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Protecting People and the Environment

NUREG-1910
Supplement 1

Environmental Impact Statement for the Moore Ranch ISR Project in Campbell County, Wyoming

Supplement to the Generic Environmental Impact Statement for In-Situ Leach Uranium Milling Facilities

Draft Report for Comment

U.S. Nuclear Regulatory Commission
Office of Federal and State Materials and Environmental Management Programs

I/61

3.5.2 Groundwater

3.5.2.1 Regional Groundwater Resources

As noted in Section 3.3.4.3 of the GEIS, the Powder River Basin where the proposed Moore Ranch Project is located is part of the Wyoming East Uranium Milling Region (NRC, 2009a). In this region, uranium bearing aquifers are part of the Northern Great Plains regional aquifer system which extends over one-third of Wyoming.

The Northern Great Plains aquifer system consists of five major aquifers which from shallowest to deepest are designated as the Lower Tertiary, Upper Cretaceous, Lower Cretaceous, Upper Paleozoic, and Lower Paleozoic aquifers. The shallowest Lower Tertiary aquifers are located in sandstone beds within the Wasatch and Fort Union Formations which are up to 1400 m (4600 ft) thick. These aquifers act as important regional water supplies for drinking water and livestock. Below them are the Upper Cretaceous aquifers which are found in sandstone beds in the Lance, Hell Creek and Fox Hills sandstones. These formations when combined are up to 1070 m (3850 ft) thick. The Fox Hills Sandstone is a significant water source. The next Lower Cretaceous aquifers are located beneath a regional thick sequence of shales known as the Pierre, Lewis and Steele shales. Water yielding aquifers in the Lower Cretaceous are widespread and include the Muddy Sandstone and the Inyan Kara in the Powder River Basin. These Lower Cretaceous aquifers contain little freshwater. The Upper Paleozoic aquifers are the Madison and the Tensleep Limestone in the western portion of the Powder River Basin and the Minnelusa Formation in the eastern portion. They are deeply buried and contain little to no freshwater. The Lower Paleozoic aquifers are the Winnipeg sandstone, the Red River limestone and Stonewall limestone formations. They are not typically used for water supplies as they are very deep and slightly saline to moderately saline in the southern extent and contain freshwater only in a small area in north-central Wyoming.

3.5.2.2 Local Groundwater Resources

The uranium-bearing aquifer at the proposed Moore Ranch Project is located in the Wasatch Formation which is part of the shallow Lower Tertiary aquifer system. The Wasatch formation is described as an arkosic fine-to coarse-grained sandstone with siltstone, claystone, and coals. The contact between the underlying Fort Union Formation and the Wasatch is gradational in the vicinity of Moore Ranch and is generally arbitrarily set at the top of the thicker coals or thick sequence of clays and silts. The applicant has identified the boundary between the two formations to be the top of the Roland Coal. The total thickness of the Wasatch Formation ranges between 244 and 335 m (800 and 1,100 ft) in the project area. In the southern portion of the Powder River Basin, the Wasatch generally dips to the northwest at 1.0 to 2.5 degrees.

There are commonly multiple water-bearing sands within the Wasatch Formation. Due to their higher permeability, these water bearing sands provide the primary sources for groundwater withdrawal. Groundwater within the Wasatch aquifers is typically under confined (artesian) conditions, although locally unconfined conditions exist. Well yields from the Wasatch in the southern part of the Powder River Basin where the site is located are reported to be as high as 1,900 Lpm (500 gal/min). The overall flow of groundwater in the shallow aquifers in the vicinity of the proposed Moore Ranch Project is toward the Powder River to the north-northwest.

As previously discussed in Section 3.4.1, the applicant has adopted the nomenclature used by Conoco for the hydrostratigraphic units of interest within the Moore Ranch project. Sands above the Roland Coal are numbered, increasing upward. The 40 and 50 Sands lie immediately above the Roland Coal and are regionally extensive sands that are considered significant aquifers. The approximate thickness of the 40 and 50 Sands in the proposed license area are 24 to 27 m (80 and 90 ft), respectively. The 58 Sand varies in thickness from 1.5 to 24 m (5 to 80 ft). The 60 Sand is approximately 30 m (100 ft) thick and is continuous throughout the project area. It is separated from the 58 Sand by about 1.5 to 21 m (5 to 70 ft) of shale and mudstone. The 68 Sand is the first sand underlying the 70 Sand which contains the economic ore deposits in the area. The 68 Sand ranges from 12 to 30 m (40 to 100 ft) across the proposed license area and coalesces with the 60 Sand on the west side of the proposed license area. The 70 Sand is the proposed ore production zone and coalesces with the 68 Sand in one of the proposed well fields. The 72 Sand overlies the 70 Sand and is the shallowest sand over the majority of the proposed license area. The 70 Sand is separated from the overlying 72 Sand by a continuous shale layer ranging in thickness from 1 to 49 m (3.3 - 160 ft) in some areas. Over small portions of the proposed license area, the 80 Sand overlies the 72 Sand.

3.5.2.3 Uranium-Bearing Aquifers

The 70 Sand is the proposed production aquifer located 30.5- 91.4 m (100-300 ft) below ground surface in the project area. The 70 Sand is laterally extensive and ranges from 12.2 to 36.6 m (40 to 120 ft) thick. The 70 Sand dips to the northwest at about 1 degree. It outcrops approximately 1.6 km (1 mi) south of the project area. The 70 Sand is not completely saturated over its thickness in most of the proposed license area. Since the water levels in the 70 Sand are below the overlying shale, it is defined as an unconfined aquifer. Water produced from wells in unconfined aquifers comes from physical drainage of water from the formation pores, not from compression of the sediments and expansion of water due to pressure decreases as in confined aquifers. The natural groundwater flow is estimated to be to the northwest in the 70 Sand at about 2.4 m/yr (7.8 ft/year) based on the reported gradient of 0.004 ft/ft and hydraulic conductivity of 5.36 ft/day.

3.5.2.3.1 <u>Hydrogeologic characteristics</u>

The hydraulic properties of the 70 Sand production aquifer have been evaluated through a series of pumping tests. Aquifer testing was performed between 1978 and 1980 while Conoco was investigating the Moore Ranch site as a possible surface mine site. Additional pumping tests were conducted by the applicant in 2007 and 2008. Analysis of data from the 2008 test estimated the transmissivity and hydraulic conductivity of the 70 Sand to be 37.6 m^2/day (405 ft^2/day) and 1.63 m/day (5.36 ft/day), respectively. Estimates of specific yield for the unconfined aquifer ranged from 0.011 to 0.039.

3.5.2.3.2 <u>Level of confinement</u>

The 70 Sand is separated from the overlying 72 Sand by a continuous shale and coal seam across the license area. Water levels in the 72 Sand are much higher than the 70 Sand. The 70 Sand is also not completely saturated. These two features demonstrate that the aquifers are not hydraulically connected. All of the pumping tests conducted in the 70 Sand to date have demonstrated no response in the 72 Sand, which supports the lack of a hydraulic interconnection. As the 70 Sand is not completely saturated, the groundwater in the 72 Sand is likely perched on the shale separating the two aquifers.

The 70 Sand is separated from the underlying 68 Sand by a shale over much of the project area. Pumping tests conducted to date have identified no hydraulic interconnection between these sands in proposed Wellfield 1. In portions of proposed Wellfield 2, however, boring data indicates that the shale is missing or less than five feet thick. In this area the 68 Sand coalesces with the 70 Sand. Pumping tests in Wellfield 2 where the shale is absent have shown a hydraulic connection between the 68 and 70 Sand. Water levels in the 68 and 70 Sands are also similar, supporting a potential hydraulic connection. In the area in Wellfield 2 where the 68 and the 70 Sands coalesce, the applicant considers the 60 Sand to be the underlying aquifer.

3.5.2.3.3 Groundwater Quality

Baseline groundwater quality programs have characterized the quality of groundwater within the shallow Wasatch aquifers within the Moore Ranch project area (Table 3-3). Groundwater quality in the 72 Sand aquifer and production zone 70 Sand exceed the WDEQ Class I standards for TDS and sulfate. The radionuclides radium-226 and uranium are elevated above EPA Maximum Contaminant Levels (MCLs) for drinking water in the majority of samples collected from the production zone 70 Sand aquifer and the underlying 68 Sand aquifer. The average radium 226-228 concentration in the production zone is an order of magnitude greater than the EPA MCL. The 68 Sand aquifer also exceeds the EPA MCL for selenium. In Wellfield 2, the 60 Sand aquifer exceeds the EPA MCL for selenium and uranium. Elevated concentrations of these radionuclides is consistent with the presence of uranium ore-bodies.

Table 1-1. Average Pre-Operational Baseline Groundwater Quality for Site Aquifers

Water Quality Parameter	Average		
	"72 sand"	"70 sand"	"68 sand"
Bicarbonates as HCO3 (mg/l)	208.2	277.2	148.6
Carbonates asCO3(mg/l)	1.6	1.0	10.4
Chloride (mg/l)	4.1	2.3	2.0
Conductivity (umhos/cm)	1051.6	1034.2	753.3
Fluoride (mg/l)	0.2	0.2	0.2
pH (s.u.)	8.07	7.58	8.99
Total Dissolved Solids (mg/l)	770.6	712.5	416.5
Sulfate (mg/l)	401.0	330.3	162.0
Gross Alpha (pCi/l)	5.7	259.1	78.24
Gross Beta(pCi/l)	14.4	80.6	40.09
Lead 210 (pCi/l)	2.0	9.2	6.81
Polonium 210(pCi/l)	1.2	5.6	3.55
Radium 226 (pCi/l)	1.1	95.6	21.1
Radium 228 (pCi/l)	1.9	1.7	1.2
Thorium 230 (pCi/l)	0.3	0.3	0.2
Nitrogen, Ammonia as N (mg/l)	0.214	0.1	0.5
Nitrogen, Nitrate+Nitrite as N (mg/l)	0.4	0.2	0.3
Aluminum (mg/l)	0.1	0.1	0.1
Arsenic (mg/l)	0.001	0.002	0.002
Barium (mg/l)	0.1	0.1	0.1
Boron (mg/l)	0.1	0.1	0.1
Cadmium (mg/l)	0.005	0.005	0.005
Calcium (mg/l)	137.4	135.2	54.4
Chromium (mg/l)	0.05	0.05	0.05
Copper (mg/l)	0.01	0.01	0.011
Iron (mg/l)	0.082	0.151	0.052

Table 1-1. Average Pre-Operational Baseline Groundwater Quality for Site Aquifers			
Water Quality Parameter	**Average**		
	"72 sand"	**"70 sand"**	**"68 sand"**
Lead (mg/l)	0.001	0.002	0.005
Magnesium (mg/l)	37.3	31.8	7.4
Manganese (mg/l)	0.064	0.033	0.016
Mercury (mg/l)	0.001	0.001	0.001
Molybdenum (mg/l)	0.1	0.1	0.1
Nickel (mg/l)	0.05	0.05	0.05
Potassium (mg/l)	16.6	10.2	14.7
Selenium (mg/l)	0.001	0.025	0.135
Silica(mg/l)	10.9	13.0	11.2
Sodium (mg/l)	32.3	33.3	63.4
Uranium (mg/l)	0.001	0.161	0.050
Vanadium (mg/l)	0.1	0.1	0.1
Zinc (mg/l)	0.01	0.01	0.01
Lead 210, suspended (pCi/l)	1.0	18.8	2.1
Polonium 210, suspended (pCi/l)	1.0	17.6	3.7
Radium 226, suspended (pCi/l)	0.3	1.8	3.2
Thorium 230, suspended (pCi/l)	0.3	0.5	3.3
Uranium suspended (pCi/l)	0.0006	0.0033	0.0182

Using WDEQ standards, Uranium One classified the class of use for each shallow aquifer on a well by well basis in the proposed license area. WDEQ Class I is drinking water, Class II is agricultural use, Class III is for livestock use and Class VI is water that is unsuitable for any of these uses. The single well in the perched 80 Sand aquifer was classified as Class VI. One well in the 72 Sand aquifer was classified as Class I, another as Class II and two others as Class III. In the 70 Sand production zone aquifer, all eight wells were Class VI and one well outside the ore zone was Class I. All four wells in the 68 Sand and three wells in the 60 Sand were found to be Class VI.

For ISR operations to be conducted in an aquifer, it must be declared as an exempt aquifer under either State or Federal UIC regulations. An exempt aquifer is one that is not nor will ever be used for drinking water given its water quality. In Wyoming, the EPA has the authority to make this declaration. The water quality of the 70 Sand production zone aquifer in the project area is Class VI under WDEQ standards, which means the groundwater can not be used for drinking, livestock or agricultural use as a consequence of its uranium and radium-226 concentrations. It would therefore be a candidate for an exempt aquifer declaration. The 68 Sand would also be a candidate given its water quality is also Class VI.

3.5.2.3.4 Current Groundwater Uses

According to a search of the WSEO database, there are 559 wells with groundwater rights located within the 3.2-km (2-mi) radius of the proposed Moore Ranch Project as of June 2009. Groundwater rights for wells are granted on a well by well basis through the WSEO (Uranium One, 2009b). Domestic and stock wells have a limit of 94.7 L/min (25 gal/min) per well. There are no minimum water levels entitled with the groundwater rights. The vast majority of water rights in and near the Moore Ranch project area are for CBM activities in the Fort Union formation at depths exceeding 244 m (800 ft).

Of the wells identified in the search, 465 are CBM or stock–CBM wells. All of these CBM and stock-CBM wells which have completion records are greater than 213 m (700 ft) deep. Of those with no completion records it is unlikely they are completed in shallower Wasatch sands as the target for CBM production is the Fort Union formation which is located at depths exceeding 244 m (800 ft) in the Moore Ranch project area. Given the depth of these wells, it is unlikely they will be impacted by operations in the 70 Sand production zone.

Within the 3.2-km (2-mi) radius, there are three domestic water wells ranging from 41.7 to 134 m (137 to 440 ft) in depth. Two are located east of the Moore Ranch project area near the limit of the 3.2 km (2 mi) radius. One well is located in the license area and is permitted as an industrial, domestic well by Rio Algom Mining Corporation. While these wells are permitted for domestic use, there are no currently occupied residences within the project area and 3.2-km (2-mi) radius. Therefore, these wells are not being primarily utilized for human consumption. Given the depth of these wells is close to the depth of the 70 Sand production zone, they could potentially be impacted by ISR operations.

Also within the 3.2-km (2-mi)) radius there are twenty seven permitted stock wells, of which three are located in the project area. Of these wells, twenty five are completed at depths greater than 213 m (700 ft) and two less than 213 m (700 ft). At least four other unpermitted stock wells are known to be in the project area for which no completion information is available, but they are estimated to be in the 68, 70 and 72 Sands. An inoperable windmill with an unpermitted well is also located in the project area. Some of these wells which are located in the shallow 68, 70 and 72 Sands may be impacted by operations within the 70 Sand production zone.

There are no irrigation water wells in the 3.2-km (2-mi) radius. The deepest water well which has groundwater rights within the 3.2-km (2-mi) radius is permitted as a CBM well and is 430 m (1410 ft) deep. It is not likely to be impacted by ISR operations. The remaining deep wells in the project area are oil and gas wells.

3.5.2.4 Surrounding Aquifers

In addition to the sands of the Wasatch discussed above, the underlying Fort Union Formation and Fox Hills Sandstones include potentially important aquifers. However, due to the relatively shallow depth of 30.5- 91.4 m (100-300 ft) for the 70 Sand production zone in the overlying Wasatch, these deeper aquifers which are separated by thick sequences of shales are not likely to be impacted by ISR operations in the production zone.

The shallowest potential target for deep well disposal is the Lance formation at depths of 1128 – 1738 m (3700- 5700 ft) below ground surface, The aquifers at these depths are not typically used as drinking water, livestock or irrigation wells because of their depth and poor water quality. They are therefore not expected to be impacted by the operation of a deep disposal well in the Lance Formation.

4.5.2 Groundwater Impacts

Potential environmental impacts to groundwater at the proposed Moore Ranch Project could occur during all phases of the ISR facility's lifecycle, but primarily during operations and aquifer restoration. Detailed discussion of the potential environmental impact to groundwater from the construction, operation, aquifer restoration, and decommissioning at the proposed Moore Ranch Project is described in the following sections.

ISR activities can impact aquifers at varying depths (separated by aquitards) above and below the uranium-bearing aquifer as well as adjacent surrounding aquifers in the vicinity of the uranium-bearing aquifer. Surface or near-surface activities that can introduce contaminants into soils are more likely to impact shallow aquifers while ISR operations and aquifer restoration will likely impact the deeper uranium-bearing aquifer and potentially impact any aquifers above and below and adjacent surrounding aquifers.

ISR facility impacts to groundwater resources can occur from surface spills and leaks, releases from shallow surface piping, consumptive water use, horizontal and vertical excursions of leaching solutions from production aquifers, degradation of water quality from changes in the production aquifer's chemistry, and waste management practices involving deep well injection. Detailed discussion of the potential impacts to groundwater resources from construction, operations, aquifer restoration, and decommissioning are provided in the following sections.

4.5.2.1 Proposed Action (Alternative 1)

4.5.2.1.1 Construction Impacts to Groundwater

Section 4.3.4.2.1 of the GEIS indicated that potential impacts to groundwater during construction would primarily be from consumptive use of groundwater, injection of drilling fluids and muds during well drilling, and the potential spills of fuels and lubricants from construction equipment. The GEIS further stated that groundwater use during the construction phase would be limited and would be expected to be protected by implementing best management practices such as spill prevention and cleanup. The volume of drilling fluids and muds introduced into the environment during well installation would be limited. Thus, the construction impacts to groundwater would be SMALL based on the limited nature of construction activities and the implementation of best management practices to protect shallow groundwater (NRC, 2009a).

The consumptive water use during construction would be generally limited to dust control, drilling support, and cement mixing. Most water used for construction at the proposed Moore Ranch Project would be extracted from a well completed in the 40 and 50 Sands. These sands are significant aquifers located at depths of 143-180 m (470-590 ft) below surface and hydrologically separated from the 70 production sand and 72 Sand surficial aquifer at Moore Ranch. The consumptive water use during construction is expected to be SMALL and temporary relative to the water supply available in the 40 and 50 Sands.

The volume of drilling fluids and muds used during well installation is expected to be limited and best management practices would be applied to prevent, identify and correct impacts to soils and the surficial 72 Sand aquifer at Moore Ranch. Drilling fluids and muds would be placed into mud pits to control the spread of the fluids, to minimize the area of soil contamination and to enhance evaporation. According to Figure CR3.4.3.2 in the applicant's technical report, the depth to the water table in the surficial 72 Sand at Moore Ranch ranges from 9 to 61 m (30-200 ft) below ground surface (EMC, 2007b). Therefore any small amount of leakage from the pits or spills from drilling activities should result in only a small amount of infiltration and not cause any changes in the 72 Sand surficial aquifer water quality. The introduction of drilling fluids to the 72

Sand, 70 Sand, 68 and 60 Sand aquifers may occur during drilling of production wells and monitoring wells, but is expected to be small, since drilling muds are designed to seal the hole so casing may be set.

As wells are installed, some water may be pumped from aquifers for hydrologic tests such as pumping tests. This water would be discharged to the surface in accordance with approved permits from the State of Wyoming that the applicant would obtain prior to any release. The surface discharge permits would protect near surface aquifers by limiting the discharge volume and prescribing concentration limits to waters that can be discharged.

During all construction operations at the proposed Moore Ranch Project, the groundwater quality of near surface aquifers would be protected by best management practices during facility construction and well field installation including implementation of a spill prevention and cleanup program to prevent soil contamination from fuels and lubricants from construction equipment. The volume of fuels and lubricants to be kept in the proposed license area is expected to be small and any leaks or spills would result in an immediate cleanup response to prevent soil contamination or infiltration to groundwater.

Based on this analysis, consumptive groundwater use during the construction phase would be limited and would be expected to have a SMALL and temporary impact. The impact to groundwater resources during well field and facility construction would be SMALL based on the limited nature of construction activities and implementation of best management practices to protect soils and shallow groundwater.

Additionally, after its independent review of Uranium One's license application (EMC, 2007a; EMC, 2007b); the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS for groundwater and incorporates by reference the GEIS's conclusions that the impacts to groundwater during construction are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.2 Operation Impacts to Groundwater

Section 4.3.4.2.2 of the GEIS discussed potential impacts to shallow (near-surface) aquifers during ISR operations. During this phase of an ISR operation, shallow aquifers could potentially be affected by lixiviant leaks from pipelines, wells, or header houses and to waste management practices such as the use of evaporation ponds and disposal of treated wastewater by land application. Potential environmental impacts to groundwater resources in the production and surrounding aquifers also include consumptive water use and changes to water quality that could result from normal operations in the production aquifer and from possible horizontal and vertical lixiviant excursions beyond the production zone. Disposal of processing wastes by deep well injection during ISR operations could also potentially impact groundwater resources (NRC, 2009a).

4.5.2.1.2.1 Operation Impacts to Shallow (Near-Surface) Aquifers

The GEIS (Section 4.3.4.2.2.1) discussed the potential impacts to shallow aquifers during ISR operations. A network of buried pipelines is used during ISR operations for transporting lixiviant between the header house and the satellite or main processing facility and also to connect injection and extraction wells to manifolds inside the pumping header houses. The failure of pipeline fittings or valves, or failures of well mechanical integrity in shallow aquifers could result in leaks and spills of pregnant and barren lixiviant which could impact water quality in shallow aquifers. The potential environmental impact of such pipeline, valve, or well integrity failure depends on a number of factors, including the depth to shallow groundwater, the use of shallow groundwater, and the degree of hydraulic connection of shallow aquifers to regionally important aquifers. As indicated in the GEIS, potential environmental impacts could be MODERATE to LARGE if:

1) The groundwater in shallow aquifers is close to the ground surface;
2) The shallow aquifers are important sources for local domestic or agricultural water supplies; and
3) Shallow aquifers are hydraulically connected to other locally or regionally important aquifers.

The potential environmental impacts could be SMALL if shallow aquifers have poor water quality or yields not economically suitable for production, and if they are hydraulically separated from other locally and regionally important aquifers.

Hydrogeologic data from the Moore Ranch site indicates that the 72 Sand is the first aquifer encountered below the land surface. In some small areas, isolated occurrences of perched water are encountered in the 80 Sand which overlies the 72 Sand across the proposed license area. The 72 Sand is not saturated in the southern portion of the proposed license area. In these areas the 70 Sand is the surficial aquifer.

Because of the shallow depth to groundwater in the 72 Sand and 80 Sand where they occur, they could potentially be impacted by releases at or near the ground surface during operations. A surface release could potentially impact the groundwater depending on the depth to the water table, the permeability of the materials in the unsaturated zone, the potential adsorption of constituents in the unsaturated zone, and the volume of any potential releases. The 72 and 80 Sand aquifers could also be subject to the impact from potential well casing leaks during operations.

As indicated in the GEIS, the potential impact of surface releases on shallow groundwater could be greatly reduced by leak detection programs required by the NRC. All wells would be tested for mechanical integrity every five years to prevent casing leaks. Wells that failed mechanical integrity tests would be corrected or removed from operation. An aggressive leak detection and spill cleanup program would also be followed during operations. High and low flow alarms for individual wells would be employed as the primary means for timely identification of a pipe rupture. Header houses would be equipped with a "wet building" alarm to detect the presence of liquids in building sumps. In addition, a program of daily visual inspections of well field monitoring would be conducted. Spills exceeding 1,590 L (420 gal) would be required to be reported to the WDEQ accompanied by a report to NRC. Following repair of well field leaks, contamination surveys would be performed; and contaminated soils may could either be immediately remediated if concentrations exceeded regulatory requirements or left in place and cleaned up during decommissioning. The concrete curb around the perimeter of the central plant and the underlying concrete pad would be designed to contain the contents of the largest tank within the central plant in the event of a rupture. Plant fluid spills would be contained and would drain to the sump system and be pumped to the waste disposal system. Thus, the best management practices would include various measures to minimize the potential release of wastes and to mitigate their potential impact on shallow groundwater.

Since the 72 Sand is the overlying aquifer to the 70 Sand production zone it would be monitored by monitoring wells installed to detect vertical excursions. These monitoring wells would be located in the well fields at a density of one well to every four acres. The wells would be sampled every two weeks for excursion parameters to detect the presence of production fluids.

This monitoring would provide an extra level of surveillance in the well fields to detect any impacts to the 72 Sand aquifer from either surface spills or casing leaks.

No water wells for domestic, agricultural or livestock use are completed in the 72 Sand within the proposed Moore Ranch license area. Therefore, the shallow aquifer in the 72 Sand is not an important source for local domestic or agricultural water supplies. Furthermore, the 72 Sand is a perched aquifer over the majority of the proposed license area; therefore, it is not hydraulically connected to other locally or regionally important aquifers. Where the 72 Sand aquifer is not perched, it is underlain by a sufficiently thick shale layer to prevent a hydraulic connection to other significant aquifers.

Based on this analysis, the impact of operations on shallow groundwater in the 72 Sand and on any groundwater in the perched 80 Sand aquifer at the proposed Moore Ranch Project would be expected to be SMALL. Impacts to any surrounding aquifer from an impact in the 72 Sand would also be expected to be SMALL.

Additionally, after its independent review of the Uranium One's license application; the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions are comparable to those described in the GEIS for groundwater and incorporates by reference the GEIS's conclusions that the impacts to shallow (near-surface) aquifers during operation are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.2.2 Operation Impacts to Production and Surrounding Aquifers

The potential environmental impact to groundwater supplies in the production and other surrounding aquifers are related to consumptive use and groundwater quality.

Water Consumptive Use:

As discussed in Section 4.3.4.2.2.2 of the GEIS, groundwater is withdrawn and reinjected into the production zone during ISR operations (NRC, 2009a). Most of the water withdrawn from the aquifer is returned to the aquifer. That portion of groundwater that is not returned to the aquifer is referred to as consumptive use. The consumptive use is primarily from production bleed and also includes other smaller losses. Production bleed is the net withdrawal maintained to ensure groundwater hydraulic gradients draw water in toward the production network to minimize the potential movement of lixiviant and its associated contaminants out of the well field.

The portion of an aquifer where the production occurs must be designated as an exempt aquifer by EPA pursuant to the Federal underground injection control (UIC) regulations before any production begins. An exempt aquifer designation means the aquifer is not, nor would it ever be a source of drinking water in the location covered by the exemption. At the proposed Moore Ranch Project, portions of the 70 Sand in which production operations would occur and typically a buffer zone would be sought to be declared as exempt by EPA. Groundwater in the aquifer outside the designated exempt zone would still be considered a possible source of drinking water, if of appropriate quality.

Consumptive water use during ISR operations could potentially impact local water users who also extract water from wells completed in the production aquifer outside the exempted zone. This potential impact would result from drawing down water levels in nearby wells, thus potentially reducing the yield of these wells. Furthermore, if the production zone is hydraulically connected to other aquifers above and/or below, consumptive use could impact the water levels in both overlying and underlying aquifers and create a drawdown in water level, thus reducing the potential yield from nearby wells using water from these aquifers (NRC, 2009a).

As previously discussed in Section 3.5.2, the 70 Sand production zone at the Moore Ranch Project is not completely saturated over much of the proposed license area. Therefore, it is an unconfined aquifer. The unconfined conditions in the production zone help to reduce the potential impact of the consumptive use anticipated during ISR operations. For a given net withdrawal, an unconfined aquifer exhibits substantially less drawdown in water level over a smaller area relative to that exhibited in a confined aquifer. As shown in Figure 4-1, the water produced from a well in an unconfined aquifer (water level below overlying aquitard) comes from dewatering of the aquifer pore space in the production zone.

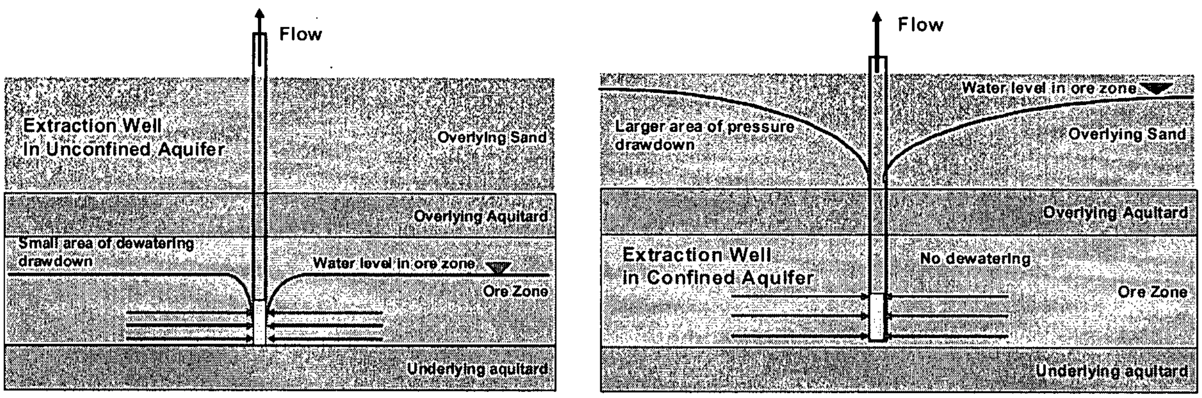

Figure 4-1 Difference In Size and Type of Drawdown in an Unconfined Aquifer and Confined Aquifer from an Extraction Well Operating at a Same Rate

However, the water moving to a well in a confined aquifer (water level above overlying aquitard) comes from the compression of the sediments and expansion of water from the pressure drawdown in the production zone, but does not drain the pore spaces. Therefore, much more water is produced from dewatering drawdown over a small area of an unconfined aquifer to meet the well rate, whereas the pressure drawdown to produce water from a confined aquifer must occur over a larger area to meet the well rate.

To assess the potential drawdown in the unconfined aquifer at Moore Ranch, an unsaturated groundwater flow model was developed for the 70 Sand over the entire proposed license area. The model was created within the Groundwater Vistas platform and used MODFLOW – SURFACT Version 3.0, an industry standard unsaturated groundwater flow code. The model was calibrated to site specific conditions and verified by Moore Ranch field pumping test data. The modeling, which was reviewed and found acceptable by NRC staff, is presented in Appendix B-4 of the applicant's technical report (EMC, 2007b).

The model analyzed drawdowns during various phases of ISR production and aquifer restoration. For production operations, it assumed production rates of approximately 11,360 L/min (3,000 gal/min) and production bleeds ranging between 0.8 and 1.3 percent which translates into a production consumptive use rate of 90.9 L/min to 147.6 L/min (24 gal/min to 39 gal/min).

The model simulations of drawdown in the 70 Sand predicted at the end of production operations for the above consumptive use rates were provided in Figure CR4.4.2.1-1b of the applicant's technical report (EMC, 2007b). The end of production provides the best estimate of the maximum drawdown for total consumptive use during the operations phase. The results of the drawdown simulations show that the cone of depression created by the consumptive use at the end of operations results in a drawdown of about 0.30 to 1.2 m (1- 4 ft) at the proposed license area boundary. The drawdown contour of 1 ft extends outside the proposed license area to the north, northwest, west and southwest for approximately one to two miles.

To estimate the potential impact of the simulated drawdown on private wells, private well users with wells completed in the 68-70 Sand, 70 Sand, and 70-72 Sand located within 3.2 km (2 mi) of the proposed Moore Ranch Project boundary were identified. Their locations are shown in Figure CR4.4.2.1-1a of the applicant's technical report (EMC, 2007b). The drawdown in each of these private wells was simulated and the results shown in Table CR4.4.2-1-2b of the applicant's technical report (EMC, 2007b). Only one private well, drilled to a depth of 108 m (355 ft) below ground surface with a static water level of 46 m (150 ft) below ground surface, and completed in the 70 Sand was impacted by a drawdown of more than one foot. This well was located just outside the northwest portion of the proposed license area. The drawdown in this well was estimated to be 1.08 m (3.53 ft) at the end of the operations phase which would result in a negligible impact on well yield.

Given the hydraulic isolation separating the 72 Sand and 70 Sand production zone, there appears to be little potential impact on water levels in the 72 Sand resulting from the consumptive use in the 70 Sand production zone. However, there appears to be hydraulic interconnection between the underlying 68 Sand and the 70 Sand production zone in the portion of Wellfield 2 where the 68 and 70 Sands coalesce (See Section 3.5.2). In this portion of Wellfield 2, the 68 Sand would be included as part of the production zone, although no production wells would be installed.

To determine the impact of production operations on water levels in the 68 Sand and surrounding users, a worst case estimate scenario was assumed. In this scenario, the drawdown in the 68 Sand, which would not have any operating wells completed in it, was assumed to be the same as that simulated for the 70 Sand at the end of production operations. This is a conservative drawdown estimate since pumping tests indicate that there will be less drawdown in the 68 Sand where the 70 and 68 Sands coalesce. Using this assumption, Table CR4.4.2.1-2b shows that three wells completed in the 68 Sand and located to the northeast and southeast outside of the proposed license area would have nominal drawdowns of 0.02, 0.07, and 0.003 m (0.08, 0.23 and 0.01 ft), respectively (EMC, 2007b). These drawdown values would not be expected to affect well yields.

Based on the consumptive use and groundwater modeling predictions of drawdown in the 70 production sand and the 68 Sand during operations, private wells within 3.2 km (2 mi) radius surrounding the proposed license area would have only a small or nominal drawdown in their private wells which would not impact well yields. Therefore, the potential environmental impact to groundwater supplies and users in the production and other surrounding aquifers would be expected to be SMALL.

Excursions and Groundwater Quality.

As discussed in the GEIS (NRC, 2009a), groundwater quality in the production zone would be degraded as part of ISR operations. The portion of the aquifer used for production would be recommended for exemption by WDEQ to EPA as an underground source of drinking water. After production operations are completed, the licensee would be required to initiate aquifer restoration activities to restore the production zone to baseline water quality, if possible. If the aquifer could not be returned to baseline conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in Table 5C of 10 CFR Part 40 Appendix A or to Alternate Concentrations Limits (ACLs) approved by NRC. For proposed ACLs to be approved, they must be shown to be protective of public health at the site. For these reasons, potential impacts to the water quality of the uranium-bearing production zone aquifer as a result of ISR operations would be expected to be SMALL.

In Section 2.11.4 of the GEIS, the NRC staff documented that based on historical information at operating ISR facilities, excursions have occurred at these facilities. Separately, the NRC staff analyzed the environmental impacts from both horizontal and vertical excursions at three NRC-licensed ISR facilities (NRC, 2009b). In that analysis, which involved 60 events at the three facilities, the NRC staff found that, for most of the events, the licensees were able to control and reverse the excursions through pumping and extraction at nearby wells. Most excursions were short-lived, although a few continued for several years. In all cases, none resulted in environmental impacts (NRC, 2009b).

To prevent horizontal excursions, inward hydraulic gradients are expected to be maintained in the production aquifer during ISR operations (NRC, 2009a). These inward hydraulic gradients are created by the net groundwater withdrawals (production bleeds) maintained through continued pumping during ISR operations. Groundwater flows in response to these inward hydraulic gradients, thus ensuring that groundwater flow is toward the production zone. This inward groundwater flow toward the extraction wells prevents horizontal excursions of lixiviant solutions away from the production zone.

NRC also requires the licensee to take preventive measures to reduce the likelihood and consequences of potential excursions. A ring of monitoring wells within and encircling the production zone is required for early detection of horizontal excursions. If excursions are suspected, corrective actions are required. The impacts from these excursions would therefore be expected to be SMALL.

The GEIS also discussed potential for vertical excursions into aquifers overlying or underlying the production zone aquifer. The GEIS analysis indicated, the potential for migration of leaching solution into an overlying or underlying aquifer is SMALL if the thickness of the aquitard separating the production zone from the overlying and underlying aquifer is of sufficient thickness and the aquitard has low permeability (NRC, 2009a). The vertical hydraulic gradient between the production zone and overlying or underlying aquifers is also used to determine the potential for vertical excursions. The NRC also requires monitoring in the overlying and underlying aquifers. Corrective action is also required if any vertical excursions are detected.

At Moore Ranch, the 70 Sand aquifer would be designated as an exempt aquifer before production operations began, which means that it neither has nor will it ever be used as a source of drinking water. The groundwater chemistry will be changed as lixiviant is injected to mobilize uranium for extraction. At the end of operations, aquifer restoration using Best Practicable Technology would be initiated to return the 70 Sand aquifer to baseline conditions, or the maximum contaminant levels provided in Table 5C of 10 CFR Part 40 Appendix A or to ACLs. Restoration to these standards would ensure that groundwater within the exemption boundary after restoration will not pose a threat to surrounding groundwater. For these reasons, potential impacts to the water quality of the 70 Sand production zone aquifer and surrounding aquifers as a result of ISR operations would be expected to be SMALL.

The occurrence of an unconfined aquifer in the 70 Sand production zone at the proposed Moore Ranch Project presents special considerations when evaluating the creation of the necessary inward hydraulic gradient, the reliability of monitoring around the periphery of the well field, and the capability to pull back a potential horizontal excursion. As discussed earlier, an unsaturated numerical groundwater model was developed to simulate drawdown in the unconfined conditions in the 70 Sand production zone at Moore Ranch. The model was calibrated using site-specific hydraulic data and presented in Appendix B-4 of the applicant's technical report

(EMC, 2007b). Model simulations indicate that it would be possible to maintain the necessary inward gradient during ISR operations to prevent horizontal excursions (EMC, 2007b)

To detect horizontal excursions from the proposed well fields at the Moore Ranch Project, monitoring well rings would be installed at each well field with the monitoring wells completed in the 70 Sand production zone. The monitoring wells would be located approximately 500 ft from the edge of each well field and spaced 152 m (500 ft) apart around the perimeter of the well field. The wells would be sampled biweekly for chloride, alkalinity and conductivity which are excursion parameters indicative of the presence of production fluids. Any well with samples found to contain more than two of these excursion indicators at prescribed levels derived based on baseline values would be placed on excursion status and WDEQ and NRC must be notified in 24 hours. All wells on excursion status would be monitored every seven days until the indicators return to non-excursion levels. Wellfield operations would be modified as necessary near wells on excursion status to correct the excursion. If the well remained on excursion for more than 60 days, a plan would be provided to NRC to correct the excursion.

Given the maintenance of an inward hydraulic gradient to prevent excursions and the presence of a monitoring well ring to detect excursions as well as a plan to correct them, it would be expected that the impact from horizontal excursions at the proposed Moore Ranch Project would be SMALL.

The 72 Sand aquifer overlies the 70 Sand production aquifer. The water table within the 72 Sand is perched on the underlying aquitard that separates the 72 Sand from the 70 Sand production aquifer. The water levels in the 72 Sand are generally much higher than in the 70 Sand. The combination of the perched water table and the high water levels in the 72 Sand relative to the 70 Sand demonstrate the absence of a hydraulic interconnection between the 72 and 70 Sands. The unconfined conditions in the 70 Sand further support this conclusion. Pumping tests conducted to date not demonstrated any hydraulic connection between the 70 and 72 Sands. Therefore, the potential for vertical excursions from the production zone into the overlying 72 Sand would be expected to be SMALL.

A relatively thick and low permeability aquitard separates the 70 Sand production aquifer from the underlying 68 Sand throughout much of the proposed license area. Pumping tests conducted to date indicate that the 68 Sand is hydraulically isolated in Wellfield 1. Therefore, the potential for vertical excursions from the production zone into the underlying 68 Sand in Wellfield 1 is very SMALL. In portions of Wellfield 2; however, the aquitard separating the 68 and 70 Sand is missing as previously discussed in Section 3.5.2. The 68 and 70 Sands coalesce where the aquitard is missing, and the two aquifers appear to be hydraulically interconnected. The 68 Sand would be included as part of the production zone in the area where the 68 and 70 Sands coalesce. The underlying 60 Sand, which is separated by a continuous shale layer, would be treated as the underlying aquifer. The potential for vertical excursions from the production zone in Wellfield 2 into the underlying 60 Sand is SMALL.

To detect potential vertical excursions at the proposed Moore Ranch Project, the aquifers that overly and underlie the 70 Sand, which include the 72, 68 and 60 Sands, would be monitored by a spacing of one well per four acres. The same sample constituents and process would be followed to monitor for vertical excursion as was described above for horizontal excursions.

Given the isolation of the overlying and underlying aquifers from the 70 Sand production zone by low permeability shale layers and the use of monitoring wells to detect excursions and correct them, the impact from a potential vertical excursion at the proposed Moore Ranch Project would be expected to be SMALL.

Additionally, after its independent review of Uranium One's license application (EMC, 2007a; EMC, 2007b); the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions regarding potential excursions and groundwater quality are comparable to that described in the GEIS. The GEIS concludes that impacts to production and surrounding aquifers during operations would be SMALL The staff concludes that site-specific impacts for the proposed Moore Ranch Project are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.2.3 Operation Impacts to Deep Aquifers Below the Production Aquifers

Potential environmental impacts to confined deep aquifers below the production aquifers could be due to deep well injection of processing wastes into deep aquifers. Under different environmental laws such as the Clean Water Act, the Safe Drinking Water Act, and the Clean Air Act, EPA has statutory authority to regulate activities that may affect the environment. Underground injection of fluid requires a permit from EPA or from an authorized state UIC program. The WDEQ has been authorized to administer the UIC program in Wyoming and is responsible for issuing any permits for deep well disposal at the Moore Ranch site.

Class I disposal wells would only be permitted by WDEQ if the groundwater quality in the injection zone would not be suitable for domestic or agricultural uses (e.g., high salinity), could not be designated as an underground source of drinking water, and if the injection zone was confined above by sufficiently thick and continuous low permeability layers.

The GEIS (Section 4.3.4.2.2.3) indicates that in the Wyoming East Uranium Milling Region, where the proposed Moore Ranch Project is located, the Paleozoic aquifers are hydraulically separated from the aquifer sequence that includes, from the shallowest to the deepest, the Wasatch Formation, the Fort Union Formation, the Lance Formation, and the Fox Hills Formation by thick low permeability confining layers that include the Pierre Shale, the Lewis Shale, and the Steele Shale (Whitehead, 1996). Hence, non-karstic Paleozoic aquifers (e.g., Tensleep Sandstone) can be investigated further for suitability of disposal of leaching solutions. The GEIS concluded that in the Wyoming East Uranium Milling Region, considering the relatively low water quality in and the reduced water yields from non-karstic Paleozoic aquifers and the occurrence of thick and regionally continuous aquitards confining them from above, the potential environmental impacts due to deep injection of leaching solution into non-karstic Paleozoic aquifers could be SMALL. The Pierre Shale was reported to be fractured in some places at the regional scale (Whitehead, 1996). Considering potential heterogeneities in the hydrogeologic properties of the Pierre Shale, the potential impacts could be SMALL to MODERATE where the Pierre Shale might be locally fractured.

Up to four Class I wells could be drilled at the proposed Moore Ranch Project for deep disposal of liquid effluent depending on the production rates and the capacity of each disposal well. Two permit applications for Class I disposal wells at the proposed Moore Ranch Project are under review by the State of Wyoming. The first application is for injection into the Teapot-Teckla-Parkman formation with an injection depth of 2,431 m – 2,929 m (7,916 – 9,610 ft) Injection rates for this interval are expected to be about 30 gal/min. Since the water quality in this formation is anticipated to exceed 3000 mg/L TDS, it would not be classified as an underground source of drinking water. The second application is for injection into the Lance formation at depths of 1128 m – 2286 m (3700 – 7500 ft); since the Lance formation has a much greater injection capacity, only two Class I disposal wells would be required to support the proposed Moore Ranch operations. However, the water quality in the Lance formation could be less than

3000 mg/L TDS; therefore, it could potentially be an underground source of drinking water which would eliminate it from consideration as an injection zone for a Class I deep disposal well.

The WDEQ will evaluate the suitability of the formations proposed for deep well injection and would only grant such a permit to Uranium One if it can be demonstrated that liquid effluent could be safely isolated in a deep aquifer. Consequently, it has been assumed that the potential environmental impact to deep aquifers from deep well disposal of waste in the proposed Moore Ranch Project would be SMALL.

4.5.2.1.3 Aquifer Restoration Impacts to Groundwater

The potential environmental impacts to groundwater resources during aquifer restoration are related to groundwater consumptive use and waste management practices, including deep well injection of wastes. In addition, aquifer restoration directly affects groundwater quality in the vicinity of the well field being restored. As discussed in the GEIS, the impacts of consumptive groundwater use during aquifer restoration are generally greater than during ISR operations since a larger volume of groundwater is generally withdrawn if groundwater sweeps are used during the aquifer restoration phase. Larger withdrawals could produce larger drawdowns in the production aquifer resulting in a greater impact on the yields of nearby wells.

The impacts from consumptive use during ISR production operations was previously discussed in Section 4.5.2.1. 2.2 of this SEIS which describes the use of an unsaturated numerical groundwater flow model to estimate drawdown for production phase consumptive use of the 70 Sand production zone. The same model was used to predict the drawdowns in Wellfield 1 and Wellfield 2 at the end of aquifer restoration using assumed consumptive use rates for each phase.

The predicted drawdown in the 70 Sand from model simulation of the end of aquifer restoration in Wellfield 1 is shown in Figure CR4.4.2.1-1c of the applicant's technical report (EMC, 2007b). The drawdown simulation results indicate that the cone of depression created by consumptive use during aquifer restoration would result in a drawdown in the water level of about 0.3 – 2.7 m (1- 9 ft) at the proposed license area boundary. The drawdown contour of 0.3 m (1 ft) extends outside the proposed license area to the north, northwest, west and southwest for approximately one to four miles.

The model simulation of drawdown in the 70 Sand at the end of aquifer restoration in Wellfield 2 is shown in Figure CR4.4.2.1-1d of the applicant's technical report (EMC, 2007b). The drawdown simulation results show that the cone of depression created by consumptive use during aquifer restoration would result in a drawdown of about 0.3 – 1.8 m (1 – 6 ft) at the proposed license area boundary. The drawdown contour of 0.3 m (1 ft) extends outside the proposed license area to the north, northwest, west and southwest for approximately one to four miles.

To estimate the impact of the simulated drawdown on private well users, all private wells within 3.2 km (2 mi) radius of the proposed Moore Ranch Project completed in the 68-70 Sand, 70 Sand, and 70-72 Sand were identified. Only one private well completed in the 70 Sand, located just northwest of the proposed license area would be affected by a drawdown of more than 0.3 m (1 ft) during the restoration phases of both Wellfield 1 and Wellfield 2. The drawdown in this well at the end Wellfield 1 aquifer restoration was estimated as 2.4 m (7.87 ft). The drawdown at the end of the Wellfield 2 restoration was estimated as 1.80 m (5.90 ft). The well was completed to a depth of 108 m (355 ft) below ground surface with a static water level of 46 m (150 ft) below ground surface indicating an operating water level of 62 m (205 ft). A decrease of 1.8 - 2.4 m (5.9 – 8.0 ft) would likely result in a negligible impact on well yield.

Given the hydraulic isolation of the overlying 72 Sand from the production zone, there would be little potential to impact water levels in the 72 Sand from groundwater consumptive use in the production zone during aquifer restoration. However, as previously noted since there is an apparent hydraulic interconnection between the underlying 68 Sand and the 70 Sand production zone in a portion of Wellfield 2 where the 68 and 70 Sands coalesce (see Section 3.5.2), the 68 Sand would be included as part of the production zone at this location.

To determine the impact of restoration operations on water levels in the 68 Sand and to surrounding users, a worst case estimate scenario was simulated in which the drawdown in the 68 Sand (in which no operating wells would be completed), was assumed to be the same as that simulated for the 70 Sand at the end of aquifer restoration The simulation showed three wells, completed in the 68 Sand located outside of the proposed license area to the northeast and southeast would have nominal drawdowns of 0, 21, 0.28, and 0.001 m (0, 68, 0.91 and 0.04 ft) at the end of Wellfield 1 aquifer restoration, and drawdowns of 0:3, 0.4, and 0.001 m (1.08, 1.20 and 0.04 ft) at the end of Wellfield 2 aquifer restoration. These drawdowns would not be expected to impact the yield of these wells.

Based on the consumptive use and groundwater modeling predictions of drawdown in the 70 Sand and 68 Sand in Wellfield 2 resulting from aquifer restoration, private wells within 3.2 km (2 mi) surrounding the proposed license area would only experience a small or nominal drawdown in water level which would not be expected to impact well yields. Therefore, the potential environmental impact on groundwater supplies and to other users of both the production and other surrounding aquifers would be expected to be SMALL.

The use of deep well injection is planned for disposal of waste fluids during aquifer restoration. The potential impacts from deep well injection were discussed in Section 4.5.2.1.2.3 and the potential impact would be expected to be SMALL.

Aquifer restoration should directly impact groundwater quality in the production zone. As discussed in Section 4.5.2.1.3, aquifer restoration is intended to restore groundwater quality in the production zone to baseline conditions, if possible. If the aquifer could not be returned to baseline conditions, NRC requires that the production aquifer be returned to the maximum contaminant levels provided in Table 5C of 10 CFR Part 40 Appendix A or to Alternate Concentration Limits approved by NRC.

The restoration of the 70 Sand production zones, including the potentially impacted portion of the 68 Sand in Wellfield 2 would be expected to restore the groundwater quality to water quality standards which are protective of human health and the environment and would not impact surrounding aquifers. Therefore, the impact of aquifer restoration on groundwater quality would be expected to be SMALL.

Additionally, after its independent review of Uranium One's license application (EMC, 2007a; EMC, 2007b); the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions during aquifer restoration would be comparable to those described in the GEIS. The GEIS concludes that impacts to groundwater during aquifer restoration would range from SMALL to MODERATE The staff concludes that site-specific impacts for the proposed Moore Ranch Project are expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.1.4 Decommissioning Impacts to Groundwater

Section 4.3.4.2.4 of the GEIS discussed potential impacts to groundwater during construction as being are primarily from consumptive use of groundwater, potential spills of fuels and lubricants, and well abandonment. The consumptive use of groundwater during decommissioning would be much less than during either ISR operations or aquifer restoration. Fuel and lubricant spills during decommissioning activities could potentially impact shallow groundwater. Implementation of best management practices during decommissioning would reduce the likelihood of such spills and the impact to groundwater resources in shallow aquifers from decommissioning would be SMALL.

Furthermore, prior to NRC's termination of the ISR source material license, the licensee must demonstrate that there would be no long-term impacts to underground sources of drinking water. Earlier NRC approvals for the completion of well field restoration at the site would have determined that the restoration standards were protective of public health and safety.

As part of the restoration and reclamation activities, all monitor, injection, and recovery wells at the proposed Moore Ranch Project would be plugged and abandoned in accordance with the Wyoming UIC program requirements. If this process was properly implemented and the abandoned wells are properly isolated from the flow domain, the potential environmental impacts would be SMALL.

Additionally, after its independent review of Uranium One's license application (EMC, 2007a; EMC, 2007b); the site visit, meeting with federal, state, local, and tribal officials; other stakeholders; and evaluation of other available information, the NRC staff concludes that the site-specific conditions at the proposed Moore Ranch Project would be comparable to that described in the GEIS for groundwater and incorporates by reference the GEIS's conclusions that the impacts to groundwater during decommissioning would be expected to be SMALL. Furthermore, the staff has not identified any new and significant information during its independent review that would change the expected environmental impact beyond those discussed in the GEIS.

4.5.2.2 No-Action (Alternative 2)

Under the No-Action Alternative no construction or operational activities would occur on site that might impact shallow groundwater. No lixiviant would be injected into the subsurface; therefore, there would be no affect on the aquifer and no consumptive use of groundwater. No liquid effluents would be generated; therefore, there would be no Class I well constructed for disposal of liquid wastes. Therefore, under the No-Action alternative there would be no impact to groundwater above the baseline described in Section 3.5.2.

5.5 Water Resources

5.5.1 Surface Water

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5.5.2 Groundwater

Potential environmental impacts to groundwater resources from the proposed Moore Ranch Project would occur primarily during the operations and aquifer restoration phase of the ISR facility's lifecycle. The analysis of impacts to groundwater resources from operation of the proposed Moore Ranch Project in Section 4.5.2 showed that the potential drawdown in wells outside of the license area from facility operation would be nominal and not affect the well yields. Therefore, the potential impact on groundwater resources from operating the proposed Moore Ranch Project would be expected to be SMALL.

However, within the proposed license area and within the area administered by the BLM Buffalo Field Office, there are either other ongoing or planned activities that would contribute to a cumulative impact on groundwater resources. These include the operation of other ISR facilities (although production may be from a different ore-producing zone) and CBM production.

The BLM estimated that development of CBM in the Powder River Basin through the year 2018 would remove about 3 million acre-feet, less than 0.3 percent of the total recoverable groundwater (nearly 1.4 billion acre-feet) in the Wasatch and Fort Union Formations within the Powder River Basin. An estimated 15 to 33 percent of the removed groundwater would infiltrate the surface and recharge the shallow aquifers above the coals (BLM, 2003). The redistribution of pressure within the coals after water production ended would allow the hydraulic pressure head to recover to within approximately 15 m (50 ft) or less of pre-project levels within 25 years after the project ended. The complete recovery of water levels would take tens to hundreds of years, depending on the specific location. Wells completed in developed coals that are located within the areal extent of 30 m (100-ft) drawdown contour induced by a CBM well could experience drops in water level and possibly encounter methane (BLM, 2003). BLM (2003) noted that the areal extent and magnitude of drawdown effects on coal zone aquifers and overlying or underlying sand units in the Wasatch Formation would be limited by the discontinuous nature of different coal zones within the Fort Union Formation and sandstone layers within the Wasatch Formation.

Within the vicinity of the proposed Moore Ranch Project, the CBM producing unit is the Roland Coal within the Fort Union Formation. The Fort Union Formation is separated from the 70 Sand ore production zone in the Wasatch Formation by greater than 213 m (700 ft) of interbedded clays, siltstone, and discontinuous sands. No hydrologic impacts from CBM production would be expected on the 70 Sand ore production zone and the intervening clay aquitards from ISL operations at the proposed Moore Ranch Project.

However, CBM-produced water was, and continues to be, discharged at the surface in the proposed license area potentially affecting the water quality of the surficial aquifer, the 72 Sand which overlies the 70 Sand ore production zone. The applicant performed an analysis of the surficial aquifer and determined that it would be possible for the surficial aquifer to receive infiltration from CBM-produced water within 1 to 10 years of its surface discharge.

Therefore, the cumulative impact on groundwater resources from the proposed action and past, present, and reasonably foreseeable actions in the vicinity of the proposed Moore Ranch Project was estimated to be MODERATE.

6.2.5 Groundwater Monitoring

Groundwater monitoring of wells located outside of the proposed license area would be conducted to monitor the potential for contaminated groundwater to migrate offsite. The proposed Moore Ranch Project would monitor all private wells located within one kilometer of the boundary of the well fields. These wells would be sampled quarterly, and analyzed for natural uranium and radium-226 with the landowner's consent, to identify potential impacts from the ISR operation. The sampling would be conducted in accordance with a standard operating procedure reviewed by the NRC staff. Furthermore, the water levels in private wells would be measured by the applicant every three months during operations (EMC, 2007a).

6.3 Physiochemical Monitoring

The ISR process directly affects groundwater and has the potential to contaminate it. Monitoring programs help to prevent and limit potential environmental impacts. Physiochemical monitoring provides data on operational and environmental conditions so that prompt corrective actions can be taken if an adverse condition is detected. The physiochemical monitoring program at the proposed Moore Ranch Project includes groundwater monitoring and well field and pipeline flow and pressure monitoring.

6.3.1 Well Field Groundwater Monitoring

Section 8.3 of the GEIS discussed the potential for ISR production processes to affect groundwater in and near the operating well field. Hence, groundwater conditions are extensively monitored both before and during operations, and after restoration. The proposed pre-operational and baseline groundwater monitoring that would occur at the Moore Ranch Project is discussed below in Section 6.3.1.1. The groundwater quality monitoring that would occur during operation and restoration is discussed in Section 6.3.1.2.

6.3.1.1 Pre-Operational Groundwater Sampling

Section 8.3.1.1 of the GEIS discussed how a baseline groundwater quality program would be established prior to uranium production (NRC, 2009). The purpose of this program is to characterize water quality in monitoring wells used to detect lixiviant excursions from the production zone, to remediate excursions, and to establish Restoration Target Values (RTVs) for aquifer restoration after the operations phase is complete.

Groundwater monitoring wells were installed at Moore Ranch to evaluate pre-operational water quality as part of the site characterization discussed in Section 3.5.2 of this SEIS. Four well groups, each with a well in the 70 Sand production zone aquifer, the overlying 72 Sand aquifer, and the underlying 68 Sand aquifer were installed across the proposed license area. Three wells were also completed in the 60 Sand aquifer. Four additional wells completed in the 70 Sand aquifer, installed in the 1980s by Conoco, and existing stock water wells completed in either the production aquifer or the underlying and/or overlying aquifers were also sampled for the WDEQ LQD Guideline 8 groundwater quality parameters to establish the WDEQ class of use as described in Section 3.5.2 of this SEIS.

This sampling program in combination with groundwater sampling data from the 1980 Conoco project, provided a preliminary baseline of groundwater quality. The purpose of the preoperational analysis is to evaluate the overall groundwater quality in the proposed license area under normal pre-operational conditions. It is not used to establish the baseline water quality which forms the basis for establishing restoration criteria for the individual well fields.

To establish baseline water quality at the proposed Moore Ranch Project before operations began, monitoring wells would be installed in the 70 Sand production zone at a density of one well per 1.2 ha (3 ac) of the two planned well fields. Each monitoring well would be analyzed for all WDEQ LQD Guideline 8, Appendix 1, parts III and IV parameters shown in Table 5.7-1 of the applicant's Technical Report (EMC, 2007b). The third and fourth sampling events would be analyzed for a reduced list of parameters defined by the previous sample results. If certain constituents were not detected during the first and second sampling events, then they would not be analyzed for again during the third and fourth sample events. Data for each water quality parameter would be averaged. If the collected well field data indicated that waters of different underground water classes coexist (WDEQ-WQD Rules and Regulations, Chapter VIII), then the data would not be averaged but rather treated as sub-zones. Sub-zone specific data would also be averaged. A sub-zone boundary would be delineated half-way between the sampled well sets as appropriate.

Once the baseline water quality is established for each well field, it would be used to determine the appropriate restoration target values to assess the effectiveness of ground water restoration on a well field-specific basis. The restoration target values are a combination of the average and range of baseline values for specific constituents in wells completed in the 70 Sand production zone. The WDEQ would review and approve the baseline water quality assessment and restoration target values for each well field; NRC would also review and approve the restoration target values for specific constituents.

Monitoring wells would be installed in a ring around each well field in the 70 Sand production zone and in the overlying 72 Sand and underlying 68 and 60 Sand aquifers prior to the start of operations. The wells would be sampled to determine baseline water quality data to establish upper concentration limits (UCL) for operational excursion monitoring. The wells would be sampled four times, at least two weeks apart. The first sample would be analyzed for the full set of constituents required by the WDEQ; subsequent samples would only be analyzed for the UCL parameters (see Section 6.3.1.2).

The applicant's Technical Report provides detailed procedures for sampling and analysis, including methods for measuring water levels, well purging and sampling protocols, sample preservation and documentation, analytical methods, and quality assurance/quality control (QA/QC) requirements (EMC, 2007b).

6.3.1.2 Groundwater Quality Monitoring

Section 8.3.1.2 of the GEIS discussed the placement of monitoring wells around the perimeter of the well fields, in the aquifers overlying and underlying the ore-bearing production aquifers, and within the well fields to provide early detection of potential horizontal and vertical lixiviant excursions during production operations. Monitoring well placement is based on a number of factors including the nature and extent of the confining layer and the occurrence of drill holes, hydraulic gradient and aquifer transmissivity, and well abandonment procedures used in the region. The ability of a monitoring well to detect groundwater excursions is influenced by several factors, such as the aquifer thickness being monitored, the distance between the monitoring wells and the well field, the distance between adjacent monitoring wells, the frequency of groundwater sampling, and the magnitude of changes in lixiviant migration indicator parameters. Therefore, the spacing, distribution, and number of monitoring wells are site specific and established by license conditions.

The groundwater monitoring program at the proposed Moore Ranch Project would be designed to detect excursions of lixiviant outside the well field under production and into the overlying and/or underlying water bearing strata. The groundwater monitoring is divided into four phases: pre-operational, baseline, production and restoration monitoring. Section 5.7.8 of the applicant's Technical Report documents the groundwater monitoring program that would be implemented at the proposed Moore Ranch Project (EMC, 2007b). Monitoring wells completed in the 70 Sand production zone would be installed around the perimeter of each well field. Approximately 24 groundwater wells would monitor the perimeter of Wellfield 1 and approximately 27 groundwater wells would be used to monitor the perimeter of Wellfield 2. Within the pattern area wells completed in the overlying 72 Sand aquifer and in the underlying 68 Sand aquifer would be spaced at one well per every 6.4 ha (4 ac) of pattern area resulting in approximately 6 monitor wells completed in the overlying and underlying aquifers in Wellfield 1 and about 9 monitor wells completed in overlying and underlying aquifers in Wellfield 2 since it covers a larger area. In the Wellfield 2 area where the 68 and 70 Sands coalesce, the sands would be treated as one aquifer and the underlying aquifer would be the 60 Sand. Additional monitoring wells would be placed in the 68 Sand in this area detect potential impacts. Wells would also be completed in the underlying 60 Sand in the area where the 68 and 70 Sands coalesce in Wellfield 2. The final number of such wells would be determined during final well field planning and submitted to the WDEQ-LQD and NRC for review and approval.

The distance between the perimeter monitoring wells surrounding the production wells would be no more than 152 m (500 ft) and the distance between the perimeter monitoring wells and the production pattern would also be approximately 152 m (500 ft) base on the output from a groundwater flow model and the estimated hydraulic properties within the production area. Model simulations were also used to demonstrate that if an excursion occurred, the perimeter monitoring ring would be able to detect an excursion in a timely manner. Appendix B-4 of the Technical Report presents the groundwater model and an analysis of the model results (EMC, 2007b).

At the proposed Moore Ranch Project, the constituents selected as lixiviant migration indicators for which UCLs would be established are chloride, conductivity, and total alkalinity. Chloride was selected because it has a low background concentration in native groundwater and because it would be introduced into the lixiviant from the ion exchange process. Chloride is also very mobile in groundwater. Conductivity was selected because it is an indicator of overall groundwater quality. Total alkalinity was selected because bicarbonate is the major constituent added to the lixiviant during production; therefore, elevated concentrations of total alkalinity could be indicative of an excursion.

The applicant must provide a field demonstration of the hydraulic interconnection between the monitoring wells and production pattern using pump tests before operations can be initiated. Because of the unconfined nature of the groundwater aquifer in the 70 Sand at the proposed Moore Ranch Project, the typical pump tests used for a confined aquifer are ineffective. The applicant therefore used the numerical groundwater model presented in Appendix B-4 of the Technical Report to develop a pump test strategy that could demonstrate the hydraulic connections between the monitoring wells and production pattern in the 70 Sand unconfined aquifer (EMC, 2007b). This pump test strategy would be implemented after the required monitoring and production wells were completed but prior to operations.

A Wellfield Hydrologic Data Package would be prepared by the licensee following the installation of the production pattern and monitoring well network in a well field. This package would provide the monitoring well locations, the pump test results, baseline water quality for all wells, and RTVs for each well field production zone. The applicant's Safety and Environmental Review Panel, responsible for monitoring any proposed change in the facility or process, would review the data package to ensure that the hydrologic testing results and planned ISR activities would be consistent with technical requirements and did not conflict with NRC regulatory requirements. The Wellfield Hydrologic Data Package would be submitted to the WDEQ and NRC for review and approval to ensure the acceptability of the baseline data and the RTVs. WDEQ and NRC would also review the monitoring well locations and the well field-specific monitoring program to ensure they would provide timely detection and correction of potential horizontal or vertical excursions.

After operations were completed, the well fields would be restored. During restoration, lixiviant injection would be suspended; thereby reducing the potential for an excursion. The applicant has therefore proposed a reduced groundwater monitoring program. During the aquifer restoration phase, wells located in the perimeter monitoring ring and completed in the overlying and underlying aquifers would be sampled every sixty days for chloride, alkalinity and conductivity excursion parameters. An excursion would be defined in the same manner as during operations and subject to the same correction requirements.