II-B

5 MITIGATION MEASURES

5.1 MITIGATION MEASURES FOR LAND USE IMPACTS

As discussed in Section 3.1 of this Environmental Report (ER), rangeland is the primary land use within the Moore Ranch License Area and the surrounding 2.0-mile review area. Oil and gas production facilities and infrastructure are also located on rangeland throughout the review area. The review area also contains pastureland to the west. Based on a site reconnaissance conducted in May 2007, a 2006 aerial photo, and ongoing EMC activities at the site since 2007, there are no occupied housing units in the License Area. Figure 3.1-1 depicts land use in the review area.

Construction of the Moore Ranch Central Plant and associated structures will encompass approximately 6 acres. Operation of the Moore Ranch Project will ultimately encompass approximately 150 acres. Use of the land as rangeland will be excluded from this area during the life of the project. Oil and gas production facilities will not be affected. Considering the relatively small size of the area impacted by construction and operation, the exclusion of grazing from this area over the course of the Moore Ranch project will have an insignificant impact on local livestock production. 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 temporary loss of agricultural production over the course of the project include site reclamation and decommissioning efforts to return the land to its beneficial use(s) before the proposed project and are discussed in this section.

All lands disturbed by the Moore Ranch project will be returned to their pre-mining land use of livestock grazing and wildlife habitat unless an alternative use is justified and is approved by the state and the landowner, i.e. the rancher desires to retain roads or buildings. The objectives of the surface reclamation effort is to return the disturbed lands to production capacity of equal to or better than that existing prior to mining. The soils, vegetation and radiological baseline data will be used as a guide in evaluating final reclamation. This section provides a general description of the proposed facility decommissioning and surface reclamation plans for the Moore Ranch Project. The following is a list of general decommissioning activities:

- Plug and abandon all wells as detailed in Section 5.1.1.
- Determination of appropriate cleanup criteria for structures (Section 5.1.6) and soils (Section 5.1.7).

- 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 5.1.6.

- Decontamination of items to be released for unrestricted use to levels consistent with the requirements of NRC.

- 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.

Pre-reclamation radiological surveys will be conducted in a manner consistent with the baseline radiological surveys so that the data can be directly compared for identification of potentially contaminated areas. For example, a comprehensive gamma scan of the site will be performed, including conversion of raw scan data to 3-foot HPIC equivalent gamma exposure rate readings and/or to estimates of soil Ra-226 concentration. These data sets will be kriged in GIS to develop continuous estimates across the site, making direct spatial comparisons with baseline survey maps possible for any given area at the site. Both qualitative assessments and quantitative statistical comparisons between kriged data sets can be made to assess significant differences, taking into account potential magnitudes of estimation uncertainty. In cases of identified contamination at the soil surface, subsurface soil sampling will also be conducted to determine the vertical extent of contamination that would require remediation under applicable soil cleanup criteria.

Final status surveys after any remediation has occurred will also be conducted such that results can be directly compared to pre-operational baseline survey data. As with pre-reclamation surveys, final status gamma scan data will be converted to 3-foot HPIC equivalent gamma exposure rates and/or to estimates of soil Ra-226 concentrations, then kriged using GIS for comparative assessments against pre-operational baseline data. For aspects of the final status survey, pre-operational baseline data may be used instead of a physically separated reference area to provide information on background conditions for statistical comparative testing. Subsurface sampling will be conducted as part of the final status survey only if residual subsurface contamination is known to remain after any remediation has been completed. Other post-operational environmental monitoring data such as sediments, surface waters, groundwater, air particulates, radon, and vegetation may also be compared quantitatively and/or qualitatively against pre-operational baseline data.

The following sections describe in general terms the planned decommissioning activities and procedures for the Moore Ranch facilities. EMC will, prior to final decommissioning of an area, submit to the NRC a detailed Decommissioning Plan for their review and approval at least 12 months before planned commencement of final decommissioning.

5.1.1 Well Plugging and Abandonment

Wellfield plugging and surface reclamation will be initiated once the regulatory agencies concur that the groundwater has been adequately restored and that groundwater quality is stable. All production, injection and monitor wells and drillholes will be abandoned in accordance with WS-35-11-404 and Chapter VIII, Section 8 of the WDEQ-LQD Rules and Regulations to prevent adverse impacts to groundwater quality or quantity.

Wells will be plugged and abandoned in accordance with the following program.

- All pumps and tubing will be removed from the well.
- All wells will be plugged from total depth to within 23 feet of the collar with a nonorganic well abandonment plugging fluid of neat cement or bentonite based grout mixed in the recommended proportion of 20 lbs per barrel of water, to yield an abandonment fluid with a 10 minute gel strength of at least 20 lbs/100 sq ft and a filtrate volume not to exceed 13.5 cc.
- The casing is cut off at least three feet below the ground surface. Abandonment fluid is topped off to the top of the cut-off casing. A steel plate is placed atop the sealing mixture showing the permit number, well identification, and date of plugging.
- A cement plug is placed at the top of the casing (if cement is not within three feet of the surface), and the area is backfilled, smoothed, and leveled to blend with the natural terrain.

As an alternative method of well plugging, a dual plug procedure may be used where a cement plug will be set using slurry of a weight of no less than 12 lbs/gallon into the bottom of the well. The plug will extend from the bottom of the well upwards across the first overlying aquitard. The remaining portion of the well will be plugged using a bentonite/water slurry with a mud weight of no less than 9.5 lbs/gallon. A 10-foot cement top plug will be set to seal the well at the surface.

5.1.2 Surface Disturbance

The primary surface disturbances associated with ISR mining are the sites containing the central processing plant, maintenance and office areas. Surface disturbances also occur during the well drilling program, pipeline and well installations, and road construction. These more superficial disturbances involve relatively small areas or have very short-term impacts.

Disturbances associated with the central processing plant, office and maintenance buildings, and field header buildings, will be for the life of those activities and topsoil will be stripped from the areas prior to construction. Disturbance associated with drilling and pipeline installation is limited, and is reclaimed and reseeded as soon as weather conditions permit. Vegetation will normally be reestablished over these areas within two years. Surface disturbance associated with development of access roads will occur at the Moore Ranch site and topsoil will be stripped from the road areas prior to construction and stockpiled.

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. 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 to the extent possible.

- Removal of buried wellfield piping.

- 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 NRC guidelines for decommissioning.

An ongoing process during ISL mining operations is drilling, which results in the production of drill cuttings. Drill cuttings that have not been exposed to lixiviant are classified as Technically Enhanced Naturally Occurring Radioactive Material (TENORM). If the cuttings have been exposed to lixiviant, they are classified as 11e.(2) byproduct material. Drill cuttings will be managed using the following methods:

- TENORM drill cuttings will be buried in the drill pits. This method is discussed in a recent EPA report (EPA, 2007), which states "these wastes are typically deposited in pits on site, which are subsequently buried during reclamation. Some slight radioactivity may occur in accumulated solids in the pit bottoms". As discussed in Section 2.2.5 of the ER, the Moore Ranch orebody ranges in grade from less than 0.05% to greater than 0.5%, with an average grade estimated at 0.1%. The relatively small volume of low concentration TENORM drill cuttings deposited at the bottom of the drill pits will not present a hazard. Additionally, TENORM material is not subject to the soil clean-up criteria from 10 CFR Part 40 Appendix A.
- ISL operations occasionally require drilling or recompletion of wells into an active mining zone. In these instances, the drill cuttings are considered 11e.(2) byproduct material and must be collected. The cuttings will be removed, dewatered, packaged and disposed at a facility licensed to receive byproduct material.

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 decontaminated until they are releasable. If the equipment cannot be decontaminated to meet release limits, it will be disposed of at a licensed disposal facility.

Wellfield decommissioning will be an independent ongoing operation throughout the mining sequence. 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.

5.1.3 Topsoil Handling and Replacement

In accordance with WDEQ-LQD requirements, topsoil is salvaged from building sites, permanent storage areas, main access roads, graveled wellfield access roads and chemical storage sites. 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 will be determined during final wellfield construction activities.

As described in Section 3, topsoil thickness varies within the permit area from non-existent to several feet in depth. However, typical topsoil stripping depths are expected to range from 3 to 6 inches.

Salvaged topsoil is stored in designated topsoil stockpiles. These stockpiles will be generally located on the leeward side of hills to minimize wind erosion. Stockpiles will not be located in drainage channels. The perimeter of large topsoil stockpiles may be bermed to control sediment runoff. Topsoil stockpiles will be seeded as soon as possible after construction with the permanent seed mix. In accordance with WDEQ-LQD requirements, all topsoil stockpiles will be identified with a highly visible sign with the designation "Topsoil."

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 only remain open a short time, usually less than 30 days. Similarly, during pipeline construction, topsoil is stored separate from subsoil and is replaced on top of the subsoil after the pipeline ditch is backfilled.

5.1.4 Final Contouring

Recontouring of land where surface disturbance has taken place will restore it to a surface configuration that will blend in with the natural terrain and will be consistent with the post mining land use. Since no major changes in the topography will result from the proposed mining operation, a final contour map is not required. As a result, the pre-operations contour shown on Figure 1.2-4 will generally show post-mining contour.

5.1.5 Revegetation Practices

Revegetation practices will be conducted in accordance with WDEQ-LQD regulations and the mine permit. During mining operations the topsoil stockpiles, and as much as practical of the disturbed wellfield areas will be seeded to establish a vegetative cover to minimize wind and water erosion. After topsoiling prior to final reclamation, an area will normally be seeded with a nurse crop to establish a standing vegetative cover along with the permanent seed mix. A long term temporary seed mix may be used in the wellfields and other areas where the vegetation will be disturbed again prior to final decommissioning and final revegetation. This long term seed mix typically consists of one or more of the native wheat grasses (i.e. Western Wheatgrass, Thickspike Wheatgrass).

Permanent seeding is accomplished with a seed mix approved by the WDEQ-LQD. The permanent mix typically contains native wheat grasses, fescues, and clovers. Typical seeding rates will be 12-14 lbs of pure live seed per acre.

The success of permanent revegetation in meeting land use and reclamation success standards will be assessed prior to application for bond release by utilizing the "Extended Reference Area" method as detailed in WDEQ-LQD Guideline No. 2 - Vegetation (March 1986). This method compares, on a statistical basis, the reclaimed area with adjacent undisturbed areas of the same vegetation type.

The Extended Reference Areas will be located adjacent to the reclaimed area being assessed for bond release and will be sized such that it is at least half as large as the area being assessed. In no case will the Extended Reference Area be less than 25 acres in size.

The WDEQ-LQD will be consulted prior to selection of Extended Reference Areas to ensure agreement that the undisturbed areas chosen adequately represent the reclaimed areas being assessed. The success of permanent revegetation and final bond release will be assessed by the WDEQ-LQD.

5.1.6 Procedures for Removing and Disposing of Structures and Equipment

The following sections describe in general terms the planned decommissioning activities and procedures for the Moore Ranch facilities. EMC will, prior to final decommissioning of an area, submit to the NRC a detailed Decommissioning Plan for their review and approval at least 12 months before planned commencement of final decommissioning.

5.1.6.1 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 5.7 of the Technical Report) 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.

5.1.6.2 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 for future use;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other unrestricted use by others.

EMC believes that process buildings will be decontaminated, dismantled and released for use at another location. If decontamination efforts are unsuccessful, the material will be sent to a permanent licensed disposal facility. Cement foundation pads and footings will be broken up and trucked to a solid waste disposal site or to a licensed 11e.(2) byproduct material disposal facility if contaminated.

All waste that could pose a threat to human health and the environment will be disposed of offsite. This will effectively control, minimize, or eliminate post-closure escape of nonradiological hazardous constituents, leachate, contaminated rainwater or waste composition products to the ground or surface waters, or to the atmosphere.

5.1.6.2.1 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 NRC guidance. Release limits for alpha radiation are as follows:

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

Decontamination of surfaces will be guided by the ALARA principle to reduce surface contamination to levels as far below the limits as practical. Particular attention will be given to equipment and structures in which radiological materials could accumulate in inaccessible locations including piping, traps, junctions, and access points. Contamination of these materials will be determined by surveys at accessible locations. Items that cannot be adequately characterized or that are too large to be scanned will be considered contaminated in excess of the limits and will be disposed at a properly licensed facility.

Non-salvageable contaminated equipment, materials, and dismantled structural sections will be sent to a 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.

5.1.6.2.2 Preparation for Disposal at a Licensed Facility

If facilities or equipment are to be moved to a facility licensed for disposal of 11e.(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.

5.1.6.3 Waste Transportation and Disposal

Materials, equipment, and structures that cannot be decontaminated to meet the appropriate release criteria will be disposed at a disposal site licensed by the NRC or an Agreement State to receive 11e.(2) byproduct material. EMC is investigating alternatives for disposal at existing sites licensed to receive 11e.(2) byproduct material including Pathfinder Mines, Kennecott Uranium Company, and Denison Mines. An agreement for disposal of 11e.(2) byproduct material will be in place before operation of the Moore Ranch project commences. A current disposal agreement will be maintained at a minimum of one licensed disposal facility throughout licensed operations.

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 NRC transportation regulations (10 CFR 71).

5.1.7 Methodologies for Conducting Post-Reclamation and Decommissioning Radiological Surveys

The following sections describe in general terms the planned decommissioning activities and procedures for the Moore Ranch facilities. EMC will, prior to final decommissioning of an area, submit to the NRC a detailed Decommissioning Plan for their review and approval at least 12 months before planned commencement of final decommissioning.

5.1.7.1 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 5.1-2.

On April 12, 1999, the NRC issued a Final Rule (64 FR 17506) that requires the use of the existing soil radium standard to derive a dose criterion for the cleanup of byproduct material. The amendment to Criterion 6(6) of 10 CFR Part 40, Appendix A was effective on June 11, 1999. This "benchmark approach" requires that NRC licensees model the site-specific dose from the existing radium standard and then use that dose to determine the allowable quantity of other radionuclides that would result in a similar dose to the average member of the critical group. These determinations must then be submitted to NRC with the site reclamation plan or included in license applications. This section documents the modeling and assumptions made by EMC to derive a standard for natural uranium in soil for the proposed Moore Ranch Project.

Concurrent with publication of the Final Rule, NRC published draft guidance (64 FR 17690) for performing the benchmark dose modeling required to implement the final rule. Final guidance was published as Appendix E to NUREG-1569. This guidance discusses acceptable models and input parameters. This guidance, guidance from the RESRAD Users Manual, the Data Collection Handbook to Support Modeling Impacts of Radioactive Material in Soil and site-specific parameters were used in the modeling as discussed in the following sections.

5.1.7.1.1 Determination of Radium Benchmark Dose

RESRAD Version 6.3 computer code was used to model the Moore Ranch site and calculate the annual dose from the current radium cleanup standard.

The following supporting documentation for determination of the radium benchmark dose is attached in Appendix D:

- The RESRAD Data Input Basis (Appendix D-1) provides a summary of the modeling performed with RESRAD and the values that were used for the input parameters. A sensitivity analysis was performed for parameters which are important to the major component dose pathways and for which no site specific data was available.
- Selected graphs produced with RESRAD that present the results of the sensitivity analysis performed on the input parameters are attached (Appendix D-2)
- A full printout of the final RESRAD modeling results for the resident farmer scenario with the chosen input values is attached (Appendix D-3 and D-4). The printout provides the modeled maximum annual dose for calculated times for the

1,000- year time span and provides a breakdown of the fraction of dose due to each pathway.

- Graphs produced by RESRAD in Appendix D-5 provide the modeling results for the maximum dose during the 1,000 year time span for both radium-226 and natural uranium. A series of graphs depicts the summed dose for all pathways and the component pathways that contribute to the total dose.

The maximum dose from Ra-226 contaminated soil at the 5 pCi/g above background cleanup standard, as determined by RESRAD, for the residential farmer scenario at Moore Ranch was 39.5 mrem/yr. This dose was based upon the 5 pCi/g surface (0 to 6-inch) Ra-226 standard and was noted at time, t = 0 years. The two major dose pathways were external exposure and plant ingestion (water independent). For these two pathways, a sensitivity analysis was performed for important parameters for which no site specific information was available. The 39.5 mrem/yr dose from radium is the level at which the natural uranium radiological end point soil standard will be based as described in Section 5.1.7.1.2.

5.1.7.1.2 Determination of Natural Uranium Soil Standard

RESRAD was used to determine the concentration of natural uranium in soil distinguishable from background that would result in a maximum dose of 39.5 mrem/yr. The method involved modeling the dose from a set concentration of natural uranium in soil. This dose was then compared to the radium benchmark dose and scaled to arrive at the maximum allowable natural uranium concentration in soil.

For ease of calculations, a preset concentration of 100 pCi/g natural uranium was used for modeling the dose. The fractions used were 48.9 percent (or pCi/g) U-234, 48.9 percent (or pCi/g) U-238 and 2.2 percent (or pCi/g) U-235. The distribution coefficients that were selected for each radionuclide were RESRAD default values. A sensitivity analysis was performed using a range of distribution coefficients to evaluate potential effects of not using site specific data. All other input parameters were the same as those used in the Ra-226 benchmark modeling. The RESRAD output showing the input parameters is provided in Appendix D-3.

Using a natural uranium concentration in soil of 100 pCi/g, RESRAD determined a maximum dose of 7.5 mrem/yr. at time, t = 0 years. The printout of the RESRAD data summary is provided in Appendix D-4.

To determine the uranium soil standard, the following formula was used:

$$\text{Uranium Limit} = \left(\frac{100 \text{ pCi/g natural uranium}}{7.5 \text{ mrem/yr. natural uranium dose}} \right) \text{x } 39.5 \text{ mrem/yr radium benchmark dose}$$

$$\text{Uranium Limit} = 526 \text{ pCi/g natural uranium}$$

The natural uranium limit is applied to soil cleanup with the Ra-226 limit using the unity rule. To determine whether an area exceeds the cleanup standards, the standards are applied according to the following formula:

$$\left(\frac{\text{Soil Uranium Concentration}}{\text{Soil Uranium Limit}} \right) + \left(\frac{\text{Soil Radium Concentration}}{\text{Soil Radium Limit}} \right) < 1$$

This approach will be used to determine the radiological impact on the environment at Moore Ranch from releases of source and byproduct materials.

5.1.7.1.3 Uranium Chemical Toxicity Assessment

The chemical toxicity effects from uranium exposure are evaluated by assuming the same exposure scenario as that used for the radiation dose assessment. In the Benchmark Dose assessment for the resident farmer scenario, it was assumed that the diet consisted of 25 percent of the meat, fruits, and vegetables grown at the site. No intake of contaminated food through the aquatic or milk pathways was considered probable. Also, the model showed that the contamination would not affect the groundwater quality. Therefore, the same model will be used in assessing the chemical toxicity. The intake from eating meat was shown to be negligible compared to the plant pathway and therefore is not shown here. This is confirmed by the results of the RESRAD calculations shown in Appendix D-4.

The method and parameters for estimating the human intake of uranium from ingestion are taken from NUREG/CR-5512 Vol. 1. The uptake of uranium in food is a product of the uranium concentration in soil and the soil-to-plant conversion factor. The annual intake in humans is then calculated by multiplying the annual consumption by the uranium concentration in the food. Since the soil-plant conversion factor is based on a dry weight, the annual consumption must be adjusted to a dry-weight basis by multiplying by the dry-weight to wet-weight ratio. Parameters for these calculations are given in Section 6.5.9 of NUREG/CR-5512. Table 5.1-1 provides the parameters used in these calculation and results for leafy vegetables, other vegetables, and fruit. Annual intakes of 14 kg/year and 97 kg/year were assumed for leafy vegetables and other vegetables and fruit, respectively. Consistent with Appendix D-3 dose calculations, it was assumed that 25 percent of the food was grown on the site. It was also assumed that the uranium concentration in the garden or orchard was 526 pCi/g. This corresponds to the uranium Benchmark Concentration for surface soils. Using a conversion factor for natural uranium of 1 mg = 677 pCi, then 526 pCi/g is equivalent to 777 mg/kg. The human intake shown in the first column of Table 5.1-1 is equal to the product of the parameters given in the subsequent columns. Table 5.1-1 shows that the total annual uranium intake from all food sources from the site is 51 mg/yr.

The two-compartment model of uranium toxicity in the kidney from oral ingestion was used to predict the burden of uranium in the kidney following chronic uranium ingestion. This model allows for the distribution of the two forms of uranium in the blood, and consists of a kidney with two compartments, as well as several other compartments for uranium distribution, storage and elimination including the skeleton, liver, red blood cells (macrophages) and other soft tissues.

Table 5.1-1: Annual Intake of Uranium from Ingestion

Human Intake (mg/yr)	*Soil Concentration (mg/kg)*	*Soil to Plant Ratio (mg/kg plant to mg/kg soil)*	*Annual Consumption (kg)*	*Dry Weight Wet Weight Ratio*	*Food Source*
9.2	777	1.7E-2	3.5	0.2	Leafy Vegetables
35	777	1.4E-2	13	0.25	Other Vegetables
6.7	777	4.0E-3	12	0.18	Fruit
51					Total

The total burden to the kidney is the sum of the two compartments. The mathematical representation for the kidney burden of uranium at steady state can be derived as follows:

$$Q_P = \frac{IR \times f_1}{\lambda_P\left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pk} - f_{pk1}\right)}$$

Where:

Q_P	=	uranium burden in the plasma, µg
IR	=	dietary consumption rate, mg U/d
f_l	=	fractional transfer of uranium from GI tract to blood, unit less
f_{ps}	=	fractional transfer of uranium from plasma to skeleton, unit less
f_{pr}	=	fractional transfer of uranium from plasma to red blood cells, unit less
f_{pl}	=	fractional transfer of uranium from plasma to liver, unit less
f_{pt}	=	fractional transfer of uranium from plasma to soft tissue, unit less
f_{pk1}	=	fractional transfer of uranium from plasma to kidney, compartment 1, unit less;
λ_p	=	biological retention constant in the plasma, d-1.

The burden in kidney compartment 1 is:

$$Q_{k1} = \lambda_P \times Q_P \times \frac{f_{pk1}}{\lambda_{k1}}$$

Where:

Q_{k1}	=	uranium burden in kidney compartment 1, mg;
λ_{k1}	=	biological retention constant of uranium in kidney compartment 1, d-1.

Similarly, for compartment 2 in the kidney, the burden is:

$$Q_{k2} = \lambda_P \times Q_P \times \frac{f_{pk2}}{\lambda_{k2}}$$

Where:

Q_{k2}	=	uranium burden in kidney compartment 2, µg;
λ_{k2}	=	biological retention constant of uranium in kidney compartment 2, d-1;
f_{pk2}	=	fractional transfer of uranium from plasma to kidney compartment 2, unit less.

The total burden to the kidney is then the sum of the two compartments is:

$$Q_{k1} + Q_{k2} = \frac{IR \times f_1}{\left(1 - f_{ps} - f_{pr} - f_{pl} - f_{pt} - f_{pk1}\right)} \times \left(\frac{f_{pk1}}{\lambda_{k1}} + \frac{f_{pk2}}{\lambda_{k2}}\right)$$

The parameter input values for the two-compartment kidney model include the daily intake of uranium estimated for residents at this site, and the ICRP 69 values recommended by the ICRP as listed below. The daily uranium intake rate was estimated to be 0.14 mg/day (51 mg/year) from ingestion while residing at this site.

IR = 0.14 mg/day
f_1 = 0.02
f_{ps} = 0.105
f_{pr} = 0.007
f_{pl} = 0.0105
f_{pt} = 0.347
f_{pk1} = 0.00035
f_{pk2} = 0.084
λ_{k1} = ln(2)/5 yrs
λ_{k2} = ln(2)/7 days
where ln(2) = 0.693…

Given a daily uranium intake of 0.14 mg/day at this site and the above equation, the calculated uranium in the kidneys is 0.0093 mg U, or a concentration of 0.03 µg U/g kidney. This is three percent of the 1.0 µg U/g value that has generally been understood to protect the kidney from the toxic effects of uranium. Some researchers have suggested that mild effects may be observable at levels as low as 0.1 µg U/g of kidney tissue. Using 0.1 µg U/g as a criterion, then the intake is thirty percent of the level where mild effects may be observable.

The EPA evaluated the chemical toxicity data and found that mild proteinuria has been observed at drinking water levels between 20 and 100 µg/liter. Assuming water intake of 2 liters/day, this corresponds to an intake of 0.04 to 0.2 mg/day. Using animal data and a conservative factor of 100, the EPA arrived at a 30 µg/liter limit for use as a National Primary Drinking Water Standard (Federal Register/Vol.65, No.236/ December 7, 2000). This is equivalent to an intake of 0.06 mg/day for the average individual. Naturally, since large diverse populations are potentially exposed to drinking water sources regulated using these standards, the EPA is very conservative in developing limits.

This analysis indicates that a soil limit of 526 pCi/g of natural uranium would result in an intake of approximately 0.14 mg/day. Using the most conservative daily limit corresponding to the National Primary Drinking Water standard, a soil limit of 225 pCi/g corresponds to the EPA intake limit from drinking water with a uranium concentration of 0.06 mg/day. Therefore exposure to soils containing 225 pCi/g of natural uranium should not result in chemical toxicity effects. Since the roots of a fruit tree would penetrate to a considerable depth, limiting subsurface uranium concentrations to 225 pCi/g will be considered appropriate as well.

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.

EMC 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. The uranium concentration should be limited to 225 pCi/g for all soil depths because of chemical toxicity concerns.

Table 5.1-2
Soil Cleanup Criteria and Goals

	Radium-226 (pCi/gm)		Natural Uranium (pCi/gm)	
Layer Depth	*Limit*	*Goal*	*Limit*	*Goal*
Surface (0-15 cm)	5	5	225	150
Subsurface (15 cm layers)	15	15	225	225

5.1.7.2 Excavation Control Monitoring

EMC will use hand-held and GPS-based gamma surveys 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.

5.1.7.3 Surface Soil Cleanup Verification and Sampling Plan

Cleanup of surface soils will be restricted to potentially contaminated areas. Final GPS-based gamma surveys will be conducted in potentially contaminated areas. Areas will be divided into 100 m^2 grid blocks. Soil samples will be obtained from grid blocks with gamma count rates exceeding the gamma action level. The samples will be five-point composites and will be analyzed at an offsite laboratory for radium-226 and natural uranium.

Section 2.9.2.2.3 and 2.9.2.2.5 of the Technical Report present two predictive models to estimate radium-226 soil concentrations from exposure rate measurements. One model is a linear model and is best used when predicting radium-226 concentrations when exposure rates are greater than 20 μR/hr. The second model is a power function model and is best used when predicting radium-226 concentrations when exposure rates are less than 20 μR/hr. Section 2.9.3.2.1 of the Technical Report concludes that pre-ISR radium-226 concentrations in soil are unlikely to exceed 2 pCi/g. Based on the radium-226 soil standard contained in 10 CFR 40, Appendix A, Criterion 6-6 and the background radium-226 concentration being below 2 pCi/g, the radium-226 soil cleanup standard for most areas on Moore Ranch site would be about 7 pCi/g. Using the linear model described above, this radium-226 soil concentration would correspond to an exposure rate of approximately 23 μR/hr. Using the power function model described above, this radium-

226 soil concentration would correspond to 23.2 μR/hr. Both equations are in agreement that 23 μR/hr correlates to a radium-226 soil concentration equal to the cleanup standard for most areas of approximately 7pCi/g. The gamma count rates corresponding to an exposure rate of 23 μR/hr from instruments used to perform pre-reclamation gamma surveys will be used as an appropriate and conservative gamma action limit.

There are other physical factors that influence gamma count rates other than radium-226 concentrations in soil and include source geometry and land topography. As such, gamma count rates may not be a reliable tool to provide a 95% assurance that the soil units meet the cleanup guidelines. The gamma action level established above, coupled with pre-ISR gamma survey results contained in Section 2.9 of the Technical Report will provide sufficient evidence to indicate radium-226 soil concentrations above cleanup guidelines. This evidence will trigger soil removal activities and subsequent post remediation gamma surveys and soil sampling.

Gamma count rates used to identify radium-226 in soil cannot be as easily correlated to natural uranium due to its limited gamma signature. As described in Section 5.1.7.1.3, the presence of a radium-226 and natural uranium mixture will tend to drive the cleanup of radium-226 to concentrations below the cleanup level, consequently the uranium in soil will also be remediated.

In case where uranium is suspected to be the only radionuclide of concern, other instruments are available, such as a Field Instrument for the Detection of Low Energy Radiation (FIDLER), which are sensitive to the low energy x-rays emitted by natural uranium and could be used to guide soil remediation efforts. Field studies would have to be conducted to correlate the FIDLER response to natural uranium soil concentrations. If needed, the method used to correlate FIDLER (or equivalent) responses to uranium soil concentrations will be described in a detailed Decommissioning Plan for the facility which is required to be submitted to the USNRC for review and approval at least 12 months before planned commencement of final decommissioning.

The results of the soil sampling will be compared to established soil cleanup goals for radium-226 and natural uranium to demonstrate the effectiveness of the reclamation activities including any confidence level that the soil units meet the cleanup guidelines.

Pre-reclamation surveys will also be conducted as described in Section 5.1 in areas where known contamination has occurred or the potential for unknown soil contamination exists.

5.1.7.4 Quality Assurance

Verification soil samples will be sent to a commercial laboratory for analysis of radium-226 and natural uranium. The commercial laboratory will be required to have 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. EMC will maintain a laboratory QA file that will include, at a minimum, the laboratory's Quality Assurance Manual (QAM) and audit reports.

5.2 MITIGATION MEASURES FOR TRANSPORTATION IMPACTS

5.2.1 Access Road Construction Impacts

The impacts associated with upgrading and extending the existing gravel road to provide access to the central plant site are minor, consisting primarily of air quality impacts from equipment exhaust and dust. Mitigation measures for air quality impacts are discussed in detail in Section 5.6.

5.2.2 Transportation Accident Risk

Transportation of hazardous materials to and from the Moore Ranch Project can be classified as follows:

1. Shipments of uranium-laden resin from the Moore Ranch plant to a licensed facility for toll "milling" and return shipments of barren, eluted resin. Resin will be transported in tank trucks.

2. Shipments of dried yellowcake. Yellowcake will be transported in 208-L (55-gal.) drums to a distant conversion facility for refining and conversion.

3. Shipments of process chemicals or fuel from suppliers to the site.

4. Shipment of radioactive waste from the site to a licensed disposal facility.

Resin or eluate shipments will be treated similarly to yellowcake shipments in regards to Department of Transportation (DOT) and USNRC regulations.

5.2.2.1 Ion Exchange Resin Transportation Risk

Shipments will be handled as Low Specific Activity (LSA) material for both uranium-laden and barren resin. General shipping procedures are outlined as follows:

- The resin, either loaded or eluted, will be shipped as "Exclusive Use Only". This will require the outside of each container or tank to be marked "Radioactive LSA" and placarded on four sides of the transport vehicle with "Radioactive" diamond signs.

- A bill of lading will be included for each shipment (including eluted resin). The bill of lading will indicate that a hazardous cargo is present. Other items identified shall be the shipping name, ID number of the shipped material, quantity of material, the estimated activity of the cargo, the transport index and the package identification number.

- Before each shipment of loaded or barren eluted resin, the exterior surfaces of the tanker will be surveyed for alpha contamination. In addition, gamma exposure rates will be obtained from the surface of the tanker and inside the cab of the tractor. All of the survey results will appear on the bill of lading.

Accident Prevention

Actions taken to prevent accidents involving shipments of ion exchange resins include the following:

- Properly licensed and trained drivers will transport the resin between the Moore Ranch Project and satellite or toll "milling" facilities.

- Trucks and tanker trailers used to transport ion exchange resins will be maintained in good operating condition.

- Inspections will be conducted of the truck and tanker trailer prior to shipment of ion exchange resins. Transportation equipment will be taken out of service if any significant deficiencies are identified that could affect safe operation and transport and will not be place back into service until the deficiencies are corrected.

- Transport of ion exchange resin will only occur on maintained gravel or paved roads and will not occur during extreme or unsafe weather conditions.

Mitigation/Accident Response

EMC will develop an emergency response plan for transportation accidents to or from the Moore Ranch Project. EMC personnel will receive training for responding to a transportation accident. The emergency response plan will include descriptions of the following provisions:

- DOT Regulations
- Carrier Emergency Response Procedures
- Spill Kits
- Immediate Response and notification
- Accident Scene Response
- Spill cleanup
- Concluding Activities
- Review of Accident Documentation
- Review of Monitoring and Sampling Data
- Site Abandonment
- Reporting

In the event of a transportation accident involving the resin transfer operation, EMC will institute its emergency response plan for transportation accidents. To minimize the impacts from such an accident, the following procedures will be followed:

- Each truck will be equipped with a communication device that will allow the driver to communicate with either the shipper or receiver. In the event of an accident and spill, the driver will be able to communicate with either site to obtain help.

- A check-in and check-out procedure will be instituted where the driver will notify the receiving facility prior to departure from his location. If the resin shipment fails to appear within a set time, an emergency response team will respond and search for the vehicle. This system will assure reasonably quick response time in the case that the driver is incapacitated in the accident.

- Each resin transport vehicle will be equipped with an emergency spill kit which the driver can use to begin containment of any spilled material. The kit will include plastic sheeting to cover spilled material until cleanup operations can begin.

- Both the shipping and receiving facilities will be equipped with emergency response kits to quickly respond to a transportation accident.

- Personnel and truck drivers will have specialized training to handle an emergency response to a transportation accident.

5.2.2.2 Yellowcake Shipment Transportation Risk

As with resin shipments, yellowcake shipments will be made in accordance with DOT and USNRC regulations. Shipments will be handled as Low Specific Activity (LSA) material and will follow the same general shipping procedures as outlined for ion exchange resin shipments.

Accident Prevention

Actions taken to prevent accidents involving shipments of yellowcake include the following:

- Properly licensed and trained drivers will transport the yellowcake between the Moore Ranch Project and the conversion facility.
- Trucks and trailers used to transport yellowcake will be maintained in good operating condition.
- Inspections will be conducted of the truck and trailer prior to shipment of yellowcake. Transportation equipment will be taken out of service if any significant deficiencies are identified that could affect safe operation and transport and will not be place back into service until the deficiencies are corrected.
- Transport of yellowcake will only occur on maintained gravel or paved roads and will not occur during extreme or unsafe weather conditions.

Mitigation/Accident Response

EMC will develop an emergency response plan for transportation accidents to or from the Moore Ranch Project. EMC personnel will receive training for responding to a transportation accident. The emergency response plan will include descriptions of the following provisions:

- DOT Regulations
- Carrier Emergency Response Procedures
- Spill Kits
- Immediate Response and notification

- Accident Scene Response
- Spill cleanup
- Concluding Activities
- Review of Accident Documentation
- Review of Monitoring and Sampling Data
- Site Abandonment
- Reporting

The worst case accident scenario involving yellowcake transportation would be an accident involving the transport truck where the integrity of one or more drums containing yellowcake was breached, resulting in a release to the environment. Unlike ion exchange resin shipments, ISR operators do not typically transport their own yellowcake to conversion facilities but rather contract with transport companies that specialize in shipments of yellowcake. These companies have extensive emergency response programs including spill response equipment on board, drivers trained in radiological emergency response, constant monitoring of truck location and operating parameters, and standing contracts with environmental emergency response contractors for cleanup of spills. As with ion exchange resin, the primary environmental impact associated with an accident involving the spill of yellowcake would be the salvage of soils impacted by the spill area and the subsequent damage to the topsoil and vegetation structure. To minimize the impacts from such an accident, the following procedures will be followed:

- Each truck will be equipped with a communication device that will allow the driver to communicate with either the shipper or receiver. In the event of an accident and spill, the driver will be able to communicate with either site to obtain help.

- Each yellowcake transport vehicle will be equipped with an emergency spill kit which the driver can use to begin containment of any spilled material. The kit will include plastic sheeting to cover spilled material until cleanup operations can begin.

- Both the shipping and receiving facilities will be equipped with emergency response kits to quickly respond to a transportation accident.

Personnel and truck drivers will have specialized training to handle an emergency response to a transportation accident.

5.2.2.3 Byproduct Material Transportation Risk

Low level radioactive 11e.(2) by-product material or unusable contaminated equipment generated during operations will be transported to a licensed disposal site. Because of the low levels of radioactive concentration involved, these shipments are considered to have minimal potential environmental impact in the event of an accident. Shipments are generally made bulk in sealed roll off containers in accordance with the applicable DOT hazardous materials shipping provisions and will follow the same general shipping procedures, accident prevention, mitigation, and accident response outlined for ion exchange resin and yellowcake shipments.

5.3 MITIGATION MEASURES FOR GEOLOGIC AND SOILS IMPACTS

5.3.1 Geologic Impacts

The potential exists for earthquakes to impact the Moore Ranch Project. The International Building Code (IBC) is based upon probabilistic seismic analyses. Campbell County adopted the IBC in 2005. As the historic record is limited, it is nearly impossible to determine when a 2,500-year event last occurred in the county. Because of the uncertainty involved, and based upon the fact that the IBC utilizes 2,500-year events for building design, it is recommended that the 2,500-year probabilistic maps be used for Campbell County analyses. EMC will use this conservative approach is in the interest of public safety.

5.3.2 Soil Impacts

Soil erosion mitigation will be implemented in accordance with WDEQ-LQD Rules and Regulations, Chapter 3, Environmental Protection Performance Standards. Typical erosion protection measures that may be implemented at the Moore Ranch Project include the following:

- Temporary diversion of surface runoff from undisturbed areas around the disturbed areas and the use of water velocity dissipation structures;
- Retaining sediment within the disturbed areas through the use of best management practices such as silt fencing, retention ponds, or other effective means;
- Salvage and stockpiling of topsoil from the central plant facility area and from secondary wellfield access roads in a manner to avoid wind and/or water erosion. This is accomplished by grading stockpiles to the appropriate slopes, avoiding

excessive compaction, establishing a temporary vegetative cover, using appropriate fencing and signs, and installation of sedimentation catchments;
- Reestablishment of temporary or permanent native vegetation as soon as possible after disturbance; and
- Constructing roads to minimize erosion through practices such as surfacing with a gravel road base, constructing stream crossings at right angles with adequate embankment protection and culvert installation, and providing adequate road drainage with runoff control structures and revegetation.

Implementation of Best Management Practices (BMPs) will minimize the effects to soils associated with the construction and operation of the Moore Ranch Project.

5.4 MITIGATION MEASURES FOR WATER RESOURCES IMPACTS

5.4.1 Surface Water Impacts

5.4.1.1 Surface Water Impacts from Sedimentation

In areas where surface facilities including wellfields and associated structures, access roads, office buildings, pipelines, facilities and other structures associated with ISR mining and processing of uranium may affect surface water drainage patterns, diversion ditches and culverts will be used to prevent excessive erosion and control runoff. In areas where runoff is concentrated, energy dissipaters are used to slow the flow of runoff to minimize erosion and sediment loading in the runoff.

Construction and industrial stormwater National Pollutant Discharge Elimination System (NPDES) permits will be obtained in accordance with WDEQ - Water Quality Division regulations. Best management practices will be implemented to reduce erosion impacts according to storm water management plans developed for those permits.

5.4.2 Groundwater Impacts

Mitigation measures for potential environmental impacts to groundwater resources from mining and restoration are described in this section.

5.4.2.1 Groundwater Consumption

5.4.2.1.1 Monitoring

To assess the impacts from mining and restoration operations on local groundwater, the following monitoring will be performed:

- Measure background water levels in the private domestic or livestock water wells surrounding the project area before mining and every three months during operations; and,
- Measure background water levels in regional monitoring wells installed by EMC before mining and every three months during operations

5.4.2.1.2 Mitigation

It is likely that the wells surrounding the Moore Ranch License Area may provide stock water for private or public (BLM) leases. If significant impacts to those wells are observed (e.g., water levels drop to a point that impairs the usefulness of the wells), the following mitigation measures would be considered:

- Lowering the pump level in the wells, if possible;
- Deepening the wells, if possible; or,
- Replacing the wells with new wells completed in deeper sands that are not impacted by ISR operations.

5.4.2.2 Impacts on Groundwater Quality

The State of Wyoming and the NRC require restoration of affected groundwater in the mining zone following production activities. Successful groundwater restoration has been demonstrated using the methods proposed by EMC as discussed in this section. Therefore, long term impacts on groundwater quality are expected to be minimal.

5.4.2.2.1 Groundwater Restoration Criteria

The purpose of groundwater restoration is to protect groundwater adjacent to the mining zone. Approval of an aquifer exemption by the WDEQ and the EPA is required before mining operations can begin. The aquifer exemption removes the mining zone from protection under the Safe Drinking Water Act (SDWA). Approval is based on existing water quality, the ability to commercially produce minerals, and the lack of use as an underground source of drinking water (USDW). Groundwater restoration prevents any mobilized constituents from affecting aquifers adjacent to the ore zone.

The goal of groundwater restoration will be to return the concentration of a hazardous constituent in the production zone to an NRC-approved background concentration or to the maximum concentration limit (MCL), whichever is higher, or to an alternate standard approved by NRC using Best Practicable Technology (BPT). The pre-mining class of use will be determined by the baseline water quality sampling program which is performed for each wellfield, as compared to the use categories defined by the WDEQ, Water Quality Division (WQD). Baseline, as defined for this project, shall be the mean of the pre-mining baseline data after outlier removals. Restoration shall be demonstrated in accordance with Chapter 11, Section 5(a)(ii) of the WDEQ, Land Quality Division Rules and Regulations and NUREG-1569 Section 6.

The evaluation of restoration of the groundwater within the production zone shall be based on the average baseline quality over the production zone. Baseline water quality will be collected for each wellfield from the wells completed in the planned production zone (i.e., MP-Wells). In the areas where the 70 sand (production zone) and 68 sand coalesce, baseline water quality will also be collected from monitor wells completed in the 68 sand. The evaluation of restoration will be conducted on a parameter by parameter basis. Restoration Target Values (RTVs) are established for the list of baseline water quality parameters. The RTVs for the wellfields will be the average of the pre-mining values. In the areas where the 70 sand (production zone) and 68 sand coalesce, RTVs will also be established for the 68 sand as the average of the pre-mining values for the 68 sand monitor wells. Table 5.4-1 entitled Baseline Water Quality Parameters lists the parameters included in the RTVs.

Baseline values will not be changed unless the operational monitoring program indicates that baseline water quality has changed significantly due to accelerated movement of groundwater, and that such change justifies redetermination of baseline water quality. Such a change would require resampling of monitor wells and review and approval by the WDEQ.

In some instances, residual elevated concentrations may remain following restoration. These residual elevated concentrations, also known as ‘hot spots” could potentially impact groundwater outside of the exempted aquifer. The mean wellfield concentration +/- 2 standard deviations will be the primary indicator of a hot spot. If a hot spot is identified using that criterion, additional evaluation will be conducted to determine potential impacts that such a hot spot could have on water quality outside of the exempted aquifer. The additional evaluation may include, but is not limited to, trend analysis, solute transport modeling, collection of extra water samples, or analysis of added parameters (to assess post-restoration redox conditions). Based on the results of the analysis, additional restoration would be conducted as needed to ensure the protection of water quality outside the exempted aquifer.

Table 5.4-1 Baseline Water Quality Parameters

Parameter (units)
Dissolved Aluminum (mg/l)
Ammonia Nitrogen as N (mg/l)
Dissolved Arsenic (mg/l)
Dissolved Barium (mg/l)
Boron (mg/l)
Dissolved Cadmium (mg/l)
Dissolved Chloride (mg/l)
Dissolved Chromium (mg/l)
Dissolved Copper (mg/l)
Fluoride (mg/l)
Gross Alpha (pCi/l)
Gross Beta (pCi/l)
Total and Dissolved Iron (mg/l)
Dissolved Mercury (mg/l)
Dissolved Magnesium (mg/l)
Total Manganese (mg/l)
Dissolved Molybdenum (mg/l)
Dissolved Nickel (mg/l)
Nitrate + Nitrite as N (mg/l)
Dissolved Lead (mg/l)
Radium-226 (pCi/L)
Radium-228 (pCi/L)
Dissolved Selenium (mg/l)
Dissolved Sodium (mg/l)

Table 5.4-1 Baseline Water Quality Parameters

Parameter (units)
Sulfate (mg/l)
Uranium (mg/l)
Vanadium (mg/l)
Dissolved Zinc (mg/l)
Dissolved Calcium (mg/l)
Bicarbonate (mg/l)
Carbonate (mg/l)
Dissolved Potassium (mg/l)
Total Dissolved Solids (TDS) @ 180°F (mg/l)

Source: WDEQ LQD Guideline 8, Hydrology, March 2005

5.4.2.2.2 Ground Water Restoration Method

The commercial groundwater restoration program consists of two stages, the restoration stage and the stability monitoring stage. The restoration stage typically consists of three phases:

1) Groundwater transfer;
2) Groundwater sweep;
3) Groundwater treatment.

These phases are designed to optimize restoration equipment used in treating groundwater and to minimize the volume of groundwater consumed during the restoration stage. EMC will monitor the quality of groundwater in selected wells as needed during restoration to determine the efficiency of the operations and to determine if additional or alternate techniques are necessary. Online production wells used in restoration will be sampled for uranium concentration and for conductivity to determine restoration progress on a pattern-by-pattern basis.

The unconfined conditions present in the 70 Sand result in development of relatively steep drawdown cones during pumping that are of limited areal extent. Therefore the area of "dewatering" tends to be localized around the production well. Data collected during the 5-Spot Pump Test indicates that aquifer recovery occurs rapidly once an extraction well is shut in. Efficient groundwater sweep for both production and restoration can be accomplished by "pulsing" of extraction wells by cycling them on and off. The pulsing can be achieved by either switching groups of extraction wells on and off or by alternating between injection and extraction cycles within individual well patterns. Pulsing of wells will effectively resaturate portions of the aquifer that may have been temporarily dewatered by any individual extraction well. A model simulation illustrating this technique and a description of the model development is provided in Appendix A2 (technical memorandum "5 Spot Pump Test, Results, Analysis and Modeling, Moore Ranch Uranium Project," Petrotek 2008a).

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

A reductant may be added at any time during the restoration stage to lower the oxidation potential of the mining zone. Either a sulfide or sulfite compound may be added to the injection stream in concentrations sufficient to establish reducing conditions within the mining zone. Reductants are beneficial because several of the metals, which are solubilized during the leaching process, are known to form stable insoluble compounds, primarily as sulfides. Dissolved metal compounds that are precipitated under reducing conditions include those of arsenic, molybdenum, selenium, uranium and vanadium.

Ground Water Transfer

During the ground water transfer phase, water may be transferred between a wellfield commencing restoration and a wellfield commencing mining operations. Also, a ground water transfer may occur within the same wellfield, if one area is in a more advanced state of restoration than another.

Baseline quality water from the wellfield commencing mining will be pumped and injected into the wellfield in restoration. The higher TDS water from the wellfield in restoration will be recovered and injected into the wellfield commencing mining. The direct transfer of water will act to lower the TDS in the wellfield being restored by displacing affected ground water with baseline quality water.

The goal of the ground water transfer phase is to blend the water in the two wellfields until they become similar in conductivity. The water recovered from the restoration wellfield may be passed through ion exchange (IX) columns and/or filtered during this phase if suspended solids are sufficient in concentration to present a problem with blocking the injection well screens.

For the ground water transfer between wellfields to occur, a newly constructed wellfield must be ready to commence mining. Therefore this phase may be initiated at any time during the restoration process. If a wellfield is not available to accept transferred water, ground water sweep or some other activity will be utilized as the first phase of restoration.

The advantage of using the ground water transfer technique is that it reduces the amount of water that must ultimately be sent to the waste water disposal system during restoration activities.

Ground Water Sweep

Ground water sweep may be used as a stand-alone process where ground water is pumped from the wellfield without injection 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 water has lower ion concentrations that act to strip off the cations that have attached to the clays during mining. The plume of affected water near the perimeter of the wellfield is also drawn inside the boundaries of the wellfield. Ground water sweep may also be used in conjunction with the ground water treatment phase of restoration. The water produced during ground water sweep is disposed of in an approved manner.

The rate of ground water sweep will be dependent upon the capacity of the waste water disposal system and the ability of the wellfield to sustain the rate of withdrawal.

Ground Water Treatment

Either following or in conjunction with the groundwater sweep phase water will be pumped from the mining zone to treatment equipment at the surface. Ion exchange (IX), reverse osmosis (RO) or Electro Dialysis Reversal (EDR) treatment equipment will be utilized during this phase of restoration.

Groundwater recovered from the restoration wellfield will be passed through an IX system prior to RO/EDR treatment, as part of the waste disposal system or it will be re-injected into the wellfield. The IX columns exchange the majority of the contained soluble uranium for chloride or sulfate. Additionally, prior to or following IX treatment, the groundwater may be passed through a de-carbonation unit to remove residual carbon dioxide that remains in the groundwater after mining.

At any time during the process, a chemical reductant, which will be used to create reducing conditions in the mining zone, may be metered into the restoration wellfield injection stream. The concentration of reductant injected into the formation is determined by how the mining zone groundwater reacts with the reductant. The goal of reductant addition is to decrease the concentrations of redox sensitive elements.

All or some portion of the restoration recovery water can be sent to the RO unit. The use of an RO unit 1) reduces the total dissolved solids in the affected 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. The RO passes a high percentage of the water through the membranes, leaving 60 to 90 percent of the dissolved salts in the brine water or concentrate. The clean water, called permeate, will be re-injected or stored for use in the mining process. The permeate may also be de-carbonated prior to re-injection into the wellfield. The brine water that is rejected contains the majority of dissolved salts in the affected groundwater and is sent for disposal in the waste system. Make-up water, which may come from water produced from a wellfield that is in a more advanced state of restoration, water being exchanged with a new mining unit, water being pumped from a different aquifer, the purge of an operating wellfield or a combination of these sources, may be added prior to the RO or wellfield injection stream to control the amount of "bleed" in the restoration area.

The chemical reductant added to the injection stream during this 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 the reductant, the Eh of the aquifer is lowered thereby decreasing the solubility of these elements. Regardless of the reductant used, a comprehensive safety plan regarding reductant use will be implemented.

If necessary, sodium hydroxide may be used during the groundwater treatment phase to return the groundwater to baseline pH levels. This will assist in immobilizing certain parameters such as trace metals.

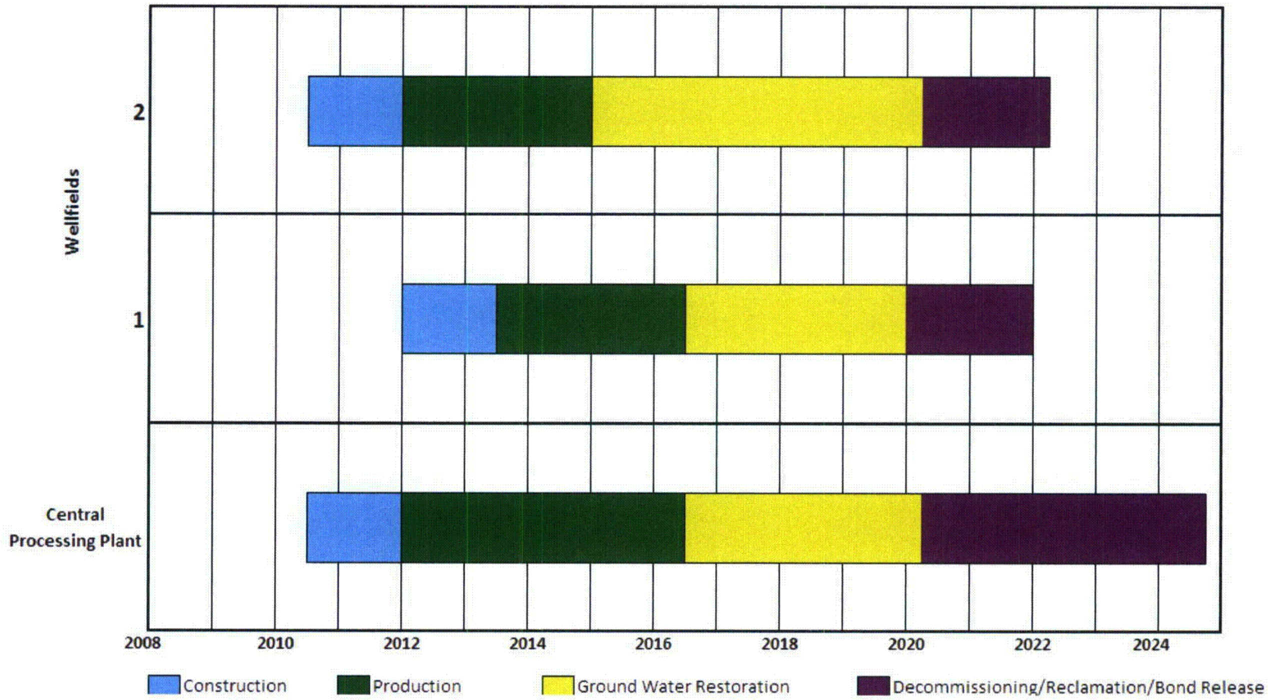
The number of pore volumes treated and re-injected during the groundwater treatment phase will depend on the efficiency of the RO in removing Total Dissolved Solids (TDS) and the success of the reductant in lowering the uranium and trace element concentrations. Estimates of the number of pore volumes required for each restoration phase are discussed in Section 6.6 of the Technical Report.

5.4.2.2.3 Restoration Schedule

The proposed Moore Ranch mine schedule is shown in Figure 5.4-1 showing the estimated schedule for restoration. The restoration schedule is preliminary based on EMC's current knowledge of the area and are based the completion of mining activities for the two wellfields. As the Moore Ranch Project is developed, the restoration schedule will be defined further.

Numerical modeling results indicate that it will take longer than 2.5 years to complete restoration, because of the limited saturated thickness of the aquifer and the need to balance drawdown between the two wellfields during concurrent production and restoration phases. Assuming 6 pore volumes of groundwater is required to reach restoration goals, modeling estimates indicate it will take approximately 3.75 years to restore Wellfield 1 and 5.5 years to restore Wellfield 2 included limited Groundwater sweep. Note that Wellfield 2 now includes what was previously Wellfields 2 and 3 in the License Application. This results in a larger pore volume calculation than would be the case if the wellfields were considered separately. Results of the simulation and full description of the model development and model simulations is provided in the Appendix A4 report "Numerical Modeling of Groundwater Conditions Related to Insitu Recovery at the Moore Ranch Uranium Project, Wyoming" (Petrotek 2008b).

Figure 5.4-1 Proposed Moore Ranch Operations and Restoration Schedule



5.4.2.2.4 Effectiveness of Ground Water Restoration Techniques

The groundwater restoration methods described in this application have been successfully applied at other uranium ISR facilities in the Powder River Basin as well as in Nebraska and Texas. A number of uranium ISR mines in Wyoming, Nebraska, and Texas have successfully restored groundwater and obtained regulatory approval of restoration using these techniques. The following two ISR facilities are located in the Powder River Basin near the proposed Moore Ranch Project.

- Smith Ranch/Highland Uranium Project

Groundwater restoration activities at the Smith Ranch-Highland Uranium Project currently operated by Power Resources, Inc. (PRI) have been approved by the NRC and the WDEQ for the R&D operations and for the A-Wellfield during commercial operations. In 1987, the NRC confirmed successful restoration of the Q-sand project. Although one well exhibited uranium and nitrate levels above the target restoration values, the wellfield averages on a whole were below the targets.

In 2004, the NRC concurred with the WDEQ's determination that the A-wellfield at Highland had been restored in accordance with the applicable regulatory requirements. Not all of the parameters were returned to baseline conditions, but the groundwater quality was consistent with the pre-mining class of use.

- Irigaray/Christensen Ranch Uranium Project

Groundwater restoration activities at the Irigaray Uranium Project conducted by Cogema Mining, Inc. have been approved by the NRC and the WDEQ for Wellfields 1 through 9 following commercial operations and groundwater restoration. Post-mining water quality in the nine production units was described in Section 4.4. The WDEQ determined that twenty-seven of twenty-nine constituents were restored below the restoration target values. Only bicarbonate and manganese did not meet the baseline range. WDEQ determined that these two constituents met the criteria of pre-mining class of use. Based on this, the WDEQ determined that the groundwater, as a whole, had been returned to its pre-mining class of use and that the post restoration groundwater conditions did not significantly differ from the background water quality.

In 2006, the NRC concurred with the WDEQ's determination that wellfields 1 through 9 at Irigaray had been restored in accordance with the applicable regulatory requirements. NRC determined that Cogema used best practicable technology and agreed that the WDEQ class-of-use standards were met.

Based on the effectiveness of groundwater restoration at other ISR mines in the Powder River Basin, EMC expects that the proposed groundwater restoration techniques will successfully return the mining zone at Moore Ranch to the restoration target values. As discussed in Section 6.1.1, the purpose of restoring the groundwater to these restoration target values is to protect adjacent groundwater that is outside the production zone. If a constituent cannot technically or economically be restored to its restoration target value within the exploited production zone, WDEQ and NRC will require that EMC demonstrate that leaving the constituent at a higher concentration will not be a threat to public health and safety or the environment or produce an unacceptable impact to the use of adjacent groundwater resources. EMC believes that the application of proven best practicable technology for groundwater restoration and the regulatory requirements that are in place at the State and federal level will ensure that there is no adverse impact on the water quality of groundwater outside the production zone.

5.4.2.2.5 Groundwater Restoration Monitoring

Monitoring During Active Restoration

During restoration, lixiviant injection is discontinued and the quality of the groundwater is constantly being improved, thereby greatly diminishing the possibility and relative impact of an excursion. Therefore, the monitor ring wells (M-Wells), overlying aquifer wells (MO or MS-Wells), and underlying aquifer wells (MU or MD-Wells) are sampled once every 60 days and analyzed for the excursion parameters, chloride, total alkalinity and conductivity. Water levels are also obtained at these wells prior to sampling.

In the event that unforeseen conditions (such as snowstorms, flooding, equipment malfunction) occur, the WDEQ will be contacted if any of the wells cannot be monitored within 65 days of the last sampling event.

The mining zone will monitored on a frequent basis adequate enough to determine success of restoration, optimize efficiency of restoration techniques, and determine any areas of the wellfield that need additional attention. Samples will be monitored for all of the parameters shown in Table 5.4-2 at the start of restoration and all or selected parameters through restoration as needed. In the areas where the 70 Sand (mining zone) coalesces with the 68 Sand, the 68 Sand will be monitored as part of the mining zone, during both production and restoration. Monitor wells will be placed in the 68 Sand at the same density as in the mining zone (one well per three acres). In the areas of coalescing 68 and 70 Sands, the 68 Sand monitor wells will be monitored at the same frequency and for the same constituents as the 70 Sand throughout production and restoration.

Table 5.4-2 provides a summary of the proposed restoration groundwater monitoring schedule and analysis.

Table 5.4-2
Restoration Groundwater Monitoring Schedule and Analysis

Restoration Phase	Sample Origin	Frequency	Analytical Parameters
Post Mining	Designated Restoration Wells Ore Zone	Once	WDEQ Guideline 8
	Monitor Wells Ore Zone Monitors Underlying Zone Overlying Zone	Biweekly	Excursion Parameters
Restoration	Recovery Stream Composite	Weekly	HCO_3/CO_3, SO_4, Cl, Conductivity, pH, Uranium
		As Needed	Add Na, Ca, TDS, etc.
		End of each pore volume displacement	WDEQ Guideline 8
	Designated Restoration Wells Ore Zone	End of each restoration phase	WDEQ Guideline 8
	Monitor Wells Ore Zone Monitors Underlying Zone Overlying Zone	Every 60 days	Excursion Parameters
Post-Restoration Stability	Designated Restoration Wells Ore Zone	Beginning, Middle and End	WDEQ Guideline 8
	Monitor Wells Ore Zone Monitors Underlying Zone Overlying Zone	Every 60 days	Excursion Parameters

Restoration Stability Monitoring

A minimum twelve month groundwater stability monitoring period as shown in Table 5.4.2 will be implemented to show that the restoration goal has been adequately maintained. The following restoration stability monitoring program will be performed during the stability period:

- The monitor ring wells will be sampled once every 60 days and analyzed for the excursion parameters (chloride, total alkalinity (or bicarbonate) and conductivity); and
- At the beginning, middle and end of the stability period, the MP-Wells will be sampled and analyzed for the parameters in Table 5.4-1.

In the event that unforeseen conditions (such as snowstorms, flooding, equipment malfunction) occur, the WDEQ will be contacted if any of the M-Wells or MP-Wells cannot be monitored within 65 days of the last sampling event.

Table 5.4-2 provides a summary of the proposed restoration stability monitoring schedule and analysis.

A minimum six month stability monitoring period is specified in WDEQ-LQD Guideline 4. The criteria to establish restoration stability will be based on wellfield averages for water quality. A determination of aquifer stability should be made based upon the "trends" in the data; i.e., a stable aquifer should not exhibit rapid upward or downward trends or be oscillating back and forth over a wide range of values. The data is evaluated against baseline quality and variability to determine if the restoration goal is met and if the water is restored at a minimum to within the class of use. If increasing trends are confirmed during the stability period for all or part of a wellfield, then an evaluation of the potential cause of the increasing trends will be conducted and corrective actions will be taken, including continued restoration using Best Practical Technology if needed.

5.4.2.2.6 Restoration Wastewater Disposal

EMC plans to install deep disposal wells (EPA UIC Class I non-hazardous wells) at the Moore Ranch Uranium Project as the primary liquid waste disposal method. EMC believes that permanent deep disposal is preferable to evaporation in evaporation ponds. Disposal in a Class I well permanently isolates the waste water from the public and the environment. Alternatives assessed by EMC for waste water disposal are discussed in Section 2.

Based on the expected post mining concentrations of groundwater quality constituents discussed in Section 4.4.3 and the proposed groundwater restoration techniques discussed in Section 5.4.2.2.2, EMC projects that the restoration injection stream will exhibit the range of characteristics shown in Table 5.4-3.

Table 5.4-3 Projected Moore Ranch Restoration Injection Stream Water Quality

Parameter	Units	Min	Max
Calcium	mg/l	350	700
Magnesium	mg/l	50	150
Sodium	mg/l	400	950
Potassium	mg/l	40	90
Carbonate	mg/l	0	0.3
Bicarbonate	mg/l	200	1250
Sulfate	mg/l	900	2500
Chloride	mg/l	300	1000
Nitrate	mg/l	0.01	0.5
Fluoride	mg/l	0.01	2
Silica	mg/l	10	65
Total Dissolved Solids	mg/l	1000	6500
Conductivity	µmho/cm	1000	5500
Alkalinity	mg/l	165	1025
pH	Std. Units	6	12
Arsenic	mg/l	0.01	1
Cadmium	mg/l	0.0001	0.001
Iron	mg/l	0.5	15
Lead	mg/l	0.01	0.04
Manganese	mg/l	0.01	1.5
Mercury	mg/l	0.0001	0.001
Molybdenum	mg/l	0.1	1.5
Selenium	mg/l	0.01	0.5
Uranium	mg/l	0.05	15
Ammonia	mg/l	0.1	0.5
Radium-226	pCi/l	500	5000

All compatible liquid wastes generated during groundwater restoration at Moore Ranch will be disposed in the planned deep wells. An application for a Class I UIC Permit for the Moore Ranch Project is currently under review by the WDEQ.

5.4.2.3 Potential Groundwater Impacts from Accidents

5.4.2.3.1 Lixiviant Excursions

EMC will control the lateral movement of lixiviant by maintaining well field production flow at a rate slightly greater than the injection flow. This difference between production and injection flow is referred to as process bleed. The bleed solution will either be recycled in the plant or sent to the liquid waste disposal system. When process bleed is properly distributed among the many mining patterns within the Mine Unit, mining solutions are contained within the monitor well ring.

EMC will monitor for lateral movement of lixiviant using a horizontal excursion monitoring system. This system consists of a ring of monitor wells completed in the same aquifer and zone as the injection and production wells. Monitor wells will be installed as discussed in Section 6. Monitor wells will be sampled at least twice monthly and at least 10 days apart for approved excursion indicators.

The historical experience at other ISR uranium operations indicates that the selected indicator parameters and UCLs allow detection of horizontal excursions early enough that corrective action can be taken before water quality outside the exempted aquifer boundary is significantly degraded. As noted in NUREG/CR-6733, significant risk from a horizontal excursion would occur only if it persisted for a long period without being detected.

EMC will prevent vertical excursions through aquifer testing programs and rigorous well construction, abandonment, and testing requirements. Aquifer testing is conducted before mining wells are installed to detect any leaks in the confining layers. Aquifer test reports are submitted to the WDEQ for review and approval before well construction activities may proceed. Well construction and integrity testing will be conducted in accordance with WDEQ regulations and methods approved by NRC and WDEQ. Construction and integrity testing methods were discussed in detail in Section 1. Well abandonment is conducted in accordance with methods approved and monitored by the WDEQ and discussed in detail in Section 5.1.1.

EMC will monitor for vertical excursions in the overlying aquifer using shallow monitor wells. These wells will be located within the wellfield boundary at a density of one well per four acres. Shallow monitor wells will be sampled biweekly for approved excursion indicators.

5.4.2.3.2 Wellfield Spills

All piping from the plant, to and within the wellfield will be buried for frost protection. Pipelines will be constructed of high density polyethylene (HDPE) with butt welded joints, or equivalent. All pipelines will be pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each Mine Unit will have a number of header houses where injection and production wells will be continuously monitored for pressure and flow. Individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the control room via the computer system. In addition, each wellfield building will have a "wet building" alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective in detection of significant piping failures (e.g., failed fusion weld).

Occasionally, small leaks at pipe joints and fittings in the wellhouses or at the wellheads may occur. Until remedied, these leaks may drip process solutions onto the underlying soil. EMC will implement a program of continuous wellfield monitoring by roving wellfield operators and will require periodic inspections of each well that is in service. Small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination. Following repair of a leak, EMC will require that the affected soil be surveyed for contamination and the area of the spill documented. If contamination is detected, the soil is sampled and analyzed for the appropriate radionuclides. Contamination may be removed as appropriate.

5.5 MITIGATION MEASURES FOR ECOLOGICAL RESOURCES IMPACTS

5.5.1 Vegetation

The presence of two State-designated weeds, Canada thistle and field bindweed, was observed in the Moore Ranch area during the baseline surveys along with other undesired annual grass species such as cheat grass brome. EMC will conduct weed control as needed to limit the spread of undesirable and invasive, non-native species on disturbed areas.

Mitigation of vegetation impacts will consist of temporary and permanent surface revegetation of disturbed areas. Revegetation practices will be conducted in accordance with WDEQ-LQD regulations and the mine permit. Disturbed areas will be seeded to establish a vegetative cover to minimize wind and water erosion and the invasion of undesired plant species. A long term temporary seed mix may be used in wellfield and other areas where the vegetation will be disturbed again prior to final decommissioning and final revegetation. This long term seed mix typically consists of one or more of the native wheat grasses (e.g., Western Wheatgrass and Thickspike Wheatgrass). Permanent seeding is accomplished with a seed mix approved by the WDEQ-LQD. The permanent mix typically contains native wheat grasses, fescues, and clovers. Wellfield areas may be fenced as necessary to prevent livestock access, which will enhance the establishment of temporary vegetation.

5.5.2 Wildlife and Fisheries

The likelihood for the impacts resulting in injury or mortality for wildlife is greatest during the construction phase due to increased levels of traffic and physical disturbance during that period. Traffic will persist during production, but should occur at a reduced, and possibly more predictable level. Speed limits will be enforced during all construction and maintenance operations to reduce impacts to wildlife throughout the year, but particularly during the breeding season.

During the construction and operation phases of the project, open mud pits used for well drilling and maintenance activities could pose a hazard to wildlife. This potential impact will be mitigated by the use of temporary fencing around all open mud pits to protect wildlife from this hazard.

5.5.3 Birds

Enforced speed limits during all phases of the Moore Ranch Project would reduce impacts to wildlife throughout the year, particularly during the breeding season.

5.5.4 Raptors

Wildlife studies on the Moore Ranch Project will include annual raptor surveys. It is not anticipated that mining related activities will adversely affect a raptor nest, or disturb a nesting raptor as there is a lack of nesting raptors on and near the plant and wellfield areas due to the lack of trees and other nesting sites. Additionally, mining related activities are limited to relatively small areas for limited periods of time. According to surveys summarized in Section 3, eight raptor nests were observed within the proposed

Moore Ranch License Area including 5 ferruginous hawks, 2 great horned owls, and one red-tailed hawk. Seventy five other nests were observed within one mile of the license area.

In accordance with WDEQ-LQD requirements, a raptor nest survey is conducted in late April or early May each year to identify any new nests and assess whether known nests are being utilized. The survey covers all areas of planned activity for the life of mine (i.e., wellfields and central plant facility) and a one mile area around the activity. Status and production at known nests will be determined, if possible. This survey program is primarily intended to protect against unforeseen conditions such as the construction of a new nest in an area where operations may take place.

No raptor nests were observed within one-half-mile of the proposed central plant facilities in the 2007 survey. As a result, it is very unlikely that any raptor nests will be disturbed in the future. In the very unlikely event that it is necessary to disturb a raptor nest, a mitigation plan and appropriate permit will be acquired from the U.S. Fish and Wildlife Service, Wyoming Field Office, in Cheyenne, Wyoming.

Overhead power lines can present an electrocution hazard to raptors. In order to mitigate this hazard, all new power lines will be constructed using designs that meet or exceed current APLIC (2006) recommendations, thus minimizing any risks of electrocution on those structures. Those designs include, but are not limited to:

- a minimum of 60 inches between parallel phase lines (energized wires) achieved using 10-foot cross arms or by lowering the cross arm to increase spacing from the center wire
- the use of perch deterrents where 60-inch spacing cannot be achieved and between lightening arrestors or other hardware that might result in electrocution;
- covered/insulated jumper lines;
- covered ground wires;
- bushing covers on transformers;
- insulation on other energized hardware on transformers, cross arms, etc.; and
- other appropriate equipment, as needed to minimize impacts to perched raptors.

5.5.5 Threatened and Endangered Species

5.5.5.1 Bald Eagle

As noted in Section 4.5, bald eagles have not been documented in the project area and impacts of the proposed action would be limited to occasional foraging individuals rather than a large segment of the population. If necessary, the majority of direct impacts could be mitigated if construction activities were conducted outside the winter and early spring months, or outside the daily roosting period, should eagles be present during construction. Any bald eagles that might roost or nest in the area once the mine is operational would be doing so in spite of continuous and on-going human disturbance, indicating a tolerance for such activities.

5.5.6 Waterfowl and Shorebirds

Construction and operation of the Moore Ranch Project would have a negligible effect on migrating and breeding waterfowl and shorebirds. Habitat disturbance in drainages or other potential water sources would be reclaimed once productive operations have ceased. Replacement of any impacted jurisdictional wetlands would be required in accordance with Section 404 of the Clean Water Act.

5.6 MITIGATION MEASURES FOR AIR QUALITY IMPACTS

Air quality impacts are primarily related to fugitive dust from construction activities and vehicular traffic. As discussed in Section 4.6, these impacts are negligible. Enforcement of site speed limits and the application of water to unpaved roads would reduce the amount of fugitive dust to levels equal to or less than the existing condition.

5.7 MITIGATION MEASURES FOR NOISE IMPACTS

As a result of the remote location of the project and the low population density of the surrounding area, impact to noise or congestion within the project area or in the surrounding 2.0-mile area are not anticipated. Noise impacts will be mitigated through enforcement of site speed limits.

5.8 MITIGATION MEASURES FOR HISTORIC AND CULTURAL RESOURCES IMPACTS

None of the sites eligible for nomination are located within areas currently planned for in situ development, and in fact, are located well over a mile away from any planned development. If exploration and development plans are subsequently expanded near those areas, then all associated ground-disturbing activities will avoid impacting sites 48CA6694 and 48CA6696. If avoidance is not feasible, then a testing/data recovery plan will need to be implemented and completed prior to commencement of any ground disturbing activities to mitigate the adverse affects to the eligible sites.

5.9 MITIGATION MEASURES FOR VISUAL/SCENIC RESOURCES IMPACTS

As discussed in Section 4.9, if the visual resource evaluation rating of a proposed project area is 19 or less, no further evaluation is required by NUREG-1569. Based on field reconnaissance conducted in May 2007, the total score of the scenic quality inventory for the Moore Ranch License Area is 4; therefore, no further evaluation of existing scenic resources and any changes to scenic resources from proposed project facilities are required. However, EMC intends to implement mitigative measures to lessen the visual impact of the project.

Mitigation measures are meant to minimize adverse contrasts of project facilities with the existing landscape. One method to minimize these contrasts is the selection of paint colors for structures that harmonize with the surrounding landscape. To the extent possible, topographic features may be used to screen wellheads, plant facilities, and roads. Roads may be aligned with the contours of the topography, although this measure may result in a greater area of disturbance. Construction debris will be removed from new construction areas as soon as possible.

5.10 MITIGATION MEASURES FOR SOCIOECONOMIC IMPACTS

As discussed in Section 4.10, it is anticipated that the overall effect of the proposed Moore Ranch Project on the local and regional economy would be beneficial. Purchases of goods and services by the mine and mine employees would contribute directly to the economy. Local, state, and the federal governments would benefit from taxes paid by the mine and its employees. Indirect impacts, resulting from the circulation and recirculation of direct payments through the economy, would also be beneficial. Assuming that the entire projected work force of 40 to 60 workers relocated to the area, this increase would account for 0.1 percent of the population of Campbell and Natrona Counties, and is smaller than the projected annual growth rate. Therefore, there would be little to no effect to the vacancy rates of any type of housing in Gillette area or Campbell County. Families moving into the Natrona and Campbell County school districts would not stress the current school system because it is presently under capacity.

No mitigative measures are identified.

5.11 MITIGATION MEASURES FOR ENVIRONMENTAL JUSTICE

Section 4.11 determined that there would be no disproportionate environmental impacts to minority populations or populations living below the poverty level from the proposed project activities. No mitigative measures are identified.

5.12 MITIGATION MEASURES FOR PUBLIC AND OCCUPATIONAL HEALTH IMPACTS

5.12.1 Nonradiological Impacts

EMC will develop emergency management procedures to implement the nonradiological risk control recommendations contained in NUREG/CR-6733 analyses. Training programs will be developed to ensure that EMC personnel are adequately trained to respond to all potential emergencies. These training programs were discussed in detail in the Technical Report for this License Application.

5.12.1.1 Fires and Explosions

The fire and explosion hazard of the CPP will be minimal as the plant does not use flammable liquids in the recovery process and building and equipment materials are largely made up of non-flammable materials such as steel or concrete. Natural gas or propane used for building heat would be the primary source for a potential fire or explosion. In the CPP the uranium will be in solution, adsorbed on ion exchange resin, wet yellowcake slurry, or as a dried yellowcake powder contained in a sealed drum or the vacuum dryer. An explosion, therefore, would not appreciably disperse the uranium to the environment.

In the wellfields, injection and recovery well piping systems are installed with manifolds for ease of operational control. Piping manifolds, submersible pump motor starters/controllers, and gaseous oxygen delivery systems are situated within electrically heated, all weather buildings. These are commonly referred to as “Headerhouses”. An accumulation of gaseous oxygen would be the primary source for a potential fire or explosion. Such an event could result in the rupture of a leaching solution pipeline within the building and a spill of leaching solution.

Fire Prevention

Prevention methods utilized to minimize potential impacts to human health and the environment from fire or explosion scenarios discussed above include the following:

- Spilled liquids or slurries would be confined to the building sump or to the runoff control system.
- The sealed drums and vacuum dryer at Moore Ranch would contain the dried yellowcake powder, and any potential releases would be contained within the Dryer Building.
- Both the gaseous oxygen and primary leaching solution lines entering each headerhouse are equipped with automatic low pressure shut off valves to minimize the delivery of oxygen to a fire or of liquids to a spill.
- Additionally, each Headerhouse is equipped with a continuously operating exhaust fan that would assist in preventing the build-up of oxygen in the building.
- Procedures will be in place for confined space work or hot work for monitoring of oxygen build-up prior to start of work.

Mitigation/Emergency Response

Automatic detection and alarm systems along with sprinkler systems will be installed in the central plant and other facilities at the Moore Ranch Project. Fire extinguishers will be placed at accessible locations in all buildings and vehicles for quick response and training will be provided for appropriate personnel in use of fire extinguishers. EMC personnel will receive training for responding to a fire or explosion. The emergency response plan will include descriptions of the following provisions:

- Notification and evacuation procedures
- Personal protective equipment
- General fire fighting safety rules
- Reporting procedures
- Electrical and gas emergencies

5.12.2 Radiological Impacts

5.12.2.1 Radiological Impacts from Routine Operations

As discussed in Section 4.12.2, the maximum Total Effective Dose Equivalent (TEDE) estimated by MILDOS-AREA is 0.8 mrem/yr. to a receptor located at the northwest property boundary. This dose is 0.8 percent of the public annual dose limit from licensed operations of 100 mrem.

The dose estimates developed by MILDOS-AREA are based on the central plant system design, which includes pressurized downflow ion exchange columns to reduce the release of radon-222 to a minimum and the use of vacuum dryers, which have no airborne radioactive emissions. The EMC design applies state-of-the-art ISR technology to reduce radiological doses to the public and employees to a minimum.

A separate ventilation system will be installed for all indoor non-sealed process tanks and vessels where radon-222 or process fumes would be expected. The system will consist of an air duct or piping system connected to the top of each of the process tanks. Redundant exhaust fans will direct collected gases to discharge piping that will exhaust fumes to the outside atmosphere. The design of the fans will be such that the system will be capable of limiting employee exposures with the failure of any single fan. Discharge stacks will be located on the leeward side of the building and ventilation intakes will be on the upwind side of the building to ensure exhausted radon is not taken back into the facility from prevailing winds as recommended in Regulatory Guide 8.31. Airflow through any openings in the vessels will be from the process area into the vessel and into the ventilation system, controlling any releases that occur inside the vessel. Separate ventilation systems may be used as needed for the functional areas within the plant. Tank ventilation systems of this type have been successfully utilized at other ISR facilities and have proven to be an effective method for minimizing employee exposure.

The work area ventilation system will be designed to force air to circulate within the plant process areas. The ventilation system will exhaust outside the building, drawing fresh air in. The work area ventilation system will consist of four fans with a capacity 10,000 cfm each. Two fans will be located in the ion exchange area, one fan will be located in the resin transfer area, and one fan will be located in the precipitation area. The air exchange rate of the four fans is approximately 1.25 air exchanges per hour. During favorable weather conditions, open doorways and convection vents in the roof will provide satisfactory work area ventilation. During extreme cold outdoor temperatures, the ventilation system will provide adequate work area ventilation if doorways need to be shut. Buildings will be heated during winter months to maintain temperatures in the plant area. The design of the ventilation system will be adequate to ensure that radon daughter concentrations in the facility are maintained below 25 percent of the derived air concentration (DAC) from 10 CFR Part 20.

Yellowcake processing and drying will be carried out using a vacuum dryer with a wet condenser system, thus there are no airborne effluents from this system. The vacuum drying system is proven technology that is being used successfully in several ISR sites where uranium oxide is being produced. Air particulate controls of the vacuum drying system include a bag house, condenser, vacuum pump, and packaging hood.

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

The condenser unit is located downstream of the bag house and is water cooled. It is used to remove the water vapor from the non-condensable gases coming from the drying chamber. The gases are moved through the condenser by the vacuum system. Any particulates that pass through the bag filters are wetted and entrained in the condensing moisture within this unit.

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

The packaging system is operated on a batch basis. When the yellowcake is dried sufficiently, it is discharged from the drying chamber through a bottom port into drums. A level gauge, a weigh scale, or other suitable device will be used to determine when a drum is full. Particulate capture is provided by a sealed hood that fits on the top of the drum, which is vented through a sock filter to the condenser and the vacuum pump system when the powder is being transferred.

The system will be instrumented sufficiently to operate automatically and to shut itself down for malfunctions such as heating or vacuum system failures. The system will alarm if there is an indication that the emission control system is not performing within operational specifications. If the system is alarmed due to the emission control system, the operator will follow standard operating procedures to recover from the alarm condition, and the dryer will not be unloaded as part of routine operations, if currently loaded, or reloaded, if currently empty, until the emission control system is returned to service within specified operational conditions.

To ensure that the emission control system is performing within specified operating conditions, instrumentation will be installed that signal an audible alarm if the air pressure (i.e. vacuum level) falls below specified levels, and the operation of this system is checked and documented during dryer operations. In the event this system fails, the operator will perform and document checks of the differential pressure or vacuum every four (4) hours. Additionally, during routine operations, the air pressure differential gauges for other emission control equipment is observed and documented at least once per shift during dryer operations.

No other mitigation measures to control radiological impacts from routine operations have been identified.

5.12.2.2 Radiological Impacts from Accidents

The Moore Ranch Central Plant will be designed in accordance with standard industry building codes and will incorporate containment adequate to contain the contents of the largest tank in the facility at a minimum. The central 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 system will direct any spilled solutions back into the plant process circuit or to the waste disposal system. Bermed areas, tank containments, and/or double-walled tanks will perform a similar function for any process chemical vessels located outside the central plant building.

As discussed in Section 2, area ventilation will be provided to control concentrations of airborne radioactive material in the central plant.

All piping from the plant, to and within the wellfield will be buried for frost protection. Pipelines will be constructed of high density polyethylene (HDPE) with butt welded joints, or equivalent. All pipelines will be pressure tested at operating pressures prior to final burial and production flow and following maintenance activities that may affect the integrity of the system.

Each wellfield will have a number of headerhouses where injection and production wells will be continuously monitored for pressure and flow. Individual wells may have high and low flow alarm limits set. All monitored parameters and alarms will be observed in the control room via the computer system. In addition, each wellfield building will have a "wet building" alarm to detect the presence of any liquids in the building sump. High and low flow alarms have been proven effective in detection of significant piping failures (e.g., failed fusion weld). EMC will implement a program of continuous wellfield monitoring by roving wellfield operators and will require periodic inspections of each well that is in service.

EMC will prepare spill response procedures, provide spill response equipment and materials, require the use of protective equipment, and will train employees in proper spill response methods. A detailed discussion of these radiological protection measures is contained in Section 5.0 of the License Application Technical Report (TR). These measures include the following:

- Radiation Safety Training including training on emergency procedures (TR Section 5.5);
- Spill contingency plans (TR Section 5.7.1.3);
- Airborne uranium particulate monitoring (TR Section 5.7.3.1);
- Respiratory protection program (TR Section 5.7.3.3);and
- Bioassay program (5.7.5).

5.13 MITIGATION MEASURES FOR WASTE MANAGEMENT IMPACTS

This section describes mitigation measures for the waste management impacts from the Moore Ranch Project. The estimated waste streams and management programs were described in section 4.13.

5.13.1 Gaseous and Airborne Particulates

The radiological effluents of concern at ISR operations include the release or potential release of radon gas (radon-222), radionuclides in liquid process streams, and dried yellowcake.

Section 5.12.2 discussed the mitigation measures included in the EMC design to control gaseous and airborne impacts.

5.13.2 Liquid Waste

EMC expects that the liquid waste stream generated at the Moore Ranch Facility will be chemically and radiologically similar to the waste disposed in the current disposal wells in operation at existing ISR sites in the Powder River Basin. EMC has submitted an application to the WDEQ for the Class I UIC Permits necessary to construct and operate the disposal wells. In response to a request by the WDEQ, EMC has included a plan to drill and test the Teckla, Teapot, and Parkman (TTP) interval as a potential injection zone. Hence, the revised application includes two Volumes as follows:

Class I UIC Application: Lance Formation and Fox Hills Sandstone – Volume 1
Class I UIC Application: Teckla, Teapot and Parkman Formations – Volume 2

The Teapot-Teckla-Parkman interval is at depths of 7,916 ft to 9,610 ft (based on logs from the Sun Oil No. 1 Ross API No. 522824 located in T41N R75W, Section 3, NE ¼). Based on available data, the hydrologic properties of this interval would allow injection rates on the order of 30 gpm per well. Based on projected maximum production rates during ISR operations, four injection wells may be required to provide sufficient capacity during maximum periods of injection.

The Lance Formation is at depths of 3,700 to 7,500. The Lance interval has much greater injection capacity than the Teapot-Teckla-Parkman interval, based on regional information. Lance wells are expected to allow injection rates of 125 gpm. If this interval provides a suitable injection interval for permitting, only two wells would be necessary to meet the capacities for the project.

The proposed location of the four Tekla, Teapot, and Parkman wells and the two Lance wells is shown on Figure 3.1-4A and Figure 3.1-4B. As shown in Figure 3.1-5, anticipated disposal during operations is approximately 50.4 gpm and during restoration could be as high as 90 gpm.

EMC believes that permanent deep disposal is preferable to evaporation in evaporation ponds or land application methods for the following reasons: (1) Liquid waste disposed of through deep wells is secluded from human contact eliminating risk to human health; (2) large evaporation ponds have the potential for leaks and impacts to the environment and much larger volume of 11(e)(2) byproduct is created through use of evaporation ponds; (3) land application methods have the potential to impact surface media from prolonged discharge and would require extensive treatment to meet land application standards. Further discussion of the liquid waste disposal alternatives considered by EMC is contained in Section 2 of this Environmental Report.

All compatible liquid wastes at the Moore Ranch Facility will be disposed in the planned deep wells. The application for the proposed deep disposal wells at Moore Ranch was submitted to the WDEQ-WQD on May 12, 2008. A revised application based on WDEQ direction was submitted on August 17, 2009 and is currently under review.

5.13.2.1 Liquid Waste Monitoring and Reporting

A composite sample of the waste stream will be collected quarterly, or when process change occurs that could significantly alter the chemical composition of the waste stream. Samples will be collected upstream of the high-pressure injection pump. Analyses will be performed using approved methods and in accordance with WDEQ Rules and Regulations, Chapter VIII, Section 7. The proposed parameter list follows:

Ra-226 (pCi/l)
Uranium (mg/l)
TDS (mg/l)
PH (units)
Total Alkalinity (mg/l)

It is understood that WDEQ recently has been requesting an EPA 624 Analysis for the waste stream. If this standard should be required by the WDEQ, EMC will comply.

Monitoring records will be submitted to WDEQ quarterly (within 30 days after the end of the quarter) and will include:

1) Date, location and time of sampling
2) Name(s) of sampling personnel
3) Date(s) of analysis
4) Analytical laboratory and name(s) of analytical technician(s)
5) Analytical procedures or methods used
6). Analytical results

Reporting will include injection and annulus pressures. Further, the average reservoir pressure will be determined once per year by conducting a pressure falloff test on one of the EMC wells.

5.13.2.2 Disposal Well Mechanical Integrity

After completion of deep disposal well construction, Part I mechanical integrity will be demonstrated for each well before injection commences, in accordance with the procedures specified by WDEQ.

Part II integrity will be demonstrated prior to injection by either (1) a Radioactive Tracer Log and Temperature Survey coupled with a casing pressure check, or (2) an oxygen activation log. Part II MIT will also be demonstrated (1) if any abnormal annulus pressures are observed, (2) every five years at a minimum, and (3) any time the tubing and packer are removed from the well.

5.13.2.3 Potential Pollution Events Involving Liquid Waste

Although there are a number of potential sources of pollution present at the Moore Ranch facility, existing regulatory requirements from the NRC and WDEQ, and provisions of EMC's environmental management procedures will establish a framework that significantly reduces the possibility of an occurrence. Extensive training of all personnel is standard policy for EMC operations and will be implemented at the Moore Ranch Facility. Frequent inspections of waste management facilities and systems will be conducted. Detailed procedures will be prepared by EMC.

Potential sources of pollution include the following:

5.13.2.3.1 Spills from Wellfield Buildings, Pipelines, and Well Heads

Wellfield buildings or pipelines are not considered to be a potential source of pollutants during normal operations, as there will be no process chemicals or effluents stored within them. The only instance in which these wellfield features could contribute to pollution would be in the event of a release of injection or recovery solutions due to pipe or well failure. The possibility of such an occurrence is considered to be minimal as the piping will be leak checked first. In addition, the flows through the pipe will be at a relatively low pressure and can quickly be stopped, thus any release would not migrate far. Wellfield headerhouses will also be equipped with wet alarms for early detection of leaks. Piping from the wellfields will generally be 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. All piping will be leak checked prior to operation.

In general, piping from the plant, to and within the wellfield will be constructed of PVC or high density polyethylene pipe (HDPE) with butt welded joints or the equivalent. All pipelines will be pressure tested before 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 will be protected from a major cause of potential failure which is vehicles driving over the lines causing breaks. Typically, the only exposed pipes will be at the central plant, at the wellheads, and in the headerhouses in the wellfield. Trunkline flows and manifold pressures will be monitored for process control.

Engineering and administrative controls will be 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.

Should a leak in the wellfield buildings, pipelines, or at wellheads occur, the primary health and safety hazards presented by the spilled mining solutions would be ingestion or inhalation of the spilled liquid or dried residue, direct gamma exposure, and release of radon gas. These hazards would primarily apply to EMC personnel responding to the spill. Section 5 of the Technical Report discusses in detail the administrative controls that will be implemented by EMC to maintain radiological exposures as low as reasonably achievable, including employee training and the use of standard operating procedures (SOPs) or radiation work permits (RWPs). All employees will receive training in the proper response to solution spills during radiation worker training. SOPs and/or RWPs will specify worker monitoring and protective equipment requirements for spill response.

Spilled mining solutions will contain elevated concentrations of uranium, radium-226, and trace metals. Although these concentrations are not high enough to present a significant health and safety risk when absorbed in soil, they could present an increased hazard in areas where spilled solutions may pond or build up over time. All cleanup of spilled material will be performed with proper protective equipment. If soil cleanup of a spill area is necessary due to the exceedance of the soil concentration limits in 10 CFR Part 40, Appendix A, engineering controls will be used to minimize the generation of dust. Direct gamma radiation exposure is not expected to be a significant hazard from solution spills due to the low concentrations of gamma-emitting radionuclides in the mining solution. Radon may be a hazard in enclosed spaces (e.g., within a headerhouse) but this hazard can be controlled through the use of ventilation.

5.13.2.3.2 Spills from the Central Plant

The Central Plant will serve as a central hub for the mining operations in the Moore Ranch Project. Therefore, the Central Plant area will have the greatest potential for spills or accidents resulting in the release of potential pollutants. Spills could result from a release of process chemicals from bulk storage tanks, piping failure, or a process storage tank failure.

The design of the central plant building will be such that any release of liquid waste would be contained within the structure. A concrete curb will be built around the entire process building. This pad will be 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 will immediately shut down, limiting any release. Liquid inside the building, both from a spill or from washdown water, will be drained through a sump and pumped to the liquid waste system.

The potential health and safety hazards from spills within the Central Plant are similar to those discussed in Section 5.13.2.3.1 above. The Central Plant will be equipped to handle liquid spills. The building will include sumps that will recover spilled solutions and direct them to the wastewater system. Building ventilation will control the radon released by spilled solutions.

5.13.2.4 Spills from Deep Well Pumphouses, Lines, and Wellheads

The design of the deep well pumphouses and wellheads will be such that any release of liquids will be contained within the building or in a bermed containment area surrounding the facilities. Liquid inside the building will be contained and managed as appropriate.

The wells will be equipped with a high-level shutoff switch on the injection tubing to prevent operation of the pumps at pressures greater than the Limiting Surface Injection Pressure. In addition, the wells will be equipped with a low-pressure shut-down switch on the surface injection line that will deactivate the injection pump in the event of a surface leak. Finally, the wells will include a high/low pressure shutdown switch with a pressure sensor on the tubing/casing annulus. This switch will stop the injection pump in the event of either (1) a tubing leak or (2) a casing, packer, or wellhead leak.

The potential health and safety hazards from spills within the deep well pumphouses and at the wellheads are similar to those discussed in section 5.13.2.3.2 above.

5.13.2.5 Soil Contaminated as a Result of Releases

Leaks may drip process solutions onto the underlying soil. Surface and subsurface soil at a solution mine may become contaminated by leaks and spills of process solutions. Although the specific concentration of radionuclides in these process solutions is relatively low, the concentration of contamination in the soil may exceed regulatory limits if the solution is confined to a small area or if there are multiple spills in the same location. EMC will implement a program of continuous wellfield monitoring by roving wellfield operators and will require periodic (at a minimum of daily) inspections of each wellfield that is in service or in restoration. Small leaks in wellfield piping typically occur in the injection system due to the higher system pressures. These leaks seldom result in soil contamination above cleanup standards. Following repair of a leak, EMC will require that the affected soil be surveyed for contamination and the area of the spill documented as required by the NRC. The soils potentially impacted by a spill of injection or production fluid are typically sampled and scanned for gamma radiation. The surface extent of any spill will be delineated horizontally by use of a field GPS system. If contamination is detected by gamma surveys, the soil will be sampled and analyzed for the appropriate radionuclides. Contamination may be removed immediately if concentrations exceed regulatory requirements or left in place and documented for future clean up (if necessary) during the decommissioning phase of site closure.

In the event of a minor spill where the amount of fluid is limited with minimal chance of significant infiltration of the fluid, samples may be obtained at only the 0-6 inch depth. In the case of significant pooling of fluid, soil samples may be necessary at the 0-6 inch and 6-12 inch intervals. The first steps after a release is discovered will be to immediately stop the source of the leak and limit the horizontal migration of released fluid then initiate the process of recovering any free standing fluids.

The cleanup of surface and subsurface soils is governed by the limits in 10 CFR Part 40, Appendix A. Those limits for the concentration of Ra-226 in soil are 5 pCi/gm above background for the first 15 cm surface layer, averaged over not more than 100 m^2 and 15 pCi/gm above background for each successive 15 cm subsurface layer, averaged over not more than 100 m^2. Soil clean up and survey methods will be designed to meet current requirements of the USNRC and will be described in the Decommissioning Plan required by NRC License Condition.

All site release information and survey results will be maintained as a component of the decommissioning records as required by 10 CFR §20.2103. Documentation of annual releases from the site will be provided with a Map to the WDEQ-LQD in the annual Mine Permit report.

5.13.2.6 Spill Reporting Procedures

The WDEQ-LQD will be verbally notified (per telephone or email) within 24 hours of discovery of a spill of ISR process fluids exceeding 420 gallons. A written report will be provided to the WDEQ-LQD within 5 days of discovery containing the information described in WDEQ-LQD Rules and Regulations, Chapter 11, Section 12(a)(B)(ii).

The NRC will be verbally notified (per telephone or email) within 48 hours of discovery of a spill of ISR process fluids reportable to the WDEQ-LQD. A written report will be provided to the NRC within 30 days of discovery containing the information required per NRC License Conditions.

Other unanticipated spills of reportable quantities from chemicals bulk storage areas will be reported to the WDEQ in accordance WDEQ-WQD, Rules and Regulations, Chapter 17, Part E and 40 CFR 302 (CERCLA).

Other operational reporting and applicable requirements include the following:

- Corrective Actions and Compliance Schedules- WDEQ-LQD Rules and Regulations, Section 13 and NRC License Conditions.

- Quarterly Monitoring Reports- WDEQ-LQD Rules and Regulations, Section 15.
- Annual Operations Reports- WDEQ-LQD Rules and Regulations, Section 15.
- Well Abandonment Reports- WDEQ-LQD Rules and Regulations, Section 15
- Deep Disposal Well Monitoring Reports- Done in accordance with UIC injection well permit issued by the WDEQ-LQD.
- NRC Semi-Annual Effluent and Environment Report- Done in accordance with 10 CFR Part 40.65.

5.13.3 Solid Waste

5.13.3.1 Uncontaminated Solid Waste

In Section 4.13.3.1, EMC estimated that the proposed Moore Ranch Project will produce approximately 2,000 cubic yards (yd^3) of uncontaminated solid waste per year. Uncontaminated solid waste will be collected on the site on a regular basis and disposed of in the nearest sanitary landfill. EMC will employ waste minimization and recycling to reduce the quantity of solid waste generated to a minimum.

5.13.3.2 Byproduct Material

In Section 4.13.3.2, EMC estimated that the proposed Moore Ranch Project will produce approximately 100 yd^3 of 11e.(2) byproduct material per year. These materials will be stored on site inside the restricted area until such time that a full shipment can be shipped to a licensed waste disposal site or mill tailings facility.

To the extent feasible, EMC will strive to reduce the quantity of 11e.(2) material produced on site. One waste minimization method that will be employed is decontamination. Decontaminated materials must have activity levels lower than those specified in NRC guidance. Methods for decontamination and release of contaminated equipment are discussed in further detail in Section 5 of the Technical Report.

All contaminated items that cannot be decontaminated to meet release criteria will be properly packaged, transported, and disposed at a disposal site licensed to accept 11e.(2) byproduct material. Radioactive solid waste that has a contamination level requiring controlled disposal will be isolated in drums or other suitable containers.

5.13.3.3 Septic System Solid Waste

Domestic liquid wastes from the restrooms and lunchrooms will be disposed of in an approved septic system that meets the requirements of the WDEQ for Class V UIC wells. Disposal of solid materials collected in septic systems must be performed in accordance with WDEQ Solid Waste Management rules and regulations.

5.13.3.4 Hazardous Waste

Based on preliminary waste determinations conducted by EMC in consideration of the processes and materials that will be used on the project, EMC will likely be classified as a Conditionally Exempt Small Quantity Generator (CESQG), defined as a generator that generates less than 100 kg of hazardous waste in a calendar month and that complies with all applicable hazardous waste program requirements. EMC expects that only used waste oil and universal hazardous wastes such as spent batteries will be generated at Moore Ranch. EMC will develop management programs to meet the WDEQ regulatory requirements for a CESQG.

6 ENVIRONMENTAL MEASUREMENTS AND MONITORING PROGRAMS

6.1 PREOPERATIONAL RADIOLOGICAL MONITORING

6.1.1 Introduction

The Moore Ranch Project (Figure 6.1-1) involves about 7,110 acres located along State Highway 387, approximately 24 miles southwest of the town of Wright. Proposed locations of wellfields, monitoring well rings, and the Central Plant and associated facilities are shown in Figure 6.1-1.

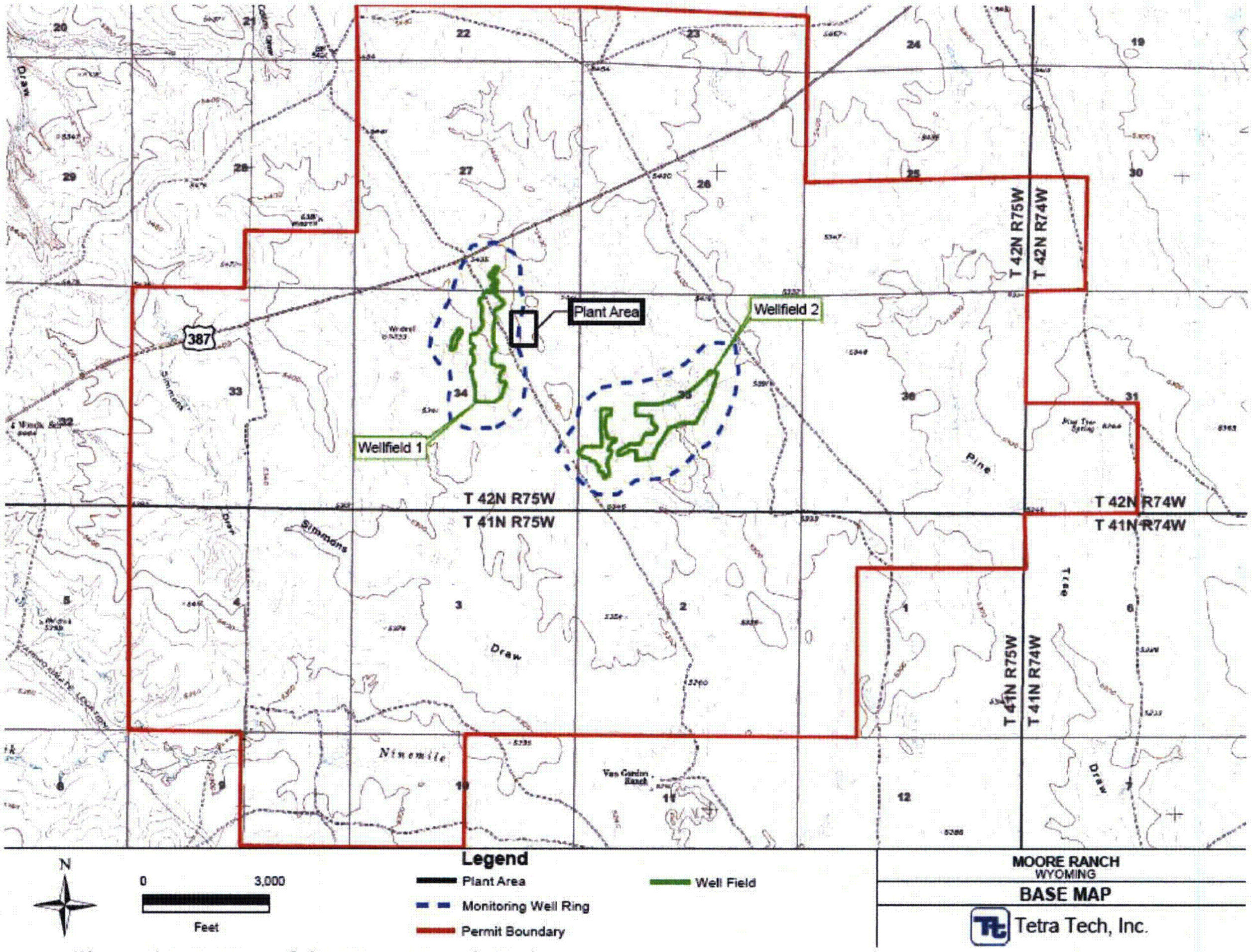


Figure 6.1-1: Map of the Moore Ranch Project

Topography at the Moore Ranch Uranium Project is primarily low rolling hills interspersed with relatively flat areas and small ephemeral drainages. Vegetation types range from sagebrush to short grass prairie varieties. The site is used extensively for grazing and oil and gas production and includes privately owned land, grazing leases, and state school sections. There are no residents currently within the area.

In 1979 and 1980, baseline radiological sampling and measurements were conducted at this site in support of proposed conventional surface uranium mining (Conoco, 1980). Those studies were never completed as plans for uranium surface mining were abandoned prior to completion of baseline sampling activities. In 2006, EMC contracted Tetra Tech Inc. to assist with the development of a new radiological baseline characterization of the site for proposed ISR uranium recovery operations. Radiological survey planning for this project was developed under the assumption that all phases of the ISR uranium recovery and processing cycle will be performed within the Moore Ranch License Area.

Basic guidance for radiological baseline surveys at uranium recovery sites can be found in Regulatory Guide 4.14 (NRC, 1980). Although Regulatory Guide 4.14 does not address special considerations associated with ISR uranium recovery sites, the U.S. Nuclear Regulatory Commission (NRC) and the Wyoming Department of Environmental Quality / Land Quality Division (WDEQ/LQD) both currently recommend following Regulatory Guide 4.14 for conducting radiological baseline surveys of ISR sites (NRC, 1982; NRC, 2003; WDEQ/LQD, 2007).

Current and historical baseline surveys of the site have both been conducted based on Regulatory Guide 4.14 protocols. The historical data set is substantial yet technically incomplete in terms of these regulatory guidelines. Available data from both studies are presented in this report for consideration by the NRC and WDEQ/LQD as potentially sufficient overall documentation of baseline conditions with respect to licensing/permitting applications.

Throughout the remainder of this report, reference to data or other aspects of the 1979-1980 Conoco baseline survey are associated with the term "historical survey". All other discussion of baseline survey information refers to recent sampling conducted as a result of proposed ISR uranium mining. Some aspects of current radiological survey efforts have been further developed according to more recent NRC regulatory guidance documents as referenced in applicable sections of this report. The following sections describe methods, activities, and results to date of radiological baseline surveys for the Moore Ranch Uranium Project.

6.1.2 Gamma Survey

Regulatory Guide 4.14 calls for a pre-operational gamma survey covering a maximum area of 1750 acres with up to 80 individual gamma exposure rate measurements (NRC, 1980). The suggested sampling design includes higher density of measurements clustered near the mill location, with more dispersed measurements in a radial pattern at greater distances from the mill. Regulatory Guide 4.14 does not address differences or special considerations associated with ISR uranium mining and recovery operations.

Consistent with ISR License Application guidelines described in Regulatory Guide 3.46 (NRC, 1982) and NUREG-1569 (NRC, 2003), as well as with decommissioning considerations outlined in MARSSIM, the Multi-Agency Radiation Survey and Site Investigation Manual (NRC, 2000), Tetra Tech proposed using more recent GPS-based scanning technologies capable of providing much higher density and more uniform gamma measurements across very large areas. The proposed scanning system can be mounted in various configurations including backpacks, all-terrain vehicles (ATVs), or trucks, and has been used for remedial support at a number of uranium mill site decommissioning projects as well as other radiological site characterization applications in the U.S. and abroad.

Discussions between Tetra Tech and various NRC representatives regarding ISR baseline surveys have resulted in a general consensus that application of an ATV-mounted version of this scanning system for such surveys would likely meet or exceed minimum guidelines outlined in Regulatory Guide 4.14 and other applicable regulatory guidance documents. This system is among current state-of-the-art technologies for conducting radiological site characterizations and can provide far more detailed information on baseline radiological conditions at ISR sites relative to past approaches.

6.1.2.1 Methods

6.1.2.1.1 Baseline Gamma Survey

Various GPS-based scanning system configurations have been field tested and successfully used by Tetra Tech (Figure 6.1-2). For the Moore Ranch survey, the most recently developed Yamaha Rhino-mounted system (Figure 6.1-2, photo C) was used. Given the large size of the site, along with occasional rugged terrain and sagebrush vegetation, these two-seater Rhino ATVs with roll-bar cages and conventional driver control systems (i.e. steering wheel, foot-controlled gas and brake pedals) were best suited for the project. Equipped with special extra-wide tires, these vehicles are well suited to safely negotiating sites like Moore Ranch while minimizing environmental impact.

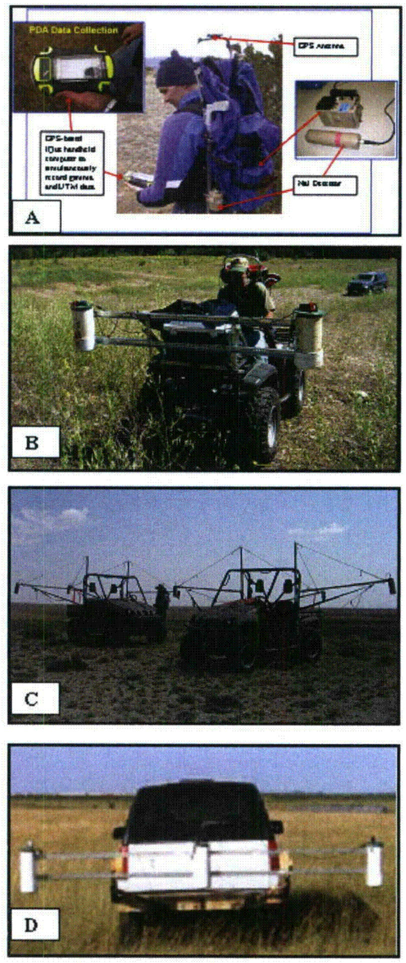


Figure 6.1-2: Various GPS-based scanning system configurations:
(A) single detector backpack system; (B) 2-detector ATV-mounted system; (C) 3-detector Rhino-mounted system; (D) 3-detector truck-mounted system.

In addition to addressing safety considerations, roll-bar cages on Rhino ATVs provides a support system for adjustable outriggers designed to mount three Ludlum 44-10 NaI gamma detectors and paired GPS receivers. The detectors are coupled to Ludlum 2350 rate meters housed in a cooler carried in the ATV cargo bed. Simultaneous GPS and gamma exposure rate data are recorded using an onboard PC with data acquisition software developed by Tetra Tech.

System configuration involves about 10-foot spacing between detectors (measured perpendicular to direction of travel), with each detector positioned at 4.5 feet above the ground surface. A 3-foot detector height is generally accepted, but not mandated, by the NRC. This height was impractical at the site given the relatively frequent tall brush, ravines, or fence gate crossings. A detector height of 4.5 feet was the lowest practical height for the system under site conditions. Experimental measurements were later performed to statistically quantify any measurement difference between 3-foot and 4.5-foot detector heights.

Based on previous Tetra Tech experiments conducted under similar scanning geometries, lateral detector response to significantly elevated planar (non-point) gamma sources at the ground surface is about 5 feet, giving each detector an estimated "field of view" of about 10 feet in diameter at the ground surface. This does not imply a system detector can pick up readings from a small point source 5 feet away, but does suggest that scattered photons from larger elevated source areas (e.g. 100 m^2) are likely to be detected at that distance. Within this conceptual framework, the scanning track width for each vehicle's scanning system is estimated to be about 30 feet across, perpendicular to the direction of travel. Vehicle scanning speeds ranged between 2 and 10 mph depending on the roughness of the terrain, with an estimated average speed of 6-7 mph.

Data were downloaded daily into a project database and mapped using Gamma Viewer software developed by Tetra Tech (Tetra Tech Inc., 2006). In addition to daily quality control (QC) measurements used to evaluate instrument performance and insure data quality (discussed later), daily scan results were evaluated in terms of general agreement between onboard detectors to help identify any problems that may have occurred during data acquisition throughout the day. Gamma Viewer field maps also helped to assess adequacy of scan coverage on a daily basis.

Initial results indicated that spatial variability in gamma exposure rates at the site was relatively uniform in most areas, prompting use of fairly narrow data bin increments for mapping to better illustrate subtle patterns or trends in variability. In areas near ore bodies or proposed operational facilities, attempts were made to achieve scanning coverage close to 100%. After assessment of initial scanning results for these areas, along with experience gained from scanning other sites, a distance of 15-30 feet between the adjacent detectors in both vehicles was deemed practical and sufficient to resolve smaller-scale variability in the areas targeted for higher density scanning coverage. This vehicle spacing provides an estimated effective ground scan coverage of 75-90%. In one area targeted for high-density scanning, a mechanical problem with one of the vehicles necessitated a reduction in coverage to about 50%. Despite the reduction in coverage, spatial variability in this area can still be adequately determined from the scan track data.

In other portions of the license area, 5-10% was the initial target coverage though practical considerations such as safety, terrain, and natural obstructions often dictated actual distances maintained between vehicles. For most areas of the site, a target distance of 300 feet between vehicles was a conservative goal employed during scanning as this provides an estimated scan coverage of about 15%. In terrain deemed unsafe for ATV scanning, every attempt was made to scan as closely as possible along the perimeters of such terrain.

6.1.2.1.2 Cross-calibration of NaI Detectors against a High-Pressure Ionization Chamber

Gamma exposure rates measured by NaI detectors are only relative measurements as response characteristics of NaI detectors are energy dependent. True gamma exposure rates are best measured with an energy independent system such as a high-pressure ionization chamber (HPIC). Depending on the radiological characteristics of a given site, NaI detectors can have measurement values significantly higher than corresponding HPIC measurement values. NaI systems are useful for ISR mining sites because they can quickly and effectively demonstrate relative differences between pre- and post-operational gamma exposure rate conditions. Unless the same equipment and scanning geometry is used for both surveys, however, it is necessary to normalize the data to a common basis of comparison. This is the purpose of performing NaI/HPIC cross-calibration measurements. Cross-calibration insures that the results of future gamma scans, which are likely to use different detectors (and perhaps different detector heights, detector models, or measurement technologies), can be meaningfully compared against the results of pre-ISR gamma surveys.

To perform NaI/HPIC cross-calibrations, static measurements were taken at various discrete locations covering a range of exposure rates representative of the license area. At each cross-calibration measurement location, 10-20 individual HPIC readings were recorded and averaged. The center of the HPIC's sensitive volume is about 3 feet above the ground surface. A pin flag was pushed into the ground directly below the center of the HPIC to mark the exact spot for subsequent NaI measurements. The ATVs were then systematically positioned such that each NaI detector was located directly above the pin flag when taking measurements. For each NaI detector, 20 individual NaI readings at a 4.5-foot detector height were automatically collected and averaged using a special data acquisition software program. Mean values were recorded. A picture of this process is shown in Figure 6.1-3.

6.1.2.1.3 Gamma / Ra-226 Correlation Grids

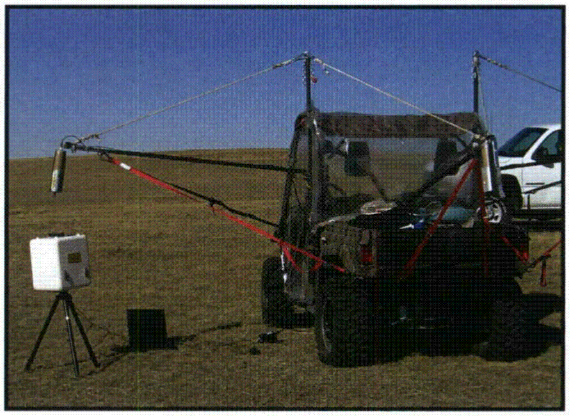


Figure 6.1-3: Measurements for cross-calibration of NaI detectors against the HPIC at a 4.5-foot NaI detector height.

Regulatory Guide 4.14 indicates that 40 baseline surface soil samples should be collected at 5-cm depths within 1.5 kilometers from the center of the milling area, with additional samples collected at air monitoring stations. NUREG-1569 suggests that 15-cm depths should also be sampled for consistency with decommissioning criteria. This guidance, combined with the large size of the Moore Ranch Uranium Project area, prompted a number of gamma/Ra-226 correlation grids to be sampled. Depending on the statistical strength of any gamma/Ra-226 relationship, such correlations can be used to estimate approximate Ra-226 soil concentrations (to a 15-cm depth) across the entire site based on gamma survey results.

Correlation soil sampling was conducted as composite sampling over 10x10 meter grids. Within each grid, 10 soil sub-samples were collected to a depth of 15 cm then composited into a single sample. GPS coordinates were taken at the center of each sampling grid and recorded. Samples were sent to Energy Laboratories Incorporated (ELI) in Casper, WY for analysis of Ra-226 concentrations. Samples were dried, crushed, and thoroughly homogenized prior to analysis to insure a representative average radionuclide concentration over each 100 m^2 grid. Samples were then canned, sealed, and held 21 days prior to counting to allow sufficient ingrowth of radon and short-lived progeny before Ra-226 analyses were performed using high-purity germanium (HPGe) gamma spectroscopy (method E901.1).

Following methods described in Johnson et al. (2006), each 100 m^2 soil sampling grid was also scanned using the same ATV-mounted system and detector configuration used to scan the entire license area. The average NaI gamma reading over each grid was calculated and recorded to pair with the corresponding average Ra-226 concentration. A diagram depicting the sampling design for correlation grid measurements is shown in Figure 6.1-4.

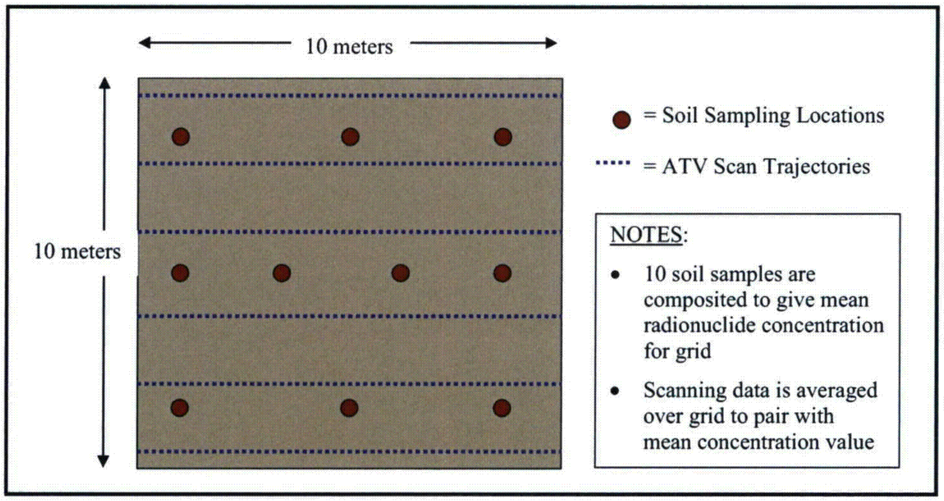


Figure 6.1-4: Diagram of soil sampling / gamma measurement correlation grid design.

6.1.2.1.4 Data Quality Assurance / Quality Control

Data quality assurance and quality control issues for the gamma survey at the Moore Ranch ISR license area are addressed in various ways. In general, quality assurance (QA) includes qualitative factors that provide confidence in the results, while quality control (QC) includes quantitative evidence that supports the validity of results (e.g. data accuracy and precision).

Quality control documentation for this project includes the following:

Daily QC measurements were performed for each NaI detector used in gamma scanning activities and results were plotted on system instrument control charts. Background as well as Cs-137 check-source QC measurements were taken each day indoors under a controlled geometry. Any instrument with measurements falling outside ± 3 standard deviations from the mean of all QC measurements on both background and check source charts indicates unacceptable instrument performance. Detectors performed within acceptable QC limits throughout the project.

Each day, the actual performance of each scanning system was tested in the field by scanning along a designated strip near the vehicle staging area. These "field strip" scans were conducted before and after each day's scanning. Under actual field conditions, scanning systems performed within acceptable QC limits throughout the project.

Re-scanning is an important tool for verification and demonstrating reproducibility of measurements in the field. Part of re-scan verification involved comparing data from various discrete measurement locations across the site (collected as part of HPIC cross-calibration and gamma/Ra-226 correlation grid activities) with original scan data. In general, these discrete measurement data showed good agreement with original continuous scan data (see Section 6.1.2.2.1).

With respect to soil sampling results from Energy Laboratories, final official reports indicated that all QC indicators (e.g. duplicate sample analyses, blanks, laboratory control samples, sample matrix spikes) "met EPA or laboratory specifications" for quality control. No flags or analytical problems were noted in the reports. Copies of these reports are available upon request.

Data quality assurance factors for this project include the following:

- All detectors used for gamma scanning at the license area, along with the HPIC, were calibrated by the manufacturer within one year prior to the date of use on this project.
- A detailed field log book of daily activities was maintained.
- Chain-of-custody protocols were followed for soil sampling and contract laboratory analyses.
- Scanning system methodologies and technology are published in peer-reviewed radiation protection and measurement research publications (Johnson et al., 2006; Meyer et al. 2005a; Meyer et al. 2005b; Whicker et al., 2006).

Daily scan results for each vehicle were reviewed for consistency along track paths for all onboard detectors. Obvious inconsistencies prompted further investigation and in any cases where technical problems were discovered or where the data were otherwise clearly incorrect, the affected data were omitted from the project database. Although a few incorrect data points were discovered and omitted during this project, there were no cases in which significant technical problems with scanning systems or data were detected.

6.1.2.2 Gamma Survey Results

6.1.2.2.1 Baseline Gamma Survey Results

NaI-based gamma survey results are shown in Figure 6.1-5. There is a relatively small degree of variability in gamma exposure rates in most areas of the Moore Ranch site. The centralized area of higher density scanning shown in Figure 6.1-5 covers the approximate region of planned wellfield operations and plant facility locations. The unscanned area along the northern boundary of the site was added to the license area after gamma survey activities had been conducted.

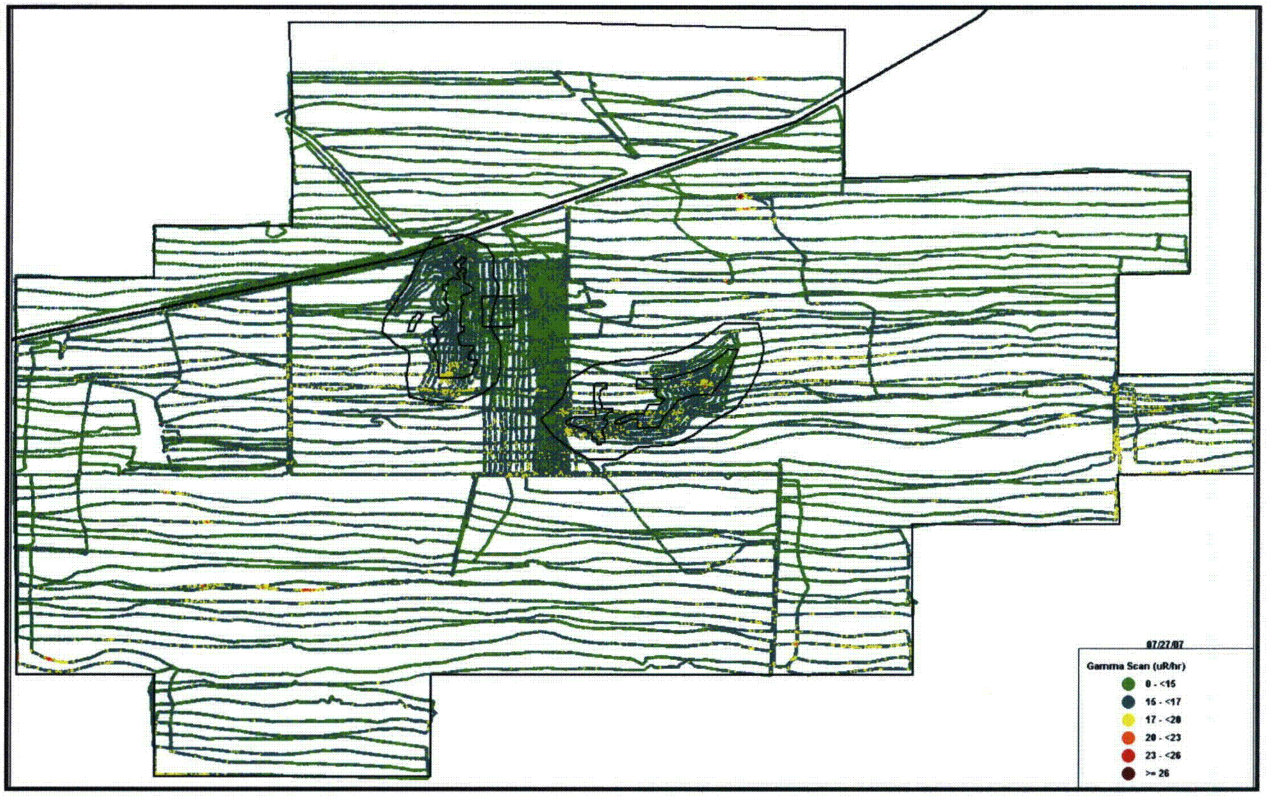


Figure 6.1-5: Baseline gamma survey results for the Moore Ranch site.

Discrete, re-scan measurements taken at HPIC cross-calibration and correlation grid survey locations generally confirmed the results of the ATV scans (Figure 6.1-6). In some cases, areas at the site with the highest readings appear to have certain geomorphologic features that could be associated with higher gamma exposure rates (e.g. hill tops or other areas with outcrops of exposed rocks or unusual soil layers). The most notable example of this was found in the vicinity of HPIC measurement locations "PIC-6" and "CP-6" as shown in the northeast corner of Figure 6.1-6. Here, in a small, localized area at the top of a hill, gamma readings at 4.5 feet above the ground surface approached 40 μR/hr. This is about twice that of scan readings found at most other locations across the site. There are numerous weathered sedimentary rocks lying on the ground surface at this location. Other locations with exposed rocks and soil that are similar in appearance did not exhibit the same apparent association with elevated gamma exposure rates.

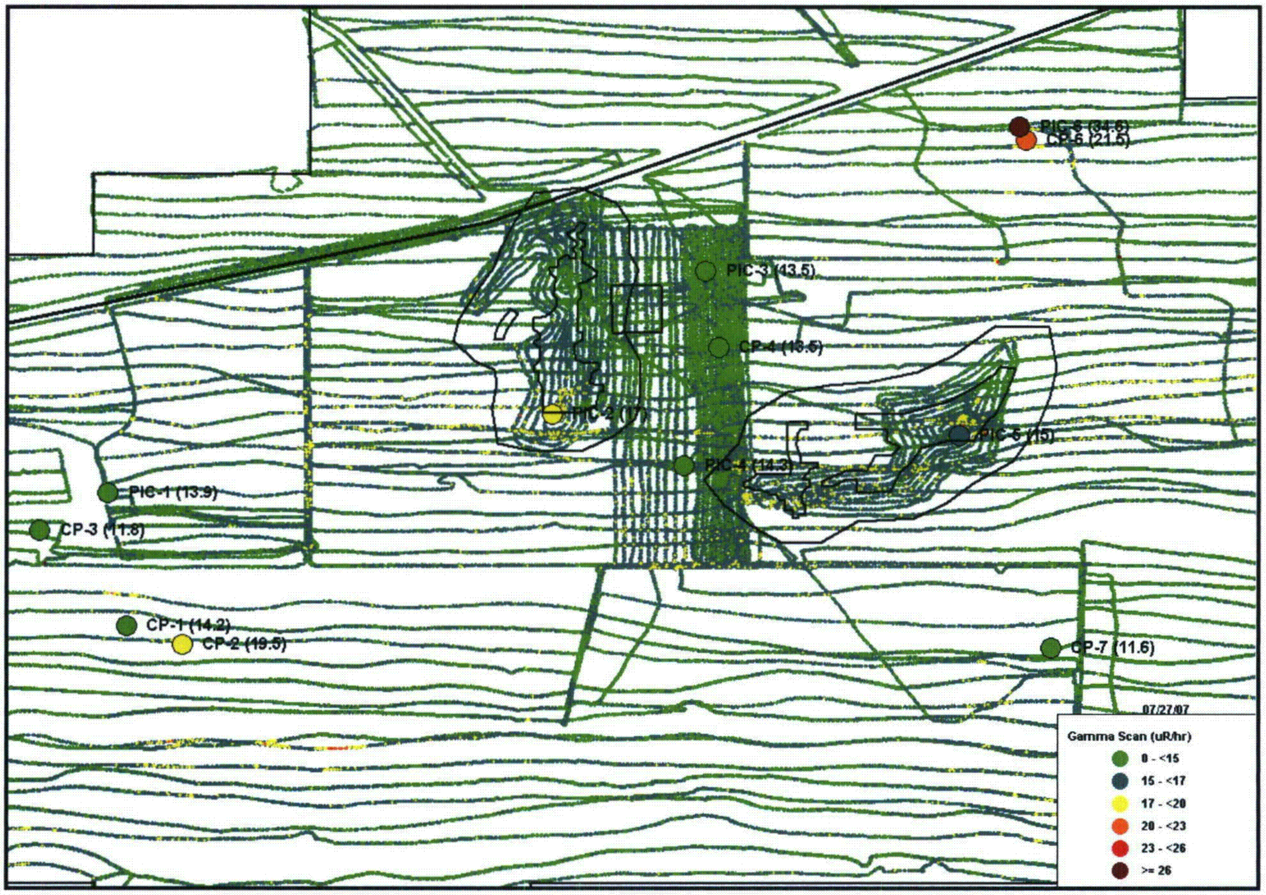


Figure 6.1-6: Select portion of baseline gamma survey results with discrete re-scan measurement overlays (denoted by the large circles).

6.1.2.2.2 HPIC / NaI Cross-calibration Results

Results of the cross-calibration between HPIC and NaI detectors positioned at 4.5-foot detector heights are shown in Figure 6.1-7. Regression coefficients are noticeably different from those measured by Tetra Tech at other uranium recovery sites. Typically, HPIC readings at such sites are expected to be about 60-70% that of NaI readings. In this case, HPIC readings averaged over 90% that of corresponding 3-foot NaI readings. Because this curve is influenced by the presence of a single data point that is of much higher magnitude than the rest (this data point was measured at location "PIC-6" as shown in Figure 6.1-6), another regression was performed that excluded this data point in order to better model the relationship only in the lower range of values (Figure 6.1-8). The vast majority of readings across the site fall in this category (e.g. below 20 μR/hr).

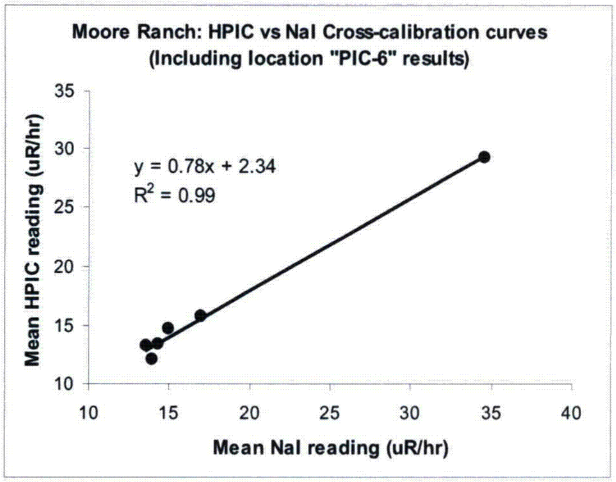


Figure 6.1-7: Cross-calibration curves for the HPIC versus NaI detectors positioned at 4.5-foot detector heights.

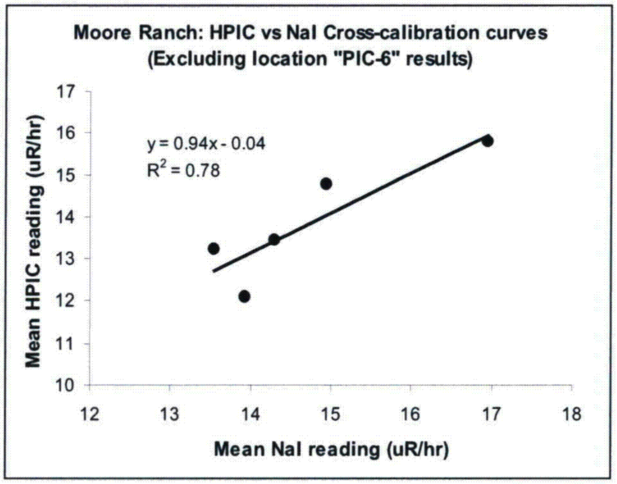


Figure 6.1-8: Cross-calibration curves for the HPIC versus NaI detectors positioned at 4.5-foot detector heights (excluding measurement results for location "PIC-6").

One possible explanation for the small difference between HPIC and NaI readings at the Moore Ranch site could be that terrestrial sources of radioactivity have less influence on NaI readings relative to higher energy cosmic radiation. Photons from terrestrial radioactivity reaching a NaI detector are mostly comprised of low energy scattered photons from adjacent areas. If soil radionuclide concentrations at the site are low, the difference in readings between NaI and HPIC measurement systems might be minimized relative to the site's elevation and related cosmic component. There is some evidence in the literature to support this idea. A study of gamma exposure rates across portions of Colorado indicated that the relative contribution of terrestrial and cosmic sources to total background gamma radiation (Figure 6.1-9) varies significantly depending on geophysical factors and elevation (Stone et al., 1999). Results of current and historical soil sampling data (Section 6.1.3), along with the Ra-226/gamma correlation grid measurements (Section 6.1.2.2.3), confirm generally low Ra-226 concentrations across the site (averaging about 1 pCi/g).

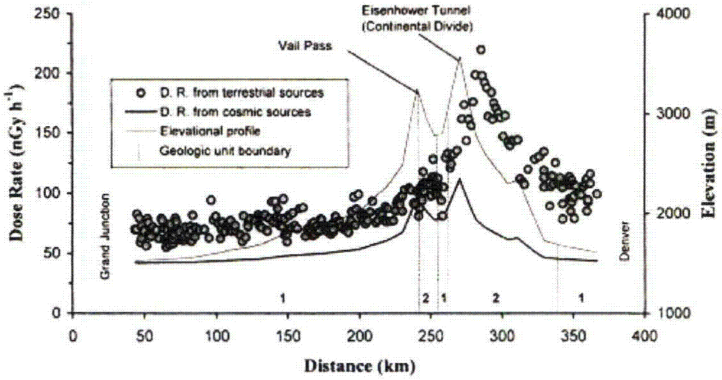


Figure 6.1-9: Estimated background dose rates to air from cosmic and terrestrial sources along I-17 from Grand Junction to Denver with generalized elevation profile and geology superimposed. Geologic units are simplified into two general types: 1 = sedimentary; 2 = granitic. (Adopted from Stone et al., 1999).

6.1.2.2.3 NaI/Ra-226 Correlation Grid Results

An overlay of correlation grid sampling locations, color-coded and annotated to show soil Ra-226 results on the baseline NaI gamma scan map, are shown in Figure 6.1-10. Soil sampling results represent average 15-cm depth Ra-226 concentrations over 100 m^2 sampling grids.

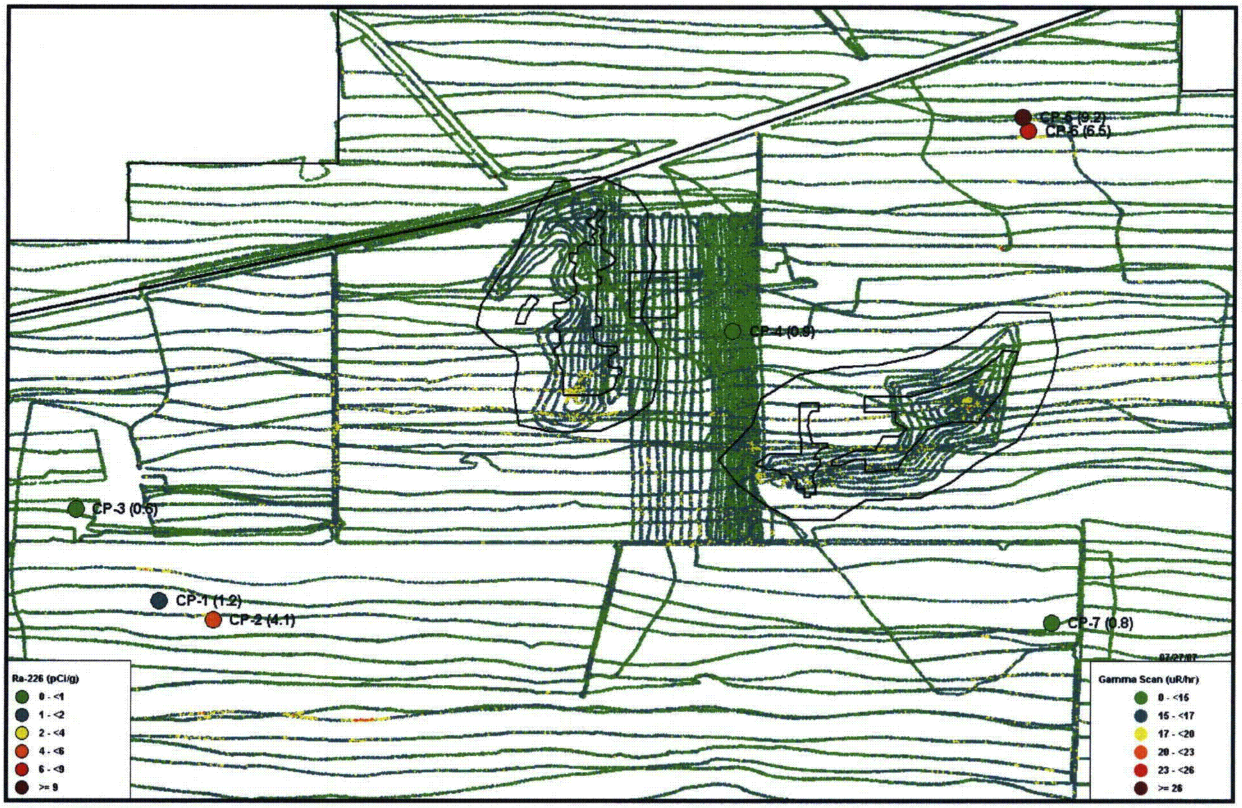


Figure 6.1-10: Overlay of correlation grid measurement locations and soil Ra-226 concentration results on the NaI gamma survey map.

Correlation grid data demonstrated a significant linear relationship (Figure 6.1-11) between mean Ra-226 soil concentration and mean gamma exposure rate across all sampling grids (Table 6.1-1).

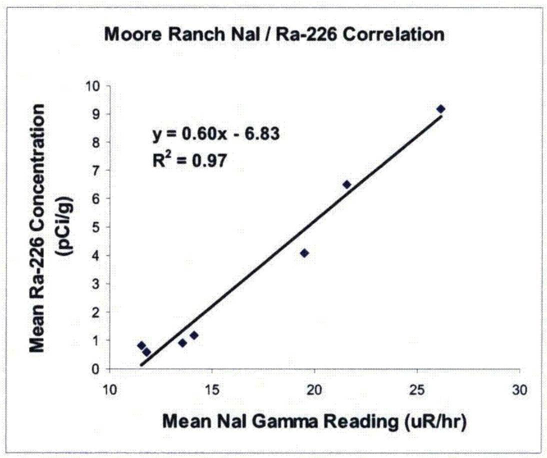


Figure 6.1-11: Correlation between Ra-226 soil concentration and NaI-based gamma exposure rate reading.

Table 6.1-1: Correlation grid locations and results

Sample ID	Latitude dd North	Longitude dd West	Mean NaI Gamma Reading (μR/hr)	Mean Ra-226 (pCi/g)
CP-1	43.55824	105.87460	14.2	1.2
CP-2	43.55736	105.87204	19.5	4.1
CP-3	43.56264	105.87860	11.8	0.6
CP-4	43.57114	105.84736	13.5	0.9
CP-5	43.58133	105.83356	26.1	9.2
CP-6	43.58069	105.83328	21.5	6.5
CP-7	43.55719	105.83210	11.6	0.8

6.1.2.2.4 Final Gamma Exposure Rate Mapping

All 2006 gamma survey data have been normalized to a 3-foot HPIC equivalent gamma exposure rate to create a final data set for the Moore Ranch license area. Regression equations from both Figures 6.1-7 and 6.1-8 were used for this purpose. Data values greater than 15 μR/hr were converted to 3-foot HPIC equivalent using the regression in Figure 6.1-7, while all other data were converted using the regression in Figure 6.1-8. The cut-off value of 15 μR/hr was selected because this is the approximate value at which HPIC equivalent values from the two regression equations have about the same degree of difference with NaI readings (Table 6.1-2). Final official results of the gamma baseline survey of the Moore Ranch license area are shown in Figure 6.1-12, an E-sized version included at the end of Section 6.1.

Hypothetical 4.5-foot NaI Exposure Rate Reading (μR/hr)	3-foot HPIC Equivalent (μR/hr) using 4.5-foot Cross-calibration from Figure 2-6	3-foot HPIC Equivalent (μR/hr) using 4.5-foot Cross-calibration from Figure 2-7
12	11.7	11.2
13	12.5	12.2
14	13.3	13.1
15	14.0	14.1
16	14.8	15.0
17	15.6	15.9
18	16.4	16.9

Table 6.1-2: Comparison of predicted 3-foot HPIC equivalent values using the two 4.5-foot NaI cross-calibration equations from Figures 2-6 and 2-7

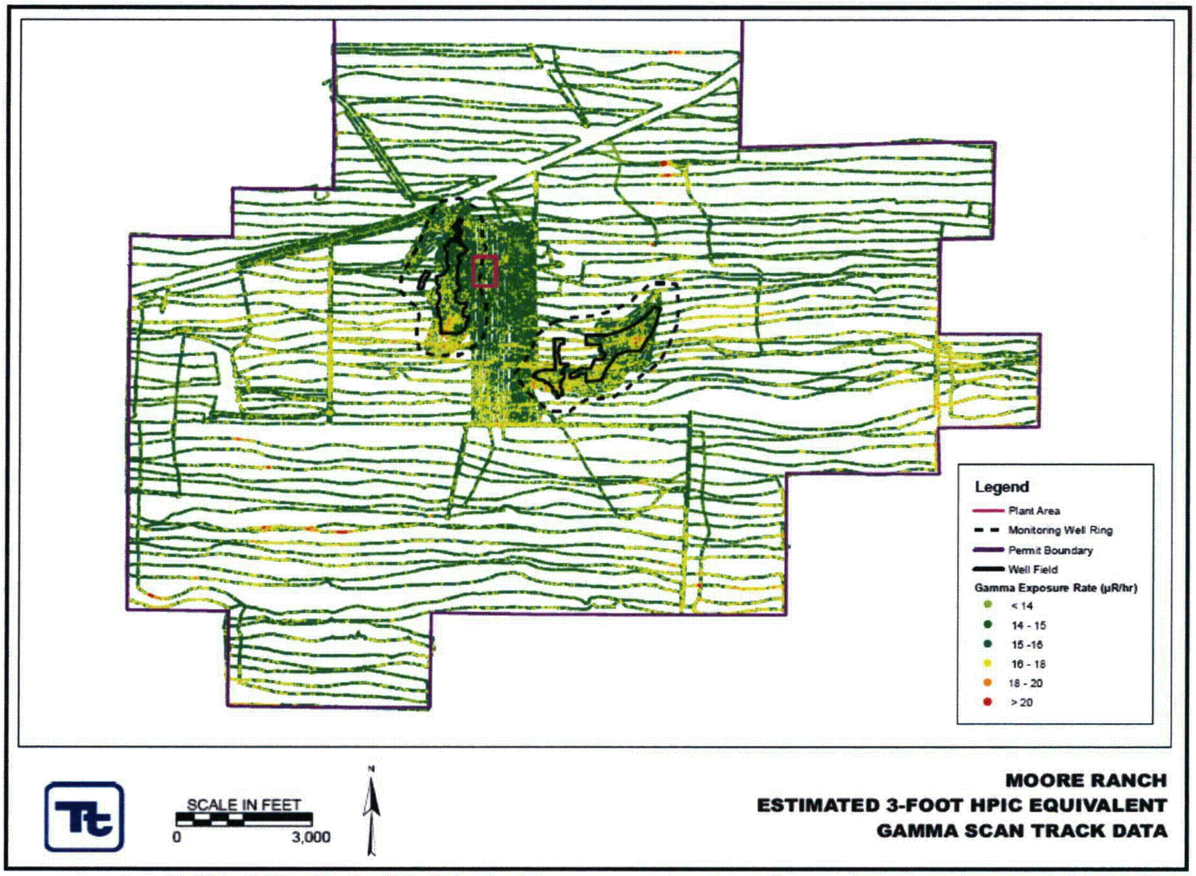


Figure 6.1-12: Estimated 3-foot HPIC equivalent gamma exposure rates in the Moore Ranch Area

Note that unlike the gamma maps shown in previous figures of this report, the final official scan track maps provided as Figure 6.1-12 have a different legend and respective gamma scale increments. This is because the data in the final maps of official gamma survey results have been converted to 3-foot HPIC equivalent values.

A kriging program in ArcGIS, along with the final data set shown in Figure 6.1-12, was used to develop continuous estimates of 3-foot HPIC equivalent gamma exposure rates throughout the license area. Kriging is a geostatistical interpolation procedure that fits a mathematical function to a specified number of nearest points within a defined radius to determine an output value for each location. A given "location" is represented by a cell of specified areal dimensions that may or may not include any measured data points. Values closer to the cell are given more weight than values further away and distances, directions, and overall variability in the data set are all considered in the predictive semivariogram model. Approximate input parameters used for this application were as follows:

Cell size:	10 feet × 10 feet
Max search radius:	300 feet
Semivariogram model:	Exponential
Number of nearest data points:	10

A map of estimated 3-foot HPIC equivalent gamma exposure rates throughout the license area is shown in Figure 6.1-13, an E-sized version included at the end of Section 6.1.

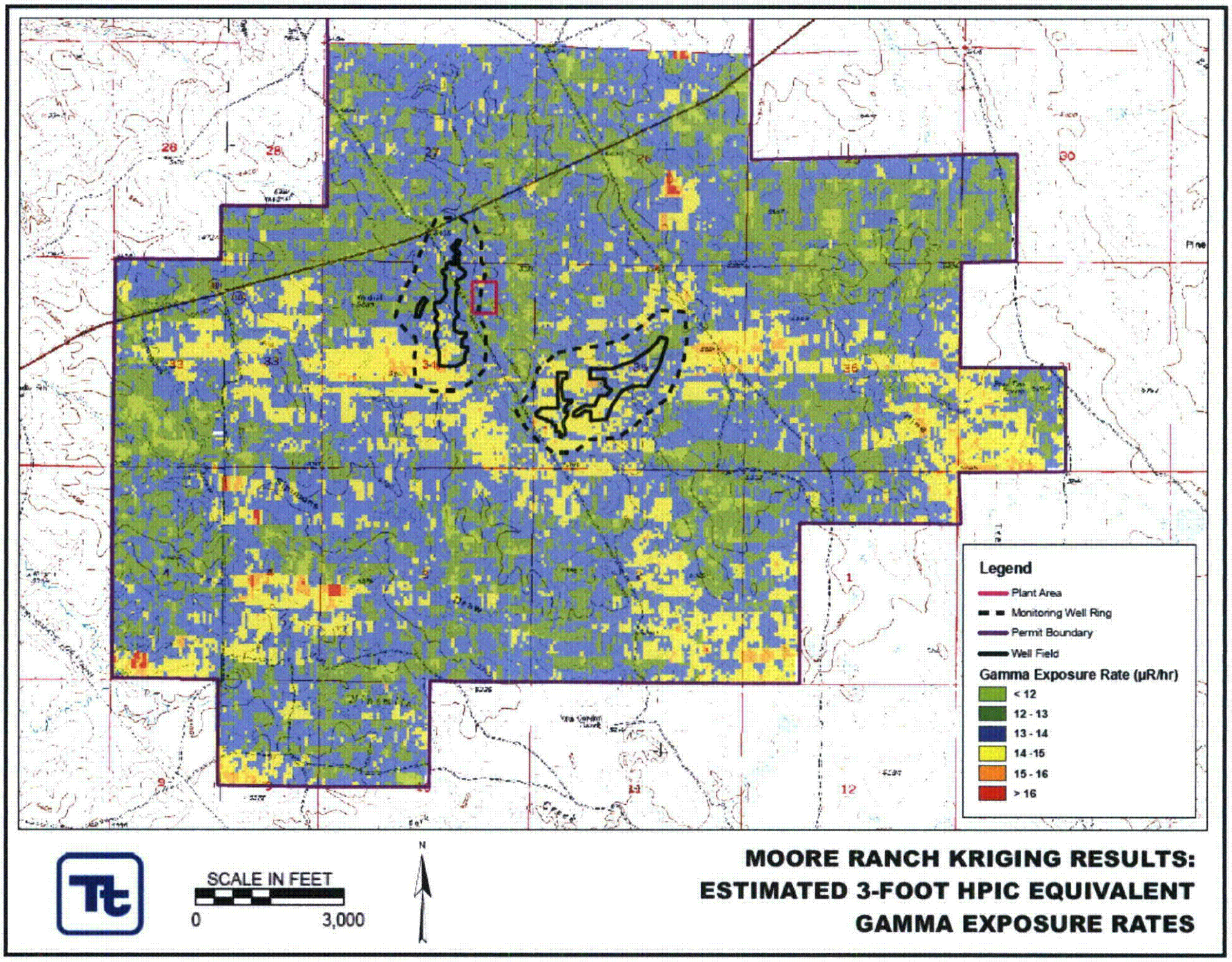


Figure 6.1-13: Continuous, kriged estimates of 3-foot HPIC equivalent gamma exposure rates in the Moore Ranch license area.

6.1.2.2.5 Soil Ra-226 Concentration Mapping

Based on gamma/Ra-226 correlation data, NaI scan results were also converted into estimates of soil Ra-226 concentrations across the site. The linear regression equation shown in Figure 6.1-11, however, did not provide the best possible fit to gamma readings less than 20 μR/hr (the range representing a vast majority of readings across the site as shown in Figure 6.1-14). A power function (Figure 6.1-15) provided a better fit to these data was thus used for converting gamma scan data to Ra-226 concentration estimates.

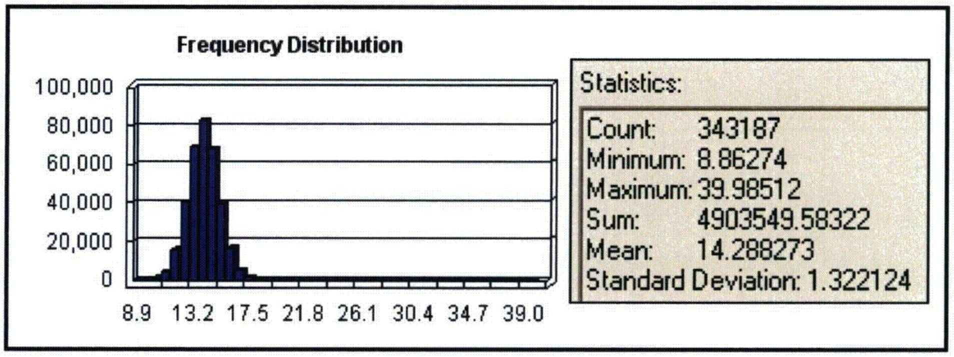


Figure 6.1-14: Frequency histogram of all NaI-based gamma exposure rate survey readings across the Moore Ranch license area.

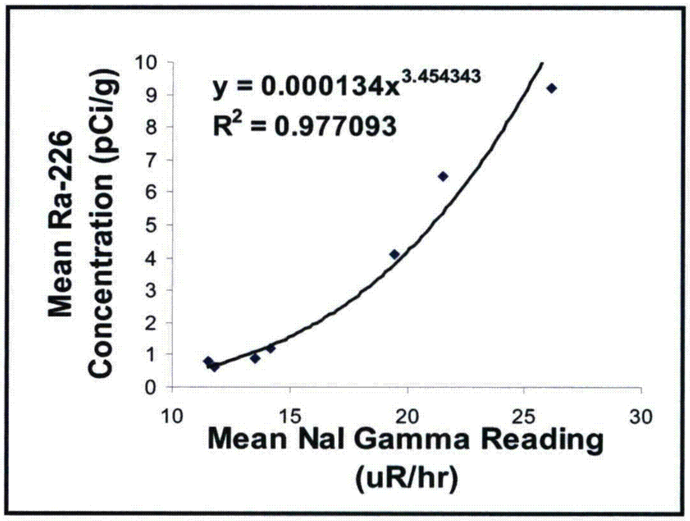


Figure 6.1-15: Power function fitted to gamma/Ra-226 correlation data to best model the relationship for the vast majority of readings across the site (readings < 20 μR/hr).

After conversion using the power function shown in Figure 6.1-15, the data were kriged to estimate continuous Ra-226 concentrations across the site as shown in Figure 6.1-16, an E-sized version included at the end of Section 6.1. This kriged soil Ra-226 concentration map shows good agreement with individual soil sample results (see Section 6.1.3.).

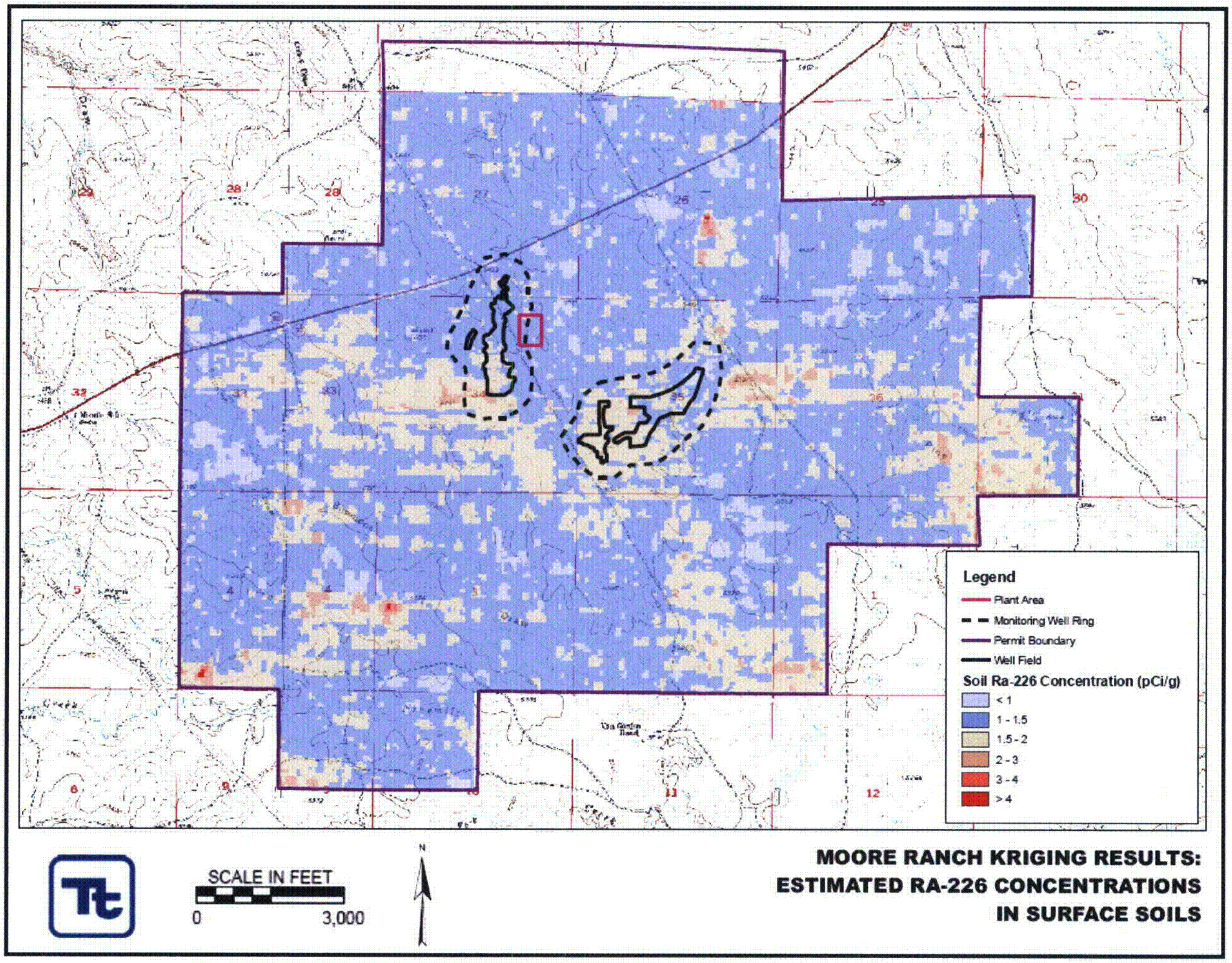


Figure 6.1-16: Continuous, kriged estimates of Ra-226 in the Moore Ranch license area based on gamma survey results.

6.1.2.2.6 Data Uncertainty

For comparison of pre- and post-operational measurements, converting gamma survey data to a 3-foot HPIC equivalent is only one important consideration. It is also necessary to take into account the degree of uncertainty in measurements. Sources of measurement uncertainty include instrument variability, spatial variability in gamma exposure rates (differences in readings due to small differences in measurement location), and temporal variability in gamma exposure rates (differences over time due to changes in soil moisture, barometric pressure, etc. which can affect ambient radon levels and/or photon attenuation characteristics of the soil profile).

Quality control measurements performed each day at an indoor location under controlled geometry indicated instrument variability for background readings was generally on the order of ± 1 μR/hr (based on standard deviations of 20 successive readings). Day-to-day variability in QC measurements along the field strip near the field staging area provides an indication of relatively small-scale spatial variability, as well as temporal variability over successive days, in background gamma exposure rates. Based on instrument control charts maintained over the course of the project, these sources of variability appear to also approach ± 1 μR/hr. These data and observations suggest that the total amount of potential uncertainty in NaI scanning measurements at the staging area ranged up to ± 2 μR/hr. The evidence indicates that approximately the same amount of uncertainty is applicable to 3-foot HPIC equivalent data. The field strip was located in an area having measured background gamma readings in the range of 12 – 14 μR/hr (at the lower end of the range of values found at the site). In areas of higher gamma exposure rates, the degree of uncertainty in measurements may be higher.

6.1.2.3 Conclusions

The 2006 baseline gamma survey of the Moore Ranch Uranium Project area in Campbell County, WY provides a detailed characterization of natural background gamma exposure rates and associated Ra-226 soil concentrations that exist at the site. The data collected are of high quality and should meet or exceed regulatory guidelines for baseline gamma surveys. These data will help insure that any potential radiological contamination that could result from ISR mining activities at the site can be effectively identified for remedial action. High density measurements, HPIC cross-calibrations, gamma/NaI correlations, thorough quality control, and advanced spatial analysis techniques provide the most thorough and accurate documentation possible of these important baseline radiological parameters. This is important for insuring that future remediation can return the land to its pre-operational state. The technology and methods used, while new to the ISR permitting process, are likely to benefit all stakeholders.