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 and a 2006 aerial photo, 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 11 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.

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.

- When practicable, 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.

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 NRC 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.

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

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 NRC-licensed disposal facility if contaminated.

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

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:

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

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

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_1	=	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 a few areas where there are known spills and, potentially, small spills near wellheads. Final GPS-based gamma surveys will be conducted in potentially contaminated areas. 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.

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. 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.

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

EMC will develop an emergency response plan for yellowcake and other transportation accidents to or from the Moore Ranch Project. EMC personnel will receive training for responding to a transportation accident.

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.

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.

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.

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 the groundwater restoration efforts will be to return the groundwater quality of the production zone, on a wellfield average, to the standard of pre-mining class of use or better using Best Practicable Technology (BPT) as defined in §35-11-103(f)(i) of the Wyoming Environmental Quality Act, 2006. 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.

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). 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. 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.

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)
Sulfate (mg/l)
Uranium (mg/l)
Vanadium (mg/l)
Dissolved Zinc (mg/l)

Table 5.4-1 Baseline Water Quality Parameters

Parameter (units)
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 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. EMC may also employ bioremediation as a reduction process.

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 reductant (either biological or chemical), 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 reductant (either biological or chemical) 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.

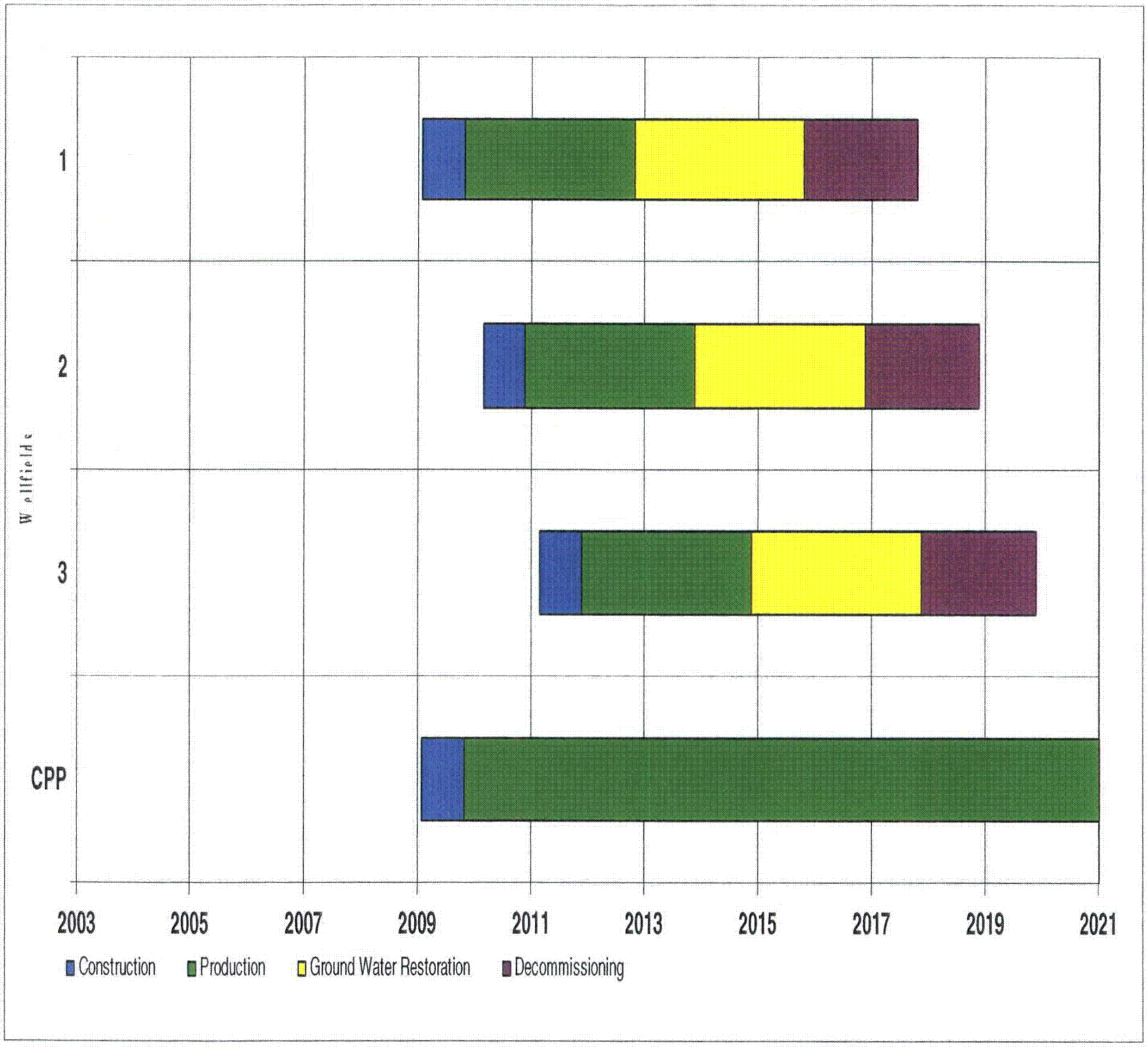
If necessary, sodium hydroxide may be used during the groundwater treatment phase to return the groundwater to baseline pH levels. This will assist in immobilizing certain parameters such as trace metals.

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 three wellfields. As the Moore Ranch Project is developed, the restoration schedule will be defined further.

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/Christensen Ranch Uranium Project operated 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 5.4.2.2.1, 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.

Restoration Stability Monitoring

A minimum six month groundwater stability monitoring period 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 two months and analyzed for the UCL 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.

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 0, EMC projects that the restoration injection stream will exhibit the range of characteristics shown in Table 5.4-2.

Table 5.4-2 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 is under preparation for submittal to the WDEQ for a Class I UIC Permit for the Moore Ranch Project.

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 biweekly 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.

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.

5.5.5 Threatened and Endangered Species

5.5.5.1 Bald Eagle (Federal Threatened)

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.

5.10 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.

5.12.2 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 away from building ventilation intakes to prevent introducing exhausted radon into the facility 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. During favorable weather conditions, open doorways and convection vents in the roof will provide satisfactory work area ventilation. 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.

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 plans to install two or more deep disposal wells at the Moore Ranch Facility as the primary liquid waste disposal method. EMC believes that permanent deep disposal of liquid wastes is preferable to evaporation in evaporation ponds or land application methods. All compatible liquid wastes at the Moore Ranch Facility will be disposed in the planned deep wells. An application is currently in development and will be submitted to the WDEQ-WQD for a Class I UIC Permit for the Moore Ranch Facility in the late summer of 2007.

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 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.

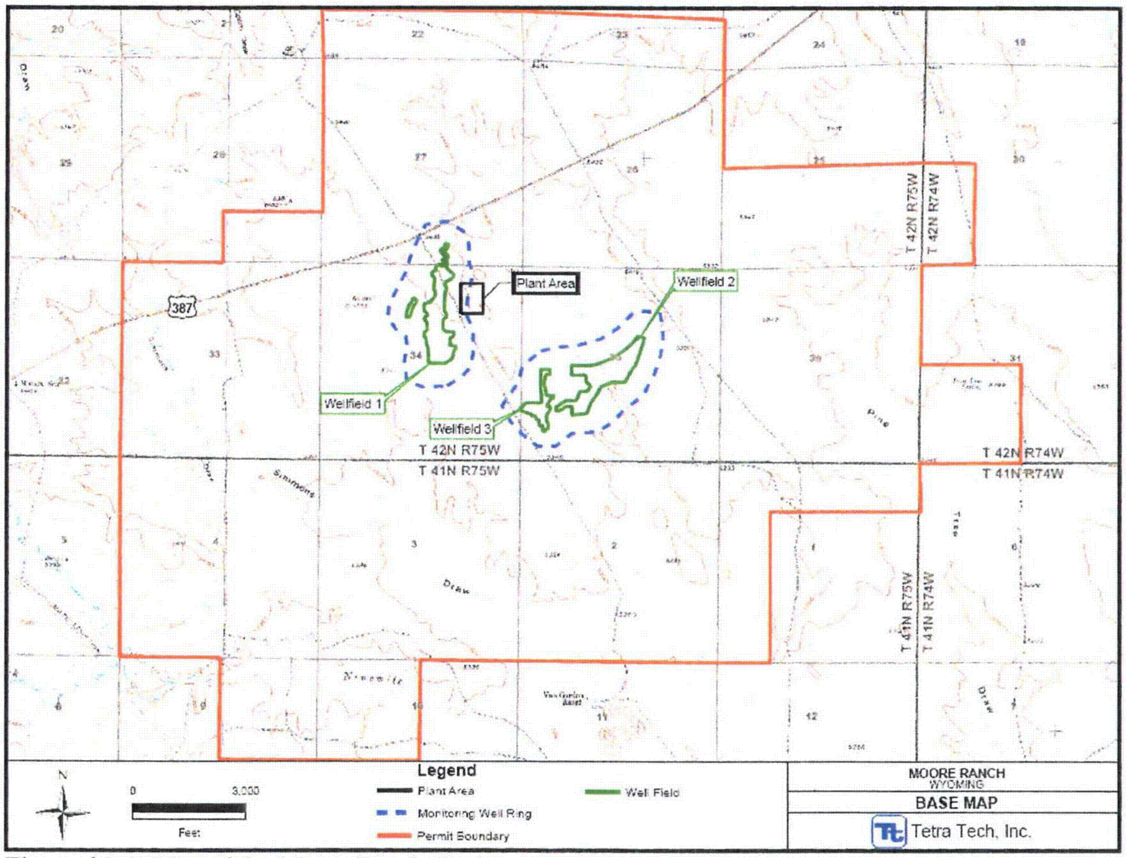


Figure 6.1-1: Map of the Moore Ranch Project

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. As with current survey data, the historical data set is substantial yet still 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 prior to completion of the current radiological baseline survey program. Remaining data from the current study will be submitted to both agencies as they become available.

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.

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

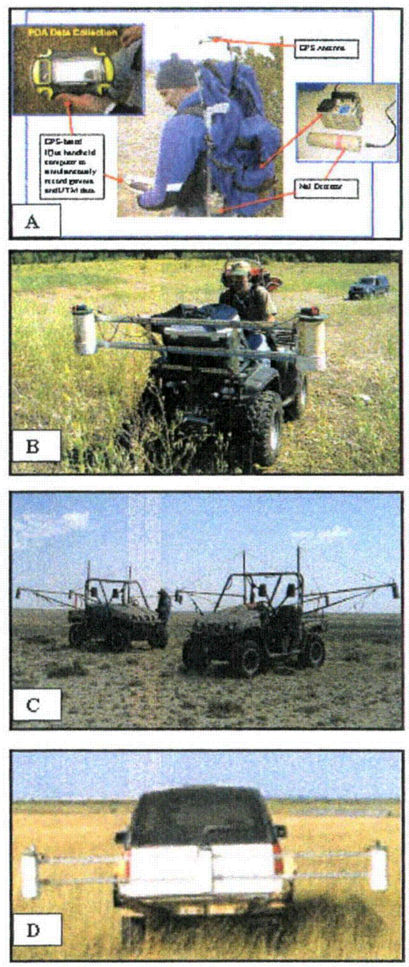


Figure 6.1-2: Various GPS-based scanning system configurations: (A) single detector backpack system; (B) 2-detector ATV-mounted system; (C) 3-detector Rhino-mounted system; (D) 3-detector truck-mounted system.

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.

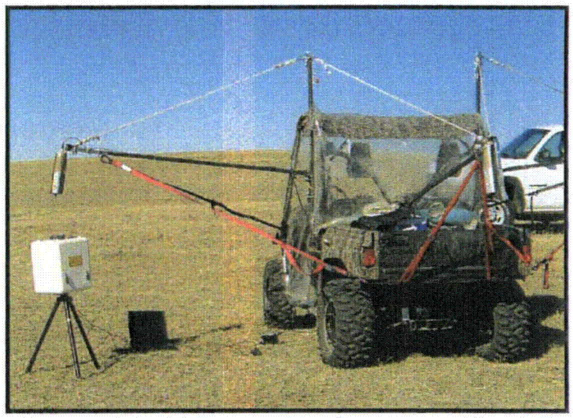


Figure 6.1-3: Measurements for cross-calibration of NaI detectors against the HPIC at a 4.5-foot NaI detector height.

6.1.2.1.3 Gamma / Ra-226 Correlation Grids

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.

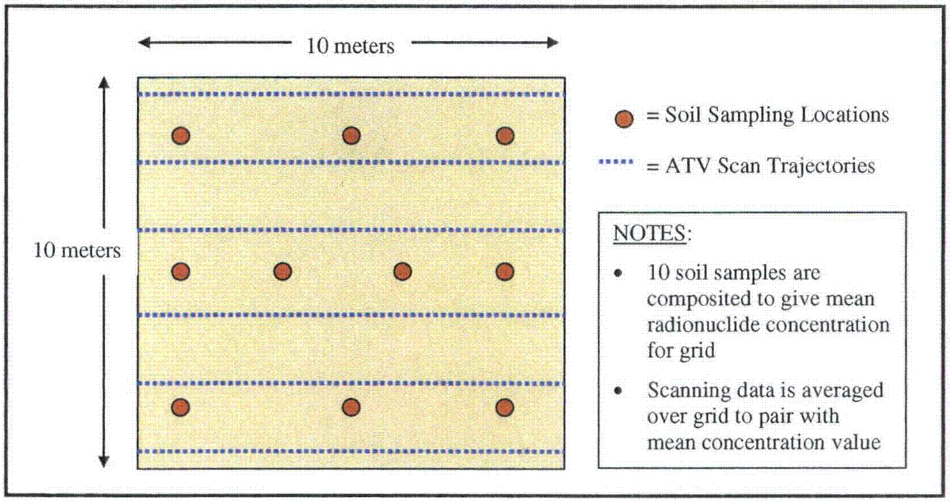


Figure 6.1-4: Diagram of soil sampling / gamma measurement correlation grid design.

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.

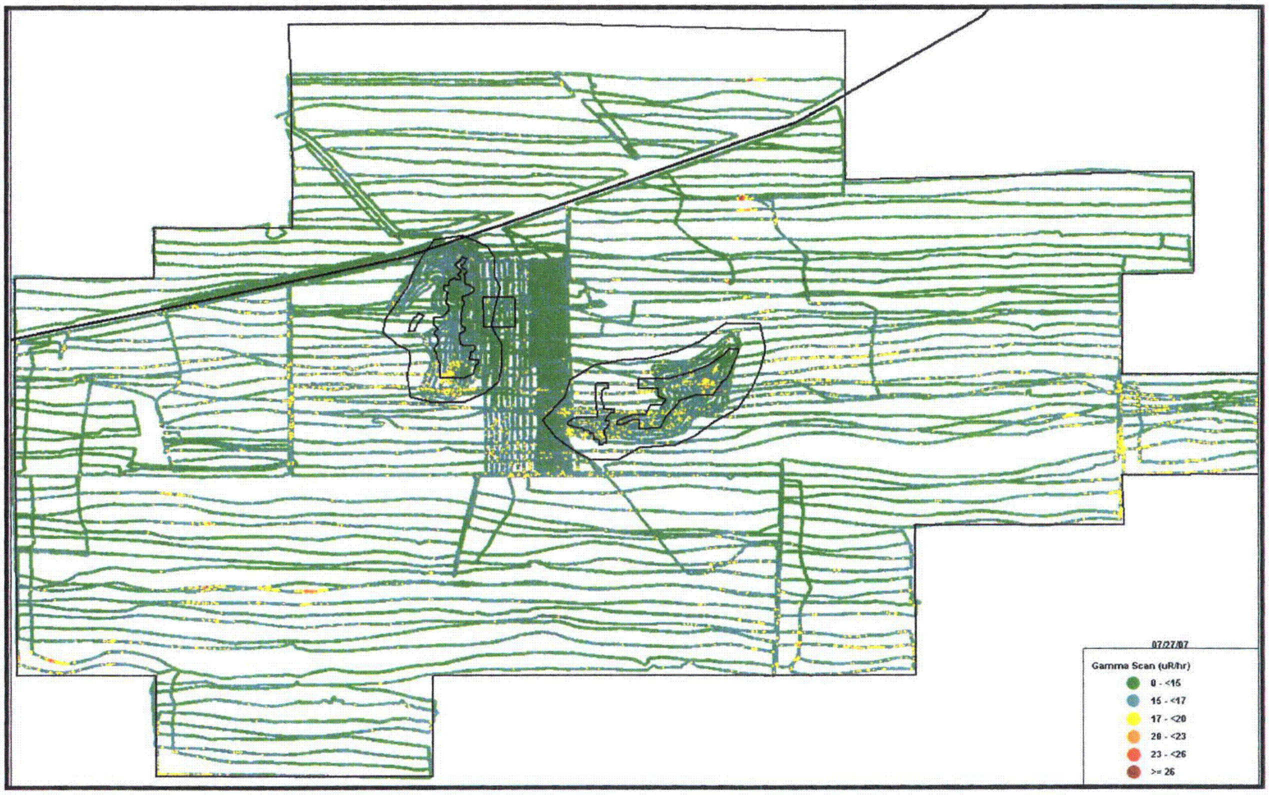


Figure 6.1-5: Baseline gamma survey results for the Moore Ranch site.

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.

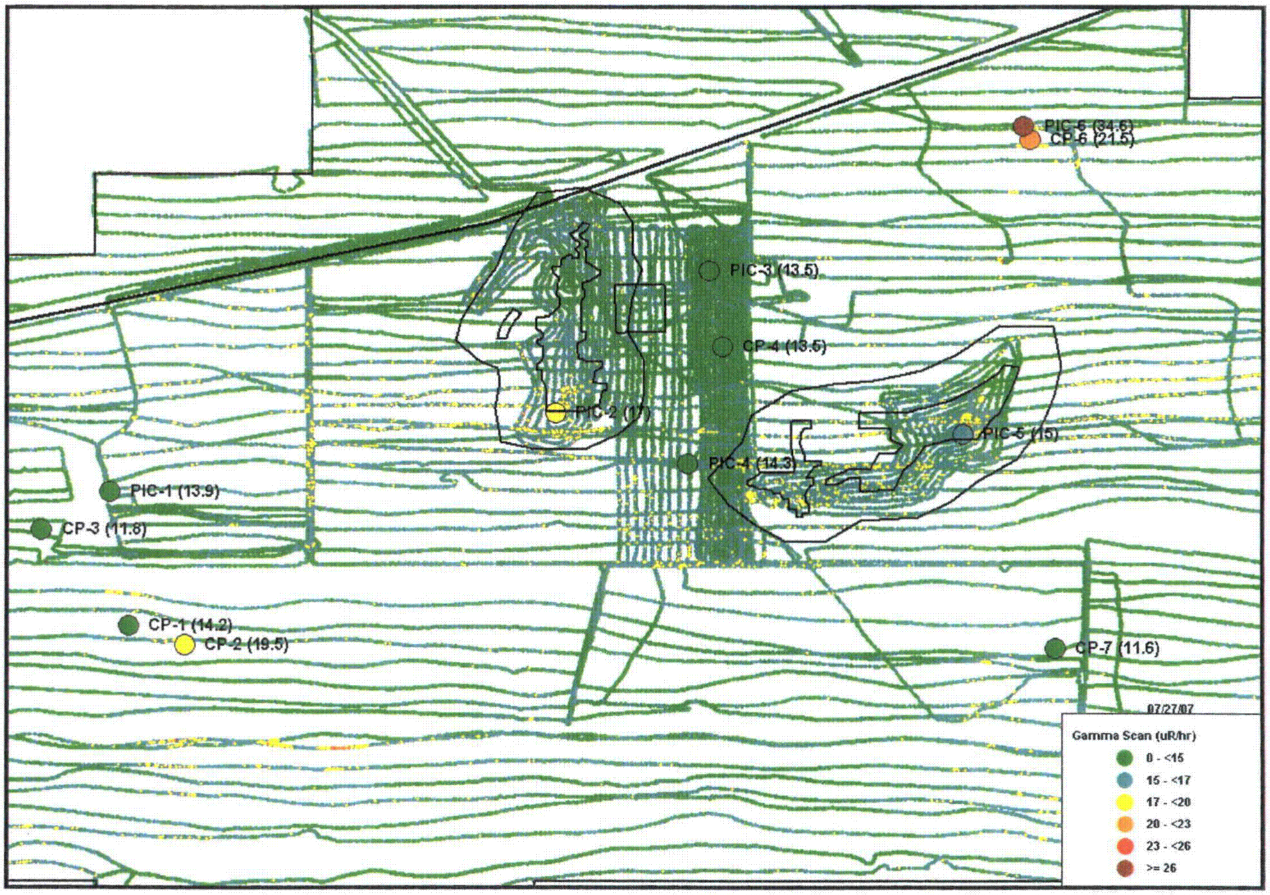


Figure 6.1-6: Select portion of baseline gamma survey results with discrete re-scan measurement overlays (denoted by the large circles).

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).

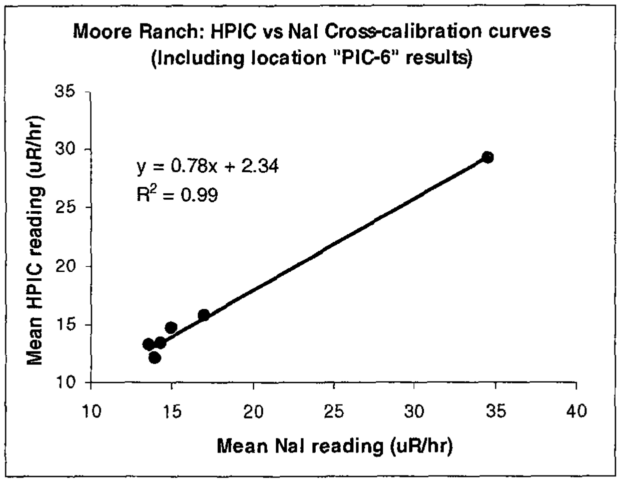


Figure 6.1-7: Cross-calibration curves for the HPIC versus NaI detectors positioned at 4.5-foot detector heights.

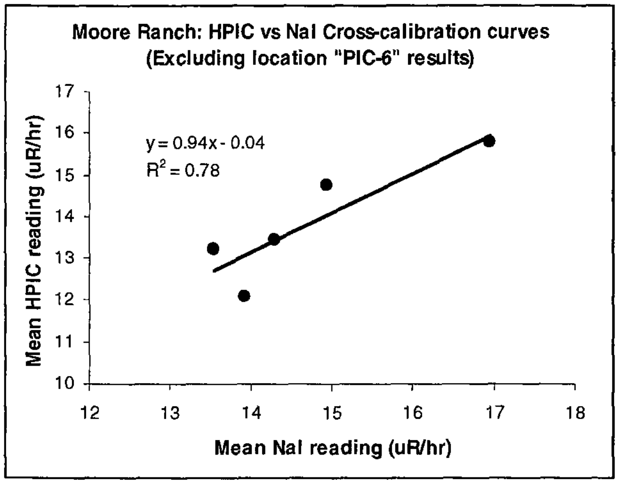


Figure 6.1-8: Cross-calibration curves for the HPIC versus NaI detectors positioned at 4.5-foot detector heights (excluding measurement results for location "PIC-6").

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).

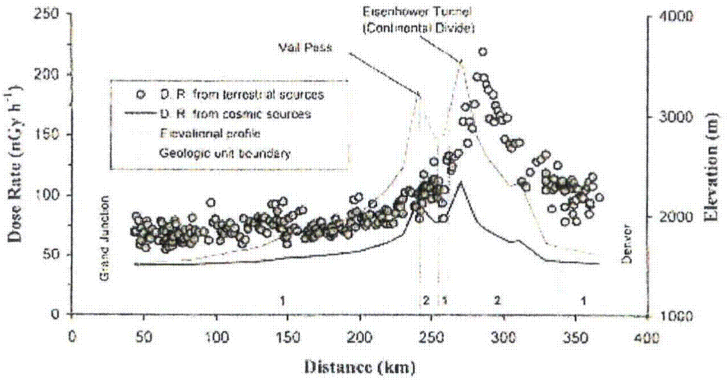


Figure 6.1-9: Estimated background dose rates to air from cosmic and terrestrial sources along I-17 from Grand Junction to Denver with generalized elevation profile and geology superimposed. Geologic units are simplified into two general types: 1 = sedimentary; 2 = granitic. (Adopted from Stone et al.,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

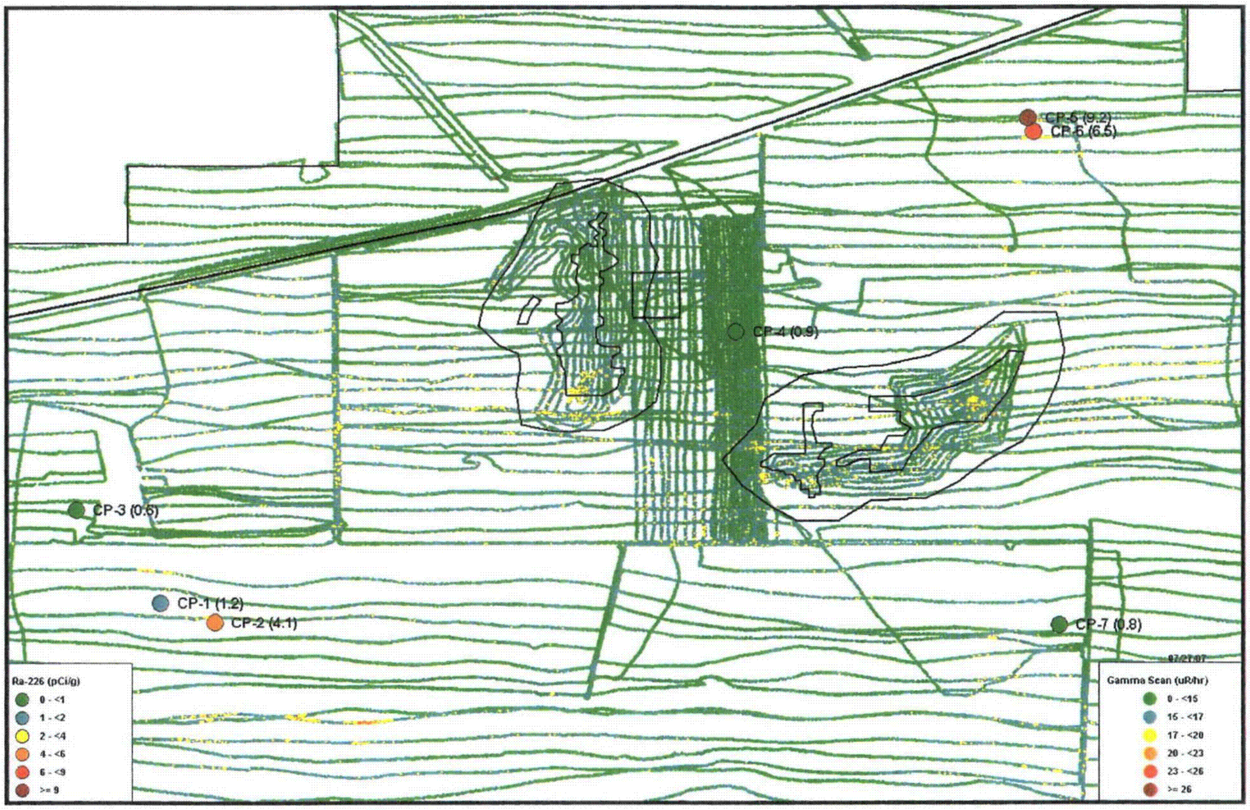


Figure 6.1-10: Overlay of correlation grid measurement locations and soil Ra-226 concentration results on the NaI gamma survey map.

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).

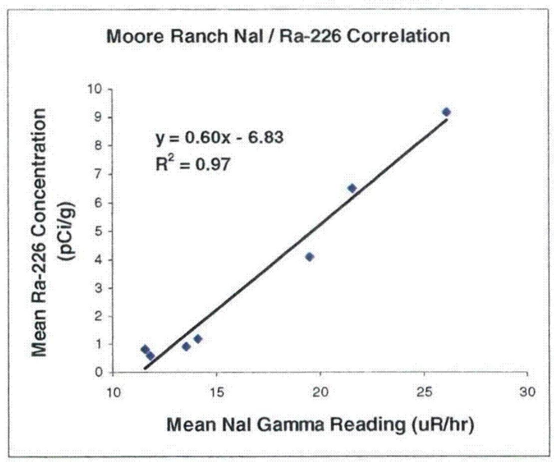


Figure 6.1-11: Correlation between Ra-226 soil concentration and NaI-based gamma exposure rate reading.

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

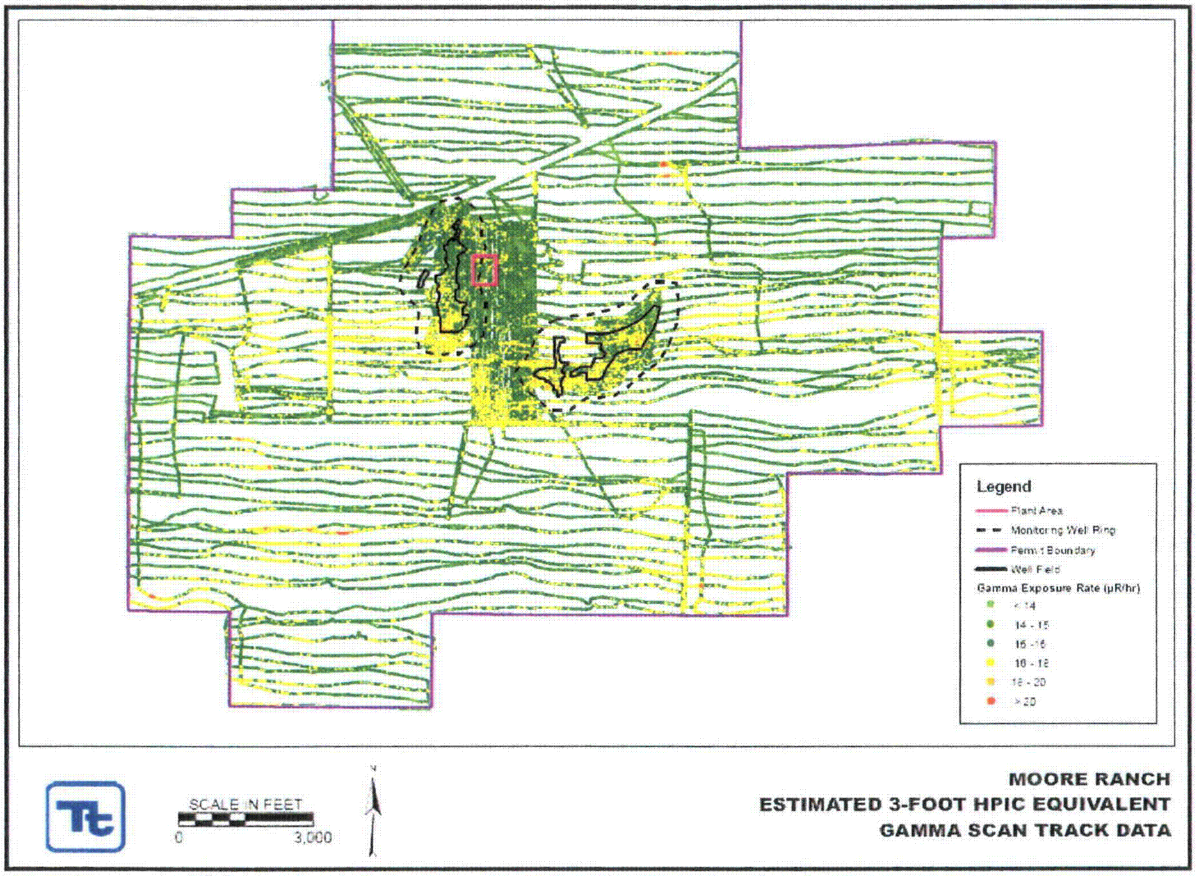


Figure 6.1-12: Estimated 3-foot HPIC equivalent gamma exposure rates in the Moore Ranch Area

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 permit area is shown in Figure 6.1-13, an E-sized version included at the end of Section 6.1.

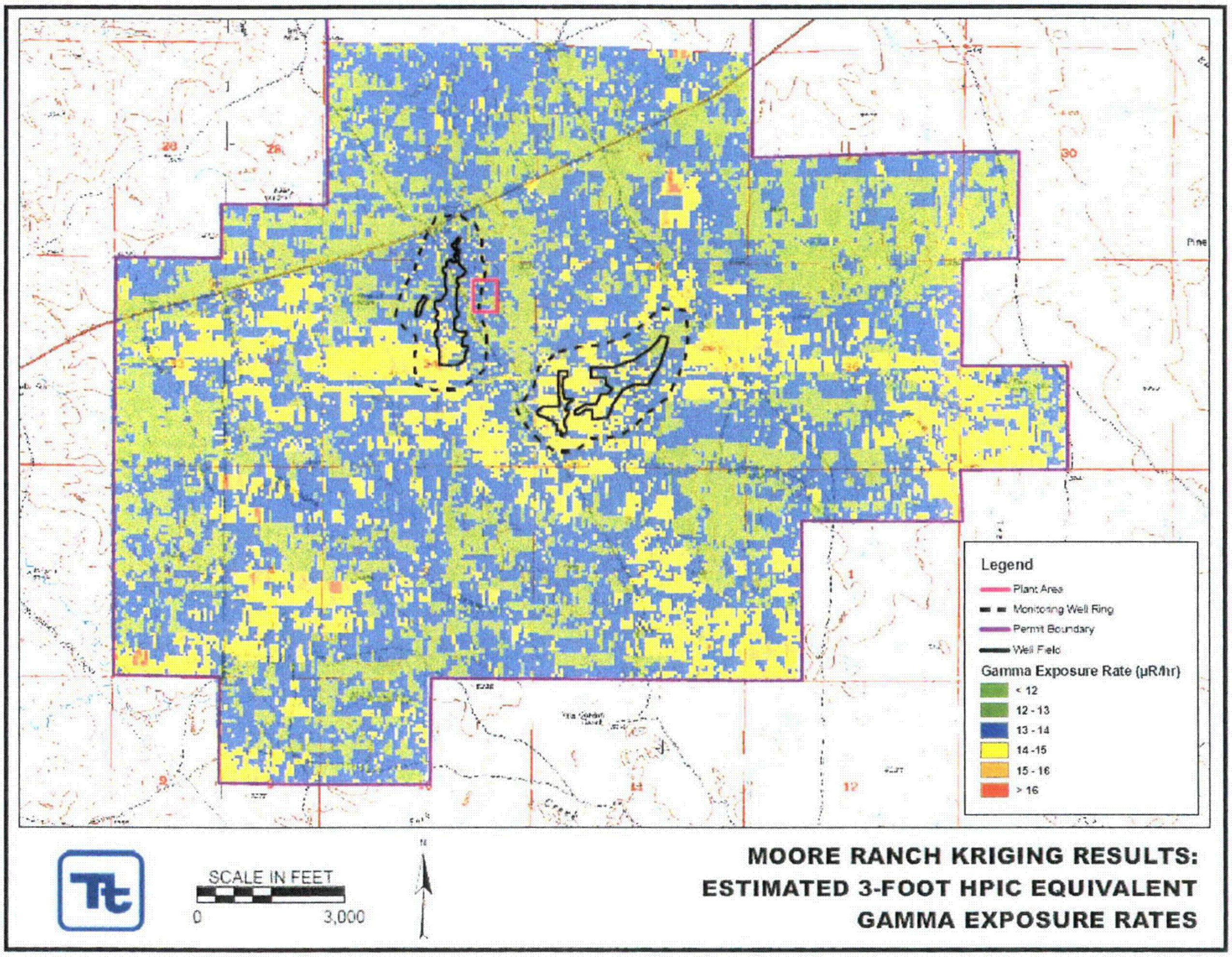


Figure 6.1-13: Continuous, kriged estimates of 3-foot HPIC equivalent gamma exposure rates in the Moore Ranch license area.

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.

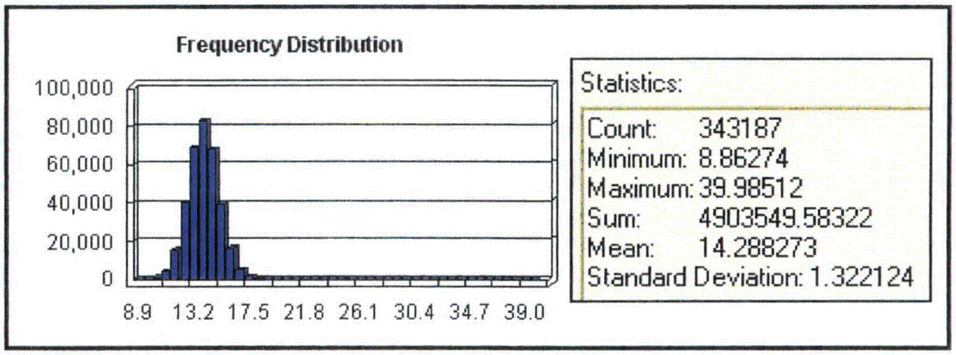


Figure 6.1-14: Frequency histogram of all NaI-based gamma exposure rate survey readings across the Moore Ranch license area.

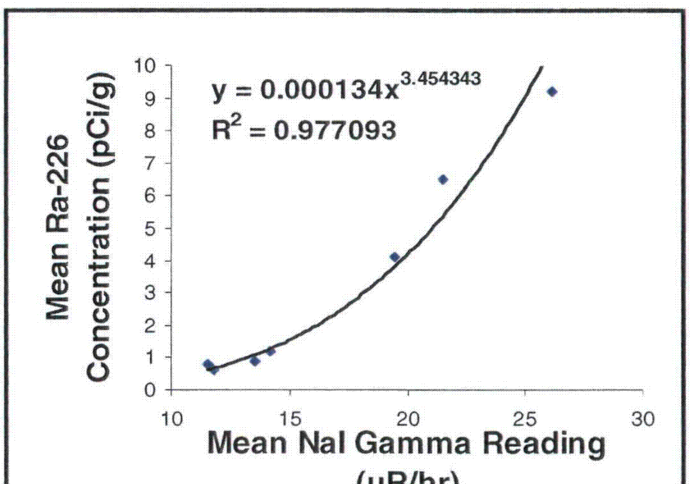


Figure 6.1-15: Power function fitted to gamma/Ra-226 correlation data to best model the relationship for the vast majority of readings across the site (readings < 20 μR/hr).

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.).

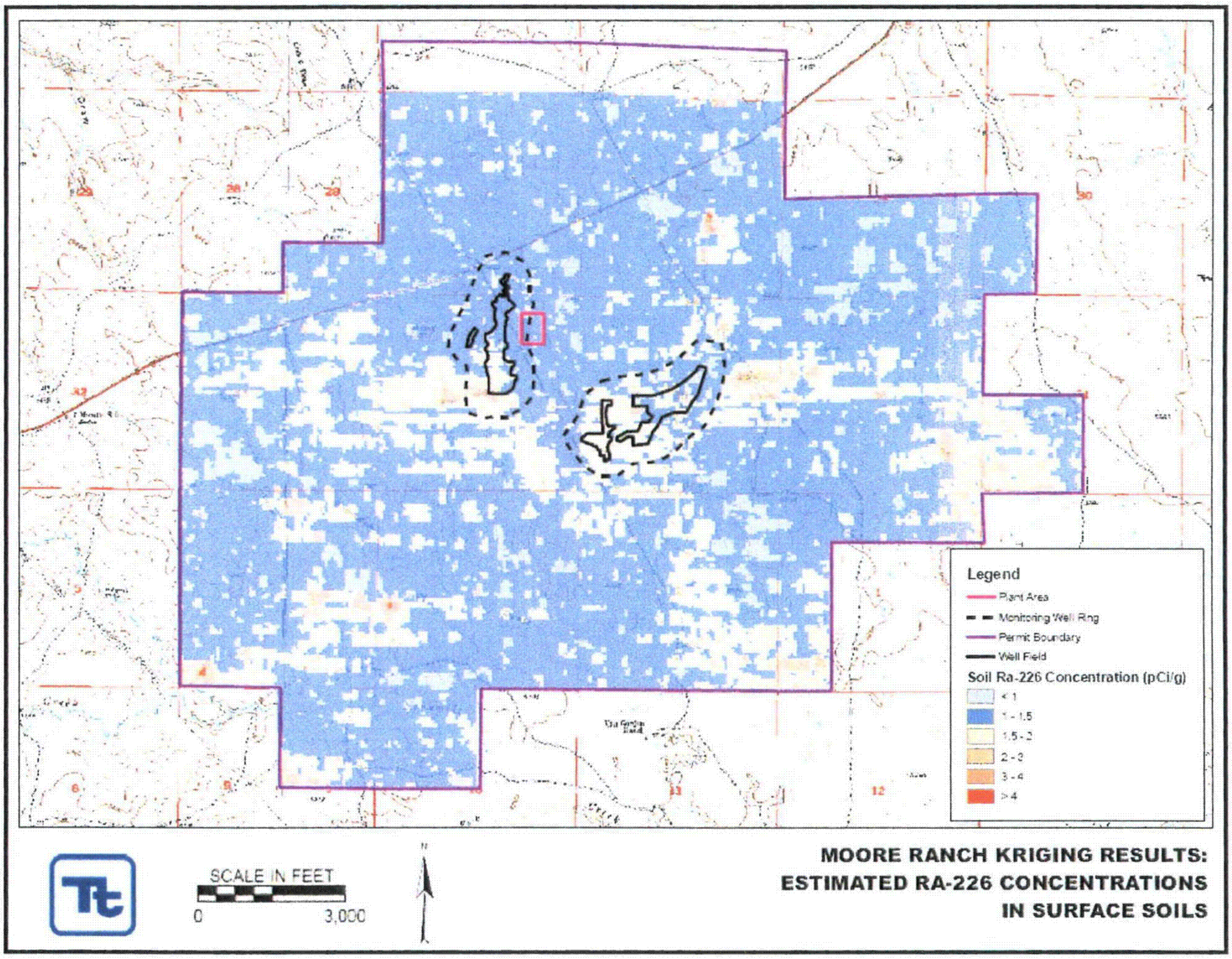


Figure 6.1-16: Continuous, kriged estimates of Ra-226 in the Moore Ranch license area based on gamma survey results.

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.

6.1.3 SOIL SAMPLING

In addition to the estimates of surface soil Ra-226 concentrations presented in Section 6.1.2 of this report (based on gamma survey results), comprehensive baseline soil sampling and analyses were conducted in accordance with Regulatory Guide 4.14 protocols. Data from these sampling efforts represent discrete, systematic locations involving 5-cm sampling depths for surface soils and incremental profile sampling to a depth of 1 meter for subsurface soils (NRC, 1980). With gamma/Ra-226 correlation grid and subsurface soil samplings, 15-cm surface soil depths are also represented in the survey data set. Surface soil radionuclide concentration data from both 5-cm and 15-cm soil depths are presented in this section in accordance with NUREG-1569 application review recommendations (NRC, 2003). In addition, summary descriptive statistics for historical survey data from the site (Conoco, 1980) are presented for comparison purposes and to further augment the overall characterization of soil radionuclide concentrations across the site.

6.1.3.1 Methods

6.1.3.1.1 Surface Soil Sampling

Soil sampling for the current survey was conducted in April of 2007. The surface soil sampling design involved a radial grid pattern with the proposed Moore Ranch Central Plant at the center of the grid. Discrete soil samples were collected along transects radiating in 8 compass directions from the plant at 300 meter intervals. Each transect was about 1,500 meters long, resulting in the collection of 5 samples per transect for a total of 41 "grid samples" that were subsequently analyzed by Energy Laboratories, Inc. (ELI) in Casper, WY. All samples were analyzed for Ra-226, along with other select analytes that are automatically included with ELI's high-purity germanium (HPGe) gamma spectroscopy analysis package for analysis of naturally occurring radionuclides. In addition, 10 percent of these samples were further analyzed for natural uranium (U-nat), Th-230, and Pb-210. An additional 4 surface soil samples were collected at the air particulate monitoring stations per Regulatory Guide 4.14 specifications.

All grid and air station surface soil samples were collected with a hand trowel to a depth of 5 cm, double bagged, and labeled. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book. Samples were hand-delivered to ELI in Casper, WY along with chain of custody / analysis request forms. Samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. For samples analyzed by HPGe gamma spectroscopy, aliquots were weighed and placed into counting tins, then sealed for about 21 days prior to counting to allow ingrowth of short-lived Ra-226 progeny and approximate equilibrium conditions to become established. Separate aliquots were used for analyses requiring wet radiochemical methods.

6.1.3.1.2 Depth Profile Soil Sampling

Five depth profile sampling locations were selected also based on Regulatory Guide 4.14 recommendations. One location was in the approximate center of planned Moore Ranch Central Plant facilities, with the other four locations located along radial transects used for surface soil sampling, at 750 meters from the plant in four compass directions.

Samples were collected with a hand-coring soil sample collector in 15-cm increments to a depth of 105 cm or until rocks prevented further coring device penetration. Sample collection, lab delivery, chain of custody, sample preparation, and analysis protocols were the same as those described above in Section 6.1.3.1.1 for surface soil samples. All soil depth profile samples were analyzed by HPGe gamma spectroscopy for Ra-226 and ELI's suite of naturally occurring radionuclides. The top-most and bottom-most layers of each depth sampling location were further analyzed for natural U, Th-230, and Pb-210 by wet radiochemical methods.

6.1.3.2 Soil Sampling Results

6.1.3.2.1 Surface Soil Sample Results

Frequency histograms of Ra-226 concentrations for all 0-5 and 0-15 depth samples are provided in Figure 6.1-17, with tabulations of respective summary statistics. The 0-15 cm result statistics include a mix of discrete, depth profile sample locations and composited correlation grid sampling locations. In both categories, results exceeding 2 pCi/g are from samples selectively collected in small, localized areas of higher gamma exposure rate readings. Excluding these few higher results, surface soil Ra-226 concentrations across the site averaged about 1.1 pCi/g.

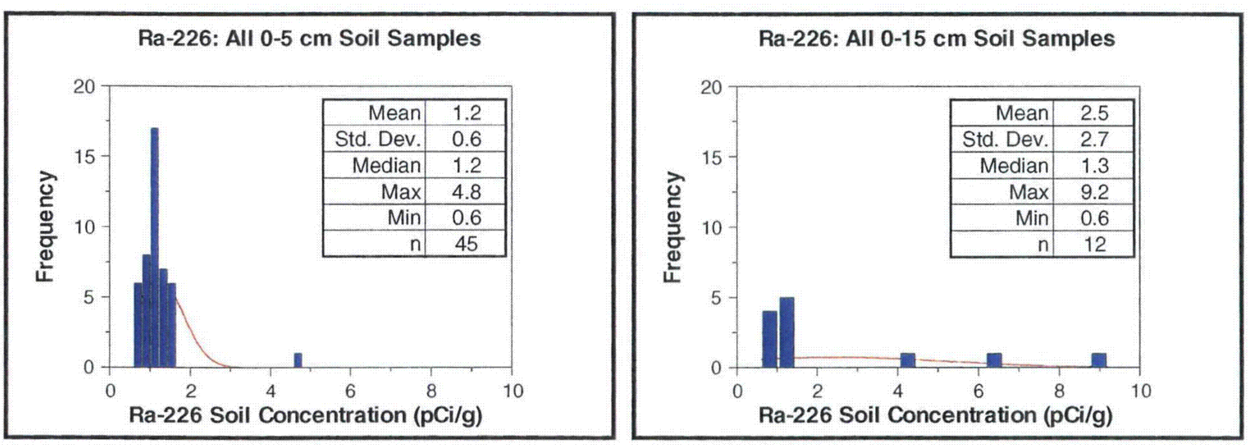


Figure 6.1-17: Frequency histograms and tabular summary statistics for soil Ra-226 concentrations among 0-5 cm and 0-15 cm samples. The 0-15 cm samples included composited correlation grid samples and discrete, depth profile sampling locations.

All 2007 surface soil sampling locations are shown in Figure 6.1-18, with color-coded Ra-226 ranges and annotations to show individual results. Given that low-end measurements averaged about 1.1 pCi/g, and respective analytical uncertainty was on the order of ± 0.2 – 0.5 pCi/g, it is reasonable to conclude that aside from relatively small, localized areas where consistently higher gamma readings exist at the site, baseline soil Ra-226 concentrations are unlikely to exceed 2 pCi/g. This conclusion is supported by comparison of measured soil sampling results with the continuous, kriged map of estimated soil Ra-226 concentrations based on gamma scan data (Figure 6.1-19).

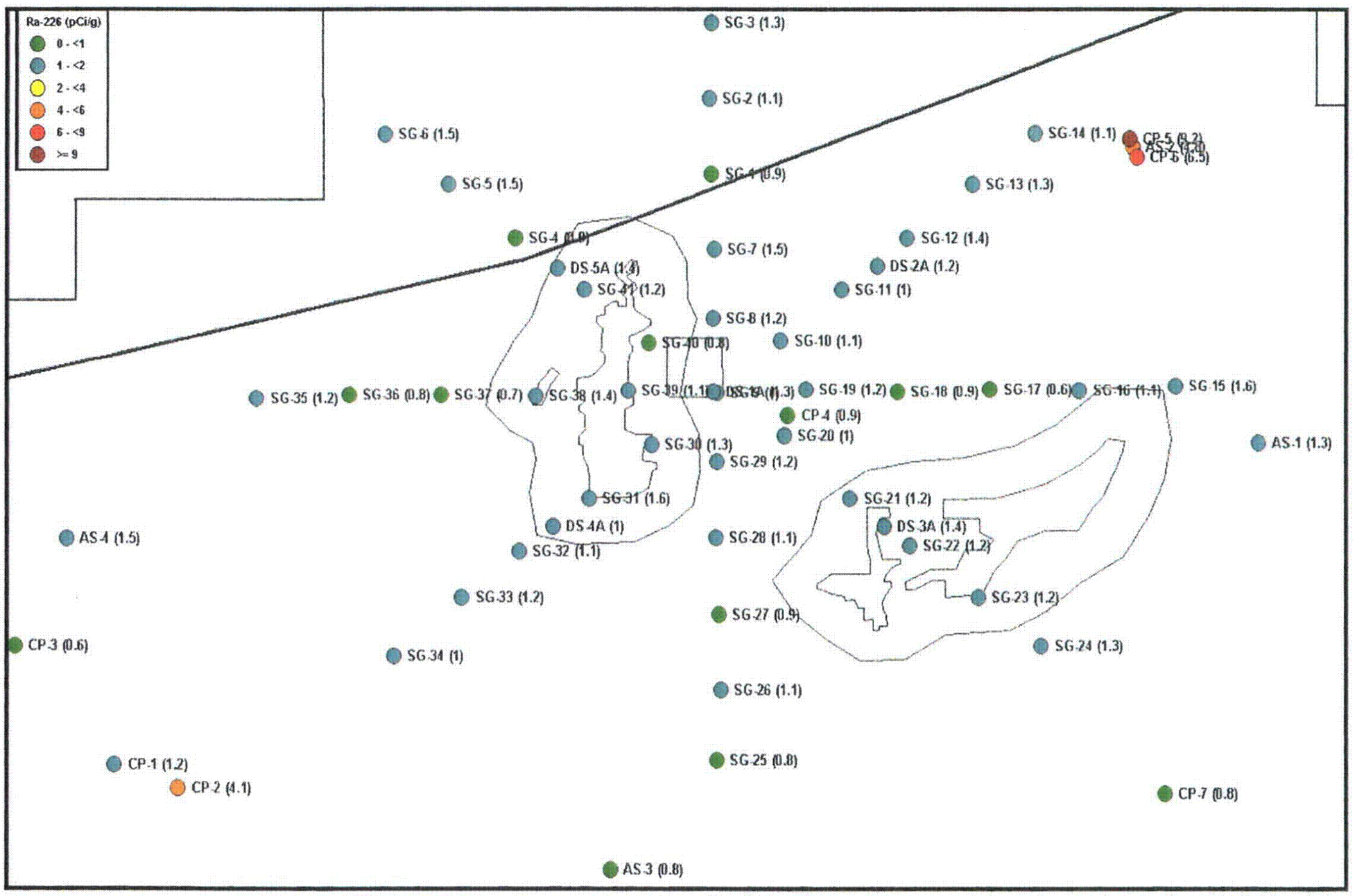


Figure 6.1-18: Surface soil sampling locations with color-coded Ra-226 ranges and individually annotated ID numbers and results.

In general, Figure 6.1-19 shows good agreement between measured and estimated Ra-226 concentrations in surface soils. Although there are apparent differences in some cases, mapping increment breakpoints are somewhat arbitrary for illustrative purposes, and the width of mapping increments is relatively narrow in relation to analytical uncertainties. Furthermore, mapped soil sample results primarily represent discrete samples and small-scale spatial variability (e.g. within a few meters) can be equally significant. In other words, small numerical differences between measured and estimated values (e.g. 0.1 – 0.5 pCi/g) can suggest disagreement on the map in Figure 6.1-19, even though respective results are unlikely to be significantly different in a statistical or truly quantitative sense. Overall, soil sampling results support the validity of continuous kriged estimates of Ra-226 concentrations based on gamma scan data (Figures 6.1-14 and 6.1-19).

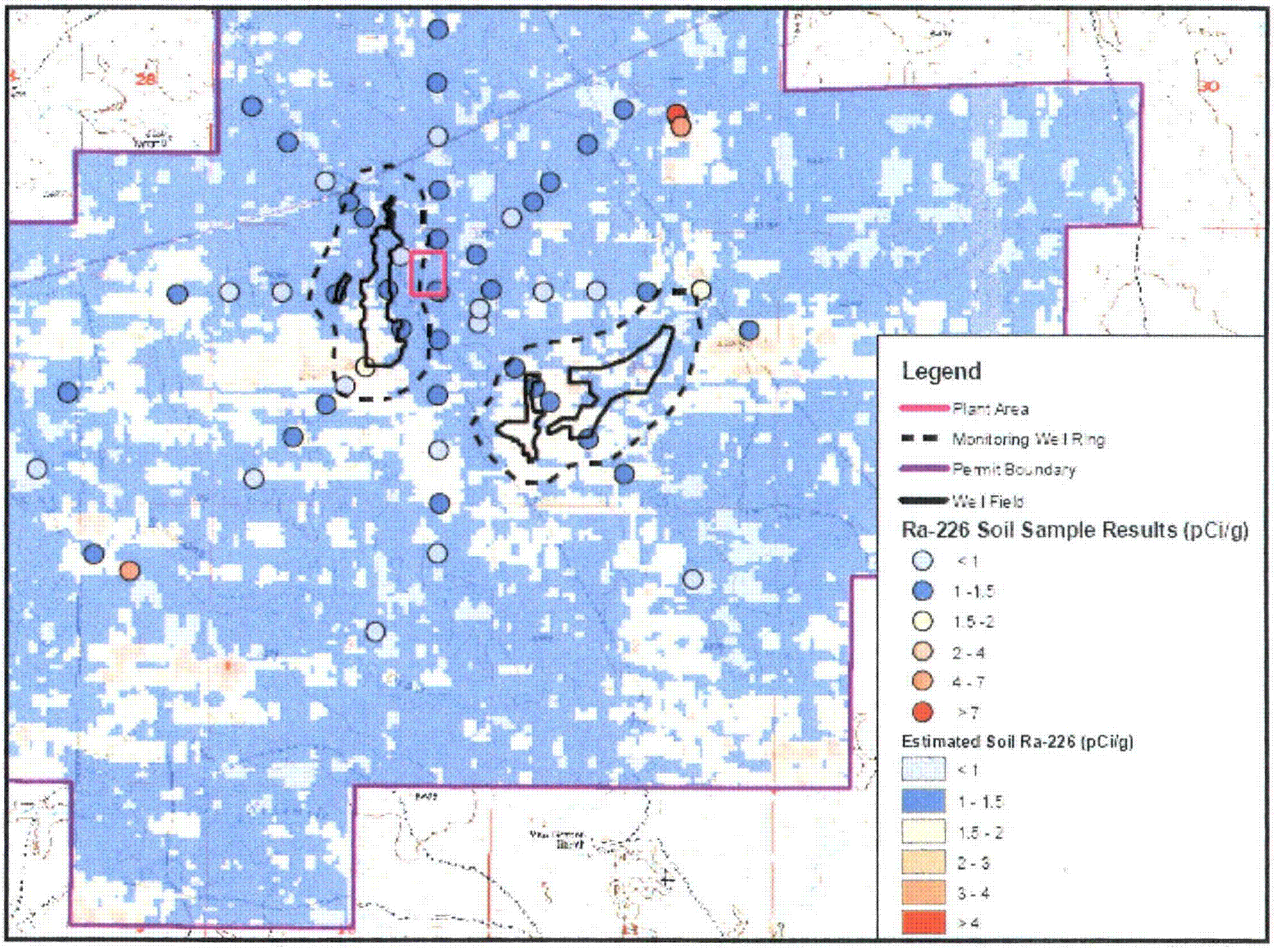


Figure 6.1-19: Gamma survey-based estimates of soil Ra-226 concentrations across the Moore Ranch License Area, with an overlay of actual surface soil sample results. Note that mapping increments in the upper half of the scale for soil sample results are widened to better illustrate measured Ra-226 results exceeding 4 pCi/g.

The historical Conoco survey data for surface soil Ra-226 concentrations (Figure 6.1-20) also agree reasonably well with the above results. A t-test comparison of 0-5 cm depth soil sampling results from the current and historical surveys did not reveal a significant difference between data sets at the 95% confidence level ($p = 0.08$), but a non-parametric Wilcoxon Rank Sum did ($p = 0.009$). There is no documented information on what analytical methods were used in the Conoco study. Despite some apparent distributional differences, mean and median values were nearly identical. Qualitatively, both data sets support the earlier conclusion that outside of the few relatively small areas of the site with elevated gamma readings, Ra-226 concentrations in surface soils are unlikely exceed 2 pCi/g. It does not appear that any areas with significantly elevated gamma readings were sampled in the historical survey.

Summary statistics for analytes other than Ra-226 in surface soil samples are given in Table 6.1-3. These statistics are given by sample series as denoted by their respective sample ID prefixes [AS = air station; SG = soil grid; DS (A) = depth sample (surface layer)], as well as for the historical survey data. Cases of higher mean and maximum values in the AS series are attributable to a sample collected in a location where high Ra-226 and gamma readings were also found (see sample locations AS-2, CP-5 and CP-6 in Figure 6.1-18). In general, historical survey data results for these analytes compare reasonably well with current survey data. This is particularly true when looking at median values, which helps reduce the influence of at least one notable exception - the comparatively high maximum Pb-210 value of 60 pCi/g found in one historical sample.

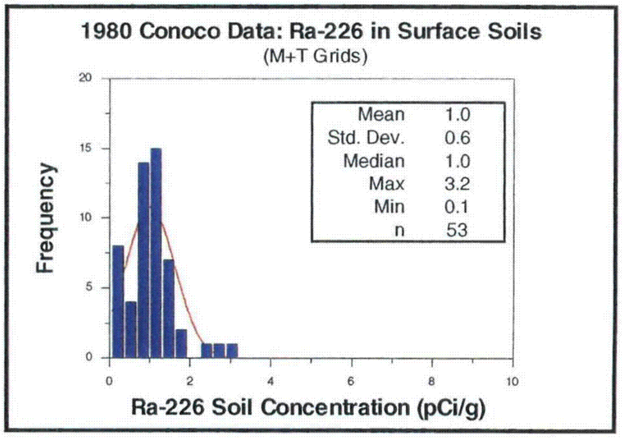


Figure 6.1-20: Frequency histogram and tabular summary statistics for 0-5 cm soil Ra-226 concentrations from the historical Conoco baseline survey.

Table 6.1-3: Summary statistics for Pb-210, Th-230, and U-nat in surface soil samples.

Sample Series	Sample Depth (cm)	Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
AS	0-5	Pb-210	2.3	1.0	2.3	3.5	1.1	4
		Th-230	1.4	1.9	0.5	4.3	0.3	4
		U-nat	1.2	1.1	0.8	2.8	0.6	4
SG	0-5	Pb-210	3.2	1.3	3.2	4.6	2.0	4
		Th-230	0.4	0.1	0.4	0.5	0.3	4
		U-nat	0.8	0.1	0.8	0.9	0.7	4
DS (A)	0-15	Pb-210	0.5	0.4	0.5	1.2	0.1	5
		Th-230	0.4	0.1	0.4	0.5	0.3	5
		U-nat	0.9	0.1	0.9	1.0	0.7	5
Historical Data	0-5	Pb-210	8.4	18.2	2.7	60	1.4	10
		Th-230	1.4	0.6	1.3	2.7	0.8	10
		U-nat	1.6	1.6	0.9	5.1	0.0	10

6.1.3.2.2 Subsurface Soil Sample Results

Subsurface sampling locations and respective surface layer Ra-226 results are shown in Figure 6.1-18, with "DS" sample ID prefixes (labeling for sample location DS-1 is obscured in the figure, but is located in the very center of the radial grid pattern where processing plant facilities will be located). Summary statistics for each depth sample increment and each indicated Regulatory Guide 4.14 analyte are provided in Table 6.1-4. There are no readily apparent trends between analyte and depth, suggesting that vertical distribution of these radionuclides is fairly consistent to a depth of 1 meter. None of the localized areas at the site with consistently higher gamma readings were sampled for subsurface soil profiles as the applicable Regulatory Guide 4.14 grid pattern for this investigation was followed.

Table 6.1-4: Summary statistics for Ra-226, Pb-210, Th-230, and U-nat in depth profile soil samples.

Sample Series	Sample Depth (cm)	Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
DS (A)	0-15	Ra-226	1.3	0.2	1.3	1.4	1.0	5
		Pb-210	0.5	0.4	0.5	1.2	0.1	5
		Th-230	0.4	0.1	0.4	0.5	0.3	5
		U-nat	0.9	0.1	0.9	1.0	0.7	5
DS (B)	15-30	Ra-226	1.4	0.2	1.3	1.6	1.2	5
DS (C)	30-45	Ra-226	1.4	0.3	1.3	1.8	1.1	5
DS (D)	45-60	Ra-226	1.3	0.2	1.2	1.6	1.1	5
DS (E)	60-75	Ra-226	1.1	0.3	1.3	1.4	0.8	5
DS (F)	75-90*	Ra-226	1.1	0.3	1.3	1.4	0.8	5
DS (G)	90-105*	Ra-226	1.1	0.3	1.1	1.4	0.9	4
		Pb-210	0.3	0.1	0.3	0.4	0.1	5
		Th-230	0.5	0.1	0.5	0.7	0.3	5
		U-nat	1.5	1.2	0.8	3.2	0.6	5
DS (A-G)	All depths	Ra-226	1.2	0.2	1.3	1.8	0.8	34
		Pb-210	0.4	0.31	0.4	1.2	0.1	10
		Th-230	0.5	0.13	0.5	0.7	0.3	10
		U-nat	1.2	0.87	0.9	3.2	0.6	10

*One sample was truncated at 85 cm due to rock

Despite differences in depth sampling increments, the historical survey data for Ra-226 in subsurface samples (Table 6.1-5) agree well with the summary statistics provided above in Table 6.1-4. General similarities can also be seen for Pb-210, Th-230, and U-nat in most cases (Table 6.1-6). As with 2007 survey data, there do not appear to be any significant differences or trends with depth for the historical radionuclide data.

Table 6.1-5: Summary statistics of historical baseline survey data (Conoco, 1980) for Ra-226 in subsurface depth profile soil samples.

Sample Series	Sample Depth (ft)	Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
M+T Grids	0-1	Ra-226	1.3	0.4	1.3	2.1	0.7	10
M+T Grids	1-2	Ra-226	1.3	0.5	1.3	2.4	0.8	10
M+T Grids	2-3	Ra-226	1.1	0.4	1.2	1.9	0.6	10

Table 6.1-6: Individual sample results for Pb-210, Th-230, and U-nat in subsurface soil samples from the historical baseline survey.

Sample Series	Sample Depth (ft)	Analyte	Result (pCi/g)
M Grid (center)	0-1	Pb-210	0.8
		Th-230	1.0
		U-nat	1.6
M Grid (center)	1-2	Pb-210	1.6
		Th-230	1.4
		U-nat	2.5
M Grid (center)	2-3	Pb-210	0.6
		Th-230	1.0
		U-nat	1.7
T Grid (center)	0-1	Pb-210	0.6
		Th-230	1.4
		U-nat	2.4
T Grid (center)	1-2	Pb-210	1.1
		Th-230	2.1
		U-nat	2.3
T Grid (center)	2-3	Pb-210	3.1
		Th-230	3.3
		U-nat	3.6

6.1.3.3 Conclusions

Baseline soil radionuclide data from the 2007 survey were collected and analyzed according to Regulatory Guide 4.14 protocols. The corresponding historical survey data generally corroborate 2007 survey results. These data sets, combined with the continuous kriged estimates of Ra-226 concentrations across the site based on the extensive gamma survey data presented in Section 6.1.2, provide a thoroughly detailed and comprehensive characterization of existing soil radionuclide concentrations across the site. This information should meet respective baseline characterization requirements as indicated by the USNRC and the WDEQ/LQD for ISR licensing/permitting applications.

Note: Radionuclides listed in Tables 6.1-4 through 6.1-6 are believed to be in approximate secular equilibrium. Apparent discrepancies may be due to differences in analytical techniques (gamma spectroscopy versus dissolution/wet radiochemistry).

6.1.4 Sediment Sampling

In April of 2007, baseline sediment sampling was conducted at the Moore Ranch Project area in accordance with Regulatory Guide 4.14 protocols (NRC, 1980). Both ephemeral stream drainage channels and surface water impoundments were sampled. In all, 7 samples were collected from three primary stream drainage channels found at the site, at license area boundaries both upstream and downstream of the planned plant location. Stream drainage channel sediment sampling in April was the first of two planned sampling events, the other scheduled to occur in late summer or fall of 2007. These two sampling events are intended to characterize radionuclide content in stream sediments during seasonal runoff and low-flow conditions (NRC, 1980). Although drainage channel sampling locations generally had moist sediments during the spring sampling, none of locations sampled had flowing or standing water present and most were grassy in nature (Figure 6.1-21).

Figure 6.1-21: Sediment sampling: typical ephemeral stream drainage channel at the Moore Ranch site.

Sediment samples were collected from 13 surface water impoundments representing the majority of impoundments found at the site (primarily stockponds). These locations all had surface water present at the time of sampling (Figure 6.1-22). For surface water impoundment sediments, a one-time sampling event is indicated by Regulatory Guide 4.14 as sufficient to document respective radiological conditions.

Figure 6.1-22: Sediment sampling: typical surface water impoundment at the Moore Ranch site.

This section presents results of 2007 sediment sampling at the Moore Ranch Uranium Project area. Summary statistics of sediment sampling data from the historical survey of the site (Conoco, 1980) are presented for comparison purposes and to further augment the overall characterization of radionuclide concentrations in sediments across the site.

6.1.4.1 Methods

6.1.4.1.1 Stream Sediment Sampling

Stream sediment sampling locations were determined from topographical maps to represent the primary drainages found at the site. At each location, four sediment sub-samples were collected with a hand trowel to a depth of 5 cm each, along a transect spanning the width of the lowest portion of the ephemeral stream channel. The four sub-samples were composited to represent the average radionuclide concentration across the drainage channel. Composite sediment samples were subsequently double bagged, and labeled. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book.

Samples were hand-delivered to ELI in Casper, WY along with chain of custody / analysis request forms. Samples were dried, crushed, ground, and thoroughly homogenized prior to analysis. All samples were analyzed for Ra-226, along with other select analytes that are automatically included with ELI's gamma spectroscopy analysis package for analysis of naturally occurring radionuclides. In addition, all stream sediment samples were further analyzed for U-nat, Th-230, and Pb-210. For samples analyzed by HPGe gamma spectroscopy, aliquots were weighed and placed into counting tins, then sealed for about 21 days prior to counting to allow ingrowth of short-lived Ra-226 progeny and approximate equilibrium conditions to become established. Separate aliquots were used for analyses requiring wet radiochemical methods.

6.1.4.1.2 Surface Water Impoundment Sediment Sampling

Sediment sampling locations for surface water impoundments (hereafter referred to as "ponds") were determined from a combination of topographical maps and consultation with a staff member from EMC familiar with actual pond locations (most ponds were not shown on available maps). At each pond, a single grab sample of sediment was collected with a hand trowel to a depth of 5 cm, in a location near the waters edge that was both convenient for sampling and that appeared relatively undisturbed (Figure 6.1-23). Pond sediment samples were double bagged and labeled. Location ID numbers, date, and GPS coordinates for each sampling location were recorded in the field log book.

Figure 6.1-23: Pond sediment sampling at the Moore Ranch Uranium Project site.

Lab delivery, chain of custody, sample preparation, and analysis protocols for pond sediment samples were the same as those described in above in Section 6.1.4.1.1 for stream sediment samples. All samples were analyzed by gamma spectroscopy for Ra-226 and ELI's suite of naturally occurring radionuclides, as well as for U-nat, Th-230, and Pb-210 by wet radiochemical methods.

6.1.4.2 Sediment Sampling Results

6.1.4.2.1 Stream Sediment Sample Results

Descriptive summary statistics of the stream sediment data for each indicated Regulatory Guide 4.14 analyte are provided in Table 6.1-7. Individual stream drainage channel sampling locations and respective Ra-226 results are shown in Figure 6.1-24, with "SS" sample ID prefixes. In general, stream sediment baseline results are similar to those found for both surface and subsurface soils at the site.

Table 6.1-7: Summary statistics for radionuclide concentrations in stream sediment samples from the Moore Ranch Uranium Project area.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.2	0.30	1.3	1.6	0.7	7
Pb-210	1.7	0.80	1.5	3.2	1.0	7
Th-230	0.5	0.10	0.5	0.7	0.4	7
U-nat	0.8	0.18	0.8	1.0	0.5	7

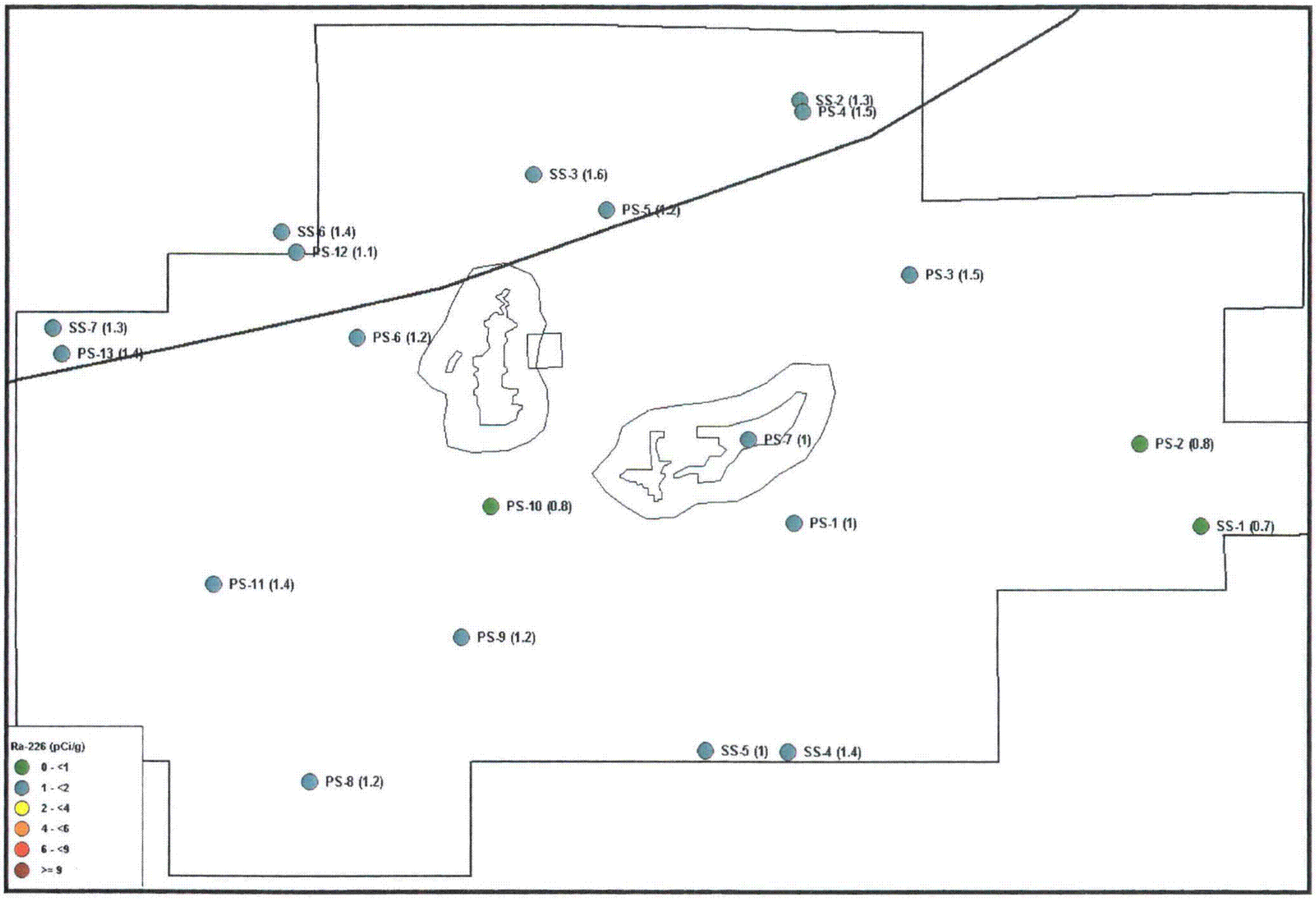


Figure 6.1-24: Sediment sampling locations and respective Ra-226 concentration results for both ephemeral stream drainage channels and surface water impoundments (ponds).

Stream sediment sample results from the historical survey (Conoco, 1980) are summarized in Table 6.1-8. Results for Pb-210 were not completed at the time of the Conoco report, but the other results are very similar to results from the 2007 survey. Because the historical samples were collected in the fall of 1980, they represent "low-flow" conditions and suggest that seasonal variations in stream sediment radionuclide concentrations are not likely to be significant. Furthermore, historical "low-flow" data combined with "high-flow" data collected in the spring of 2007 might be considered by NRC and WDEQ as sufficient overall documentation of stream sediment conditions with respect to license applications.

Table 6.1-8: Summary statistics for radionuclide concentrations in stream sediment samples from the historical 1980 survey.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.3	0.46	1.2	1.8	0.8	4
Pb-210*	-	-	-	-	-	-
Th-230	1.4	0.40	1.4	2.0	0.9	5
U-nat	1.9	1.06	2.1	3.3	0.6	5

* Analysis results not completed at time of 1980 Conoco report

6.1.4.2.2 Pond Sediment Sample Results

Descriptive summary statistics of these data for each indicated Regulatory Guide 4.14 analyte are provided in Table 6.1-9. Individual pond sediment sampling locations and respective Ra-226 results are shown in Figure 6.1-10, with "PS" sample ID prefixes. In general, pond sediment results are similar to those of stream sediments as well as surface/subsurface soils at the site.

Table 6.1-9: Summary statistics for radionuclide concentrations in 2007 pond sediment samples from the Moore Ranch Project area.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.2	0.24	1.2	1.5	0.8	13
Pb-210	1.1	0.57	1.1	2.2	-0.1	13
Th-230	0.5	0.20	0.4	1.0	0.3	13
U-nat	1.1	0.78	1.0	2.7	0.1	13

Pond sediment sample results from the historical survey (Conoco, 1980) are summarized in Table 6.1-10. Results for Pb-210 were not completed at the time of the Conoco report, but the other results agree reasonably well with pond sediment results from the 2007 survey.

Table 6.1-10: Summary statistics for radionuclide concentrations in pond sediment samples from the historical 1980 survey.

Analyte	Mean (pCi/g)	Std. Dev. (pCi/g)	Median (pCi/g)	Max (pCi/g)	Min (pCi/g)	n
Ra-226	1.3	0.93	0.9	3.5	0.4	12
Pb-210*	-	-	-	-	-	-
Th-230	1.3	0.28	1.3	1.6	0.8	12
U-nat	2.1	1.20	1.7	4.5	0.5	13

* Analysis results not completed at time of 1980 Conoco report

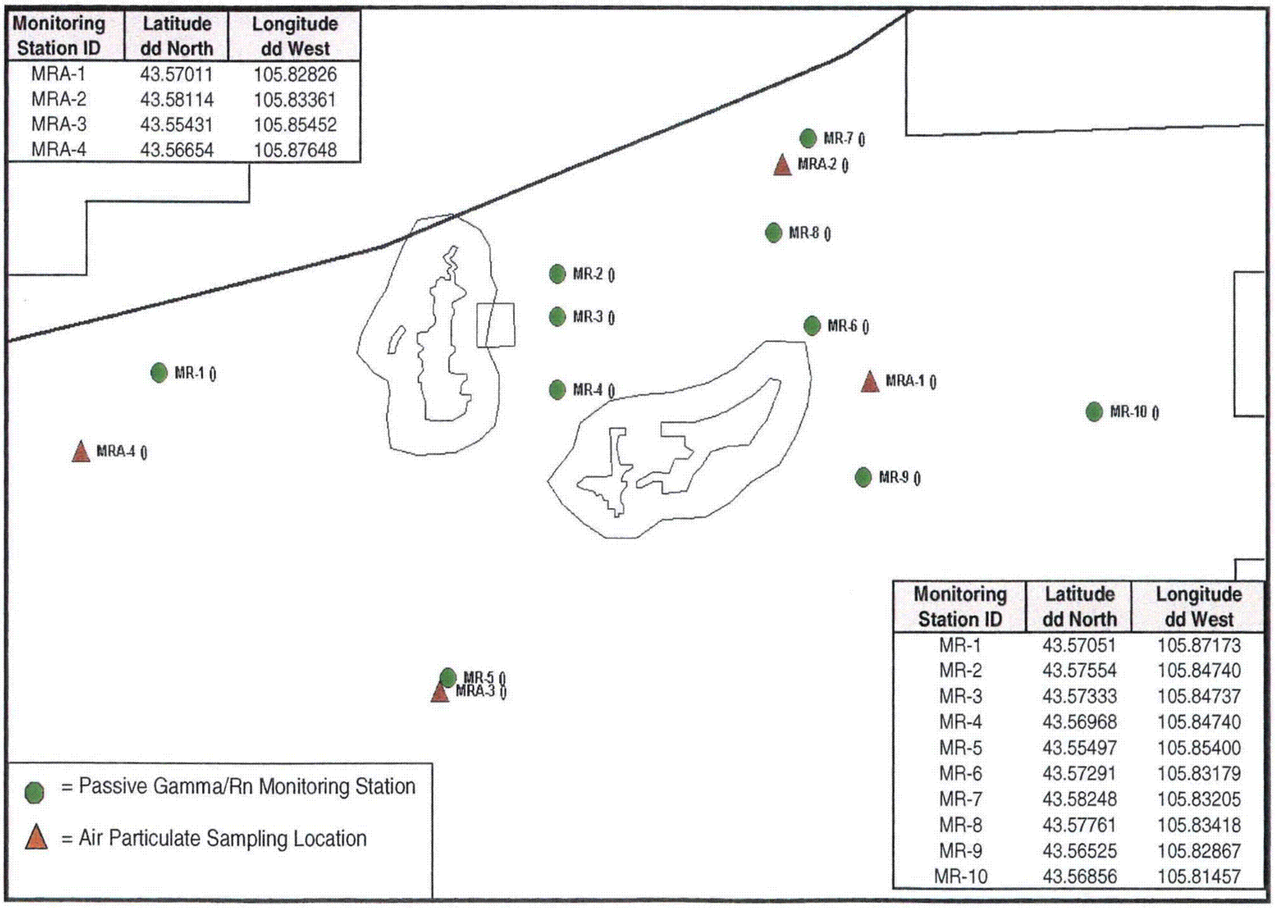
6.1.4.3 Conclusions

Baseline sediment radionuclide data from the 2007 survey were collected and analyzed according to Regulatory Guide 4.14 protocols. The corresponding historical survey data generally corroborate 2007 survey results. With respect to stream sediments, the 2007 and historical data sets, while technically incomplete individually, combined may be considered sufficient by the NRC and WDEQ/LQD in terms of adequately characterizing potential seasonal variations in overall radionuclide concentrations. The scheduled second sampling of stream sediments during the fall of 2007 will be carried out as planned and results provided to both agencies as soon as completed. With respect to pond sediment data, the historical data simply augment the 2007 survey data resulting in a more robust respective characterization. This information should be sufficient to meet the completeness requirements for site characterization of sediment radionuclide concentrations for administrative review as indicated by the USNRC and the WDEQ/LQD.

6.1.5 Ambient Gamma and Radon Monitoring

Continuous passive monitoring of ambient gamma dose rates and radon concentrations was initiated in December 2006. Regulatory Guide 4.14 calls for 12 consecutive months of respective monitoring data as part of the overall radiological characterization of the site (NRC, 1980). These data are being collected and reported on a quarterly basis. As of the effective date of this report, 2 quarters of 2006-2007 monitoring data (hereafter termed "2007 data") are available and presented in this section.

Corresponding historical data (Conoco, 1980) are also summarized and compared to currently available 2007 monitoring data. The historical data set is also technically incomplete with respect to Regulatory Guide 4.14 specifications, however, the combined data sets might be considered by the NRC and WDEQ/LQD as sufficient documentation of baseline conditions to meet completeness requirements for administrative acceptance of licensing applications prior to completion of the final 2 quarters of data collection and analysis. In either case, those final data will be submitted to both agencies as they become available.



Monitoring Station ID	Latitude dd North	Longitude dd West
MRA-1	43.57011	105.82826
MRA-2	43.58114	105.83361
MRA-3	43.55431	105.85452
MRA-4	43.56654	105.87648

Monitoring Station ID	Latitude dd North	Longitude dd West
MR-1	43.57051	105.87173
MR-2	43.57554	105.84740
MR-3	43.57333	105.84737
MR-4	43.56968	105.84740
MR-5	43.55497	105.85400
MR-6	43.57291	105.83179
MR-7	43.58248	105.83205
MR-8	43.57761	105.83418
MR-9	43.56525	105.82867
MR-10	43.56856	105.81457

Figure 6.1-25: Passive gamma/radon and air particulate monitoring station locations at the Moore Ranch Project area.

Passive devices for monitoring ambient gamma dose rates and radon levels are each housed at the same station. Station locations were selected based on Regulatory Guide 4.14 guidance, including consideration for the locations of plant facilities, prevailing wind directions, air monitoring stations, and practical access. In all, 10 of these passive stations were installed, including one or more stations located near each air particulate monitoring station. Locations of passive monitoring stations, as well as air particulate sampling stations, are shown in Figure 6.1-25.

6.1.5.1 Methods

6.1.5.1.1 Ambient Gamma Dose Rate Monitoring

Passive monitoring of gamma dose rates at the site is being conducted with thermo-luminescent dosimeters (TLDs) supplied by Landauer, Incorporated. The TLDs are housed in insulated plastic spigot covers, attached to fence posts (Figure 6.1-26). Radon monitoring devices are also housed in these spigot covers.

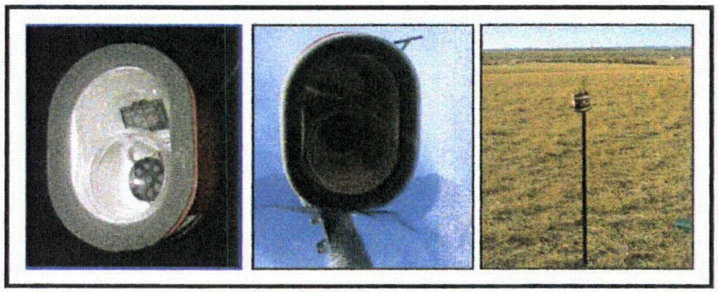


Figure 6.1-26: Photos of passive gamma/radon monitoring station equipment.

Each batch of TLDs contains a "transit" and "deploy" control TLD badge to account for background doses received by field badges when not actually deployed at the site. The transit control is stored at the Tetra Tech office in Fort Collins, Colorado (away from any radioactive sources) at all times except while in transit to and from Landauer. The deploy control badge accompanies the transit control badge at all times except for the short period of time it must travel to or from the site along with field badges during their respective deployment or removal from the site.

Landauer reports a "net" dose result, calculated by subtracting the gross deploy control badge result from each field badge result. This gives the net above background dose, which is useful for occupational dose assessments relative to regulatory dose limits, but is not applicable for environmental monitoring where the total dose received at the site during the monitoring period is of interest. For this, a different calculation is required, one that subtracts only the fraction of control badge dose that corresponds with the amount of time the field badges are not actually deployed at the site. For Moore Ranch, the calculations used to obtain this gamma dose value are outlined as follows:

1. Determine the average daily dose rate for the transit control badge:
   - Assuming the control badge receives background doses at a relatively constant rate, this is calculated as the gross reported dose (mrem), divided by the total number of days from TLD issuance to TLD analysis by the dosimetry vendor.

2. Determine the total dose to the field dosimeter whenever accompanied by the transit control badge:
   - Assume the field badge receives the same average daily dose rate as the transit control badge for all periods while stored or transported together with the transit control badge.
   - Calculate the total dose to the field dosimeter whenever accompanied by the transit control badge as: (Result from step 1 above) × (number of days from TLD issuance to TLD analysis, minus the number of days the field badge was actually deployed at the site)
3. Determine any additional background dose received by the field badge during deployment to and from the site:
   - Calculate the difference between the deploy control badge and the transit control badge, assuming this value represents the additional total dose received by the field badge during transport to and from the site.
4. Calculate total dose received by the field TLD while not deployed at the site:
   - Add the total doses calculated in steps 2 and 3 above.
5. Calculate the total dose received by the field TLD while deployed at the site:
   - Subtract the result in step 4 above from the gross result for the field TLD as reported by the vendor.

Due to scheduling issues involving initial TLD issuance from Landauer versus initial deployment of badges to the site to begin the gamma monitoring program, begin/end dates for the first two quarters of TLD data for Moore Ranch were out of sync with Landauer's normal quarterly schedule. The third quarterly change out will be delayed one month to synchronize the TLD monitoring schedule with Landauer's normal quarterly schedule. This will not affect the results, but should simplify calculations and records keeping.

6.1.5.1.2 Ambient Radon-222 Monitoring

Passive monitoring of Rn-222 air concentrations at the site is being conducted with Radtrak® alpha-track radon gas detectors supplied by Landauer. These radon detectors are housed along with the environmental TLDs as shown in Figure 6.1-26. The radon detectors are supplied by the vendor in special sealed packages designed to prevent the detectors from radon exposure prior to the beginning of the monitoring period. Upon completion of the site monitoring period, special sealing stickers supplied by the vendor are applied to detector openings to prevent further radon exposure until the device is analyzed by the vendor for average Rn-222 concentration (in pCi/L).

Prior to initial deployment of radon detectors to Moore Ranch, it was necessary to open the first quarter's batch of detectors prior to traveling to the site in order construct the housing assemblies. This operation was performed as quickly as possible to minimize any potential radon exposures not due to site conditions. Within a few hours, housing assemblies were completed and this first batch of radon detectors was double-sealed in plastic bags and placed inside the company truck (parked outside in Fort Collins, Colorado) until deployment to the site two days later.

Another issue arose with the first batch of radon detectors while constructing the housing assemblies. Two of the sealed bags (containing 3 radon detectors each) were discovered to be compromised. As a result, one of these detectors was designated for use as a "control" detector and immediately sealed with the sealing sticker. This detector was sent back to Landauer for processing, and a replacement detector was ordered for subsequent deployment to the site. Landauer was notified of the faulty packaging, and no other cases of compromised packaging seals have been discovered.

6.1.5.2 Ambient Gamma and Radon Results

6.1.5.2.1 Ambient Gamma Dose Rate Monitoring

Passive gamma dose monitoring results to date are presented in Table 6.1-11. Assuming conventional radiation weighting and quality dose factors for photons, the estimated gamma dose rates (mrem/hr) shown in Table 6.1-11 agree reasonably well with the gamma exposure rate scan data presented in Section 6.1.2 of this report. Similarly, these gamma dose rate values agree closely with the historical gamma exposure rate data (μR/hr) provided for M and T grids in the Conoco report, which were measured by a pressurized ionization chamber (Conoco, 1980).

Table 6.1-11: Environmental gamma dose rate monitoring data for quarters 1 and 2 at Moore Ranch.

Passive Monitoring Station ID	TLD Issue Date	Field Installation Date	Monitoring End Date*	Landauer GROSS Result (mrems)	Landauer NET Result (mrems)	Estimated Quarterly Field Dose (mrem)[1]	Estimated Daily Field Dose (mrem)[1]	Estimated Field Dose Rate (mrem/hr)[1]
QUARTER 1								
MR-1	10/1/2006	12/4/2006	3/5/2007	47.1	7.3	29.6	0.325	0.014
MR-2	10/1/2006	12/4/2006	3/5/2007	50.3	10.5	32.8	0.360	0.015
MR-3	10/1/2006	12/4/2006	3/5/2007	47.1	7.3	29.6	0.325	0.014
MR-4	10/1/2006	12/4/2006	3/5/2007	47.8	8.0	30.3	0.333	0.014
MR-5	10/1/2006	12/4/2006	3/5/2007	42.1	2.3	24.6	0.270	0.011
MR-6	10/1/2006	12/4/2006	3/5/2007	54.6	14.8	37.1	0.408	0.017
MR-7	10/1/2006	12/4/2006	3/5/2007	51.1	11.3	33.6	0.369	0.015
MR-8	10/1/2006	12/4/2006	3/5/2007	52.1	12.3	34.6	0.380	0.016
MR-9	10/1/2006	12/4/2006	3/5/2007	44.8	5.0	27.3	0.300	0.013
MR-10	10/1/2006	12/4/2006	3/5/2007	41.0	1.2	23.5	0.258	0.011
Transit control	10/1/2006	-	3/5/2007	39.2	-0.6	-	-	-
Deploy control	10/1/2006	-	3/5/2007	39.8	0.0	-	-	-
QUARTER 2								
MR-1	1/1/2007	3/5/2007	6/9/2007	58.4	7.3	34.1	0.355	0.015
MR-2	1/1/2007	3/5/2007	6/9/2007	56.5	10.5	32.2	0.335	0.014
MR-3	1/1/2007	3/5/2007	6/9/2007	55.9	7.3	31.6	0.329	0.014
MR-4	1/1/2007	3/5/2007	6/9/2007	56.3	8.0	32.0	0.333	0.014
MR-5	1/1/2007	3/5/2007	6/9/2007	47.0	2.3	22.7	0.236	0.010
MR-6	1/1/2007	3/5/2007	6/9/2007	68.8	14.8	44.5	0.464	0.019
MR-7	1/1/2007	3/5/2007	6/9/2007	69.9	11.3	45.6	0.475	0.020
MR-8	1/1/2007	3/5/2007	6/9/2007	78.5	12.3	54.2	0.565	0.024
MR-9	1/1/2007	3/5/2007	6/9/2007	73.1	5.0	48.8	0.508	0.021
MR-10	1/1/2007	3/5/2007	6/9/2007	71.8	1.2	47.5	0.495	0.021
Transit control	1/1/2007	-	6/9/2007	74.4	-0.6	-	-	-
Deploy control	1/1/2007	-	6/9/2007	58.7	0.0	-	-	-

1 - Results listed in blue calculated using deploy control dose only due to suspect transit control result

It appears that continuous monitoring of ambient field gamma dose rates at the site with TLDs or other dosimeters was not conducted during the historical Conoco study (no gamma dose rate information was provided in that report). However, given that the field dose rates (mrem/hr) for quarters 1 and 2 in Table 6.1-11 are fairly similar to each other in most cases, and both agree reasonably well with gamma exposure rate data collected in the fall of 2007 (see Section 6.1.2.2.4, Figure 6.1-13), suggests that temporal fluctuations in ambient field gamma dose rates at a given location are unlikely to vary by more than 0.01 mrem/hr. Spatial and temporal variability in background sources of gamma radiation, combined with measurement uncertainty, are likely responsible for the higher degree of variation observed in some cases through two quarters.

6.1.5.2.2 Ambient Rn-222 Monitoring

Passive Rn-22 monitoring results to date are presented in Table 6.1-12. Note that the "control" radon detector for quarter 1 registered a significantly higher value relative to all other detectors. Landauer's review of the records for this detector revealed no analysis or reporting errors. Other than for the early return shipping trip to Landauer, this detector was subject to the exact same conditions as all other detectors in the same batch, suggesting that this detector was somehow exposed to elevated alpha radiation during return shipping. It is thus reasonable to exclude this result from consideration as a control detector as intended. Because all other quarter 1 detectors had readings similar to one another (whether respective packaging was compromised or not), it is also reasonable to assume that the compromised packaging for some detectors did not significantly affect the results of the detectors involved. Therefore, all data for detectors actually deployed in the field in quarter 1 are assumed to be valid as reported.

Table 6.1-12: Ambient radon-222 monitoring data for quarters 1 and 2 at Moore Ranch.

Passive Monitoring Station ID	Radon Detector ID	Package Open Date	Field Installation Date	Quarter End (seal) Date	Quarterly Result (pCi-days/L)[1]	Quarterly Result (pCi/L)[1]
QUARTER 1						
MR-1	4639785	12/2/2006	12/4/2006	3/5/2007	9.4	0.1
MR-2	4639861	12/2/2006*	12/4/2006	3/5/2007	34.4	0.4
MR-3	4639862	12/2/2006*	12/4/2006	3/5/2007	42.3	0.5
MR-4	4639864	12/2/2006*	12/4/2006	3/5/2007	43.5	0.5
MR-5	4639874	12/2/2006	12/4/2006	3/5/2007	34.4	0.4
MR-6	4639875	12/2/2006	12/4/2006	3/5/2007	36.8	0.4
MR-7	4639876	12/2/2006	12/4/2006	3/5/2007	37.4	0.4
MR-8	4639884	12/2/2006*	12/4/2006	3/5/2007	31.3	0.3
MR-9	4639885	12/2/2006*	12/4/2006	3/5/2007	38.6	0.4
MR-10	4639886	12/2/2006*	Not installed**	12/2/2006	35.6	3.6
MR-10	4619417 (replacement)	1/9/2007	1/9/2007	3/5/2007	6.0	0.11
QUARTER 2						
MR-1	4639785	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-2	4639861	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-3	4639862	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-4	4639864	3/5/2007	3/5/2007	6/9/2007	11.5	0.1
MR-5	4639874	3/5/2007	3/5/2007	6/9/2007	12.0	0.1
MR-6	4639875	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-7	4639876	3/5/2007	3/5/2007	6/9/2007	17.9	0.2
MR-8	4639884	3/5/2007	3/5/2007	6/9/2007	18.6	0.2
MR-9	4639885	3/5/2007	3/5/2007	6/9/2007	6.0	0.06
MR-10	4639886	3/5/2007	3/5/2007	6/9/2007	12.0	0.1

[1] Results shown in blue are below analytical reporting limits

*Comprimised packaging seal from Landauer

**Sealed immediately and submitted for analysis - intended as a control detector for units with compromised packaging

Quarter 1 and 2 results are higher on average than Rn-222 concentrations reported in the historical baseline survey (Figures 6.1-27 and 6.1-28), particularly during quarter 1. Considering spatial, temporal, sampling, and analytical variability in radon measurements, however, the range of values for both data sets is not considered inconsistent with the national average ambient outdoor background level of about 0.4 pCi/L (Foster, 1993). No information in the Conoco report is provided with respect to how the historical Rn-222 data were collected or analyzed.

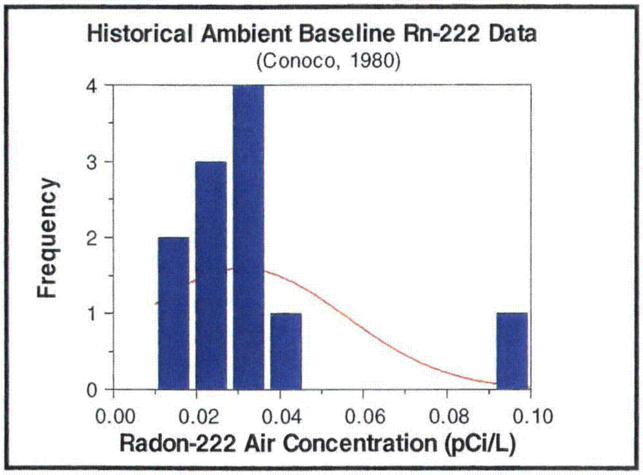


Figure 6.1-27: Frequency histogram of average monthly concentrations across all sampling locations for the historical data.

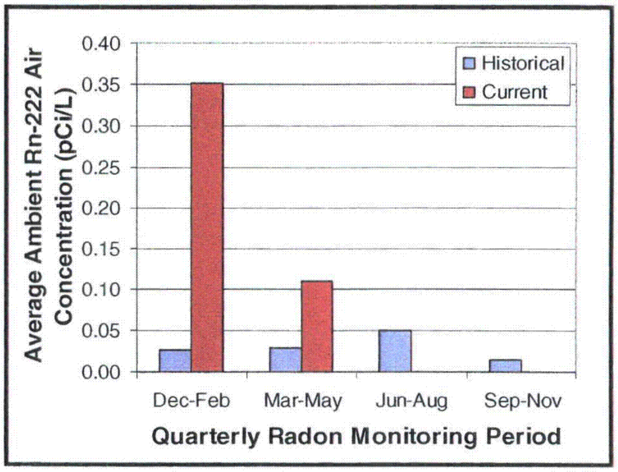


Figure 6.1-28: Current average quarterly results to date for all locations and corresponding average quarterly values across the site based on the historical data.

The historical data were collected on a monthly basis from May 1979 through March 1980. Thus, only the month of April is not represented in that data set. Combined, the historical and current data sets to date provide a reasonable idea of the magnitude of ambient Rn-222 air concentrations that can be expected to result in the remaining quarters of the current radon monitoring program. Based on all currently available data, the remaining quarters are unlikely to produce results in excess of the national average (0.4 pCi/L).

6.1.5.3 Conclusions

Baseline ambient gamma dose rate and radon-222 air concentration data for the 2007 radiological survey of the Moore Ranch Uranium Project area are being collected and analyzed according to Regulatory Guide 4.14 protocols. To date, two quarters of data are available and those results are presented. The remaining data will be submitted to the NRC and WDEQ/LQD as soon as they are available. The historical ambient gamma and radon data from the 1980 Conoco study were evaluated and compared to the current data to allow consideration to determine the completeness of licensing/permitting applications for administrative review prior to completion of the recommended full year of monitoring for these radiological parameters. The data and comparisons presented provide a reasonable indication of the results expected in the remaining quarters of the current year-long baseline monitoring program.

6.1.6 Air Particulate Monitoring

Continuous monitoring of baseline air particulate radionuclide concentrations was initiated in early February 2007 at four on-site locations. Regulatory Guide 4.14 calls for 12 consecutive months of respective monitoring data as part of the overall radiological characterization of the site (NRC, 1980). These data are being collected and reported on a quarterly basis. As of the effective date of this report, one quarter and one additional month of 2007-2008 monitoring data (hereafter termed "2007 data") are available and are presented in this section. No off-site locations were planned for the air monitoring program as no known residences are currently located within 10 kilometers of the site as described in Regulatory Guide 4.14 (NRC, 1980).

Historical air particulate data as reported in the historical survey report (Conoco, 1980) are believed to be in error. Overall, those data are some 5 to 7 orders of magnitude greater than data collected in 2007, and are clearly inconsistent with any reasonably expected range of background values. Thus, the historical data were not used in this section to augment data from the current study. Miscalculation or mislabeling of radiometric units in the Conoco report may be responsible for the general magnitude of values indicated for those data.

As an alternative to comparisons with historical data from the Conoco report, more recent air monitoring data from other nearby ISR sites in this region of Wyoming have been compiled and compared to current results to date for Moore Ranch.

Low-volume air particulate sampling station locations were selected based on the historical air sampling locations and Regulatory Guide 4.14 guidance, including consideration for the locations of plant facilities, prevailing wind directions, available electrical power, and practical access. Initially, only two of the four air sampling stations had available hard-line electrical power. The other two stations were set up using solar/wind generation equipment to supply electrical power to the air samplers. Locations of the air particulate monitoring stations are shown in Figure 6.1-25 of the previous section of this report.

6.1.6.1 Methods

The air particulate monitoring program is being conducted with Model DF-40L-8 electric powered air samplers from F&J Specialty Products, Inc. (Figure 6.1-29). These samplers are calibrated by the manufacturer and programmed to draw about 30 liters of air intake per minute through a 47 mm glass fiber air sampling filter. The air samplers are housed in protective coolers mounted on elevated steel platforms such that the intake and sample filter holder assembly is positioned at about 5 feet above the ground surface (Figure 6.1-30). This is intended to approximate an average breathing zone height.

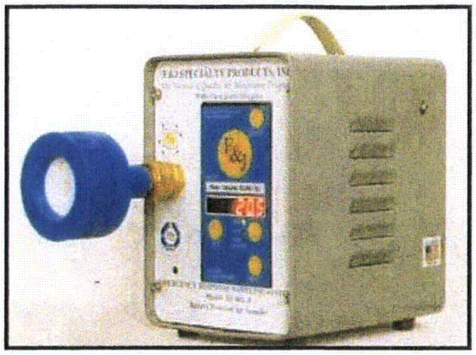


Figure 6.1-29: F&J air particulate sampler.

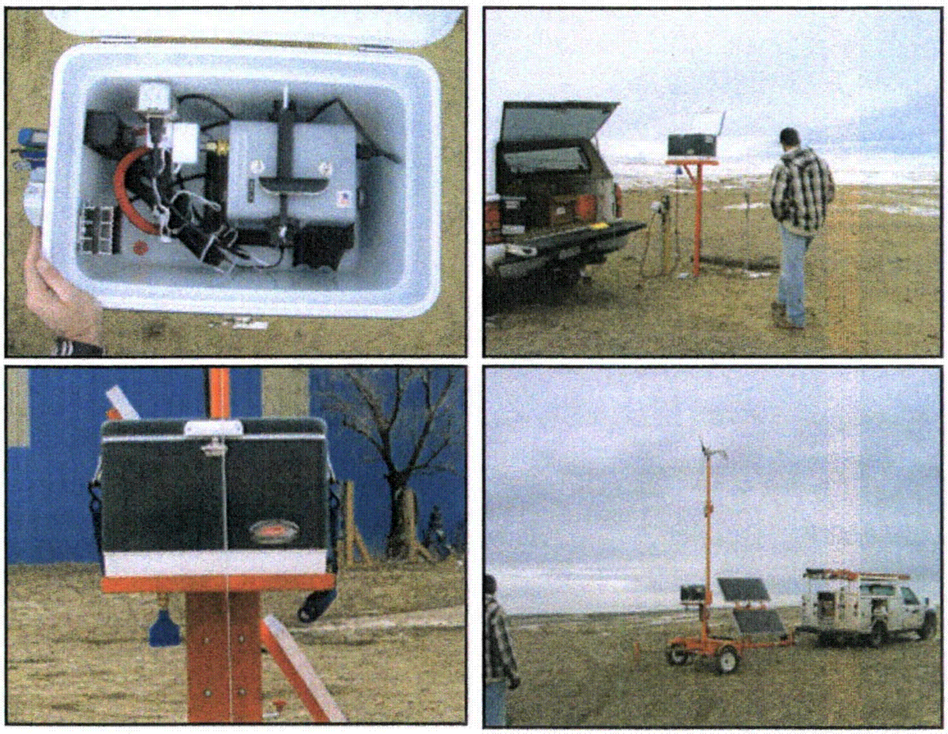


Figure 6.1-30: Air sampling station equipment and systems setup including hard-line and solar/wind powered units at Moore Ranch.

Filters are collected weekly to help prevent dust loading and are composited on an approximate quarterly basis to provide respective estimates of average radionuclide concentrations as specified in Regulatory Guide 4.14. Each quarterly batch of air filters from the four monitoring stations is submitted to ELI in Casper, WY for analysis of Ra-226, U-nat, Th-230, and Pb-210.

6.1.6.2 Air Particulate Sampling Results

Baseline air particulate sampling results to date are presented in Table 6.1-13 and are also graphically illustrated in Figure 6.1-31. In most cases, analytical results are above the lower limits of detection (LLD). The LLD values listed are those specified in Regulatory Guide 4.14. The effluent concentration values are provided by ELI as a relevant part of reporting for these data because they represent regulatory limits for each listed radionuclide in terms of doses to the public. This gives an indication of baseline conditions in this context and will help with evaluations of above background internal dose assessments via inhalation and ingestion pathways for data collected during ISR recovery operations.

Table 6.1-13: Air particulate monitoring data for quarter 1 (Feb 6 – May 9) and a subsequent 1-month period of monitoring (May 21 – June 28) at Moore Ranch.

Air Station ID	Monitoring Period	Air Volume Sampled (mL)	Radionuclide	Concentration (uCi/mL)	Error Estimate (uCi/mL)	LLD (uCi/mL)	Effluent Conc.* (uCi/mL)	% Effluent Concentration
MRA-1	2/6/07 - 5/9/07	2.83E+09	U-nat	4.24E-16	N/A	1.00E-16	9.00E-14	0.47
			Ra-226	3.18E-16	2.83E-16	1.00E-16	9.00E-13	0.04
			Pb-210	1.02E-14	2.19E-15	2.00E-15	6.00E-13	1.70
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.5
	5/21/07 - 6/28/07	3.08E+09	U-nat	1.62E-16	N/A	1.00E-16	9.00E-14	0.18
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	5.84E-15	1.92E-15	2.00E-15	6.00E-13	0.97
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50
MRA-2	2/6/07 - 5/9/07	2.32E+09	U-nat	5.60E-16	N/A	1.00E-16	9.00E-14	0.62
			Ra-226	4.74E-16	3.45E-16	1.00E-16	9.00E-13	0.05
			Pb-210	1.19E-14	2.63E-15	2.00E-15	6.00E-13	1.98
			Th-230	4.31E-16	3.02E-16	1.00E-16	2.00E-14	2.16
	5/21/07 - 6/28/07	1.71E+09	U-nat	3.51E-16	N/A	1.00E-16	9.00E-14	0.39
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	< 2.00E-15	N/A	2.00E-15	6.00E-13	< 0.33
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50
MRA-3	2/6/07 - 5/10/07	1.76E+09	U-nat	3.98E-16	N/A	1.00E-16	9.00E-14	0.44
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	9.32E-15	3.13E-15	2.00E-15	6.00E-13	1.55
			Th-230	1.93E-15	6.25E-16	1.00E-16	2.00E-14	9.66
	5/21/07 - 6/28/07	6.99E+08	U-nat	7.15E-16	N/A	1.00E-16	9.00E-14	0.795
			Ra-226	< 1.00E-16	N/A	1.00E-16	9.00E-13	< 0.01
			Pb-210	2.02E-14	8.15E-15	2.00E-15	6.00E-13	3.36
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50
MRA-4	2/6/07 - 5/10/07	1.80E+09	U-nat	7.22E-16	N/A	1.00E-16	9.00E-14	0.80
			Ra-226	8.33E-16	4.44E-16	1.00E-16	9.00E-13	0.09
			Pb-210	1.22E-14	3.22E-15	2.00E-15	6.00E-13	2.03
			Th-230	5.56E-16	3.89E-16	1.00E-16	2.00E-14	2.78
	5/21/07 - 6/28/07	1.62E+09	U-nat	2.47E-16	N/A	1.00E-16	9.00E-14	0.27
			Ra-226	8.64E-16	6.79E-16	1.00E-16	9.00E-13	0.10
			Pb-210	< 2.00E-15	N/A	2.00E-15	6.00E-13	< 0.33
			Th-230	< 1.00E-16	0.00E+00	1.00E-16	2.00E-14	< 0.50

Final prep volume is 0.95 liter
LLD's are from Reg. Guide 4.14
*Effluent concentration limit from 10 CFR Part 20 - Appendix B - Table 2
Solubility Class:
- Year for Natural Uranium
- Week for Radium-226
- Day for lead-210

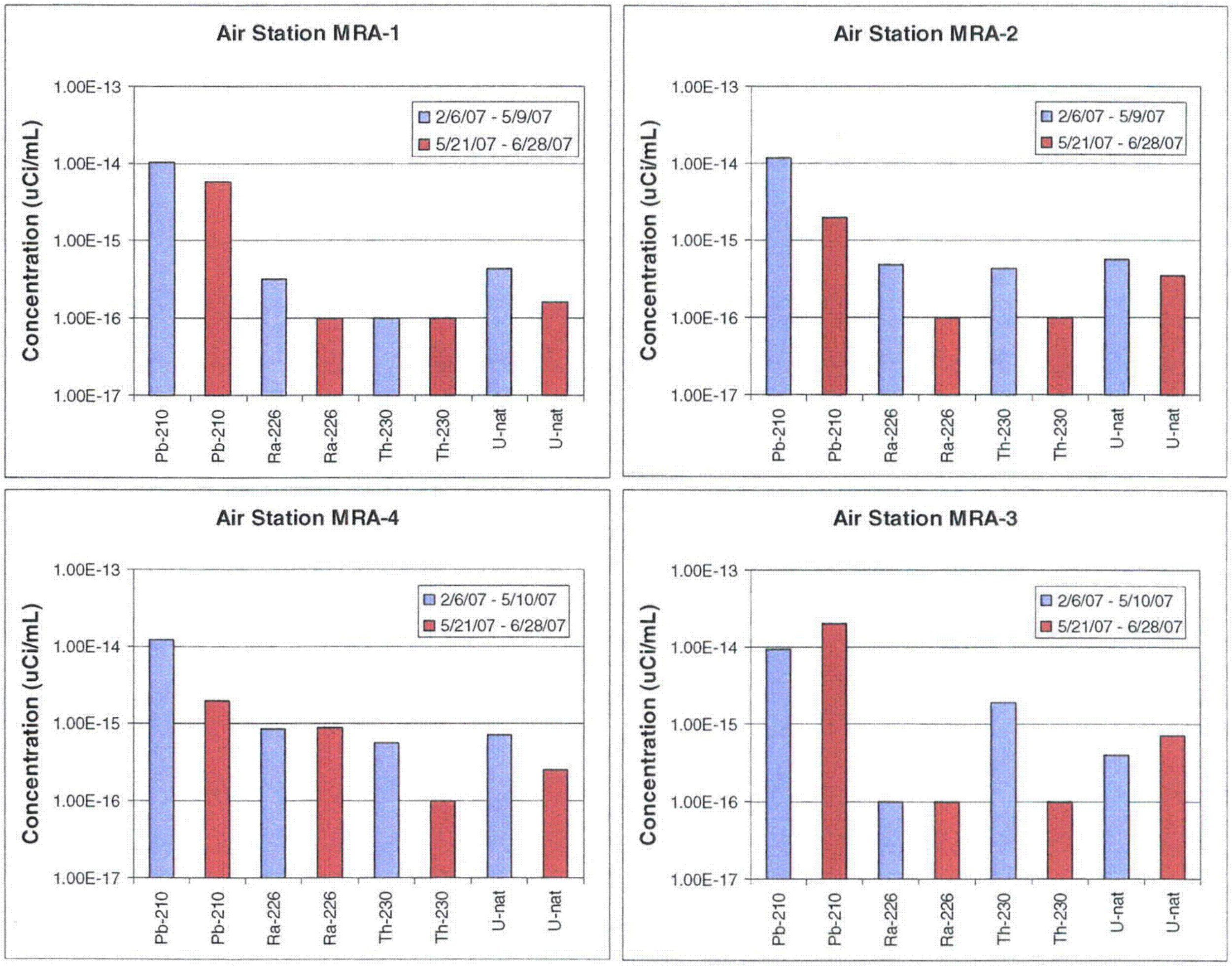


Figure 6.1-31: Air particulate results for quarter 1 and the subsequent month of sampling.

A comparison of average air particulate radionuclide concentrations to date at Moore Ranch with average corresponding concentrations at other nearby uranium recovery sites in this region of Wyoming (see Figure 2.2-2) is shown in Figure 6.1-32. In general, results are reasonably comparable for most radionuclides evaluated. In particular, data for Smith Ranch (about 37 miles SSW of the Moore Ranch site) and Christensen Ranch (about 19 miles NNW of the Moore Ranch site) are very similar to results to date for Moore Ranch. Lead-210 and U-nat results for the North Butte site (about 16 miles NNW of the site) are significantly lower than data from the other sites shown in Figure 6.1-32, but Ra-226 and Th-230 data are very similar across all of these sites. Real differences in background site characteristics could be responsible for lower Pb-210 and U-nat values at the North Butte site compared to other sites in the region, but differences in collection methods and analytical uncertainty could also contribute. In general, this comparison suggests that air particulate data for the remaining quarters of the baseline monitoring period are not likely to differ significantly from results to date, or with data from most nearby uranium recovery sites.

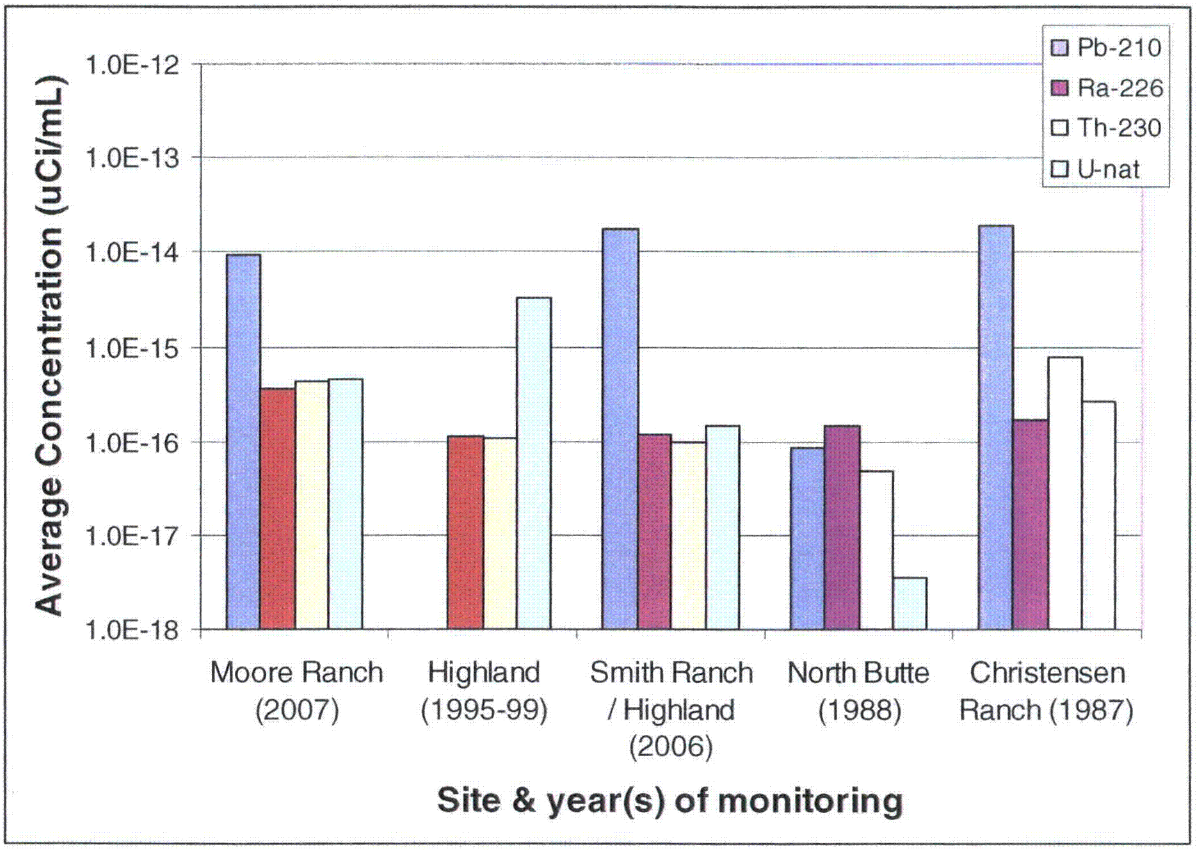


Figure 6.1-32: Average air particulate results to date for Moore Ranch compared to nearby uranium recovery sites in the region including Highland (NRC, 2004), Smith Ranch/Highland (NRC, 2004), North Butte (NRC, 2006) and Christensen Ranch (Cogema Mining, Inc 1996)

6.1.6.3 Conclusions

Baseline air particulate concentration data for the 2007 radiological survey of the Moore Ranch Uranium Project area are being collected and analyzed according to Regulatory Guide 4.14 protocols. To date, one quarter and one additional month of data are available and those results are presented in this section. The historical air particulate data as reported in the 1980 Conoco study are thought to be incorrect and thus were not used to augment this portion of radiological characterizations. Alternate comparisons with air particulate data from nearby uranium recovery sites in the region generally support a conclusion that remaining data for the 2007 monitoring program are likely to be similar to those collected to date and that the air particulate characterization of the Moore Ranch site should be deemed complete for purposes of administrative review of the application. Remaining data for the 2007 monitoring program will be submitted to the NRC and WDEQ/LQD as soon as they are available.

6.1.7 Radon Flux Measurements

Regulatory Guide 4.14 indicates that radon flux measurements should be conducted at eight locations within 1.5 km of the mill, during three separate months between spring and fall when the ground is thawed. Because there will be no tailings impoundments or evaporation ponds at the Moore Ranch Uranium Project, radon flux is unlikely to be an applicable radiological parameter for baseline characterization. There are historical data available from the Conoco study as provided below (Table 6.1-14 and Figure 6.1-33). Additional radon flux measurements are not planned at this time.

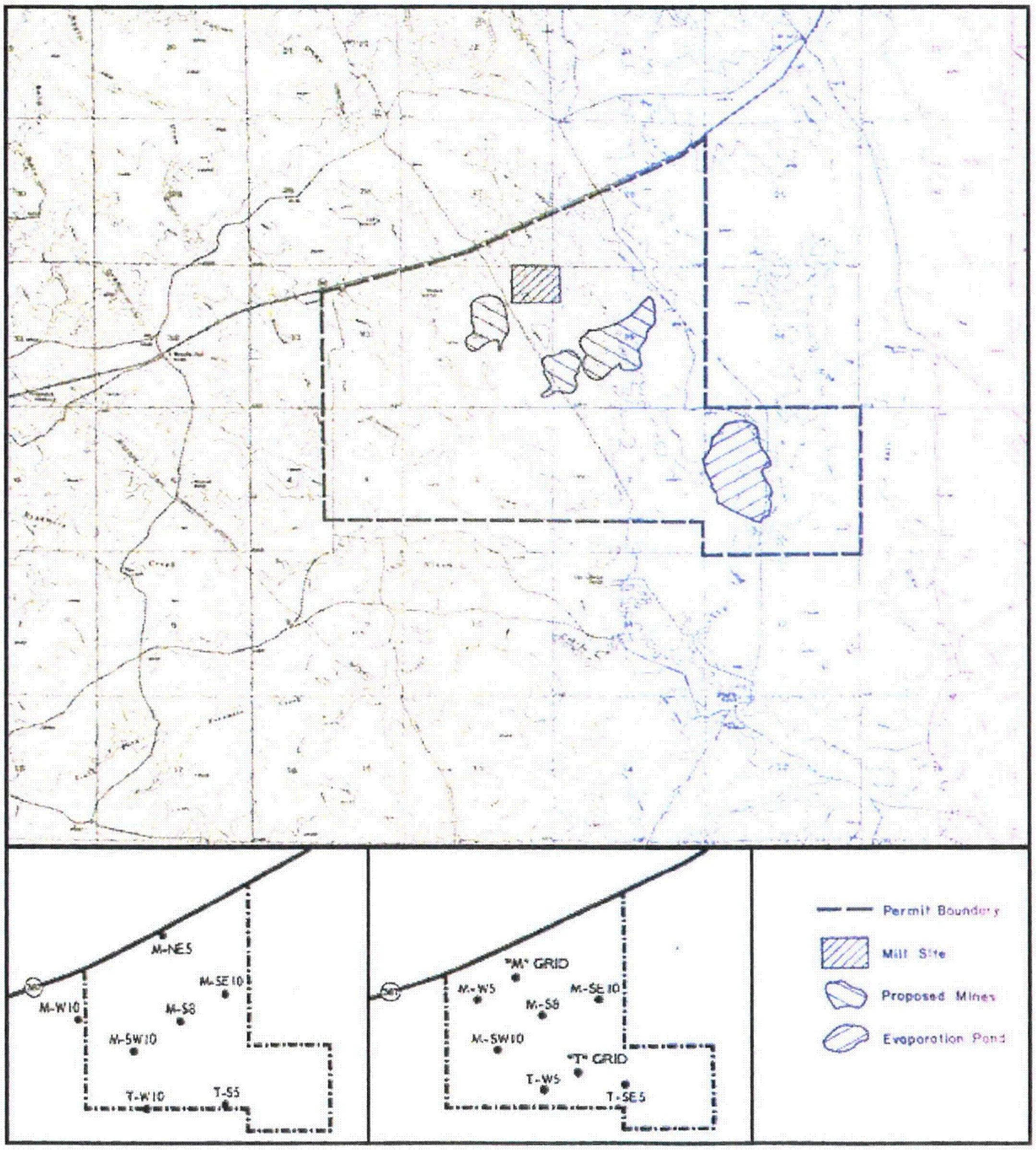


Figure 6.1-33: Historical radon flux measurement locations within the former mill site license area (adapted from Conoco, 1980).

Table 6.1-14: Historical radon flux data for the former Conoco mill site

Radon Emanation Charcoal Canister Technique [pCi/m²/sec(a)]

Location ID	Set 1 8/31/79-9/6/79	Set 2 9/6/79-9/25/79	Set 3 9/25/79-10/11/79	Set 4 10/11/79-10/26/79
M-SW 10	1.9	0.8	1.2	1.3
M-S 8	-	0.9	2.6	1.6
M-NE 5	1.5	0.9	1.8	2.1
M-SE 10	1.4	-	1.3	1.4
M-W 10	2.3	-	0.9	0.9
T-W 10	2.0	0.7	1.4	-
T-S 5	2.3	-	2.9	1.3

Radon Emanation Drum Method [pCi/m²/sec(a)]

Location ID	Set 1 8/31/79	Set 2 9/6/79	Set 3 9/15/79	Set 4 10/11/79
M-SW 10	1.25	-	0.7	0.7
M-W 5	0.8	-	0.8	0.7
M-SE 10	-	-	0.8	2.7
M-S 8	-	1.4	2.4	1.2
"M" Grid Center	1.4	-	2.2	0.4
T-W 5	0.9	0.4	0.4	0.4
T-SE 5	2.4	1.3	0.8	1.4
"T" Grid Center	0.6	1.0	0.8	1.2

(a) An overall uncertainty of ± 10% should be assigned at 2σ. Individual cumulative errors are less than this value.

6.1.8 Groundwater Sampling

Baseline groundwater sampling is being conducted at the Moore Ranch Uranium Project area in general accordance with Regulatory Guide 4.14 protocols (NRC, 1980). In this case, however, there are no tailings impoundments and respective guidance has been interpreted accordingly. Monitoring wells are located within mineralized areas, as well as at locations up and down hydrologic gradients from these areas. Wells that are or could be used for drinking, livestock watering, or crop irrigation have also been sampled. Quarterly sampling is continuing, with data for radiological parameters available to date presented in this section. A map of approximate well locations in the vicinity of proposed wellfields and the plant facility is shown in Figure 6.1-34. Comprehensive information on well locations and all water quality parameters is provided in sections of the licensing applications related specifically to groundwater (Section 3.4.3).

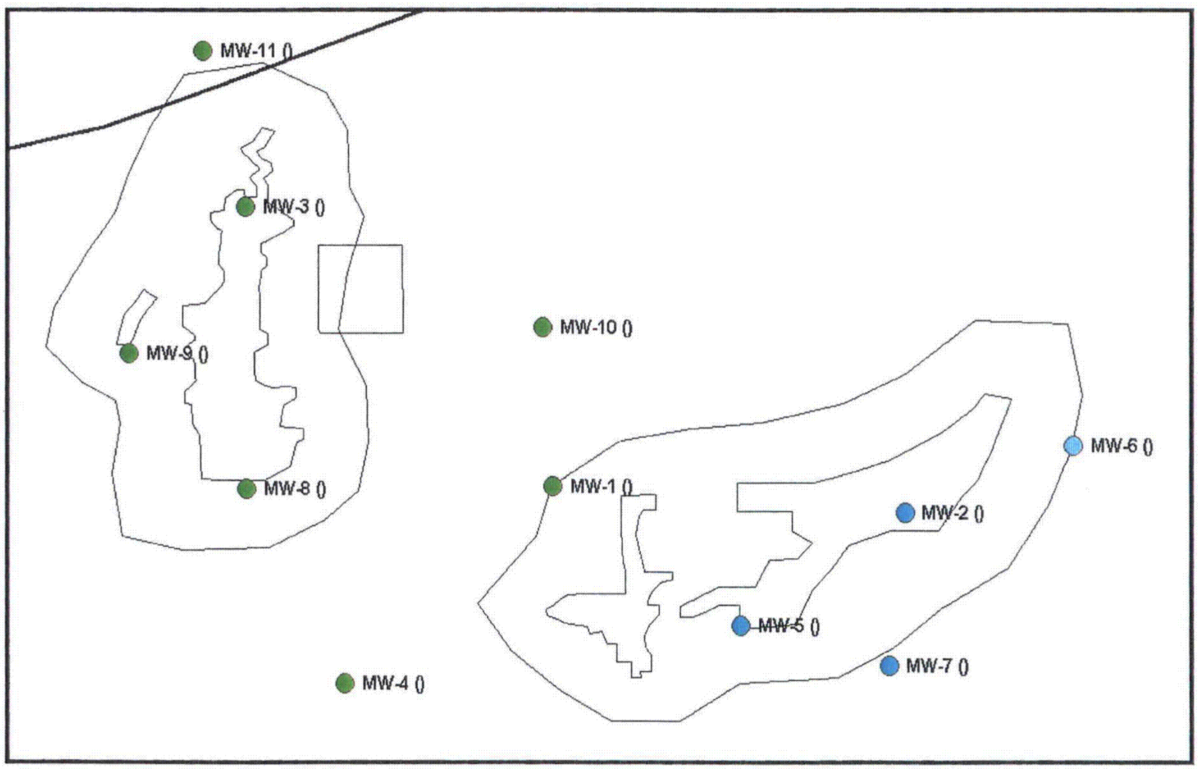


Figure 6.1-34: Groundwater monitoring wells at the Moore Ranch site near planned wellfields and central plant facilities.

With respect to historical groundwater monitoring, a map of well locations (Figure 6.1-35) and summary comparisons between radionuclide results from the current and historical data sets are presented. These comparisons may provide sufficient documentation of radiological groundwater parameters with respect to licensing applications prior to completion of the baseline groundwater monitoring program. As the monitoring program progresses, new data will be submitted to the NRC and WDEQ/LQD as they become available.

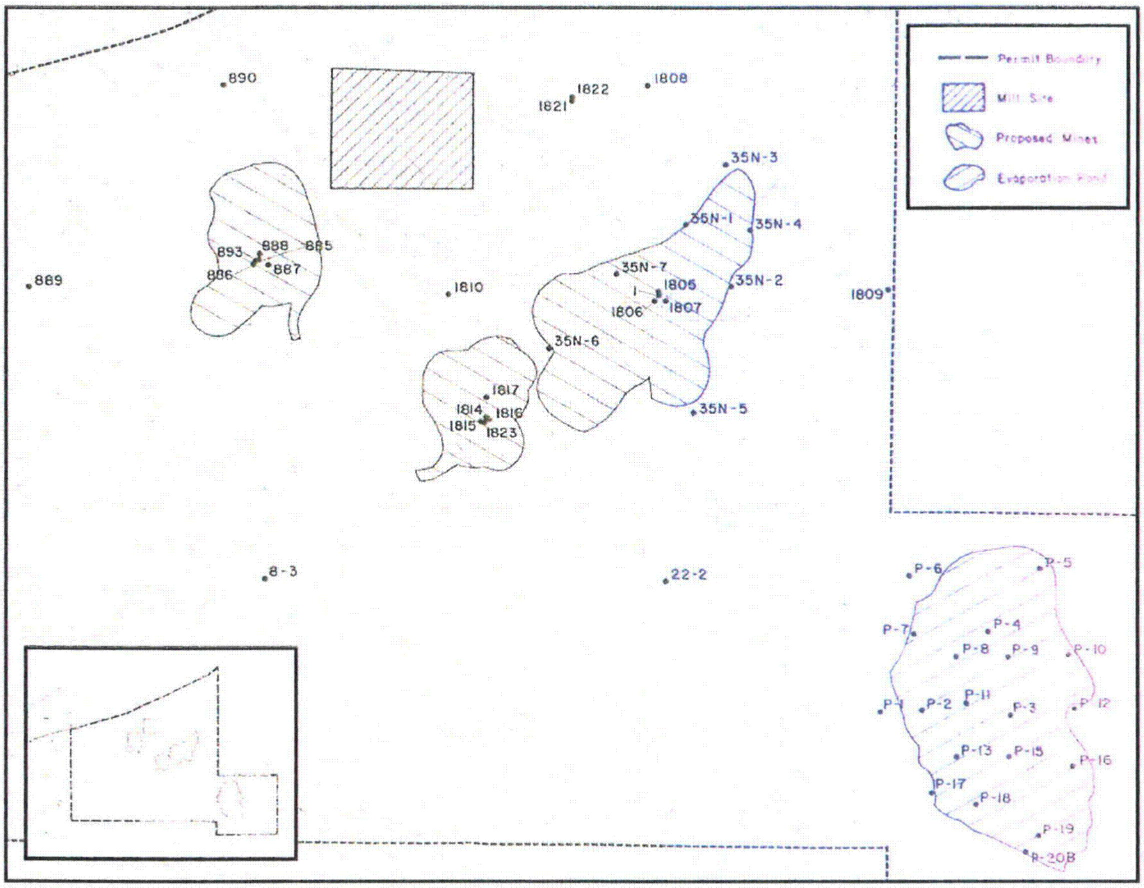


Figure 6.1-35: Historical groundwater monitoring wells at the Moore Ranch site near ore bodies (as estimated in 1980), and the formerly planned mill site and evaporation pond areas.

6.1.8.1 Methods

Prior to sampling a well, static water levels are monitored using an electrical measuring line (an “e-line”). All readings are reported to within at least one tenth of a foot and preferably to within a hundredth of a foot. After the static water level is measured, wells are purged at a sufficient volume induce the flow of formation water through the well screen. Wells with a high enough yield are purged for a minimum of three well volumes, and also until one or more indicator parameters are stable. Parameters monitored for stabilization include pH, temperature, and conductivity. For low yielding wells, the wells are pumped dry then allowed to recover. Samples are taken after sufficient well recovery. Accurate records of well purging are maintained to document the number of casing volumes purged from the well before sampling.

Groundwater field measurements and samples are taken as soon as the well is adequately purged. Sampling container(s) are completely filled, so all air is excluded from the container. Field measurements including pH, conductivity, and temperature are taken and recorded. Meters used to take field measurements are calibrated daily.

6.1.8.2 Groundwater Sampling Radiological Results

Results to date for dissolved radiological groundwater parameters are shown in Table 6.1-15. Parameters in suspended form were also evaluated, but all were below analytical reporting limits and are not presented here (those data, reporting limits, and other details can be found in Section 3.4.3 of the application pertaining specifically to groundwater).

Table 6.1-15: Analytical results to date for radiological parameters in groundwater samples collected during 2007 baseline surveys. Values with less-than qualifiers were all below analytical reporting limits.

Well No.	Gross Alpha pCi/L	Gross Beta pCi/L	Pb-210 pCi/L	Po-210 pCi/L	Ra-226 pCi/L	Ra-228 pCi/L	Th-230 pCi/L	Uranium pCi/L*
MR-PW-1	627	78.9	10	<1.0	82.6	2.1	<0.2	126
MR-OMW-1	3.5	20.4	<1.0	<1.0	0.8	2.8	<0.2	6.7
MR-UMW-1	13.3	25	<1.0	<1.0	0.8	<1.0	<0.2	6.4
MR-MW-2	1050	327	31	51	138	<1.0	<0.2	495
MR-OMW-2	9.6	8.6	<1.0	<1.0	1.1	2.5	1	1.8
MR-UMW-2	83.3	36.8	<1.0	1.8	1	<1.0	<0.2	75
MR-MW-3	370	162	69	34	280	<1.0	<0.2	56
MR-UMW-3	1.8	13.6	<1.0	<1.0	1.1	9.5	<0.2	0.9
MR-MW-4	201	53.8	<1.0	<1.0	45.7	1.7	<0.2	87
MR-OMW-4	3.5	14.4	<1.0	<1.0	1.8	2	<0.2	0.5
MR-UMW-4	53.4	18.4	<1.0	<1.0	1	3.3	<0.2	46
MR-MW-6	17	13.6	<1.0	<1.0	1.3	<1.0	<0.2	6.7
MR-MW-7	21.2	11.4	<1.0	1.6	1.1	<1.0	<0.2	6.7
MR-MW-9	47.1	24.6	<1.0	2	2.5	<1.0	<0.2	39
MR-MW-11	156	47.3	<1.0	<1.0	26	3.5	0.9	69
MR-885	293	147	41	31	309	1.8	<0.2	51
MR-1808	30.9	12.8	<1.0	<1.0	9.1	<1.0	0.4	0.8
MR-8-3	3.6	12.9	<1.0	<1.0	0.8	3	<0.2	1.3
Stockwell #1	68.2	24	<1.0	<1.0	0.8	1.6	<0.2	6.7
Stockwell #2	2	7.9	<1.0	<1.0	0.9	3.9	<0.2	6.7
Stockwell #3	24.3	16.5	<1.0	<1.0	3.3	3.5	<0.2	6.7
Stockwell #4	5.9	5.5	<1.0	<1.0	<0.2	<1.0	0.9	4.8

*Converted from units of mg/L to activity units of pCi/L using a conversion factor of 670 pCi/mg

Some groundwater sampling in 2007 is being conducted at or near historical wells as indicated in the 1980 Conoco study. All reported radiological analytes from the historical study, along with corresponding well ID location numbers from the current monitoring program, are shown in Table 6.1-16. To make comparisons between data sets, historical data were averaged in cases where multiple results at a given well location were provided for different sampling dates. In cases where reported results were listed as below reporting limits, the reporting limit was assigned to represent an approximate concentration.

In general, there is reasonable agreement among the two data sets, with the most notable exceptions being for uranium in historic wells 1808 and 8-3 (see Section 2.7). The results for these locations, corresponding to current wells MR-1808 and MR-8-3, suggest a two-orders-of-magnitude difference between current and historical samplings (Figure 6.1-36). Unless anthropogenic activities disturb groundwater system conditions, concentrations should not change significantly over a few decades as these systems are usually fairly well buffered geochemically.

Table 6.1-16: Historical analytical results for radiological parameters in groundwater samples as reported in the Conoco study (Conoco, 1980).

Historical Well No.	Pb-210 pci/L	Po-210 pci/L	Ra-226 pci/L	Th-230 pci/L	Uranium pCi/L	Corresponding 2007 Well No.
I			69 ± 10		338	MR-MW-2
I			27.6 ± 1.7		399	MR-MW-2
I	0 ± .2	0.2 ± .03	8.0 ± .4	0.0 ± .1	294 ± 15	MR-MW-2
1807			6.6 ± 2.3		3.4	MR-UMW-2
885			163 ± 20		38	MR-885
893			302		81	MR-885
893	10 ± .5	1.5 ± .1	126 ± 6	0.3 ± .1	58 ± 3	MR-885
1808	0 ± .6	0.12 ± .03	0.60 ± .07	0 ± .4	71 ± 4	MR-1808
8-3	0 ± 0.6	0.12 ± .03	0.60 ± .07	0 ± .4	71 ± 4	MR-8-3
T-1	0 ± .4	0.02 ± 0'01	0.41 ± 0.06	0.3 ± 0.1	44 ± 2	Stockwell #1
T-1			0.2 ± 0.2	0.6 ± 0.1	21 ± 2	Stockwell #1
P'-11						Stockwell #2
P'-9	1.6 ± 0.02	0.40 ± 0.05	2.0 ± 0.1	0.2 ± 0.1	32. ± 2.0	Stockwell #3
P'-9			2.1 ± 0.1	1.1 ± 0.1	22. ± 2.	Stockwell #3

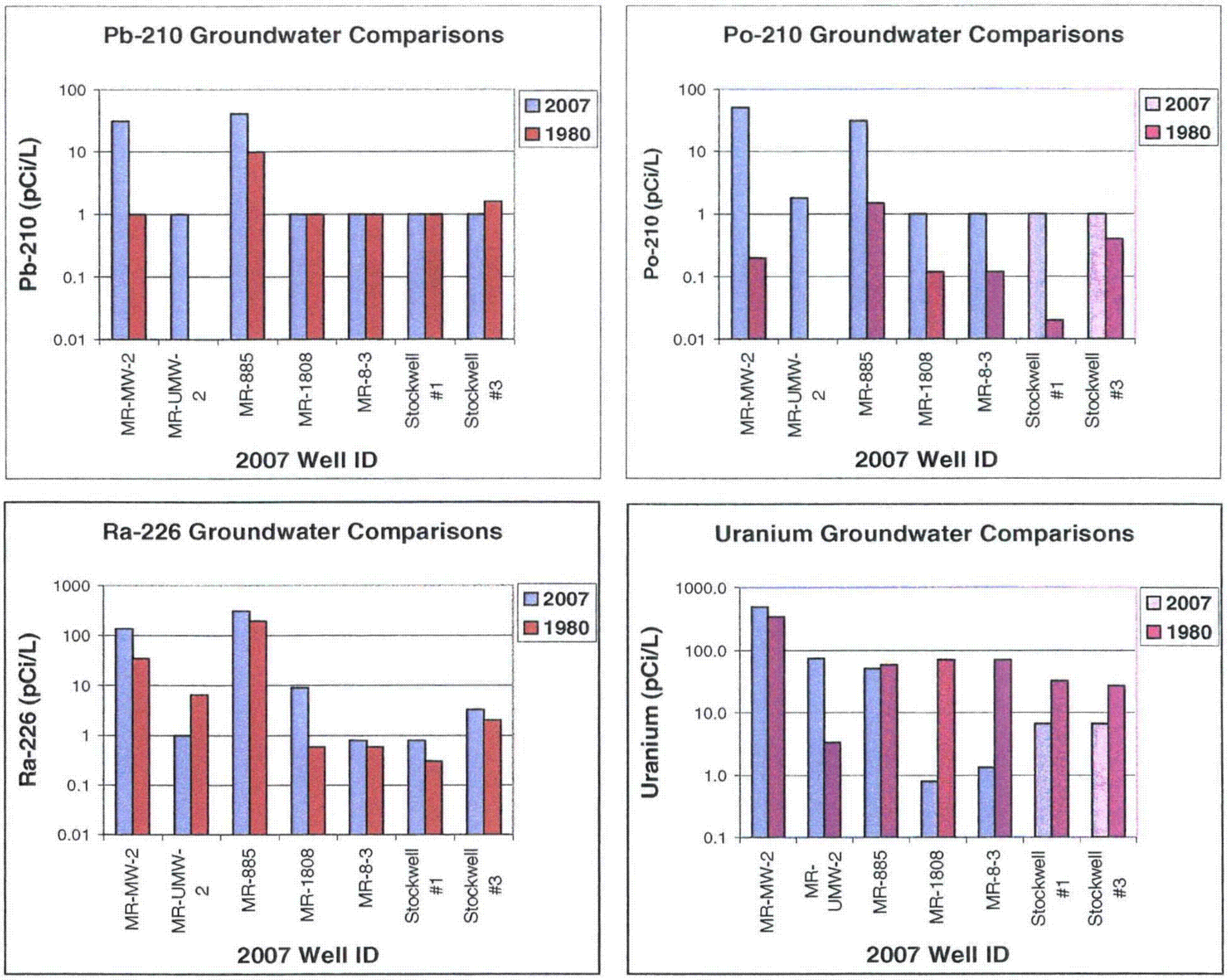


Figure 6.1-36: Comparisons of current (2007) and historical (1980) results for select radionuclide concentrations in groundwater samples collected at similar or identical well locations. The current well location ID numbers are given.

The most plausible explanation for the lack of agreement in uranium results for historic wells corresponding to current wells MR-8-3 and MR-1808 is error in data transcription in the historic Conoco report. Note that results for these two historic wells in Table 6.1-16 are listed as having identical results across all radionuclides. Clearly that is an analytical improbability. Thus it is suggested that these results are ignored and only the current data are considered valid at these two locations, particularly since both appear to be located well outside of currently estimated mineralized zones at the site (see Figure 6.1-35). Thorium-230 comparisons, not shown, were in good agreement as all results were near ELI's reporting limit of 0.2 pCi/g.

6.1.8.3 Conclusions

Radiological groundwater data for the Moore Ranch Uranium Project is being collected and analyzed according to Regulatory Guide 4.14 protocols. Results to date, along with historical groundwater data and summary comparisons of analytical results between the two data sets, are presented in this section. Current and historical data have reasonable agreement for most parameters. Uranium results deviate significantly in a few cases, two of which appear related to transcription errors in the historical report. Respective results for historic wells 8-3 and 1808 should not be considered. Remaining data for the current groundwater monitoring program will be submitted to the NRC and WDEQ/LQD as they become available. The combined data sets provide a reasonable characterization of radionuclide concentrations in groundwater and these parameters are unlikely to change significantly through the remainder of the baseline monitoring program. Based on this conclusion, the data should be considered complete for purposes of administrative review of the license and permit applications.

6.1.9 Surface Water Sampling

Baseline surface water sampling is being conducted at the Moore Ranch Uranium Project area in accordance with Regulatory Guide 4.14 protocols (NRC, 1980). Beginning in 2000, coal bed methane (CBM) production was introduced to the site and many ponds are now primarily fed by CBM groundwater discharge. (The CBM gas recovery method is discussed extensively in Section 4.14). As a result, during much of the year, surface water quality is a reflection of CBM discharge water. Historical data have not been analyzed or presented for comparison since they may not accurately represent current baseline conditions.

The year-long sampling program is continuing, with data for radiological parameters available to date presented in this section. New data will be submitted to the NRC and WDEQ/LQD as they become available. A map showing pond sampling locations relative to ore bodies and the proposed plant facility is presented in Figure 6.1-37. Comprehensive presentation of surface water sampling locations and all water quality parameters is provided in sections of licensing applications related specifically to surface water (see Section 3.4.2).

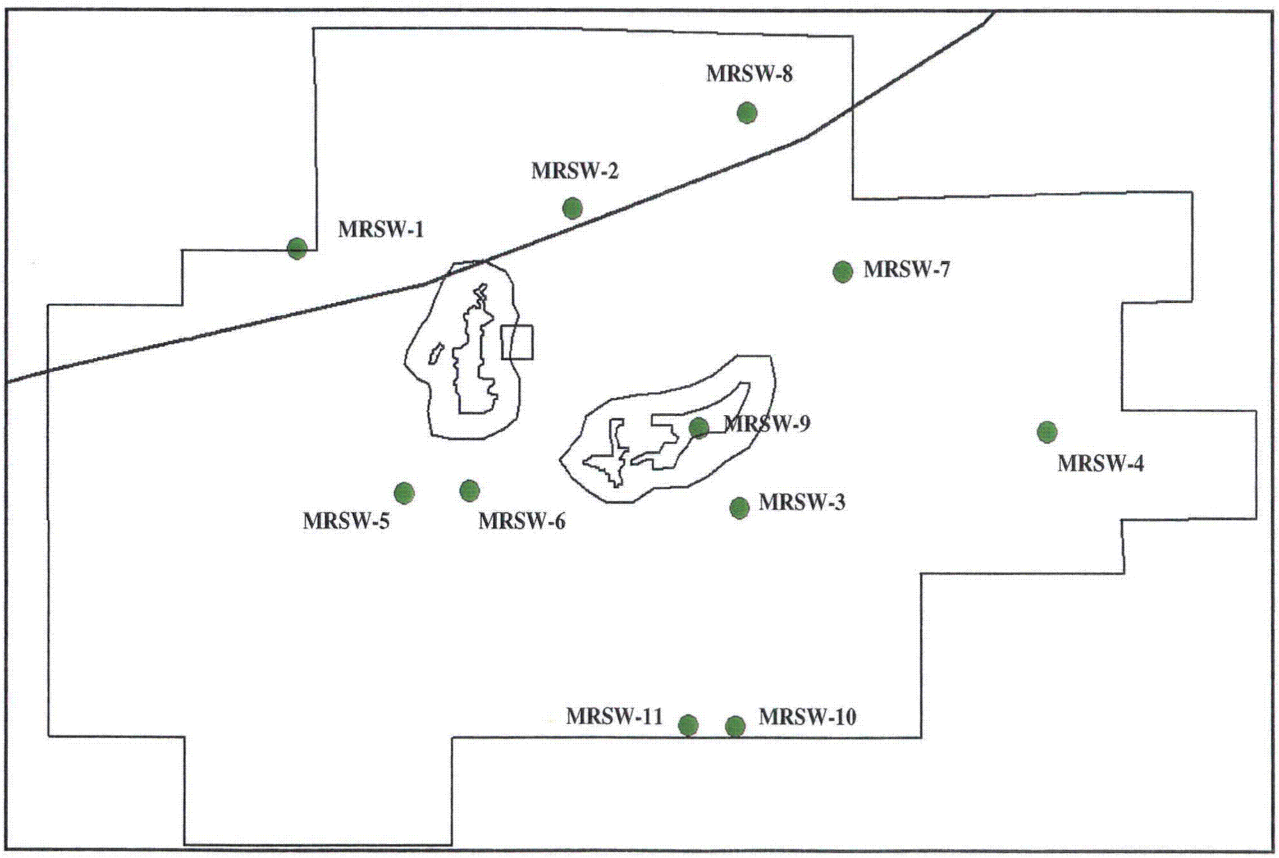


Figure 6.1-37: Surface water sampling locations at the Moore Ranch site.

6.1.9.1 Methods

Surface water samples are collected in the appropriate containers provided by the contract laboratory. Field meters were used to measure pH, specific conductance, and temperature of water samples and calibrated before each day's use as discussed in the Owner's Manual. Sample containers are flushed with the sample water in order to remove potential contaminants from the container. The bottle is then filled directly from the stream or pond with the with the sample bottle in a manner to prevent collecting debris or filled by using an alternate clean container. All samples analyzed by a contract laboratory are accompanied by a chain of custody to ensure proper analysis is performed and the sample is tracked.

6.1.9.2 Surface Water Sampling Results

Select results to date for dissolved radiological groundwater parameters are shown in Table 6.1-17. Parameters in suspended form were also evaluated, but virtually all were below analytical reporting limits and are not presented here (those data, reporting limits, and other details can be found in Section 3.4.2 of the application pertaining specifically to surface water)

Table 6.1-17: Analytical results to date for radiological parameters in surface water samples collected during 2007 baseline surveys. Values with less-than qualifiers were all below analytical reporting limits.

Surface Water Sampling ID	Sampling Date	Gross Alpha pCi/L	Gross Beta pCi/L	Pb-210 pCi/L	Po-210 pCi/L	Ra-226 pCi/L	Ra-228 pCi/L	Th-230 pCi/L	Uranium pCi/L*
MRSW-1	11/3/2006	6.8	21.8	170	<0.2	<0.2	<1.0	<0.2	3.5
	3/23/2007	1	10.3	<1.0	<1.0	<0.2	<1.0	<0.2	0.5
MRSW-2	10/25/2006	3	14	<1.0	<1.0	<0.2	<1.0	<0.2	13.4
	3/23/2007	1.5	9.7	<1.0	<1.0	<0.2	<1.0	<0.2	0.3
MRSW-3	10/25/2006	12.7	13.5	<1.0	<1.0	<0.2	<1.0	<0.2	8.7
	3/22/2007	7.9	9.7	<1.0	<1.0	<0.2	<1.0	<0.2	8.0
MRSW-4	10/25/2006	5.6	11.9	<1.0	<1.0	<0.2	<1.0	<0.2	4.6
	3/27/2007	2.5	7.6	<1.0	<1.0	<0.2	<1.0	<0.2	2.3
MRSW-5	11/3/2006	11	32.7	9.9	<1.0	<0.2	<1.0	<0.2	0.7
	3/22/2007	2.4	11	<1.0	<1.0	1.5	<1.0	<0.2	1.9
MRSW-6	3/22/2007	1.1	6.9	<1.0	<1.0	<0.2	<1.0	<0.2	<0.2
MRSW-7	10/25/2006	5.4	13.1	<1.0	<1.0	<0.2	<1.0	<0.2	0.4
MRSW-8	10/25/2006	4.3	20.9	<1.0	<1.0	<0.2	<1.0	<0.2	2.7
	3/23/2007	2.4	10.1	<1.0	<1.0	<0.2	<1.0	<0.2	0.6
MRSW-9	3/21/2007	1.7	3.9	8.6	<1.0	<0.2	<1.0	<0.2	1.1

*Converted from units of mg/L to activity units of pCi/L using a conversion factor of 670 pCi/mg

Locations MRSW-10 and MRSW-11 as shown in Figure 6.1-37 have not been sampled because surface water has yet to be observed in these impoundments. Most sample results to date for dissolved uranium are above analytical reporting limits, with a few values ranging between 40-70% of the U.S. Environmental Protection Agency's (EPA's) current 30 µg/L drinking water standard for uranium (EPA, 2000). Based on the conversion factor indicated in Table 6.1-17, an equivalent EPA uranium drinking water standard in units of specific activity is 20 pCi/L.

The fall 2006 sampling effort produced an unusually high result for Pb-210 in pond MRSW-1, as well as a slightly elevated Pb-210 result just downstream along the same drainage channel in pond MRSW-5. A second sampling of these two ponds in the spring of 2007 each had corresponding results below analytical reporting limits. In terms of drinking water standards, Pb-210 is not currently regulated by the EPA, though a standard of 1 pCi/L was proposed in 1999 (EPA, 2000). Most other radiological analytes specified in Regulatory Guide 4.14 have thus far been below analytical reporting limits across all sampling locations.

6.1.9.3 Conclusions

Radiological surface water data for the Moore Ranch Uranium Project area is being collected and analyzed according to Regulatory Guide 4.14 protocols. Results to date are presented in this section and remaining data will be submitted to the NRC and WDEQ/LQD as they become available. Comparisons with historical surface water data from the Conoco study (Conoco, 1980) are not appropriate as baseline conditions may have changed due to the introduction of coal bed methane groundwater discharges to surface water systems. In general, surface water concentrations of most radiological analytes specified in Regulatory Guide 4.14 are low, though the data suggest that baseline uranium levels can approach the current EPA drinking water standard at some locations. A possible explanation for the one unusually high Pb-210 result at pond location MRSW-1 in 2006 is not apparent based on the available data.

EMC believes that the 2007 surface water data meets the completeness criteria for administrative review of the license application, particularly since NUREG-1569 states that "...where perennial surface-water sources are present, surface-water quality measurements should be taken on a seasonal basis for a minimum of 1 year before implementation of in situ leach operations." All drainages at the Moore Ranch Uranium Project are ephemeral. Furthermore, during much of the year, surface water quality is a reflection of CBM discharge water.

6.1.10 Vegetation Sampling

Vegetation sampling at the Moore Ranch site was initiated in April of 2007. Regulatory Guide 4.14 calls for three rounds of sampling during the growing season (NRC, 1980). As of the effective date of this report, two of the three scheduled samplings are completed and those results are presented. Data from the remaining sampling event will be provided to the NRC and WDEQ/LQD as soon as available.

Historical vegetation data from the 1980 baseline survey (Conoco, 1980) are also summarized and compared to the available 2007 data. The historical data set for vegetation is also technically incomplete with respect to Regulatory Guide 4.14 specifications, however, the combined data sets might be considered by the NRC and WDEQ/LQD as meeting the completeness criteria for administrative review. Both early and later months during the growing season are represented between the two data sets.

Vegetation sampling locations for the 2007 survey were selected based on Regulatory Guide 4.14 guidance including three different areas near proposed facilities which have potential to be impacted by ISR operations. Locations of vegetation sampling areas in relation to processing plant facilities and ore deposits are shown in Figure 6.1-38.

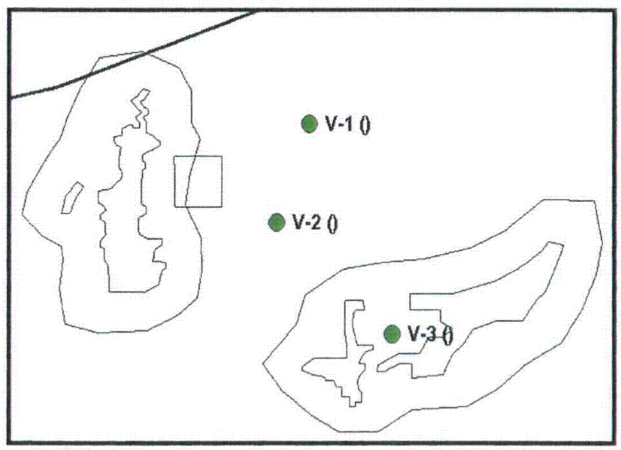


Figure 6.1-38: Vegetation sampling locations in relation to processing facilities area and subsurface ore deposits.

6.1.10.1 Methods

Vegetation samples were collected using ordinary gardening tools (hedge clippers, etc.) as mixed, above-ground growth across several hundred square meter areas at each sampling location. All varieties of vegetation present at each location were sampled and composited into a single sample. These varieties consisted mostly of short grasses and clover plants. At the first sampling event in April, new vegetation growth was limited resulting in difficulty in collecting sufficient volumes of sample for analysis (only 1-2 kilograms of total vegetation mass per sample were able to be collected). The second sampling event in June had considerably more vegetative growth and about 4-5 kilograms per sample were collected. All composited samples were collected in large plastic bags and hand delivered within 24 hours of collection, along with chain of custody forms, to ELI in Casper, WY. Analytes requested included all radiological parameters as recommended in Regulatory Guide 4.14.

6.1.10.2 Vegetation Sampling Results

For each Regulatory Guide 4.14 radionuclide, the second sampling had lower values than the first (Figure 6.1-39). The location with the highest average uranium content in vegetation was to the southeast of the proposed processing plant (V-3), otherwise, the location to the northeast of processing facilities (V-1) area had the highest mean radionuclide levels of the three sampling locations (Figure 6.1-40). Lead-210 had the greatest activity levels of the five radionuclides analyzed, which is likely due to a higher relative abundance of Pb-210 in air particulates from radon decay products. This latter observation is supported by the air particulate data presented in Section 6.1.6 (note in Table 6.1-18 that Pb-210 concentrations are 1-2 orders of magnitude higher than other radionuclides evaluated).

Table 6.1-18: Summary statistics for all vegetation samples collected to date (two of three scheduled samplings) for all sampling locations.

Analyte	Mean (uCi/kg)	Std. Dev. (uCi/kg)	Median (uCi/kg)	Max (uCi/kg)	Min (uCi/kg)	n
Pb-210	9.6E-05	5.9E-05	5.8E-05	1.7E-04	4.3E-06	6
Po-210	8.9E-06	9.2E-06	6.0E-06	2.7E-05	1.5E-06	6
Ra-226	2.2E-05	1.6E-05	1.7E-05	5.1E-05	1.3E-06	6
Th-230	5.2E-06	3.1E-06	4.9E-06	9.8E-06	1.1E-06	6
U-nat	2.2E-05	2.3E-05	5.2E-06	6.0E-05	0.0E+00	6

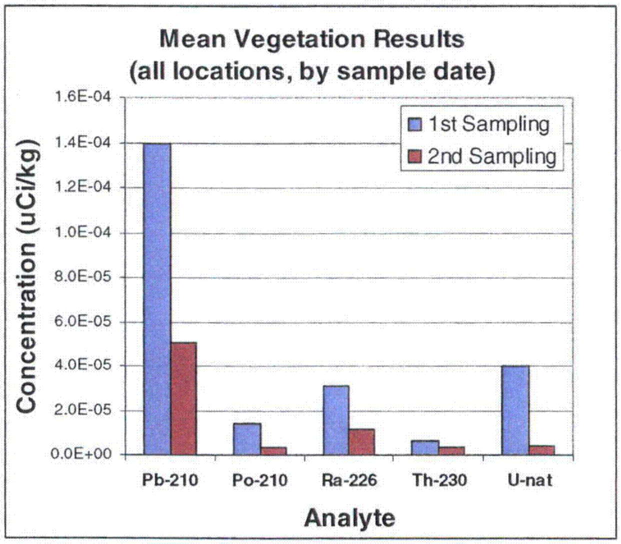


Figure 6.1-39: Analytical results for vegetation samples by sampling date for all locations.

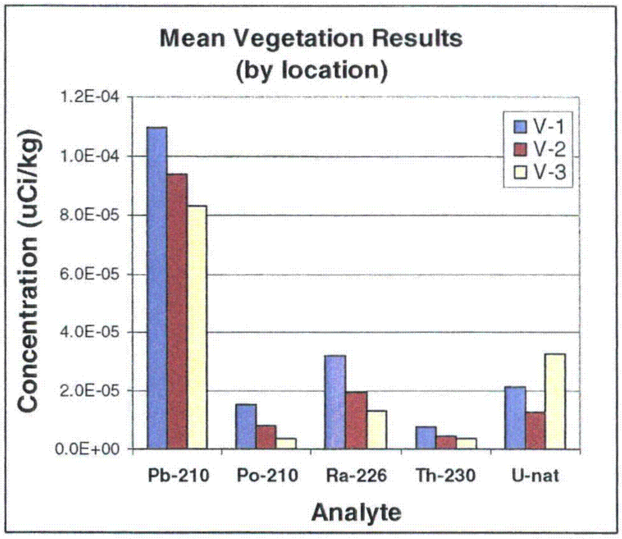


Figure 6.1-40: Analytical results for vegetation samples by sampling location.

Historical results consistently suggest higher radionuclide contents in vegetation at the site compared to the current data (Figure 6.1-41). As with other current/historical survey comparisons described in this report, uncertainty due to random analytical variability, or systematic uncertainty due to differences in analytical methods, are both possible contributors to such differences. Again, there was no information presented in the Conoco report of analytical methods used. For Ra-226 and uranium, there is reasonable agreement between the two data sets. Based on the historical data, there is no indication of significant differences in radionuclide concentrations by vegetation type (Figure 6.1-42). Thus, compositing of all vegetation types encountered at a given sampling location is likely to be generally representative of any given species.

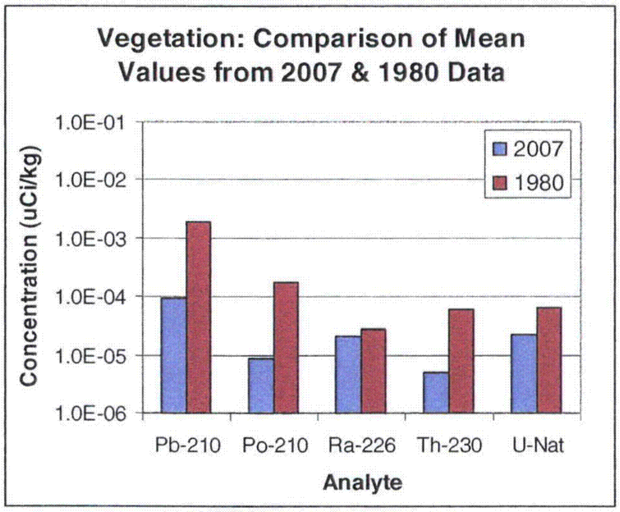


Figure 6.1-41: Mean results for vegetation samples from the 2007 survey compared to historical results (Conoco, 1980).

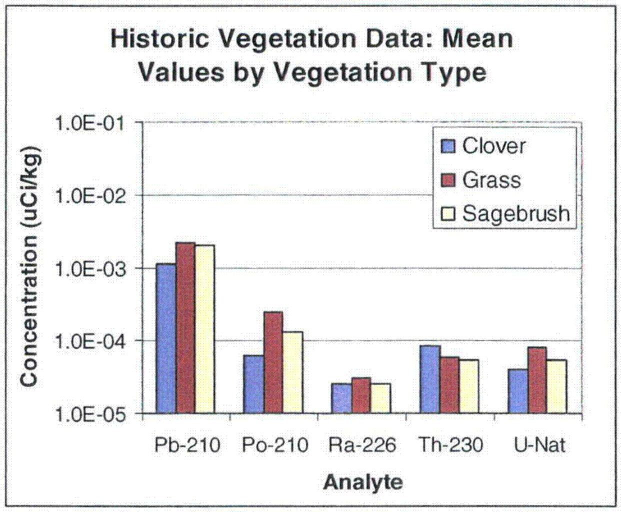


Figure 6.1-42: Mean historical results by vegetation type.

6.1.10.3 Conclusions

Baseline vegetation sampling data for the 2007 radiological survey of the Moore Ranch Uranium Project area are being collected and analyzed according to Regulatory Guide 4.14 protocols. To date, data from two of three scheduled sampling events are available and those results are presented in this section. The historical vegetation data as reported in the 1980 Conoco study are higher on average for each radionuclide analyzed, but data uncertainty due to differing analytical methods may be responsible for much of the difference. Remaining data for the final 2007 sampling (scheduled for late summer or early fall) will be submitted to the NRC and WDEQ/LQD as soon as they are available.

6.1.11 Food Sampling

Sampling of food items from the site such as meat from local grazing livestock is not planned at this time. All radiological baseline parameters relevant to food chain dose pathways (e.g. soil, sediment, air particulate samples, water, and vegetation) are comprehensively characterized in this report. The historical Conoco baseline study included food pathway data for various locally raised agricultural products. Those data are provided in Table 6.1-19.

Table 6.1-19: Food sampling results from the historical baseline radiological survey (adapted from Conoco, 1980).

Sample Type	Collection Date	Analysis	Concentration (pCi/g)	± 2σ
Squash Composite	9/22/1979	Ra-226	0.014	± 0.002
		Th-230	0	± 0.02
		Pb-210	0	± 0.01
		Po-210	0.01	± 0.01
		Total U-Nat	0.0	± 0.02
Leafy Vegetables Composit	9/22/1979	Ra-226	0.20	± 0.002
		Th-230	0	± 0.02
		Pb-210	0.02	± 0.01
		Po-210	0.034	± 0.006
		Total U-Nat	0.18	± 0.06
Root Vegetable Composite	9/22/1979	Ra-226	0.027	± 0.003
		Th-230	0.030	± 0.01
		Pb-210	0	± 0.01
		Po-210	0.028	± 0.007
		Total U-Nat	0.05	± 0.02
Sheep I Meat	10/15/1979	Ra-226	0	± 0.001
		Th-230	0.010	± 0.005
		Pb-210	0	± 0.01
		Po-210	0.011	± 0.002
		Total U-Nat	0	± 0.1
Sheep I Bone	10/15/1979	Ra-226	0.70	± 0.03
		Th-230	0	± 0.06
		Pb-210	0.76	± 0.06
		Po-210	0.14	± 0.02
		Total U-Nat	0.04	± 0.01
Sheep II Meat	10/15/1979	Ra-226	0.001	± 0.0003
		Th-230	0	± 0.01
		Pb-210	0	± 0.001
		Po-210	0.021	± 0.002
		Total U-Nat	0.020	± 0.01
Sheep II Bone	10/15/1979	Ra-226	0.480	± 0.02
		Th-230	0.10	± 0.05
		Pb-210	0.72	± 0.05
		Po-210	0.16	± 0.02
		Total U-Nat	0.78	± 0.09
Steer I Meat	10/15/1979	Ra-226	0.001	± 0.0003
		Th-230	0	± 0.05
		Pb-210	0.009	± 0.005
		Po-210	0.003	± 0.001
		Total U-Nat	0.01	± 0.01
Steer I Kidney	10/15/1979	Ra-226	0.002	± 0.001
		Th-230	0	± 0.01
		Pb-210	0.54	± 0.03
		Po-210	0.131	± 0.01
		Total U-Nat	0.04	± 0.01
Steer II Meat	10/15/1979	Ra-226	< 0.01	
		Th-230	0	± 0.01
		Pb-210	0.050	± 0.005
		Po-210	0.023	± 0.005
		Total U-Nat	0.03	± 0.01
Steer II Kidney	10/15/1979	Ra-226	0	± 0.001
		Th-230	0	± 0.01
		Pb-210	0.32	± 0.02
		Po-210	0.09	± 0.01
		Total U-Nat	0.01	± 0.01
Steer I and II Bone Composite	10/15/1979	Ra-226	0.008	± 0.007
		Th-230	0	± 0.01
		Pb-210	0.99	± 0.08
		Po-210	0.30	± 0.05
		Total U-Nat	0.13	± 0.03

6.1.12 Summary and Overall Conclusions

Comprehensive baseline radiological surveys of the Moore Ranch Project area in Campbell County, Wyoming are currently being conducted in accordance with Regulatory Guide 4.14 (NRC, 1980) as part of licensing/permitting application submittals to the USNRC and WDEQ/LQD. As of the effective date of this report, surveys of gamma exposure rates and radionuclide concentrations in soils and pond sediments are completed. Monitoring of air particulates, ambient radon/gamma dose rates, groundwater, and surface water continues, with 1-2 quarters of data collected to date. The final sampling event for stream sediments and vegetation have been completed and analysis is underway.

The current gamma exposure rate survey data, collected in the fall of 2006 using the latest GPS scanning system technologies, represent much higher survey coverage than was practical or possible at the time Regulatory Guide 4.14 was published. These data, combined with established analysis techniques and new mapping approaches, provides a very detailed characterization of the magnitude and spatial variability in background gamma exposure rates and soil Ra-226 concentrations across the entire site (about 8,000 acres). Soil/sediment sampling results generally corroborate applicable radiological characterizations based on the gamma survey, and support a conclusion that this approach will provide significant benefits to all stakeholders.

Although some data from current monitoring/sampling activities has yet to be collected, historical radiological survey data from the site (Conoco, 1980) have been compiled and compared to current data and where possible, incorporated into the overall assessment of baseline conditions across the site. The current data, when considered in conjunction with the historical data, provide a good characterization of expected results from remaining survey activities. This characterization should be considered complete for purposes of administrative review prior to completion of currently remaining radiological survey activities. All remaining baseline monitoring/sampling results will be provided to the NRC and WDEQ/LQD as they become available.

6.2 PHYSIOCHEMICAL GROUNDWATER MONITORING

6.2.1 Program Description

During operations at the Moore Ranch Project, a detailed water sampling program will be conducted to identify any potential impacts to water resources of the area. EMC's operational water monitoring program will include the evaluation of groundwater on a regional basis, groundwater within the permit or licensed area and surface water on a regional and site specific basis.

6.2.2 Groundwater Monitoring

The groundwater monitoring program is designed to detect excursions of lixiviant outside of the wellfield under production and into the overlying and/or underlying water bearing strata.

6.2.2.1 Wellfield Baseline Sampling

Production zone wells (injection and production pattern area) will be sampled four times with a minimum of 2 weeks between samplings during baseline characterization. Wells will be selected based on a density of one well per three acres of mine unit. The first and second sample events will include analyses for all WDEQ LQD Guideline 8, Appendix 1, parts III and IV parameters as shown in Table 6.2-1. The third and fourth sampling events will be analyzed for a reduced list of parameters as defined by the results of the previous sample events. If certain elements are not detected during the first and second samplings, then those elements will not be analyzed during the third and fourth sample events.

Data for each parameter are averaged. If the data collected for the entire mine unit indicate that waters of different underground water classes (WDEQ-WQD Rules and Regulations, Chapter VIII) exist together, the data are not averaged together, but treated as sub-zones. Data within specific sub-zones are averaged. Boundaries of sub-zones, where required, are delineated at half-way between the sets of sampled wells which define the sub-zones. The Restoration Target Values (RTV's) are determined from the baseline water quality data and are used to assess the effectiveness of ground water restoration activities. The average and range of baseline values determined for the wells completed in the Production Zone within the wellfield area constitute the RTV's.

Table 6.2-1
Baseline Water Quality Parameters
WDEQ LQD Guideline 8

Constituents (reported in mg/l unless noted)	*Analytical Method*
Ammonia Nitrogen as N	EPA 350.1
Nitrate + Nitrite as N	EPA 353.2
Bicarbonate	EPA 310.1/310.2
Boron	EPA 212.3/200.7
Carbonate	EPA 310.1/310.2
Fluoride	EPA 340.1/340.2/340.3
Sulfate	EPA 375.1/375.2
Total Dissolved Solids (TDS) @ 180°F	EPA 160.1/SM2540C
Dissolved Arsenic	EPA 206.3/200.9/200.8
Dissolved Cadmium	EPA 200.9/200.7/200.8
Dissolved Calcium	EPA 200.7/215.1/215.2
Dissolved Chloride	EPA 300.0
Dissolved Chromium	EPA 200.9/200.7/200.8
Total and Dissolved Iron	EPA 236.1/200.9/200.7/200.8
Dissolved Magnesium	EPA 200.7/242.1
Total Manganese	EPA 200.9/200.7/200.8/243.1/243.2
Dissolved Molybdenum	EPA 200.7/200.8
Dissolved Potassium	EPA 200.7/258.1
Dissolved Selenium	EPA 270.3/200.9/200.8
Dissolved Sodium	EPA 200.7/273.1
Dissolved Zinc	EPA 200.9/200.7/200.8
Radium-226 (pCi/l)	DOE RP450/EPA 903.1/SM 7500-R-AD
Radium-228 (pCi/l)	SM 7500-R-AD
Gross Alpha (pCi/l)	DOE RP710/CHEMTA-GP B1/EPA 900
Gross Beta (pCi/l)	DOE RP710/CHEMTA-GP B1/EPA 900
Uranium	DOE MM 800/EPA 200.8
Vanadium	EPA 286.1/286.2/200.7/200.8

6.2.2.2 Monitor Well Baseline Water Quality

Monitor well ring wells are installed within the Production Zone, outside the mineralized portion of the ore zone and production pattern area in a "ring" around the mine area. These wells are used to obtain baseline water quality data and characterize the area outside the production pattern area. Upper Control Limits (UCL's) are determined for these wells from the baseline water quality data used in operational excursion monitoring. As determined from the modeling described in Addendum 6.2-A, the distance between these monitor wells will be no more than 500 feet and the distance between these monitor wells and the production patterns will be approximately 500 feet. The acceptable distance between the monitor wells and the production patterns was determined using a ground water flow model and estimated hydraulic properties for the proposed production area. The acceptable distance between monitor wells and the production patterns also took into account the demonstration that if an excursion were to occur, production fluids could be controlled within 60 days, as required by WDEQ requirements.

Monitor wells will be installed within the overlying aquifer (72-Sand) and underlying aquifer (68-sand) at a density of one well per every four acres of pattern area. These wells will be used to obtain baseline water quality data to be used in the development of UCL's for these zones.

After completion, wells will be developed (by air flushing or pumping) until water quality in terms of pH and specific conductivity appears to be stable and consistent with the anticipated water quality of the area. After development, wells will be sampled to obtain baseline water quality. Wells will be purged before sample collection to ensure that representative water is obtained. All monitor wells including ore zone and overlying and underlying monitor wells will be sampled four times at least two weeks apart. The first sample will be analyzed for the parameters shown in Table 6.2-1. Subsequent samples will be analyzed for the UCL parameters only (i.e., chloride, conductivity, and total alkalinity). Results from the samples will be averaged arithmetically to obtain a baseline mean value determination of upper control limits for excursion detection. If the data collected for the monitor well ring unit indicate that waters of different underground water classes (WDEQ-WQD Rules and Regulations, Chapter VIII) exist together, the data are not averaged together, but treated as sub-zones. Data within specific sub-zones are averaged. Boundaries of sub-zones, where required, are delineated at half-way between the sets of sampled wells which define the sub-zones.

6.2.2.3 Wellfield Hydrologic Data Package

Following completion of the field data collection, the Wellfield Hydrologic Data Package is assembled and submitted to the WDEQ for review. In accordance with NRC Performance Based Licensing requirements, the Wellfield Hydrologic Data Package is reviewed by a Safety and Environmental Review Panel (SERP) to ensure that the results of the hydrologic testing and the planned mining activities are consistent with technical requirements and do not conflict with any requirement stated in NRC regulations or in the NRC license. A written SERP evaluation will evaluate safety and environmental concerns and demonstrate compliance with applicable NRC license requirements as discussed in Section 5 of the Technical Report. The written SERP evaluation will be maintained at the site.

The Wellfield Hydrologic Data Package contains the following:

1. A description of the proposed mine unit (location, extent, etc.).

2. A map(s) showing the proposed production patterns and locations of all monitor wells.

3. Geologic cross-sections and cross-section location maps.

4. Isopach maps of the Production Zone sand, overlying confining unit and underlying confining unit.

5. Discussion of how the hydrologic test was performed, including well completion reports.

6. Discussion of the results and conclusions of the hydrologic test including pump test raw data, drawdown match curves, potentiometric surface maps, water level graphs, drawdown maps and when appropriate, directional transmissivity data and graphs.

7. Sufficient information to show that wells in the monitor well ring are in adequate communication with the production patterns.

8. Baseline water quality information including proposed UCLs for monitor wells and average production zone/restoration target values.

9. Any other information pertinent to the area tested will be included and discussed.

6.2.2.4 Operational Upper Control Limits and Excursion Monitoring

After baseline water quality is established for the monitor wells for a particular production unit, upper control limits (UCLs) are set for chemical constituents which would be indicative of a migration of lixiviant from the well field. The constituents chosen for indicators of lixiviant migration and for which UCLs will be set are chloride, conductivity, and total alkalinity.

Chloride was chosen due to its low natural levels in the native groundwater and because chloride is introduced into the lixiviant from the ion exchange process (uranium is exchanged for chloride on the ion exchange resin). Chloride is also a very mobile constituent in the groundwater and will show up very quickly in the case of a lixiviant migration to a monitor well. Conductivity was chosen because it is an excellent general indicator of overall groundwater quality. Total alkalinity concentrations should be affected during an excursion as bicarbonate is the major constituent added to the lixiviant during mining. Water levels are obtained and recorded prior to each well sampling. However, water levels are not used as an excursion indicator. Upper control limits will be set at the baseline mean concentration plus five standard deviations for each excursion indicator. For chloride with a low baseline mean and little noted variation during baseline sampling, the UCL may be determined by adding 15 mg/l to the baseline mean if that value is greater than the baseline mean plus five standard deviations.

Operational monitoring consists of sampling the monitor wells at least twice monthly and at least 10 days apart and analyzing the samples for the excursion indicators chloride, conductivity, and total alkalinity. EMC requests that in the event of certain situations such as inclement weather, mechanical failure, or other factors that may result in placing an employee at risk or potentially damaging the surrounding environment, NRC allow a delay in sampling of no more than five days. In these situations, EMC will document the cause and the duration of any delays.

To assure that water within the well casing has been adequately displaced and/or formation water is sampled, wells will be purged before sample collection to ensure that representative water is obtained. Samples will be taken when field water quality parameters such as pH and specific conductivity appear to be stable and consistent with the anticipated water quality of the area. Low flow purging may also be used in certain instances to prevent pulling of mining fluids to the monitor well from excessive purging and ensure only formation water is sampled.

Water level and analytical monitoring data for the UCL parameters are reported to the WDEQ-LQD on a quarterly basis. This data is retained on site for review by the NRC.

6.2.2.5 Excursion Verification and Corrective Action

During routine sampling, if two of the three UCL values are exceeded in a monitor well, , the well is resampled within 24 hours of the determination that a sample has exceeded two of the three UCL values and analyzed for the excursion indicators. The verification sample is split and analyzed in duplicate to assess analytical error. If results of the confirmatory sampling are not complete within 30 days of the initial sampling event, then the excursion will be considered confirmed for the purpose of meeting the reporting requirements described below. If the second sample does not exceed the UCLs, a third sample is taken within 48 hours. If neither the second or third sample results exceeded the UCLs, the first sample is considered in error.

If the second or third sample verifies an exceedance, the well in question is placed on excursion status. Upon verification of the excursion, the USNRC Project Manager and the WDEQ-LQD is notified by telephone or email within 24 hours and notified in writing within thirty (30) days. A written report describing the excursion event, corrective actions, and corrective action results will be submitted to the NRC within 60 days of the excursion confirmation.

If an excursion is verified, the following methods of corrective action will be instituted (not necessarily in the order given) dependent upon the circumstances:

- A preliminary investigation will be completed to determine the probable cause.
- Production and/or injection rates in the vicinity of the monitor well will be adjusted as necessary to increase the net bleed, thus forming a hydraulic gradient toward the production zone.
- Individual wells will be pumped to enhance recovery of mining solutions.
- Injection into the well field area adjacent to the monitor well may be suspended. Recovery operations continue, increasing the overall bleed rate and the recovery of wellfield solutions.

In addition to the above corrective actions, sampling frequency of the monitor well on excursion status will be increased to once every seven days.

If an excursion is not controlled within 30 days following confirmation of the excursion, a sample must be collected from each of the affected monitoring wells and analyzed for the following parameters: ammonia; antimony; arsenic; barium; beryllium; bicarbonate; boron, cadmium, calcium, carbonate; chloride; chromium; conductivity; copper; fluoride; gross alpha; gross beta; iron; lead; magnesium; manganese; mercury; molybdenum; nitrate + nitrite; pH; potassium; selenium; sodium; sulfate; radium-226 and 228; thallium; TDS; uranium; vanadium; and zinc.

If the concentration of the UCL parameters detected in the monitor well(s) does not begin to decline within 60 days after the excursion is verified, injection into the production zone adjacent to the excursion will be suspended to further increase the net water withdrawals. Injection will be suspended until a declining trend in the concentration of the UCL parameters is established. Additional measures will be implemented if a declining trend does not occur in a reasonable time period. After a significant declining trend is established, normal operations will be resumed with the injection and/or production rates regulated such that net withdrawals from the area will continue. The declining trend will be maintained until the concentrations of excursion parameters in the monitor well(s) have returned to concentrations less than respective UCLs.

If an excursion is controlled, but the fluid which moved out of the production zone during the excursion has not been recovered within 60 days following confirmation of the excursion, EMC will submit to the WDEQ-LQD and the NRC within 90 days following confirmation of the excursion a plan and compliance schedule meeting the requirements of LQD Rules and Regulations, Chapter 13, Section 13(b).

A monthly report on the status of an excursion shall be submitted to the LQD administrator beginning the first month the excursion is confirmed and continuing until the excursion is over. The monthly report shall contain the requirements described in LQD Rules and Regulations, Chapter 12, Section 12(e). An excursion will be considered concluded when the concentrations of excursion indicators do not exceed the criteria defining an excursion, or if only one excursion indicator exceeds its respective UCL by less than 20%.

6.3 ECOLOGICAL MONITORING

6.3.1 Wildlife

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 permit area 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 3.5, eight raptor nests were observed within the proposed Moore Ranch Permit 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 permit 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 (wellfields and central Plant site) 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 wellfield areas and 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.

Baseline monitoring studies have repeatedly demonstrated that sage-grouse do not inhabit the MR area. As described previously in Section 3.5, those surveys encompassed most of the Moore Ranch Project and its one-mile perimeter for much of that period. No sage-grouse leks were observed in that region during any survey year. WGFD records and USDA-FS records also failed to document any sage-grouse leks within the approximately area that encompasses the general analysis area (i.e., proposed Moore Ranch license boundary and a one-mile perimeter). Given the lack of sage-grouse observations in the area, and the minimal quantity and marginal quality of potential sage-grouse habitat, EMC does not plan to conduct operational monitoring for sage-grouse at this time.

6.4 QUALITY ASSURANCE PROGRAM

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

The QA program will address the following:

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

QA procedures will include:

1. Environmental monitoring procedures.
2. Testing procedures.
3. Exposure procedures.
4. Equipment operation and maintenance procedures.
5. Employee health and safety procedures.

6. Incident response procedures.

Addendum 6.2-A

Groundwater Modeling to Assess Monitor Well Ring Spacing Wellfield 1, Moore Ranch Uranium ISR Project

Groundwater Modeling to Assess Monitor Well Ring Spacing
Wellfield 1, Moore Ranch Uranium ISR Project

Prepared by
Petrotek Engineering Corporation

Introduction

A groundwater flow model was developed for the Moore Ranch Uranium Project to assess the spacing of monitor wells around the uranium ISR wellfield. This memorandum briefly describes key features of the model development including the conceptual model and the numerical model code, domain, grid, boundary conditions, and simulation results. A 500-foot monitor well ring spacing is proposed for the Moore Ranch ISR Wellfield 1. Results of the model simulations indicate that the proposed spacing is adequate to allow for recovery of excursions related to operation of the ISR mine.

Conceptual Model

A conceptual hydrologic model for the Moore Ranch Project area is briefly summarized here. Details of the geology and hydrogeology of the site can be found in the NRC Source Materials License application that is submitted concurrently with this document.

The aquifer simulated is the 70 Sand, which is the proposed uranium production zone for the Moore Ranch Project. The 70 Sand averages approximately 80 feet in thickness within the area of Wellfield 1 and dips north-northwesterly at approximately 0.5 to 1 degree. In the vicinity of Wellfield 1, the 70 Sand aquifer is predominately a confined system. The 70 Sand aquifer transitions to an unconfined system toward the south where the sand crops out. Groundwater flow within the 70 Sand is toward the north under a hydraulic gradient of 0.004 ft/ft. Transmissivity of the aquifer is 300 to 400 ft^2/d (2,250 to 3,000 gpd/ft). The hydraulic conductivity determined from a recent pumping test at well MW3 was 4.5 ft/d. Porosity of the 70 Sand is estimated at 26 percent. Within the vicinity of Wellfield 1, the 70 Sand is bounded above and below by low permeability clays and silts that act as confining units.

Recharge occurs to the 70 Sand within a few miles to the south where this hydrostratigraphic unit crops out. There are no known discharge areas from the 70 Sand within the Permit Area.

Groundwater velocity under ambient, non-pumping conditions can be estimated using the Darcy equation:

$$v = \frac{k^* i}{\varnothing}$$

where v = interstitial groundwater velocity (ft/d)
k = hydraulic conductivity (ft/d)
i = hydraulic gradient (ft/ft)
∅ = porosity (unitless)

Using site-specific values of 4.5 ft/d (from the MW3 pumping test), 0.004 ft/ft (potentiometric surface map of the 70 Sand) and 0.26 (estimated) for the k, i, and ∅ terms, respectively, the groundwater velocity under natural (background) conditions is calculated as 0.072 ft/d, or approximately 26.3 ft/yr. The modeling demonstrates that if mining related fluids reach the monitor well ring, changes in the localized pumping rates within the wellfield are capable of recovering those fluids, and then keeping them within the monitor well ring (the proposed aquifer exemption area).

Model Code

The model used was MODFLOW, a finite difference numerical simulator developed by the USGS (McDonald & Harbaugh 1988). MODFLOW was selected for simulating groundwater flow at the Moore Ranch site because it is capable of a wide array of boundary conditions, in addition to being a public domain code that is well accepted in the scientific community. The code simulates groundwater flow using a block-centered, finite-difference approach. Modeled aquifers can be simulated as unconfined, confined, or a combination of confined and unconfined. MODFLOW also supports variable thickness layers (i.e. variable aquifer bottoms and tops. Documentation of all aspects of the code is provided in the users manual (McDonald & Harbaugh 1988).

A particle-tracking code also was utilized that could easily incorporate information collected from the MODFLOW groundwater flow model. The code chosen was MODPATH (Pollock, 1994), which was designed to use the output head files from MODFLOW to calculate particle velocity changes over time in three dimensions. MODPATH was used to provide computations of groundwater seepage velocities and groundwater flow directions at the site. MODPATH is also a public domain code that is well accepted in the scientific community.

The pre/post-processor Groundwater Vistas (Environmental Simulations, Version 4, 2004) was used to assist with input of model parameters and output of model results. Groundwater Vistas serves as a direct interface with MODFLOW and MODPATH. Groundwater Vistas provides an extensive set of tools for developing, modifying and calibrating numerical models and allows for ease of transition between the groundwater flow and particle tracking codes.

Model Domain and Grid

The model domain assigned for this assessment encompasses nearly two square miles with a north-south dimension of 8,200 ft and an east-west dimension of 6,300 ft. The model grid is centered over Wellfield 1 of the Moore Ranch Project. The wellfield is approximately 3,000 feet long and 600 feet wide and is oriented with the long axis along a north-south trend. The model extends approximately 2,500 feet beyond each side of the wellfield. The model consists of 328 rows and 254 columns. Each cell in the model has uniform dimensions of 25 ft by 25 ft. Because of the presence of overlying and underlying confining units, only the 70 Sand was simulated, so the model contains a single layer. The base of the model and the top of the model are simulated as no flow boundaries that approximate the overlying and underlying confining units. The domain of the model is illustrated in Figure 1.

Boundary Conditions

Boundary conditions imposed on a numerical model define the external geometry of the groundwater flow system being studied as well as internal sources and sinks. Boundary conditions assigned in the model were determined from observed conditions. Descriptions of the types of boundary conditions that can be implemented with the MODFLOW code are found in McDonald & Harbaugh (1988). Boundary conditions used to represent hydrologic conditions at the Moore Ranch Project included general-head (GHB) and wells. The locations of boundary conditions within the model are illustrated in Figure 1. Discussion of the placement and values for these boundary conditions is provided below.

The GHB was used in the Moore Ranch model to account for inflow and outflow from the model domain. GHBs were assigned along the edges of the model domain where available water-level data suggest the aquifer is being recharged from, or discharging to, a source external to the model domain. GHBs were used because the groundwater elevation at those boundaries can change in response to simulated stresses. In the Moore Ranch model, GHBs were assigned to the south, west, north and east boundaries of the model. The values of head assigned to the GHB ranged from 5196.4 ft along the south edge of the model 5163.6 ft, along the north edge. This resulted in simulated background potentiometric surface with a hydraulic gradient of 0.004 ft/ft.

The model domain was extended a suitable distance from the limits of the wellfield outline to eliminate perimeter boundary effects on the interior of the model. The conductance term for the GHB cells was set to a relatively large value ($2x10^6$) so that groundwater flow in and out of the cells was not constricted and the boundary conditions would not limit the response of the aquifer to internal stresses (primarily from the wells).

The MODFLOW well package was used to simulate injection and extraction (production) wells within proposed Wellfield 1. As shown in Figure 1, the wellfield configuration includes a series of five spot patterns with an extraction well located in the center, surrounded by four injection wells. The distance between injectors is 100 feet. The distance from each injector to any extraction well is 70.7 feet. When the well patterns are placed adjacent to one another, the injector wells may supply fluids to as many as four different extraction wells. Using this well configuration to cover the area of Wellfield 1 required 131 extraction wells and 174 injection wells. Figure 2 shows the distribution of injection and extraction wells within the wellfield (note that a potential inclusion area to Wellfield 1, and parts of Wellfield 2 are shown, but have no impact on this analysis. A monitor well ring was placed around the wellfield approximately 500 feet from the outermost injection wells. The monitor well ring roughly approximates the minimum extent of the aquifer exemption area.

Aquifer Properties

Input parameters used in the model to simulate aquifer properties are consistent with site-derived data including; hydraulic conductivity, storativity, hydraulic gradient, saturated thickness and porosity. Hydraulic conductivity determined from the MW3 pumping test was 4.5 ft/d. As previously described under the boundary conditions, a hydraulic gradient of 0.004 ft/ft was imposed on the model using the GHB cells along the perimeter of the model. The top and bottom of the 70 Sand were simulated as dipping to the north at 0.004 ft/ft to coincide with the hydraulic gradient of the potentiometric surface to maintain a constant aquifer saturated thickness of 80 feet. Storativity was estimated from other pumping tests conducted in the area. The storativity value used in the model simulations was 0.0006. Similarly, porosity of the aquifer was estimated from other ISR operations in the region. A value of 25 percent was used in the simulation.

Model Simulations

The model was set up to initially simulate non-pumping, pre-mining conditions. Results of this simulation generally replicate the baseline conditions in the aquifer prior to ISR mining with northward groundwater flow direction at a hydraulic gradient of 0.004 ft/ft. Figure 3 shows the results of the non-pumping simulation.

A simulation was then run in which the wellfield is operational. In this simulation, 131 extraction wells are pumping at a combined rate of 2,977 gpm of groundwater and 173 injection wells are injecting at a combined total of 2,939 gpm. This ratio provides a one percent bleed (over pumpage) such that there is net inward flux of groundwater into the wellfield (Figure 4). The pumping rate was the same for each of the extraction wells (22.7 gpm). For the injection wells, higher rates were simulated for the interior pattern wells in the central portion of the wellfield (19.8 gpm) and lower rates were simulated for wells along the edges of the wellfield (ranging from 6.2 to 15.6 gpm).

Particle tracking was used to evaluate if all lixiviant injected into the injection wells was recovered by the production wells (Figure 5). Particles were placed over the location of the perimeter injection wells to determine the flowpaths from those wells. The figure illustrates that all of the flowpaths from the injection wells are captured by the site extraction wells, although in some cases there is appreciable flare. In some cases, injected water moves out away from the wellfield and is not captured by the five-spot pattern it came from, but is eventually captured further northward by other well patterns Figure 6 shows the particle tracking results in greater detail without the potentiometric surface. The amount of potential flare shown on these figures is not a concern as wellfield balancing will be performed during operations.

The next simulations were run to determine if an excursion detected at the site monitoring ring wells could be recovered by adjusting operating rates within the wellfield. Any number of hypothetical scenarios could be developed for obtaining mining-derived fluids out to the monitor well ring. Rather than attempt to develop scenarios that would require failure of the wellfield configuration to retain ISR related fluids within the monitor well ring, the model was used to evaluate whether or not ISR related fluids detected at the monitor well ring could be recovered by altering the wellfield production/injection rates.

Sampling of the monitor ring wells will occur every 14 days. Therefore, the longest period that an ISR-derived constituent could move beyond the monitor well ring undetected would be 14 days. It is assumed that it could take a week (7 days) for a corrective action plan to be developed and implemented. Therefore, the maximum travel time for an ISR-derived constituent to move beyond the monitor well ring is assumed to be 21 days in the simulation. The model simulation of this scenario is set up by placing particles at the monitor wells located directly north of the orebody. The particles represent an ISR-derived fluid that has managed to reach the monitor well ring. The model is initially run for a period of 21 days under the normal operating rates to determine how far beyond the monitor well ring the particle would travel.

The area north of the wellfield is the most critical with respect to monitoring and potential excursions because it is directly downgradient of the wellfield and has the greatest potentiometric difference that has to be overcome in order to recover groundwater after a hypothetical excursion. Areas upgradient of the wellfield will naturally flow toward the wellfield. Monitor wells located along the east and west sides of the wellfield are generally crossgradient of the wellfield and would not require as much hydraulic control to capture. Therefore, the focus of the modeling effort is on the area and monitor wells directly north of Wellfield 1.

Results of the first stress period (21 days of normal operation) indicate that the particle placed in the monitor well that is directly downgradient 500 feet north of the wellfield traveled a total distance of approximately one foot. This is consistent with the previous calculation of groundwater velocity under non-pumping conditions (0.72 ft/d x 21 days = 1.51 ft). The travel distance under the pumping scenario is slightly less than the non-pumping scenario because of the net drawdown and subsequent depression in the potentiometric surface within the wellfield

The corrective action simulated with the model was to turn off the six northernmost injection wells, but maintain the normal operation rates for the extraction wells. The model was run under these conditions for a simulated period of 100 days. Results of this second stress period of the model are shown in Figure 7. There is a significant cone of depression centered around the northern edge of the wellfield. The capture zone from the potentiometric surface resulting from the corrective action pumping scenario is shown in Figure 8. For purposes of clarity, the capture zone only includes the four northernmost extraction wells. As shown on the figure, all of the monitor wells fall within the capture zone that develops under this scenario. Note that this pumping scenario did not involve an increased pumping rate at the extraction wells, only a reduction in the injection rate for selected neighboring wells. During the 100 days of excursion recovery pumping, the particle that had moved 1 foot north of the monitor well would move 8 feet back toward the wellfield and be inside of the monitor well ring. Obviously, excursion recovery can be achieved in a shorter time frame if more injection wells are shut off, or if the rate of production is increased. In this regard, the assumptions shown herein are conservative.

Conclusions

The groundwater model developed for the EMC Moore Ranch Uranium Project indicates that the proposed pumping/injection plan is suitable for ISR mining. Maintenance of a one percent bleed effectively captures all of the lixiviant introduced into the injection wells. In the event that an excursion occurs resulting in ISR-derived fluids reaching the monitor well ring, feasible alteration to the production/injection rates within reasonable operating ranges will be sufficient to bring those fluids back into the monitor well ring.

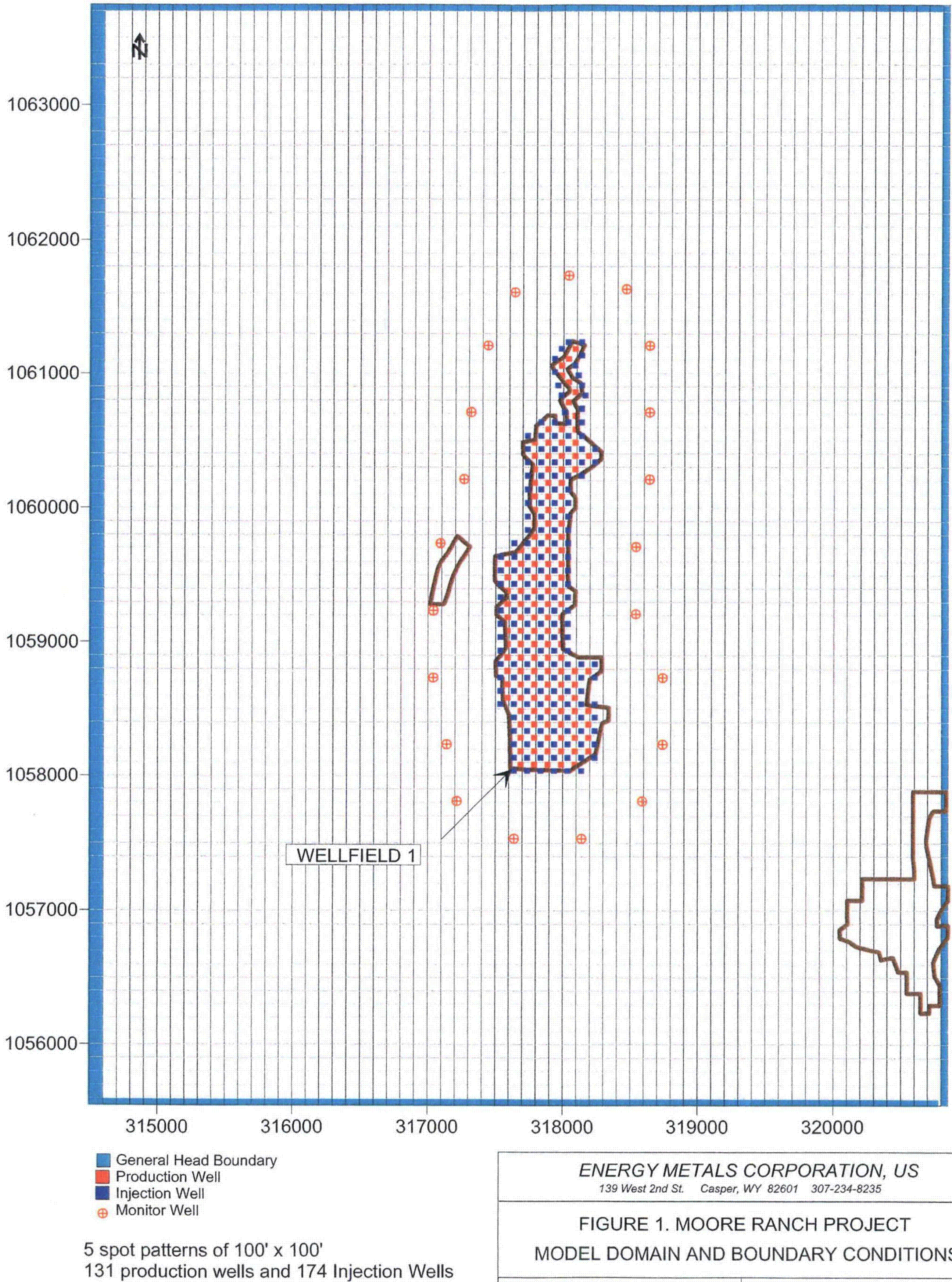


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FIGURE 1. MOORE RANCH PROJECT
MODEL DOMAIN AND BOUNDARY CONDITIONS

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG1.SRF	BY: EPL CHECKED: HPD

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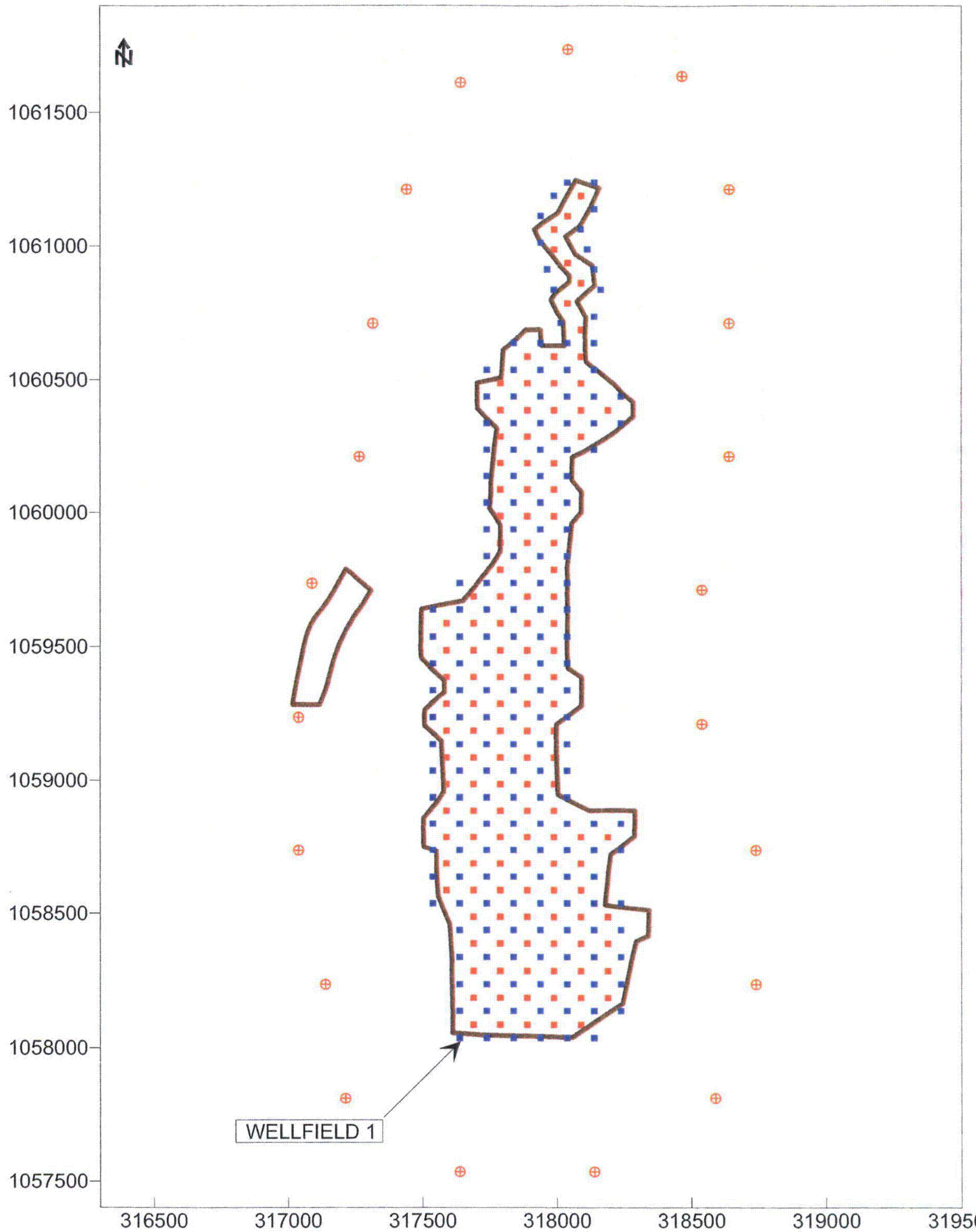

General Head Boundary
Production Well
Injection Well
⊕ Monitor Well

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 2. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE DETAIL-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007	
DWG: EMCMRWSMFIG2.SRF	BY: EPL	CHECKED: HPD

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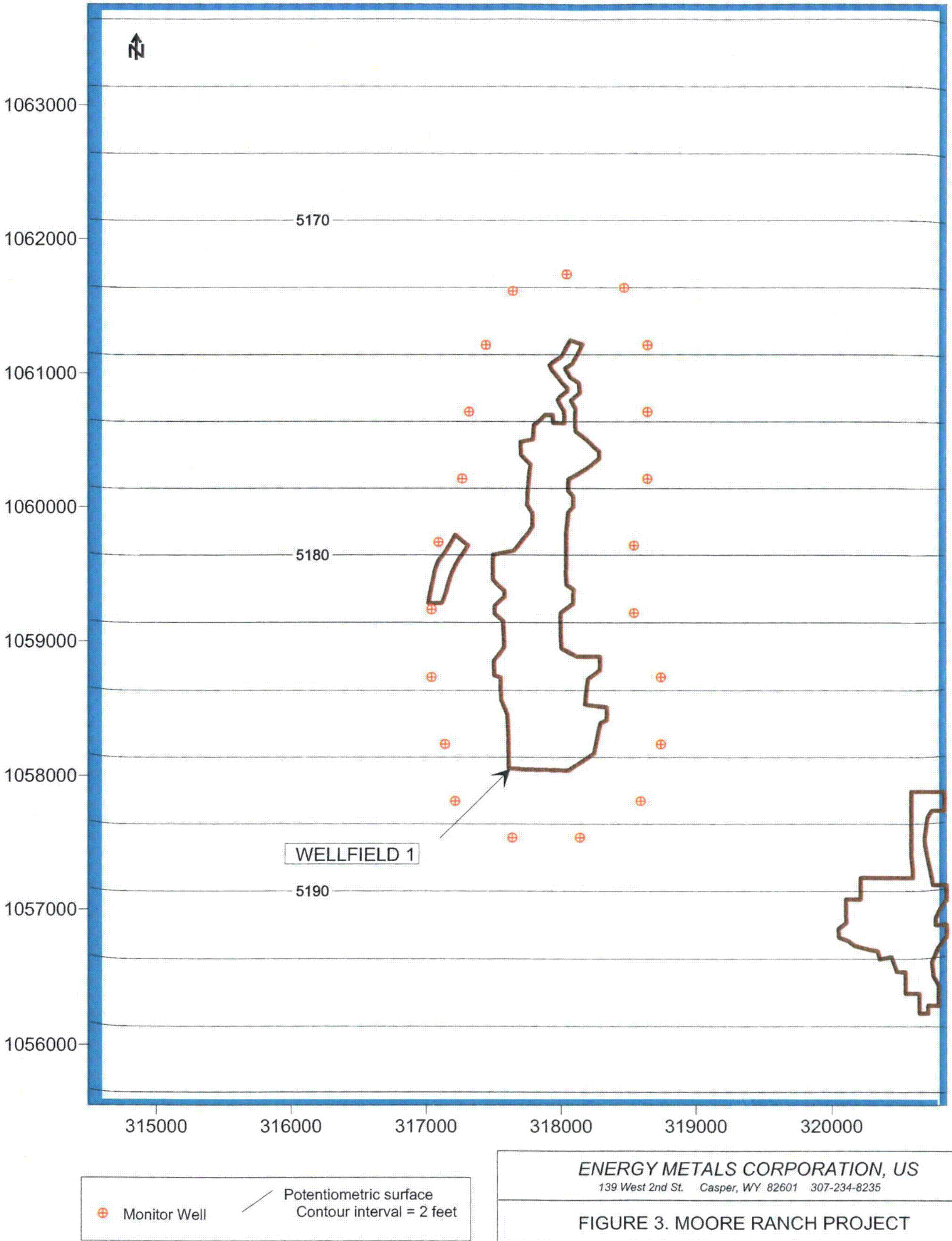

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FIGURE 3. MOORE RANCH PROJECT

SIMULATED POTENTIOMETRIC SURFACE-NO PUMPING

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG3.SRF	BY: EPL CHECKED: HPD

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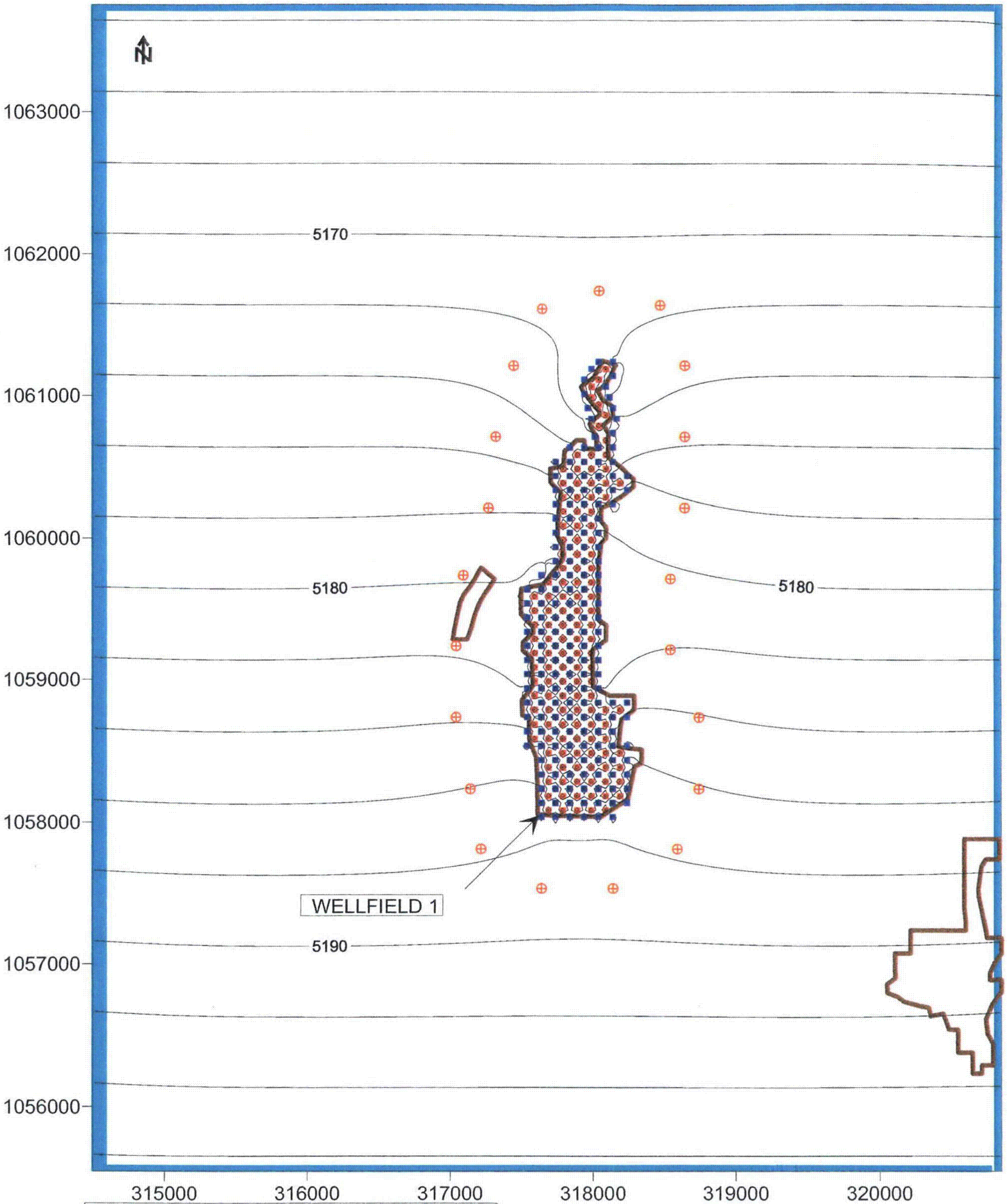

General Head Boundary
Production Well
Injection Well
Monitor Well

Potentiometric surface
Contour interval = 2 feet

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 4. MOORE RANCH PROJECT
SIMULATED POTENTIOMETRIC SURFACE-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG4.SRF	BY: EPL CHECKED: HPD

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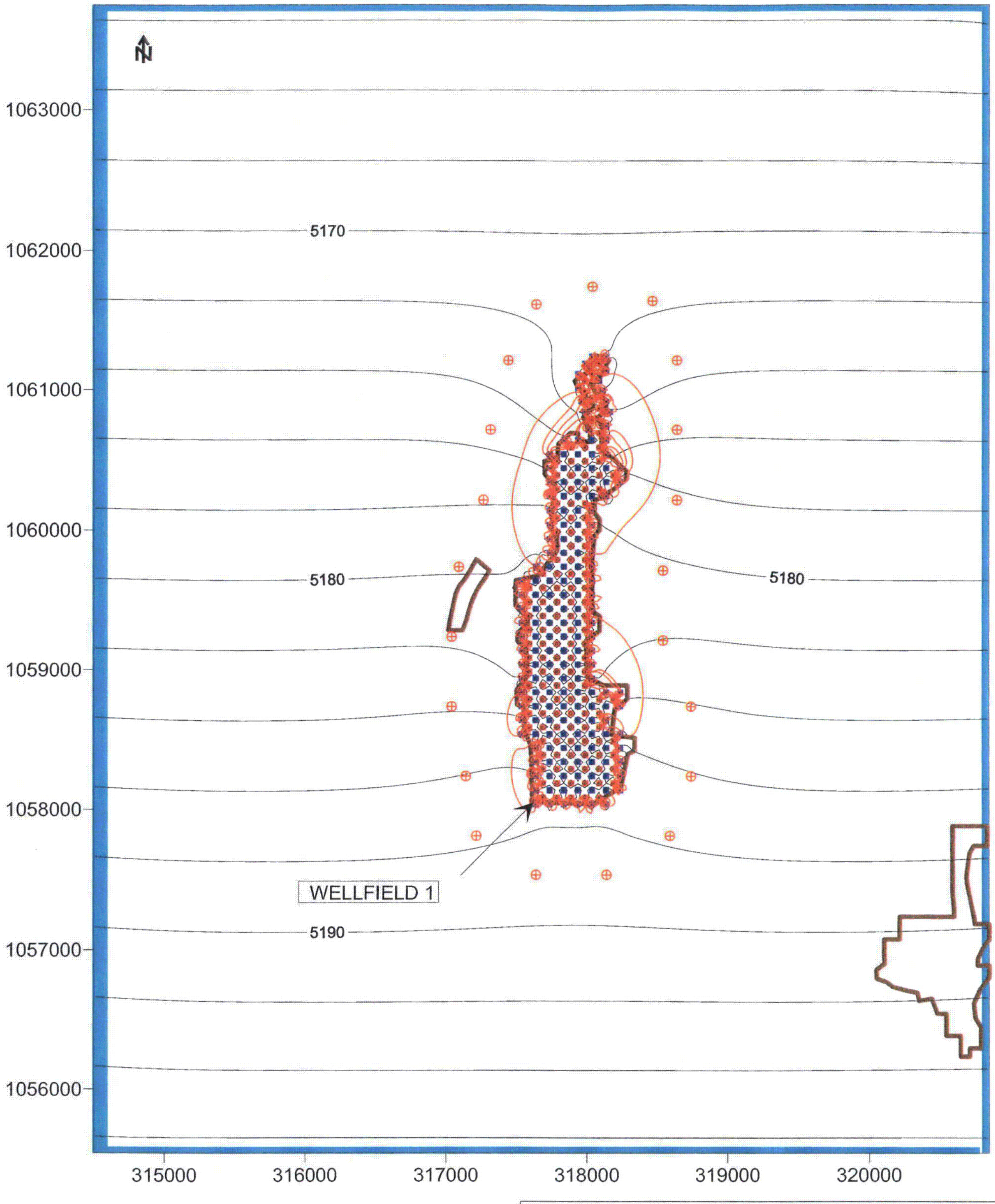

General Head Boundary
Production Well
Injection Well
Monitor Well
Groundwater Flowpath
Potentiometric surface
Contour interval = 2 feet

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 5. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG5.SRF	BY: EPL CHECKED: HPD

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General Head Boundary
Production Well
Injection Well
Monitor Well
Groundwater Flowpath

5 spot patterns of 100' x 100'
131 production wells and 174 Injection Wells

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FIGURE 6. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE DETAIL-1% BLEED

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG6.SRF	BY: EPL CHECKED: HPD

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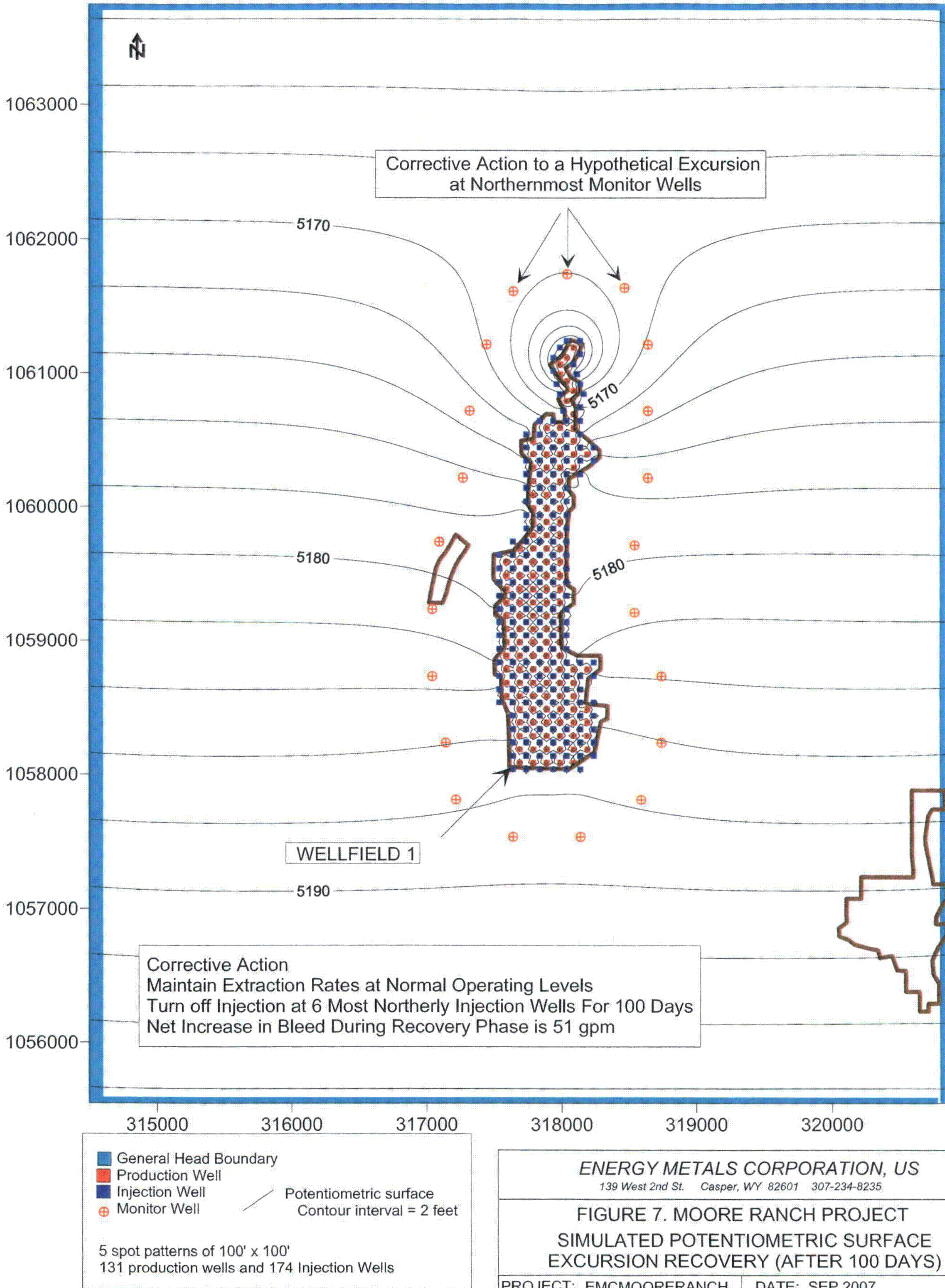

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FIGURE 7. MOORE RANCH PROJECT

SIMULATED POTENTIOMETRIC SURFACE EXCURSION RECOVERY (AFTER 100 DAYS)

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG7.SRF	BY: EPL CHECKED: HPD

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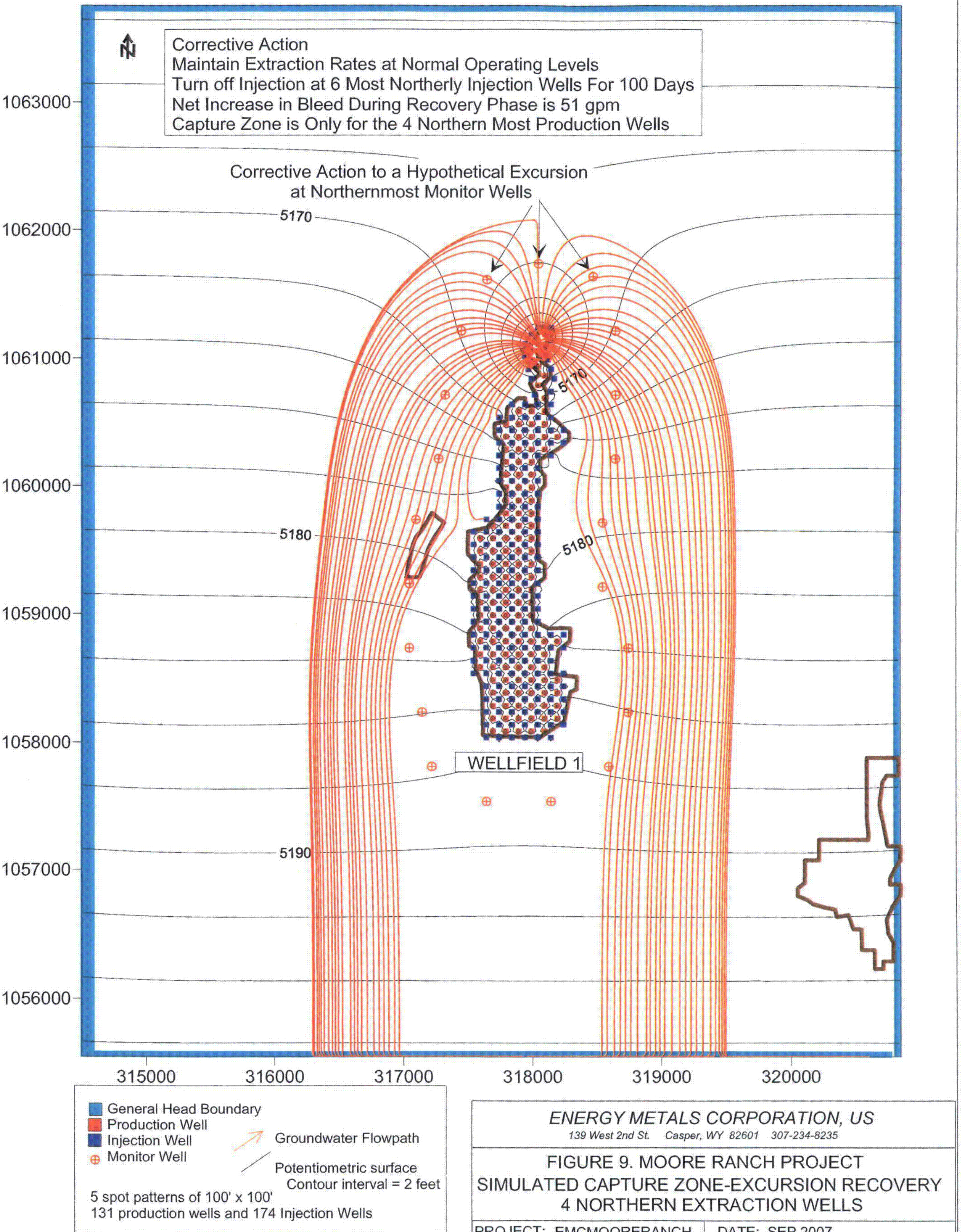

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FIGURE 9. MOORE RANCH PROJECT
SIMULATED CAPTURE ZONE-EXCURSION RECOVERY
4 NORTHERN EXTRACTION WELLS

PROJECT: EMCMOORERANCH	DATE: SEP 2007
DWG: EMCMRWSMFIG8.SRF	BY: EPL CHECKED: HPD

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7 BENEFIT-COST ANALYSIS

7.1 BENEFIT-COST ANALYSIS GENERAL BACKGROUND

Benefit-cost analysis (BCA) has established that the proposed development of a new uranium in-situ recovery facility at the Moore Ranch Project is potentially a cost-effective project to undertake and will provide a net economic benefit to the State of Wyoming.

This analysis has been specifically tailored to meet the requirements established by the Nuclear Regulatory Commission (NRC) NUREG 1569, and includes a description of the economic benefits from the construction and operation of the proposed Moore Ranch Project and a discussion of the temporary and long-term external costs. Where possible, benefit and cost estimates are monetized; however, reliable monetary estimates for some potential impacts are not readily available so the narrative examines several factors in non-monetary or qualitative terms.

The following analyses use IMPLAN (IMpact Analysis for PLANning), a standard industry software package that models the economic impacts of capital intensive projects, to calculate the potential economic impacts to the county. It was originally developed by the United States Department of Agriculture (USDA) Forest Service in cooperation with the Federal Emergency Management Agency (FEMA) and the United States Department of the Interior (USDI) Bureau of Land Management (BLM) for land and resource management planning (IMPLAN 2004). Currently, it is being managed by the Minnesota IMPLAN Group, Inc. (MIG).

7.2 ALTERNATIVES AND ASSUMPTIONS

BCA is widely used analytical tool for helping decision makers determine whether the cost of a project today will result in sufficient benefits to justify expenditure on a capital intensive project (Brown 2003; Zerbe and Bellas 2006). To provide value and to assist in the decision process, the BCA needs to be clear about the alternatives being considered and the underlying assumptions including quantities of goods, labor costs, market conditions and discount rates used to compute net present value. The following discussion briefly identifies alternatives and key assumptions used throughout the analysis.

7.2.1 Development Alternatives

This BCA evaluates the benefits and costs of building the Moore Ranch Project and all the costs and benefits resulting from its ongoing operation in Campbell County, Wyoming. The BCA tradeoff under consideration involves comparing a future with the proposed Moore Ranch Project to a future that represents a continuance of the no action.

7.2.1.1 No Action Alternative

Under the no action alternative, there would be no change in the current land cover or land and water uses at the site; therefore, there would be no change in the existing underlying socioeconomic and demographic trends.

7.2.1.2 Proposed Action

The proposed action involves the construction and operation of a uranium in-situ recovery (ISR) facility. ISR involves leaving the ore where it is in the ground and using liquids which are pumped through it to recover the minerals out of the ore. Consequently, the proposed action involves limited surface disturbance at the Moore Ranch Project and no tailings or waste rock would be generated.

7.2.2 Key Assumptions and Limitations

Key assumptions about the costs and benefits associated with the proposed Moore Ranch Project involve: (1) The Operating Life of the project; (2) the Discount Rate used; (3) the Scope of the Impact; and (4) Non-monetary Impacts. Each of these is described in more detail below.

7.2.2.1 Operating Life of Moore Ranch Project

The Moore Ranch Project will be a single unit of analysis including the wellfields, central plant, and outlying related structures. For this analysis, the total effective life of the Project is assumed to be 27 years. Within this time frame, there are three distinct phases of operation with a distinct suite of costs and benefits:

- 2 years of site development and facility construction (1 year for initial construction and 1 year for construction related to plant expansion during operations some time in the future)

- 10 years of wellfields and central plant operation
- 15 years of the central plant continuing operation after decommissioning the wellfields.

7.2.2.2 Discount Rate

Computing the net present value (NPV) of the proposed Moore Ranch Project requires that future benefits and costs be discounted. This discounting reflects the time value of money that benefits and costs are worth more if they are expected sooner. Following guidelines established by circular A-94 from the United States Office of Management and Budget (OMB), net present value estimates of benefits and costs are reported using a real discount rate of 7 percent (OMB 1992). Circular A-94 was revised in 1992 based on extensive review and public comment and currently reflects the best available guidance on standardized measures of costs and benefits. This rate approximates the marginal pretax rate of return on an average investment in the private sector in recent years.

7.2.2.3 Scope of Impact

A critical step in any BCA is establishing a viable scope of impact and thus establishing who will be affected by the Moore Ranch Project (Zerbe and Bellas 2006). As a practical matter the proposed project would be limited to the potential impact it may have on Campbell County.

7.2.2.4 Non-monetary Impacts and Benefit-Cost Ratio

Conventional BCA uses monetary values to compare goods and services derived from a project or program. The values of goods and services represent their relative importance so that if the total value of the benefits is greater than the total value of the costs, the Moor Ranch Project is desirable. The standard result is a quantified benefit-cost ratio (BCR), equal to a project's total net benefits divided by its total cost. BCR's above one have positive net economic impacts. While many inputs in the Moore Ranch Project BCR are goods and services (skilled labor, construction material) that are regularly traded in markets at well known and predictable prices, others (changes to land or water, aesthetic impacts) are not directly traded and are more difficult to value. Where reliable monetary values are not available a qualitative approach based on the best available information is required.

7.3 ECONOMIC BENEFITS OF PROJECT CONSTRUCTION AND OPERATION

This section considers the potential economic impacts resulting from construction and operation-related activities over the life of the Moore Ranch Project. Economic benefits are those that have the potential to affect the local economy, including the number of jobs created and state and local tax revenues generated from project related business activities.

These analyses use IMPLAN to calculate the potential economic impacts to Campbell County. IMPLAN allows the user to build an input-output model tailored to model the potential impact of a proposed project on a specific community or region. The system is flexible and contains a database of over 500 industrial sectors gathered from counties throughout the United States. By identifying the location and industrial sector of the project (i.e., construction and mining), the analyst can therefore estimate the total potential economic impact of a given project. The model requires labor and capital expenditures data as inputs in order to evaluate the potential economic impacts of the project. The output is the potential direct and indirect employment impacts and generated tax revenue.

This analysis focuses on Campbell County, Wyoming and two economic sectors most closely associated with the distinct phases of the proposed Moore Ranch Project: new construction (IMPLAN code 41) and support activities for mining (IMPLAN code 29). Unfortunately, IMPLAN does not currently have a uranium mining sector for Campbell County, so all tax revenue estimates drawn from IMPLAN should be treated as lower-bound estimates given that ad valorem and severance taxes will likely differ for different mining sectors.

7.3.1 INPLAN Input Data

This analysis assumes that the Moore Ranch Project begins in 2009 for initial construction and construction activities take place through late 2009. The second year of construction will occur at a later time during operations for plant expansion and is not included in this analysis. The total estimated number of construction workers employed directly by the applicant is 50 per year, of which 25 (50 percent) would likely be from Campbell County. Construction capital expenditures are estimated at $50 million (including initial construction and future plant expansion), or $25 million per year for the duration of the initial construction period (Table 7.3-1).

Following one year of facility construction, the wellfields and central plant would be fully-operational, employing 60 full-time workers per year for the first 10 years. After completion of mining and restoration activities, 40 full-time workers will be required for continuing plant operations, accepting loaded ion exchange resin from satellite facilities for processing. Approximately 30 (50 percent) of workers would be located in Campbell County. The Moore Ranch Project has the potential to incur up to $12 million in non-payroll-related operating costs annually for the first 10 years, and $1.8 million thereafter.

Table 7.3-1 Input Data for the Moore Ranch Project

Activities	IMPLAN Code	Per Year 2008 - 2009	2010 - 2019	2020 - 2034
Construction Expenditures				
Non-payroll[1]	41	$25 M	NA	NA
Payroll[2]	41	25 workers	NA	NA
Operations Expenditures				
Non-payroll	29	NA	$12 M	$1.8 M
Payroll	29	NA	30 workers	20 workers

1 Does not include land purchase cost
2 Limited to Campbell County

7.3.2 Employment Benefits

Using the above assumptions, Table 7.3-2 summarizes the potential employment-related effects generated by the Moore Ranch Project. IMPLAN defines employment as total wage and salary employees, including self-employed jobs that are related to the proposed project. It also includes both full-time and part-time workers and is measured in annual average jobs.

Table 7.3-2 also shows the potential direct, indirect and induced effects on county-wide employment. The direct employment effects refer to the employment directly generated by the Moore Ranch Project. For the initial construction phase in years 2008 to 2009, the model estimated 285 additional non-payroll workers hired in Campbell County per year based on the 25 payroll workers engaged directly in construction activities, and the $25 million of non-wage capital expenditures incurred by the Moore Ranch Project per year.

Potential indirect effects pertain to the inter-industry effects from the direct effects and could include increased labor demand, goods and services required to support the Moore Ranch Project (such as restaurant and hotel staff). In addition, new workers living within Campbell County would spend their income locally which induces additional income and employment. Construction workers living in the county for the construction period would purchase local goods and services which help generate additional employment. The sum of potential direct, indirect and induced effects represents the total potential employment impacts of the Moore Ranch Project.

These results indicate that the Moore Ranch Project is expected to create 401 additional jobs per year for the first year of intensive construction, 147 additional jobs per year in the next 10 years during full operation, and 53 additional jobs per year in the last 15 years of operation. It is important to note that the total potential economic impacts from the Moore Ranch Project could extend to the surrounding areas of Converse, Natrona and Johnson counties. As a result, the total potential employment impacts predicted by this analysis are conservative.

Table 7.3-2 Employment Effects of the Moore Ranch Project in Campbell County

Years	Employment per Year			
	Direct	Indirect	Induced	Total
2008 - 2009	285	59	57	401
2010 - 2019	75	38	34	147
2020 - 2034	27	14	12	53

7.3.3 State and Local Tax Revenue Benefits

In addition to aggregate employment effects, IMPLAN provides an estimate of expected state and local tax revenue impacts over the life of the Moore Ranch Project associated with mining activities. In order to remain consistent with the scope of impact, Federal taxes are not included in this analysis. The results standardized to 2007 dollar equivalents using the OMB recommended real discount rate of 7 percent are presented in Table 7.3-3.

Potential state and local tax implications associated with the proposed Project are presented in Table 7.3-3. While IMPLAN includes employee and employer social insurance taxes as well as personal tax items like income tax, property tax and motor vehicle license tax, these tax revenues are not reported here because they are paid by county workers and their families and thus represent a transfer of wealth rather than a net economic gain. Conversely, corporate dividend taxes and the indirect business tax category associated with the proposed Project consist of tax items such as property tax, sales tax and a state-levied severance tax on uranium production. These revenues stem directly from the construction and operation of the Moore Ranch Project, are paid by the operator of the proposed Moore Ranch Project, and therefore can be counted as net economic gains when compared to the no action alternative.

As Table 7.3-3 shows, the results from the IMPLAN analysis show that the construction and operation of the Moore Ranch Project is expected to generate a net present value of approximately $8.0 million in total enterprise and business tax revenues over the life of the Moore Ranch Project.

Table 7.3-3 State and Local Tax Revenue IMPLAN Projections

	Net Present Value ($ Millions) *		
Activities	**Enterprise (Corporate) Tax**	**Indirect Business Tax**	**Total Taxes**
Construction	0.2	1.2	1.4
Operations	1.3	5.3	6.6
Total	1.5	6.5	**8.0**

*2007 DOLLAR EQUIVALENTS

Additionally, severance taxes associated with uranium mining in Campbell County are levied by the State of Wyoming, Mineral Tax Division of the Department of Revenue. The current uranium severance tax is 4% of taxable market value coming from mining operations (Wyoming Department of Revenue—Mineral Tax Division 2007). Current resource estimates for the proposed project are 5.8 million lbs (43-101 compliant). This does not include reserve estimates as these projections are not yet complete. Assuming that the identified 5.8 million lbs were sold at current market prices of approximately $90 per pound, the severance tax would yield approximately $20,800,000 in net economic benefits over the life of the operation.

In sum, the results show that $28.8 million net quantifiable economic benefits can be linked to the proposed project. It is noted that this figure represents a lower bound estimate as it excludes potential reserve resources and does not include potential benefits derived from taxes on royalties or lease payments to local landowners stemming from the operation of the proposed Moore Ranch Project.

7.4 EXTERNAL COSTS OF PROJECT CONSTRUCTION AND OPERATION

In this section of the analysis, external costs of the proposed Moore Ranch Project are identified and compared to the no action alternative. Both short-term and long-term external costs that may affect the interest of people other than the owners and operators of the proposed Moore Ranch Project are also identified and described.

7.4.1 Short Term External Costs

7.4.1.1 Housing Shortages

Approximately 50 percent of the total construction and operating work force for the proposed Moore Ranch Project would likely come from Campbell County. The remaining workforce would likely be based in Casper, located in neighboring Natrona County. The IMPLAN model results show that in 2008-2009, the Moore Ranch Project is expected to generate 401 new jobs due to construction-related activities. In 2010, 147 new jobs are generated for operations-related activities, which are expected to continue until 2019. In 2020, 53 jobs would be needed for central plant operations.

Since the Moore Ranch Project lies within commuting distance of Natrona County, no impacts on the housing situation in nearby cities or towns are anticipated. In the event that workers from out-of-state are hired for the short-term construction phase of the Moore Ranch Project, the present available stock of motel/hotel rooms would accommodate the temporary workers.

In the event that the entire direct payroll and non-payroll workforce relocated to Campbell County, the population increase would be a maximum of 718 for the first phase, 189 for the second phase and 68 for the final phase of operation, based on the 2005 average household size of 2.52 in Wyoming. This increase would account for 2.5 percent of the population of Campbell County as of 2006, thereby posing little or no change from the no action alternative on housing needs in the area.

7.4.1.2 Impacts on Schools and Other Public Services

Two schools are located in Campbell County approximately 22 miles northeast of the Moore Ranch Project area: Cottonwood Elementary School and Cottonwood High School. The total enrollment in the elementary school increased by only 13 percent from 2002 to 2006. The total enrollment for the high school decreased by 15 percent over the same period. The elementary school currently has a student-to-teacher ratio of 12.5 to 1, while the high school has a ratio of 9.7 to 1. In the neighboring Natrona County, the Midwest School provides classes for students from preschool through grade 12. It has a student to teacher ratio of 9.4 to 1.

Families moving into the Campbell County School District as a result of the proposed Moore Ranch Project are not expected to significantly stress the current school system because it is presently under-capacity. Likewise, there is no significant change anticipated from the no action alternative in the demand for other public services such as fire, police, water and utilities. The maximum population increase resulting from the permanent migration of workers into Campbell County represents only 2.5 percent of the population.

7.4.1.3 Impacts on Noise and Congestion

There are no occupied housing units in the vicinity of the proposed Project. Open rangeland is the primary land use within and in the surrounding 2.0-mile area. Other land uses include oil and gas production facilities, as well as pastureland located to the west of the Project area. 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. Additionally, given the maximum increase in population due to migrant workers is insignificant, noise and congestion impacts are not anticipated in Campbell or other neighboring counties.

7.4.2 Long Term External Costs

7.4.2.1 Impairment of Recreational and Aesthetic Values

While opportunities for developed and dispersed recreation exist throughout the five-county region surrounding the Moore Ranch Project, there are currently no recreational uses within the Moore Ranch Project area or in the surrounding 2.0-mile area, and no developed recreation opportunities are provided on federal and state lands within a 50 mile radius of the proposed Moore Ranch Project. Most developed recreation opportunities offered by the private sector are community facilities in townships or urban areas for tourist services and facilities.

The physical remoteness of the proposed Moore Ranch Project and its lack of proximity to any well recognized federal or state sites of recreational interest indicated that there are no significant long-term impairments to recreational values from developing the Moore Ranch Project.

7.4.2.2 Land Disturbance

The Moore Ranch Project area has been used historically for grazing, prospecting and oil and gas development; therefore, it is unlikely that any undisturbed land area currently exists within the proposed Moore Ranch Project area. A significant, pre-existing human footprint on the landscape is evident in existing grazing activities and facilities (stock tanks, fences), oil production facilities, natural gas production facilities, and infrastructures that support these activities. Oil and gas field infrastructure within the Moore Ranch Project area and the surrounding 2.0-mile review area includes access roads, overhead electric distribution lines, and cleared rights-of-way for underground utilities, which are generally found along access roads. There would be negligible changes in land cover or land use from existing conditions outside of the 2.0-mile review area.

As the proposed Project would use in-situ recovery instead of conventional surface mining techniques, there would be limited land surface disturbance associated with the wellfield development and operation of the site. Land surface disturbance associated with wellfield development would also be short term as interim stabilization with native vegetation species is implemented as soon as construction activities are complete and maintained through the life of the wellfield. No tailings or waste rock would be generated. The Central Plant and private access roads would be confined to clearly delineated areas within the Moore Ranch Project area. While there would be some land use changes from the existing condition within the Moore Ranch Project area, potential impacts will be minimal.

7.4.2.3 Habitat Disturbance

Currently, there is no federally or state designated wildlife habitat located within the proposed Moore Ranch Project area. As the Moore Ranch Project area has been historically used extensively for livestock grazing and oil and gas development, there are no anticipated long-term losses to wildlife or wildlife habitat relative to the existing conditions resulting from the construction and operation of the proposed Moore Ranch Project.

7.4.3 Groundwater Impacts

It is unlikely that any future irrigation development would occur within the proposed Moore Ranch Project area due to limited water supplies, topography, and climate. Irrigation within the 2.0-mile review area is anticipated to be consistent with the past. Based on population projections, future water use within the 2.0-mile review area would likely be a continuation of present use; therefore, it is anticipated that there would be no significant changes from the existing conditions for public water supply in the area.

Following standard mining practice, any impacted water drawn from the aquifer on site would either be treated before re-injection or disposed through deep well injection. Upon decommissioning, wells would be sealed and remaining groundwater would be restored as discussed in Section 5.4. The goal of the groundwater restoration program would be to return groundwater affected by mining operations to a quality consistent with pre-mining use. Prior to mining in each mining unit, baseline groundwater quality would be determined. This data would be established for each wellfield at the minimum density of one production or injection well per four acres. Upon completion of restoration, a groundwater stabilization monitoring program would begin in which the restoration wells and any monitor wells on excursion status during mining operations would be sampled and analyzed for the restoration parameters.

Given the historically limited irrigation, the lack of domestic groundwater use, and the groundwater restoration program associated with the proposed Moore Ranch Project, there would be no permanent commitment of water resources required and any potential long-term changes from the no action groundwater conditions would be limited to those identified and addressed in the groundwater restoration program.

7.4.4 Radiological Impacts

As the proposed Moore Ranch Project would be using in-situ recovery techniques, most of the identified radioactivity in the orebody would remain permanently underground. Following standard ISR procedures, routine operational monitoring of air, dust and surface contamination would be undertaken by EMC as discussed in Section 6. Prior to central plant decommissioning, a preliminary radiological survey would be conducted to identify any potential radiological hazards. The survey will also support the development of procedures for dealing with such hazards prior to commencement of decommissioning activities.

Decommissioning of process facilities would be scheduled only after agency approval. This would be accomplished in accordance with an approved decommissioning plan and the most current applicable USNRC rules and regulations, permit and license stipulations and amendments in effect at the time of the decommissioning activity.

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

- Removal to a new location within the Moore Ranch Project area for further use or storage;
- Removal to another licensed facility for either use or permanent disposal; or
- Decontamination to meet unrestricted use criteria for release, sale or other non-restricted use by the landowners and others.

It is likely that process buildings would be dismantled and moved to another location or to a permanent licensed disposal facility. Cement foundation pads and footings would be broken up and trucked to a local disposal site or to a licensed facility if contaminated. The landowners may request that a building or other structures be left on site for future use. In that case, the building would be decontaminated to meet unrestricted use criteria. At the present time, burial of non-contaminated wastes on site is not anticipated.

Under the proposed operating and decommissioning conditions, the potential long-term external radiological impacts at the Moore Ranch Project are anticipated to be negligible compared to the existing background no action conditions.

7.5 BENEFIT-COST SUMMARY

A primary economic benefit of the Moore Ranch Project is the creation of 601 new job opportunities within the county, including the direct, indirect and induced employment effects over the construction and operating life of the Moore Ranch Project (Table 7.5-1). Additionally, the Moore Ranch Project may generate up to $28.8 million in total state and local business tax revenues over the life of the Moore Ranch Project, which is a significant economic gain compared to the no action alternative.

Table 7.5-1 further shows that the short-terms effects on housing, schools and public facilities and the increased potential for noise and congestion in the county involve little or no change compared to the current conditions. Based on the historical land uses, physical remoteness and proposed reclamation practices, no potential quantifiable long-term impairments appear to significantly offset the benefits of the proposed Moore Ranch Project.

The proposed Moore Ranch Project is likely to place negligible short-term or long-term cost burdens on the county, while providing increased revenue and employment opportunities; therefore, the development and operation of the proposed Moore Ranch Project would provide a net economic benefit to Campbell County when compared to the no action alternative.

Table 7.5-1 **Summary of Benefits and Costs for the Moore Ranch Project**

Benefits	Costs
• **Tax revenue** $28.8 million • **Temporary and permanent jobs** 601 jobs	• **Housing impacts** Little or no change • **Schools and Public Facilities** Negligible • **Noise and Congestion** None • **Impairment of recreational and Aesthetic values** Negligible • **Land Disturbance** Minor • **Groundwater impacts** Controlled through mitigation • **Radiological Impacts** Controlled through mitigation

8 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

This Environmental Report has characterized the existing baseline environment of the proposed Moore Ranch Uranium Project and the surrounding area in Section 3. The potential environmental impacts (adverse and positive) of the proposed action were discussed in detail in Section 4. In this impact analysis, EMC identified unavoidable impacts of the proposed action. Alternatives for mitigation for these impacts were discussed in Section 5.

This section summarizes the environmental impacts that cannot be avoided. Where available, means of mitigation are also summarized.

Table 8-1 summarizes the unavoidable environmental impacts of the proposed construction, operation, and decommissioning of the Moore Ranch Project. Each impact is quantified (where possible). All impacts are short-term, i.e., the predicted impact will exist during the construction, operation, and decommissioning of the Moore Ranch Project. No significant long-term impacts that would extend beyond the duration of the project have been identified. For each impact, mitigative measures are summarized.

Table 8-1: Unavoidable Environmental Impacts

Impact	Estimated Impact	Mitigation Measures
Production		
Production of U3O8 (lbs./yr.)	4,000,000 pounds	None
Use of Natural Resources		
Temporary Land Surface Impacts (acres)	Significant land surface impacts to 11 acre central plant site; minimal disturbance to remaining 139 estimated acres of wellfield; impacted for the duration of the project.	Sediment and topsoil management during construction and operation; Surface reclamation following operational activities to return surface to pre-operational condition.
Temporary Land Use Impacts	Restriction of agricultural use of proposed 150 acre site; impacted for the duration of the project.	Surface reclamation following operational activities to return surface to pre-operational use.
Groundwater consumption (net gpm)	Average net consumptive use of 105 gpm for 12 ½ year mining and restoration life.	None
Groundwater quality impacts	Temporary impacts to groundwater quality in the mining zone.	Proven groundwater restoration following mining to return groundwater quality to baseline or pre-operational water uses.
Visual and scenic impacts	Noticeable minor industrial component in existing agricultural/rural landscape;	Use of harmonizing colors; use of existing vegetation and topography; avoidance of straight line site roads to follow topography; removal of construction debris.
Emissions		
Dust emissions (tons/yr.)	15.5	Dust control measures implemented where appropriate.
Radon emissions (Curies/yr.)	604.7	None
Radiological Impacts		
Additional maximum predicted dose (mrem/yr.)	0.8	None

Table 8-1: Unavoidable Environmental Impacts

Impact	Estimated Impact	Mitigation Measures
Fractional increase to background continental dose (percent)	0.000045	None
Socioeconomic Impacts		
Direct Employment		
Full time employment	40 to 60	None
Contractor employment	10 to 20	None
Part time and contractor employment during construction	50	None
Construction Capital Expenditures	$50,000,000	None
Non-payroll workers (Construction, 2008-2009)	401	None
Non-payroll workers (Full operations, 2010-2019)	147	None
Non-payroll workers (Restoration, Satellite operations, 2020-34)	53	None
Total Enterprise and Business Tax revenues	$8,000,000	None
Total Severance Tax revenues	$20,800,000	None
Non-payroll operating costs (operations and restoration, 2010-2019) ($/yr)	12,000,000	None
Non-payroll operating costs (Restoration, Satellite operations, 2020-34) ($/yr)	1,800,000	None
Waste Management Impacts		
Wastewater (gpm)	105 gpm average net consumptive use	Permanent disposal in Class I UIC disposal well(s)
Solid waste produced (yd^3/yr.)	2,000	Permanent disposal at license landfill
11e.(2) byproduct waste produced (yd^3/yr.)	100	Waste minimization; decontamination; permanent disposal at a licensed disposal facility.

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