle facility such as the Crow Butte Project involves comparing the societal benefit of a constant U_3O_8 supply (ultimately providing energy) against possible local environmental costs for which there is no directly-related compensation. For this project, there are basically three of these potentially uncompensated environmental costs:

- Groundwater impact
- Radiological impact
- Disturbance of the land

The groundwater impact is considered to be temporary in nature, as restoration activities will restore the groundwater to a pre-mining quality. The successful restoration of groundwater during the Research and Development (R&D) project and the commercial restoration of Mine Unit 1 have demonstrated that the restoration process can meet this criterion successfully.

The radiological impacts of the current and proposed project are small, with all radioactive wastes being transported and disposed of off-site. Radiological impacts to air and water are also minimal. Extensive on-going environmental monitoring of air, water, and vegetation has shown no appreciable impact to the environment from the Crow Butte Project.

The disturbance of the land for an ISL facility is quite small, especially when compared with conventional surface mining techniques. All of the disturbed land will be reclaimed after the project is decommissioned and will become available for previous uses.

9.4 SUMMARY

In considering the energy value of the U_3O_8 produced to U.S energy needs, the economic benefit to the local communities, the minimal radiological impacts, minimal disturbance of land, and mitigable nature of all other impacts, it is believed that the overall benefit-cost balance for the Crow Butte Project is favorable, and that issuing an license renewal for SUA-1534 is the appropriate regulatory action.

9.4.1 References

Nebraska Department of Economic Development. 2006. *Nebraska Databook*, December 2006. [Web Page] Located at: http://info.neded.org/stathand/isect10.htm.

Nebraska Department of Roads. Undated. *Traffic Flow Map of the State Highways, State of Nebraska*,. [Web Page] Located at: http://www.dor.state.ne.us/maps/Statewide%20Traffic%20Flow%20Maps/2004%20Statewide%20Traffic%20Flow%20Map.pdf.

U. S. Department of Labor, Bureau of Labor Statistics. 2007. as of March 5, 2007.

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10 ENVIRONMENTAL APPROVALS AND CONSULTATIONS

10.1 ENVIRONMENTAL APPROVALS FOR THE CURRENT LICENSED AREA

As discussed previously, this is an LRA for Radioactive Source Materials License SUA-1534, originally submitted in September of 1987 and renewed in 1997. All other required permits for the existing Crow Butte Project have been obtained and maintained since that time. A summary of the relevant permits and authorizations for the current License Area is given in **Table 10.1-1**.

Table 10.1-1: Environmental Approvals for the Current License Area

Issuing Agency	Permit Description
Nebraska Department of Environmental Quality PO Box 98922 Lincoln, Nebraska 68509-8922	Underground Injection Control Class III Authorization NE0122611 Approved: April 24, 1990
	Aquifer Exemption Approval Effective: March 23, 1984
	Underground Injection Control Class I Authorization NE0206369 Approved: September 9, 1994 Replaced: July 2, 2004
	Underground Injection Control Class I Authorization NE0210457 Approved: July 2, 2004
	National Pollutant Discharge Elimination System Permit NE0130613 Approved: September 30, 1994 Renewed: October 1, 2006
	Mineral Exploration Permit NE0209317 Approved: June 3, 2003 Replaced: July 16, 2007
	Mineral Exploration Permit NE0210679 Approved: July 16, 2007
	Evaporation Pond Design Approved: July 21, 1988
	Construction Stormwater NPDES General Permit NER100000 Authorization # NER105203 Approved: December 19, 2006
Nebraska Department of Natural Resources 301 Centennial Mall South Lincoln, Nebraska 68509-4676	Industrial Ground Water Permit I-2 Approved: August 7, 1991
Nebraska Department of Health and Human Services Regulation and Licensure PO Box 95007 Lincoln, Nebraska 68509-5007	Class IV Public Water Supply Permit NE3121024 Approved: April 12, 2002

Table 10.1-1: Environmental Approvals for the Current License Area

Issuing Agency	Permit Description
U.S. Nuclear Regulatory Commission Washington, DC 20555	Source Materials License SUA-1534 Issued: December 29, 1989 Renewed: February 28, 1998
U.S. Environmental Protection Agency 1200 Pennsylvania Ave, NW Washington, DC 20460	Aquifer Exemption Approval Effective: June 22, 1990

10.1.1 References

USNRC Regulatory Guide 3.11.1, *Operational Inspection and Surveillance of Embankment Retention Systems for Uranium Mill Tailings* (Revision 1, October 1980).