2.0 SITE CHARACTERIZATION

2.1 SITE LOCATION AND LAYOUT

The Nichols Ranch ISR Project is located in the Pumpkin Buttes Mining District of the Powder River Basin in Johnson and Campbell Counties Wyoming. The project is divided into three project units, the Nichols Ranch, the Hank and Jane Dough Units. The Nichols Ranch Unit encompasses approximately 1,120 acres of land located in Township 43 North Range 76 West, Sections 7, 8, 17, 18, and 20. **The Jane Dough Unit encompasses approximately 3,680 acres of land located in Township 43N, Range 76, portions of Sections 20, 21, 27, 28, 29, 30, 31, 32, 33, and 34.** The Hank Unit encompasses approximately 2,250.53 acres of land located in Township 44 North Range 75 West, Sections 30 and 31 and Township 43 North Range 75 West, Sections 5, 6, 7, and 8. The Nichols Ranch Unit will be the site of the main processing facility consisting of the central processing plant (CPP), main office building, and a maintenance building. **The Jane Dough Unit is located adjacent to and immediately south of the Nichols Ranch Unit and will consist only of wellfield production areas.** The Hank Unit will be a satellite operation consisting of a satellite ion exchange plant, an office building, and a maintenance building. Access to the Nichols Ranch ISR Project site is either via Wyoming State Highway 50 to Van Buggenum Road to T-Chair Livestock ranch roads, or from U.S. Highway 387 north on **the Iberlin Road to the** T-Chair Livestock ranch roads. Figure 2-1 (see map pocket) shows the general location and access to the project areas.

The current land surface ownership of the Nichols Ranch ISR Project includes approximately 3,090.53 acres of private ownership, mainly by the T-Chair Livestock Company, and approximately 280 acres of United States Government ownership administrated by the Bureau of Land Management (BLM). **The Jane Dough Unit contains approximately 3,680 acres of privately-owned land.**

Names and addresses of the surface and mineral owners of record within and adjacent (within 0.5 mi of each unit) to the project are provided in Appendix A and B of this application. Appendix A lists all surface and mineral owners located within the two project units. Appendix B lists all surface and mineral owners for lands located within 0.5 mi of the project units. The legal descriptions of the project units are contained in Appendix C including tabulations of all lands in the project units and tabulation of No Right to Mine lands.

2.2 USES OF ADJACENT LANDS AND WATERS

2.2.1 General

The lands within the Nichols Ranch ISR Project have historically been used for cattle grazing and wildlife habitat. Presently the lands are used for a variety of purposes. Livestock grazing, oil and gas extraction, coal bed methane extraction, and uranium recovery activities are all currently taking place on or near the project area. The immediate future land use for the project area and adjacent areas will be continued livestock grazing, in situ uranium recovery, coal bed methane extraction, and oil and gas extraction.

No residential sites are located within the two Unit permit areas. There are two ranches located near the Unit permit areas. The Pfister Ranch is located approximately 0.6 mi north of the Hank Unit in Township 44 North Range 75 West, Southwest Quarter of Section 19. The Dry Fork Ranch lies approximately 0.9 mi to the west of the Nichols Ranch Unit in Township 42 North Range 76 West, Northeast Quarter of Section 24. Other residential sites that are located near the Nichols Ranch ISR Project are listed in Table 2-1. All of these residents are located outside the Nichols Ranch ISR Project area. Figure D1-2 (see map pocket) of the attached Appendix D1 – Land Use shows the location of the residents listed in Table 2-1 in relation to the Nichols Ranch ISR Project.

Three NRC licensed in situ uranium recovery facilities are located within 50 mi of the Nichols Ranch ISR Project. COGEMA's Christensen Ranch ISR facility is located approximately 6.0 mi north of the Nichols Ranch Unit and approximately 4.0 mi to the northwest of the Hank Unit. Power Resources Inc. (PRI) licensed North Butte amendment area lays approximately 2.0 mi to the north of the Hank Unit and 5.0 mi to the northeast of the Nichols Ranch Unit. PRI's Smith-Highlands Ranch (SR-HUP) ISR facility is located approximately 45 mi to the southeast of the Nichols Ranch ISR Project. Two of the licensed facilities, Christensen Ranch and SR-HUP, currently have existing yellowcake processing plants with the SR-HUP being in operation. The Christensen Ranch plant was idle, but is back in production. PRI's North Butte amendment area is currently active with a satellite facilty and related wellfields.

Table 2-1 Nearest Residents.

Nearest Residences	Number of Inhabitants	Nearest Permit Area	Distance From Permit Area (mi)	Direction
T-Chair (Rolling Pin) Ranch*	5	Nichols Ranch, Jane Dough, Hank	1.9, 1.6, 2.9	E, SW
Pfister Ranch	3	Hank	0.6	N
Pumpkin Buttes Ranch	2	Hank	1.1	E
Van Buggenum Ranch	0	Hank	4	E
Ruby Ranch	2	Hank	6.1	E
Dry Fork Ranch	3	Nichols, Jane Dough	0.9, 0.9	W
Christensen Ranch	1	Hank	3.5	NW

* T-Chair Ranch sits between the Nichols Ranch and Hank Unit areas.

Figure 1-4 (see map pocket) of Chapter 1.0, Proposed Activities, shows the location of each facility in relation to Uranerz Energy Corporation's Nichols Ranch ISR Project.

After mining activities are completed, the land will be returned to the pre-mining land use of wildlife habitat and livestock grazing. Decommission and reclamation activities of the affected areas resulting from the uranium recovery activities are detailed in Chapter 6.0 of this application.

2.2.2 Agricultural

Livestock grazing is the main activity on the project area and adjacent lands. No known sources of mass food production for human consumption exist within 10 km of the project area. Hay was grown in the past on approximately 127.8 acres of the southern part of the Nichols Ranch Unit, but because of drought conditions over the last seven years, this crop has not been produced. The National Resources Conservation Service (NRCS) stocking rate for the Nichols Ranch ISR Project ranges from 1.0 to 3.0 animal units per acre, per month on range that varies from average to excellent as listed in the NRCS Technical Guides for the Northern Plains.

2.2.3 Recreation

Recreational activities within a 50-mi radius of the Nichols Ranch ISR Project are mainly outdoor activities such as camping, hiking, fishing, and hunting. Almost all of the land on and adjacent to the Nichols Ranch ISR Project area is private with limited access, but public lands such as the Thunder Basin National Grassland, located approximately 24 mi to the east/southeast of the Hank Unit, and the Bighorn Mountains, approximately 27 mi to the west, provide areas for recreational activities. The Powder River, located approximately 9.0 mi to the west of the project area, also provides recreational opportunities for public use.

2.2.4 Water Rights

Surface and groundwater rights on, adjacent to, and within 3.0 mi of the Nichols Ranch ISR Project are listed in Appendix D-6 (Hydrology) of this application. No adjudicated surface water rights are located in or adjacent (within 0.5 mi of the permit boundary) to the Nichols Ranch ISR Project. The surface water rights that do exist within the proposed Nichols Ranch ISR Project area are limited to stock/storage ponds and ephemeral creeks. Groundwater rights in the Nichols Ranch ISR Project area are mainly associated with old monitoring wells and stock wells. No other adjudicated water rights are in the project area and lands adjacent to the project area according to the Wyoming State Engineer's Office. Uranerz Energy Corporation also does not hold any adjudicated water rights in the project area. Most wells that are located within the Nichols Ranch ISR Project area were installed by prior uranium exploration companies, the private land owners, or coal bed methane companies. Several additional wells have been completed in the project area by Uranerz Energy Corporation for use in collecting baseline groundwater quality data.

Wells in the area of the proposed Nichols Ranch ISR Project area are uniformly distributed over the area excluding monitoring/sampling wells that are permitted by Uranerz Energy Corporation. Most of the wells are used for livestock watering through the use of windmills or electric well pumps. Well depths vary from 180 ft to 1,000 ft in depth, most of which are completed in sands other than the ore zone sands. Those wells which are completed in the ore zone sand will either

be abandoned using acceptable WDEQ methods will have the ore zone interval isolated, or will be used as monitoring wells if not completed in multiple sands. One domestic water well is located in the vicinity of the central processing plant and is permitted with the WSEO and WDEQ accordingly. The well is completed at a depth stratigraphically below the zones planned for the ISR extraction. The WDEQ permit identified possible contaminant sources and based on the aquifer media and proposed type of domestic water system, a source water area for the well was identified. Thile the sources lie within the source water protection area, the aquifer is not vulnerable to contaminats because of the distance from the wellhead, the annual seal around the well that extends to a depth of 650 ft and the thickness of the overlying geologic confining units. Bottled water will be provided for drinking water. A domestic water supply well is found on the Pfister Ranch, located approximately 0.6 mi north of the northern boundary of the Hank Unit. This well is completed at a depth that is stratigraphically below the zones planned for the ISR extraction. Additionally, the well is located at a distant from any planned wellfields and in sandstone units that do not contain any uranium mineralization of economic significance. Any extraction activities that take place in the area are very unlikely to affect this well because the well is completed in a sandstone unit that is separated from the ore zone sandstone by an aquiclude consisting of mudstone. The extensive groundwater monitoring program utilized during the extraction phase should detect any problems prior to either of these wells being adversely affected.

Any water wells that Uranerz Energy Corporation constructs in the project area will be completed in sands that are stratigraphically below or above the ore zone. The purpose of the wells will be for providing process and wash down water to the plant facilities.

Appendix D6, Hydrology, of this license application contains detailed hydrologic information for the Nichols Ranch ISR Project.

2.2.5 Industrial

2.2.5.1 General/Oil/Gas

Coal bed methane and oil and gas development have and will be taking place in the proposed project area and on the lands adjacent to the Nichols Ranch ISR Project area. The Hank Unit lies within the Hartzog/Pumpkin Buttes Oil Fields. Presently six oil/gas wells exist on lands within and adjacent to the Hank Unit. No oil/gas wells are located within or adjacent to the Nichols Ranch Unit. According to the Wyoming Oil and Gas Conservation Commission, no further oil and gas

development will take place in the Nichols Ranch ISR Project. The locations of the oil/gas wells for the Hank Unit are shown in Exhibit D6-5 (see map pocket) of the attached Appendix D6- Hydrology. Table 2A-1 of Addendum 2A lists all oil/gas wells found within a 3.0 mi radius of the project area.

The oil/gas wells located in the Hank Unit should not cause any issues with the proposed extraction activities. The location of the wells and the depths that they are drilled to (< 9,000 ft deep) will not interfere with the ISR extractions since the ore zone is much shallower than the oil/gas wells. None of the oil/gas wells penetrate the ore zones. Additionally the completion techniques used by the oil/gas companies are such that the wells will not cause any potential excursions to occur. The oil and gas wells in the project area are typically cemented from at least 1,000 ft deep to the surface. This amount of cement is sufficient to protect the oil/gas wells from acting as a conduit for any uranium recovery fluids. Pressure monitoring on the oil/gas wells also ensures that the oil/gas wells are working properly and that the wells integrity is intact.

Presently there are three conventional oil/gas wells exist on the lands within the Jane Dough Unit. According to the Wyoming Oil and Gas Conservation Commission, no further oil and gas development would take place in the Nichols Ranch ISR Project. The locations of the conventional oil/gas wells in the Jane Dough Unit are shown in Exhibit JD-D6-3 (see map pocket) of the attached Appendix D6, Hydrology.

2.2.5.2 Coal Bed Methane

Coal bed methane (CBM) activity is widespread throughout the Powder River Basin. The methane is produced at a depth of approximately 1,000 ft and greater which is approximately 400 ft deeper than the uranium mineralization found in the Nichols Ranch and Hank Units. Since the CBM activity and uranium mineralization are stratigraphically separated with layers of sandstone, mudstone, and clay, it is very unlikely that any of the CBM wells will be impacted by the extraction activity and vice versa.

Currently there are 24 permitted and completed CBM wells located in or adjacent to the Nichols Ranch Unit. Thirty-three permitted and completed CBM wells are found in the lands in and adjacent to the Hank Unit. The Nichols Ranch ISR Project will not impact any of the current or proposed CBM wells as none of the existing or purposed CBM wells are or will be located within the planned wellfield areas. Communication between the CBM producers and Uranerz Energy Corporation has been established with all parties working together to avoid conflicts. Maps of the

CBM producers proposed well sites, access roads, water and gas pipeline routes, and utility corridors have been provided to Uranerz Energy Corporation for use in developing extraction activities.

CBM discharge water will not be impacted by extraction activities in the Nichols Ranch ISR Project area. Both CBM producers on the Nichols Ranch and Hank Units will be piping water produced by CBM drilling to locations out of the project area and adjacent lands. The CBM produced water will then be either discharged on the surface or stored in large storage tanks, pumped some thirty miles away, and then re-injected into the ground.

Exhibits D6-3 and D6-4 (see map pockets) of the attached Appendix D6 – Hydrology show all CBM wells on, adjacent to, and within three miles of the Nichols Ranch and Hank Units. Table's 2A-2 through 2A-5 of Addendum 2A details all CBM wells that are permitted and completed in the project area. Table 2A-6 of Addendum 2A defines the abbreviations used in Tables 2A-1 through 2A-5.

Presently there are 47 CBM wells exist on the lands within the Jane Dough Unit. According to the Wyoming Oil and Gas Conservation Commission, no further oil and gas development would take place in the Nichols Ranch ISR Project. The locations of the conventional oil/gas wells in the Jane Dough Unit are shown in Exhibit JD-D6-4 (see map pocket) of the attached Appendix D6, Hydrology.

2.3 POPULATION DISTRIBUTION

The population within 50 mi (~80 km) of the Nichols Ranch ISR Project consists mainly of rural areas. The community of Gillette, Wyoming is the closest major urban area to the mine site located approximately 46 air mi away. Casper, Wyoming is the next closet major urban area to the mine site located approximately 61 air mi away. These two communities provide the major locations of public services such as schools, churches, medical care facilities, public parks, and commodities. Wright and Buffalo, Wyoming also provide public services near the mining site. Table 2-2 lists the cities located within a 50 mi (~80 km) radius of the Nichols Ranch ISR Project area **and this information has been updated for 2010.** Table 2-3 also lists the estimated populations of all major towns and cities within Campbell, Johnson, and Natrona Counties. Figure 2-2 (see map pocket) shows the location of towns and cities within 50 mi (~80 kilometers) of the project area.

Table 2-2 Cities Within a 50-mi Radius of the Nichols Ranch ISR Project Area.

City	Population[1]	Distance From Permit Area (mi)	Direction
Gillette	**28,729**	46	Northeast
Buffalo[2]	**4,888**	57	Northwest
Kaycee	**263**	35	West
Midwest	**404**	25	Southwest
Edgerton	**195**	23	Southwest
Wright	**1,807**	22	East
Casper[2]	**54,874**	61	Southwest

[1] Source: U.S. Census Bureau Population Division **(2010).**
[2] Major Wyoming cities just beyond 50 mi.

Casper, Wyoming is the County Seat of Natrona County and the second largest city in Wyoming. The city serves as the economic center of central Wyoming servicing a 150-mi radius that encompasses all or part of seven counties. Oil and gas, mining, and retail services are all found in the city. Casper also is home to the Casper Events Center which hosts many public events such as concerts, trade shows, and sporting events. The population of Casper is in an upward trend with the recent resurgence in oil and gas development and uranium mining. **According to the U.S. Census Bureau, the estimated population in Casper has increased 9.5% from 2000 to 2010 (Table 2-3). The population of Casper is expected to continue to follow an upward trend with an average growth rate comparable to the state growth rate of 2.58%.**

Gillette, Wyoming is the County Seat of Campbell County. The city has been experiencing major growth over the last few years. Coal bed methane, oil and gas development, and coal mining have played significant roles in expanding the city's population by almost 12% from April 2000 through July 2005. According to the Campbell County Economic Development Corporation, Campbell County Housing Needs Assessment of January 2005, Campbell County is projected to grow at a consistent pace between 7% and 11% for the next 15 years due to the expansion of the work force and natural population growth. With the influx of industry, Gillette also serves a regional center for oil and gas, mining, and CBM support services.

Table 2-3 Wyoming Population Data Campbell, Johnson, and Natrona Counties.

Place	Census 2000 Population	April 1, 2000 Population Estimates Base	July 1, 2001 Population	July 1, 2002 Population	July 1, 2003 Population	July 1, 2004 Population	July 1, 2005 Population	% Change July, 2004 to July, 2005	% Change April, 2000 to July, 2005
Wyoming	**493,782**	**493,782**	**494,045**	**499,045**	**501,915**	**505,887**	**509,294**	**0.7**	**3.1**
Campbell County	**33,698**	**33,698**	**34,670**	**36,155**	**36,423**	**36,654**	**37,405**	**2.0**	**11.0**
Gillette city	19,646	20,271	20,870	21,819	22,053	22,174	22,685	2.3	11.9
Wright town	1,347	1,347	1,379	1,426	1,418	1,408	1,425	1.2	5.8
Balance of Campbell County	12,705	12,080	12,421	12,910	12,952	13,072	13,295	1.7	10.1
Johnson County	**7,075**	**7,075**	**7,171**	**7,413**	**7,537**	**7,606**	**7,721**	**1.5**	**9.1**
Buffalo city	3,900	3,902	3,956	4,100	4,212	4,230	4,290	1.4	9.9
Kaycee town	249	249	253	261	265	269	273	1.5	9.6
Balance of Johnson County	2,926	2,924	2,962	3,052	3,060	3,107	3,158	1.6	8.0
Natrona County	**66,533**	**66,533**	**66,909**	**67,519**	**68,238**	**68,988**	**69,799**	**1.2**	**4.9**
Bar Nunn town	936	936	944	955	970	1,139	1,292	13.4	38.0
Casper city	49,644	49,737	49,867	50,236	50,770	51,223	51,738	1.0	4.0
Edgerton town	169	169	169	170	171	172	173	0.6	2.4
Evansville town	2,255	2,255	2,269	2,285	2,297	2,304	2,328	1.0	3.2
Midwest town	408	408	408	411	417	427	431	0.9	5.6
Mills town	2,591	2,632	2,739	2,830	2,866	2,873	2,898	0.9	10.1
Balance of Natrona County	10,530	10,396	10,513	10,632	10,747	10,850	10,939	0.8	5.2

Note: The April 1, 2000 Population Estimates Base reflects modifications to the Census 2000 population as documented in the Count Question Resolution program, updates from the Boundary and Annexation Survey, and geographic program revisions. An "(X)" in the Census 2000 field indicates a locality that was formed or incorporated after Census 2000 or was erroneously omitted from Census 2000. Additional information on these localities can be found in the Geographic Change Notes (see "boundary changes" under the Geographic Topics section of the Estimates page). Dash (-) represents zero or rounds to zero.

Source: Population Division, U.S. Census Bureau Release Date: June 21, 2006

Wright, Wyoming is the closest town to the project area located approximately 22 mi away. Like most towns in Wyoming, Wright has continued to grow with the development of coal bed methane, oil and gas, and coal mining in Campbell County. **The town has experienced an estimated 13.1% growth from 2000 to 2010.**

Several small communities exist in Johnson County, Wyoming. The county seat, Buffalo, is the largest town in Johnson County. Buffalo is located approximately 57 air mi to the northwest of the Nichols Ranch ISR Project area and houses the Bureau of Land Management office that oversees all federal land in Northeast Wyoming. The population of Johnson County is expected to grow at a rate of 1.5% to 1.7% from 2005 to 2012 according the Johnson County Comprehensive Land Use Plan of 2005. Much of the population growth is expected to come from the development of coal bed methane in Johnson County.

Several ranches are found within five miles of the Nichols Ranch ISR Project area. The closest inhabited dwelling is the Pfister Ranch. This ranch is located approximately 0.6 mi north of the Hank Unit. Currently three people reside at the ranch. The next closest inhabited dwelling is the Dry Fork Ranch located 0.9 mi to the West of the Nichols Ranch Unit. Three people also reside at this ranch. Four other ranches lie within 5.0 mi of the Nichols Ranch ISR Project area. The name of the ranches and the number of inhabitants are listed in Table 2-1. All together, the six ranches results in a total of 14 people residing within 5.0 mi of the Nichols Ranch ISR Project area. This results in an occupational density of 0.31 persons per square mile for the area within five miles of the project area. Figure 2-3 (see map pocket) shows the population density for Wyoming and for a 50 mi (~80 km area) surrounding the project area.

Two ranches are found within five miles of the Jane Dough Unit. The closest inhabited dwellings are the Dry Fork and Rolling Pin Ranches. Each ranch is located approximately 1.0 mile west and east, respectively of the Jane Dough Unit. Currently three people reside at the Dry Fork Ranch and five people reside at the Rolling Pin Ranch. Five other ranches are located between 5 and 11 miles from the Jane Dough Unit. All together, the two ranches

result in a total of eight people residing within 5.0 mi of the Jane Dough Unit. This results in an occupational density of 0.06 persons per square mile for the area within 5.0 mi of the project area.

Because of the remote location of the Nichols Ranch ISR Project, visitation to the project location will be limited mainly to vendors, contractors, regulatory agency personnel, coal bed methane employees, and pre-arranged public tours.

Figures 2-4 through 2-6 (see map pockets) provides detailed information regarding the county profiles of Campbell, Johnson, and Natrona County. Included in this information are details about minority populations, county employment statistics, and landowners in the counties. Table 2-4 contains information on the minority populations in Campbell, Johnson, and Natrona Counties.

Table 2.4 Population by Place, by Minority, 2000 and 2010.

	Total			Non-hispanic, White			Total Minority					Hispanic/Latino		
										% of Total				
Area Name	**2000**	**2010**	% Chg	**2000**	**2010**	% Chg	**2000**	**2010**	% Chg	**2000**	**2010**	**2000**	**2010**	% Chg
Wyoming	493,782	544,270	9.3	438,799	509,018	13.8	54,983	35,252	-56.0	11.1	6.9	31,669	43,977	28.0
County														
Campbell	33,698	43,967	23.4	31,701	42,974	26.2	1,997	1,936	-3.2	5.9	4.5	1,191	3,611	67.0
Johnson	7,075	8,531	17.1	6,771	8,267	18.1	304	238	-27.7	4.3	2.9	148	276	46.4
Natrona	66,533	74,508	10.7	61,023	70,015	12.8	5,510	3,825	-44.1	8.3	5.5	3,257	5,231	37.7
Place														
Buffalo (city)	3,900	4,888	20.2	3,715	4,378	15.1	185	207	10.6	4.7	4.7	71	159	55.3
Casper (city)	49,644	54,874	9.5	45,334	51,048	11.2	4,310	4,268	-1.0	8.7	8.4	2,656	4,070	34.7
Evansville (town)	2,255	2,504	9.9	1,964	2,311	15.0	291	2,813	89.7	12.9	121.7	190	317	40.1
Gillette (city)	19,646	28,729	31.6	18,350	26,831	31.6	1,296	2,256	42.6	6.6	8.4	774	2,764	72.0
Mills (town)	2,591	3,574	27.5	2,394	3,252	26.4	197	209	5.7	7.6	6.4	102	226	54.9
Wright (town)	1,347	1,550	13.1	1,298	1,707	24.0	49	100	51.0	3.6	5.9	31	112	72.3

2.4 HISTORIC, SCENIC, AND CULTURAL RESOURCES

2.4.1 General

The following reports attached as Addendum 2B, Addendum 2B2, **Addendum 2B3** Addendum 2C, **Addendum 2C2**, Exhibit 2-1, and Exhibit **2-1A** contain information that is considered confidential information under 10 CFR 2.390. This information must be withheld from public disclosure.

2.4.2 Cultural Resources

2.4.2.1 Class I Literature Search for Uranerz Energy Corporation's Nichols Ranch and Hank Units

File searches were conducted from November 2007 through January 2010, through the Cultural Records Office of the Wyoming State Historic Preservation Office (SHPO) for Sections 7, 8, 17, 18, and 20, T43N, R76W; Sections 30 and 31, T44N, R75W; and Sections 5-8, T43N, R75W. Uranerz Energy Corporation's proposed Nichols Ranch ISR Project occurs within these legal descriptions.

Twelve projects have been conducted within the sections listed above for nine block and three block/linear surveys (Table 2-5). A few recent projects have not been accessioned into the SHPO database; therefore, they do not have accession numbers in Table 2-5. Fifty-four sites have been recorded in the 11 sections listed above. Of these, 46 sites are prehistoric, five sites are historic, and three site are multicomponent prehistoric/historic. The sites are summarized in Table 2-6. Of the prehistoric sites, 17 are eligible for listing on the National Register of Historic Places (NRHP), 20 are not eligible, eight are not eligible with SHPO concurrence, and one (Site 48CA6153) is unevaluated with SHPO concurrence. The five historic sites are not eligible, one (Site 48JO2951) with SHPO concurrence. Of the three multicomponent sites, one (Site 48CA268, Pumpkin Buttes Traditional Cultural Property [TCP]) is eligible for the NRHP with SHPO concurrence, and two are not eligible with SHPO concurrence.

Table 2-5 Previous Cultural Resource Inventories Within or near Uranerz Energy Corporation's Nichols Ranch and Hank Units.

Accession No.	Project Name	Contractor [1]	Type [2]	Legal Location
76-352-0	Brown's Ranch Uranium Mine	OWSA	B	Section 6, T43N, R75W
77-1-0	Brown's Ranch Uranium Mine	OWSA	B	Section 30, T44N, R75W
79-680-0	Brown's Ranch Uranium Mine	PE	B/L	Section 6, T43N, R75W
80-1209-0	Fed BZ 1	AS	B/L	Section 7, T43N, R76W
81-2054-0	Fed B-R-1	AC	B	Section 6, T43N, R75W
81-2054-0	Parker Fed 34-6 Testing	AEC	B	Section 17, T48N, R71W
4-2191-0	East Bullwhacker CBM POD	SWCA	B	Section 20, T43N, R76W
6-1350-0	Dry Willow CBM POD #1	SWCA	B	Section 31, T44N, R75W
6-1350-2	Dry Willow POD 1 Supplement	SWCA	B	Section 31, T44N, R75W
6-1465-0	Dry Willow POD Block Survey	Arcadis	B	Section 20, T43N, R76W
n/a	80-Acre Parcel in Hank Unit	TRC	B	Section 5, T43N, R76W
n/a	Tex Draw	WLS	B	Sections 7, 8, 17, 18, 20 T43N, R76W

[1] AC = Archeo Consultants; Arcadis = Arcadis U.S. Inc.; AEC = Archaeological Energy Consulting; AS = Archaeological Services; OWSA = Office of the Wyoming State Archaeologist; PE = Powers Elevation, TRC = TRC Environmental Corporation, WLS = Western Land Services

[2] B = block; B/L = combination block/linear, n/a = Not applicable

Table 2-6 Previously Recorded Sites Within or near Uranerz Energy Corporation's Nichols Ranch and Hank Units.

	Legal Location					NRHP		
Site No.	Township	Range	Section	Site Type	Landowner	Eligibility Status [1]	Time Period [2]	Accession No. [3]
48CA268 [4], [5]	43N, 44N	75W	6, 31	TCP	BLM/Private	E/SHPO	P/H	5-1851
48CA379 [5]	44N	75W	31	Lithic scatter	Private	NE/SHPO	P	6-1350
48CA5386 [5]	43N	76W	8	Lithic scatter	Private	NE	P	--
48CA5390 [5]	43N	76W	17	Lithic scatter	Private	E	P	--
48CA5391 [5]	43N	76W	17	Lithic scatter	Private	E	P	--
48CA5393 [5]	43N	76W	20	Inscription	Private	NE	P	--
48CA5392	43N	76W	20	Lithic scatter	Private	NE/SHPO	P	--
48CA5406 [5]	43N	76W	17	Lithic scatter	Private	NE	P	--

Table 2-6 (Continued)

Site No.	Legal Location			Site Type	Landowner	NRHP Eligibility Status [1]	Time Period [2]	Accession No. [3]
	Township	Range	Section					
48CA6146 [5]	44N	75W	31	Open camp	BLM	NE/SHPO	P	6-1350
48CA6147 [5]	44N	75W	31	Open camp/trash scatter	BLM	NE/SHPO	P/H	6-1350
48CA6148 [5]	44N	75W	31	Lithic scatter	BLM	NE/SHPO	P	6-1350
48CA6149 [5]	44N	75W	31	Lithic scatter	BLM	NE/SHPO	P	6-1350
48CA6150	44N	75W	30	Lithic scatter	Private	NE/SHPO	P	6-1350
48CA6151 [5]	44N	75W	30	Lithic scatter	Private	NE/SHPO	P	6-1350
48CA6153	44N	75W	30	Open camp	Private	U/SHPO	P	6-1350
48CA6155	44N	75W	30	Lithic scatter	Private	NE/SHPO	P	6-1350
48CA6342 [5]	43N	75W	6	Open camp	BLM	NE	P	--
48CA6343 [5]	43N	75W	6	Open camp	BLM	NE	P	--
48CA6344 [5]	43N	75W	6	Open camp	BLM	NE	P	--
48CA6345 [5]	43N	75W	6	Open camp	BLM	NE	P	--
48CA6474	43N	75W	8	Rockshelter	Private	E	P	--
48CA6475 [5]	43N	75W	7	Open camp	Private	E	P	--
48CA6476	43N	75W	8	Open camp	Private	E	P	--
48CA6477	43N	75W	7	Lithic scatter	Private	NE	P	--
48CA6478	43N	75W	8	Open camp	Private	E	P	--
48CA6479	43N	75W	8	Open camp	Private	E	P	--
48CA6480	43N	75W	8	Open camp	Private	E	P	--
48CA6481	43N	75W	8	Open camp	Private	E	P	--
48CA6489	43N	75W	8	Open camp	Private	E	P	--
48CA6490 [5]	43N	75W	6, 7	Open camp	Private	E	P	--
48CA6491 [5]	43N	75W	7	Lithic scatter	Private	NE	P	--
48CA6498 [5]	43N	75W	8	Lithic scatter	Private	NE	P	--
48CA6499 [5]	43N	75W	6, 7	Lithic scatter	Private	NE	P	--
48CA6748 [5]	43N	75W	6	Open camp	BLM	E	P	--
48CA6749 [5]	43N	75W	6	Lithic scatter	Private	NE	P	--
48CA6750 [5]	44N	75W	31	Lithic scatter	BLM	NE	P	--
48CA6751 [5]	44N	75W	31	Open camp	BLM	E	P	--
48CA6752 [5]	44N	75W	31	Open camp	BLM	NE	P	--
48CA6753 [5]	44N	75W	31	Open camp	BLM	E	P	--

Table 2-6 (Continued)

Site No.	Legal Location: Township	Range	Section	Site Type	Landowner	NRHP Eligibility Status [1]	Time Period [2]	Accession No. [3]
48CA6754 [5]	44N	75W	31	Lithic scatter	BLM	E	P	--
48CA6926 [5]	43N	75W	5	Lithic scatter	Private	NE	P	--
48CA6927 [5]	43N	75W	5	Open camp	Private	E	P	--
48JO2944 [5]	43N	76W	8	Trash scatter	Private	NE	H	--
48JO2945	43N	76W	8	Trash scatter	Private	NE	H	--
48JO2946 [5]	43N	76W	7, 8	Open camp	Private	E	P	--
48JO2947	43N	76W	7	Lithic scatter	Private	NE	P	--
48JO2948 [5]	43N	76W	17	Lithic scatter	Private	NE	P	--
48JO2949 [5]	43N	76W	17	Trash scatter	Private	NE	H	--
48JO2950 [5]	43N	76W	17	Trash scatter	Private	NE	H	--
48JO2951	43N	76W	18	Homestead	Private	NE/SHPO	H	--
48JO2953 [5]	43N	76W	20	Lithic scatter/ building remains	Private	NE/SHPO	P/H	--
48JO2957 [5]	43N	76W	17	Lithic scatter	Private	NE	P	--
48JO2959	43N	76W	18	Lithic scatter	Private	NE	P	--
48JO2960	43N	76W	18	Lithic scatter	Private	NE	P	--

1 E = eligible; NE = not eligible; E/SHPO = eligible with SHPO concurrence; NE/SHPO = not eligible with SHPO concurrence; U/SHPO = unevaluated with SHPO concurrence.
2 H = historic; P = prehistoric; P/H = multicomponent prehistoric/historic.
3 -- = sites that are not yet accessioned with projects, sites associated with projects that have not yet been accessioned in the cultural records office, and sites with projects that do not extend into this section.
4 48CA268 was not listed in the SHPO database at the time of file search.
5 Site is located in the permit boundary and illustrated on Exhibit 3-1.

The entire area encompassed by the Nichols Ranch Unit permit boundary (within Sections 7, 8, 17, 18, and 20, T43N, R76W) was inventoried at the Class III level by Western Land Services, Sheridan, Wyoming, for the Tex Draw CBM POD, which has been approved by the BLM (personal communication, December 22, 2009, with Clint Crago, Archaeologist, BLM Buffalo Field Office).

Within the Hank Unit permit boundary, all of Section 30 and all but the SENE, NESE, and SESE of Section 31 were inventoried for the Dry Willow 1 POD, which has been approved by BLM

(personal communication, November 21, 2007, with Clint Crago, Archaeologist, BLM Buffalo Field Office). The SENE, NESE, and SESE of Section 31 were inventoried in 2007 for the Uranerz Energy Corporation's Hank In Situ Uranium Project, but it has not been reviewed by BLM. All of Sections 6-8 T43N, R75W, were inventoried at the Class III level in 2006 by Arcadis U.S., Inc. for the Dry Willow Phase 4 POD.

2.4.2.2 Class I Literature Search for Uranerz Energy Corporation's Jane Dough Unit

For the Jane Dough Unit, a file search Wyoming State Historic Preservation Office (WSHPO) [File Search No. 25735] was conducted through the Cultural Records Office of the WSHPO for Sections 20, 21, 27, 28, 29, 30, 31, 32, 33, and 34, T43N, R76W, on May 14, 2010, and includes a description of archaeological and historical resources within the Jane Dough Unit and includes the full sections of land directly associated with this project. The Jane Dough Unit occurs within a majority of these legal descriptions. Once the list of sites is obtained from the WSHPO database, the sites within each section were plotted to determine if they occur within the physical boundaries of the Jane Dough Unit. The file search for this area indicates that 10 projects have been conducted with 31 archaeological and historic sites located within the full sections listed above.

The 10 projects conducted within the full sections listed above were completed between 1984 and 2008 for a variety of energy development projects, including five CBM plans of development (PODs), four oil/gas wellfield surveys, and one seismic project (Table 2-6a). The projects consist of nine (9) Class III inventories and one historic trail evaluation project. Of the nine inventory projects seven contain inventory areas that overlap within the current project area.

Based on comprehensive inventory area and project accession dates, four of these inventory projects (WSHPO Project Nos. 99-1041, 99-1142, 4-2191, and 8-425) were utilized to determine which portions of the current project area did not require additional Class III inventory. Approximately 2,660 acres of the 3,680-acre Jane Dough Unit had been previously inventoried in association with these four projects and are shown on Exhibit JD-D3-1 (presented in Appendix D-3) and discussed below.

Table 2-6a Cultural Resource Inventories Completed Within or near Uranerz Energy Corporation's Jane Dough Unit.

Accession No. [1]	Project Name	Contractor [2]	Type [3]	Legal Location
84-540	77 Drill Holes and Block	TVA	B	Section 27, T43N, R76W
84-725	Taylor Unit No. 9	PAS	B	Section 33, T43N, R76W
99-1041	Dry Fork Block Survey	PAS	B	Sections 29, 30, 31, 32, and 33, T43N, R76W
99-1142	West Pumpkin Buttes Prospect	PAS	B	Section 34, T43N, R76W
4-2191	East Bullwhacker CBM POD	SWCA	B	Sections 20, 29, 30, 31, and 32, T43N, R76W
4-2191-3	East Bullwhacker CBM POD Trails Evaluation	ACR	B/L	Sections 30 and 31, T43N, R76W
6-615	Mojave 3-D Seismic Project	TRC	L	Section 31, T43N, R76W
6-1465	Dry Willow Phase 2 POD	Arcadis	B	Section 27, R43N, R76W
7-1669	Blade CBM POD	ACR	B/L	Sections 20, 21, 28, and 29, T43N, R76W
8-425	Tex Draw Federal POD	WLS	B	Sections 20, 21, 27, 28, and 29, T43N, R76W
--	Jane Dough Unit ISR Project	TRC	B	Sections 20, 28, 29, and 32, T43N, R76W

1 -- = report has not been accessioned.
2 ACR = ACR Consultants, Inc.; Arcadis = Arcadis U.S. Inc.; PAS = Pronghorn Archaeological Services; SWCA = SWCA Environmental Consultants; TRC = TRC Environmental Corporation; TVA = Tennessee Valley Authority; WLS = Western Land Services.
3 B = block; B/L = combination block/linear; L = linear.

The northern portion of the Jane Dough Unit, including the S1/2N1/2, NSE1/4, and S1/4ESE1/4 of Section 20, all of the project portions in Sections 21 and 27, the N1/2 of Section 28, and the E1/2NE1/4 of Section 29, T43N, R76W, was inventoried by Western Land Services as part of the Tex Draw Federal POD project. The inventory report for that project was accessioned by WSHPO in 2008 (Project No. 8-425). The E1/2SW1/4 and SW1/4SE1/4 of Section 20 in the northern portion of the Jane Dough Unit and all of southwestern portion of the project area in Sections 30 and 31 were inventoried by SWCA Environmental Consultants (SWCA) as part of the East Bullwhacker CBM POD. The report was accessioned by WSHPO in 2004 (Project No. 4-2191). The central portion of the Jane Dough Unit, including the W1/2NE1/4 and SE1/4 of Section 29, the S1/2 of Section 32, and all of the project area within Section 33, was inventoried by Pronghorn Archaeological Services (PAS)

in 1999 as part of the Dry Fork Block Survey. The report was accessioned by WSHPO in 1999 (Project No. 99-1041). The portion of the project area in Section 34 in the southeastern portion of the Jane Dough Unit was inventoried by PAS in 1999 as part of the West Pumpkin Buttes Prospect. The report was accessioned by WSHPO in 1999 (Project No. 99-1142).

TRC evaluated the current Jane Dough Unit area and determined that a majority of the project area had been previously inventoried as described above. However, a total of 1,040 acres had not been inventoried. As a result, TRC inventoried the remaining uninventoried portion of the project area (portions of Sections 20, 28, 29, and 32, T43N, R76W) in 2010 and the report is presented in Addendum JD-D3-A and it has been added to Table ER3-6. Results of the 2010 inventory indicate that no newly identified historical or archaeological sites were found; however, one newly identified segment and three previously identified segments of the Deadwood Road were recorded. This report will be reviewed by NRC and WDEQ/LQD and will be submitted to the WSHPO for review after it is accepted by the NRC.

Fourteen sites have been recorded within the Jane Dough Unit boundary covered by the file search and the inventory completed in 2010 by TRC. The 14 sites consist of nine prehistoric and five historic sites (Table 2-6b).

The results of the current and previously conducted Class III inventories indicate that 14 sites and two IRs are located within the project area for Uranerz's Jane Dough Unit (refer to Table ER3-6 in the Jane Dough Unit Environmental Report). The 14 sites consist of two sites that are eligible for listing on the National Register of Historic Places (NRHP) and 12 that are ineligible.

Impact Assessment/Project Effect to Cultural Resources

Of the 85 sites previously identified within and near the Nichols Ranch Unit, the Hank Unit, and the Jane Dough Unit, 59 of these sites are located within the permit boundary of the Nichols Ranch project area (13 sites are in the Nichols Ranch Unit, 24 sites are in the Hank Unit, **and 22 sites are in the Jane Dough Unit** (see Table 2-6 and Exhibit 2-1). Of these 37 sites within the Nichols Ranch permit area, 11 sites are eligible for the NRHP: three within the Nichols Ranch Unit and eight within the Hank Unit (see Table 2-6). They include multicomponent Site 48CA268

Table 2-6b. Recorded Sites Within or near Uranerz Energy Corporation's Jane Dough Unit.

Site No.	Time Period[1]	Site Type	NRHP Eligibility Status [2]	Legal Location
48CA1568/48JO2292	H	Deadwood Road	E/WSHPO	Sections 27, 28, 29, 30, 31, 33, and 34, T43N, R76W
48CA5393	P	Lithic scatter	NE/WSHPO	Section 20, T43N, R76W
48CA5394	H	Trash scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5395	P	Lithic scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5396	P	Lithic scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5397	P	Lithic scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5398	H	Oil/gas wellfield	NE/WSHPO	Section 21, T43N, R76W
48CA5399	P	Lithic scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5400	P	Lithic scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5401	P	Lithic scatter	NE/WSHPO	Section 21, T43N, R76W
48CA5412	P	Lithic scatter	NE/WSHPO	Section 28, T43N, R76W
48CA6583	H	Trash scatter	NE/WSHPO	Section 27, T43N, R76W
48JO134	H	Bozeman Trail	E/WSHPO	Sections 30 and 31, T43N, R76W
48JO3452	P	Lithic scatter	NE/WSHPO	Section 32, T43N, R76W

1 **H = historic; P = prehistoric.**
2 **E = eligible; E/WSHPO = eligible with WSHPO concurrence; NE = not eligible; NE/WSHPO = not eligible with WSHPO concurrence; U/WSHPO = unevaluated with WSHPO concurrence.**

(Pumpkin Buttes TCP), which occurs within and adjacent to the east side of the Hank Unit (Exhibit 2-1). Of the 22 sites within the Jane Dough Unit, two sites are eligible for the NRHP (see Table 2-6b and Exhibit 2-1A).

Project Effects to Cultural Resource Sites within the Nichols Ranch Unit

There are three NRHP-eligible cultural resource sites within the Nichols Ranch Unit and there will be no adverse effects to any of the three NRHP-eligible cultural resources (Sites 48JO2946, 48CA5390, and 48CA5391). Uranerz will avoid these sites during ground disturbing activities and there will be no adverse effects to any of these sites. To provide further protection to the two eligible sites that are located within or near the projected wellfield (specifically sites 48JO2944

and 48CA5391), Uranerz will delineate and fence around these sites. The fencing will protect these sites from inadvertent disturbance while allowing livestock and wildlife to move freely in, out, and through the site.

In addition, the Nichols Unit will not adversely affect the setting, feeling, and association of Site 48CA268 because it occurs almost 5.0 mi west of the Pumpkin Buttes TCP (see Exhibit 2-1). The Programmatic Agreement prepared for this site has determined that only ground disturbing activities within 2.0 mi of the appropriate base elevations of Site 48CA268 will have an adverse effect to the contributing setting surrounding the TCP. Therefore, project-related activities in the Nichols Ranch Unit will not have an adverse effect to Site 48CA268.

Project Effects to Cultural Resources within the Hank Unit

There are eight NRHP-eligible cultural resource sites within the Nichols Ranch Unit and there will be no adverse effects to any of the eight NRHP-eligible cultural resources (Sites 48CA268, 48CA6475, 48CA6490, 48CA6748, 48CA6751, 48CA6753, 48CA6754, and 48CA6927). Uranerz will avoid these sites during ground disturbing activities and there will be no adverse effects to any of these sites. **To provide further protection to the two eligible sites that are located within the projected wellfield (specifically sites 48CA6754 and 48CA6727), Uranerz will delineate and fence around these sites. The will protect these sites from inadvertent disturbance while allowing livestock and wildlife to move freely in, out, and through the site.**

Additionally, Uranerz will comply with the mitigation measures stipulated in the 2009 Programmatic Agreement for in-situ uranium operations for the Pumpkin Butte TCP. Detailed information concerning specific mitigation measures is presented in Section MP 3.16. Therefore, there will be no adverse effect to the Pumpkin Butte TCP (Site 48CA268) from project-related activities in the Hank Unit. Table 2-6c summarizes the NRHP eligibility and project effect to the eight NRHP-eligible sites.

Table 2-6c NRHP-eligible Sites within the Hank Unit.

Site Number	Time Period	NRHP Eligibility	Project Effects
48CA268	Prehistoric/Historic	Eligible	No adverse effect with avoidance
48CA6475	Prehistoric	Eligible	No adverse effect with avoidance
48CA6490	Prehistoric	Eligible	No adverse effect with avoidance
48CA6748	Prehistoric	Eligible	No adverse effect with avoidance
48CA6751	Prehistoric	Eligible	No adverse effect with avoidance
48CA6753	Prehistoric	Eligible	No adverse effect with avoidance
48CA6754	Prehistoric	Eligible	No adverse effect with avoidance
48CA6927	Prehistoric	Eligible	No adverse effect with avoidance

Project Effects to Cultural Resources within the Jane Dough Unit

The results of the current and previously conducted Class III inventories indicate that 14 sites and two IRs are located within the project area for Uranerz's Jane Dough Unit (Table 2-6d). The 14 sites consist of two sites that are eligible for listing on the NRHP and 12 that are ineligible. There will be no effect to the 12 ineligible sites and the two IRs because of their NRHP eligibility, and no further work is recommended for those cultural resources. A discussion of the project effects and management recommendations for the two NRHP-eligible sites is provided below.

Two segments of the NRHP-eligible Bozeman Trail (Site 48JO134-Segments 65 and 66) and four segments of the NRHP-eligible Deadwood Road (Site 48CA1568-Segment 31 and Site 48JO2292-Segments 14, 15, and 16) were revisited or recorded within the project area in 2010. One of the two Bozeman Trail segments (Site 48JO134-Segment 65) and three of the four segments of the Deadwood Road (Site 48CA1568-Segment 31 and Site 48JO2292-Segments 14 and 15) are recommended as noncontributing segments. There would be no adverse effect to these segments because of their NRHP eligibility, and no further work is recommended.

The remaining segments of the Deadwood Road (48JO2292-Segment 16) and the Bozeman Trail (48JO134-Segment 66) are both recommended as contributing to their sites' overall eligibilities. While the two segments are both located outside the proposed wellfield, they could be potentially disturbed by other project-related activities. However, the project

Table 2-6d Summary of Project Effects and Management Recommendations for Sites Within the Jane Dough Unit.

Site No.	Site Type	Current NRHP Eligibility Recommendation	Project Effects and Management Recommendations
Eligible Sites			
48JO134-Segment 65	Bozeman Trail-Segment 65	Eligible-Noncontributing	No adverse effect
48JO134-Segment 66	Bozeman Trail-Segment 66	Eligible-Contributing	No adverse effect with physical avoidance; no adverse visual effects
48JO2292-Segment 14[1]	Deadwood Road-Segment 14	Eligible-Noncontributing	No adverse effect
48JO2292-Segment 15[1]	Deadwood Road-Segment 15	Eligible-Noncontributing	No adverse effect
48JO2292-Segment 16[1]	Deadwood Road-Segment 16	Eligible-Contributing	No adverse effect with physical avoidance; no adverse visual effects
48CA1568-Segment 31[1]	Deadwood Road-Segment 31	Eligible-Noncontributing	No adverse effect
Not Eligible Sites			
48CA5393	Lithic scatter	Not eligible	No effect
48CA5394	Trash scatter	Not eligible	No effect
48CA5395	Lithic scatter	Not eligible	No effect
48CA5396	Lithic scatter	Not eligible	No effect
48CA5397	Lithic scatter	Not eligible	No effect
48CA5398	Oil/gas well field	Not eligible	No effect
48CA5399	Lithic scatter	Not eligible	No effect
48CA5400	Lithic scatter	Not eligible	No effect
48CA5401	Lithic scatter	Not eligible	No effect
48CA5412	Lithic scatter	Not eligible	No effect
48CA6583	Trash scatter	Not eligible	No effect
48JO3452	Lithic scatter	Not eligible	No effect
Isolated Resources			
IR-1	Lithic scatter	Not eligible	No effect
IR-2	Biface	Not eligible	No effect

1 Site 48CA1568 and 48JO2292 (Deadwood Road) are treated as one historic site.

would have no adverse physical effect on either segment because Uranerz will avoid direct ground-disturbing activities to the segments. Furthermore, there would be no adverse visual effects to either segment because the integrity of the setting has been significantly compromised and no longer contributes to either segment's overall eligibility status.

In addition, Uranerz activities would not significantly impact the viewshed of any NRHP-eligible sites (e.g., Bozeman Trail and Deadwood Road segments); located outside the Jane Dough Unit project area because the proposed disturbances are consistent with the existing widespread visual disturbances associated with ongoing CBM, and conventional oil and gas development and ISR development on the surrounding landscape.

Uranerz would not conduct any ground-disturbing work within the boundaries of Sites 48JO134-Segment 66 or 48JO2292-Segment 16. In addition, Uranerz would not conduct any ground-disturbing work in areas that have not been previously inventoried and cleared for cultural resources.

2.4.3 Paleontological Resources

2.4.3.1 Nichols Ranch and Hank Units

A paleontological survey was conducted for the Nichols Ranch ISR Project. From the survey performed, the Nichols Ranch ISR Project was concluded to have no major impact to significant fossil remains because of the geology and poor exposures of fossil bearing sediments. One recommendation from the survey is to have a monitor present to oversee any major ground-disturbing events when more than a few feet of surface are removed. Uranerz Energy Corporation will comply with this recommendation when conducting any construction that will involve the removal of several feet of soil. Additionally, if any fossil remains are found during any construction activities, Uranerz Energy Corporation will immediately contact the appropriate state and federal agencies.

The complete paleontological survey for the Nichols Ranch and Hank Units is attached as Addendum 2C.

2.4.3.2 Jane Dough Unit

A paleontological survey was conducted for the Jane Dough Unit. The survey did not produce any vertebrate fossil bearing strata and no vertebrate fossils were discovered. However, some limited invertebrate fossils (e.g., clams and mollusks) were discovered, these resources were located on private lands and are not scientifically important. The results of the survey indicate that the Jane Dough Unit will not have any impact to significant fossil

remains because of the geology and poor exposures of fossil bearing sediments. One recommendation from the survey is to have a paleontological monitor present to oversee any major ground disturbing events when more than a few feet of surface are removed.

The complete paleontological survey for the Jane Dough Unit is attached as Addendum 2D.

2.4.4 Cultural Resource Mitigation

Uranerz Energy Corporation will comply with the following cultural resource mitigation measures.

1. Uranerz will not conduct any ground disturbing work in areas that have not been previously inventoried and cleared for cultural resources.

2. Uranerz will protect all cultural properties that have been determined eligible to the National Register of Historic Places within the permit area from ground disturbing activities until appropriate cultural resource mitigation measures can be implemented as part of an approved mining and reclamation plan unless modified by mutual agreement in consultation with the SHPO and other regulatory agencies.

3. To protect a previously identified traditional cultural property, Uranerz will also not conduct any ground disturbing activities above the 5,500 foot elevation within the Hank Unit.

4. If cultural resources are discovered during operations, Uranerz will immediately stop ground disturbing activities in the area of the discovery and will immediately notify the NRC, WDEQ-LQD, the BLM (if the resources are located on BLM-administered lands), the SHPO, and any other appropriate regulatory agency.

2.4.5 Scenic Resources

2.4.5.1 Nichols Ranch and Hank Units

Because the Nichols Ranch ISR Project is located almost entirely on private land in a remote location, the operations aesthetic impact is limited to only the landowner and those that have

permission to be on the landowner's property. The 280 acres of BLM land near the Hank Unit is landlocked by private land limiting access to the land.

The Nichols Ranch Unit will be the site for central processing facility (CPP) along with an office building and a maintenance building. The plant and buildings would be the prominent features of the landscape since the area where they are to be located is mostly flat with little to no other cover. Even though the plant and buildings will stand out, their existence will not be seen by the public.

The Hank Unit will be the site of a satellite plant along with one maintenance building. These facilities will sit to the west of the Pumpkin Buttes on private land. Several oil/gas wells exist in the region, so the Hank Unit satellite plant will not be the only prominent feature in the area. Several transmission towers are completed outside of the Hank Unit permit boundary on top of South Middle Butte. Additionally coal bed methane development has and will take place in the Hank Unit area. Coal bed methane well houses will be present in the area. The Hank Unit will not be visible from the main T-Chair Livestock Company ranch road, but will be visible from the top of the Pumpkin Buttes. The Pumpkin Buttes have been recognized as a potential Traditional Cultural Property (TCP) by the Bureau of Land Management (BLM). Visual concerns from coal bed methane development and coal bed methane development in general were addressed in Environmental Assessments for Anadarko Petroleum Corporation Dry Willow Phase I and Dry Willow Phase II. These environmental assessments detail the agreement that was reached between the Bureau of Land Management and Anadarko Petroleum Corporation in regards to what mitigation steps would be taken to minimize the visual effects of coal bed methane in regards to the Pumpkin Buttes as a potential TCP. The main concerns that were voiced were to avoid development on the tops and sides of the Pumpkin Buttes, bury pipelines, power lines, etc, and to paint structures so that they will blend into the natural landscape. Uranerz Energy Corporation plans on doing these measures for both the Hank and Nichols Ranch plant sites. Pipelines running to and from the wellfield to the plants will be buried not only to mitigate a visual impact, but for freeze protection of the pipelines. No extraction activities will take place on top of North and South Middle Butte, and buildings, well head covers, and header houses will be painted a color that will allow the structures to blend in with the existing landscape. The

following is an excerpt from the Dry Willow Phase II Environmental Assessment on the visual resource impact regarding the coal bed methane development in the same area that the Nichols Ranch ISR Project will take place in. Much of what is observed will be the same for the proposed Nichols Ranch ISR Project with the exception that the Hank Unit will sit at the base of North and South Middle Buttes. The Nichols Ranch Unit central processing plant will be located approximately 6.0 mi to the west of the Buttes.

> "Recently constructed oil and gas related facilities are visible from the base of the Buttes to approximately 15 miles westward. Modern visual distractions include conventional gas and oil wells, well pads, pump jacks, access roads (both crowned and ditched and two track), pipeline scars, reservoirs, fence lines, power lines, a large water storage facility, uranium mine facilities, ranch buildings and dust from vehicle traffic. The setting of the Pumpkin Buttes as they face the project area is nearly dominated by modern visual distractions.
>
> As excerpted from *Pumpkin Buttes Visual Assessment* by Gary D. Long, Outdoor Recreation Planner for the Wyoming BLM State Office:
>
>> Roads and Trails: Roads were readily visible at distances up to five miles. Roads were most visible where located in darker, sagebrush-dominated landscapes. This was because of the contrast created by a light colored linear feature in a dark colored landscape that was devoid of similar natural linear features.
>>
>> Coal Bed Natural Gas Development (CBM): While this could be seen, the structures associated with CBM are not readily seen at distances over one mile. What is seen are the roads and well site locations, particularly when cleared in sagebrush-dominated landscapes.
>>
>> Reservoirs: Reservoirs were readily seen at distances equal to or exceeding two miles.
>>
>> Power Lines: Several single pole power lines were noted. They could be seen but at distances exceeding a mile would not attract the attention of the casual observer.
>
> A few proposed wells and accesses are within 2 and 1/2 miles of North Middle and South Middle Buttes. The project area can be viewed from all the Buttes. At distances over two miles, the frost boxes associated with CBM wells will be painted to blend into the background and will not be visible. All major access roads (crowned and ditched roads) associated with the project are already constructed and are visible from the Buttes. Construction of pipelines

and parallel two track roads accessing wells are over two miles away, will re-vegetate and will not be visible from the Buttes. There is very little sage in the project area (mostly grass) and the construction and reclamation of new accesses or pipelines will not create a vegetation contrast. There are not any reservoirs or other large production related facilities associated with the project. The majority of the power lines associated with the project will be buried.

Overhead lines associated with the project will be well over 2 miles from the buttes. It does not appear that the construction of the Dry Willow II POD will add visual distractions to the setting of Pumpkin Buttes, especially considering the existing developments that attract the viewers' attention. Additionally, the setting of the buttes is nearly compromised by modern oil and gas related activities. Construction of the project will result in "no effect" to Pumpkin Buttes (48CA268)."

2.4.5.2 Jane Dough Unit

The Jane Dough Unit is located in southwest portion of the Powder River Basin in northeast Wyoming (Knight 1994). The project area is unit located west and southwest of the North Middle Butte in the Pumpkin Butte area. The Jane Dough Unit is located approximately 6.0 mi west of South Butte Unit on the border between Johnson and Campbell Counties. Topography in this area is relatively flat with gently rolling hills and low ridges that drain north toward Cottonwood Creek (an intermittent stream) that is located outside of the unit and the remaining portion of the Jane Dough Unit drains southwest toward Seventeenmile Creek which cuts through a small portion of the Jane Dough Unit. Elevations in the Nichols Ranch Unit range from 4,670 to 4,960 ft AMSL. Exhibit ER3-1 (see map pocket) of the Jane Dough Environmental Report depicts the Jane Dough Unit from an aerial view.

The Jane Dough Unit encompasses approximately 3,680 acres and surface ownership is completely privately-owned. The two closest residences are the Dry Fork Ranch and Rolling Pin Ranch. The Dry Fork Ranch is located approximately 1 mile to the west of the northwest corner of the Jane Dough Unit and the Rolling Pin Ranch is located is located approximately 1.0 mile east of the eastern boundary Jane Dough Unit (refer to Figure JD-D11-1 in Appendix JD-D11).

Because the Jane Dough Unit is located entirely on private land in a remote location, the operations aesthetic impact is limited to only the landowner and those that have permission to be on the landowner's property. In addition, there are no visually sensitive areas within 4.0 miles of the Jane Dough Unit.

CBM and conventional oil and gas well are present in the Jane Dough Unit and surrounding area. There are no sensitive visual resources within 4.0 miles of the Jane Dough Unit and the visually sensitive Pumpkin Buttes area is more than 4.0 miles away. Therefore, the Jane Dough Unit would have no visual impacts on the surrounding area.

2.5 METEOROLOGY

2.5.1 Introduction

The Nichols Ranch ISR Project area is located in northeastern Wyoming, where the climate is generally classified as having relatively low annual precipitation (10-20 inches per year) but it is sufficient for the growth of short sparse grass. This climate is due in part to the effective barrier to moisture from the Pacific Ocean offered by numerous mountain ranges that run primarily north and south throughout the state, perpendicular to the prevailing west winds. The topography in this portion of Wyoming tends to restrict the passage of storms and thereby restricts precipitation in eastern Wyoming (Curtis and Grimes 2004).

Uranerz installed a meteorological station at the central processing plant within the adjacent Nichols Ranch Unit. This meteorological station became operational in July 2011 and data for temperature, wind speed and wind direction have been collected, analyzed, and is presented in Appendix JD-D4. Meteorological data has also been collected from the seven meteorological stations that surround the project area (between 25 and 62 mi) (Table 2-7 and Figure 2-7). These seven met stations encompass all existing met stations within 62 mi of the Nichols Ranch ISR Project area. Six of the stations are operated by the National Weather Service (NWS) and one station is operated by a private firm (Intermountain Laboratory (IML). The Antelope Coal Company Mine (Antelope) met station is operated and maintained in accordance

Table 2-7 Meteorological Stations Included in Climate Analysis.

Weather Station (ID Number)	Data Collected By	Distance from Nichols Ranch ISR Project Area (miles)	Direction from Nichols Ranch ISR Project Area (compass)	Elevation (ft above sea level)	Meteorological Parameters Used in this Report	Period of Records [2]
Antelope [3]	IML	48.5	ESE	4,675	Wind, temperature, precipitation	1987-2007
Buffalo (481165) [1]	NWS	58	NW	4,670	Wind, temperature, precipitation	1899-2007
Casper (481570) [1&4]	NWS	60	SSW	5,338	Wind, temperature, precipitation, humidity, evaporation	1948-2007
Dull Center 1 SE (482725) [1]	NWS	54	ESE	4,415	Temperature, precipitation	1926-2007
Gillette 9 ESE (483855) [1]	NWS	46.5	NNW	4,640	Wind, temperature, precipitation	1902-2006
Glenrock 5 ESE (483950) [1]	NWS	62	S	4,948	Temperature, precipitation	1941-2006
Midwest (486195) [1]	NWS	25	SW	4,860	Temperature, precipitation	1939-2006

1 Data was obtained from the western Regional Climate Center website http://www.wrcc.dri.edu/summary/Climsmwy.html. Temperature is measured 2 m Above Ground Level (AGL) anemometers are 20 ft AGL and precipitation is collected 2-3 ft AGL.

2 The period of record indicates the beginning and ending dates for which the station was open. IMPORTANT: The availability of data from any given station is not directly related to the period of record. Many stations do not provide data to NCDC. To determine what data is available for a given station, please check the station's Data Inventories. Please contact NCDC if confirmation of data availability is needed.

3 IML = Inter-Mountain Labs Temperature is measured 3 m AGL and anemometers are 10 m AGL.

4 Data was obtained Wyoming Climate Atlas Curtis and Grimes 2004.

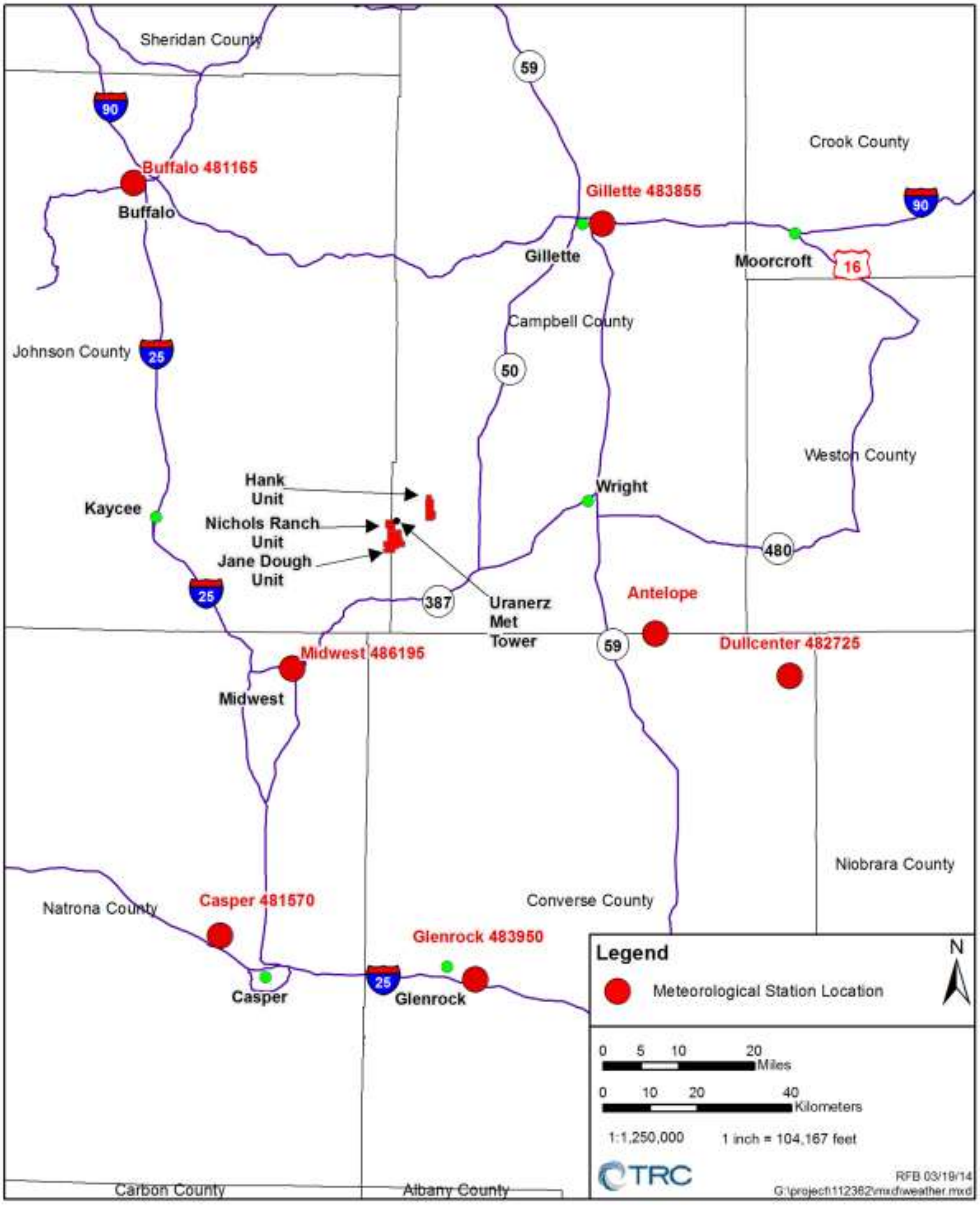


Figure 2-7 Location of Regional Meteorological Stations.

an air quality permit issued by the Wyoming Department of Environmental Quality/Air Quality Division and has been in operation since 1987. Data recovery for the Antelope met station is greater than 90% for all parameters. The NWS stations were selected because they are the closest meteorological stations to the Nichols Ranch ISR Project area and will be used to provide regional and local weather information that is relevant to the Nichols Ranch ISR Project area.

All of the selected meteorological weather stations provide temperature and precipitation data. Only the Casper, Antelope, Gillette, and Buffalo met stations provide wind data and only the Casper met station reports relative humidity and evaporation data.

The Antelope met station was chosen as a surrogate met station for the Nichols Ranch ISR Project area based on the meteorological parameters measured (e.g., wind speed and direction, temperature and precipitation), its relatively close proximity to the Nichols Ranch ISR Project area and most importantly its similarity of topography and vegetation to the Nichols Ranch ISR Project area. Specifically, the Nichols Ranch ISR Project area is characterized by rolling hills and it is located in a semi-arid or steppe climate and vegetation types are mainly native grasses with some sagebrush and sparse woody coverage. As documented in Table 2-7 and Figure 2-7, the Antelope met station is located approximately 48.5 mi east-southeast from the Nichols Ranch ISR Project area. The Antelope met station is located on gently rolling hills with native grasses and shrub plant communities (Knight 1994). There are no major topographic or vegetation differences between the meteorological conditions at the Nichols Ranch ISR and the Antelope met station site except for minor differences related to microclimates associated with each location.

The Casper, Gillette, or Buffalo met stations could also be used as the surrogate met station for the Nichols Ranch ISR Project area. However, a review of the physical location of these sites and the data collected from these sites indicated that these met stations would not be the most appropriate surrogate sites as discussed below.

The Casper met station is located approximately 60 miles southwest of the Nichols Ranch ISR project area. The Casper met station is also located approximately 5 miles north of Casper Mountain which is the north extend of the Laramie Mountain Range (Knight 1994). Casper Mountain rises about 2,700 ft above the city of Casper and about 2,500 ft above the elevation of

the Casper met station. While winds at the Casper met station are predominately from the southwest the local weather patterns are likely affected to some degree by Casper Mountain which is a major local topographic feature and would likely result in more microclimate affects compared to those that would be expected at the Nichols Ranch ISR Project area. Therefore, based on the increased distance of the Casper met station to the Nichols Ranch ISR Project area and the microclimatic affects of Casper Mountain it is reasonable to hypothesize that the Antelope met station is a better surrogate met station.

The Gillette and Buffalo met stations are located approximately 46.5 miles north-northwest and 58 miles northwest of the Nichols Ranch ISR Project area, respectively. The wind pattern for these stations generally show a westerly pattern with a relatively strong component from the north that appears to be reflective of a stronger northern influence of Canadian weather systems that push down directly from northern latitudes or from pacific weather systems that move around the Big Horn Mountain Range and then south. Therefore, based on the microclimatic affects of Big Horn Mountain Range on these two met stations it is reasonable to postulate that the Antelope met station would be a better surrogate met station.

The Antelope station offers the most representative data for the generation of the monthly wind roses and seasonal diurnal temperature norms required by the NRC. The NRC also approved use of the Antelope met station for Energy Metals Corporation's Moore Ranch Uranium Project License Application that is located approximately 10 mi south of the Nichols Ranch ISR Project area. The other meteorological stations presented in Table 2-7 will be used in the discussion of regional climatology and meteorology.

Regarding maintenance, inspections, and service of the Antelope met station, it is important to remember that Uranerz did not collect data, operate, or maintain the Antelope met station. As noted above, the Antelope met station is operated and maintained by Intermountain Laboratories in accordance with an air quality permit issued by the Wyoming Department of Environmental Quality/Air Quality Division and has been in operation since 1987. Since this station is mandated

by the Wyoming Department of Environmental Quality/Air Quality Division the Antelope met station is operated and maintained in accordance with the EPAs regulatory modeling application criteria and adheres within a strict set of operating and maintenance guidelines. These system/equipment accuracies and resolutions are generally more stringent than those of National Weather Service systems. In accordance with EPA guidelines, the Antelope met station is audited once every six months and calibrations and repairs are performed on an "as found" basis. It should also be noted that the Wyoming Department of Environmental Quality/Air Quality Division typically has not identified issues or concerns with the collection of data from this station. Had there been any problems with data collection from this met station the Wyoming Department of Environmental Quality/Air Quality Division would have required appropriate corrective action. All calibrations and repairs at this station are performed immediately after they are identified as the EPA minimum data recovery criteria is 75%. As stated in above, data recovery from this site is greater than 90% for all parameters.

2.5.2 Regional Overview

2.5.2.1 Temperature

Regional temperature information was collected from the seven meteorological stations listed in Table 2-8. Regional monthly average, monthly minimum, and monthly maximum temperatures is presented in Figures 2-8, 2-8a, and 2-8b respectively. The region has an average annual temperature between 45-50°F (Curtis and Grimes 2004) (Table 2-9), an average monthly maximum temperature between 85-90°F (which occurs in July), and an average monthly minimum temperature between 10-18°F (that occurs in January) (refer to Figures 2-8a and 2-8b).

Table 2-8 Annual Average Temperature for Select Stations.

Station	Average Annual Temperature (°F)
Antelope	46
Buffalo	46
Casper	45
Dull Center	46
Gillette	45
Glenrock	47
Midwest	46

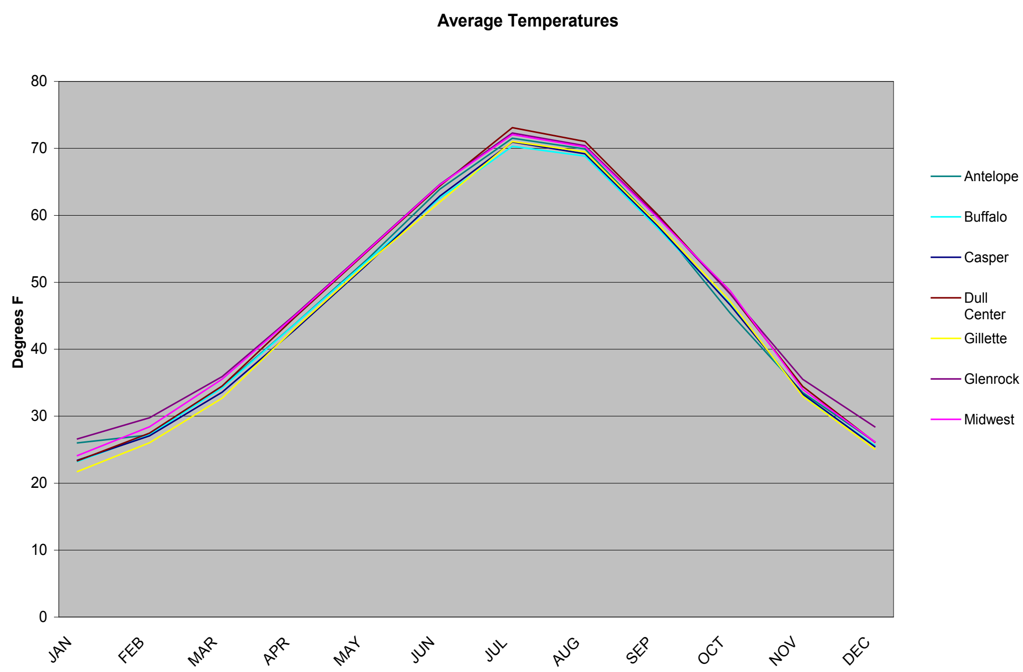


Figure 2-8 Average Monthly Temperatures for Select Meteorological Stations.

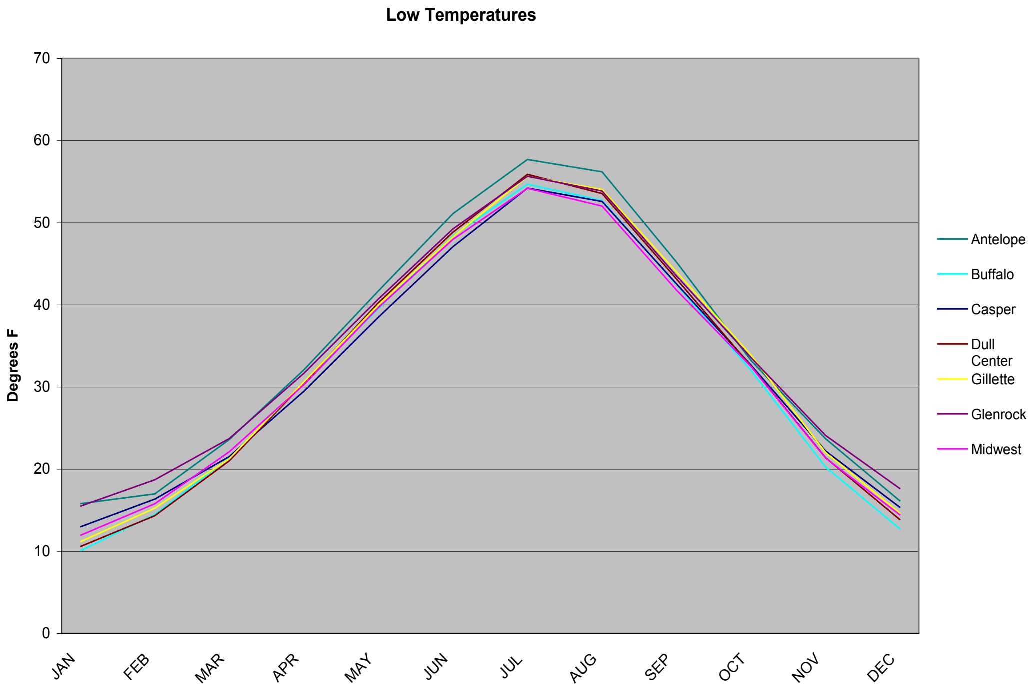


Figure 2-8a Average Monthly Minimum Temperatures for Select Meteorological Stations.

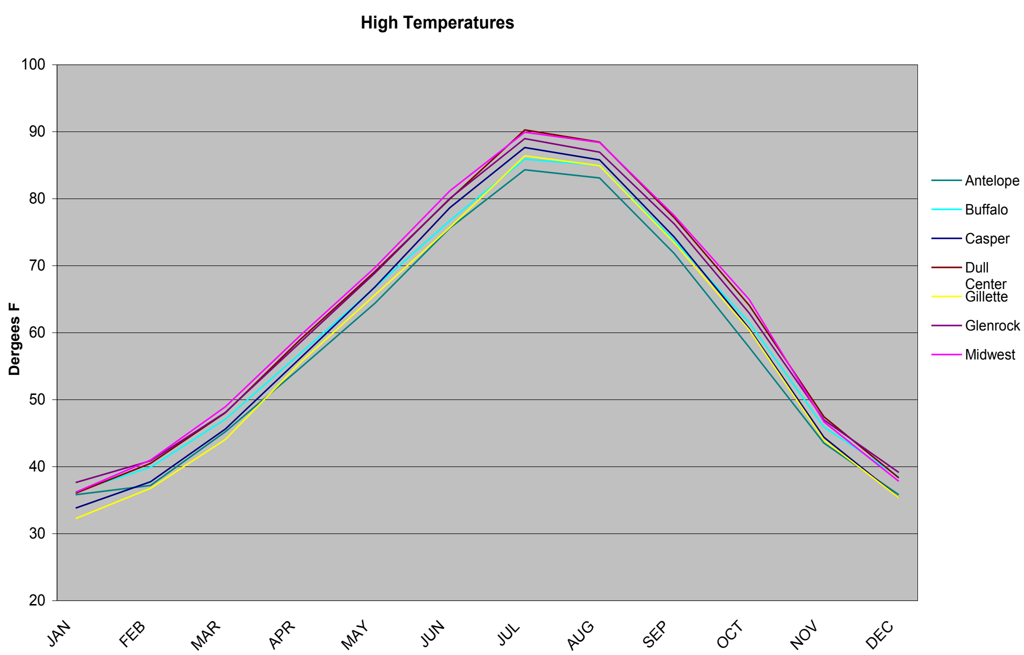


Figure 2-8b Average Monthly Maximum Temperatures for Select Meteorological Stations.

According to Curtis and Grimes (2004) there are approximately 101-120 frost-free days a year in the region, with the number of frost-free days decreasing with increasing elevation. Large diurnal temperature variations are found in the region due in large part, to its altitude and low humidity. Figure 2-8c depicts the seasonal diurnal temperature variations at the Antelope Station (Intermountain Laboratory 2009). As expected summer has the highest average diurnal temperature with winter and spring recording the lowest average diurnal temperatures. The highest daily temperatures occur between 12:00 noon and 6:00 pm local time. The coolest temperatures are in the early morning hours between 4:00 and 6:00 am.

2.5.2.2 Precipitation

The regional near the Nichols Ranch ISR Project area is representative of the high plains in Wyoming and receives an average of 11-15 inches of precipitation per year (Table 2-9) (Curtis and Grimes 2004). Of the seven stations used to report precipitation data, the Gillette Station has the highest annual average precipitation with 15.6 inches per year and the Antelope

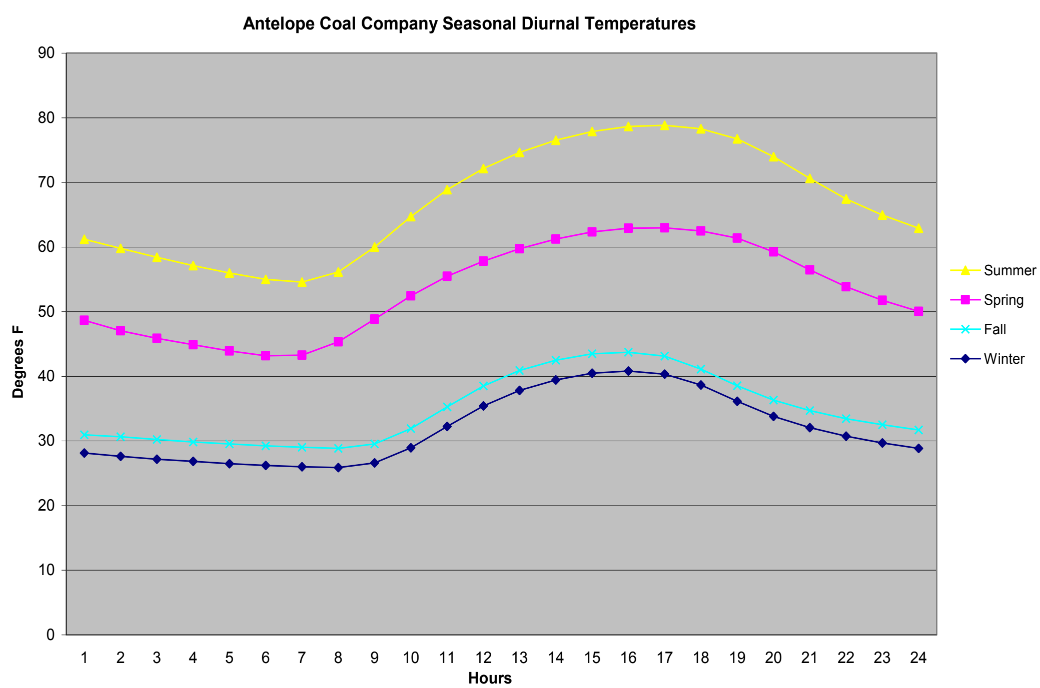


Figure 2-8c Seasonal Diurnal Temperature Variations at the Antelope Station.

Table 2-9 Average Annual Precipitation for Select Stations.

Station	Average Annual Precipitation (In)
Antelope	11.2
Buffalo	13.4
Casper Natrona County Airport	11.9
Dull Center	12.6
Gillette	15.6
Glenrock	12.5
Midwest	12.7

Station had the lowest annual average precipitation of 11.2 inches per year. Monthly average precipitation for the seven stations is presented in Figure 2-9. The average monthly maximum precipitation for all satiations ranges between 0.16 and 2.75 inches per month and the seven meteorological stations show a similar pattern of precipitation. Most precipitation occurs in May or June across the region and the least amount of precipitation occurs in the months of December, January, and February.

Monthly minimum and maximum precipitation for the selection meteorological stations is presented in Figures 2-9a and 2-9b respectively. Minimum precipitation amounts for the select stations are generally less than 0.10 of an inch, with only a few months for a few stations consistently having a minimum of more than 0.20 inches. The maximum monthly precipitation amounts for the select stations are much more variable with a majority of the stations recording a maximum between 1.0 and 8.0 inches per month and documents heavy thunderstorms that are common in the region during the late spring and summer months. Only the Gillette Station has ever recorded monthly maximum precipitation of more than 8.0 inches, and these were 10.0 and 11.0 inches.

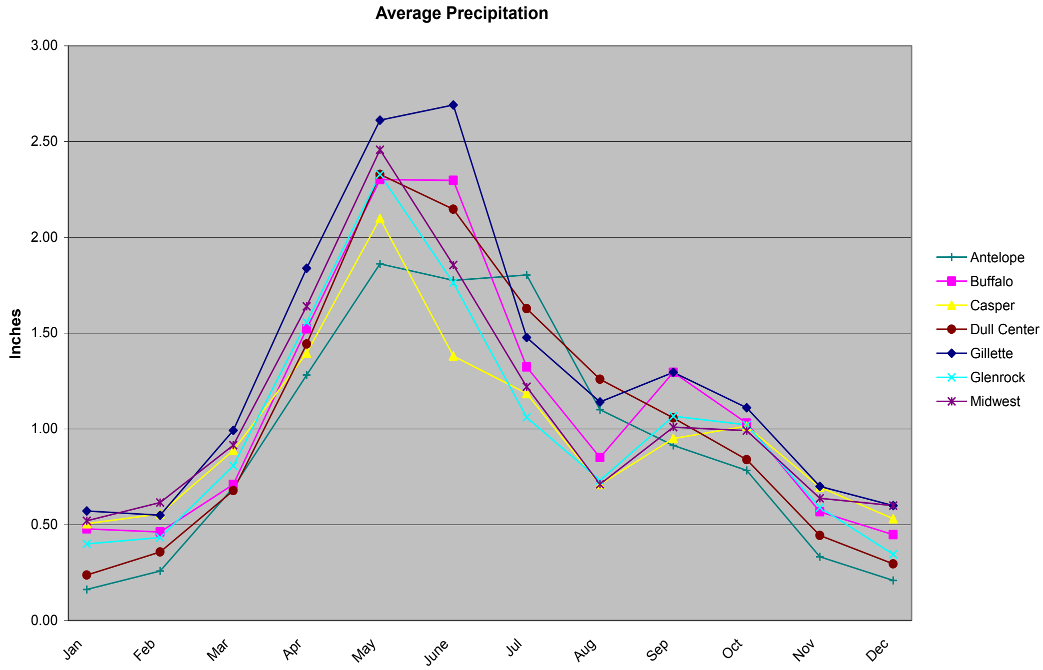


Figure 2-9 Monthly Average Precipitation (in inches) for Select Station.

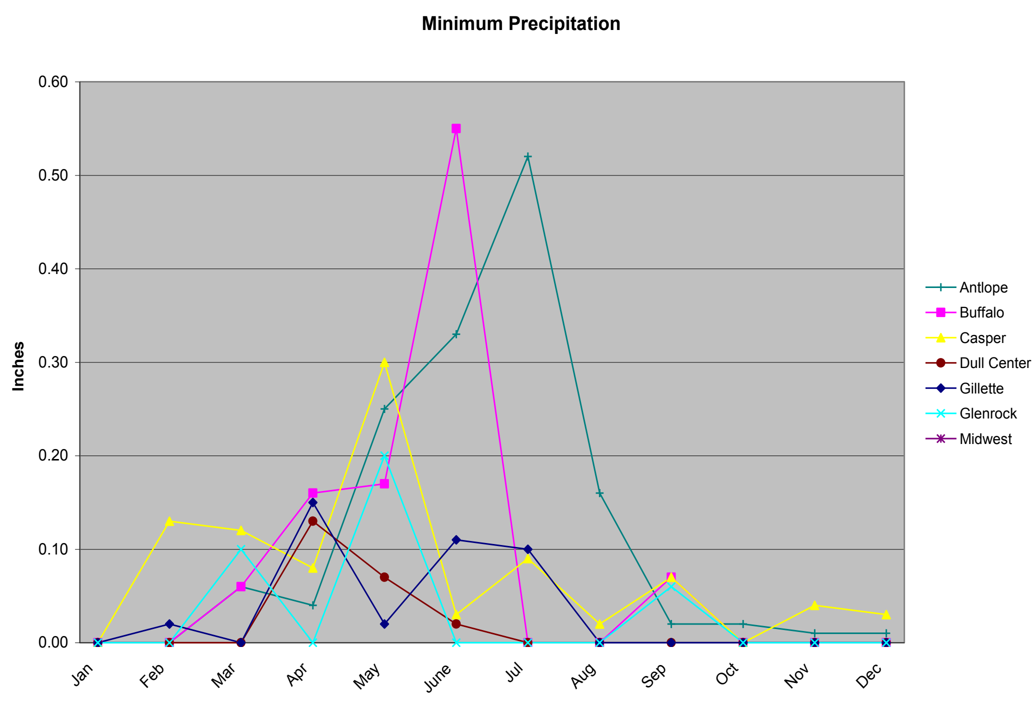


Figure 2-9a Monthly Minimum Precipitation (in inches) for Select Stations.

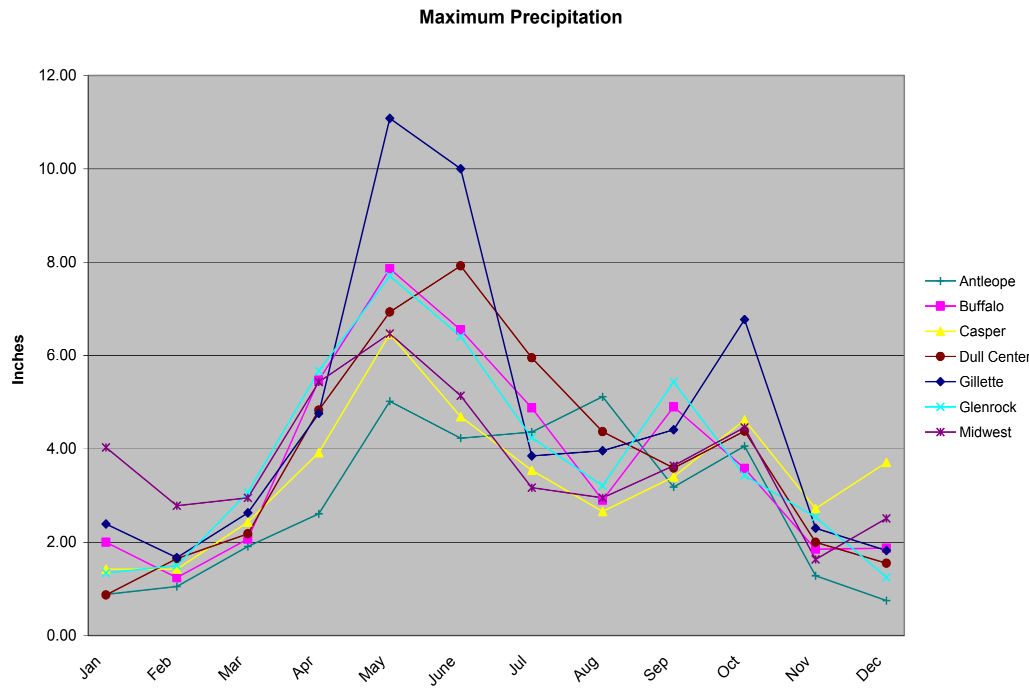


Figure 2-9b Monthly Maximum Precipitation (in inches) for Select Stations.

2.5.2.3 Wind

The entire state of Wyoming is windy and ranks 1st in the US with an annual average wind speed of 12.9 mph. During the winter there are frequent periods when the wind reaches 30 to 40 mph with gusts of 50 or 60 mph (Curtis and Grimes 2004). Of the meteorological stations used in this regional analysis only four stations have any wind data and these are the Antelope, Buffalo, Casper, and Gillette Stations. Both the Antelope Station and the Nichols Ranch ISR project area are located in open rolling hill country and it is closest to the project area. The Antelope Station is located approximately 48 mi southeast of the Nichols Ranch ISR project area and is slightly lower than the Nichols Ranch ISR project area. The Antelope Station is located at an elevation of 4,675 ft above mean sea level (AMSL) and the elevation within the Hank Unit ranges from 5,055 to 5,860 ft AMSL and the elevation within the Nichols Ranch Unit ranges 4,670 to 4,920 ft AMSL. Wind data from the Antelope meteorological station are reasonably representative of the

climate in the general area and are consequently used as the basis for the following discussion. On-site analysis of wind is more in depth and will be discussed later on.

2.5.2.4 Wind Speed

Based on the Antelope Station, the annual average wind speed is approximately 11 mph and the maximum wind speed averages approximately 47 mph. Based on wind data from the four meteorological stations it appears that the winds are weakest in the pre-dawn hours and strongest in the mid-afternoons, tapering off again as night falls. Wind speeds are highest in the early spring and significantly reduced during winter months (Curtis and Grimes 2004).

2.5.2.5 Wind Direction

Based on the data from the four select stations, the regional wind directions are highly variable and are strongly influenced by local topography and general weather patterns. The wind pattern for the stations located in the northern portion of the region (Buffalo and Gillette) show a general westerly pattern with a relatively strong component from the north. Stations in the central and southern portion of the region (Antelope and Casper) also show a generally westerly pattern with a stronger west-southwestern component.

For the central and southern portion of the region (including where the Nichols Ranch ISR project is located), winter months show wind primarily from 200-230 degrees, roughly south southwest. Then by spring and into summer winds are from the south-southwest early in the day and become more southerly toward evening. By the fall, winds return to a south-southwest pattern for most of the day (Curtis and Grimes 2004).

2.5.2.6 Humidity

Wyoming's annual average relative humidity is quite low and is particularly low in the summer. In the project area, the mean annual relative humidity is between 52% and 60%. However, during the warmer part of the summer days, the humidity across the state can drop to about 25

to 30% and on a few occasions it will be as low as five to 10%. Late at night, when the temperature is lowest, the humidity will generally rise to 65 or 75%. This results in an average diurnal variation of about 40 to 45% during the summer, but in the winter the variation is much less (Curtis & Grimes 2004).

2.5.2.7 Evaporation

Wyoming's low humidity, abundant sunshine, and relentless winds contribute to a high rate of evaporation. Annually, statewide evaporation rates range from 30 to about 50 inches. In the Nichols Ranch ISR project area evaporation is likely 40 to 45 inches annually. Evaporation in Wyoming varies much less on a yearly basis than precipitation. Even extreme variations in annual total evaporation are within 25 percent of the long term annual average (Curtis and Grimes 2004).

2.5.2.8 Severe Weather

Information on severe weather in the region of interest is not available; however, severe weather in Wyoming is relatively uncommon in part because of the Rocky Mountains' ability to separate and block prevailing air flows from the Gulf of Mexico, north-central North America, and the Pacific Ocean thus minimizing clashes between contrasting air masses that produce severe weather (Curtis and Grimes 2004). Thunderstorms and hailstorms are the most common severe weather events in the state and region and hailstorms are the most destructive type of events. Severe hail (size 0.75 inch or larger) events occur about 29 times a year across the state with the greatest frequency by far occurring over the extreme southeast part of the state. The annual frequency of thunderstorms range from about 30 days per year on its western border; to about 50 days per year in the extreme northeast and southeast corners of the state (Curtis and Grimes 2004).

Tornados are not a common occurrence in the area and "significant" tornados are much rarer. Tornado intensity is measured by the Fujita (F-Scale) and range from the weakest intensity

storms (F0) to the strongest storms (F5). Significant tornadoes are considered to be F2 intensity winds, between 113 and 157 mph or stronger, or if a weaker tornado kills a person. Significant tornadoes occur in about four out of 100 tornadoes in Wyoming (Curtis and Grimes 2004).

2.5.2.9 Mixing Height

Mixing height or inversion height data is limited for the Nichols Ranch ISR project region. The meteorological station at Lander Wyoming reports the only archived mixing height data for the state and it is available at http://www.epa.gov/scram001/mixingheightdata.htm. Mixing height for the state fluctuates widely. The extreme low, one meter and extreme high over 57,900 m were recorded in the same year. The average morning mixing height for the 5-year period at the Lander Station between 1987 and 1991 was 659 m. For the same period, the average afternoon mixing height was 4,074 m.

2.5.3 Site Specific Analysis

2.5.3.1 Temperature

Summer temperatures vary widely across the state of Wyoming, with the typical climate characterized by warm sunny days and cool nights. State record high and low temperatures are 116°F and -66°F, respectively (Curtis and Grimes 2004). Based on 2 years of weather data collected at the Nicholas Ranch meteorological station, the maximum temperature recorded was 100.8°F and the minimum temperature was -9.6°F (Inter-Mountain Labs [IML] 2013). On average, for this region of Wyoming, summer temperatures reach 90°F or above about 48 times per year, while winter temperatures fall to 0°F or below about 18 times per year (Martner 1986). On average, there are 100-125 frost-free days a year in the project area, with the length of frost-free days decreasing with increasing elevation (Martner 1986).

The mean monthly temperatures for the Nichols Ranch ISR Project area based on 2 years of data collected in the project area and are summarized in Table 2-9a.

Figure 2-10 compares monthly average temperature for Year 1, the Baseline Year and Year 2 and the monthly average high and low temperature for both years. Temperatures were similar in Year 1 and 2 with the exception of a cooler spring in 2013 compared to 2012 (IML 2013).

Table 2-9a Mean Monthly Temperatures for Jane Dough Unit[1] (IML 2013).

Month	Daily Mean Temperature (°F)
January	26.9
February	26.7
March	40.2
April	42.4
May	54.3
June	67.5
July	74.3
August	72.7
September	61.9
October	46.5
November	36.1
December	26.4

[1] **Data collected at the Nichols Ranch Meteorological Station.**

2.5.3.2 Precipitation

Precipitation data was not collected at the Nichols Ranch ISR Project area. The nearest precipitation station is the National Weather Service Midwest 1SW weather station, which is located approximately 27 mi southwest of the project area. Average monthly and annual precipitation values for data collected at the Midwest 1SW weather station for the 30-year period 1971-2000 are summarized in Table 2-9b. During this 30-year period, average maximum precipitation occurs during the month of May, and average minimum precipitation occurs during the month of January (Curtis and Grimes 2004). In winter, mean annual snowfall totals are 45-53 inches (Curtis and Grimes 2004). The average number of days with snowfall totals of 1 inch or more is 16 to 26 days for the area, with the highest average monthly snowfall occurring from February to April (Martner 1986).

2.5.3.3 Wind

The entire state of Wyoming is windy and ranks 1st in the US with an annual average wind speed of 12.9 mph. During the winter there are frequent periods when the wind reaches 30 to 40 mph with gusts of 50 or 60 mph (Curtis and Grimes 2004). Detailed on-site information concerning wind speed and direction is presented below.

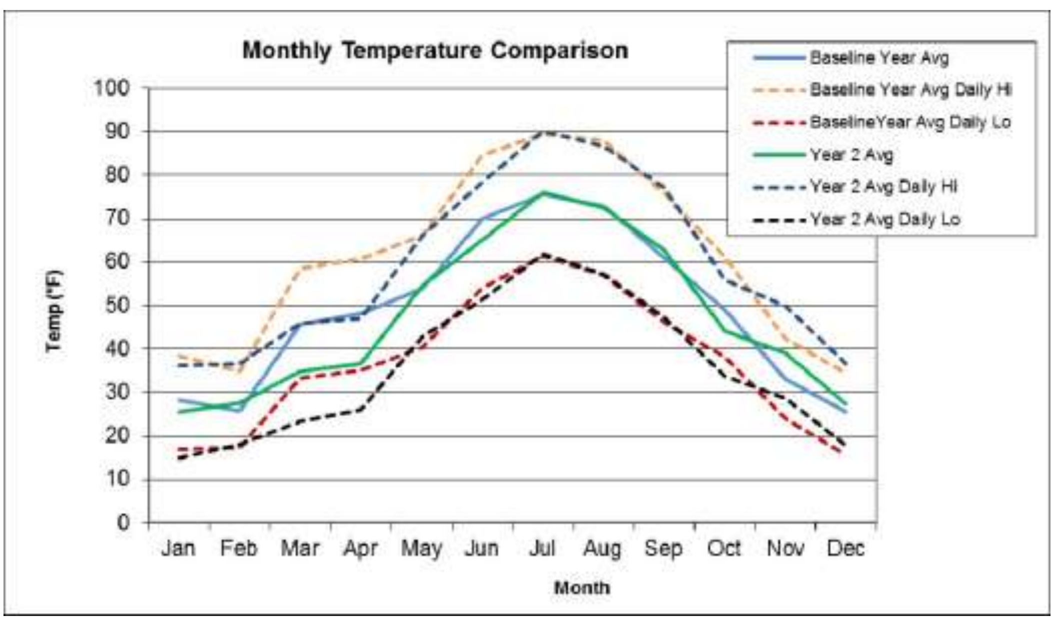


Figure 2-10 Monthly Temperature Comparison, for the Jane Dough Unit.

Table 2-9b Average Precipitation Values[1].

Month	Inches
January	0.54
February	0.61
March	0.95
April	1.71
May	2.55
June	1.95
July	1.35
August	0.72
September	0.86
October	1.13
November	0.69
December	0.70
Annual	13.76

1 Data from the Midwest, Wyoming Meteorological Station (MW1) 1971-2000).

2.5.3.3.1 Wind Speed

Based on 2 years of wind data collected hourly at the Nichols Ranch meteorological station, the average wind speed is 10.6 mph. The highest wind speed collected was 51.3 mph. The weakest winds occur in the mornings and the strongest winds generally occur in early to mid-afternoon. Figure 2-10a provides a monthly comparison between the Baseline Year, Year 1 to Year 2, a second year of data. Figure 2-10b compares the wind roses for the two, 12-month monitoring periods for the baseline year and second year of data collected at the Nichols Ranch ISR Project area meteorological station. The wind roses demonstrate fairly consistent wind speed and direction from year to year.

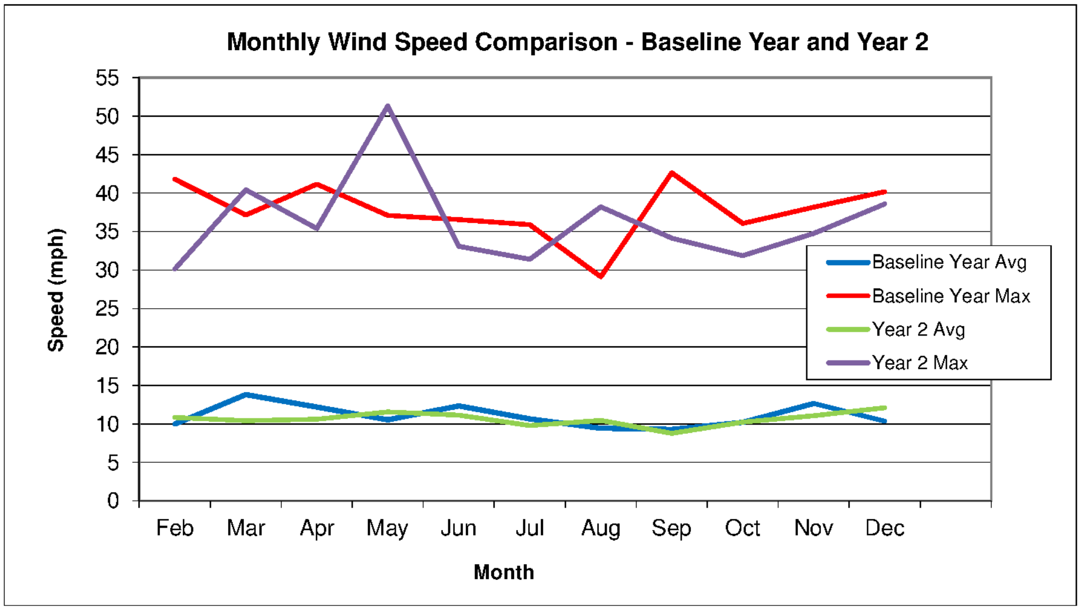
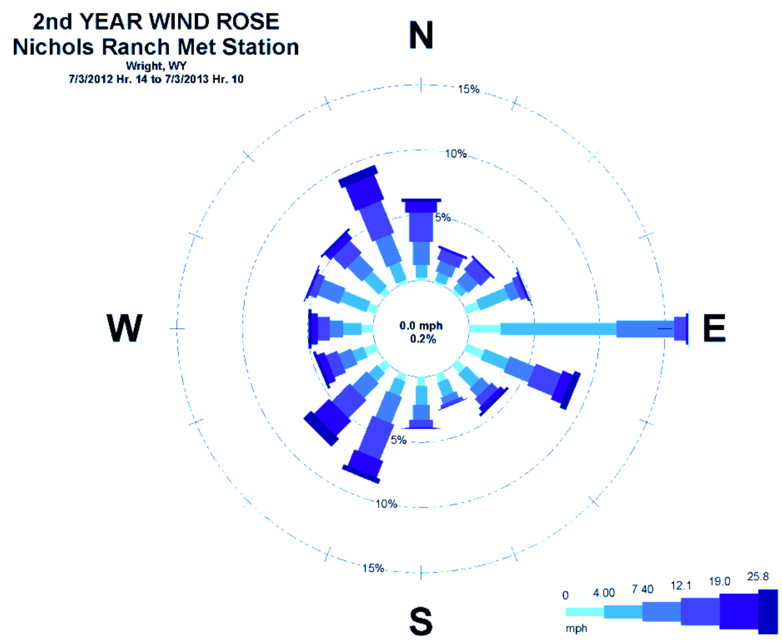


Figure 2-10a Monthly Wind Speed Statistics, Baseline (Year 1) and Year 2 Comparison for the Jane Dough Unit.

2.5.3.3.2 Wind Speed Frequency

The MILDOS-AREA model was used to determine wind speed frequency wind distribution based on 2 years of collected data. The wind speeds were divided into six classifications ranging from mild (zero to three mph) to strong (>24 mph). A seventh classification is denoted as "calm," indicating wind speeds below the instrument threshold (IML 2013).

The percent of the time that winds occur in each of the seven wind speed categories can be represented as a wind speed frequency distribution. Figure 2-10c compares the frequency of occurrence of each of the seven classifications during the Baseline Year and Year 2 at the Nichols Ranch meteorological station. The percent of the time the wind speed falls within each of the seven wind speed classes shown, is quite similar for the two monitoring periods.



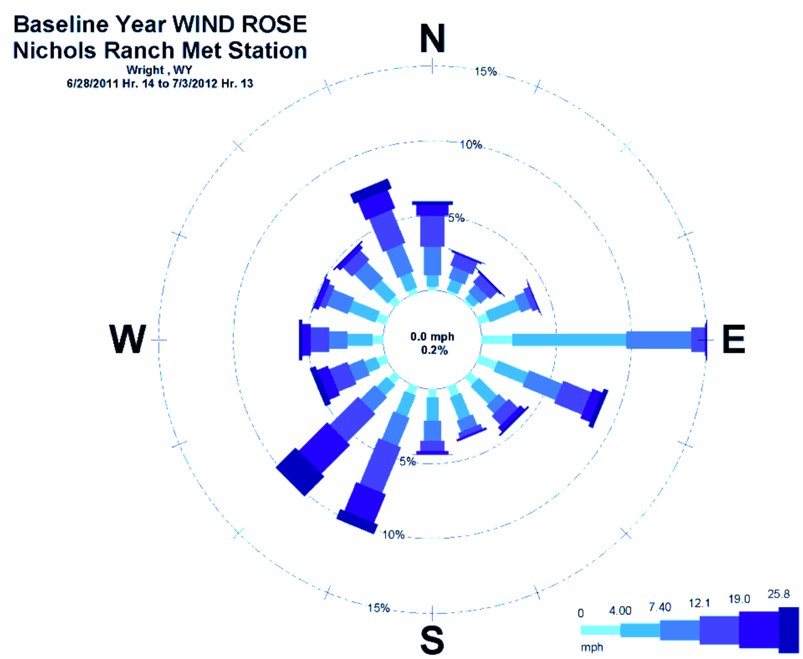


Figure 2-10b Wind Rose Comparison, Baseline (Year 1) and Year 2 for the Jane Dough Unit.

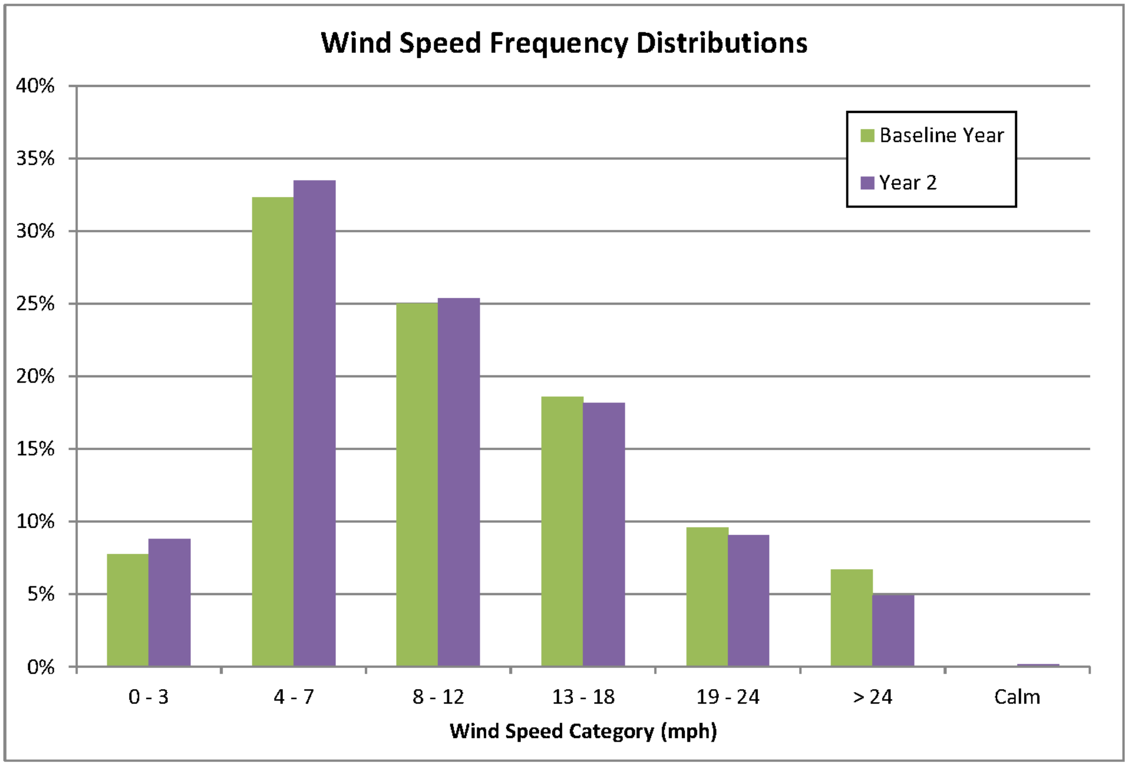


Figure 2-10c Wind Speed Frequency Distributions Year 1 and Year 2 for the Jane Dough Unit.

2.5.3.4 Wind Direction

Predominant wind direction was from the predominately from east accounting for 16.8% of the possible winds (see Figures 2-10b and2-10c) (IML 2013). Wind direction was similar from year to year.

2.5.3.5 Wind Direction Frequency

The MILDOS-AREA model was also used to determine wind direction frequency wind distribution based on 2 years of collected data at the Nichols Ranch meteorological station. Wind directions were divided into 16 categories corresponding to the compass directions illustrated in the wind roses (refer to Figure 2-10b). A 17th category is denoted as "calm," indicating wind speeds below the threshold to move the wind vane. The percent of the time

that winds blow from each of the 17 directions can be represented as a wind direction frequency distribution. Figure 2-10d shows that the percent of the time the wind direction falls within each of the 17 wind direction categories shown, is quite similar for the two monitoring periods (IML 2013).

2.5.3.6 Humidity

Wyoming's annual average relative humidity is quite low and is particularly low in the summer. In the project area, the mean annual relative humidity is between 52% and 60%. However, during the warmer part of the summer days, the humidity across the state can drop to about 25 to30% and on a few occasions it would be as low as five to 10%. Late at night, when the temperature is lowest, the humidity would generally rise to 65 or 75%. This results in an average diurnal variation of about 40 to 45% during the summer, but in the winter the variation is much less (Curtis & Grimes 2004).

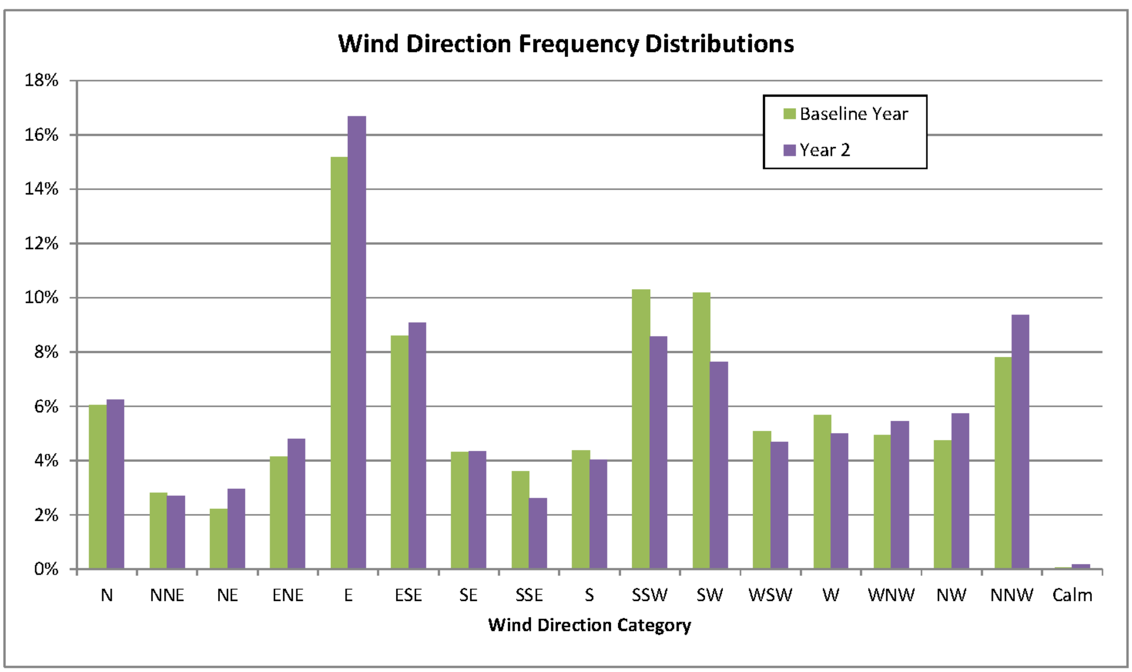


Figure 2-10d Nichols Ranch Wind Direction Frequency Distributions Year 1 and Year 2.

2.5.3.7 Evaporation

Wyoming's low humidity, abundant sunshine, and relentless winds contribute to a high rate of evaporation. Annually, statewide evaporation rates range from 30 to about 50 inches. In the Jane Dough Unit evaporation is likely 40 to 45 inches annually. Evaporation in Wyoming varies much less on a yearly basis than precipitation. Even extreme variations in annual total evaporation are within 25 percent of the long term annual average (Curtis and Grimes 2004).

2.5.3.8 Severe Weather

Information on severe weather in the region of interest is not available; however, severe weather in Wyoming is relatively uncommon in part because of the Rocky Mountains' ability to separate and block prevailing air flows from the Gulf of Mexico, north-central North America, and the Pacific Ocean thus minimizing clashes between contrasting air masses that produce severe weather (Curtis and Grimes 2004). Thunderstorms and hailstorms are the most common severe weather events in the state and region and hailstorms are the most destructive type of events. Severe hail (size 0.75 inch or larger) events occur about 29 times a year across the state with the greatest frequency by far occurring over the extreme southeast part of the state. The annual frequency of thunderstorms range from about 30 days per year on its western border; to about 50 days per year in the extreme northeast and southeast corners of the state (Curtis and Grimes 2004).

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2.5.3.9 Effects of Local Terrain

The following analysis was prepared subsequent to the collection and analysis of two years of wind speed and direction data from the meteorological station located in the Central Processing Plant.

Approximately 6 mi east of **the Jane Dough** and Nichols Ranch Units and immediately adjacent to the Hank Unit is a series of buttes known as Pumpkin Buttes. These buttes rise approximately 1,200 feet above the proposed project area of the **Jane Dough Unit**. The proximity of the Pumpkin Buttes to the Nichols Ranch ISR Project cannot be ignored and likely creates a microclimate on the surrounding area. Considering that the prevailing winds in the area are from the east, the change in elevation is relatively minor, temperature and relative humidity in the region are quite low, topographically generated weather systems are expected to be nominal. However, it is possible that the buttes do produce some microclimatic effects on the local precipitation pattern but these effects would be variable and diverse especially given the variable nature of summer precipitation events.

The along-slope wind systems, while certainly present, are expected to be insignificant since the daytime adabatic or upslope wind has just a few hundred meters to gather strength before reaching the apex of the buttes. Returning katabatic or down slope winds in the evening should also be minimal as winds in the area tend to decrease with nightfall. The potential for mountain-gap wind between North Butte and North Middle Butte exists but is expected to be negligible. First, the narrow dimensions of the buttes do not allow for a buildup of wind speed as would be expected in a true valley situation. Secondly, in general when air stratification is stable, the air flow tends to be from high to low pressure and wind could emerge through a gap as a "jet" known as mountain-gap wind. However, joint frequency distribution data shows stability class F winds, the most stable, to be quite light in the region. Therefore, while the buttes themselves are a striking visual characteristic of the landscape topographically speaking they are of limited magnitude.

2.5.4 Air Quality

2.5.4.1 General

Uranerz submitted a permit application to WDEQ/AQD for the Nichols Ranch and Hank Units and permit CT-8644 was issued. Uranerz will prepare and submit a modification to WDEQ/AQD for the Jane Dough Unit to its existing air quality construction permit (CT-8644). The application will include all required information for construction and operation of the Jane Dough Unit.

2.5.4.2 Impacts due to the Nichols Ranch and Hank Units

Impacts on air quality associated with the operations of the Nichols Ranch ISR Project will be very minimal. Access to the project area will be via 8.5 mi of Campbell County maintained gravel road, then 8.5 mi of gravel ranch roads if accessing the project area from Wyoming Highway 50, or approximately 22.3 mi of gravel ranch roads if accessing the property from U.S. Highway 387. Both the county and ranch roads are currently used by numerous oil/gas and coal bed methane companies that are active in the region. These roads have been developed and range from 18 to 24 ft wide crowned-and-ditch roads. The closest residence to the access route is the Pfister Ranch located approximately less than a 0.25 mi to the west of the route and approximately 0.6 mi to the North of the Hank Unit. With the prevailing wind direction out of the southwest**, dust produced by the mining operations and vehicular traffic will generally be blown to the northeast which should not affect ranching operations.**

Particulate emissions associated with the Nichols Ranch ISR Project will also be minimal. **Of the 7,050 acres within the project area, only approximately 401 acres or less of lands will be disturbed with stripping of topsoil occurring approximately 135 acres or less.** In order to reduce particulate emissions in the wellfield by drilling equipment and wellfield maintenance vehicles, access roads will be maintained via motorized patrol. Natural vegetation will also be left undisturbed whenever possible to prevent wind erosion.

Vehicle traffic entering the Nichols Ranch ISR Project is estimated at eight passenger vehicles per day per week along with six tractor trailers per week. Fugitive dust emissions from this traffic are estimated at approximately 135.9 tons per year using the longer of the two access routes as a basis for the fugitive dust calculations. Wellfield fugitive dust emissions were not considered in calculating the overall fugitive dust emissions since the wellfield is not considered a major source of emissions. Estimated fugitive dust emissions during construction of the facilities of the Nichols Ranch ISR Project were also not included in the fugitive dust emission calculation since the amount of vehicular activity that will be taking place during the construction will be similar to the traffic of the actual operation. Figure 2-11 outlines the methods used to calculate the fugitive dust emissions.

From the above calculations, it is estimated that an emission rate of 135.9 tons per year can be expected for the Nichols Ranch ISR Project. As this is below the 250 tons per year threshold for PSD review, an analysis to determine air quality impact is considered unnecessary.

All other emissions from the Nichols Ranch ISR Project are minimal. Table 2-10 details the other potential operation emissions and their potential emission quantity.

Assumptions:

1. For the purpose of calculating fugitive dust emissions, the well field was not considered a significant emitting source.

2. Estimated daily vehicle traffic includes eight passenger/truck vehicles entering the Nichols Ranch ISR Project. Approximately six tractor trailers will also travel to the permit area per week.

3. Estimated disturbance within the 3370.53 acre Nichols Ranch ISR Project permit area is 300 acres or less.

4. All fugitive dust calculations were based on EPA AP-42 Chapter 13.2.2.

5. Calculation Data Givens:
   Wyoming Unpaved Road Surface Material Surface Silt Content = 4.2% (Source AP-42)
   Access road vehicle speed = 30 mph
   Access road length = 15 mi

Calculations:

Access Road Vehicle Miles per Day

$$\frac{8 \ vehicles}{day} \times 15 \ miles = \frac{120 \ miles}{day}$$

$$\frac{0.86 \ semi's}{day} \times 15 \ miles = \frac{12.9 \ miles}{day}$$

Vehicle Miles per Year

$$Passenger \ Vehicles \Rightarrow \frac{120 \ miles}{day} \times \frac{7 \ days}{week} \times \frac{52 \ weeks}{year} = \frac{43{,}680 \ miles}{year}$$

$$Semi's \Rightarrow \frac{12.9 \ miles}{day} \times \frac{7 \ days}{week} \times \frac{52 \ weeks}{year} = \frac{4{,}695.6 \ miles}{year}$$

Figure 2-11 Fugitive Dust Calculations (1 of 3).

Emissions for Unpaved Roads

$$E = \frac{\left[k\left(\frac{s}{12}\right)^{a}\left(\frac{S}{30}\right)^{b}\right]}{\left(\frac{M}{0.5}\right)^{c}} - C$$

Where:

E = size specific emission factor (lbs/vehicle mile traveled)
s = surface material silt content (%) from AP 42 Tables
W = mean vehicle weight (tons)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor from AP 42 Tables

For PM-10:

k, a, b, and c are constants derived from AP 42 13.2.2
k = 1.5
a = 0.9
b = 0.45
c = N/A or 1

Correcting For Natural Mitigation:

$$E = \left[\frac{\left[k\left(\frac{s}{12}\right)^{a}\left(\frac{S}{30}\right)^{b}\right]}{\left(\frac{M}{0.5}\right)^{c}} - C\right]\left[\frac{(365 - P)}{365}\right]$$

Where: P = number of days in a year with at least 0.01 inches of precipitation from AP 42 charts

Figure 2-11 Fugitive Dust Calculations (2 of 3).

Therefore, using the following inputs:

s = 4.2
a = 0.9
b = 0.45
c = 1
S = 30 mph
M = 0.5
C = 0.0047
P = 100

E = 0.420 lbs/vehicle miles traveled

Total Fugitive Dust Emissions

Total Vehicle Miles Traveled Per Year = 47,375.6 mi per vehicle

9 vehicles total, so

$$\left(9 \text{ vehicles}\right) \times \left(47375.6 \text{ milesper year}\right) \times \left(0.42 \text{ lbs per VMT}\right) = 179{,}079.8 \text{lbs per year or } 89.5 \text{ tons per year}$$

This is below the 250 tons per year standard established for PSD.

From the above calculations, it is estimated that an emission rate of 135.9 tons per year can be expected for the Nichols Ranch ISR Project. As this is below the 250 tons per year threshold for PSD review, an analysis to determine air quality impact is considered unnecessary.

Figure 2-11 Fugitive Dust Calculations (3 of 3).

Table 2-10 Emissions Inventory, Nichols Ranch, Hank and Jane Dough Units.

Emission	Estimated Emission (tons/yr)
CO_2	353.70
HCL	0.017
H_2O_2	0.003
NaOH	0.0003
Fugitive Dust	135.9

2.5.4.3 Impacts due to the Jane Dough Unit

The air quality impacts of the proposed project in the local and regional areas are minimal. The main impact to the air quality would be from fugitive dust that is generated from the construction of facilities, construction and operation of the wellfields, and the increase in traffic from the operation of the proposed project. Fugitive dust releases are estimated to be the same during the construction of the Jane Dough Unit as they are during the operation of the proposed project since the amount of vehicle traffic is expected to be the same. Detailed calculations of the amount of estimated fugitive dust that would be released by the project are presented in Appendix JD-D4). The estimated release of fugitive dust from the proposed project is under the allowable 250 tons per year increment for prevention of significant deterioration of air quality.

The potential for fugitive dust emissions from wind erosion would be minimized by promptly reclaiming disturbed soil and establishing vegetative cover on soil stockpiles. Most of the work associated with wellfield installation would take place with stationary equipment hence any additional fugitive dust releases resulting from vehicular traffic in the wellfield would be small because of low traffic volume.

It is possible that radon gas could be released as result of operations in the wildlife. This gas can be present in the processing solutions and could escape into the atmosphere in several

locations. In order to escape, the dissolved radon gas would first have to be vented in the wellfield from either individual well vents or from the header house.

The radiological effects of radon or any radiological emission upon the local and surrounding area was completed using the NRC MILDOS model for predicting radiological doses. The results of the MILDOS modeling are described in Chapter 7.0, Section 7.3 of the NRC Technical Report. The estimated releases from the Jane Dough Unit are small fractions of the allowable does limit for the general public.

Figure 2-11a outlines the methods used to calculate the fugitive dust emissions.

From these calculations, it is estimated that an annual emission rate of 135.9 tons per year can be expected for the Jane Dough Unit. As this is below the 250 tons per year threshold for PSD review, an analysis to determine air quality impact is considered unnecessary.

All other emissions from the Jane Dough Unit are minimal. Table 2-10a details the other potential operation emissions and their potential emission quantity.

Assumptions:

1. **For the purpose of calculating fugitive dust emissions, the well field was not considered a significant emitting source.**

2. **Estimated daily vehicle traffic includes eight passenger/truck vehicles entering the Nichols Ranch ISR Project. Approximately six tractor trailers will also travel to the permit area per week.**

3. **Estimated disturbance within the 3,680 acre Jane Dough Unit permit area is 101 acres or less.**

4. **All fugitive dust calculations were based on EPA AP-42 Chapter 13.2.2.**

5. **Calculation Data Givens:**
   Wyoming Unpaved Road Surface Material Surface Silt Content = 4.2% (Source AP-42)
   Access road vehicle speed = 30 mph
   Access road length = 15 mi

Calculations:

<u>Access Road Vehicle Miles per Day</u>

$$\frac{8\ vehicles}{day} \times 15\ miles = \frac{120\ miles}{day}$$

$$\frac{0.86\ semi's}{day} \times 15\ miles = \frac{12.9\ miles}{day}$$

<u>Vehicle Miles per Year</u>

$$Passenger\ \ Vehicles \Rightarrow \frac{120\ miles}{day} \times \frac{7\ days}{week} \times \frac{52\ weeks}{year} = \frac{43{,}680\ miles}{year}$$

$$Semi's \Rightarrow \frac{12.9\ miles}{day} \times \frac{7\ days}{week} \times \frac{52\ weeks}{year} = \frac{4{,}695.6\ miles}{year}$$

Figure 2-11a Fugitive Dust Calculations (1 of 3).

Emissions for Unpaved Roads

$$E = \frac{\left[k\left(\frac{s}{12}\right)^{a}\left(\frac{S}{30}\right)^{b}\right]}{\left(\frac{M}{0.5}\right)^{c}} - C$$

Where:

E = size specific emission factor (lbs/vehicle mile traveled)
s = surface material silt content (%) from AP 42 Tables
W = mean vehicle weight (tons)
M = surface material moisture content (%)
S = mean vehicle speed (mph)
C = emission factor from AP 42 Tables

For PM-10:

k, a, b, and c are constants derived from AP 42 13.2.2
k = 1.5
a = 0.9
b = 0.45
c = N/A or 1

Correcting For Natural Mitigation:

$$E = \left[\frac{\left[k\left(\frac{s}{12}\right)^{a}\left(\frac{S}{30}\right)^{b}\right]}{\left(\frac{M}{0.5}\right)^{c}} - C\right]\left[\frac{(365 - P)}{365}\right]$$

Where: P = number of days in a year with at least 0.01 inches of precipitation from AP 42 charts

Figure 2-11a Fugitive Dust Calculations (2 of 3).

Therefore, using the following inputs:

s = 4.2
a = 0.9
b = 0.45
c = 1
S = 30 mph
M = 0.5
C = 0.0047
P = 100

E = 0.420 lbs/vehicle miles traveled

<u>Total Fugitive Dust Emissions</u>

Total Vehicle Miles Traveled Per Year = 47,375.6 mi per vehicle

9 vehicles total, so

$$\left(9 \text{ vehicles}\right) \times \left(47375.6 \text{ milesper year}\right) \times \left(0.42 \text{ lbs per VMT}\right) = 179{,}079.8 \text{lbs per year or } 89.5 \text{ tons per year}$$

This is below the 250 tons per year standard established for PSD.

From the above calculations, it is estimated that an emission rate of 135.9 tons per year can be expected for the Nichols Ranch ISR Project. As this is below the 250 tons per year threshold for PSD review, an analysis to determine air quality impact is considered unnecessary.

Figure 2-11a Fugitive Dust Calculations (3 of 3).

2.6 GEOLOGY AND SEISMOLOGY

2.6.1 Regional Geology

The Nichols Ranch ISR Project is located in the Powder River Basin (PRB) which is a large structural and topographic depression parallel to the Rocky Mountain trend. The basin is bounded on the south by the Hartville Uplift and the Laramie Range, on the east by the Black Hills, and the Big Horn Mountains and the Casper Arch on the west. The Miles City Arch in southeastern Montana forms the northern boundary of the basin.

The PRB is an asymmetrical syncline with its axis closely paralleling the western basin margin. During sedimentary deposition, the structural axis (the line of greatest material accumulation) shifted westward resulting in the basin's asymmetrical shape. On the eastern flank of the PRB, sedimentary rock strata dip gently to the west at approximately 0.5 to 3 degrees. On the western flank, the strata dip more steeply, 0.5 to 15 degrees to the east with the dip increasing as distance increases westward from the axis. The Nichols Ranch ISR Project site location within the PRB is shown in Figure 2-12 (see map pocket), Structural Map of Wyoming.

The PRB hosts a sedimentary rock sequence that has a maximum thickness of about 15,000 ft along the synclinal axis. The sediments range in age from Recent (Holocene) to early Paleozoic

(Cambrian - 500 million to 600 million years ago) and overlie a basement complex of Precambrian-age (more than a billion years old) igneous and metamorphic rocks. Geologically, the PRB is a closed depression in what was, for a long geologic time period, a large basin extending from the Arctic to the Gulf of Mexico. During Paleozoic and Mesozoic time, the configuration of this expansive basin changed as the result of uplift on its margins. By late Tertiary- Paleocene time, marked uplift of inland masses surrounding the Powder River Basin resulted in accelerated subsidence in the southern portion of the basin with thick sequences of arkosic (containing feldspar) sediments being deposited. Arkosic sediments were derived from the granitic cores of the Laramie and Granite Mountains exposed to weathering and erosion by the Laramide uplift. Near the end of Eocene time, northward tilting and deep weathering with minor erosion took place in the basin. Subsidence resumed in the late Oligocene and continued through the Miocene and into the Pliocene. A great thickness of tuffaceous sediments was deposited in the basin during at least a part of this period of subsidence. By the late Pliocene, regional uplift was taking place, leading to a general rise in elevation of several thousand feet. The massive erosion pattern that characterizes much of the PRB began with the Pliocene uplift and continues to the present.

Of particular interest in the project area are the Tertiary-age formations:

Formation	Age (Million Years)
White River (Oligocene)	25-40
Wasatch (Eocene)	40-60
Fort Union (Paleocene)	60-70

The White River Formation is the youngest Tertiary unit that still exists in the PRB. Locally, its only known remnants are found on top of the Pumpkin Buttes. Elsewhere the unit consists of thick sequences of buff colored tuffaceous sediments interspersed with lenses of fine sand and siltstone. A basal conglomerate forms the resistant cap rock on top of the buttes. This formation is not known to contain significant uranium resources in this area.

The Wasatch Formation consists of interbedded mudstones, carbonaceous shales, silty sandstones, and relatively clean sandstones. In the vicinity of the Pumpkin Buttes, the Wasatch Formation is known to be 1,575 ft thick (Sharp and Gibbons, 1964). The interbedded mudstones, siltstones, and relatively clean sandstones in the Wasatch vary in degree of lithification from uncemented to moderately well cemented sandstones, and from weakly compacted and cemented mudstones to fissile shales. The Wasatch contains significant uranium resources and hosts the ore bodies for which this application is subject to.

The Fort Union Formation in the PRB is lithologically similar to the Wasatch Formation. The Fort Union includes interbedded silty claystones, sandy siltstones, relatively clean sandstones, claystones, and coal. The degree of lithification is quite variable, ranging from virtually uncemented sands to moderately well cemented siltstones and sandstones. The total thickness of the Fort Union in this area is approximately 3,000 ft. The Fort Union contains significant uranium mineralization at various locations in the basin. The Fort Union is also the target formation for Coal Bed Methane (CBM) extraction activities. CBM target depths in the Nichols Ranch Unit are about 1,000 ft and 1,200 ft at the Hank Unit. A minimum of 300 ft of primarily mudstones and impermeable shales interspersed with fine-grained sands and siltstones separate the proposed uranium mining from CBM production horizons at both Nichols Ranch and Hank. Since CBM wells have their casings cemented to the surface, no interference, water loss, or water invasion is anticipated.

Maps of the surface and sub-surface geology of the Powder River Basin are depicted in Exhibits 5a and 5b (see map pockets) of Appendix D5 in Volume V.

2.6.2 Site Geology

2.6.2.1 Nichols Ranch and Hank Units

The Nichols Ranch Unit site is located in the Eocene Wasatch Formation about eight miles west of the South Pumpkin Butte and straddles the Johnson and Campbell County lines. The mineralized sand horizons are in the lower part of the Wasatch, at an approximate average depth of 550 ft. The host sands are primarily arkosic in composition, friable, and contain trace amounts of carbonaceous material and organic debris. There are locally sandy mudstone/siltstone intervals within the sands and the sands may thicken or thin to the point of removal in some areas.

The Hank Unit site is also located in the Eocene Wasatch Formation about five miles east-northeast of the Nichols Ranch Unit central processing plant in Campbell County. The mineralized sand horizons are in the lower part of the Wasatch, at an approximate average depth of 365 ft. The host sands are similar in composition and material make-up to those found at Nichols Ranch.

There are three primary Wasatch Formation sand members in the Nichols Ranch Unit and one minor sand unit. The sand members have been identified as F, B, and A Sands and the 1 (one) Sand unit. The F Sand member is the shallowest and the 1 Sand unit is the deepest. The principle uranium ore zone sand member is the A Sand and is 60 to 100 ft thick. Within the Nichols Ranch Unit, all the sands have separating aquicludes.

There are four primary Wasatch Formation sand members at the Hank Unit and two minor sand units. The sand members have been identified as F, C, B, and A Sands and the G and H Sand units. The H Sand unit is the shallowest and the A Sand member is the deepest. The principle uranium ore zone sand member at Hank is the F Sand and it is 75 ft thick. Within the Hank Unit, all the sands have separating aquicludes.

The Nichols Ranch Unit A Sand ore zone is bounded above and below by impermeable layers. The upper and lower aquicludes are composed of shales or mudstones, silty shales and shaley lignite horizons. The B Sand has been designated the overlaying aquifer and the 1 Sand the underlying aquifer.

The Hank Unit F Sand ore zone is bounded above and below by impermeable layers. The upper and lower aquicludes are composed of shales or mudstones, silty shales and shaley lignite horizons. The G Sand has been designated the overlaying aquifer and the C or B Sand the underlying aquifer.

Site geology and stratigraphy are summarized in cross section Exhibits D5-1, D5-2, D5-10, D5-11, and D5-12 (see map pockets) located in Appendix D5 Volumes V and Va for the Nichols Ranch Unit and Exhibits D5-3, D5-4, D5-6, D5-7, D5-8, and D5-9 (see map pockets) also located in

Appendix D5 in Volumes V and Va for the Hank Unit. These cross sections each run north/south and east/west through their respective ore bodies. Exhibit D5-5 shows an electric cross section running from the Nichols Ranch Unit to the Hank Unit, a distance of approximately six miles. This cross section provides for correlation of the sand units, aquitards, and the nomenclatures utilized for each in the project areas. It also illustrates the gentle 0.5 to 1.0 westward dip of the Wasatch formation.

Isopach maps depicting the B Sand, A-B Shale, A Sand, 1-A Shale, and 1 Sand for Nichols Ranch are found as Exhibits D5-13 through D5-17 (see map pockets) located in Appendix D5 in Volume Va. The Hank isopach maps for the G-H Sand, G Sand, G-F Shale, F Sand, C-F shale, C Sand, and B Sand are depicted in Exhibits D5-17a though D5-24 (see map pockets). These isopach maps are also located in Volume Va of Appendix D5. The ore zones at the Nichols Ranch and Hank Units are typical Powder River Basin roll front deposits. Uranium ore, where present, is found at the interface of a naturally occurring chemical boundary between reduced and oxidized sandstone facies. Due to the nature of fluvial sandstone deposition, an individual sand member may have several vertically superimposed subsidiary roll fronts. This is due to small differences in sandstone permeability or the occasional vertical contact between sand members resulting in development of multiple roll fronts which overlay each other in complex patterns.

The Nichols Ranch and Hank Unit ore zones have uranium mineralization composed of amorphous uranium oxide, sooty pitchblende, and coffinite. The uranium is deposited upon individual detrital sand grains and within authigenic clays in the void spaces. The host sandstones are composed of quartz, feldspar, accessory biotite and muscovite mica, and locally occurring carbon fragments. Grain size ranges from very fine-grained sand to conglomerate. The sandstones are weakly to moderately cemented and friable. Pyrite and calcite are associated with the sands in the reduced facies. Hematite or limonite stain from pyrite, are common oxidation products in the oxidized facies. Montmorillonite and kaolinite clays from oxidized feldspars are also present in the oxidized facies. Figure 2-13 (see map pocket) details a typical stratigraphic column of the Nichols Ranch ISR Project area.

2.6.2.2 Jane Dough Unit

In the Pumpkin Buttes Mining District, the Eocene Wasatch Formation hosts the geologic setting for uranium mining at the Jane Dough Unit. The Wasatch Formation in this area was deposited in a multi-channel fluvial and flood plain environment. The climate at the time of deposition was wet tropical to subtropical with medium stream and river sediment load depositing a majority of medium grained materials. The source of the sediments, as evidenced by abundant feldspar grains in the sandstones, was the near-by Laramie and Granite Mountains (see Figure JD-D5-1a).

At the Jane Dough Unit location, there are eight identified fluvial sandstone horizons or units. Beginning with the deepest unit they are the 1, A, B, C, F, G and H Sand units which are stratigraphically the same as at Nichols Ranch ISR (see Figure JD-D5-2 in Appendix JD-D5). Separating the sand units are horizons composed of siltstones, mudstones, carbonaceous shales and poorly developed thin coals. These fine-grained materials were deposited in flood plain, shallow lake (lacustrine) and swamp environments. Ultimately, deposition of the Wasatch Formation was a function of stream bed load entering the basin and subsidence from within the basin. However, in the central part of the Powder River Basin, long periods of balanced stability occurred. During these periods the stream gradients were relatively low and allowed for development of broad (0.5 to 6.0 mi wide) meander belt systems, associated overbank deposits, and finer grained materials in flood plains, swamps and shallow bodies of water. Evidence for depositional stability exists as a number of coal bed markers with little or no channel scouring are in contact with the major sand horizons (Davis, 1970). The A Sand at Jane Dough is in close proximity to basal lignite and carbonaceous shales.

In a fluvial meandering stream process, the flow channel is sinuous in plan view with the highest flow energy concentrated on the outside edge of the channel as it turns through a meander. This results in cutting into the outside channel wall and caving material into the channel especially during flooding. In cross section view, the outside edge of a meander is the steepest and the inside of the meander is sloped more gently. The inside edge of a

meander is where deposition takes place. Finer materials are deposited in the shallower (upper) slow flow region of the inside slope and coarser materials are deposited in the lower region. The major fraction of sand in the Wasatch Formation in the Pumpkin Buttes area is medium-grained with lesser fractions of coarse and fine grains. This is accompanied with mostly medium scale festoon cross bedding and current lamented cross bedding. These features can only be seen in cores. In a typical point bar sedimentation process, grain size and sediment structure fine upwards within a single point bar accumulation (see Figure JD-D5-2a).

The meandering stream environment is a process of cut and fill. Each time a cut occurs, the inside slope fills with sand and sediment. A single increment of this process results in a structure called a point bar and an accumulation of point bars is sometimes referred to as a meander belt. As the meander process progresses, meander loops eventually migrate down gradient in the direction of flow and can laterally spread out in almost any direction. The size of the complete meander belt system is a function of the size of the valley or basin and stream flow rate, load and gradient. If the subsidence rate and stream load are in the proper proportion, successive layers of meander belts, or meander belt systems, may form as the stream channel wanders back and forth during subsidence.

Meander belts in the Wasatch formation are generally 5 to 30 ft thick. The A Sand at Jane Dough is made up of three to four stacked meander belts. Individual meander belt layers will rarely terminate at the same location twice. Meanders have been noted to frequently terminate in the interior of a belt system but are more likely to terminate somewhere closer to the edge of the meander stream valley. The net effect for fluvial sands is to generally thin away from the main axis of the meander belt system. The A Sand meander belt system at Jane Dough is four miles wide as at Nichols Ranch.

On an electric log resistivity curve, the fineness grading is apparent where the curve sharply deflects from low to higher resistance and then gradually returns to lower resistance in an upward direction. Other meander belt system sand features such as overbank and crevasse

deposits are present as fingers of sand that taper out from a meander termination. These are thin sands without a lot of grain size sorting. Inter –meander channel sands occur between meanders that are migrating in different directions. These sands have more uniform grain size and show on the electric log as a semi-flat curve with only small variations. Tributary and meander cut-off channel sand features form where pre-existing sediments are scoured by a river or stream and subsequently fill with medium and coarse sediments. These channels may cut randomly into meander belts, flood plain or swamp sediments (see Figure JD-D5-2b in Appendix JD-D5). On the electric resistivity log, channel fills have a massive semi-rounded signature.

2.6.3 Seismology

2.6.3.1 Nichols Ranch and Hank Units

The area of central Wyoming where the Nichols Ranch ISR Project site is located lies in a relatively minor seismic region of the United States. Although distant earthquakes (such as the western Wyoming area) may produce shocks strong enough to be felt in the Powder River Basin, the region is ranked as a one (1) seismic risk as shown in Figure 2-14 (see map pocket). Few earthquakes capable of producing damage have originated in this region.

The seismically active region closest to the site is the Intermountain Seismic Belt of the Western United States, which extends in a northerly direction between Arizona and British Columbia. It is characterized by shallow earthquake foci between 10 and 25 mi in depth, and normal faulting. Part of this seismic belt extends along the Wyoming-Idaho border, more than 350 km (approximately 200 mi) west of the Nichols Ranch ISR Project area. More detailed information can be found in the reports "Basic Seismological Characterization for Campbell County, Wyoming and Basic Seismological Characterization for Johnson County, Wyoming" by the Wyoming State Geological Survey, which is contained in Addendum 2D.

Table 2-11 lists the largest recorded earthquakes (greater than 4.0 magnitude on the Richter Scale) that have occurred within 200 km (120 mi) of the Nichols Ranch ISR Project sites and gives the maximum ground acceleration that could be realized at the site as a result of these disturbances from the period 1873 through 2006 (Sources – Wyoming State Geological Survey, 2002 and USGS, 2007). The earthquake of highest intensity recorded during that time interval was the Casper, Wyoming earthquake of 1897. This earthquake has been assigned a probable maximum Mercalli shaking intensity of VI -VII (5.7 on the Richter scale) based on accounts of damage incurred.

No surface faulting or fault traces in the project area has been reported, nor is any faulting evident from geophysical log interpretations. Based on historic data, the ground accelerations reported in Table 2-11 (.01g to .04g) are not considered to be of a magnitude that would disturb the operations or facilities in the event that an earthquake occurred.

Table 2-11 Maximum Expected Earthquakes Intensities and Ground Accelerations at the Nichols Ranch ISR Project Site.

Earthquake Location and Year	Epicenter Intensity (Mercalli)	Magnitude (Richter)	Distance From Nichols Ranch ISR Project	Ground Acceleration at Nichols Ranch ISR Project
Casper (1894)	V	4.5	65	0.01g
Casper (1897)	VI-VII	5.7	64	0.04g
Kaycee (1965)	V	4.7	30	0.02g
Pine Tree Jct. (1967)	V	4.8	10	0.04g
West of Gillette (1976)	IV-V	4.3	38	0.02g
SW of Gillette (1976)	V	4.8	18	0.03g
Bar Nunn (1978)	V	4.6	56	0.01g
West of Kaycee (1983)	V	4.8	65	0.01g
West of Gillette (1984)	V	5.1	30	0.03g
West of Gillette (1984)	V	5	28	0.03g
Laramie Mtns (1984)	VI	5.5	95	0.01g
Mayoworth (1992)	V-VI	5.2	52	0.02g
W Converse Co. (1996)	IV-V	4.2	54	0.01g

2.6.3.2 Jane Dough Unit

The area of central Wyoming where the Jane Dough Unit site is located lies in a relatively minor seismic region of the United States. Although distant earthquakes (such as the western Wyoming area) may produce shocks strong enough to be felt in the Powder River Basin, the region is ranked as a one (1) seismic risk as shown in Figure JD-D5-4 (see map pocket). Few earthquakes capable of producing damage have originated in this region.

The seismically active region closest to the site is the Intermountain Seismic Belt of the Western United States, which extends in a northerly direction between Arizona and British Columbia. It is characterized by shallow earthquake foci between 10 and 25 miles in depth, and normal faulting. Part of this seismic belt extends along the Wyoming-Idaho border, more than 350 kilometers (approximately 200 miles) west of the project area. More detailed information can be found in the report "Basic Seismological Characterization for Campbell County and

Basic Seismological Characterization for Johnson County, Wyoming" by the Wyoming State Geological Survey.

Table 2-12 lists the largest recorded earthquakes (greater than 4.0 magnitude on the Richter Scale) that have occurred within 200 km (120 mi) of the Jane Dough Unit site and gives the maximum ground acceleration that could be realized at the site as a result of these disturbances from the period 1873 through 2006 (Sources-Wyoming State Geological Survey, 2002 and USGS, 2007). The earthquake of highest intensity recorded during that time interval was the Casper, Wyoming earthquake of 1897. This earthquake has been assigned a probable maximum Mercalli shaking intensity of VI -VII (5.7 on the Richter scale) based on accounts of damage incurred.

No surface faulting or fault traces in the project area has been reported, nor is any faulting evident from geophysical log interpretations. Based on historic data, the ground accelerations reported in Table 2-12 (.01g to .04g) are not considered to be of a magnitude that would disturb the operations or facilities in the event that an earthquake occurred.

Table 2-12 Maximum Expected Earthquates Intensities and Ground Accelerations at the Jane Dough Unit.

Earthquake Location and Year	Epicenter Intensity (Mercalli)	Magnitude (Richter)	Distance From Jane Dough Unit	Ground Acceleration at Jane Dough Unit
Casper (1894)	V	4.5	65	0.01g
Casper (1897)	VI-VII	5.7	64	0.04g
Kaycee (1965)	V	4.7	30	0.02g
Pine Tree Jct. (1967)	V	4.8	10	0.04g
West of Gillette (1976)	IV-V	4.3	38	0.02g
SW of Gillette (1976)	V	4.8	18	0.03g
Bar Nunn (1978)	V	4.6	56	0.01g
West of Kaycee (1983)	V	4.8	65	0.01g
West of Gillette (1984)	V	5.1	30	0.03g
West of Gillette (1984)	V	5	28	0.03g
Laramie Mtns (1984)	VI	5.5	95	0.01g
Mayoworth (1992)	V-VI	5.2	52	0.02g
W Converse Co. (1996)	IV-V	4.2	54	0.01g

2.7 HYDROLOGY

2.7.1 Surface Water

2.7.1.1 Nichols Ranch and Hank Units

The Section 2.7 Hydrology pages, tables, figures and exhibits are sequentially numbered in this section, such as 2-1. The addendums referenced in this section are presented in the attached Appendix D6 Hydrology, Volume VI and VIa, text.

2.7.1.1.1 Drainage Basin Description

The Nichols Ranch ISR Project areas exist in the Cottonwood and Willow Creek drainage areas. The Nichols Ranch Unit is located in the Cottonwood Creek drainage while the Hank Unit is located in the Willow Creek drainage.

The Nichols Ranch Unit is located near the confluence of the Cottonwood Creek drainage with the Dry Fork of the Powder River. Figure 2-15 (see map pocket) shows the Cottonwood drainage area. The majority of the Nichols Unit drains directly to Cottonwood Creek while a portion of the northern part of the area drains to Tex Draw which is a tributary to the Dry Fork of the Powder River. Cottonwood Creek is a tributary to the Dry Fork of the Powder River and its confluence is located approximately 0.5 mi downstream of the project area. Tex Draw also enters the Dry Fork of the Powder River approximately 2.0 mi downstream of the project area.

Area of the Cottonwood Creek drainage basin is 80.2 sq mi. Dry Fork of the Powder River is a tributary to Powder River which is a tributary to the Yellowstone River, which is a part of the Missouri River drainage basin. Land surface elevation in Cottonwood Creek drainage varies from 5,974 to 4,590 ft-msl at the mouth. The channel elevation varies from 4,622 to 4,660 ft-msl in the project area. Cottonwood Creek channel is flat at a gradient of approximately 0.003 ft/ft.

The Tex Draw drainage area is 5.2 sq mi and its elevation varies from a peak of 5,085 to an elevation of 4,540 ft-msl at its confluence with the Dry Fork of the Powder River. None of the Tex Draw channel exists within the Nichols Ranch Unit area but the northwestern portion of the project area drains to Tex Draw. Tex Draw has a much steeper gradient due to being a smaller ephemeral channel and has an approximate gradient of 0.01 ft/ft just north of the project area.

The local drainages in Cottonwood Creek in the Nichols Ranch Unit have been divided into six small drainage basins. These drainage basins are presented on Figure 2-15 and have been named NDA-1 through NDA-6. Table 2-12 presents the areas of these drainage basins. The slopes of these drainages vary from 1.5 to 2.9%.

The Hank Unit is located in the Dry Willow and Willow Creek drainages. Dry Willow is a tributary to Willow Creek which is a tributary of the Powder River. Dry Willow and a portion of Willow Creek drainage upstream of the Dry Willow confluence are shown in Figure 2-15 (see map pocket). The Hank Unit is roughly 16 mi upstream of the confluence of Willow Creek and the Powder River. Willow Creek is oriented in a westerly direction through the northern end of the unit.

The area of the Willow Creek drainage basin above the Dry Willow Creek confluence is approximately 13.2 sq mi. Elevation in the Willow Creek drainage varies from 6,052 - 4,795 ft msl at the confluence of Dry Willow Creek. The short reach of the Willow Creek channel within the unit boundary, ranges in elevation from 5,015 to 5,040 ft-msl. The gradient of the stream channel within the Hank Unit is about 0.008 ft/ft, and the active stream channel width varies from a few feet to several tens of feet.

The drainage area of Dry Willow Creek is 12.2 sq mi. The maximum elevation in this drainage basin is 6,018 ft and the elevation at the confluence is 4,795 ft. The elevation of the channel in the Hank Unit area of Dry Willow Creek varies from 4,995 ft to 5,085 ft-msl. The stream channel in this area has a gradient slightly greater than 0.01 ft/ft.

The local drainages in Dry Willow Creek at the Hank site have been divided into 8 sub-basins. These small sub-basins have been labeled HDA-1 through HDA-8 on Figure 2-15. Table 2-12 shows that the channel bottoms for these drainages vary from 2.8 to 4%.

2.7.1.1.2 Surface-Water Flow

Dry Willow, Willow and Cottonwood Creeks and Tex Draw are classified as ephemeral streams in the project area. Stream flows only occur in response to heavy snow melt and to large rainstorms. Runoff flows are typically intermittent in the spring and early summer and the stream channels are dry the remainder of the year except during major thunderstorms in the area.

The estimated peak flows for various recurrence intervals for Cottonwood, Tex, Dry Willow and Willow Creek drainages are presented in Table 2-12. The technique that was used to estimate the peak flows is presented in Lowham (1976).

Table 2-12 Surface Drainage Properties, Estimated Peak Flows, and Velocities.

SITE	DRAINAGE AREA (sq. mi)	ESTIMATED PEAK FLOWS (CFS) RECURRENCE INTERVAL (YRS) 2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
Cottonwood Creek	80.2	454	1220	2150	3760	5420	7500
Tex Draw	5.2	170	456	782	1370	1970	2720
Dry Willow Creek	12.2	231	620	1070	1870	2700	3730
Willow Creek	13.2	231	638	1100	1930	2780	3840

10-YEAR VELOCITIES

Channel Station (ft)	Base Width (ft)	Side Slope (?H:1V)	Bottom Slope (ft/ft)	Discharge (cfs)	Normal Flow Depth (ft)	Flow Area (ft^2)
CTW CRK	100	2	0.0030	3760	4.768	522.3
Tex DRW	10	2	0.0100	1370	5.681	121.3
DRY WIL	20	2	0.0100	1870	5.211	158.5
WIL CRK	20	2	0.0080	1930	5.621	175.6

Channel Station (ft)	Wetted Perimeter (ft)	Hydraulic Radius (ft)	Flow Velocity (fps)	Top Width (ft)	Froude Number	Average Unit Discharge (cfs/ft)
CTW CRK	121.32	4.30	7.20	119.07	0.61	34.33
Tex DRW	35.40	3.43	11.29	32.72	1.03	64.14
DRY WIL	43.30	3.66	11.80	40.84	1.06	61.47
WIL CRK	45.14	3.89	10.99	42.49	0.95	61.77

The predicted peak flows in Table 2-12 vary from 454 cubic ft per second (cfs) for a two-year recurrence interval to 7,500 cfs for a 100-year recurrence interval for Cottonwood Creek drainage. The peak flows for Tex Draw vary from 170 to 2,720 cfs for the two and 100-year recurrence intervals.

The predicted peak flows for the Dry Willow Creek and Willow Creek above Dry Willow Creek vary from a low of 231 cfs for the two year recurrence interval for Dry Willow up to a peak of 3,840 for the 100-year recurrence interval. The estimates for Dry Willow and Willow Creek are very similar due to similarity in drainage area.

The smaller drainages at the Nichols unit were divided into drainages NDA1-NDA6. The Craig-Rankl method (1978) for small drainage basins in Wyoming was used to estimate the peak discharges for the small sub-basins. Each of these drainages drain to the north side of Cottonwood Creek. The 25-year peak flows from these drainages vary from a low of 172 to a high of 950 csf. Eight sub basins were divided for the Hank unit. These sub-basins are labeled HDA1-HDA8 and are shown on Figure 2-15 in Appendix D6. Table 2-12 in Appendix D6 presents the peak flows for these sub-basins with a ten-year flood varying from 109 to 384 csf using the Craig-Rankl method (1978).

The flow velocities for the 25-year peak discharges are calculated to present an estimate of the channel velocities during a significant runoff event. The bottom half of Table 2-12 presents the calculation of the flow velocities based on typical channel slope and the 25-yr peak discharge. The 25-year peak discharge was selected as representing a reasonable design period for the life of this operation. These 25-year peaks are calculated for the confluence of the drainages and therefore are a very conservative representation of the peak at the project location. The peak velocities for Cottonwood Creek are smaller due to the wide floodplain and the milder channel slope. Cottonwood Creek does have an incised pilot channel which has been dammed and; therefore, runoff flow during any significant event will be spread over a very significant width of the floodplain. The velocities in Tex Draw, Dry Willow and Willow Creek will be much greater due to the steeper channel slope and are near 10 ft/sec.

The flow velocity over the 25-year peak discharge for the smaller sub-basins is also presented in Table 2-12. The velocities for the Nichols Ranch unit vary from a low of 8.2 to a high of 12.1 ft/sec. Flow velocities were also calculated for the 8 sub basins for the Hank Unit and those flood velocities vary from 9.8 to 13.8 ft/sec.

The 25-five year peaks and conveyance from Table 2-12 were used to define the flood inundated areas for the Nichols Ranch permit areas. Figure 2-15a shows the Nichols Ranch Unit inundated areas. A pattern is shown over the Cottonwood Creek inundated area. This entire area should be flooded during the 25-year peak runoff event. The 25-year peak runoffs for the incised small tributaries within the Nichols Ranch Unit will be confined to these channels and the approximate flooded area is shown by the narrow channel lines presented on Figure 2-15a.

Figure 2-15b presents the 25-year flood inundated areas for the Hank Unit. This figure shows the areas where a 25-year flood will cause the inundation of the incised channels at the Hank Unit.

The upgradient side of the plant at Nichols Ranch and Hank will contain a ditch and berm which will have the conveyance to drain the 25-year flood around the plant facility. Uranerz will also use the erosion practices presented for the Nichols Ranch Unit within areas of the 25-year flood for Cottonwood Creek and for the Hank Unit within the areas of the 25-year flood for Dry Willow Creek. The wellfield at the Hank Unit does not extend to the Willow Creek 25-year floodplain.

As a general rule, installation of injection, production and monitoring wells in drainages will be avoided. If an injection, production, and/or monitoring well must to be constructed in a drainage, appropriate erosion protection controls will be used to minimize the impact to the drainage. Protection controls that could be used, but not limited to, are: grading and contouring, placement of hay bales, culvert installation, rocked low water crossings, placement of water contour bars, and designated traffic routes. The drainage bottoms will be restricted to the work activities that are needed to construct and maintain the wells. If the wells are placed in a location in the drainage where runoff and/or flooding has the potential to impact the well, measures will

be taken to protect the well and wellhead. Barriers surrounding the well such as cement blocks, protective steel casing around the wellheads, or other measures to protect the wells from damage will be utilized. Additionally, if a new road or any access roads have to cross an ephemeral drainage, efforts will be made to cross the drainage at right angles to minimize erosion with the appropriate sized culverts installed. Rocked low water crossings or culverts in combination with a low water crossing will be designed to pass a 25-year peak runoff event. The minimum culvert size of 18" will be used in diverting drainage from roads or for crossing small drainages. In the event that drainage has to be crossed, but cannot be crossed at a right angle or along elevation contours, appropriate measures for erosion control will be examined and implemented. All measures will use the best management practices (rock, riprap, etc.) in accordance to WDEQ-LQD Rules and Regulations, Chapter 3 or those stated in 10 CFR Part 40.

2.7.1.1.3 Surface-Water Quality

The surface water quality from the Cottonwood, Tex, Dry Willow and Willow Creek drainages is generally very good in the upper channel reaches of these areas. A typical TDS is 200 mg/l. Water quality generally deteriorates as the surface water flows further downstream and is in contact with the streambed for longer periods of time.

The U. S. Geological Survey has monitored the Dead Horse Creek drainage which is approximately 30 mi north of the confluence of the Dry Fork with the Powder River and roughly 20 mi north of the confluence of Willow Creek with the Powder River. Dead Horse Creek drainage area is 151 square mi, which is significantly greater than the local drainages of the mining area. Limited water quality data from this gauging station shows that ion concentrations are significant with conductivity of greater than 2,000 umhos/cm.

Table D6A.1-1 in Addendum D6A of Appendix D6 presents water quality data available from surface water samples within the drainages in the project. Figure 2-15 shows the location of surface water quality samples. These surface water results should be representative of conditions in 2007 because CBM discharges in this area have not started. Discharges to Tex Draw are expected to start in 2008 but a large portion of this area will not have CBM discharges because

one of the major CBM producers is piping water to a deep injection well. The three surface water samples in early 2008 should also be representative of pre-CBM discharges because no CBM surface discharges have occurred in these drainages. The Dry Willow Reservoir which is upstream of the Hank Unit had a TDS of 174 mg/l. The Brown Water Pond also had a very low TDS due to the pond proximity to the drainage divide. This pond captures water after it has moved only a relatively short distance. The Dry Willow Reservoir and Brown Water Pond were dry in September of 2007 and early 2008. Additional samples on Dry Willow Creek and Cottonwood Creek show that the TDS can exceed 2,000 mg/l in the surface runoff. The spring of 2008 TDS from Dry Willow Creek and Cottonwood Creek downstream (D) of the Nichols Ranch Unit are much lower; while the TDS from the Cottonwood Creek upstream (U) of the Nichols Ranch Unit, which is similar to the late 1970 higher values. This data shows that the surface water quality can naturally vary greatly. Surface runoff water quality is generally dominated by bicarbonate concentrates, but increase concentrations of calcium and sulfate are observed with increasing exposure time in channels.

2.7.1.1.4 Coal Bed Methane Surface Water

Coal Bed Methane (CBM) or Coal Bed Natural Gas (CBNG) has and will occur in the region of the Nichols Ranch ISR Project. One aspect of the CBNG activity is the removal of water from the targeted coal seam and the pumping of the water from the coal seam to the surface to be discharged into a surface impoundment. The following information details locations where CBNG water will be or has been discharged to the surface within one mile of each license area and how the discharge CBNG water may or may not impact the surface water quality at the Nichols Ranch and Hank Units.

The coal bed methane water contains a high sodium and bicarbonate concentration while the sulfate concentration is very low. The Nichols Ranch G Sand water quality near the CBM wells has relatively low sodium and bicarbonate and higher sulfate concentrations. These three parameters should enable the effects of the CBM water on the surficial aquifer to be easily determined.

2.7.1.1.4.1 Permitted CBM/CBNG Discharge Facilities

Permitted Wyoming Pollution Discharge Elimination System (WYPDES) facilities within the Hank Unit permit boundary and a one-mile radius of the permit boundary are depicted on Exhibit 2-2 and detailed in Table 2-12a. Discharge monitoring reports (DMRs) submitted through June 30, 2008 indicate no discharge to the outfalls listed in Table 2-12a. Permitted WYPDES facilities within the Nichols Ranch Unit permit boundary and a one-mile radius of the permit boundary are depicted on Exhibit 2-3 and detailed in Table 2-12b. There are currently five permits active in the area; however, discharge has only occurred at five out of the seventeen permitted outfalls. These outfalls are denoted on the map and shaded in Table 2-12b.

Table 2-12a Outfalls Inside and Within a One-Mile Radius of the Hank Unit License Boundary.

Permit #	Permit Operator	Permit Name	Outfall Within 1.0-mi of Permit Boundary	Associated Reservoir(s) and WSEO Permit Number
WY0056171	Yates Petroleum Corporation	All Day POD, Cottonwood Creek	002	Ox Bar (P18329S)
WYG2900001*	Bill Barrett Corporation	Willow Creek Permit	001	Reservoir 16-1 (Not Permitted) and Davis Reservoir (P4479R)
WY0056774	Yates Petroleum Corporation	All Day POD, Dry Willow Creek	001	South Dry Willow #1 (P18282S)
			002	South Dry Willow #2 (P18283S)
			003	Westside (P18496S)

*Outfall and reservoirs beyond 1-mile radius but upstream of Permit Boundary.

Table 2-12b Outfalls Inside and Within a One-Mile Radius of the Nichols Ranch Unit License Boundary.

Permit #	Permit Operator	Permit Name	Outfall Within 1-mi of Permit Boundary	Associated Reservoir(s) and WSEO Permit Number
WY0051161	Williams Production RMT Company	T-Chair Unit	001	NA
WY0051241	Williams Production RMT Company	Bullwhacker Creek-Dry Fork Land	001	NA - Outfall not constructed
WY0054411	Williams Production RMT Company	East Bullwhacker Creek	002	Johnson 24-12-4377 Reservoir (P16121S)
			003	Johnson 23-19-4376 Reservoir (P17383S)
			004	Johnson 34-19-4376 Reservoir (P17384S)
			012	Johnson 11-29-4376 Reservoir (P17386S)
			018	Johnson 24-12-4377 Reservoir (P16121S)
WY0055824	Yates Petroleum Corporation	Blade POD CBM Facility	013	Stepanek (Pending)
			014	William (Pending)
			022	Ill Prepared (Pending)
			023	Backwards (Pending)
			024	Bull Pasture #2 (P18278S)
			025	Bull Pasture #1 (P18277S)
WY0056502	Yates Petroleum Corporation	Rolling Pin Spatula State	001	Bull Pasture #3 (P18653S)
			002	Bull Pasture #4 (P18733S)
			003	Dune (P18794S)
			004	Thumper (P18691S)
			005	Tex (P18615S)
			006	Zink (P187325)

*Shading indicates outfalls that have received discharge water, per Wyoming Department of Environmental Quality discharge monitoring reports (DMRs).

2.7.1.1.4.2 CBM/CBNG Discharge Parameters

Effluent limitations for Yates Petroleum Corporation and Bill Barrett Corporation's WYPDES facilities near the Hank Unit are detailed in Table 2-12c. Notice that watershed based permits such as Bill Barrett Corporations permit on Willow Creek lacks a maximum flow; these permits are written such that the permittee is required to contain all produced waters during operating conditions. Yates' pending permit in the Willow Creek watershed will likely have similar language. Table 2-12d provides the WYPDES effluent limitations for William's T-Chair Unit (WY0051161), Bullwhacker Creek Unit (WY0051241), and East Bullwhacker Creek (WY0054411) as well as Yates' Blade POD CBM Facility (WY0055824) and Rolling Pin Spatula State Project (WY0056502).

Effluent limits are detailed in Tables 2-12c and 2-12d. The limits depict the end-of-pipe maximum concentrations for the selected parameters. None of the permits require containment unit sampling or the monitoring of the water quality directly from the impoundments.

2.7.1.1.4.3 CBM/CBNG Effect on Surface Water/Surficial Aquifer

With the exception of WY0051161, the WYPDES permits detailed previously are total containment. Any water discharged from WY0051161 would flow out of the Nichols Ranch License Boundary in less than a 0.25 mile. Additionally, permit WY0051161 is due to expire on March 31, 2009. Currently WDEQ requires that discharges be contained in non-discharging impoundments and that end of pipe effluent concentrations meet downstream irrigation standards. The permitted irrigation right on Cottonwood Creek is depicted on Exhibit 2-3.

For the remainder of the permits, discharge can only occur to non-discharging impoundments not directly to the ephemeral channels. Discharge from the impoundments is permitted only during significant runoff events, where the produced water is diluted by natural runoff. Any discharge beyond overtopping during heavy precipitation constitutes a violation of the permits. Based on the permit requirements and the necessity to maintain available freeboard in the impoundments, Uranerz believes that the CBNG produced water will not impact the surface water quality at either project in accordance with WDEQ permit stipulations.

Table 2-12c WYPDES Effluent Limitations for Permits within One Mile of the Hank Unit Project.

Operator, Project, Permit and Outfall	Effluent Characteristic	Daily Maximum
Yates Petroleum Corporation All Day POD, Cottonwood Creek WY0056171 Outfalls 001, 002 and 003	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	2,800
	Sodium Adsorption Ratio, unitless	17
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	1.52
Bill Barrett Corporation Willow Creek CBM Facility WYG290001 Outfall 001*	Chlorides, mg/L	230
	Dissolved Iron, ug/L	1,000
	Dissolved Cadmium, ug/L	4
	Dissolved Lead, ug/L	4
	Dissolved Copper, ug/L	10
	Dissolved Zinc, ug/L	90
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	1,330
	Sodium Adsorption Ratio, unitless	7
	Sulfates, mg/L	3,000
	Total Arsenic, ug/L	7
	Total Barium, ug/L	1,800
	Total Dissolved Solids, mg/L	887
	Total Flow, MGD	N/A
Yates Petroleum Corporation All Day POD Willow Creek WY0056774 Outfalls 001, 002 and 003	N/A Permit Pending--Likely very similar to BBC's Watershed Based WYPDES Permit Detailed Above	N/A Permit Pending--Likely Very Similar to BBC's Permit Limits Detailed Above

*Outfall and reservoirs beyond 1-mile radius but upstream of Permit Boundary.

Table 2-12d WYPDES Effluent Limitations for Permits in or near the Nichols Ranch Project.

Operator, Project, Permit and Outfall	Effluent Characteristic	Daily Maximum
Williams Production RMT Company T-Chair Unit WY0051161 Outfall 001	Chlorides, mg/L	46
	Dissolved Iron, ug/L	1,000
	Dissolved Manganese, ug/L	646
	pH, s.u.	6.5 - 8.5
	Specific Conductance, umhos/cm	7,500
	Sulfates, mg/L	3,000
	Total Arsenic, ug/L	7
	Total Barium, ug/L	1,800
	Total Dissolved Solids, mg/L	5,000
	Total Petroleum Hydrocarbons, mg/L	10
	Total Radium 226, pCi/L	1
	Total Flow, MGD	0.057
Williams Production RMT Company Bullwhacker Creek WY0051241 Outfall 001	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Arsenic, ug/L	8.4
	Total Barium, ug/L	1,800
	Total Flow, MGD	N/A
Williams Production RMT Company East Bullwhacker Creek WY0054411 Outfalls 002 and 018	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	N/A
Williams Production RMT Company East Bullwhacker Creek WY0054411 Outfalls 003-004 and 012	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	3,570
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	N/A
Yates Petroleum Corporation Blade POD CBM Facility WY0055824 Outfalls 001-025	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	2,800
	Sodium Adsorption Ratio, unitless	17
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	1.66

Table 2-12d (Continued)

Operator, Project, Permit and Outfall	Effluent Characteristic	Daily Maximum
Yates Petroleum Corporation Blade POD CBM Facility WY0055824 Outfalls 001-025	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH	6.5 - 9.0
	Specific Conductance, umhos/cm	2,800
	Sodium Adsorption Ratio, unitless	17
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	1.66
Yates Petroleum Corporation Rolling Pin Spatula State WY0056502 Outfalls 001-004, 006	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	2,800
	Sodium Adsorption Ratio, unitless	17
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	N/A
	Chlorides, mg/L	150
Yates Petroleum Corporation Rolling Pin Spatula State WY0056502 Outfalls 005	Dissolved Iron, ug/L	1,000
	pH	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	N/A

Additionally, anecdotal evidence provided by the WDEQ-WQD for surface water facilities permitted to receive CBNG produced water provides few instances in which water infiltrating from the facilities has impacted groundwater resources. Groundwater quality has been adversely affected and class of use has changed 16 out of 109 permitted impoundments due to infiltration from overlying reservoirs/infiltration pits. In these rare instances, the class of use has typically changed due to increases in the concentrations of selenium, TDS or sulfate. This data represents nearly four years of collection from 259 monitor wells installed at sites across the Powder River Basin. Based on the few sites that have received CBNG produced water and the limited duration of these discharges, it is exceedingly unlikely that the baseline water quality measured in the surficial aquifers has been compromised in any manner. Further, per WDEQ regulations, all containment reservoirs permitted after August 1, 2004 require groundwater monitoring that includes baseline characterization and quarterly monitoring of the down gradient well of a three-well network. Although groundwater impacts are unlikely in place monitoring will detect impacts to the surficial aquifers.

2.7.1.2 Jane Dough Unit

The Appendix JD-D6 Hydrology pages, tables, figures, and exhibits are sequentially numbered in this section, such as JD-D6-1. The addendums are numbered by the sub-section, such as Figure JD-D6B.1-1.

2.7.1.2.1 Drainage Basin Description

The Jane Dough Unit is split between the Cottonwood Creek drainage to the northeast and the Seventeen Mile Creek drainage to the southwest. Cottonwood and Seventeen Mile Creek are tributaries of the Dry Fork of the Powder River. The confluence of Seventeen Mile Creek is approximately 3 miles upstream from the confluence of Cottonwood Creek and the Dry Fork of the Powder River. These drainage areas are shown in Figure JD-D6-1.

Area of the Cottonwood Creek drainage basin is 80.2 square miles. Approximately 3.9 square miles of the basin is located within the Jane Dough Unit boundary. Dry Fork of the Powder River is a tributary to Powder River which is a tributary to the Yellowstone River, which is a part of the Missouri River drainage basin. Land surface elevation in Cottonwood Creek drainage varies from 5,974 to 4,590 ft-msl at the mouth. The channel elevation varies from 4,640 to 4,680 ft-msl in the project area. Cottonwood Creek channel is flat at a gradient of approximately 0.003 ft/ft.

The Seventeen Mile Creek drainage area is 11.5 square miles; only around 2 square miles are within the boundary of the Jane Dough Unit. The land surface elevation change in this area varies from 5,280ft to 4,650 ft-msl. The slope of this channel is 0.009 ft/ft with the base width of this channel averaging roughly 20 ft.

The drainages in the Jane Dough Unit were sub divided into minor drainages. Only one minor drainage was divided out of the Seventeen Mile Creek drainage area (JDA1) and the Cottonwood Creek drainage area was divided into four smaller drainage areas labeled JDA3- JDA6. There is one more minor drainage that is within the Jane Dough Unit, but is not apart of either the Cottonwood or Seventeen Mile Creeks drainages and drains directly to the Dry Fork of the Powder River. This minor drainage is labeled JDA2. Table JD-D6-1 presents the channel bottom slopes of these minor drainages for the Seventeen Mile and

Cottonwood Creek drainages. The minor drainage that flows into Seventeen Mile Creek (JDA1) has a slope of 3% and the JDA2, which flows into the Dry Fork of the Powder River, has a slope of 2%. The minor drainages that flow into Cottonwood Creek (JDA3-JDA6) vary from 1.5 to 4.5%.

2.7.1.2.2 Surface Water Flow

Cottonwood and Seventeen Mile Creeks are classified as ephemeral streams in the project area. Stream flows only occur in response to heavy snow melt and to large rainstorms. Runoff flows are typically intermittent in the spring and early summer and the stream channels are dry the remainder of the year except during major thunderstorms in the area.

The estimated peak flows for various recurrence intervals for Cottonwood and Seventeen Mile Creek drainages are presented in Table JD-D6-1. The technique that was used to estimate the peak flows is presented in Lowham (1976).

The predicted peak flows in Table JD-D6-1 vary from 454 cubic feet per second (csf) for a two-year recurrence interval to 7,500 csf for a hundred year recurrence interval for the Cottonwood Creek drainage.

The smaller drainages at the Jane Dough Unit were divided in drainages JDA1-JDA6. The Craig-Rankl method (1978) for small drainage basins in Wyoming was used to estimate the peak discharges for the small sub-basins. JDA1 drains into the Seventeen Mile Creek. JDA2 drains directly to the Dry Fork of the Powder River. JDA3-JDA6 all flow to the south side of Cottonwood Creek. Table JD-D6-1 presents the peak flows for these sub basins with a ten year flood varying from 177 to 475 cfs using the Craig-Rankl method (1978).

The flow velocities for the 25-year peak discharges are calculated to present an estimate of the channel velocities during a significant runoff event. The bottom half of Table JD-D6-1 presents the calculation of the flow velocities based on typical channel slope and the 25-year peak discharge. The 25-year peak discharge was selected as representing a reasonable design period for the life of this operation. These 25-year peaks are calculated for the confluence of the drainages and therefore are a very conservative representation of the peak at the project location. The peak velocities for Cottonwood Creek are smaller due to the wide flood plane and the milder channel slope. Cottonwood Creek does have an incised pilot channel which has been dammed and; therefore, runoff flow during any significant event will be spread

over a very significant width of the flood plane. The velocity in Seventeen Mile Creek will be greater due to the steeper channel slope and smaller channel width and are near 10 ft/sec. The flow velocity over the 25-year peak discharge for the smaller sub basins is also presented in Table JD-D6-1. The velocities for the Jane Dough Unit vary from a low of 9.29 to a high of 13.11 ft/sec.

The 25-year peaks and conveyance from Table JD-D6-1 were used to define the flood inundated areas for the Jane Dough permit areas. Figure JD-D6-2 shows the Jane Dough Unit inundated areas. A pattern in shown over the Cottonwood Creek inundated area. This entire area should be flooded during the 25-year peak runoff event. The 25-year peak runoffs for the incised small tributaries within the Jane Dough Unit will be confined to these channels and are the approximate flooded area is shown by the narrow channel lines presented on Figure JD-D6-2.

2.7.1.2.3 Surface Water Quality

The surface water quality from the Dry Fork of the Powder River, Cottonwood, and Seventeen Mile Creek drainages is generally very good in the upper channel reaches of these areas. A typical TDS is 200 mg/l. Water quality generally deteriorates as the surface water flows further down stream and is in contact with the streambed for longer periods of time. The U. S. Geological Survey has monitored the Dead Horse Creek drainage which is approximately 30 miles north of the confluence of the Dry Fork with the Powder River and roughly 20 miles north of the confluence of Willow Creek with the Powder River. Dead Horse Creek drainage area is 151 square miles, which is significantly greater than the local drainages of the mining area. Limited water quality data from this gauging station shows that ion concentrations are significant with conductivity greater than 2,000 mhos/cm.

Table JD-D6A.1-1 in Addendum JD-D6A presents water quality data available from surface water samples within the drainages in the project. Figure JD-D6-1 shows the location of surface water quality samples. There are two self samplers, JD SS1 and JD SS2, which are shown on the map as well. This data shows that the surface water quality can naturally vary greatly. TDS values for the reservoirs sampled range from 382 to 2,930 mg/l. T he surface sample location JD SS1 shows considerably lower TDS values than that of the reservoirs, ranging from 112 to 232 mg/l. No sample has been collected from JD SS2. Surface runoff water quality is generally dominated by bicarbonate concentrates but increase concentrations of calcium and sulfate are observed with increasing exposure time in channels.

2.7.1.2.4 Coal Bed Methane Surface Water

The following information details locations where CBNG water will be or has been discharged to the surface within one mile of the license area and how the discharge CBNG water may or may not impact the surface water quality at the Jane Dough Unit.

The Jane Dough Unit is adjacent to Nichols Ranch, and the indications of water quality impacts by CBM discharge should be similar to those from Nichols Ranch. The Jane Dough G Sand water quality near the CBM wells has relatively low sodium and bicarbonate and higher sulfate concentrations. These three parameters should enable the effects of the CBM water on the surficial aquifer to be easily determined.

2.7.1.2.4.1 Permitted CBM/CBNG Discharge Facilities

Permitted Wyoming Pollution Discharge Elimination System (WYPDES) facilities within the Jane Dough Unit permit boundary and a one-mile radius of the permit boundary are presented in Table 2-12e and Exhibit 2-4 of the Techinical Report.

2.7.1.2.4.2 CBM/CBNG Discharge Parameters

Effluent limits are detailed in Tables 2-12f. The limits depict the end-of-pipe maximum concentrations for the selected parameters. The permits do not require containment unit sampling or the monitoring of the water quality directly from the impoundments. Table 2-12f presents the WYPDES effluent limitations for William's T-Chair Unit (WY0051161), Bullwhacker Creek Unit (WY0051241), and East Bullwhacker Creek (WY0054411) as well as Wold Oil Properties' Taylor 1 Unit (WY0056456) Yates' Blade POD CBM Facility (WY0055824) and Rolling Pin Spatula State Project (WY0056502).

Table 2-12e Outfalls Inside and Within a One-Mile Radius of the Jane Dough Unit License Boundary.

Permit #	Permit Operator	Permit Name	Outfall Within 1-mi of Permit Boundary	Associated Reservoir(s)
WY0051161	**Williams Production RMT Company**	**T-Chair Unit**	**001**	**NA**
WY0051241	**Williams Production RMT Company**	**Bullwhacker Creek-Dry Fork Land**	**037***	**Johnson 31-24-4377 Reservoir**
			038*	**Johnson 24-25-4377 Reservoir**
			040*	**Johnson 32-25-4377 Reservoir**
WY0054411	**Williams Production RMT Company**	**East Bullwhacker Creek**	**003**	**Johnson 23-19-4376 Reservoir**
			004	**Johnson 34-19-4376 Reservoir**
			006	**Johnson 23-29-4376 Reservoir**
			007	**Johnson 33-30-4376 Reservoir**
			008	**Johnson 23-31-4376 Reservoir**
			009	**Johnson 24-31-4376 Reservoir**
			012	**Johnson 11-29-4376 Reservoir (P17386S)**
			013	**Johnson 31-31-4376 Reservoir**
			014	**Johnson 42-31-4376 Reservoir**
			015	**Johnson 42-31-4376 Reservoir**
			016	**Johnson 23-32-4376 Reservoir**
			017	**Iberlin 13-33-4376 Reservoir**

Table 2-12e (continued)

Permit #	Permit Operator	Permit Name	Outfall Within 1-mi of Permit Boundary	Associated Reservoir(s)
WY0056456	Wold Oil Properties Inc.	Taylor 1	003	Sundance Kid Stock Reservoir
			009	Storm Stock Reservoir
			010	North Fenceline Stock Reservoir
			013	Pumpkin View Stock Reservoir
WY0055824	Yates Petroleum Corporation	Blade POD CBM Facility	022	Well Prepared
			023	Backwards
			024	Bull Pasture #2
			025	Bull Pasture #1
WY0056502	Yates Petroleum Corporation	Rolling Pin Spatula State	002*	Bull Pasture #4
			003*	Dune
			004	Thumper
			005*	Tex
			006	Zink
WY0094536	Anadarko E&P Onshore LLC	Dry Willow	002	NA

***Outfalls located slightly more than one mile from permit boundary.**

2.7.1.2.4.3 CBM/CBNG Effect on Surface Water/Surficial Aquifer

With the exception of WY0051161 and WY0094536, the WYPDES permits detailed previously are total containment. Any water discharged from WY0051161 would flow out of the Nichols Ranch License Boundary in less than a 0.25 mile and would have no potential impact on the Jane Dough unit. Additionally, permit WY0051161 was due to expire on March 31, 2009 and the permit is no longer listed under issued permits. However, the 001 outfall for permit WY0051161 is still included in the WDEQ outfall database, so it was included for this discussion. Water discharged from WY0094563 will flow through the Jane Dough License Boundary after a stream reach length of approximately two miles. Currently WDEQ requires that discharges be contained in non-discharging impoundments and that end of pipe effluent concentrations meet downstream irrigation standards. The permitted irrigation right on Cottonwood Creek is depicted on Exhibit 2-4.

For the remainder of the permits, discharge can only occur to non-discharging impoundments not directly to the ephemeral channels. Discharge from the impoundments is permitted only during significant runoff events, where the produced water is diluted by natural runoff. Any discharge beyond overtopping during heavy precipitation constitutes a violation of the permits. Based on the permit requirements and the necessity to maintain available freeboard in the impoundments, Uranerz believes that the CBNG produced water will not impact the surface water quality at either project in accordance with WDEQ permit stipulations.

Based on the few sites that have received CBNG produced water and the limited duration of these discharges, it is unlikely that the baseline water quality measured in the surficial aquifers has been or will be compromised by the discharge. Further, per WDEQ regulations, all containment reservoirs permitted after August 1, 2004 require groundwater monitoring that includes baseline characterization and quarterly monitoring of the down gradient well of a three-well network. Although groundwater impacts are unlikely, in place monitoring will detect impacts to the surficial aquifers.

Table 2-12f WYPDES Effluent Limitations for Permits within One Mile of the Jane Dough Unit Project.

Operator, Project, Permit and Outfall	Effluent Characteristic	Daily Maximum
Williams Production RMT Company T-Chair Unit WY0051161 Outfall 001	Chlorides, mg/L	46
	Dissolved Iron, ug/L	1,000
	Dissolved Manganese, ug/L	646
	pH, s.u.	6.5 - 8.5
	Specific Conductance, umhos/cm	7,500
	Sulfates, mg/L	3,000
	Total Arsenic, ug/L	7
	Total Barium, ug/L	1,800
	Total Dissolved Solids, mg/L	5,000
	Total Petroleum Hydrocarbons, mg/L	10
	Total Radium 226, pCi/L	1
	Total Flow, MGD	0.057
WPX Energy Rocky Mountain, LLC Bullwhacker Creek WY0051241 Outfall 040	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Arsenic, ug/L	8.4
	Total Barium, ug/L	1,800
	Total Flow, MGD	NA
Wold Oil Properties Taylor 1 WY0056456 Outfalls 003, 010 and 013	Chlorides, mg/L	2,000
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
Williams Production RMT Company East Bullwhacker Creek WY0054411 Outfalls 003-004, 006-009, and 012-017	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	3,570
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	N/A
Yates Petroleum Corporation Blade POD CBM Facility WY0055824 Outfalls 001-025	Chlorides, mg/L	150
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	NA

Table 2-12f (continued)

Operator, Project, Permit and Outfall	Effluent Characteristic	Daily Maximum
Yates Petroleum Corporation Blade POD CBM Facility WY0055824 Outfalls 001-025	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	N/A
Yates Petroleum Corporation Rolling Pin Spatula State WY0056502 Outfalls 002-006	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	NA
Anadarko E&P Onshore LLC Dry Willow WY0094536 Outfall 002	Chlorides, mg/L	150
	Dissolved Iron, ug/L	1,000
	pH, s.u.	6.5 - 9.0
	Specific Conductance, umhos/cm	7,500
	Total Recoverable Arsenic, ug/L	8.4
	Total Recoverable Barium, ug/L	1,800
	Total Flow, MGD	Based on TDS Load

***Outfall and reservoirs beyond 1-mile radius but upstream of Permit Boundary.**

2.7.2 Groundwater Hydrology

2.7.2.1 Nichols Ranch and Hank Units

The regional ground-water setting has been defined by Hodson and others, 1973, and Whitehead, 1996. The Nichols Ranch permit area is located in the south-central Powder River Basin, to the west of the Middle Pumpkin Butte. The regional Quarternary aquifers are alluvial aquifer adjacent to the major drainages in the area. The North Platte, Powder River, Belle Fourche, and Cheyenne are the major streams in this region. Hodson and others, 1973, indicates a large range in transmissivity and well yields in these alluvial aquifers with the poorest water quality in the Powder River alluvium. Geologic structure in the permit area is relatively flat with a gentle dip to the southwest toward the basin axis. The Wasatch Formation is the uppermost geologic unit in the area of the Nichols Ranch permit. The sands within the Wasatch Formation create regional aquifers in this area. Whitehead, 1996 also presents information relative to the regional groundwater setting in this area. Ground water in the Wasatch aquifers generally flows to the north and northwest in this area. The transmissivity and yield from the Wasatch Formation is also highly variable with the yield up to a few hundred gallons per minute when a large thickness of saturated sands are completed in a well. The water quality in these aquifers would also generally be good, with a TDS concentration typically from <1000 mg/l to <2,000 mg/l. The aquifers of interest in this area are sands within the Wasatch Formation. The confining units between the aquifers are also within the Wasatch Formation.

The sandstones and the coal seams form aquifers in the Fort Union Formation. The aquifers will be deeper than the Wasatch aquifers but the general flow in the aquifer would be expected to be in the similar direction as the flow in the Wasatch aquifers. Whitehead (1996) indicates that some of the flow between the aquifers is upwards in this region. Groundwater quality of the Fort Union aquifers would also be expected to be relatively good with TDS generally less than 2,000 mg/l.

The Lance Formation consists mainly of very fine to fine-grained sandstone shale and coal beds. The groundwater flow direction in the Lance Formation in this area is expected to be to the north. Water quality data is very limited on the Lance Formation in this area but the TDS would be

expected to be >2000 mg/l based on the limited data. The TDS is less toward the outcrop area to the southwest. TDS concentrations near the outcrops have been reported to be <1000 mg/l.

The Foxhills Sandstone exists below the base of the Lance Formation. Foxhills is mainly a fine to medium-grained sandstone. The groundwater flow direction in the Foxhills would be expected to be to the north in this area based on a map presented in Whitehead (1996). The TDS of the Foxhills is likely to be >2000 mg/l in this area based on the limited data available for this aquifer. The TDS in the outcrop area to the southwest has been measured to be from 1000 to >2000 mg/l.

The Lewis Shale underlies the Foxhill aquifer and is mainly an aquitard. This shale contains some lenses of fine-grained sandstone but is generally not a very significant producer of water. The water quality in the Lewis Shale would be expected to be very poor. TDS in the Lewis Shale is likely to exceed 5000 mg/l in this area.

2.7.2.1.1 Hydrologic Setting and Well Construction

The Nichols Ranch ISR Project is located in the outcrop of the Wasatch Formation. The stratigraphy of the Wasatch at this site consists of alternating layers of sand and shale with lignite marker beds. The mineable ore exists in two sand members, designated as the A Sand at the Nichols Ranch Unit and F Sand at the Hank Unit. These two sand members are typically separated by the B and C Sands and adjacent aquitards.

The aquifer and aquitard sequence at the project area is shown in Figure 2-16 (see map pocket). This shows labeled sands from the 1, A, B, C, F, G, and H Sands. This figure also shows the aquitards that exist between the different sands and those aquitards are labeled by the combination of labels for the two adjacent sands. These sands are the same names that are used at Power Resources North Butte permit which exists just north of the Hank Unit site.

The majority of the wells completed in the Nichols Ranch Unit are completed in the A Sand because this is the ore bearing sand in this area. Figure 2-17 (see map pocket) shows the

locations of the Nichols Ranch Unit wells and Exhibit D6-1 in Appendix D6 shows the locations of wells within three miles of the Nichols Ranch Unit. Table 2-13 presents the tabulation of the well data for the Nichols Ranch Unit wells. The wells used to define baseline water level (L) and water quality (Q) are indicated in the last column of the Tables 2-13 and 2-14. Table 2-13 shows that eight of the wells have been completed in the A Sand for definition of baseline water level and water quality with one well completed in the C Sand, B Sand, 1 Sand and the Cottonwood alluvium. Two wells are completed in the F and G Sands for baseline measurements. Additional ranch wells are presented in the table but not used for baselining. Wells MN-1, MN-2, URZNB-1 and URZN1-2 are completed as open-hole completions, while the remaining Nichols Ranch wells have well screens in their completion interval. Addendum D6L in Appendix D6 gives the Uranium Data Submission Spreadsheets which contain additional information on the wells.

Table 2-14 presents the basic well data for the Hank Unit wells, while Figure 2-18 shows the location of the Hank Unit wells. Exhibit D6-2 in Appendix D6 shows the locations of wells within three miles of the Hank Unit. Ten of these wells are completed in the F Sand for baselining of this aquifer because this is the ore bearing sand in this area. Four of the wells are completed in the overlying G Sand and two of the wells are completed in the underlying C Sand for baseline monitoring of these aquifers. In areas where the C Sand does not exist, the B Sand is the underlying aquifer and seven of the baseline wells in this area are completed in the B Sand. Three dry alluvial wells and five surficial aquifer H Sand wells are listed in Table 2-14. Hank wells C #1, Dry Willow #1, Hank 1, NBHW-13, URZHB-6, URZHC-2, URZNF-1, URZHF-5, URZHG-3, URZHG-4 and WC-MN1 are completed as open-hole completions while the remaining Hank wells have screens. Additionally, seven existing stock wells are listed in Table 2-14 but not used for baseline purposes.

Three new Nichols Ranch Unit wells were added in late 2009 and six new Hank Unit wells were drilled. Tables 2-13 and 2-14 have been updated with this new information.

Table 2-13 Basic Well Data for the Nichols Ranch Unit Wells.

WELL NAME	NORTH. COORD.	EAST. COORD.	MP ELEV. (ft-msl)	CASING DIA. (in)	STICK-UP ABOVE LSD	WELL DEPTH (ft-mp)	WATER LEVEL DATE	WATER LEVEL DEPTH (ft-mp)	WATER LEVEL ELEVATION (ft-msl)		SCREEN INTERVAL (ft-lsd)	AQUIFER
20-9	1102911	275410	4664.08	5.0	0.9	740	---	--	---		495 - 615	A
	1102911	275410	4664.08	5.0	0.9	740	---	--	---		635 - 655	A
CALVING #1	1100015	289109	4824.00	5.0	1.6	560	---	--	---		390 - 420	A
	1100015	289109	4824.00	5.0	1.6	560	---	--	---		440 - 500	A
Dry Fork #3	1100675	273123	4720.00		---	360	---	--	---		-	C
DW-4L	1112331	276856	4969.73	5.0	0.4	795	1/18/2010	307.67	4662.06		726 - 795	A
DW-4M	1112331	276769	4970.17	5.0	0.3	441	1/18/2010	285.20	4684.97		389 - 441	C
DW-4U	1111406	276812	4966.75	5.0	0.3	310	1/18/2010	230.60	4736.15		256 - 309	F
GARDEN	---	---	---		---	---	---	--	---		-	A
MN-1	1105710	273118	4715.14	4.5	1.3	556	2/3/2010	46.03	4669.11	#	479 - 556	A
MN-2	1108147	273844	4840.00	4.5	0.7	670	1/29/2010	176.40	4663.60	#	560 - 670	A
MN-3	1106960	275167	4764.64	4.5	0.7	585	1/18/2010	93.46	4671.18		479 - 585	A
MN-4	1109835	272220	4800.36	4.5	2.2	623	1/29/2010	142.73	4657.63		520 - 623	A
MN-5	1108755	272120	4883.28	4.5	2.3	727	1/29/2010	222.83	4660.45		628 - 727	A
MN-6	1107478	272220	4761.18	4.5	2.2	593	1/18/2010	98.30	4662.88		485 - 593	A
Nichols #1	1102532	269925	4622.33	2.0	0.0	310	---	--	---		191 - 310	F
NR#1	1107430	272265	4758.88	5.0	1.2	620	1/18/2010	94.75	4664.13		550 - 565	A
Pats #1	1102872	279812	4690.00		---	405	---	--	---		375 - 405	A
Pug #1	1102383	275338	4685.00		---	370	---	--	---		340 - 370	B
URZN1-2	1105691	273081	4714.31	4.5	1.1	645	2/3/2010	60.40	4653.91	#	600 - 645	1
URZNA-7	1106069	275761	4711.00	5.0	1.5	510	1/18/2010	42.67	4668.33	#	489 - 498	A
URZNA-8	1109220	272539	4962.12	5.0	1.1	645	4/13/2010	195.16	4766.96	#	628 - 636	A
URZNA-9	1109282	272604	4852.54	5.0	1.2	685	4/13/2010	186.57	4665.97	#	669 - 679	A
URZNB-1	1105725	273149	4716.36	4.5	1.3	375	2/3/2010	58.90	4657.46	#	330 - 375	B
URZNB-10	1109279	272522	4855.98	5.0	1.1	501	4/13/2010	193.63	4662.35	#	396 - 496	1
URZNF-3	1105992	273707	4728.87	4.0	2.3	173	1/26/2010	85.50	4643.37		153 - 173	F
URZNG-5	1109316	271149	4790.62	4.0	2.0	60	8/17/2009	49.78	4740.84		30 - 60	G
URZNG-6	1107845	277024	4785.15	4.0	2.0	105	1/18/2010	73.30	4711.85		70 - 100	G
URZNQ-4	1103219	272397	4638.44	4.0	1.5	35	2/3/2010	5.40	4633.04		15 - 35	ALL
W. of WW1	1116674	286130	5080.00	6.0	2.3	720	4/22/2009	358.16	4721.84		340 - 370	C
	1116674	286130	5080.00	6.0	2.3	720	4/22/2009	358.16	4721.84		540 - 720	A

NOTE: * = Abandoned
# = Open Hole Completion
ALL = Alluvial
W. of WW1 = West of Widow Women
MP = Measuring Point (at top of casing)
MSL = Mean Sea Level
LSD = Land Surface Datum
L = Baseline Water Level
Q = Baseline Water Quality

Table 2-14 Basic Well Data for the Hank Unit.

WELL NAME	NORTH. COORD.	EAST. COORD.	MP ELEV. (ft-msl)	CASING DIA. (in)	STICK-UP ABOVE LSD	WELL DEPTH (ft-mp)	WATER LEVEL			SCREEN INTERVAL (ft-lsd)	AQUIFER
							DATE	DEPTH (ft-mp)	ELEVATION (ft-msl)		
BR-B	1129884	299194	5029.70	5.0	1.5	300	12/10/2009	139.04	4890.66	200 - 280	F
BR-F	1128473	302583	5082.25	5.0	1.6	160	12/10/2009	67.10	5015.15	60 - 100	G
BR-G	1125397	305568	5157.27	5.0	1.6	320	7/17/2009	147.89	5009.38	240 - 320	F
BR-H	1127077	293768	4957.56	5.0	1.6	200	12/14/2009	92.85	4864.71	140 - 180	G
BR-I	1128729	303971	5130.88	4.0	1.7	80	11/11/2008	59.16	5071.72	40 - 80	H
BR-K	1129697	306515	5193.00	4.0	1.7	124	11/3/2008	124.00	5069.00	84 - 124	H
Brown #5	1128252	301915	5061.76	5.0	1.3	540	9/26/2007	215.60	4846.16	460 - 540	B
Brown-W5	1125026	299713	5146.00	6.0	1.2	702	12/14/2009	264.00	4882.00	340 - 380	C
	1125026	299713	5146.00	6.0	1.2	702	12/14/2009	264.00	4882.00	425 - 465	B
	1125026	299713	5146.00	6.0	1.2	702	12/14/2009	264.00	4882.00	540 - 620	A
BR-Q	1125878	305553	5154.22	5.0	1.1	600	12/17/2007	291.61	4862.61	500 - 600	B
BR-T	1131333	300699	5033.00	5.0	---	496	3/11/1981	196.50	4836.50	390 - 470	B
BR-U	1128876	300158	4983.18	4.0	1.7	23	4/13/1982	11.86	4971.32	5 - 23	ALL
C #1	1100216	304090	5137.00	5.0	1.1	232	12/14/2009	191.20	4945.80	# 146 - 232	F
Connie #2	---	---	5310.00	6.0	---	350	---	--	---	-	F
DRYMW1	1121212	293031	4930.00	3.0	0.3	19	10/4/2007	> 19.20	< 4910.80	-	ALL
DRYMW3	1121635	292581	4920.00	3.0	0.5	19	10/4/2007	> 18.60	< 4901.40	-	ALL
DW#1	1112155	304041	5154.19	6.0	1.3	320	10/26/2009	220.88	4933.31	# 220 - 320	F
F. Brown #1	1108650	288324	4890.00	7.0	2.3	520	10/29/2009	191.43	4698.57	423 - 483	B
Hank 1	1122566	302568	5251.01	6.0	1.8	440	1/18/2010	355.08	4895.93	# 354 - 440	F
Means #1	1108983	301384	5259.86	6.0	1.1	700	10/26/2009	341.60	4918.26	320 - 330	F
	1108983	301384	5259.86	6.0	1.1	700	10/26/2009	341.60	4918.26	640 - 650	B
NBHW-13	1128356	295943	4969.86	4.5	1.7	470	12/14/2009	126.33	4843.53	# 424 - 446	B
North Dry Willo	1116100	303879	5205.00	6.0	0.3	1132	---	--	---	250 - 280	F
	1116100	303879	5205.00	6.0	0.3	1132	---	--	---	380 - 410	C
	1116100	303879	5205.00	6.0	0.3	1132	---	--	---	540 - 570	B
	1116100	303879	5205.00	6.0	0.3	1132	---	--	---	700 - 770	A
	1116100	303879	5205.00	6.0	0.3	1132	---	--	---	990 - 1100	1
Old Maid #1	1115480	292878	5080.00	6.0	2.3	300	7/17/2009	197.69	4882.31	250 - 300	F
OW43756	1115602	298221	5052.00	6.0	2.0	251	12/18/2009	142.30	4909.70	-	G
	1115602	298221	5052.00	6.0	2.0	251	12/18/2009	142.30	4909.70	-	F
Paden #1	1115635	304361	5195.85	5.0	1.8	650	12/18/2009	306.38	4889.47	400 - 440	C
	1115635	304361	5195.85	5.0	1.8	650	12/18/2009	306.38	4889.47	570 - 630	A
	1115635	304361	5195.85	5.0	1.8	650	12/18/2009	306.38	4889.47	570 - 630	B
RED WINDMILI	---	---	---	6.0	---	300	---	--	---	-	A

Table 2-14 (continued)

WELL NAME	NORTH. COORD.	EAST. COORD.	MP ELEV. (ft-msl)	CASING DIA. (in)	STICK-UP ABOVE LSD	WELL DEPTH (ft-mp)	WATER LEVEL				SCREEN INTERVAL (ft-lsd)	AQUIFER
							DATE	DEPTH (ft-mp)	ELEVATION (ft-msl)			
SS1-F	1129626	295559	4975.00	4.5	1.1	185	7/22/2009	113.71	4861.29		145 - 185	F
SS1-FPU	1129700	295428	4976.00	2.0	2.3	175	12/14/2009	199.30	4776.70		-	F
SS1-L	1129551	295690	4974.00	5.0	0.9	654	12/14/2009	136.95	4837.05		540 - 652	A
SS1-M	1129546	295602	4974.00	5.0	1.2	454	12/14/2009	136.00	4838.00		405 - 454	B
SS1-U	1129619	295647	4975.00	5.0	0.9	372	12/14/2009	134.45	4840.55		323 - 372	C
URZHB-6	1124299	302427	5213.78	4.5	1.1	650	12/18/2009	348.48	4865.30	#	536 - 650	B
URZHC-16	1122506	302466	5244.00	5.0	1.1	523	1/18/2010	364.00	4880.00	#	462 - 523	C
URZHC-2	1118511	302629	5234.76	4.5	1.3	485	12/14/2009	340.90	4893.86	#	440 - 450	C
URZHF-1	1118584	302588	5231.73	4.5	0.9	440	12/18/2009	328.00	4903.73	#	365 - 374	F
URZHF-11	1122685	301960	5232.00	5.0	1.0	420	1/18/2010	341.63	4890.37	#	330 - 420	F
URZHF-12	1122353	303021	5280.00	5.0	1.3	482	1/18/2010	381.28	4898.72	#	380 - 483	F
URZHF-13	1124729	301487	5179.00	5.0	1.0	330	2/1/2010	285.09	4893.91	#	317 - 325	F
URZHF-14	1124749	301408	5185.00	5.0	1.2	362	2/1/2010	291.61	4893.39	#	367 - 375	F
URZHF-5	1124265	302426	5217.67	4.5	1.7	410	2/1/2010	317.04	4900.63	#	369 - 386	F
URZHF-8	1122657	302570	5250.00	5.0	1.7	433	1/18/2010	354.77	4895.23		420 - 430	F
URZHG-15	1122559	302472	5244.00	5.0	1.3	314	1/18/2010	278.55	4965.45	#	255 - 314	G
URZHG-3	1118491	302556	5228.82	4.5	1.2	300	12/18/2009	273.88	4954.94	#	270 - 300	G
URZHG-4	1124257	302457	5215.78	4.5	1.1	290	12/17/2007	282.00	4933.78	#	270 - 290	G
URZHH-10	1122798	302044	5258.19	4.0	2.0	135	8/12/2009	131.18	5127.01		90 - 130	H
URZHH-7	1118639	301082	5169.37	4.0	2.2	135	12/18/2009	90.73	5078.64		115 - 135	H
	1118639	301082	5169.37	4.0	2.2	135	12/18/2009	90.73	5078.64		85 - 105	H
URZHH-9	1115596	302854	5157.68	4.0	2.0	155	8/13/2009	125.71	5031.97		135 - 150	H
WC-MN1	1121306	292653	4942.00	5.0	2.5	210	3/2/2009	92.93	4849.07	#	150 - 210	F

NOTE: * = Abandoned
# = Open Hole Completion
ALL = Alluvial
L = Baseline Water Level
Q = Baseline Water Quality

2.7.2.1.2 Summary of Aquifer and Aquitard Properties

Numerous single-well pump tests and multi-well pump tests were conducted at the Nichols Ranch and Hank Units to define the aquifer properties. The detailed hydrologic analyses and supporting data are contained in Addendums D6B and D6C in Appendix D6 for Nichols Ranch Unit and Hank Unit respectively. Three multi-well pump tests were conducted at the Nichols Ranch Unit site and are referred to in this report as the MN-1, MN-2 and MN-6 tests. Three multi-well tests were performed at the Hank Unit site. These tests are referred to as the URZHF-1, URZHF-5 and SS1F tests. Tables 2-13 and 2-14 present the basic well data for wells

used to define the aquifer properties for the Nichols Ranch and Hank Units respectively. Addendum D6J in Appendix D6 presents the aquifer test theory used to analyze the pump tests.

Additional multi-well pump tests were conducted in early 2010. The aquifer properties obtained from tests have been added to Tables 2-15 and 2-16, respectively, for the Nichols Ranch and Hank Units.

2.7.2.1.2.1 Aquifer Properties

In addition to determining the aquifer properties from the multi-well test, numerous single-well tests were conducted to define the aquifer properties. Several pump tests were previously conducted by Cleveland-Cliffs and Uranerz and the results of these tests were analyzed and included in the general hydrologic analysis.

The aquifer property tables and discussion present the ore sand first, then the overlying and underlying aquifers and finally shallowest to deeper aquifer for the remaining aquifers.

Nichols Ranch Unit

Table 2-15 presents a summary of the aquifer properties for the Nichols Ranch Unit. This table shows a summary of the aquifer properties for the A, B and 1 Sands and then the Cottonwood Alluvium, F and C Sands for the Nichols Ranch Unit. For the A Sand, the single-well pump tests are presented first and then the results for the three multi-well pump tests are presented. Transmissivities for the A Sand aquifer vary from a low of 101 to a high of 460 gal/day/ft. A value of 350 gal/day/ft is thought to best represent the A Sand in the Nichols Ranch Unit area. The hydraulic conductivity (horizontal permeability) varies from 0.18 to slightly greater than 0.7 ft/day (0.08 to 0.36 Darcy), and a value of 0.5 ft/day is thought to best represent the A Sand. Average storage coefficient for the A Sand was 1.8E-4.

Table 2-15 Summary of Aquifer Properties for the Nichols Ranch Unit.

	TRANSMISSIVITY (GAL/DAY/FT)				HOR. HYDRAULIC CONDUCTIVITY		AQUIFER	STORAGE COEFFICIENT		
	RECOVERY	JACOB	THEIS OR WTAQ	BEST VALUE	(FT/DAY)	(DARCY)	THICKNESS (FT)	JACOB	THEIS OR WTAQ	BEST VALUE
SINGLE WELL TESTS					**A ORE SAND**					
MN-1	275	453	-	275	-	-	73	-	-	-
MN-1 (2nd test)	-	276	-	276	0.65	0.31	73	-	-	-
MN-3	454	465	-	460	0.57	0.27	107	-	-	-
MN-4	314	308	-	311	0.42	0.2	98	-	-	-
MN-5	284	747	-	-	-	-	104	-	-	-
MN-5 (2nd test)	322	357	-	322	0.41	0.20	104	-	-	-
DW-4L	53	101	-	101	0.18	0.084	77	-	-	-
MULTI WELL TESTS										
MN-1 TEST	303	355	-	329	0.6	0.29	73	-	-	-
MN-2 OBS	610	1034	180	180	0.33	0.16	73	1.5E-04	1.4E-04	1.4E-04
MN-3 OBS	471	1095	265	265	0.48	0.23	73	1.2E-04	1.2E-04	1.2E-04
NICHOLS 1 OBS	570	631	414	414	0.76	0.36	73	1.0E-04	1.7E-04	1.7E-04
MN-6 TEST	360	346	-	353	0.44	0.21	108	-	-	-
NICHOLS 1 OBS	369	384	359	371	0.46	0.22	108	2.8E-05	3.1E-05	-
MN-5 OBS	477	620	359	359	0.44	0.21	108	1.1E-04	1.5E-04	1.5E-04
MN-2 OBS	792	688	337	337	0.42	0.20	108	3.8E-05	3.8E-04	3.8E-04
MN-2 TEST	160	196	-	178	0.23	0.11	102			
MN-1 OBS	51	588	180	180	0.24	0.11	102	1.1E-04	1.0E-04	1.0E-04
URZNA-7 TEST	290	310	-	300	0.43	0.21	93	-	-	-
MN-1 OBS	-	-	260	260	0.37	0.18	93	-	1.1E-04	1.1E-04
MN-3 OBS	-	-	270	270	0.39	0.19	93	-	1.1E-04	1.1E-04
URZNA-9 TEST	310	350	-	310	0.41	0.2	100	-	-	-
URZNA-8 OBS	230	200	190	210	0.25	0.13	100	5.3E-04	1.3E-04	1.3E-04
MN-2 OBS	-	-	340	340	0.45	0.22	100	-	1.8E-04	1.8E-04
MN-4 OBS	-	-	320	320	0.43	0.2	100	-	1.1E-04	1.1E-04
MN-5 OBS	-	-	280	280	0.39	0.18	100	-	4.4E-05	4.4E-05
SINGLE WELL TESTS					**B OVERLYING SAND**					
URZNB-1	-	306	-	-	-	-	63	-	-	-
URZNB-1 (2nd test)	127	174	-	174	0.37	0.18	63	-	-	-
SINGLE WELL TESTS					**1 UNDERLYING SAND**					
URZN1-2	93	105	-	-	-	-	45	-	-	-
URZN1-2 (2nd test)	83	73	-	88	0.26	0.12	45	-	-	-
SINGLE WELL TESTS					**COTTONWOOD ALLUVIUM**					
URZNQ-4	9520	8670	-	8,670	39	18	30	-	-	-
SINGLE WELL TESTS					**F SAND**					
DW-4U	1460	1360	-	1410	3.6	1.7	52	-	-	-
DW-4U (2nd test)	-	1470	-	-	-	-	-	-	-	-
URZNF-3	-	470	-	470	1.4	0.68	44	-	-	-
SINGLE WELL TESTS					**C SAND**					
DW-4M	-	45	-	45	0.099	0.047	61	-	-	-

The one single-well pump test in the B Sand produced a transmissivity of 174 gal/day/ft and a horizontal permeability of 0.37 ft/day. The single-well pump tests for the 1 Sand produced a transmissivity of 88 and 101 gal/day/ft for the 1 Sand for the Cottonwood Alluvium. A significantly higher transmissivity was obtained from the single-well test for the F Sand well at 1,410 gal/day/ft and a hydraulic conductivity of 3.6 ft/day. A small transmissivity of 45 gal/day/ft and hydraulic conductivity of 0.099 ft/day were determined for the C Sand.

Hank Unit

Table 2-16 presents the summary of aquifer properties for the Hank Unit. This table presents results of aquifer properties testing for the F ore sand, G overlying aquifer, C and B underlying aquifers and finally the H and A Sands in the Hank Unit area.

The properties in the F Sand vary greatly in the Hank Unit area. The transmissivities vary from a low of 19 to a high of 6,670 gal/day/ft. Hydraulic conductivity varies from a low of 0.14 ft/day to a high of 9.4 ft/day (0.07 to 4.5 Darcy). A transmissivity of 400 gal/day/ft is thought to best represent the majority of the F Sand in the Hank Unit and the hydraulic conductivity of 0.6 ft/day is also thought to best represent the F Sand. A storage coefficient of 6.8E-5 was determined for the F Sand at the SS1-F site. The water level in the ore zone of the Hank Unit is near the top of the sand; therefore, the F Sand is not fully saturated and is an unconfined aquifer at the Hank Unit. The primary storage property for an unconfined aquifer is specific yield and a specific yield of 0.14 is thought to best represent the F Sand in this area.

Table 2-16 presents the summary of aquifer properties for the Hank Unit. This table presents results of aquifer properties testing for the F, A, B, C and G aquifers in the Hank Unit area.

The properties in the F Sand vary greatly in the Hank Unit area. The transmissivities vary from a low of 18 to a high of 6,670 gal/day/ft. Hydraulic conductivity varies from a low of 0.14 ft/day to a high of 9.4 ft/day (0.07 to 4.5 Darcy). A transmissivity of 400 gal/day/ft is thought to best represent the majority of the F Sand in the Hank Unit and the hydraulic conductivity of 0.6 ft/day

Table 2-16 Summary of Aquifer Properties for the Hank Unit.

	TRANSMISSIVITY (GAL/DAY/FT)				HOR. PERMEABILITY		AQUIFER	STORAGE COEFFICIENT		
	RECOVERY	JACOB	THEIS	BEST VALUE	(FT/DAY)	(DARCY)	THICKNESS (FT)	JACOB	THEIS	BEST VALUE
SINGLE WELL TESTS						**F SAND**				
HANK 1	2210	2210	-	2210	3.5	1.7	84	-	-	-
Dry Willow #1	7020	6670	-	6670	9.4	4.5	95	-	-	-
BR-B	2210	2530	-	-	-	-	88	-	-	-
BR-B (2nd Test)	-	1970	-	2240	3.4	1.6	88	-	-	-
BR-G	2.1	19	-	19	0.14	0.067	18	-	-	-
OW43756	-	18	-	18	-	-	-	-	-	-
MULTI WELL TESTS										
URZHF-5	-	470	-	470	0.69	0.33	91	-	-	-
HANK 1	-	-	-	-	-	-	91	-	-	-
BR-G	-	-	-	-	-	-	91	-	-	-
URZHF-1	149	-	-	149	0.28	0.13	71	-	-	-
SS1-F	-	1530	-	1530	6.4	3.1	32	-	-	-
SS1-FPU	1380	1530	-	1450	6.1	2.9	32	6.80E-05	-	6.80E-05
SINGLE WELL TESTS						**G SAND**				
BR-F	-	0.62	-	-	-	-	10	-	-	-
BR-F (2nd Test)	0.4	2.3	-	0.4	0.005	0.003	10	-	-	-
BR-H	-	2.7	-	-	-	-	18	-	-	-
BR-H (2nd test)	2.9	2.9	-	2.9	0.022	0.01	18	-	-	-
SINGLE WELL TESTS						**C SAND**				
URZHC-2	-	1.9	-	1.9	0.025	0.012	10	-	-	-
SINGLE WELL TESTS						**B SAND**				
BR-Q	264	176	-	264	0.38	0.18	93	-	-	-
NBHW-13	742	1300	-	1300	2.2	1.1	78	-	-	-
SINGLE WELL TESTS						**A SAND**				
SS1-L	954	1100	-	1030	1.1	0.52	126	-	-	-
SS1-L (2nd test)	-	843	-	843	0.89	0.43	126	-	-	-

is also thought to best represent the F Sand. A storage coefficient of 6.8E-5 was determined for the F Sand at the SS1-F site. The water level in the ore zone of the Hank Unit is near the top of the sand; therefore, the F Sand is not fully saturated and is an unconfined aquifer at

the Hank Unit. The primary storage property for an unconfined aquifer is specific yield and a specific yield of 0.05 is thought to best represent the F Sand in this area.

Similar tests were conducted on two G Sand wells. The transmissivities of this G Sand varied from 0.4 to 2.9 gal/day/ft with hydraulic conductivities varying from 0.005 to 0.022 ft/day. The aquifer properties for the underlying sands were determined for the C and B underlying aquifer. The aquifer properties for the C Sand were a low transmissivity of 1.9 gal/day/ft and a hydraulic conductivity of 0.025 ft/day. The transmissivities for the B Sand varied over a much larger range from 264 to 742 gal/day/ft. Hydraulic conductivities for the B Sand varied from 0.38 to 2.2 ft/day.

Table 2-16 shows the hydraulic properties for the Hank Unit URZHH-7 well. This H Sand well has a best value transmissivity of 1.1 gallons/day showing that it contains a very low hydraulic conductivity of 0.006 ft/day.

The A Sand was tested at one site and the two tests for the A Sand produced transmissivities of 843 and 1,030 gallons/day/ft and yield hydraulic conductivities of 0.89 and 1.1 ft/day for the A Sand.

2.7.2.1.2.2 Aquitard Properties

The multi-well pump tests were used to define the confinement of the aquitards between the ore aquifer and the overlying and underlying aquifers. The MN-1 multi-well pump test had no indication of connection between the A Sand and the overlying B Sand and the underlying 1 Sand during this multi-well pump test. The MN-2 multi-well pump test showed that no indication of connection existed between the A Sand and the overlying B Sand and the underlying 1 Sand.

The multi-well pump test in the Hank Unit also did not show any indication of connection between the F Sand and the overlying and underlying aquifers. The multi-well pump test URZHF-5 did not show any indication of connection between the overlying and underlying

observation wells indicating that the aquitards in this area adequately separate the ore sand from the overlying and underlying aquifers. The URZHF-1 multi-well pump test also did not show connections with the overlying and underlying aquifers during this pump test. This shows that the aquitards in this area adequately separate the overlying and underlying aquifers from the ore sand.

The most important parameter for confinement of the ore sand from the adjacent aquifers is the thickness of the aquitard. Experience has shown that the continuity of only a few feet of Powder River shale is needed to form an adequate confinement between the ore sand and adjacent aquifers. Exhibit D5-14 in Appendix D5 presents the aquitard thickness for the A-B Shale. This isopach map shows that the thinnest location observed is 13 ft with the majority of Mine Unit 1 consisting of an aquitard thickness of greater than 20 ft. Exhibit D5-16 in Appendix D5 presents the aquitard thickness between the 1-A Sand in the Nichols Ranch Unit area. These figures show that this aquitard has adequate thickness to function as a confinement between the A ore sand and B and 1 Sands. Exhibit D5-19 in Appendix D5 presents the aquitard thickness for the shale between the F-G Sands. This aquitard thickness is less than 30 ft in a small portion of the Hank Mine Unit 1 and generally much thicker than this amount. The overlying aquitard therefore should be adequate in the Hank mine area. Exhibit D5-21 in Appendix D5 presents the thickness of the shale between the F ore sand and the next underlying aquifer, which is the B Sand in some cases and C Sand in the northern portion of the mine area. This aquitard thickness also is slightly less than 30 ft in a portion of Mine Unit 1 with values significantly greater than this in the remainder of the mine unit. The underlying aquitard at the Hank Unit should be adequate for confinement between the F Sand and the underlying aquifer.

The vertical hydraulic conductivities of the aquitard in the Powder River Basin have been defined at numerous locations. These hydraulic conductivities have been measured in multi-well pump tests with the Neuman-Witherspoon (1972) method, determined from the results from the leaky aquifer pump test analysis with the modified Hantush (1960) method, and from laboratory measurements. This data has shown that the vertical hydraulic conductivity of these aquitards is low enough that site specific measurements of the aquitard hydraulic conductivity are not necessary. Aquitard hydraulic conductivity was measured in the area just north of the

Hank Unit in Power Resources North Butte permit. This permit presents aquitards evaluated with the Neuman-Witherspoon field test for the C-F aquitard between the F and C Sands. Table 2-16a presents the North Butte aquitard properties. The vertical hydraulic conductivity of this material was 3.4E-8 cm/sec (3.5E-2 ft/yr). A second multi-well test at the North Butte site defined the 1-A aquitard hydraulic conductivity between the A Sand and the 1 Sand. The results of this test were 4.1E-8 cm/sec (4.2E-2 ft/yr). Additional field tests were evaluated using the modified Hantush method to define the vertical hydraulic conductivity of the aquitard. These calculated hydraulic conductivities varied from a low of 6.7E-9 to a high of 6.9E-8 cm/sec (6.9E-3 to 7.1E-2 ft/yr). Laboratory hydraulic conductivities were also measured on two samples of the aquitards at the North Butte permit and these hydraulic conductivities varied from 6.4E-9 to 1.3E-8 cm/sec (6.6E-3 to 1.3E-2 ft/yr).

Additional test of aquitard properties have been made in this area at the Ruth and Ruby projects. The Ruth project located approximately 6.0 mi southwest of the Nichols Ranch project while the Ruby project is approximately 6.0 mi east of the Hank project. Table 2-16a presents additional field and laboratory aquitard properties for the Ruby and Ruth projects. The aquitards between the A-B Sands and 1-A Sands were measured at the Ruth project. The aquitards between the B-C Sands and A-B Sands were measured at the Ruby project. These aquitard properties show that the aquitards at both the Ruth and Ruby sites are similar to those that were measured at the North Butte site. This data shows that the aquitards in this area have sufficiently small vertical hydraulic conductivities to restrict the movement of ground water from one aquifer to the next. Aquifer confinement will be further defined for each of the wellfields during the wellfield multi-well pump test.

2.7.2.1.3 Groundwater Flow

Water levels have been measured in the wells in the Nichols Ranch and Hank Unitto define the direction and gradient of the groundwater movement and define water-level changes in the aquifers in this area. Addendum D6D in Appendix D6 presents the water-level plots and tabulation of groundwater levels. Addendum D6L in Appendix D6 also presents a tabulation of the water levels in the Uranium Data Submission Spreadsheets.

Table 2-16a Summary of Aquitard Properties at North Butte, Ruth and Ruby.

	NEUMAN-WITHERSPOON		
	VERTICAL HYDRAULIC CONDUCTIVITY		
AQUITARD	(ft/day)	(ft/yr)	(cm/sec)
NORTH BUTTE			
C-F	9.60E-05	3.50E-02	3.40E-08
1-A	1.20E-04	4.20E-02	4.10E-08
RUTH			
A-B	2.00E-04	7.20E-02	7.00E-08
1-A	2.80E-04	1.00E-01	1.00E-07
RUBY			
B-C	9.95E-05	3.60E-02	3.50E-08
A-B	7.10E-05	2.60E-02	2.50E-08

	MODIFIED HANTUSH		
	VERTICAL HYDRAULIC CONDUCTIVITY		
AQUITARD	(ft/day)	(ft/yr)	(cm/sec)
NORTH BUTTE			
C-F	2.00E-04	7.30E-02	6.90E-08
C-F	1.30E-04	4.70E-02	4.50E-08
C-F	7.80E-05	2.80E-02	2.70E-08
C-F	1.70E-04	6.20E-02	6.00E-08
C-F	8.20E-05	3.00E-02	2.90E-08
C-F	1.90E-05	6.90E-03	6.70E-09

	LABORATORY				
AQUITARD	VERTICAL HYDRAULIC CONDUCTIVITY		COEFFICIENT OF COMPRESSIBILTY	POROSITY	SPECIFIC STORAGE
	(ft/day)	(cm/sec)	(sq. ft/lb)		(1/ft)
NORTH BUTTE					
C-F	1.80E-05	6.40E-09	3.80E-07	0.222	1.94E-05
1-A	3.70E-05	1.30E-08	3.30E-07	0.233	1.67E-05
RUTH					
C-F	4.00E-05	1.40E-08	4.20E-07	0.216	2.16E-05
1-A	4.30E-06	1.50E-09	3.90E-07	0.243	1.96E-05
RUBY					
B-C	1.10E-04	3.90E-08	1.18E-06	0.382	5.30E-05
A-B	1.10E-05	4.00E-09	3.92E-07	0.194	2.10E-05

The historical and current water-level elevation maps for the aquifers in this area are essentially the same. Water-level plots show that historically only small changes have occurred in these water levels since the late 1970s. Also, the coal bed methane production in the immediate area has not started and therefore the 2007 piezometric surface maps can be used as historical water-level elevations. The CBM production has caused large drawdown in the coal aquifer but these drawdowns have not been observed in the aquifer adjacent to the production zones. The drawdowns in the sands above the CBM production aquifers have generally been observed in some of the sands closer to the coal aquifer. These drawdowns should generally be relatively small and decrease in sands with greater distances from the coal aquifer.

Nichols Ranch Unit

The water-level elevation for the A Sand, which is the production sand at the Nichols Ranch Unit, is presented in Figure 2-19. This water-level elevation map shows that the groundwater in the A Sand is flowing to the northwest with an average gradient of 0.0033 ft/ft. This gradient, an effective porosity of 0.05 and an average hydraulic conductivity of 0.5 ft/day indicates that the groundwater in the A Sand is flowing at an average rate of 0.033 ft/day (12 ft/yr).

The regional piezometric surface of the A Sand aquifer is developed from the Nichols Ranch Unit A Sand wells and from three additional A Sand wells in this region. Figure 2-19a presents the regional water-level elevation map for the A Sand. This map shows that the regional groundwater flow direction is the same as that in the Nichols Ranch Unit area. The regional groundwater velocity would be expected to be similar to the local groundwater velocity in the Nichols Ranch Unit area.

An F Sand well was added at the Nichols Ranch Unit to define the shallow groundwater at this site. Figure 2-20 (see map pocket) shows the water-level elevation for F Sand well URZNF-3. The water-level elevation of this shallow sand is roughly 25 ft higher than the water-level elevation than the A Sand at this location. An additional shallow monitoring well was installed at the Nichols Ranch Unit in the Cottonwood alluvium. This monitoring well is located on the

downstream edge of the Nichols Ranch Unit area (refer to Figure 2-17 for location [see map pocket]). Completion information for this well is presented in Table 2-10 and the well has a water-level elevation of 4,629 ft-msl. This water-level elevation is approximately 35 ft below the water-level elevation of the A Sand in this area.

Figure 2-20 (see map pocket) shows the water-level elevation for the F Sand for the Nichols Ranch ISR Project area. This map includes wells in both the Nichols Ranch and Hank Units. The groundwater elevation shows that the water in the F Sand is flowing west with an average gradient of 0.005 ft/ft. This gradient, along with an average hydraulic conductivity of 0.6 ft/day and an effective porosity of 0.014, indicates that the groundwater velocity is moving at 0.02ft/day (8 ft/yr). Groundwater in the F Sand flows into the Cottonwood alluvium in the area of the Nichols Ranch Unit.

A water-level elevation for the 1 Sand, the underlying aquifer to the Nichols Ranch A Sand production, is presented in Figure 2-20a. This water-level elevation map shows that the groundwater flow in the 1 Sand is mainly to the northwest. The gradient of the 1 Sand piezometric surface is 0.006 ft/ft and this gradient, and a hydraulic conductivity of 0.26 ft/day and an effective porosity of 0.05 indicates groundwater in the 1 Sand is moving at 0.03 ft/day (11ft/yr).

Figure 2-21 presents the water-level elevations for wells that are completed in the B and C Sands. The water-level elevations in these sands indicate that the gradient is to the west in the Nichols Ranch ISR Project area for both the Nichols Ranch and Hank Units (see Figure 2-21). The piezometric gradient in the ground-water systems has a north-northwest gradient further to the north of the Hank Unit. Similar gradients are observed in the B and C Sand aquifers as in the A and F Sand aquifers.

The depth to water in the surficial aquifer for the Nichols Ranch Unit is presented in Figure 2-21a. This figure shows a pattern the cottonwood alluvial area where the depth to water is less than 10 ft. The green contours present the depth to water in the F Sand. The F Sand is the surficial aquifer in the southern portion of the wellfields. This figure shows that the depth to

water gets to greater than 100 ft in the F Sand in the central portion of the Nichols Ranch wellfields. The F Sand is the surficial aquifer in the southern third of the Nichols Ranch Unit while the G Sand is the surficial in the remainder of the unit. Estimated depths to water in the G Sand are presented with the red contours based on depths to water in the two G Sand wells. The G Sand is the surficial aquifer north of the 50 foot contour for the G Sand in areas where the sand is adequately developed. The G Sand may not be the surficial aquifer in some of this area due to the sand pinching out. Two G Sand wells were added to define the G Sand in the northern portion of the Nichols Ranch. The G Sand wells are shown on Figure 2-21a.

Hank Unit

The water-level elevation for the F Sand in the area of the Hank Unit is presented in more detail in Figure 2-20b. The gradient of the F Sand in the Hank wellfield area is generally 0.005 ft/ft. This gradient steepens to the east of the wellfield to a gradient of 0.01 ft/ft.

The H Sand is the surficial aquifer in the area of the Hank Unit. The BLM has monitored the Dry Willow alluvial wells which have recently been dry. The one alluvial well in Willow Creek is also dry; therefore, the alluvial aquifer is not considered the surficial aquifer in any of the Hank Unit. Figure 2-21b presents the depth to water for the H Sand. This shows that the H Sand depth to water is typically 100 ft in the wellfield area. The depths get less than 50 ft in the southwestern portion of the Hank Unit and greater than 200 ft in the eastern portion of the Hank Unit. Two additional H Sand wells were installed at the Hank Unit to further define the H Sand as the surficial aquifer in this area.

The shallow sands in the Hank Unit area are more likely to be affected by local topography changes than the deeper sands. Figure 2-21c presents a water-level elevation map for the G Sand which is the overlying sands for the F Sand in the Hank Unit. These piezometric contours are for the G Sand and show a much steeper gradient of 0.014 ft/ft to the west. This gradient, an average hydraulic conductivity of 0.005 ft/day and an effective porosity of 0.05 indicate that the ground water in these sands is moving at an average rate of 0.0014 ft/day (0.5 ft/year).

The head in the H Sand wells URZHH-7, URZHH-9 and URZHH-10 are shown on Figure 2-22 with water-level elevations of 5032 to 5127 ft-msl. H Sand well URZHH-7 was installed to define the shallow groundwater at the Hank Site. These wells are completed in the H Sand which is above the G Sand. The H Sand has a water-level elevation approximately 150 ft higher than the G Sand in the northern area of the Hank Unit.

Nichols Ranch Unit Aquitard Flow

Table 2-16b presents the gradient calculations through the aquitards based on the heads in the adjacent aquifers and the thickness of the aquitard. The head in the A Sand is 14 ft higher than the head in the B Sand at the Nichols Ranch Unit at well MN-1. These head differences indicate a gradient of 0.2 ft/ft across the 70 ft of aquitard at this location. The actual gradient in the aquitard is expected to be mainly controlled by the higher head in the A Sand and therefore, based on observation of head measurements in aquitards in the Powder River Basin the actual gradient in the overlying aquitard at the Nichols Ranch Unit is likely to be roughly 0.1 ft/ft. The head in the underlying aquifer 1 Sand in this location is approximately 15 ft less than the head in the A Sand; therefore, a downward gradient exists between the A Sand and the underlying 1 Sand. This indicates a gradient across the aquitard that is greater than 0.3 ft/ft. The higher head in the A Sand is expected to mainly control the head in the aquitard until within a very few feet adjacent to the 1 Sand. Therefore, the gradient in the underlying aquitard is expected to be near 0.1 ft/ft at the Nichols Ranch Unit.

Hank Unit Aquitard Flow

The head in the overlying G Sand at the Hank Unit is greater than 50 ft higher than the head in the F Sand at URZHF-1. This head difference indicates a gradient of greater than 1 ft/ft in the overlying aquitard. The actual head in the overlying aquitard will be mainly governed by the higher head in the G sand and therefore the actual gradient in the overlying aquitard is expected to be near 0.1 ft/ft. A downward gradient exists in the lower aquitard at the Hank Unit where the head at URZHF-1 is 11 ft higher than the head in the underlying C Sand. These head differences

Table 2-16b Vertical Hydraulic Gradients through the Adjacent Aquitards.

AQUITARD	CALCULATED GRADIENT (ft/ft)	ESTIMATED GRADIENT (ft/ft)
Nichols Ranch Unit		
A-B	0.2	0.1
1-A	0.3	0.1
AQUITARD	CALCULATED GRADIENT (ft/ft)	ESTIMATED GRADIENT (ft/ft)
Hank Unit		
F-G	1.1	0.1
C-F	0.37	0.1

indicate a downward gradient of greater than 0.3 ft/ft in the underlying aquitard. The actual gradient in the underlying aquitard is expected to be controlled by the head in the F Sand at the Hank Unit; therefore, the actual gradient in the aquitard is expected to be near 0.1 ft/ft.

2.7.2.1.3.1 Nichols Ranch Unit Water-Level Changes

The water-level elevations have been measured on the Nichols Ranch ISR Project wells and are presented in Addendum D6D. Table D6D.1-1 in Addendum D6D presents the water-level data tabulation for the Nichols Ranch Unit wells while Table D6D.2-1 in Addendum D6D presents the water-level data collected for the Hank Unit wells. Figures D6D.1-1 through D6D.1-3 in Addendum D6D present the water-level elevations; versus time for the Nichols Ranch Unit wells. Water levels for the A Sand wells for 2007 were fairly steady with a gradual rise observed in 2008. The limited data in the late 1970s and early 1980s indicate the water levels in the A Sands were roughly 20 ft higher than the recent levels. This change is thought to be due to the drought in recent years or possibly some affect from the ISR operation to the north of Nichols Ranch. The recent data indicates that this previous decline is not due to CBM drawdowns.

Water-level elevations for the B Sand well URZNB-1 and the 1 Sand well URZN1-2 are slightly less than the water level elevation in adjacent A Sand well MN-1. The vertical head difference

between these two aquifers and the A Sand is approximately 10 ft. Water levels have varied similarly in the B Sand and 1 Sand in the Nichols Ranch Unit area to those in the A Sand.

Water-level changes in the DW-4 cluster of wells to the northeast of the Nichols Ranch Unit have also been fairly steady. These water levels were also measured in 1978 and 1979 and were slightly lower than the recent water levels. The comparison in head between the F Sand, C Sand and A Sand and a comparison of the historical 1978 and 1979 data to the recent data are presented for the DW-4 site. Water levels are about 55 ft higher in the F Sand than those observed in the C and A Sands.

Figure D6B.1-3 in Addendum D6B of Appendix D6 also presents water-level plots for the Nichols Ranch new F Sand well URZNF-3 and the Cottonwood Alluvium monitoring well URZNQ-4. Their water levels show a gradual water-level rise in 2008.

2.7.2.1.3.2 Hank Unit Water-Level Changes

The water-level changes for the Hank Unit wells are presented in Figures D6A.2-1 through D6D.2-5 in Addendum D6D in Appendix D6, while Table D6D.2-1 in Addendum D6D lists the water levels. The water-level changes for the Hank 1, Dry Willow #1, URZHF-1, URZHC-2, and URZHG-3 and URZHF-8 wells are presented in Figure D6A.2-1 Addendum D6D in Appendix D6. The recent water levels in the F Sand in Hank 1 and Dry Willow #1 wells have been fairly steady with a small increase in 2008. The recent water levels in the Hank 1 well are approximately 14 ft higher than the 1979 measurement. Water levels in the Dry Willow well are five to seven feet higher than they were in 1979.

Figure D6D.2-2 in Addendum D6D in Appendix D6 presents the water levels measured for the second new well cluster including, G Sand well URZHG-4, F Sand well URZHF-5 and B Sand well URZHB-6. The head in the G Sand in this area is approximately 35 ft higher than the head in the F Sand while the F Sand head is similarly higher than the B Sand head.

The BR wells are presented in Figure D6D.2-3 in Addendum D6D in Appendix D6 and these wells are located on the northern side of the Hank Unit. These wells were monitored in the early 1980s for a period of slightly more than two years. Recent water levels in F Sand wells BR-B and BR-G are similar to those that were measured in the early 1980s. Water-level plots for H Sand well URZHH-7 are also presented in Figure D6D.2-3. Water levels have gradual risen since monitoring began in mid-2007.

Figure D6D.2-4 in Addendum D6D in Appendix D6 presents the plot of water levels for F Sand well WC-MN1. This well is monitored continuously by the BLM in conjunction with to their coal bed methane monitoring program. A plot of data for this well shows that in 1999 through early 2000 the water level was rising in this well and then gradually declined for the next 6-7 years. During late 2006 the water levels in well WC-WN1 declined at a faster rate than the previous years. The monitoring in the last three quarters, of 2007, and early 2008 show a gradual water-level rise. This plot also shows two data points that were measured in 1979 and 1981 which are several feet lower than the present water level.

The BLM has also monitored three alluvial wells in the Dry Willow alluvial system. The water levels for these wells are shown in Figure D6D.2-5 in Addendum D6D in Appendix D6 with alluvial wells DRYMW1 showing saturation in portions of 2000 through 2001 and well DRYMW3 having some saturation in late 2003. Both of these wells were dry in August of 2007 and through the majority of the monitoring period.

2.7.2.1.3.3 Coal Bed Production Effects on Water-Levels

This section presents the potential effects of the coal bed water production on the ore sands. Coal bed methane (CBM) production has been underway for more than 10 years in the Powder River Basin. The CBM production in this uranium in-situ recovery (ISR) project area is presently in the process of being developed. The CBM wells typically produce a few tens of gallons per minute (gpm) and then production rates significantly decrease with time. This water production has typically resulted in several hundred feet of drawdown in the coal aquifer. The potential effect of the drawdowns on the ISR operation is discussed in this section.

Exhibit D6-5 in Appendix D6 shows the spacing from the base with the A Sand at the Nichols Ranch Unit to the top of the coal which is 765 ft. The base of the F Sand to the top of the coal of the Hank Unit is 1,160 ft (see Exhibit D6-5). The fluvial deposition of the sandstones creates areas where a sandstone has direct connection with other sandstones. The thickest layer of sandstone that has been observed from the logs in the Powder River Basin is approximately 150 ft. Therefore, the large zone between the ore sands and the first major coal seam should always contain some layers of shale where drawdowns from the coal should be greatly attenuated and unlikely to reach the sandstones in the interval of the coal.

Artificial connections through the shales above the first major CBM coal seam could be developed through deep exploration drill holes or deep wells which penetrate the coal seam. Typically, drill holes in the Nichols Ranch permit area are drilled only down into the 1 Sand. A few deeper exploration drill holes were drilled and a very few penetrated the coal seam. Figure D6-8a in Appendix D6 presents the location of the deep drill holes in this area that extend below 800 ft deep. This figure presents the ID name of the drill hole and the total depth for each of the holes. Drill hole CC-4-6 is the only exploration hole that extends down to the first major coal seam. The seal in drill hole CC-4-6 and drill holes CC-65 through CC-68, CC-74, CC-78 and CC-79 in the northeast portion of the wellfield will be evaluated to determine if these holes are adequately abandoned. The remainder of the other deep drill holes; are far enough from the well field that they should not create a potential problem relative to ISR containment of solutions.

The State Engineer's records have been searched for permitted wells and all wells that exceed a total depth of 800 ft and not an oil and gas well are posted on Figure D6-8a in Appendix D6. The majority of wells in this area that are greater than 800 feet depth are oil and gas wells. Figure D6-8a in Appendix D6 shows the location of eight deep permitted wells that are not oil and gas wells. The total depth of these deep wells is shown on Figure D6-8a in Appendix D6 adjacent to the well name. All of these wells are shallow enough that they would not penetrate the CBM coal seam, but two of these wells may be within a couple hundred feet of the coal seam. If the CBM drawdowns propagate up into deeper sand which is within the completion interval of one of these wells, there is a potential for further propagation of drawdown to

shallower sands depending on the well completions. Some shales should be present between the Nichols Ranch ore sands and the completion top of the most of these wells. These shales should still retard drawdowns and prevent impacts on the ore sand aquifer water levels. However, the North Dry Willow #1 well will allow the drawdowns that reach the lower sands in this well to propagate up to the ore sand at Hank. This well will be abandoned or at a minimum, the ore zone sand of the well will be sealed off prior to ISR operation in this area.

This portion of this section presents water-level changes that have been observed relative to CBM drawdowns.

The BLM has monitored water levels in the coal aquifers and sand aquifers above the coal for the last several years. The network of monitoring wells is used to define the effects of water extraction from the coal bed production zone on water levels in the coal and overlying aquifer. The monitoring well locations, drawdown and footage between the bottom of the sand completion and the top of the CBM completion is presented on Figure D6-8b in Appendix D6. The nearest monitoring site to the Hank Unit is a Wasatch Sand well which is called the Dry Willow Well. Water-level data for this well is presented in Section 2.7.2 with the Hank water levels. This sand well is completed 100 feet above the major coal seam. The next closest well is the Fourmile monitoring well which is approximately 4.0 mi to the east of Hank. Water levels for this monitoring well are discussed later in this section. The Pistol coal well is located approximately 5.0 mi due north of the northern boundary of the Hank Unit. Figure D6D.3-1 of Addendum D6D in Appendix D6 presents the water-level elevations of the Pistol Coal Well. Water levels in this coal aquifer well started to greatly decline in 2007 and had only varied over a range of slightly greater than 10 ft for the previous ten years. This well did not show a significant effect from the production of water from the coal aquifer until 2007. The drawdown in early 2009 in the Pistol coal well was 710 ft.

The Bullwacker Sand and Coal wells, which are located approximately 6.0 mi southwest of the Nichols Ranch Unit, have been monitored since 2002. Figure D6D.3-2 in Addendum D6D in Appendix D6 presents the water-level changes for the 2 Bullwacker wells. The sand well, which is completed 100 ft above the coal, has had approximately 195 ft of water level decline through

early 2009. The coal well, which has also been monitored over this same period of time, shows a decline in water level starting in 2002 with a drop of approximately 600 ft by early 2008. This indicates that, at the Bullwacker site, the coal has had a large amount of drawdown and the sand water level appears to be declining steadily with the coal. This sand unit must be hydraulically connected with the coal or some well completion is allowing connection between the coal and this sand.

The coal and sand are monitored by the BLM at a location 10 mi west of the Nichols Ranch Unit at the Streeter site. Figure D6D.3-3 in Addendum D6D in Appendix D6 presents the water-level elevation for the Streeter Sand and Coal wells. This figure shows that the water level in the Streeter Sand well has been steady in the last three years. This sand is 621 ft above the top of the coal. The water levels from the Streeter Coal well were fairly steady from late 2004 through mid 2005 when water levels started to gradually decline. Water levels from this well have declined approximately 111 ft from mid 2005 through early 2009. The early change in the water level from the Streeter Sand well is unusual because the water level initially declined and then became steady. The recent steady water levels in the sand well indicate that the sand aquifer has not been affected by the CBM production.

The sand well in the All Night Creek area is completed 124 ft above the coal. These two wells (completed in the sand and coal) are approximately 10 mi to the southwest of the Hank Unit. Figure D6D.3-4 in Addendum D6D in Appendix D6 presents the water level changes for the All Night Creek wells. The water level changes in the coal are greater than 600 ft, while the water levels have very gradually declined approximately 5.0 ft over the last few years. This small decline could be natural change.

The Beaver Federal Sand and Coal wells are located approximately 19 mi north-northeast of the Hank Unit. Figure D6D.3-5 in Addendum D6D of Appendix D6 presents the water levels for the Beaver Federal Sand and Coal wells. The water level has not changed appreciably in the Beaver Federal Sand well, while the coal's water level has declined greater than 450 ft. This sand is 561 ft above the coal, similar to the A Sand completion above the coal. The response of the ore

sand water levels in the Nichols Ranch project to coal bed production should be similar to the response in this well.

The sixth cluster of CBM monitoring wells is located to the northwest of the Nichols Ranch ISR project. The Juniper well group water-level changes are presented on Figure D6D.3-6 in Addendum D6D of Appendix D6. The water-level elevations do not show a significant change in the sand well which is completed 418 feet above the top of the coal. The coal water-level declines are greater than 600 ft in this area.

An additional CBM monitoring location was started in late 2007 approximately 4.0 mi east of the Hank site which is called the Fourmile monitoring site. Figure D6D.3-7 in Addendum D6D of Appendix D6 presents the water-level data for the Fourmile Coal and Fourmile Wasatch Sand well. The Wasatch Sand well is located approximately 534 ft above the top of the coal seam. Figure D6D.3-7 in Addendum D6D of Appendix D6 shows that no water-level declines have been observed in the sand well and shows fairly steady water levels for the Fourmile Coal well during this monitoring period. The water-level drawdowns are estimated to be approximately 100 ft in the coal sand based on pre-CBM coal water-level elevations.

An additional CBM monitoring site was also added in late 2007 approximately less than 6.0 mi south of the Nichols Ranch Unit. This monitoring site is called the West Pine Tree site. Figure D6D.3-8 in Addendum D6D of Appendix D6 shows that the water levels in the Wasatch Sand, which is 782 ft above the coal, have been fairly steady after the initial variable measurements. Therefore, no drawdown in the Wasatch Sand, 782 ft above the coal have occurred at this location. This sand is located at a similar footage above the coal as the A Sand. The coal drawdown at this location is greater than 436 ft because some drawdown very likely occurred at this location prior to the start of monitoring.

The CBM water-level monitoring shows that sand wells completed a few hundred feet above the coal in this area have not exhibited drawdowns. The exception to this is the drawdowns observed in the Bullwhacker Sand well which is completed only 100 ft above the top of the coal.

It is likely that the drawdown in this sand well is caused by some artificial connection between the sand and the coal in this area.

The drawdown in the coal seam(s) for CBM production has the potential to cause hydrologic impacts in adjacent stratigraphic layers. The magnitude of drawdown in the coal for CBM production can be large, and thus the propagation of this drawdown into and through adjacent layers is of concern for other water or mineral extraction operations within these potentially affected strata. For uranium ISR operations in the vicinity of CBM activities, both the well field operation and lixiviant control could potentially be affected by significant water level changes due to external stresses.

In the Powder River Basin (PRB), the uranium production sand/sandstones are within the Wasatch Formation and are separated from the CBM production coal seams by a substantial thickness of sand/sandstone and silt/shale sequences. The fine-grained silt or shale layers act as aquitards and greatly restrict or preclude the vertical movement of ground water. This in turn limits the vertical propagation of drawdown. In order to evaluate the potential hydrologic impacts of CBM production on the uranium ore-bearing sands in the PRB, a multi-layer MODFLOW model was constructed to represent a typical stratigraphic column at the Nichols Ranch project area. The modeled 13 layer stratigraphic column extends from the coal seam up through sandstone representing a likely uranium production sand in order to evaluate the hydrologic impacts on the sequence of layers from the coal to the uranium production sand. The horizontal modeled area was set as a rectangle 15,000 ft x 5,000 ft. This quasi-strip configuration facilitated the placement of a separate constant head boundary for each layer at one end of the strip to represent the regional supporting aquifer system. The boundary condition at the other end of the strip was set as a variable head boundary. Well extraction stresses were placed in the coal seam layer approximately one-third of the total strip dimension from the variable head boundary end of the strip. In order to evaluate drawdown impacts, the resulting drawdown in the coal and overlying layers was analyzed for a location directly over the area where the well stresses were applied.

All layers in the model were established as confined aquifers with a uniform storage coefficient of 1.0 E-05. The top layer was a 40 foot thick sand layer with a transmissivity of 424 gal/day/ft which corresponds to a hydraulic conductivity of 5.0 E-04 cm/sec. Shale/silt intervals were broken into two layers for modeling purposes to further refine estimates of drawdown within the finer grained material where large gradients could potentially develop. Layers 2 and 3 were 50 foot thick shale layers with a transmissivity of 0.5 gal/day/foot. Layers 4, 5, and 6 repeated the thickness and properties sequence of layers 1 through 3. Layers 7, 8, and 9 also repeated this sequence. Layer 10 was modeled as 40 foot thick sand with a modest transmissivity of 21 gal/day/foot. Layers 11 and 12 were 20 ft thick shale intervals with a transmissivity of 0.5 gal/day/foot. Layer 13 was a 40 foot thick coal seam with a transmissivity of 21 gal/day/foot. The total sequence thickness is 500 ft and can generally be described as the uranium production ore sand (top) and CBM production coal seam (bottom) separated by an alternating sequence comprised of four shale layers and three intermediate sand layers.

The initial water level elevation (hereafter termed head) for each layer was scaled in a generally linear manner from an arbitrary value of 500 ft for the coal seam (layer 13) to 560 ft for the upper sand aquifer (layer 1). The difference between the head in the upper and lower layers represents the likely condition of progressively higher head in overlying aquifers. A simulation was also conducted with a much larger differential in initial head between upper and lower aquifers and the results were generally similar to those presented in the following discussion.

The model simulation period was 20 years in 15 stress periods. The stress period intervals were selected to provide complete definition of the transient drawdown response for the coal and adjacent layers. The magnitude of the wells stresses in the coal seam was varied to produce a large drawdown in the coal at the end of the simulation. The vertical conveyance between layers (termed Vcont in MODFLOW) was set as a uniform value for the interface between all layers and was then varied to produce total drawdown in layers 12 and 11 that was similar in magnitude to that predicted by the Neuman-Witherspoon (1972) method. This method allows calculation of drawdown in an adjacent aquitard based on the predicted drawdown in an aquifer.

The results of the MODFLOW simulation are presented for a selected model cell in Figure D6-8c in Appendix D6. Only the results for layers 7 through 13 are presented because there were no significant changes in head for layers 1 through 6. A large degree of drawdown (493 ft) was produced in the coal seam (layer 13). Layers 12 and 11 are shale layers directly above the coal and the magnitude of predicted drawdown in these layers is still large at 291 ft and 154 ft, respectively. These drawdowns compare favorably with those predicted by the Neuman-Witherspoon (1972) method and were used in evaluating the Vcont. The predicted drawdown in the sand layer nearest to the coal seam (layer 10) was greatly muted at 32 ft. The progressively diminishing drawdown the shale/sand sequences in general reflects the very small quantities of ground water that are actually conveyed vertically in the very low permeability shales. This tiny vertical conveyance produces only a very small stress on the sand aquifer (layer 10), and thus the magnitude of drawdown rapidly decreases with increasing distance from the coal seam.

The predicted drawdown in layers 9 and 8 (shale layers overlying the deepest sand in the sequence) is 19 ft and 9.1 ft respectively, which continues the trend of rapidly diminishing drawdown while moving upward through the strata sequence. The predicted drawdown in the next sand aquifer (layer 7) is an insignificant 0.1 ft. As mentioned previously, there were no significant predicted changes in head for layers above layer 7.

A summary of the model results is that a large drawdown in the coal seam resulting from CBM production may cause significant drawdown in the adjacent aquitard(s). This drawdown may also propagate into and through aquifers located in close vertical proximity to the coal seam, but will be greatly muted by even modestly transmissive layers within the sequence. For multiple shale/sand sequences above the coal, the drawdown is progressively attenuated and will not propagate beyond one or two alternating sequences above the coal seam. The attenuation of drawdown within a shale layer is very large, so the presence of even thin continuous aquitards above the coal will greatly dampen the propagation of drawdown to overlying layers. However, any strata that have a permeability similar to or greater than that in the coal, and are in direct contact with the coal, will exhibit a drawdown response that is similar to that of the coal. With the typical lithology present in the Nichols Ranch project area, the CBM induced drawdown will

not have a measurable impact on ore sand water levels unless there is an artificial connection through an improperly completed well or improperly abandoned bore hole.

The CBM drawdowns in the coal aquifer should not increase the potential for vertical excursions. The numerous aquitards between the coal and the ore sands should prevent the occurrence of significant drawdowns in the ore sands from CBM production. An artificial connection between the ore sand and the coal aquifer through a deep drill hole or deep well is the most likely pathway for a vertical excursion and thus the potential for such a connection should be evaluated.

CBM drawdowns could potentially cause drawdown in an ore sand if there are artificial connections with the production coal. In most cases, this CBM induced drawdown is not expected to appreciably affect gradients within a mine unit; therefore, will not significantly increase the potential for horizontal excursions. Unless the artificial connection is directly within a mine unit, the changes in the piezometric surface should affect the mining in a relatively uniform manner. If drawdown occurs within a mine unit it is due to an artificial connection, this actually reduces the potential for horizontal excursion while, as previously noted, raising concerns for vertical excursion.

The modeling of the vertical propagation of CBM drawdown through the shale and sand layers shows that the first continuous shale will greatly dampen the drawdowns in the aquifers above the shale. Some drawdown is likely to occur in the first aquifer above the coal aquifer but drawdowns should be very small beyond the first sand. Some of the sands near the coal aquifer may have direct connection with the coal at some locations; therefore, significant drawdown may develop in these connected aquifers. Ore sands, which are several hundred feet above the top of the coal, should not exhibit drawdown from the coal bed production unless artificial connections between the sand and the coal aquifer. It will be very important to determine if artificial connections exist within an ISR well field area and to correct any potential connections. Artificial connections that exist at some distance from the well field should not affect the potential for vertical or horizontal excursions.

2.7.2.1.4 Groundwater Quality

The groundwater quality at the Nichols Ranch ISR Project areas has been defined by sampling numerous wells in several aquifers in this area. Addendum D6E in Appendix D6 contains a tabulation of all groundwater quality. Addendum D6L in Appendix D6 also presents the water quality data in the Uranium Data Submission Spreadsheets. Some of the older water quality results were deemed not representative of the aquifer and are not used in the summary calculations of water quality. A criterion was established whereby the largest measured constituent concentration was deemed an outlier if it was greater than five times the next highest value in the data set. These outlier water quality results are highlighted in the water quality table in Addendum D6E in Appendix D6. Addendum D6E in Appendix D6 also presents Stiff and Piper plots and a discussion of the water quality for each aquifer.

Table 2-17 presents the summary of the ground-water quality. These summaries are grouped for the A Sand, F Sand, B and C Sands together, then the G and H Sands and finally the 1 Sand. The values in Addendum D6E in Appendix D6 that are highlighted are not included in Table 2-17 calculations. Only wells listed in Tables 2-13 and 2-14 for baseline water quality are included in the summary water quality. Three sets of parameters are listed in the upper half of the first page in Table 2-17.

The A Sand wells MN-1, MN-2, MN-3, MN-4, MN-5, MN-6 and DW-4L were used to calculate the average concentrations for the A Sand. The first row presents the number of samples followed by the average of those samples for that particular constituent. The maximum, mean and standard deviation are also given in the summary tabulations. The number of samples that have a concentration above the DEQ Class I standard is presented in the last row. The A Sand water typically has very low TDS, (less than 500 mg/l), with its major components being sodium, sulfate and bicarbonate.

Table 2-17 Summary of Groundwater Quality.

A SAND WELLS: MN-1, MN-2, MN-3, MN-4, MN-5, MN-6 and DW-4L

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	30	30	30	30	30	30	30	30	30	26	30	25	27	25
Average	7.573	7.993	4.317	139.667	2.227	0.567	113.500	132.433	0.067	14.869	333.000	557.780	575.704	8.467
Maximum	11	16	24	168	5.7	1	130	183	0.65	20	370	643	720	8.74
Minimum	5.3	4	0.5	80	1.7	0.4	84	85	0.005	7.4	289	450	507	7.41
Standard Deviation	1.472	2.919	5.043	20.767	0.764	0.160	8.901	24.349	0.127	2.624	22.734	43.106	55.579	0.270
No. of Samples above Class I	-	0	-	-	-	-	-	0	1	-	0	-	-	13

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	29	29	30	25	30	29	29	29	29	29	29	29	30	28
Average	8.38897	0.0075	0.0845	0.05	0.2453	0.05	0.00186	0.05	0.0224	0.005	0.077586	0.002931	0.000478	0.05
Maximum	9.5	0.03	0.57	0.05	0.3	0.05	0.0085	0.05	0.025	0.005	0.5	0.005	0.0007	0.05
Minimum	7.26	0.005	0.02	0.05	0.1	0.05	0.0005	0.05	0.005	0.005	0.05	0.0025	0.00015	0.05
Standard Deviation	0.45776	0.0059	0.1239	1.416E-17	0.0651	2.1E-17	0.00153	2.1E-17	0.0066	2E-18	0.104014	0.000961	9.71E-05	2E-17
No. of Samples above Class I	10	0	1	0	0	-	0	0	0	0	0	0	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	29	30	30	30	29	30	29	24	29	24	24
Average	0.02224	0.0064	0.0007	0.0078567	0.05	0.00675	5.80862	0.86875	6.5276	26.229	29.5
Maximum	0.025	0.08	0.0015	0.027	0.05	0.04	36.3	4.2	38.2	131	145
Minimum	0.005	0.0005	0.0005	0.00015	0.05	0.005	0.1	0.5	0.1	0.5	1
Standard Deviation	0.00702	0.0158	0.0003	0.0077016	2E-17	0.00686	9.94523	0.865	10.116	32.248	41.63694
No. of Samples above Class I	-	4	0	-	-	0	-	-	5	13	-

F SAND WELLS: DW-4U, HANK 1, DRY WILLOW #1, WC-MN1, BR-B, C #1, SS1-F, URZHF-1, URZHF-5, URZHF-8 and URZNF-3

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	43	43	34	43	43	42	43	43	43	37	42	31	40	32
Average	103.112	5.560	0.759	168.791	7.247	23.938	189.698	612.767	0.284	12.086	1042.071	1465.323	1562.975	7.885
Maximum	293	33	6	421	16	96	261	981	3.9	17.1	1860	1910	3370	9.94
Minimum	44	0.5	0	10	5	6	94	418	0.005	8	710	994	995	7.16
Standard Deviation	47.260	4.932	1.137	78.964	2.244	15.622	35.150	142.870	0.686	2.090	244.805	236.297	427.013	0.474
No. of Samples above Class I	-	0	-	-	-	-	-	51	17	-	50	-	-	1

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	41	43	42	26	43	40	40	38	40	40	43	40	40	39
Average	7.73854	0.069	0.0468	0.0538462	0.1467	0.05788	0.00626	0.04658	0.0194	0.0173	0.091163	0.003288	0.000468	0.05
Maximum	10.4	0.26	0.13	0.1	0.5	0.4	0.188	0.05	0.03	0.33	0.8	0.014	0.0013	0.05
Minimum	6.47	0.005	0.005	0.05	0.01	0.025	0.0005	0.015	0.005	0.005	0.005	0.001	0.00015	0.05
Standard Deviation	0.77619	0.0584	0.0291	0.0135873	0.0913	0.05627	0.02957	0.01021	0.0091	0.053	0.139961	0.00213	0.000198	3E-17
No. of Samples above Class I	8	34	0	0	0	-	1	0	0	0	0	5	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	40	40	40	43	40	42	41	24	41	24	24
Average	0.0195	0.0063	0.0162	0.1665721	0.0469	0.02012	45.4659	0.79583	45.932	416.68	161.3708
Maximum	0.025	0.05	0.574	5.25	0.05	0.32	562	4	566	5090	1540
Minimum	0.005	0.0005	0.0005	0.0005	0.025	0.005	0.1	0.2	0.6	7.6	5
Standard Deviation	0.00838	0.0106	0.0905	0.8101593	0.0084	0.05049	95.8739	0.84054	96.454	1103.5	362.2063
No. of Samples above Class I	-	9	0	-	-	0	-	-	22	18	-

Table 2-17 (Continued)

B SAND WELLS: BR-Q, BR-T, F. Brown #1, Brown #5, NBHW-13, SS1-M, URZNB-1 and URZHB-6

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	46	46	35	46	46	46	35	45	45	34	44	30	37	37
Average	61.891	7.763	2.943	125.000	7.259	11.991	184.714	477.067	0.128	13.179	812.886	1206.233	1214.892	8.084
Maximum	117	80	26	242	41	22	250	620	1	18	958	1450	2100	9.63
Minimum	5	3	0.5	84	3	0.5	85	121	0.005	3	278	537	535	7.16
Standard Deviation	26.076	11.834	5.938	33.143	5.680	4.508	42.396	140.009	0.217	3.195	181.178	275.393	326.546	0.551
No. of Samples above Class I	-	0	-	-	-	-	-	44	7	-	42	-	-	6

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	34	45	45	21	42	45	45	45	44	45	44	45	44	34
Average	7.95088	0.0306	0.8028	0.05	0.1529	0.10456	0.00228	0.05067	0.0174	0.0137	0.091477	0.0042	0.000649	0.075
Maximum	9.62	0.09	26	0.05	0.88	0.7	0.007	0.15	0.025	0.2	0.5	0.02	0.00475	0.5
Minimum	6.84	0.005	0.02	0.05	0.01	0.025	0.0005	0.015	0.0025	0.005	0.005	0.0005	0.0001	0.05
Standard Deviation	0.6692	0.0236	3.999	7.11E-18	0.1646	0.12941	0.00207	0.02736	0.0094	0.0307	0.123602	0.003348	0.000947	0.0963
No. of Samples above Class I	4	8	2	0	0	-	0	0	0	0	0	6	2	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	45	45	45	44	45	44	42	21	42	21	21
Average	0.02089	0.0094	0.0022	0.0728523	0.0416	0.29023	16.3738	0.75238	16.75	72.757	33.38095
Maximum	0.07	0.13	0.025	2.16	0.2	3.19	128	2	128	404	169
Minimum	0.005	0.0005	0.0005	0.0005	0.0025	0.005	0	0.5	0	6.6	1
Standard Deviation	0.01062	0.0208	0.0038	0.3248452	0.03	0.66384	31.4438	0.4665	31.458	120.26	52.62517
No. of Samples above Class I	-	12	0	-	-	0	-	17	0	0	-

C SAND WELLS: DW-4M, SS1U and URZHC-2

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	17	17	16	17	16	17	17	17	17	16	17	10	16	12
Average	32.876	6.400	2.906	103.765	5.869	7.876	190.647	414.765	0.042	12.863	713.941	1009.100	1241.063	8.489
Maximum	49	11	13	193	13	13	240	514	0.24	17	920	1282	2010	9.68
Minimum	7	1	0	26	4	1	110	219	0.005	3	387	629	670	7.65
Standard Deviation	13.282	2.876	3.804	49.054	2.269	4.222	39.721	115.284	0.056	3.526	186.198	253.730	362.402	0.713
No. of Samples above Class I	-	0	-	-	-	-	-	15	0	-	13	-	-	5

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	16	17	17	6	17	17	17	17	17	17	17	17	17	17
Average	8.39875	0.0109	0.0553	0.05	0.2247	0.06618	0.00132	0.05353	0.015	0.0065	0.157059	0.003588	0.000376	0.0529
Maximum	10.4	0.04	0.19	0.05	0.52	0.2	0.0025	0.15	0.025	0.03	0.7	0.006	0.0005	0.1
Minimum	7.2	0.005	0.025	0.05	0.05	0.025	0.0005	0.015	0.005	0.005	0.005	0.001	0.00015	0.05
Standard Deviation	0.93835	0.0116	0.0449	7.601E-18	0.1683	0.04995	0.00079	0.03928	0.0094	0.0061	0.216254	0.001593	0.000137	0.0121
No. of Samples above Class I	4	0	0	0	0	-	0	0	0	0	0	1	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	17	17	17	16	17	17	14	6	14	6	6
Average	0.01735	0.0093	0.0017	0.008225	0.0471	0.03088	8.35714	0.675	8.6464	14.933	10.73333
Maximum	0.03	0.04	0.008	0.024	0.1	0.18	54	1.9	54	57.7	32.4
Minimum	0.005	0.0005	0.0005	0.00015	0.025	0.005	0.1	0.15	0.35	0.5	1
Standard Deviation	0.00868	0.0117	0.0019	0.006926	0.0174	0.04884	14.3368	0.61624	14.213	21.956	11.48419
No. of Samples above Class I	-	3	0	-	-	0	-	-	6	2	-

Table 2-17 (Continued)

G SAND WELLS: BR-F and BR-H

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	12	12	12	12	12	11	12	12	12	9	12	11	10	12
Average	34.667	8.167	10.900	133.833	6.250	5.773	127.917	236.333	0.337	11.400	485.583	738.091	828.500	8.659
Maximum	78	27	48	194	13	10	190	400	2.04	14.8	696	1080	1886	10.9
Minimum	8	3	0.5	13	3	0.5	74	79	0.015	6.8	236	334	414	7.1
Standard Deviation	22.952	7.590	16.602	57.887	3.079	3.587	48.391	142.551	0.601	2.328	208.249	306.943	467.752	1.146
No. of Samples above Class I	-	0	-	-	-	-	-	6	4	-	6	-	-	4

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	9	12	12	8	11	11	11	11	11	11	11	11	11	8
Average	8.47222	0.055	0.0571	0.05625	0.2791	0.27273	0.00277	0.04318	0.0232	0.0064	0.218182	0.002818	0.0005	0.05
Maximum	10.24	0.22	0.16	0.1	0.4	0.8	0.007	0.05	0.025	0.01	1	0.005	0.0005	0.05
Minimum	7.06	0.005	0.025	0.05	0.2	0.05	0.0005	0.025	0.005	0.005	0.05	0.001	0.0005	0.05
Standard Deviation	0.93209	0.0667	0.0422	0.0176777	0.0837	0.3077	0.00242	0.01168	0.006	0.0023	0.315652	0.001168	1.14E-19	7E-18
No. of Samples above Class I	4	4	0	0	0	-	0	0	0	0	1	0	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	11	11	11	11	11	10	8	8	8	8	8
Average	0.02364	0.0142	0.0018	0.0010591	0.0432	0.008	0.125	0.5875	0.7125	1.2125	2.925
Maximum	0.025	0.1	0.005	0.009	0.05	0.02	0.3	1	1.1	3.9	5.6
Minimum	0.02	0.0005	0.0005	0.00015	0.025	0.005	0.1	0.5	0.6	0.2	1
Standard Deviation	0.00234	0.0301	0.0021	0.0026397	0.0117	0.00483	0.07071	0.18077	0.21	1.1886	1.858379
No. of Samples above Class I	-	4	0	-	-	0	-	-	0	0	-

H SAND WELLS: BR-I and URZHH-7

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	6	6	6	6	6	6	6	6	6	4	6	5	4	6
Average	80.500	4.500	0.500	190.333	5.283	20.833	91.667	308.333	0.581	12.650	618.000	1023.800	990.500	7.648
Maximum	107	8	0.5	270	8	29	180	610	2.16	16.7	1010	1430	1578	8.01
Minimum	47	3	0.5	112	2	13	8	9	0.015	5.7	225	400	420	7.1
Standard Deviation	25.821	1.761	0	85.090	2.994	7.627	88.953	325.735	0.904	4.909	420.020	551.835	506.405	0.362
No. of Samples above Class I	-	0	-	-	-	-	-	3	2	-	3	-	-	0

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	3	6	6	3	6	6	6	6	6	6	6	6	6	3
Average	7.28333	0.0392	0.1558	0.05	0.1683	0.51667	0.00275	0.075	0.0217	0.0075	0.2	0.00375	0.000433	0.05
Maximum	8.8	0.17	0.66	0.05	0.2	1.6	0.005	0.25	0.025	0.01	0.5	0.005	0.0005	0.05
Minimum	6.49	0.005	0.025	0.05	0.1	0.05	0.0005	0.025	0.005	0.005	0.05	0.0025	0.0001	0.05
Standard Deviation	1.31394	0.0649	0.2482	8.498E-18	0.0402	0.72915	0.00214	0.0866	0.0082	0.0027	0.232379	0.001369	0.000163	8E-18
No. of Samples above Class I	1	1	0	0	0	-	0	0	0	0	0	0	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	6	6	6	6	6	6	5	3	5	3	3
Average	0.02333	0.0281	0.0034	0.0268167	0.0304	0.035	1.76	1.13333	2.44	78.933	26.7
Maximum	0.025	0.117	0.005	0.0462	0.05	0.1	2.1	2.9	5	89	29.9
Minimum	0.02	0.0005	0.002	0.007	0.0025	0.005	1	0	1	71.5	23.8
Standard Deviation	0.00258	0.0452	0.0013	0.0178729	0.0228	0.03768	0.43932	1.55027	1.511	9.0423	3.061046
No. of Samples above Class I	-	3	0	-	-	0	-	-	0	0	-

Table 2-17 (Continued)

1 SAND WELL: URZN1-2

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	4	4	4	4	4	4	4	4	4	2	4	4	4	4
Average	3.75	5	15.75	233.75	2.25	0.5	99.5	1.5	0.015	15.2	232	411.5	416	8.63
Maximum	4	6	24	246	3	0.5	104	2	0.015	16.3	248	425	421	9.39
Minimum	3	4	12	209	2	0.5	92	1	0.015	14.1	204	393	409	7.07
Standard Deviation	0.500	0.816	5.560	16.820	0.500	0	5.260	0.577	0.000	1.556	20.331	13.379	5.033	1.054
No. of Samples above Class I	-	0	-	-	-	-	-	0	0	-	0	-	-	3

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Average	8.935	0.005	0.07	0.05	0.65	0.05	0.0005	0.05	0.025	0.005	0.05	0.0025	0.0005	0.05
Maximum	9.15	0.005	0.09	0.05	0.7	0.05	0.0005	0.05	0.025	0.005	0.05	0.0025	0.0005	0.05
Minimum	8.78	0.005	0.05	0.05	0.6	0.05	0.0005	0.05	0.025	0.005	0.05	0.0025	0.0005	0.05
Standard Deviation	0.1698	0	0.0183	0	0.0577	0	0	0	0	0	0	0	0	0
No. of Samples above Class I	4	0	0	0	0	-	0	0	0	0	0	0	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Average	0.025	0.0005	0.0005	0.00015	0.05	0.005	0.1	0.5	0.6	0.5	1.325
Maximum	0.025	0.0005	0.0005	0.00015	0.05	0.005	0.1	0.5	0.6	0.5	2.3
Minimum	0.025	0.0005	0.0005	0.00015	0.05	0.005	0.1	0.5	0.6	0.5	1
Standard Deviation	0	0	0	0	0	0	0	0	0	0	0.65
No. of Samples above Class I	-	0	0	-	-	0	-	-	0	0	-

COTTONWOOD ALLUVIUM: URZNQ-4

	Ca	Cl	CO3	HCO3	K	Mg	Na	SO4	Fe	Temp	TDS	Cond	Cond(f)	pH
No. of Samples	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Average	507.5	30.75	0.5	483	9.25	144.5	415.75	2392.5	1.4625	9.4	3902.5	4325	4100	7.31
Maximum	543	33	0.5	499	11	152	430	2500	3.31	11.3	3980	4440	5110	7.4
Minimum	480	28	0.5	467	8	136	403	2340	0.68	4.7	3820	4170	2710	7.19
Standard Deviation	32.419	2.062	0.000	16.833	1.258	8.185	14.245	72.744	1.248	3.143	65.511	113.284	1004.191	0.088
No. of Samples above Class I	-	0	-	-	-	-	-	4	4	-	4	-	-	0

	pH(f)	Mn	NH3	NO3+NO2	F	Al	As	Ba	Cr	Cu	B	Cd	Hg	Mo
No. of Samples	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Average	6.84	1.895	0.2525	0.5	0.1925	0.05	0.0045	0.05	0.025	0.005	0.075	0.0025	0.0005	0.05
Maximum	6.95	1.95	0.34	0.5	0.2	0.05	0.006	0.05	0.025	0.005	0.1	0.0025	0.0005	0.05
Minimum	6.65	1.84	0.2	0.5	0.17	0.05	0.002	0.05	0.025	0.005	0.05	0.0025	0.0005	0.05
Standard Deviation	0.13711	0.0493	0.0618	0	0.015	0	0.00173	0	0	0	0.028868	0	0	0
No. of Samples above Class I	0	4	0	0	0	-	0	0	0	0	0	0	0	-

	Ni	Pb	Se	Unat	V	Zn	Ra226	Ra228	Ra226+ Ra228	Alpha	Beta
No. of Samples	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Average	0.025	0.0005	0.001	0.087225	0.05	0.01375	0.65	0.875	1.525	115.9	33.775
Maximum	0.025	0.0005	0.002	0.0946	0.05	0.04	0.9	1.4	2.2	164	61.9
Minimum	0.025	0.0005	0.0005	0.0832	0.05	0.005	0.4	0.3	0.9	72.6	19.6
Standard Deviation	0	0	0.0007	0.0051266	0	0.0175	0.20817	0.55603	0.5852	37.419	19.07221
No. of Samples above Class I	-	0	0	-	-	0	-	-	0	0	-

For the thirty samples, the TDS varies from a minimum of 289 to 370 mg/l with a standard deviation of 23 mg/l. The sulfate concentrations for the thirty samples vary from 85 to 183 mg/l while the chloride concentrations vary from 4 to 16 mg/l. Variations are 84 to 130 mg/l for sodium and 5.3 to 11 mg/l for calcium. The variation of uranium concentrations are over a small range from less than detection values to a maximum 0.027 mg/l. These A Sand wells are fully penetrating wells; therefore, the uranium and radium concentrations will be significantly less for the average of the aquifer than within the ore zone. Radium concentrations from the A Sand vary from less than detection to 36.3 pCi/l. The radium-226 concentrations would likely be in a few hundred pCi/l for a partially penetrating well completed only in the ore zone.

The second group of three sets of summary parameters is for the F Sand wells DW-4U, Hank 1, Dry Willow #1, WC-MN1, BR-B, C #1, SS1F, URZHF-1, URZHF-5 and URZNF-3. F Sand wells BR-G and OW43756 were not included in summary calculations because their water level elevations indicate that they are receiving water from an aquifer with a higher head. Forty-five samples have been collected from the F Sand wells, with the average TDS concentration greater than 1,000 mg/l. The range in TDS concentration is from 710 to 1,860 mg/l. Sodium, calcium, bicarbonate and sulfate are the major dissolved constituents in this water. The number of times the F Sand aquifer water exceeds the Class I standard for sulfate, iron, TDS, manganese, lead and radium-226+228 are 51, 17, 50, 34, 9 and 22 times respectively.

The sulfate concentrations varied over a large range from 418 to 981 mg/l while the chloride concentrations are low in the F Sand water with a variation of less than detection to 33 mg/l. The cations with the largest concentrations are sodium with a variation from 94 to 261 mg/l and calcium which varies from 44 to 293 mg/l. Uranium concentrations varied from less than detection to a high of 5.25 mg/l in this ore bearing sand. Radium concentrations have varied from less than detection to 566 pCi/l.

The two sands that are typically between the A and F production sands are the B and C Sands. The water quality data for these two sands were tabulated on the second page of Table 2-17 with the water quality for the B Sand on the top of the page and the C Sand on the bottom. The B Sand analysis includes wells BR-Q, BR-T, F. Brown #1, Brown #5, NBHW-13, SS1-M,

URZNB-1 and URZHB-6. TDS concentrations for this aquifer are typically above 600 mg/l with the larger major constituent concentrations being those of sodium, bicarbonate and sulfate.

The TDS of this water ranges from 278 to 958 mg/l. Sodium is the major cation in this water with concentration variations of 85 to 250 mg/l. Sulfate is a major anion with concentrated variation from 121 to 620 mg/l. These sands do show low concentrations of uranium in some areas that is attributed to limited mineralization. The radium 226+228 concentrations in the B aquifer vary from less than detection to a maximum of 128pCi/l. Sulfate, TDS and radium are the main parameters that exceed the Class I use standards in the B Sand. The water quality for the C Sand is summarized on the bottom half of the second page of Table 2-17. Wells DW-4M, SS1-U and URZHC-2 were used to develop a summary of the C Sand water quality. TDS concentrations in the C Sand vary from a minimum of 387 to 920 mg/L. The major cation in this water is sodium and the major anions are sulfate and bicarbonate. Sulfate concentrations vary from a maximum of 514 to a minimum of 219 mg/L. Fifteen of the sulfate concentrations exceed the Class I standard, while thirteen of the TDS samples exceed the Class I TDS standard. Radium-226+228 exceeds the Class I standard in six of the C Sand samples.

The group of parameters on the third page of Table 2-17 is for the G and H Sands which are the overlying and surficial sands for the F Sand in the Hank Unit area. The G Sand summary was made from water quality from BR-F and BR-H wells. This tabulation shows that, on average, the TDS is near 500 mg/l with a range of 236 to 696 mg/l. The major constituents with the highest concentrations are sodium, sulfate and bicarbonate.

The uranium and radium concentrations in these two G Sand wells were small. This data indicates that the wells completed in the G Sand are not near mineralized areas.

The summary of the water quality for the H Sand was developed using data from H Sand wells BR-I and URZHH-7. The H Sand water quality varies significantly with the major anion being sulfate in one of the wells and bicarbonate in the other. The major cation is sodium in one well and calcium in the other well. The TDS varies from a maximum of 1,010 to a minimum of 225 mg/L. Table 2-17 shows that three of the sulfate and TDS values exceed the Class I

standard for the H Sand. Three of the lead concentrations also exceed the Class I use standard. Uranium concentration in the H Sand samples varied from very low values up to 0.046 mg/L.

The fourth page of Table 2-17 presents the summary of water quality for the 1 Sand well URZN1-2 in the Nichols Ranch Unit area. This data shows that the TDS is slightly greater than 200 mg/l with sodium and bicarbonate being the major components of this water quality. The sulfate and chloride concentrations for the 1 Sand vary over a very small range. Sodium concentrations vary from 92 to 104 mg/l. Bicarbonate is the major anion in this water with very low levels of uranium and radium indicating no mineralization near this 1 Sand well. No other constituent concentrations are significant in the water from the 1 Sand.

A summary of the Cottonwood Alluvial water quality is developed from the data collected from well URZNQ-4. The TDS from the Cottonwood Alluvial ground-water is high with all values greatly exceeding the Class I use standard. The average value is 3,902 mg/L. Sulfate concentrations are also high with the maximum value being 2,500 mg/L. The high TDS and sulfate concentrations in the Cottonwood Alluvium are natural and are due to the effects of this aquifer being a very shallow aquifer and a discharge point for other aquifers. Transpiration of ground water is significant relative to increasing the TDS in this shallow ground-water system. All four of the samples from the Cottonwood Alluvial well significantly exceed the iron and manganese concentrations. These two constituents naturally exist at significant levels in groundwater. The gross alpha concentrations all significantly exceed the Class I standard for gross alpha.

All groundwater sampled for the Nichols Ranch ISR Project was analyzed for the constituents found in Table 2-17a.

Table 2-17a Baseline Water Quality Monitoring Parameters.

Table 2-17a Baseline Water Quality Monitoring Parameters*	
Parameter	*Units*
Carbonate as CO3	mg/L
Bicarbonate as HCO3	mg/L
Calcium	mg/L
Chloride	mg/L
Fluoride	mg/L
Magnesium	mg/L
Nitrogen, Ammonia as N	mg/L
Nitrogen, Nitrate+Nitrate as N	mg/L
Potassium	mg/L
Silica	mg/L
Sodium	mg/L
Sulfate	mg/L
Conductivity	umhos/cm
pH	s.u.
Total Dissolved Solids	mg/L
Dissolved Aluminum	mg/L
Dissolved Arsenic	mg/L
Dissolved Barium	mg/L
Dissolved Boron	mg/L
Dissolved Cadmium	mg/L
Dissolved Chromium	mg/L
Dissolved Copper	mg/L
Dissolved Iron	mg/L
Dissolved Lead	mg/L
Dissolved Manganese	mg/L
Dissolved Mercury	mg/L
Dissolved Molybdenum	mg/L
Dissolved Nickel	mg/L
Dissolved Selenium	mg/L
Dissolved Uranium	mg/L
Dissolved Vanadium	mg/L
Dissolved Zinc	mg/L
Total Iron	mg/L
Total Manganese	mg/L
Gross Alpha	pCi/L
Gross Beta	pCi/L
Radium-226	pCi/L
Radium-228	pCi/L

*Parameters from WDEQ-LQD Guideline No. 8, Hydrology, March 2005

2.7.2.1.4.1 Coal Bed Methane Groundwater Quality

CBM extraction has not yet begun in the Nichols Ranch Unit. CBM wells are being drilled and CBM infrastructure (pipelines, power, etc.) is being developed, but no surface discharge has occurred except in the far western edge of the license area. Maps supplied to Uranerz by a CBM producer do show the construction of one other CBM reservoir being located in the Northeast part of the Nichols Ranch Unit license area with a proposed reservoir size of 15.6 acre-ft. To date, no water has been discharged into this reservoir. Uranerz will continue to work with CBM producers in the area to monitor progress of CBM develop and to keep inform when, if any, CBM water will be discharged to surface reservoirs within the license area.

CBM activity at the Hank Unit is also in the developmental stage. Some wells have been drilled and have started pumping in 2008, but no surface discharge has occurred. The CBM producer who is developing the CBM in the Hank Unit license boundary will not have any surface water discharge. Any water that is produced from the CBM will be pumped to a large storage unit and then pumped some 35 mi away to be re-injected into a different underground formation. However, another CBM producer outside of the Hank Unit license area will be surface discharging into a reservoir outside of the Hank Unit license area. This reservoir could then discharge into Dry Willow Creek, but as explained at the end of this section, the CBM water should not have any effect on the Hank Unit groundwater. Additionally, if any new CBM ponds or basins are installed in or within a 0.25 mi of the Hank Unit, Uranerz will notify the NRC of these developments.

There are currently two outfalls located within the Nichols Ranch Unit license boundary. The location of each outfall is summarized in Table 2-18.

To date, only outfall 001 of permit WY0051161 has discharged to the surface within the license area at the Nichols Ranch Unit. Discharge monitoring report (DMR) data for the outfall is provided in Table 2-19. This table shows that the sulfate concentration is very low at 33 mg/l for this discharge. Water quality results are also presented in Table 2-19 for permit WY 0054411-10 which had a sulfate concentration less than detection. The very low sulfate concentration in the CBM water should be detectable in the surficial aquifers if the CBM water ever affects the surficial aquifer.

Table 2-18 Outfalls Located Within Nichols Ranch Unit License Boundary.

Operator, Project, Permit	Outfall	Quarter Quarter	Section	Township	Range
Williams Production RMT Company T-Chair Unit WY0051161	001	NWSE	18	43N	76W
Yates Petroleum Corporation Rolling Pin Spatula State WY0056502	002	NENE	17	43N	76W

Table 2-19 Williams Production RMT Company (WY0051161 and WY0054411-10) Average Water Quality and Discharge Rates.

			WY0051161	WY0054411-10
Parameter	**Unit**	**Permit Limit**	**Average Historical Data**	**Water Quality 2/13/07**
Bicarbonate	mg/L		1170	773
Chlorides	mg/L	46	7.5	6
Dissolved Calcium	me/L		9	1.09
Dissolved Iron	ug/L	1000	862	<30
Dissolved Magnesium	me/L		3.5	1.48
Dissolved Manganese	ug/L	646	33	12
Dissolved Sodium	me/L		14.8	9.54
pH	s.u.	6.5-8.5	7.4	7.91
Sodium Absorption Ratio	calculated		6.1	8.4
Specific Conductance	micromhos/cm	7500	2390	1120
Sulfates	mg/L	3000	33	<1
Total Alkalinity	mg/L as CaCO3		956	634
Total Arsenic	ug/L	7	1	7.9
Total Barium	ug/L	1800	2270	744
Total Flow (MGD)	MGD	0.057	0.018	-
Total Petroleum Hydrocarbons	mg/L	10	Non-Detect	-
Total Radium 226	pCi/L	1	0.9	0.9

Table 2-20 presents the estimated water quality of Yates Petroleum Corporation's WY0056502 Outfall 002. These data represent the water quality of an outfall targeting the same coal seam, located within 6.0 mi of outfall 002. The water quality analysis was included with the WYPDES permit application submitted to the WDEQ.

The impoundments and surface discharges in the Nichols Ranch Unit may infiltrate a few gallons per minute of water into the surficial aquifer in areas where the surface is very sandy. This water will likely take a very long time to affect the water quality in the F Sand or in the Cottonwood Alluvium in this area. The location of impoundments upgradient of the F Sand monitoring well URZNF-3 are greater than 4,000 ft away; therefore, the travel time is estimated to be greater than 100 years to reach well URZNF-3. It is doubtful that the water quality changes from the CBM discharges will be detected during the operation of the Nichols Ranch Unit. The most likely area to be affected is the Cottonwood Alluvium and its natural water quality has a significantly higher TDS than the CBM discharge water. Therefore, some decrease in concentration may possibly be observed in the Cottonwood Creek alluvial water.

Table 2-20 Yates Petroleum Corporation (WY0056502) Estimated Water Quality and Discharge Rate.

Parameter	Unit	Permit Limit	Estimated Concentrations
Chlorides	mg/L	150	8
Dissolved Iron	ug/L	1,000	<30
pH	s.u.	6.5 – 9.0	8.09
Sodium Adsorption Ratio	calculated	17	11
Specific Conductance	micromhos/cm	2,800	1,840
Total Arsenic	ug/L	8.4	1.8
Total Barium	ug/L	1,800	1,280
Total Flow (MGD)	MGD	N/A	N/A

The sulfate concentration in the CBM water is very low and should cause significant decline in this constituent if the CBM water has affected the surficial aquifer water quality. Typically, infiltration is most pronounced in the shallow, unconsolidated materials overlying the Wasatch Formation bedrock. Uranerz anticipates little to no infiltration through the claystones and siltstones that dominate the near surface bedrock stratigraphy. In addition, infiltration rates at CBM impoundments tend to decrease during the first six months of operation as native clays swell and disperse as the soil SAR increases. The swelling and dispersion of the clays leads to soil sealing and a reduction in the hydraulic conductivity.

The CBM produce water has not been discharged into the majority of the Nichols Ranch Unit license area prior to defining baseline water quality in the surface water and overlying aquifers; therefore, CBM has not affected the baseline water quality.

2.7.2.2 Jane Dough Unit

The regional ground-water setting has been defined by Hodson and others, 1973, and Whitehead, 1996. The Jane Dough permit area is located in the south-central Powder River Basin, to the southwest of the Middle Pumpkin Butte. The regional Quarternary aquifers are alluvial aquifers adjacent to the major drainages in the area. The North Platte, Powder River, Belle Fourche, and Cheyenne are the major streams in this region. Hodson and others, 1973, indicates a large range in transmissivity and well yields in these alluvial aquifers with the poorest water quality in the Powder River alluvium. Geologic structure in the permit area is relatively flat with a gentle dip to the southwest toward the basin axis. The Wasatch Formation is the uppermost geologic unit in the area of the Jane Dough permit. The sands within the Wasatch Formation create regional aquifers in this area. Whitehead, 1996 also presents information relative to the regional groundwater setting in this area. Ground water in the Wasatch aquifers generally flows to the north and northwest in this area. The transmissivity and yield from the Wasatch Formation is also highly variable with the yield up to a few hundred gallons per minute when a large thickness of saturated sands are completed in a well. The water quality in these aquifers would also generally be good, with a TDS concentration typically from <1,000 mg/l to <2,000 mg/l. The aquifers of interest in this area are sands within the Wasatch Formation. The confining units between the aquifers are also within the Wasatch Formation.

The sandstones and the coal seams form aquifers in the Fort Union Formation. The aquifers will be deeper than the Wasatch aquifers but the general flow in the aquifer would be expected to be in the similar direction as the flow in the Wasatch aquifers. Whitehead, 1996 indicates that some of the flow between the aquifers is upwards in this region. Groundwater quality of the Fort Union aquifers would also be expected to be relatively good with TDS generally less than 2,000 mg/l. The Lance Formation consists mainly of very fine to fine grain sandstone shale and coal beds.

The ground-water flow direction in the Lance Formation in this area is expected to be to the north. Water quality data is very limited on the Lance Formation in this area but the TDS would be expected to be >2,000 mg/l based on the limited data. The TDS is less toward the outcrop area to the southwest. TDS concentrations near the outcrops have been reported to be <1,000 mg/l.

The Foxhills Sandstone exists below the base of the Lance Formation. Foxhills is mainly a fine to medium grain sandstone. The ground-water flow direction in the Foxhills would be expected to be to the north in this area based on a map presented in Whitehead, 1996. The TDS values varied from 2,230 to 4,800 mg/l from the drill stem test for the deep disposal well in the Nichols Ranch Unit. The TDS in the outcrop area to the southwest has been measured to be from 1,000 to >2,000 mg/l.

The Lewis Shale underlies the Foxhill aquifer and is mainly an aquitard. This shale contains some lenses of fine grained sandstone but is generally not a very significant producer of water. The water quality in the Lewis Shale would be expected to be very poor. TDS in the Lewis Shale is likely to exceed 5,000 mg/l in this area.

2.7.2.2.1 Hydrologic Setting and Well Construction

The Jane Dough Unit is located in the outcrop of the Wasatch Formation. The stratigraphy of the Wasatch at this site consists of alternating layers of sand and shale with lignite marker beds. The mineable ore exists in one sand member, designated as the A Sand at the Jane Dough Unit.

The aquifer and aquitard sequence at the project area is shown in Figure JD-D6-2. This shows labeled sands from the 1, A, B, C, F, G, and H Sands. This figure also shows the aquitards that exist between the different sands and those aquitards are labeled as by the combination of labels for the two adjacent sands. The AB aquitard is absent in the eastern and northwest portions of the Jane Dough Unit as described in Appendix JD-D5. These sands are the same names that are used at Power Resources North Butte permit which exists just north of the Hank Unit site. The majority of the wells completed in the Jane Dough Unit are completed in the A Sand because this is the ore bearing sand in this area. Figure JD-D6-4 shows the locations of the Jane Dough Unit wells and Exhibit JD-D6-1 shows the locations of wells within three miles of the Jane Dough Unit. Table JD-D6-2 presents the tabulation of the well data for the Jane Dough Unit wells. Table JD-D6-2 shows that eight of the wells have been completed in the A Sand for definition of baseline water level and water quality with four wells completed in the B Sand, one well in the C Sand, three wells in the F Sand, two wells in the G Sand, three in the 1 Sand. Three wells were completed in the Cottonwood, Dry Fork, and Seventeen Mile alluviums. All of these wells with the exception of URZJG-17 and the alluvial wells, URZJQ-24-1, URZJQ-25, and URZJQ-26, are open hole completed. Additional ranch wells, Nichols #1, Pats #1, and Pug #1, are presented in the table but not used for baselining. Addendum JD-D6L gives the Uranium Data Submission Spreadsheets which contain additional information on the wells.

2.7.2.2.2 Summary of Aquifer and Aquitard Properties

Numerous single-well pump tests and multi-well pump tests were conducted at the Jane Dough Unit to define the aquifer properties. The detailed hydrologic analyses and supporting data are contained in Addendums JD-D6B and JD-D6C for the single-well and multi-well tests, respectively. Five multi-well pump tests were conducted at the Jane Dough Unit site and are referred to in this report as the URZJA-1, URZJA-7, URZJA-8, URZJA-13-1 and URZJA-14-1 tests. Table JD-D6-2 presents the basic well data for wells used to define the aquifer properties for the Jane Dough Unit. Addendum JD-D6J presents the aquifer test theory used to analyze the pump tests.

2.7.2.2.2.1 Aquifer Properties

In addition to determining the aquifer properties from the multi-well test, numerous single well tests were conducted to define the aquifer properties. Several pump tests were

previously conducted by Cleveland-Cliffs and Uranerz and the results of these tests were analyzed and included in the general hydrologic analysis.

The aquifer property tables and discussion present the ore sand first, then the overlying and underlying aquifers and finally shallowest to deeper aquifer for the remaining aquifers. Table JD-D6-3 presents a summary of the aquifer properties for the Jane Dough Unit. This table shows a summary of the aquifer properties for the AB, A, B, 1, F, and C Sands for the Jane Dough Unit. In the eastern half and northwest portion of the Jane Dough Unit, the aquitard between the A and B Sands is not continuous and thus the two sands show good connection and create the AB aquifer. Three multi-well and two single well tests were conducted in areas where that connection was evident. Transmissivities from these pump tests varied from 48 to 1,610 gal/day/ft. The vertical hydraulic conductivity near URZJA-1 is 3.1 E-4 ft/day. This value is likely due to a thin clay layer that significantly retards the vertical movement of water and isn't representative of the A sand. The average vertical hydraulic conductivity near URZJA-7 and URZJA-8 is 0.012 ft/day. The drawdown from the operation of the wellfield will cause the gradient between the A and B Sands to reverse in these areas. The gradient from the B Sand to the A Sand as well as the significantly dampened vertical hydraulic conductivity should act as an adequate confinement of the ore zone.

Two multi-well tests were conducted in the A Sand near URZJA-13-1 and URZJA-14-1. Transmissivities for these A Sand aquifer tests varied from a low of 30.8 to a high of 76.7 gal/day/ft. The hydraulic conductivity (horizontal permeability) varied from 0.10 to .16 ft/day (46.2 to 76.8 milliDarcy).

An average transmissivity of 330 gal/day/ft is thought to best represent the A Sand ore sand. Average horizontal and vertical hydraulic conductivity of 0.54 and 0.012 ft/day, respectively, are thought to best represent the A Sand. A storage coefficient of 1.3 E-4 is representative of the A Sand.

Two single-well pump tests at different locations were conducted in the B Sand and produced a range of transmissivities from 9.8 to 132 gal/day/ft. An average transmissivity of 86 gal/day/ft and a horizontal permeability of .07 ft/day are thought to best represent the

B Sand. The two single-well pump tests for the 1 Sand produced transmissivity values between 1.6 and 19.4 gal/day/ft. A value of 17.7 gal/day/ft is thought to be most representative of the 1 Sand in the Jane Dough Unit.

Three single-well pump tests were conducted in the F Sand and yielded a large range of transmissivity values. Transmissivities ranged from 7.6 to 4,440 gal/day/ft. A small transmissivity of 2.1 gal/day/ft and hydraulic conductivity of 0.01 ft/day were determined for the C Sand from the JC-10 single-well pump test.

2.7.2.2.2.2 Aquitard Properties

The multi-well pump tests were used to define the confinement of the aquitards between the ore aquifer and the overlying and underlying aquifers. The URZJA-1, URZJA-7, and URZJA-8 multi-well pump test had no indication of connection between the A Sand and the underlying 1 Sand during this multi-well pump test. The URZJA-13-1 and URZJA-14-1 multi-well pump tests showed that no indication of connection between the A Sand and the overlying B Sand.

The most important parameter for confinement of the ore sand from the adjacent aquifers is the thickness of the aquitard. Experience has shown that the continuity of only a few feet of Powder River shale is needed to form an adequate confinement between the ore sand and adjacent aquifers. Exhibit JD-D5-17 presents the aquitard thickness for the AB Mudstone. This isopach map shows that the aquitard is absent in the eastern and northwest portions of the Jane Dough Unit. Exhibit JD-D5-19 presents the aquitard thickness between the 1 and A Sands in the Jane Dough Unit area.

Above the B Sand, the BC aquitard separates the B Sand from the C Sand and the CF aquitard separates the C Sand from the F Sand. Because the C Sand is not continuous, the entire interval between the B Sand and the F Sand may consist of lower permeability material over a significant portion of the project area. The thickness of the aquitard(s) between the B Sand and the F Sand is greater than 50 feet and the average thickness of the aquitard(s) is greater than 100 feet. As indicated in Table JD-D6-4, the vertical hydraulic conductivity of the BC and CF aquitards is generally very small.

The vertical hydraulic conductivities of the aquitard in the Powder River Basin have been defined at numerous locations. These hydraulic conductivities have been measured in multiwall pump tests with the Neuman-Witherspoon (1972) method, determined from the results from the leaky aquifer pump test analysis with the modified Hantush (1960) method, and from laboratory measurements. This data has shown that the vertical hydraulic conductivity of these aquitards is low enough that site specific measurements of the aquitard hydraulic conductivity are not necessary. Aquitard hydraulic conductivity was measured in the area northeast of the Jane Dough Unit in Power Resources North Butte permit. This permit presents aquitards evaluated with the Neuman-Witherspoon field test for the CF aquitard between the F and C Sands. Table JD-D6-4 presents the North Butte aquitard properties. The vertical hydraulic conductivity of this material was 3.4E-8 cm/sec (3.5E-2 ft/yr). A second multi-well test at the North Butte site defined the 1A aquitard hydraulic conductivity between the A Sand and the 1 Sand. The results of this test were 4.1E-8 cm/sec (4.2E-2 ft/yr).

Additional field tests were evaluated using the modified Hantush method to define the vertical hydraulic conductivity of the aquitard. These calculated hydraulic conductivities varied from a low of 6.7E-9 to a high of 6.9E-8 cm/sec (6.9E-3 to 7.1E-2 ft/yr). Laboratory hydraulic conductivities were also measured on two samples of the aquitards at the North Butte permit and these hydraulic conductivities varied from 6.4E-9 to 1.3E-8 cm/sec (6.6E-3 to 1.3E-2 ft/yr).

Additional test of aquitard properties have been made in this area at the Ruth and Ruby projects. The Ruth project located approximately 5 miles southwest of the Jane Dough project while the Ruby project is approximately 11 miles to the east. Table JD-D6-4 presents additional field and laboratory aquitard properties for the Ruby and Ruth projects. The aquitards between the AB Sands and 1A Sands were measured at the Ruth project. The aquitards between the BC Sands and AB Sands were measured at the Ruby project. These aquitard properties show that the aquitards at both the Ruth and Ruby sites are similar to those that were measured at the North Butte site. This data shows that the aquitards in this area have sufficiently small vertical hydraulic conductivities to restrict the movement of ground water from one aquifer to the next. Aquifer confinement will be further defined for each of the wellfields during the wellfield multi-well pump test.

2.7.2.2.3 Aquifer Description

The analysis of aquifer and aquitard properties described in preceding sections indicates that the selection or identification of an overlying aquifer is dependent on the presence of the AB mudstone or aquitard. In the southwest portion of the Jane Dough permit area (see Exhibit JD-D5-17), the AB mudstone is present and effectively isolates the mining intervals in the A Sand from the overlying B Sand. Aquifer properties testing presented in Addendum JD-D6C of Appendix JD-D6 indicates that, when present, the AB mudstone provides sufficient isolation of the B Sand from the production intervals in the A Sand to allow designation of the B Sand as the overlying aquifer. In particular, two multi-well pump tests performed with a pumping well in the A Sand and observation wells in the A Sand, B Sand, and F Sand indicated that there was no measurable drawdown in the B Sand or the F Sand as a result of pumping from the A Sand.

The AB mudstone is absent in the east and northwest portions of the Jane Dough permit area (see Exhibit JD-D5-17). Where the AB mudstone is absent, the A Sand and B Sand effectively combine into a single aquifer and the aquifer properties testing confirms that there is vertical communication between the A and B Sands in this area (see Appendix JD-D6 and Table JD-D6-3). Where this is the case, an aquifer above the B Sand is designated as the overlying aquifer for the mining production interval. Within the named sands in the stratigraphic sequence, the C Sand is located above the B Sand and the F Sand is above the C Sand. The G Sand is located above the F Sand and is separated from the F Sand by a mudstone interval. The C Sand is not continuous within the Jane Dough permit area, and when it is encountered, the sand is relatively thin and has limited potential water production. Aquifer properties testing of C Sand well URZJC-10 (see Tables JD-D6-2 and JD-D6-3) indicates very small transmissivity. Because of the discontinuous nature and limited transmissivity, the C Sand is not generally suitable for designation as an overlying sand. The F Sand exists over the southwest portion of the Jane Dough project area and the water quality and aquifer properties have been characterized (see Appendix JD-D6). Three F Sand wells were installed in the Jane Dough permit area, and baseline water quality data was collected from each well. In addition, a single-well aquifer properties test was performed on each F Sand well (see Table JD-D6-3) and two of the wells were used as observation wells during multi-well aquifer properties testing in well clusters. Hence, the F Sand can be designated as the overlying aquifer in areas where it is present and where the AB mudstone is absent.

The vertical separation between the F Sand and B Sand is typically greater than 50 feet and the interval between the sands is typically low permeability material. A nearby F Sand well was monitored during aquifer properties testing at the URZJA-1 and URZJA-13-1/URZJA-14-1 test sites, and there was no measurable response in the F Sand aquifer as a result of pumping in the A Sand. The G Sand is present above the F Sand and is separated from the F Sand by lower permeability material in the FG aquitard. There is limited saturation in the G Sand and the general type of water is similar to that of the F Sand and the alluvial aquifer where present. With additional vertical separation and an additional aquitard separating the G Sand from the mining intervals, the potential for mining impacts to the G Sand is very limited. The G Sand may serve as the overlying aquifer where the AB mudstone, C Sand and F Sand are absent. The thickness of the interval between the top of the B Sand and the base of the G Sand is 140 feet or greater.

The vertical separation between the F Sand or G Sand and the mining production in the A Sand dramatically limits for the potential for mining impacts on the F Sand or G Sand. In a following section discussing potential CBM impacts on the overlying production sands, a MODFLOW model was used to estimate potential propagation of drawdown vertically upward through the stratigraphy between the coal intervals and uranium mining. A significant conclusion of the CBM impacts modeling was that shale layers restrict the vertical conveyance of ground water to levels where no significant drawdown stress is imparted to the overlying aquifer. This “muting” of vertical drawdown propagation is more pronounced with larger vertical separation of layers.

The expected designation of overlying aquifer(s) for the Jane Dough project will be based on presence or absence of the AB mudstone. In areas where the AB mudstone is present and has sufficient thickness and continuity to function as an aquitard, the B sand will be monitored and evaluated as the overlying aquifer. In areas where the AB mudstone is absent or areas close to the boundary of the AB mudstone, the F Sand or G Sand will typically be designated as the overlying aquifer. If future drilling for wellfield delineation indicates that the C Sand has sufficient thickness, continuity, and productivity in specific areas, the C Sand may be considered as a potential overlying aquifer

2.7.2.2.3.1 Ground Water Flow

Water levels have been measured in the wells in the Jane Dough ISR Project area to define the direction and gradient of the ground water movement and define water-level changes in

the aquifers in this area. Addendum JD-D6D presents the water-level plots and tabulation of ground-water levels. Addendum JD-D6L also presents a tabulation of the water levels in the Uranium Data Submission Spreadsheets.

The historical and current water-level elevation maps for the aquifers in this area are essentially the same. Water-level plots show that historically only small changes have occurred in these water levels since the late 1970s. Coal bed methane production in the immediate area had not started and by 2007, therefore the 2007 piezometric surface maps can be used as historical water-level elevations. CBM has started in this area and has caused large drawdown in the coal aquifer but these drawdowns have not been observed in the aquifers adjacent to the production zones. The drawdowns in the sands above the CBM production aquifers have generally been observed in some of the sands closer to the coal aquifer. These drawdowns should generally be relatively small and decrease in sands with greater distances from the coal aquifer.

The water-level elevation for the A Sand, which is the production sand at the Jane Dough Unit, is presented in Figure JD-D6-5. This water-level elevation map shows that the ground water in the A Sand is flowing to the northwest with an average gradient of 0.0064 ft/ft. This gradient, an effective porosity of 0.05 and an average hydraulic conductivity of 0.54 ft/day indicates that the ground water in the A Sand is flowing at an average rate of 0.069 ft/day (25 ft/yr).

The regional piezometric surface of the A Sand aquifer is developed from the Nichols Ranch Unit A Sand wells and from three additional A Sand wells in this region. Figure D6-5a in Appendix D6 of the Nichols Ranch permit presents the 1980 regional water-level elevation map for the A Sand. This map shows that the regional ground water flow direction is the same as that in the Jane Dough Unit area. The regional ground-water velocity would be expected to be similar to the local ground-water velocity in the Jane Dough Unit area. Three F Sand wells were added at the Jane Dough Unit to define the shallow ground water at this site. Figure JD-D6-8 shows the water-level elevation for F Sand wells URZJF-5, URZJF16, and URZJF-22. The water-level elevation of this shallow sand is an average of 27 feet less than the water-level elevation than the A Sand at this location.

Additional shallow monitoring wells were installed in the Jane Dough Unit in the Cottonwood, Dry Fork, and Seventeen Mile alluviums. These monitoring wells are located on the downstream edge of the Jane Dough Unit area while the Cottonwood well is upgradient of Jane Dough (see Figure JD-D6-10 for location). Completion information for this well is presented in Table JD-D6-2. This water-level elevation is approximately 35 feet below the water-level elevation of the A Sand near URZJQ-24-1 and URZJQ-26, but closer to 45 feet below the A Sand at URZJQ-25.

Figure D6-6 in Appendix D6 of the Nichols Ranch permit shows the regional water-level elevation for the F Sand for the Nichols Ranch ISR Project area. This map includes wells in both the Nichols Ranch and Hank Units and the new Jane Dough Unit wells exist just south of the Nichols Ranch Unit. The ground-water elevation in Figure JD-D6-8 shows that the water in the F Sand is flowing northwest with an average gradient of 0.011 ft/ft. This gradient, along with an average hydraulic conductivity of 2.2 ft/day and an effective porosity of 0.14, indicates that the ground water velocity is moving at 0.17 ft/day (62.6 ft/yr). Ground water in the F Sand likely flows into the Cottonwood alluvium in the southern area of the Nichols Ranch Unit and in the northern portion of the Jane Dough Unit.

A regional water-level elevation for the 1 Sand, the underlying aquifer to the Jane Dough Unit A Sand production, is presented in Figure D6-6a in Appendix D6 of the Nichols Ranch permit. This water-level elevation map shows that the ground-water flow in the 1 Sand is mainly to the northwest. Figure JD-D6-6 presents the water-level elevation map for the 1 Sand in the Jane Dough Unit area. The gradient of the 1 Sand piezometric surface is 0.008 ft/ft and this gradient, and a hydraulic conductivity of 0.15 ft/day and an effective porosity of 0.05 indicates ground water in the 1 Sand is moving at 0.024 ft/day (8.8 ft/yr). Figure D6-6c in Appendix D6 of the Nichols Ranch permit presents the regional water-level elevations for wells that are completed in the B Sand. The water-level elevations in these sands indicate that the gradient is to the west-northwest in the Nichols Ranch ISR Project area. The water-level elevations for the B Sand aquifer in the Jane Dough Unit area are presented in Figure JD-D6-7. The piezometric gradient in the ground-water systems has a west-northwest gradient in the Jane Dough Unit. The gradient is 0.008 ft/ft in the B Sand

aquifer in the Jane Dough area with an estimated ground-water velocity of .026 ft/day (9.3 ft/yr) based upon an effective porosity of 0.05 and a hydraulic conductivity of 0.16 ft/day.

The water-level elevations for the G Sand aquifer are presented in Figure JD-D6-9. The flow is mainly to the north with a gradient of 0.01 ft/ft. The depth to water in the surficial aquifer for the Jane Dough Unit is presented in Figure JD-D6-10. This figure shows a pattern in the Cottonwood, Dry Fork of the Powder River, and Seventeen Mile alluvial areas where the depth to water is less than 10 feet. The blue contours present the depth to water in the G Sand. The G Sand is the surficial aquifer in the wellfields. This figure shows that the depth to water gets to greater than 150 feet in the G Sand in the southern portion of the Jane Dough Unit wellfields. Depths to water in the G Sand are 50 feet in the northern portion of the wellfields. The alluvial aquifers are important surficial aquifers outside of the wellfield areas.

Table JD-D6-5 presents the gradient calculations through the aquitards based on the heads in the adjacent aquifers and the thickness of the aquitard. The head in the A Sand is 3 feet higher than the head in the B Sand at the Jane Dough Unit at well URZJA-20. These head differences indicate a gradient of 0.15 ft/ft across the 20 feet of aquitard at this location. The actual gradient in the aquitard is expected to be mainly controlled by the higher head in the A Sand and therefore, based on observation of head measurements in aquitards in the Powder River Basin the actual gradient in the overlying aquitard at the Jane Dough Unit is likely to be roughly 0.1 ft/ft. The head in the underlying aquifer 1 Sand in this location is approximately 15 feet higher than the head in the A Sand; therefore, an upward gradient exists between the A Sand and the underlying 1 Sand. This indicates a gradient across the aquitard of approximately -0.24 ft/ft. The higher head in the 1 Sand is expected to mainly control the head in the aquitard until within a very few feet adjacent to the A Sand.

2.7.2.2.3.2 Jane Dough Unit Water Level Changes

The water-level elevations have been measured on the Jane Dough Unit wells and are presented in Addendum JD-D6D. Table JD-D6D.1-1 in Addendum JD-D6D presents the water-level data tabulation for the Jane Dough Unit. Figures JD-D6D.1-1 through

JD-D6D.1-5 in Addendum JD-D6D present the water-level elevations; versus time for the Jane Dough Unit wells. Water levels for the A Sand wells since 2010 have been fairly steady with a very gradual decrease observed in 2012 and 2013.

Water levels in the northwest cluster of the Jane Dough Unit all show a very slight decrease in water level over the last two years. B Sand well URZJB-3 has had very similar water levels to A Sand wells URZJA-1 and URZJA-2 up until the beginning of 2013. The underlying 1 Sand is roughly 18 feet above the A Sand in this cluster. The F Sand, as shown by the URZJF-5, water levels in this cluster is slightly over 15 feet lower than the A Sand.

The A and B Sand water levels in the southeast cluster have very similar water levels. The AB mudstone is not continuous on the eastern portion of the Jane Dough Unit; hence the similar heads in the adjacent aquifers. The 1 Sand water level is over 35 feet higher than that of the A Sand. The C Sand, as shown by well URZJC-10, water level is roughly four feet higher than the A Sand. The most surficial aquifer, the G Sand, shows a water level nearly 30 feet higher than the A Sand.

The A Sand wells in the southwestern cluster show a slight increase in water level in 2013. The overlying B and F Sands both have water levels over 20 feet lower than the A Sand in this area.

The A Sand wells in the northwestern cluster of the Jane Dough Unit have shown a slight decline from 2011. The B Sand is approximately four feet lower than the A Sand in this area. The underlying 1 Sand shows a highly variable water level that's on average 10 feet higher than the A Sand. The overlying F Sand shows a slight increase in water level from 2011 to 2013 and is roughly 18 feet higher than the A Sand. The G Sand has a fairly steady water level over that same time frame and has a water level that is on average forty feet lower than the A Sand. The three alluvial wells in the Jane Dough Unit have all shown a slight increase in depth to water from 2011 to 2013.

2.7.2.2.3.3 Coal Bed Project Effects on Water Levels

This section presents the potential effects of the coal bed water production on the ore sands. Coal bed methane (CBM) production has been underway for more than 15 years in the

Powder River Basin. The CBM production in this uranium in-situ recovery (ISR) project area has been developed in the last few years. The CBM wells typically produce a few tens of gallons per minute (gpm) and then production rates significantly decrease with time. This water production has typically resulted in several hundred feet of drawdown in the coal aquifer. The potential effect of the drawdowns on the ISR operation is discussed in this section.

Exhibit D6-5 in Appendix D6 of the original Nichols Ranch permit shows the spacing from the base with the A Sand at the Nichols Ranch Unit to the top of the coal which is 765 feet. The base of the A Sand to the top of the coal in the Jane Dough Unit is 671 feet at a deep drill hole in the NE of the SW in Section 29. Therefore the typical geologic section presented in Exhibit D6-5 in Appendix D6 of the Nichols Ranch Unit permit is representative of the geologic section for Jane Dough. The fluvial deposition of the sandstones creates areas where a sandstone has direct connection with other sandstones. The thickest layer of sandstone that has been observed from the logs in the Powder River Basin is approximately 150 feet.

Therefore, the large zone between the ore sands and the first major coal seam should always contain some layers of shale where drawdowns from the coal should be greatly attenuated and unlikely to reach the sandstones for this interval above the coal.

Artificial connections through the shales above the first major CBM coal seam could be developed through deep exploration drill holes or deep wells which penetrate the coal seam. Typically, drill holes in the Nichols Ranch permit area are drilled only down into the 1 Sand. A few deeper exploration drill holes were drilled and a very few penetrated the coal seam.

Figure JD-D6-11 presents the location of the deep drill holes in this area that extend below 800 feet deep. This figure presents the ID name of the drill hole and the total depth for each of the holes. Drill hole CC-4-6 is the only exploration hole that extends down to the first major coal seam and is not located within the Jane Dough Unit. The deep drill holes are far enough from the Jane Dough well field that they should not create a potential problem relative to ISR containment of solutions.

The State Engineer's records have been searched for permitted wells and all wells that exceed a total depth of 800 feet and not an oil and gas well are posted on Figure JD-D6-11. The majority of wells in this area that are greater than 800 feet depth are oil and gas wells. Figure JD-D6-11 shows the location of nine deep permitted wells that are not oil and gas wells. The total depth of these deep wells is shown on Figure JD-D6-11 adjacent to the well name. All of these wells are shallow enough that they would not penetrate the CBM coal seam but one of these wells (Dry Fork Samson #1) is within one hundred feet of the coal seam and two additional wells may be within a couple hundred feet of the coal seam. If the CBM drawdowns propagate up into a deeper sand which is within the completion interval of one of these wells, there is a potential for further propagation of drawdown to shallower sands depending on the well completions. Some shales should be present between the Nichols Ranch ore sands and the completion top of the most of these wells. These shales should still retard drawdowns and prevent impacts on the ore sand aquifer water levels. However, the North Dry Willow #1 well will allow the drawdowns that reach the lower sands in this well to propagate up to the ore sand at Hank. This well will be abandoned or at a minimum, the ore zone sand of the well will be sealed off prior to ISR operation in this area.

This portion of this section presents water-level changes that have been observed relative to CBM drawdowns. The BLM has monitored water levels in the coal aquifers and sand aquifers above the coal for the last several years. The network of monitoring wells is used to define the effects of water extraction from the coal bed production zone on water levels in the coal and overlying aquifer. The monitoring well locations, drawdown, and footage between the bottom of the sand completion and the top of the CBM completion are presented on Figure JD-D6-12. The sand monitoring site one mile west of the Hank Unit and four miles northeast of the Jane Dough Unit is a Wasatch Sand well (F Sand) which is called the Dry Willow Well. Water-level data for this well is presented in Figure JD-D6D.2-1 in Addendum JD-D6D. This sand well is completed 1,100 feet above the major coal seam. Water levels have been very gradually declining the last three years in the Dry Willow Sand Well. This variation in water levels is similar to a gradual decline that was observed in 2002 to 2005 and is likely a natural water level change. The Pistol coal well is located approximately 10 miles northeast of the Jane Dough Unit. Figure JD-D6D.2-1 of Addendum JD-D6D also presents the water-level elevations of the Pistol Coal Well. Water

levels in this coal aquifer well started to greatly decline in 2007 and had only varied over a range of slightly greater than 10 feet for the previous ten years. This well did not show a significant effect from the production of water from the coal aquifer until 2007. The drawdown in early 2013 in the Pistol coal well was 790 feet.

The Bullwacker Sand and Coal wells, which are located approximately 5 miles southwest of the Jane Dough Unit, have been monitored since 2002. Figure JD-D6D.2-2 in Addendum JD-D6D presents the water level changes for the 2 Bullwacker wells. The sand well, which is completed 100 feet above the coal, has had approximately 240 feet of water level decline through early 2013. The coal well, which has also been monitored over this same period of time, shows a decline in water level starting in 2002 with a drop of approximately 600 feet by early 2008. This indicates that, at the Bullwacker site, the coal has had a large amount of drawdown and the sand water level appears to be declining steadily with the coal. This sand unit must be hydraulically connected with the coal or some well completion is allowing connection between the coal and this sand due to the very quick observed drawdowns in the sand.

The coal and sand are monitored by the BLM at a location nearly 9 miles west of the Jane Dough Unit at the Streeter site. Figure JD-D6D.2-3 in Addendum JD-D6D presents the water-level elevation for the Streeter Sand and Coal wells. This figure shows that the water level in the Streeter Sand well had been steady except for a decline in its first year of monitoring and has very gradually declined two feet in the last few years. This sand is 621 feet above the top of the coal. The Sand well water levels in recent years could be natural. The water levels from the Streeter Coal well were fairly steady from late 2004 through mid 2005 when water levels started to gradually decline. Water levels from this well have declined approximately 145 feet from mid 2005 through early 2009 and then rose in late 2009 and 2010. Water levels have gradually declined the last year. The early change in the water level from the Streeter Sand well is unusual because the water level initially declined and then became steady and recently gradually declined. The recent gradual decline in water levels in the sand well indicates that the sand aquifer could have slightly been affected by the CBM production.

The sand well in the All Night Creek area is completed 124 feet above the coal. These two wells (completed in the sand and coal) are nearly 14 miles to the east of the Jane Dough Unit. Figure JD-D6D.2-4 in Addendum JD-D6D presents the water level changes for the All Night Creek wells. The water level changes in the coal are greater than 600 feet while the water levels have very gradually declined 11 feet over the last several years. This decline is some less than the model predictions but likely due to the CBM stress.

The Beaver Federal Sand and Coal wells are located greater than 23 miles north-northeast of the Jane Dough Unit. Figure JD-D6D.2-5 of Addendum JD-D6D presents the water levels for the Beaver Federal Sand and Coal wells. The water level has a small decline of three feet in the Beaver Federal Sand well, while the coal's water level has declined greater than 450 feet. This sand is 561 feet above the coal, similar to the A Sand completion above the coal. The response of the ore sand water levels in the Jane Dough Unit to coal bed production may be similar to the response in this well.

The sixth cluster of CBM monitoring wells is located to the northwest of the Nichols Ranch ISR project. The Juniper well group water-level changes are presented on Figure JD-D6D.2-6 in Addendum JD-D6D. The water-level elevations show a significant change in the sand well with a decline of 42 feet most of which has occurred during the last four years. This well is completed 418 feet above the top of the coal. The amount of drawdown in this sand well is greater than expected for the thickness between the coal and the sand. The initial water-level elevations in the Juniper Sand Well are much lower than expected at 140 feet less than the coal in 2001. This indicates that the Juniper Sand water level had been greatly lowered prior to the installation of these two wells. This makes the Juniper Sand water levels unusable for analysis of CBM affects. The coal water-level declines are greater than 600 feet in this area.

An additional CBM monitoring location was started in late 2007 approximately 8 miles east northeast of the Jane Dough Unit which is called the Fourmile monitoring site. Figure JDD6D.2-7 presents the water-level data for the Fourmile Coal and Fourmile Wasatch Sand well. The Wasatch Sand well is located approximately 534 feet above the top of the coal seam. Figure JD-D6D.2-7 shows a very gradual water level rise has been observed in the sand well and shows a gradual water level decline for the Fourmile Coal well during

recent years. The water-level drawdowns are estimated to be approximately 140 feet in the coal based on pre-CBM coal water-level elevations.

An additional CBM monitoring site was also added in late 2007 slightly greater than 2 miles south of the Jane Dough Unit. This monitoring site is called the West Pine Tree site. Figure JD-D6D.2-8 shows that the water levels in the Wasatch Sand, which is 782 feet above the coal, have been fairly steady after the initial variable measurements with a small water level decline of approximately two feet in this Wasatch Sand. This sand is located at a similar footage above the coal as the A Sand. The coal drawdown at this location is greater than 600 feet because some drawdown very likely occurred at this location prior to the start of monitoring.

The CBM water-level monitoring shows that sand wells completed a few hundred feet above the coal in this area generally have exhibited no or small drawdowns. The exceptions to this are the drawdowns observed in the Bullwhacker and Juniper Sand wells which are completed only 100 and 418 feet respectively above the top of the coal. Water level declines starting quickly after the coal declines in the Bullwacker Sand Well questions the levels from this well. It is likely that the drawdown in this sand well is caused by some artificial connection between the sand and the coal in this area. The much lower initial water-level elevation in the Juniper Sand well than in the coal well questions the usefulness of water levels from the Juniper Sand well.

The drawdown in the coal seam(s) for CBM production has the potential to cause hydrologic impacts in adjacent stratigraphic layers. The magnitude of drawdown in the coal for CBM production can be large, and thus the propagation of this drawdown into and through adjacent layers is of concern for other water or mineral extraction operations within these potentially affected strata. For uranium ISR operations in the vicinity of CBM activities, both the well field operation and lixiviant control could potentially be affected by significant water level changes due to external stresses.

In the Powder River Basin (PRB), the uranium production sand/sandstones are within the Wasatch Formation and are separated from the CBM production coal seams by a substantial

thickness of sand/sandstone and silt/shale sequences. The fine-grained silt or shale layers act as aquitards and greatly restrict or preclude the vertical movement of ground water. This in turn limits the vertical propagation of drawdown. In order to evaluate the potential hydrologic impacts of CBM production on the uranium ore-bearing sands in the PRB, a multi-layer MODFLOW model was constructed to represent a typical stratigraphic column at the Nichols Ranch project area. The modeled 13 layer stratigraphic column extends from the coal seam up through a sandstone representing a likely uranium production sand in order to evaluate the hydrologic impacts on the sequence of layers from the coal to the uranium production sand. The horizontal modeled area was set as a rectangle 15,000 feet by 5,000 feet. This quasi-strip configuration facilitated the placement of a separate constant head boundary for each layer at one end of the strip to represent the regional supporting aquifer system. The boundary condition at the other end of the strip was set as a variable head boundary. Well extraction stresses were placed in the coal seam layer approximately one-third of the total strip dimension from the variable head boundary end of the strip. In order to evaluate drawdown impacts, the resulting drawdown in the coal and overlying layers was analyzed for a location directly over the area where the well stresses were applied.

All layers in the model were established as confined aquifers with a uniform storage coefficient of 1.0 E-05. The top layer was a 40 foot thick sand layer with a transmissivity of 424 gal/day/ft which corresponds to a hydraulic conductivity of 5.0 E-04 cm/sec. Shale/silt intervals were broken into two layers for modeling purposes to further refine estimates of drawdown within the finer grained material where large gradients could potentially develop. Layers 2 and 3 were 50 foot thick shale layers with a transmissivity of 0.5 gal/day/foot. Layers 4, 5, and 6 repeated the thickness and properties sequence of layers 1 through 3. Layers 7, 8, and 9 also repeated this sequence. Layer 10 was modeled as a 40 foot thick sand with a modest transmissivity of 21 gal/day/foot. Layers 11 and 12 were 20 foot thick shale intervals with a transmissivity of 0.5 gal/day/foot. Layer 13 was a 40 foot thick coal seam with a transmissivity of 21 gal/day/foot. The total sequence thickness is 500 feet and can generally be described as the uranium production ore sand (top) and CBM production coal seam (bottom) separated by an alternating sequence comprised of four shale layers and three intermediate sand layers.

The initial water level elevation (hereafter termed head) for each layer was scaled in a generally linear manner from an arbitrary value of 500 feet for the coal seam (layer 13) to 560 feet for the upper sand aquifer (layer 1). The difference between the head in the upper and lower layers represents the likely condition of progressively higher head in overlying aquifers. A simulation was also conducted with a much larger differential in initial head between upper and lower aquifers and the results were generally similar to those presented in the following discussion.

The model simulation period was 20 years in 15 stress periods. The stress period intervals were selected to provide complete definition of the transient drawdown response for the coal and adjacent layers. The magnitude of the wells stresses in the coal seam was varied to produce a large drawdown in the coal at the end of the simulation. The vertical conveyance between layers (termed Vcont in MODFLOW) was set as a uniform value for the interface between all layers and was then varied to produce total drawdown in layers 12 and 11 that was similar in magnitude to that predicted by the Neuman-Witherspoon (1972) method. This method allows calculation of drawdown in an adjacent aquitard based on the predicted drawdown in an aquifer.

The results of the MODFLOW simulation are presented for a selected model cell in Figure JD-D6-13. Only the results for layers 7 through 13 are presented because there were no significant changes in head for layers 1 through 6. A large degree of drawdown (493 feet) was produced in the coal seam (layer 13). Layers 12 and 11 are shale layers directly above the coal and the magnitude of predicted drawdown in these layers is still large at 291 feet and 154 feet, respectively. These drawdowns compare favorably with those predicted by the Neuman-Witherspoon (1972) method and were used in evaluating the Vcont. The predicted drawdown in the sand layer nearest to the coal seam (layer 10) was greatly muted at 32 feet. The progressively diminishing drawdown the shale/sand sequences in general reflects the very small quantities of ground water that are actually conveyed vertically in the very low permeability shales. This tiny vertical conveyance produces only a very small stress on the sand aquifer (layer 10), and thus the magnitude of drawdown rapidly decreases with increasing distance from the coal seam.

The predicted drawdown in layers 9 and 8 (shale layers overlying the deepest sand in the sequence) is 19 feet and 9.1 feet respectively, which continues the trend of rapidly diminishing drawdown while moving upward through the strata sequence. The predicted drawdown in the next sand aquifer (layer 7) is an insignificant 0.1 feet. As mentioned previously, there were no significant predicted changes in head for layers above layer 7.

A summary of the model results is that a large drawdown in the coal seam resulting from CBM production may cause significant drawdown in the adjacent aquitard(s). This drawdown may also propagate into and through aquifers located in close vertical proximity to the coal seam, but will be greatly muted by even modestly transmissive layers within the sequence. For multiple shale/sand sequences above the coal, the drawdown is progressively attenuated and will not propagate beyond one or two alternating sequences above the coal seam. The attenuation of drawdown within a shale layer is very large, so the presence of even thin continuous aquitards above the coal will greatly dampen the propagation of drawdown to overlying layers. However, any strata that have a permeability similar to or greater than that in the coal, and are in direct contact with the coal, will exhibit a drawdown response that is similar to that of the coal. With the typical lithology present in the Nichols Ranch project area, the CBM induced drawdown will not have a measurable impact on ore sand water levels unless there is an artificial connection through an improperly completed well or improperly abandoned bore hole.

The CBM drawdowns in the coal aquifer should not increase the potential for vertical excursions. The numerous aquitards between the coal and the ore sands should prevent the occurrence of significant drawdowns in the ore sands from CBM production. An artificial connection between the ore sand and the coal aquifer through a deep drill hole or deep well is the most likely pathway for a vertical excursion and thus the potential for such a connection should be evaluated.

CBM drawdowns could potentially cause drawdown in an ore sand if there are artificial connections with the production coal. In most cases, this CBM induced drawdown is not expected to appreciably affect gradients within a mine unit and therefore will not significantly increase the potential for horizontal excursions. Unless the artificial connection

is directly within a mine unit, the changes in the piezometric surface should affect the mining in a relatively uniform manner. If drawdown occurs within a mine unit it is due to an artificial connection, this actually reduces the potential for horizontal excursion while, as previously noted, raising concerns for vertical excursion.

The modeling of the vertical propagation of CBM drawdown through the shale and sand layers shows that the first continuous shale will greatly dampen the drawdowns in the aquifers above the shale. Some drawdown is likely to occur in the first aquifer above the coal aquifer but drawdowns should be very small beyond the first sand. Some of the sands near the coal aquifer may have direct connection with the coal at some locations and; therefore, significant drawdown may develop in these connected aquifers. Ore sands, which are several hundred feet above the top of the coal, should not exhibit drawdown from the coal bed production unless artificial connections between the sand and the coal aquifer. It will be very important to determine if artificial connections exist within an ISR well field area and to correct any potential connections. Artificial connections that exist at some distance from the well field should not affect the potential for vertical or horizontal excursions.

2.7.2.2.4 Ground Water Quality

The groundwater quality at the Jane Dough Unit has been defined by sampling numerous wells in several aquifers in this area. Addendum JD-D6E contains a tabulation of all groundwater quality. Addendum JD-D6L also presents the water quality data in the Uranium Data Submission Spreadsheets. Addendum JD-D6E also presents Stiff and Piper plots and a discussion of the water quality for each aquifer.

Table JD-D6-6 presents the summary of the ground-water quality. These summaries are grouped for the A Sand, B Sand, C Sand, 1 Sand, F Sand, G Sand, and the alluvial wells. Three sets of parameters are listed in the upper half of the first page in Table JD-D6-6. The A Sand wells URZJA-1, URZJA-2, URZJA-7, URZJA-8, URZJA-13-1, URZJA-14-1, URZJA-19, and URZJA-20 were used to calculate the average concentrations for the A Sand. The first row presents the number of samples followed by the average of those samples for

that particular constituent. The maximum, mean and standard deviation are also given in the summary tabulations. The number of samples that have a concentration above the DEQ Class I standard is presented in the last row. The A Sand water typically has very low TDS, (less than 500 mg/l), with its major components being sodium, sulfate and bicarbonate. For the 33 samples, the TDS varies from a minimum of 299 to 715 mg/l with a standard deviation of 71.9 mg/l. The sulfate concentrations for the 33 samples vary from 114 to 141 mg/l while the chloride concentrations vary from 5 to 113 mg/l. Variations are 95 to 127 mg/l for sodium and 3 to 29 mg/l for calcium. The variation of uranium concentrations are over a small range from less than detection values to a maximum 0.0495 mg/l. Radium-226+228 concentrations from the A Sand vary from less than detection to 247.7 pCi/l. Eleven of the radium-226+228 values exceed the Class I standard.

The B Sand analysis includes wells URZJB-3, URZJB-9, URZJB-15, and URZJB-21. TDS concentrations for this aquifer are typically above 300 mg/l with the larger major constituent concentrations being those of sodium, bicarbonate, and sulfate. The TDS of this water ranges from 303 to 451 mg/l. Sodium is the major cation in this water with concentration variations of 96 to 119 mg/l. Sulfate is a major anion with concentrated variation from 111 to 156 mg/l. These sands do show low concentrations of uranium in some areas that is attributed to limited mineralization. The radium-226+228 concentrations in the B aquifer vary from less than detection to a maximum of 4.72 pCi/l.

The water quality for the C Sand is summarized on the second page of Table JD-D6-6. Well URZJC-10 was used to develop a summary of the C Sand water quality. TDS concentrations in the C Sand vary from a minimum of 251 to 303 mg/L. The major cation in this water is sodium and the major anions are sulfate and bicarbonate. Sulfate concentrations vary from a maximum of 89 to a minimum of 84 mg/L. None of the concentrations exceeded Class I standards aside from the 5 samples with a pH higher than 8.5.

The second page of Table JD-D6-6 also presents the summary of water quality for the 1 Sand. Wells URZJ1-6, URZJ1-12, and URZJ23-1 in the Jane Dough Unit were used. This data shows that the TDS average is 378 mg/l with sodium and bicarbonate being the major components of this water quality. Sodium concentrations vary from 76 to 96 mg/l.

Bicarbonate is the major anion in this water with very low levels of uranium and radium indicating no mineralization near this 1 Sand well. No other constituent concentrations are significant in the water from the 1 Sand.

The third page presents the F Sand water quality. Jane Dough Unit wells URZJF-5, URZJF-16, and URZJF- 22 were used in the summary. Fourteen samples have been collected from the F Sand wells, with the average TDS concentration greater than 1,300 mg/l. The range in TDS concentration is from 686 to 1,810 mg/l. Sodium, calcium, bicarbonate, and sulfate are the major dissolved constituents in this water. The number of times the F Sand aquifer water exceeds the Class I standard for sulfate, iron, TDS, manganese, and radium-226+228 are 14, 4, 14, 9 and 4 times respectively. The sulfate concentrations varied over a large range from 415 to 1,080 mg/l.

The cations with the largest concentrations are sodium with a variation from 151 to 269 mg/l and calcium which varies from 19 to 279 mg/l. Uranium concentrations varied from less than detection to a high of .199 mg/l. Radium concentrations have varied from less than detection to 209.7 pCi/l. The other group of parameters on the third page of Table JD-D6-6 is for the G Sand which is the surficial sand in the Jane Dough Unit area. The G Sand summary was made from water quality from URZJG-11 and URZJG-17 wells. This tabulation shows that, on average, the TDS is above 1500 mg/l with a range of 678 to 2,000 mg/l. The major constituents with the highest concentrations are calcium, sodium, and sulfate. The radium levels exceeded the Class I standard on 3 of the 8 samples.

A summary of the Cottonwood, Dry Fork of the Powder River, and Seventeen Mile alluvial water quality is developed from the data collected from wells URZJQ-24-1, URZJQ-25 and URZJQ-26. The TDS from the Cottonwood Alluvial ground-water is high with all values greatly exceeding the Class I use standard. The average value is 3,713 mg/L. Sulfate concentrations are also high with the maximum value being 2,900 mg/L. The high TDS and sulfate concentrations in the alluvium are natural and are due to the effects of this aquifer being very shallow and a discharge point for other aquifers. Transpiration of ground water is significant relative to increasing the TDS in this shallow ground-water system. Thirteen of the fifteen samples from the alluvium well exceed the Class I manganese concentration. The gross alpha concentrations all significantly exceed the Class I standard as well.

2.7.3 Water Rights

2.7.3.1 Nichols Ranch and Hank Units

Surface and groundwater rights on, adjacent to, and within 3.0 mi of the Nichols Ranch Unit and Hank Unit are listed in Table D6F.1-1 in Addendum D6F of Appendix D6 and Table D6F.2-1 for the surface water and Tables D6G.1-1, D6G.1-2, D6G.2-1 and D6G.2-2 in Addendum D6G of Appendix D6 for the Nichols Ranch Unit and Hank Unit permitted water wells. Table D6G.1-1 in Addendum D6G of Appendix D6 lists the wells within the Nichols Ranch Unit while Table D6G.1-2 in Addendum D6G of Appendix D6 lists wells in and within 3.0 mi of the Nichols Ranch Unit. Table D6F.1-2 in Addendum D6F of Appendix D6 lists the abbreviations used by the State Engineers Office for both the surface and groundwater rights. Figures 2-23 and 2-24 present the locations of the Nichols Ranch Unit and Hank Unit surface rights respectively. Exhibits D6-1 and D6-2 in Appendix D6 show the locations of the permitted wells within 3.0 mi of the Nichols Ranch and Hank Units respectively. No adjudicated surface water rights are located in or adjacent to (within 0.5 mi of the project unit) the Nichols Ranch ISR Project. The surface water rights that do exist within the proposed mining project area are limited to stock/storage ponds and ephemeral creeks. Groundwater rights in the Nichols Ranch Unit and Hank Unit area are mainly associated with the old monitoring wells and stock wells. No other adjudicated water rights are in the project area and lands adjacent to the project area according to the

Wyoming State Engineers Office. Uranerz Energy Corporation also does not hold any adjudicated water rights in the project area. Most wells that are located within the Nichols Ranch ISR Project area were previously installed by uranium exploration companies, the T-Chair Livestock Company, or coal bed methane companies. Several additional wells have been completed in the project areas by Uranerz Energy Corporation for use in collecting baseline groundwater quality data.

The current regional groundwater use in this area is mainly wells for wildlife and livestock. A few domestic wells exist at the ranch houses. The production of water from coal bed methane has been occurring in the region for slightly greater than 10 years but is expected to start in the permit area in the near future.

Wells in the area of the proposed project area are uniformly distributed over the area excluding monitoring/sampling wells that are permitted by Uranerz Energy Corporation. Most of the wells are used for livestock watering through the use of windmills or electric well pumps. Well depths vary from 180 to 1,000 ft in depth, and most wells are completed in sands other than the ore bearing sands. Those wells that are completed in the ore bearing sand will be abandoned using acceptable WDEQ methods or will be used as monitoring wells if not completed in multiple sands. No wells in or adjacent to the project area are used for domestic water consumption. A domestic water supply well is found on the Pfister Ranch (BR-T), located approximately 0.6 mi north of the northern boundary of the Hank Unit. This well is completed at a depth that is stratigraphically below the zones planned for the ISR mining at the Hank Unit. Additionally, the well is located at a large distance from any Hank planned wellfield areas and in the B Sand. It is unlikely that any mining activities that take place in the Hank area will affect this well because of the physical separation of the well from the ore zone. The extensive groundwater monitoring program utilized during the mining project will detect any problems prior to this well being adversely affected by mining activity.

Six permitted wells exist within 0.5 mi of the Hank Unit area. These wells consist of the Connie #2 well which is nearly 0.5 mi east of the project area. This well is used to supply water for stock and has a depth of 350 ft. This well is thought to be in the top portion of the F Sand.

The Paden #1 and North Dry Willow #1 wells are very near the mineralized areas near the Hank Unit. The North Dry Willow #1 well is completed in the F Sand through sands down below the 1 Sand and will have to be abandoned before a wellfield pump test in this area. The Paden #1 well is also very near the ore zone in this area and is completed in the C, B and A Sands. This well will have to be monitored during pump testing to determine if it has any connection with the F Sand. If the Paden #1 well has connection with the F Sand it will also need to be replaced. The Brown-WS well is completed in the C, B and A Sands. It is located greater than 1,000 ft west of the mineralized area in Hank Unit. The Brown #5 stock well is located just north of the northern edge of the Hank Unit area. This well has a depth of 540 ft and is completed in the B Sand. The distance of the ISR operation from this well makes it unlikely that mining operations will affect its water-level or water quality. The sixth permitted well at the Hank Unit is the Means #1 well, which is used for stock watering and is 700 ft deep and also likely extends down to the A Sand.

Six permitted wells that are not related to the mining operations also exist within 0.5 mi of Nichols Ranch Unit. The Red Spring Artesian #1 well is located just north of the northwest corner of the project area. This well is completed to 740 ft deep and was a flowing well. The well was not flowing in August of 2007. This well likely extends to sands below the A Sand.

The other five wells are in the southern portion of the project area. The Brown 20-9 well is within the Nichols Ranch Unit and flows at approximately one gpm. This well is thought to be completed in the A Sand and has a total depth of 740 ft with perforations from 495 to 695 ft.

The Dry Fork #3 well is completed to a depth of 360 ft and was not flowing in October of 2007. With this depth, the well completion interval should be significantly shallower than the A Sand.

The Nichols #1 well, which is located in Section 19, is completed down to a depth of 310 ft. This well is likely completed in the C Sand and flows at approximately one gpm.

Based on a conversation with the current owner of the property where the Nichols Ranch once stood, the source of water was a well which was located approximately 200 yards from the old

ranch house towards Cottonwood Creek and was thought to be artesian in nature. The depth of the well was not known but it was likely hand dug and fed off the waters of Cottonwood Creek.

The water source for the Pumpkin Buttes Ranch, located approximately 1.1 mi east of the Hank Unit permit area, is currently being supplied by a new well that was drilled sometime in 2008/2009 according to the landowner. This well is approximately 500 ft deep and completed between 400 and 480 ft placing it in the G Sand. The landowner also stated that there is another well present at the ranch near the current well that can be used as a backup well. The landowner did not know the depth of the well, it is not listed in the SEO database, and the landowner did not remember when it was drilled, but did state that the well had been there for some time.

2.7.3.2 Jane Dough Unit

Surface and ground-water rights on, adjacent to, and within 3 miles of the Jane Dough Unit are listed in Table JD-D6F.1-1 in Addendum F for the surface water and Tables JD-D6G.1-1 and JD-D6G.1-2 permitted water wells. Table JD-D6G.1-1 lists the wells within the Jane Dough Unit while Table JD-D6G.1-2 in Addendum JD-D6G list wells in and within three miles of the Jane Dough Unit. Table JD-D6F.1-2 in Addendum JD-D6F lists the abbreviations used by the State Engineers Office for both the surface and groundwater rights. Figures JD-D6-4 and JD-D6-14 present the locations of the Jane Dough Unit surface rights. Exhibit JD-D6-1 shows the locations of the permitted wells within three miles of the Jane Dough Unit. No adjudicated surface water rights are located in or adjacent to (within 1/2 mile of the project unit) the Jane Dough Unit. The surface water rights that do exist within the proposed mining project area are limited to tock/storage ponds and ephemeral creeks.

Groundwater rights in the Jane Dough Unit area are mainly associated with the old monitoring wells and stock wells. No other adjudicated water rights are in the project area and lands adjacent to the project area according to the Wyoming State Engineers Office. Uranerz Energy Corporation also does not hold any adjudicated water rights in the project area. Most wells that are located within the Jane Dough Unit area were previously installed

by uranium exploration companies, the T-Chair Livestock Company, or coal bed methane companies. Several additional wells have been completed in the project areas by Uranerz Energy Corporation for use in collecting base line ground water quality data. The current regional ground water use in this area is mainly wells for wildlife and livestock. A few domestic wells exist at the ranch houses. The production of water from coal bed methane has been occurring in the region for approximately 15 years.

Wells in the area of the proposed project area are uniformly distributed over the area excluding monitoring/sampling wells that are permitted by Uranerz Energy Corporation. Most of the wells are used for livestock watering through the use of windmills or electric well pumps. Non-mining or oil company well depths vary from 135 feet to 1,593 feet in depth, and most wells are completed in sands other than the ore bearing sands. Those wells that are completed in the ore bearing sand will be abandoned using acceptable WDEQ methods or will be used as monitoring wells if not completed in multiple sands. No wells in or adjacent to the project area are used for domestic water consumption. The extensive groundwater monitoring program utilized during the mining project will detect any problems prior to this well being adversely affected by mining activity.

Seventeen permitted wells that are not related to the mining operations also exist within 1/2 mile of Jane Dough Unit. The Pat #1 well is thought to be completed in the A or B Sands based on its well depth. Water levels in this well could be affected by the Jane Dough Unit operation. Wells East Dry Fork #1, Dry Fork Flowing #3, and Pug well #1 are thought to be completed in the B Sand. Small drawdowns in these wells could be caused by the Jane Dough ISR wellfield. The Taylor #22-1 is thought to be completed in the C Sand and should not have drawdowns from the Jane Dough operations.

Six of the ranch wells within or within one half mile of the Jane Dough permit boundary are completed below the 1 Sand. These wells are Taylor Unit #9, Doughstick #2, Pug Well #2, TChair 12-22, Car Body Well #1, and Brown 21-6. Also Dry Fork Samson #1 is completed in the 1 Sand and below. The Jane Dough wellfield should not have any effects on this well.

Taylor #21-3, Seventeen Mile #1, and Fetty Well #1 are thought to be completed in the 1 Sand and should not be affected by Jane Dough.

The Brown 20-9 well is within the Nichols Ranch Unit and flows at approximately one gpm. This well is thought to be completed in the A Sand and has a total depth of 740 feet with perforations from 495 to 695 feet. The Nichols #1 well, which is located in Section 19, is completed down to a depth of 310 feet. This well is likely completed in the C Sand and flows at approximately one gpm.

Based on a conversation with the current owner of the property where the Nichols Ranch once stood the source of water; was a well which was located approximately 200 yards from the old ranch house towards Cottonwood Creek and was thought to be artesian in nature. The depth of the well

2.7.4 Coal Bed Methane Wells and Oil/Gas Wells

2.7.4.1 Nichols Ranch and Hank Units

Wells permitted for coal bed methane production is presented on Exhibits D6-3 and D6-4 in Appendix D6 for the Nichols Ranch and Hank Units respectively. The tabulation of the coal bed methane wells is presented in Addendum D6H of Appendix D6. Exhibit D6-5 in Appendix D6 shows the distance between the base of the ore sand for each of the two sites and the top of the coal bed methane coal.

The coal bed methane wells in the area of the Nichols Ranch are expected to start water production in 2008. Presently no coal bed methane water is being discharged to the stream channels, but it is expected to start in 2008 into Tex Draw. The majority of the coal bed methane wells in this area are planned to be pumped to a deep injection well.

Oil/Gas wells are shown on Exhibit D6-6 in Appendix D6 for the combined Nichols Ranch Project. Tabulation of the oil/gas wells is presented in Addendum D6H of Appendix D6.

2.7.4.2 Jane Dough Unit

Wells permitted for coal bed methane production are presented on Exhibits JD-D6-2 for the Jane Dough Unit. The tabulation of the coal bed methane wells is presented in Addendum JD-D6H. The coal bed methane wells in the area of the Jane Dough Unit have been in production for the last few years.

Oil/Gas wells are shown on Exhibit JD-D6-3 for the combined Jane Dough Unit. Tabulation of the oil/gas wells is presented in Addendum JD-D6H.

2.7.5 Exploration Drill Holes

2.7.5.1 Nichols Ranch and Hank Units

A search of the drill hole database maintained by Uranerz Energy Corporation along with drill holes provided by WDEQ-LQD resulted in a total of 841 abandoned exploration drill holes located within the Nichols Ranch ISR Project boundaries. Historically, 103 exploration drill holes were drilled and abandoned by companies other than Uranerz in the Nichols Ranch Unit license area. There were 218 historic drill holes drilled and abandoned by companies other than Uranerz in the Hank Unit license area. Holes drilled from 1997 through year to date 2009 have been plugged in accordance with current State of Wyoming regulations. A reasonable inspection of the project area showed that these abandoned holes were marked with a stake or pin flag after plugging was completed. To the best of Uranerz Energy Corporations knowledge, all holes drilled prior to 1997 were sealed and surface plugged in compliance with the State of Wyoming regulations in effect at the time of drilling. Additionally, visual inspection conducted during current drilling and reclamation operations from 2006 through 2009 in the two permit areas have found no historic drill holes that were not abandoned properly. Also there has not been any evidence of historic drill holes causing cross contamination between aquifers when conducting pump tests or when reviewing historic versus current water levels and water quality in monitor wells that are present in the permit areas. Furthermore, since the historic drill holes have been released by the WDEQ, an assumption can be made that the holes were properly abandoned according to the rules and

regulations in place at the time the drill holes were abandoned. No problems are anticipated with past abandoned drill holes impacting the production zone confinement.

Again, to the best of Uranerz knowledge holes drilled prior to 1997 were drilled with natural mud and bentonite as necessary. Current exploration drilling techniques also employ drilling with natural mud, then abandoning the holes with a bentonite plug gel. This method is in compliance with Wyoming Statue §35-11-404 and Wyoming Noncoal Rules and Regulations Chapter 8 drill hole abandonment requirements. Uranerz experience in drilling exploration drill holes in 2006, 2007, 2008, and 2009 has also shown that exploration drill holes tend to seal themselves off because of the natural swelling of clays. Uranerz has experienced this natural sealing on several occasions. If during the course of performing wellfield pump testing a discovery is made that a historic exploration hole is impacting the production zone, Uranerz will take the necessary steps to find the exploration hole, re-enter the drill hole, and properly abandoned it so that the drill hole will not impact the production zone.

All known abandoned drill holes are listed in Tables D6I.1-1, D6I.1-2, D6I.2-1 and D6I.2-2 in Volume VI, Appendix D6 and the location and density is shown on Exhibits D6-7 and D6-8 (see map pockets) in Volume VIa, Appendix D6.

2.7.5.2 Jane Dough Unit

The areas surrounding the Nichols Ranch ISR Project have been historically drilled by several different companies over the past 50 years. Companies such as Cleveland-Cliff Iron Company, American Nuclear Company, Texas Eastern Nuclear, Everest Minerals Corporation, Rio Algom Mining, and Silver King Mines have historically drilled in the Pumpkin Buttes Mining District. A search of the drill hole database maintained by Uranerz Energy Corporation and drill holes provided by the WDEQ-LQD resulted in a total of 2,165 abandoned exploration drill holes located within the Nichols Ranch ISR Project boundaries that were drilled by Cleveland Cliff Iron Company, Rio Algom, Texas Eastern Nuclear, and Uranerz Energy Corporation. Holes drilled from 2006 through year to date 2013 have been plugged in accordance with current State of Wyoming regulations. A reasonable inspection

of the project area showed that these abandoned holes were marked with a stake or pin flag after plugging was completed. To the best of Uranerz Energy Corporations knowledge all holes drilled prior to 1997 were sealed and surface plugged in compliance with the State of Wyoming regulations in effect at the time of drilling.

Additionally, visual inspection conducted during current drilling and reclamation operations from 2006 through 2013 in the two permit areas have found no historic drill holes that were not abandoned properly. Also there has not been any evidence of historic drill holes causing cross contamination between aquifers when conducting pump tests or when reviewing historic versus current water levels and water quality in monitor wells that are present in the permit areas. Furthermore, since the historic drill holes have been released by the WDEQ, an assumption can be made that the holes were properly abandoned according to the rules and regulations in place at the time the drill holes were abandoned. No problems are anticipated with past abandoned drill holes.

All known abandoned drill holes are listed in Tables JD-D6I.1-1 and JD-D6I.1-2. The first letters of the drill holes (historic and current) denote the company that drilled the hole as seen after the company name in the previous paragraph. The location and density of all drill holes is shown on Exhibit JD-D6-4.

Abandonment methods used for exploration holes drilled prior to 1997 were sealed and surface plugged in compliance with the State of Wyoming regulations in effect at the time of drilling. The methods utilized prior to 1997 mostly consisted of drilling and abandoning drill holes with drill and natural mud. No additional materials were added to increase the solids or viscosity. After 1977 bentonite was added if needed in abandoning drill holes. Drill holes abandoned by this method are denoted by a "1" in Table JD-D6I.1-2. Drill holes that have a "2" are denoted for abandonment method in Table JD-D6I.1-1 and JD-D6I.1-2 have been abandoned in accordance to current Wyoming Statue §35-11-404 and Wyoming Department of Environmental Quality – Land Quality Division (WDEQ-LQD) Noncoal Rules and Regulations, Chapter 8. These drill holes are abandoned by sealing the drill hole with additional high solids (fortified) bentonite circulated at total depth or abandonment muds as

specified in Wyoming Statue §35-11-404 and Chapter 8 of the WDEQ LQD Noncoal Rules and Regulations. All drill holes were surface sealed and marked for identification.

2.8 ECOLOGY

2.8.1 Topography

The Nichols Ranch ISR Project area is located in the Powder River Basin in northeast Wyoming (Knight 1994). The project area is composed of **three** noncontiguous units located west and southwest of the North Middle Butte in the Pumpkin Butte area. The Hank Unit is located near the western flank of the North Middle Butte and is located in southwest Campbell County. Topography of the Hank Unit includes gently rolling hills and low ridges, as well as steep terrain near North Middle Butte and some steeply eroded areas associated with Dry Willow Creek (an ephemeral stream) located in the southern portion of this unit. Elevations in the Hank Unit range from 5,055 to 5,209 ft AMSL and the area is dissected by a series of unnamed ephemeral drainages that generally drain west and southwest toward Dry Willow Creek.

The Nichols Ranch **and Jane Dough Units** are located approximately 4.2 mi southwest of the Hank Unit on the border between Johnson and Campbell Counties. Topography in this area is relatively flat with gently rolling hills and low ridges that drain south toward Cottonwood Creek (an intermittent stream) that is located in the southern portion of the unit. Elevations in the Nichols Ranch **and Jane Dough** Units range from **approximately** 4,670 to 4,900 ft AMSL.

2.8.2 Soils

Soils within the Hank and Nichols Ranch Units were inventoried and mapped based on standards of a National Cooperative Soil Survey (U.S. Department of Agriculture 1993) and include an inventory of soil types (soil map units) and soil series based on an Order 2 soil survey conducted in 2006 **and the Jane Dough Unit was inventoried and mapped to the same standard in 2011**. A soil map delineating the soil types was prepared and as directed by the Wyoming Department of Environmental Quality/Land Quality Division (WDEQ/LQD), soil samples from potential

disturbance areas were collected and analyzed. Physical and chemical characteristics of the topsoil within the potential disturbance areas and estimated depths of salvageable topsoil from the potential disturbance areas for future reclamation purposes were also estimated.

Soils occurring in the Hank, **Jane Dough,** and Nichols Ranch Units are generally fine-textured throughout with patches of sandy loam on upland areas and fine-textured soils occurring in or near drainages. The project area contains deep soils on lower toeslopes and flat areas near drainages with shallow and moderately deep soils located on upland ridges and shoulder slopes.

Based on the results of the soil sampling, there are no factors that will limit the suitability of topsoil as a plant growth medium during the reclamation phase. All laboratory values were compared to Table I-2 of WDEQ/LQD Guideline No. 2 (1994) and the results were determined to be within the suitable range, except for marginal soil texture for four soil profiles from three samples collected in the Hank Unit. These four soil profiles were determined to have clay soil textures. Additionally, based on a reconnaissance survey conducted by Natural Resource Conservation Service, no prime farmland was identified within the Nichols Ranch ISR project area.

Detailed soils information for the Nichols Ranch ISR Project area is presented in Appendix D-7 **and Appendix JD-D7** of the WDEQ/LQD Permit to Mine Application and includes a literature review, results and interpretations of the soil survey, analytical results of soil sampling, and an evaluation of soil suitability as a plant growth medium.

2.8.3 Vegetation

Baseline vegetation studies of the Nichols Ranch and Hank Unit areas were conducted in June and July 2006. **Baseline vegetation studies of the Jane Dough Unit areas were conducted in July 2010.** Baseline vegetation studies were conducted in accordance with a vegetation study plan approved by the Wyoming Department of Environmental Quality, Land Quality Division (WDEQ/LQD) for noncoal permit areas. The sampling design and methods used for the vegetation study followed Rule 1-V (revegetation performance standards): Noncoal Rules, Chapter 3 (WDEQ/LQD, amended April 25, 2006), WDEQ/LQD Guideline Number 2 (WDEQ/LQD 1997), and WDEQ/LQD Draft Guideline 2 Rewrite (WDEQ/LQD 2004).

The Nichols Ranch Project area is composed of eight vegetation/habitat types, with approximately 88% of the project area composed of two vegetation types (sagebrush shrubland and mixed

grasslands) (see Table 2-21 and **2-21a**). **Two wetland areas were found**, and this will be avoided by project activities. No federal threatened, endangered, candidate, or proposed plant species were found, and none are known to occur in the project area. Only one designated noxious weed species (Canada thistle) and one selenium indicator species (two-groove milk vetch) were found during surveys; both were found in small numbers in disturbed areas. Table 2-21 presents the results of vegetation studies conducted in the Nichols Ranch and Hank Units in June and July 2006 and **Table 2-21a presents the results of the vegetation studies conducted in the Jane Dough Unit in July 2010**.

Detailed vegetation information for the Nichols Ranch ISR Project area is presented in Appendix D8 (Nichols Ranch and Hank Unit) and Appendix JD-D8 (Jane Dough Unit) of the WDEQ/LQD Permit to Mine Application and includes results of vegetation mapping and a description of the vegetation communities, results of cover sampling, a species list, and a discussion of threatened and endangered species, noxious weeds, and selenium indicator species.

Table 2-21 Vegetation/Habitat Types, Number of Acres, and Sampling Intensity, Nichols Ranch ISR Project, 2006.[1]

Vegetation/Habitat Type	Premine No. of Acres	Percent of Project Area	Estimated Affected Acres	Minimum Sample Size[1]	Adequate Sample Size (Nmin)[2] for Vegetative Cover
Sagebrush shrubland	1,905.4	56.8	7	20	6.3
Mixed grassland	1,061.7	31.4	5	20	10.2
Juniper outcrop	148.3	4.4		20	28.2
Bottomland	125.1	3.7		20	16.5
Greasewood shrubland	64.4	1.9		15	12.2
Wetland	1.1	<0.1		Not sampled	--
Rock outcrop	17.5	0.5		Not sampled	--
Disturbed lands[3]	42.3	1.2		Not sampled	--
Total	3,370.53	100	12[4]		

1 Based on WDEQ/LQD (2004) and on approved sampling plan for the project submitted WDEQ/LQD prior to sampling.

2 Includes 8.3 acres of previously disturbed lands as evident by annual grasses and weeds and 8.8 mi (32.0 acres) of roads (30-ft wide disturbance).

3 Estimated disturbance from the two production plants. Disturbance from wells, pipelines, and additional access roads is unknown.

Table 2-21a Vegetation/Habitat Types, Number of Acres, and Sampling Intensity, Jane Dough Unit, 2010.

Vegetation/ Habitat Type	Premine No. of Acres	Percent of Project Area	Estimated Affected Acres[1]	Minimum Sample Size[2]	Adequate Sample Size (Nmin) for Vegetative Cover[3]
Sagebrush grassland	2,682.7	72.9	61.7	20	2.6
Mixed grassland	754.4	20.5	39.3	20	4.7
Bottomland	114.1	3.1	0	20	0.2
Hay meadow	66.2	1.8	0	Not sampled	--
Wetland	2.1	<0.1	0	Not sampled	--
Rock outcrop	5.3	<0.1	<1	Not sampled	--
Disturbed lands	55.2[4]	1.5	0	Not sampled	--
Total	3,680.0	100	101[5]		

1 Estimated disturbance from wells, pipelines, and additional access roads is estimated.
2 Based on WDEQ/LQD (2004) and on approved sampling plan for the project submitted WDEQ/LQD prior to sampling.
3 See Table JD-D8-7.
4 Includes 9.3 acres of previously disturbed lands from CBM pads and ponds, and 12.6 miles (46.6 acres) of roads (30-foot wide disturbance).
5 Rounded

2.8.4 Wildlife

2.8.4.1 General

The Nichols Ranch ISR Project area (including the Nichol Ranch, Hank, **and Jane Dough Units)** is located within the 10- to 14-inch Northern Plains (10-14NP) zone of Northeastern Wyoming (Natural Resources Conservation Service 1988) and the project area provides habitat for wildlife that is typical for the region. The study area has the potential to provide habitat for mule deer, elk, pronghorn antelope, jackrabbit, cottontail rabbit, coyote, bobcat, mountain lion, red fox, badger, raccoon, skunk, chipmunk, rodents, songbirds, waterfowl, eagles, hawks, owls, sage grouse, chukar, wild turkey, Hungarian partridge, mourning dove, magpie, and crow. Most species are yearlong residents; however, some species such as elk, eagles, songbirds, and waterfowl are more abundant during migration periods (Cerovski et al. 2004).

Mammal and bird species found during site specific surveys of the project area included pronghorn, mule deer, bobcat, coyote, badger, desert cottontails, white-tailed jackrabbits, greater sage-grouse, and gray partridge. Small mammals included black-tailed prairie dogs and thirteen-lined ground squirrels. Raptors confirmed breeding included great horned owl, long-eared owl, golden eagle, red-tailed hawk, and prairie falcon; wintering raptors included bald eagle, golden eagle, red-tailed hawk, and rough-legged hawk.

Detailed wildlife information for the Nichols Ranch ISR Project area is presented in Appendix D9 **(Nichols Ranch and Hank Units)** and Appendix JD-D9 **(Jand Dough Unit)** of the WDEQ/LQD Permit to Mine Application and includes a complete species list, methods and results of site-specific species surveys, potential wildlife impacts and mitigation measures, and information concerning threatened and endangered species.

2.8.4.2 Federal Threatened, Endangered, Proposed and Candidate Species

The original Uranerz license included the black-footed ferret (an endangered species) and bald eagle (a threatened species) under the Endangered Species Act in the license application and supporting information. The black-footed ferret (an endangered species) was originally included in the license application as potentially occurring in the Nichols Ranch Unit because

of the prescense of black-trail prairie dog colonies in the project area. However, since the original license was prepared in 2006. In March of 2013, the U.S. Fish and Wildlife Service (USFWS) has determined that presence/absence survyes for black-footed ferrets are not required anywhere in Wyoming. In addition, the USFWS has designated only one area in southeast Wyoming as requiring Section 7 consultation. None of the Nichols Ranch ISR project area (including Nichols Ranch, Hank, and Jane Dough Units) are located in the Section 7 designated consultation area. Therefore, the black-footed is no longer a concern for the Nichols Ranch ISR project (including the Nichols Ranch, Hank, and Jane Dough Units) and it is not addressed further is this document.

The original Uranerz license also included the bald eagle (a threatened species) in the original 2006 NRC license applicatioin. However, in 2007 the USFWS delisted the bald eagle from the Endangered Species Act (as amended). While the bald eagle is no longer listed under the Endangered Species Act, it is still protected and managed under several other federal statutes and state policies. This species occur in the Nichols Ranch ISR project area; however, it is no longer addressed as a threatened, endangered, candidate, or proposed species. Instead the bald eagle is addressed as a special status species in the next section.

The greater sage-grouse is a federal candidate species that is known to occur within the proposed project area. The species was first petitioned for federal listing as threatened or endangered in July 2002. After several additional petitions and court challenges, the USFWS issued a final determination of "warranted for listing but precluded by higher priorities" (i.e., a candidate species) in March 2010 (USFWS 2010). As a result, the greater sage-grouse was placed on the list of federal candidate species (50 C.F.R. Part 17 [FWS-R6-ES-2010-0018] [MO 92210-0-0008-B2]).

The locations of known occupied greater sage-grouse leks within 2.0 miles of the Jane Dough Unit and the location of greater sage-grouse CPAs were gathered from the WGFD databases (WGFD 2012). The WGFD identified four leks within 2.0 miles of the Jane Dough Unit: 38-Cottonwood Creek 1, 38-Cottonwood Creek 1 Satellite, 38-Cottonwood 2, and 38-Cottonwood 3 (map pocket Figure JD-D9-3 in Appendix JD-D9). All of these leks have been surveyed annually since 2005. Each lek was visited three times at sunrise and the maximum number of males and female birds were recorded.

The period-of-record activity status and number of birds observed are presented on Table JD-D9-2 in Appendix JD-D9 for each of the four lek locations. 38-Cottonwood Creek 1 was active from 2005-2009; 38-Cottonwood Creek 1 Satellite was active in 2006 and 2007; 38-Cottonwood Creek 2 was active in 2005-2010; and 38-Cottonwood Creek 3 was active in 2005-2007. No activity was noted on any of the four leks in 2011 or 2012.

The Nichols Ranch ISR project area (including the Jane Dough Unit) is located outside of any core population area (CPA) and therefore, will not impact any greater sage-grouse CPAs. The closest CPA is located approximately 9.4 miles northwest of the Jane Dough Unit. In addition, the WGFD has not identified any winter concentration or connectivity areas within or near the Nichols Ranch ISR project area. In accordance with the Wyoming Governor's Executive Order 2011-5, development activities are restricted in CPA, winter concentration areas, and connectivity areas; however, none of these areas or restrictions applies to the Nichols Ranch ISR project area.

However, one occupied greater sage-grouse lek (38-Cottonwood Creek 1) occurs within the Jane Dough Unit (0.25 miles inside the southeast boundary of the Jane Dough Unit) (refer to Figure 1). This lek been monitored annually since 2005 and Lek 38-Cottonwood Creek 1 was active annually from 2005-2009 but has not been active for the past four years (2010-2013).

Based on the location of the proposed wellfields and this lek, the Jane Dough Unit will have no direct physical impacts on any greater sage-grouse leks. The closest portion of the Jane Dough Unit wellfield is approximately 0.75 mile away from Cottonwood Creek 1 lek. In addition, the Wyoming Governor's Executive Order 2011-5, identifies areas outside of CPA but within 0.25 mile of any occupied leks as no surface occupancy areas; meaning that no development can be permitted through any state agency to occur in these areas. Therefore, Uranerz will not conduct any ground-disturbing activities within the 0.25 mile no surface occupancy area around any occupied lek.

It is also possible that construction activities could impact nesting and brood rearing activities of greater sage-grouse and they might avoid using nesting and brood rearing habitat near any occupied lek. Therefore, to address the potential disturbance near occupied

greater sage-grouse leks, Executive Order 2011-5 indicates that "a two (2) mile seasonal buffer should be applied to occupied leks." To comply with this portion of the Executive Order, Uranerz will:

- **monitor attendance at this lek annually during the lekking season (April 1 through May 7);**
- **not conduct any surface-disturbing activities (e.g., topsoil removal) within 2 miles of any occupied lek from March 15 through June 30; and**
- **if an area is physically disturbed (i.e., stripped of topsoil) prior to March 15, Uranerz will be able to continue all non-surface disturbing activities (e.g., construction, drilling, well completion, pipeline installation, etc.) within 2 miles of any occupied lek between March 15 and June 30. During the seasonal buffer period, Uranerz will limit non-surface disturbing activities to daylight hours and will minimize noise to the extent possible.**
- **Once uranium extraction facilities have been installed, Uranerz will be able to conduct year-round routine and emergency maintenance and service on all facilities within the Jane Dough Unit.**

To reduce raptor predation on greater sage-grouse, the construction of overhead power lines, permanent high-profiled structures such as storage tanks, and other perch sites would not be constructed within 0.25 mi of any active lek. In addition, some greater sage-grouse could be lost due to vehicle collisions. Therefore, Uranerz will advise project personnel of appropriate speed limits for specific access roads, that they are not allowed to haze or harass the animals, and that they should minimize any direct disturbance to all wildlife whenever possible.

2.8.4.3 Special Status Species

The Bureau of Land Management (BLM), Buffalo Field Office also monitors and manages nonlisted (under the federal Endangered Species Act) special status (SS) species (i.e., species of concern) that could occur on federal lands to reduce potential impacts that might lead to their listing by the USFWS. The BLM list of SS species included six mammals, 15 birds, two amphibians, and one fish species **within the Nichols Ranch ISR project area (including the Nichols Ranch, Hank, and Jane Dough Units).**

No mountain plovers were seen during the two surveys or during opportunistic observations throughout the 2006 field season. In addition, there are no records that mountain plovers exist within the wildlife study area (BLM 2006; WNDD 2006). The closest BLM sighting of mountain plover is approximately 4.0 mi from the project area (BLM 2006). Therefore, the Nichols Ranch ISR Project is expected to have minimal impacts to mountain plovers.

One swift fox, a BLM SS species, was observed crossing the Van Buggen road approximately 5.0 mi east of the Nichols Ranch Project area during the 2006 field season. It is likely that swift fox inhabit the wildlife survey area because of the suitable short mixed grassland habitat. Therefore, the Nichols Ranch ISR Project is expected to have minimal impacts to swift foxes.

The WNDD and BLM have occurrence records of several BLM SS species in the vicinity of the Nichols Ranch Project area including sage sparrow, Brewer's sparrow, loggerhead shrike, sage thrasher, burrowing owl, ferruginous hawk, and northern leopard frog. Based on the lack of any observations and existing data, the Nichols Ranch ISR Project is expected to have minimal impacts on these species. In addition, these are no occurrence records or observations of any of the remaining BLM SS species; therefore, the Nichols Ranch ISR Project is expected to have no impacts on any of the remaining BLM SS species.

2.9 BACKGROUND RADIOLOGICAL CHARACTERISTICS

2.9.1 Surface Soil, Subsurface Soils and Sediment

2.9.1.1 Purpose and Procedure

In June of 2007, an extensive soil and sediment sampling program was completed for the Nichols Ranch and Hank Units of the Nichols Ranch ISR Project. The purpose of the effort was to develop a representative radiological baseline for surface and subsurface soils and sediments**. An identical soil and sediment sampling program was completed in September 2011 for the Jane Dough Unit utilizing identical methodologies to that used in 2007.**

Prior to conducting a field reconnaissance and collecting the samples, a map was prepared on a large-scale U.S. Geological Survey (USGS) topographic base showing the license boundary, plant site location and ore zone footprint (as much as it was known at the time). Because of their importance in an assessment such as this, the location of cultural features (residences, ranches, water wells, water impoundments, roads, etc.) with respect to the future process facility, production areas and license boundary were considered in the sampling design.

After completing the base map described above, a field reconnaissance was conducted to visually inspect the project area. All of the features just noted were considered in terms of their respective locations to the license boundary. Following the reconnaissance, a sample site map was prepared. Coordinates for each sample site were included with the map.

In determining the number, type (surface, subsurface and sediment) and areal distribution of sampling locations, pertinent NRC documents were used, along with judgment based on many years of experience developing pre-operational and operational environmental monitoring programs for in situ recovery (ISR) operations. The primary documents included: (1) NRC Regulatory Guide 4.14, "Radiological Effluent and Environmental Monitoring at Uranium Mills," USNRC, April 25, 1980; (2) NUREG-1569, Standard Review Plan for In Situ Leach Uranium Extraction License Applications," Final Report, USNRC, June 2003; and (3) NUREG-1748 "Environmental Review Guidance for Licensing Actions Associated with NMISS Programs," Final Report, USNRC, August 2003 Regulatory Guide 4.14 is the

document that outlines the specifics of a pre-operational radiological monitoring program. Table 1 in the guide, for example, lists the suggested number, type, location and frequency of samples. Because of the age of the guide, and because it primarily addresses conventional mills, Uranerz employed a modified baseline sampling program designed for a modern ISR facility. From a standpoint of physical disturbance and radiological alteration, it is widely recognized that a modern-day ISR operation has minimal impact on surface and subsurface soils.

There are three major reasons why the impacts are insignificant: (1) the recovery technique does not require the removal of overburden nor does it require the physical removal of the ore zone; (2) it is a wet process up to the stage of drying and packaging; and (3) modern dryers and packaging systems do not have significant particulate discharges. Thus in the absence of significant particulate sources, radiological impacts on soils and sediments through aerial dispersal and subsequent deposition are not associated with modern ISR operations. Experience shows that potential radiological impacts are almost exclusively associated with accidental spills from pipe leaks or ruptures that occur off of the process facility pad (i.e., within the wellfields and between the wellfields and the process facility). Spills occurring on the process pad are fully contained by the curbed volume of the pad and its sump system. It should be noted that an accidental spill from a pipe break in a wellfield does not necessarily result in a major impact on soils or sediments. Engineering controls and a management program based on the principles of ALARA provide a high degree of assurance that impacts will be minimal. To illustrate, a pipeline break would cause a loss in pressure and this would be quickly detected by the monitoring system. In addition to engineering controls, employees who are in the wellfields on a daily basis are trained to observe routinely the condition pipelines and wellheads. Leaks or breaks would be reported immediately. In the event of a break, the wetted area would be surveyed, sampled and recorded on a spill map. Soils with significantly elevated levels of uranium and radium-226 would be removed and disposed at a licensed site.

Knowing that potential impacts are attributed to pipeline ruptures and leaks, the pre-operational sampling program was designed to thoroughly characterize radiological baseline conditions in the areas most likely to experience potential impacts. A review of Exhibit D11-1(see map

pocket), Nichols Unit-Soil and Sediment Sample Location Map, and Exhibit D11-2 (see map pocket) Hank Unit Soil and Sediment Sample Location Map in the attached Appendix D11 clearly shows that the focus of the baseline characterization was on the wellfield areas and the intermittent/ephemeral streams passing through the license area. A close examination of the map shows that sediment samples were collected from upstream and downstream locations in all of the streambeds. In addition to thoroughly sampling the wellfields and water courses, the radiological baseline was supplemented by including samples from areas within the license area (see sample sites labeled LAS on the map), the process facility location and the Rn-222/Gamma monitoring stations. Again, using Regulatory Guide 4.14 for general guidance, all soils and sediments were analyzed for Ra-226 and a large percentage of the total number of samples included analyses for U, Pb-210 and Th-230. In brief, the extensive coverage of the sampling effort provides a representative radiological baseline against which operational activities can be measured.

2.9.1.2 Sampling Methodology

The sample site map and coordinates described above, guided field personnel to the sample site locations. Surface and subsurface soils were collected with a 3-inch diameter bucket auger. Surface soils were collected from surface to a depth of 6-inches, and subsurface soils were collected in 12-inch increments to a total depth of 36 inches. The depth increments generally follow Regulatory Guide 4.14.

To avoid cross-contamination, the sampler and other tools were cleaned after each use using paper towels and de-ionized water. Samples were placed in 1-gallon plastic freezer bags and stored in ice chests prior to delivery to the laboratory. While collecting the soil samples, gamma measurements were taken using a Ludlum Model 19 μR Survey Meter. The calibration date on the meter for the June 2007 survey was June 8, 2007 (Nichols Ranch and Hank Units) **and the calibration date for the September 2011 survey was September 2, 2011 (Jane Dough Unit)**. While holding the meter at waist level, the area at and proximate to the sample point was surveyed for approximately two minutes. Gamma levels were recorded along with the GPS coordinates for each site.

The procedure for collecting sediment samples varied slightly from the soil sampling methodology. Instead of a single incremental sample, several samples were taken around each site to form a composite sample. As with the soil samples, sediments were placed in 1-gallon plastic freezer bags and placed in ice chests prior to delivery to the laboratory. Gamma measurements were taken following the protocol just described.

2.9.1.3 Nichols Ranch Unit Results

Table 2-22, Radiological Background in Surface and Subsurface Soil-Nichols Ranch Unit, provides a summary of the analyses for each sample point as well as some basic statistical measures (minimum, maximum, average and standard deviation).

Most of the surface soil sample and all of the subsurface samples have typical background radiological characteristics (approximately 1 pCi/g or less). For comparison purposes, normal soils typically have a Ra-226 content of 1 pCi/g (National Council on Radiation Protection and Measurement 1984). With the exception of one site, (LAS-5), which had a Ra-226 level of 26 pCi/g, the table shows normal background levels. The elevated level at LAS-5 might be attributed to old exploration activities.

With respect to sediment, Table 2-23 Radiological Background in Sediment - Nichols Ranch Unit shows that 40% of the samples exceed normal background levels of 1 pCi/g for Ra-226. Elevated levels were detected at sample sites SD-1, 8, 9 and 10. A possible explanation for this departure could be that earlier exploration activities may have left ore zone cuttings on the surface because a significant percentage of the sites have elevated Ra-226, the average value 9.6 pCi/g is well in excess of normal background. Pb-210 was also detected at higher than normal background levels at two of the sites, resulting in a slightly higher than normal average.

Table 2-22 Radiological Background in Surface and Subsurface Soil - Nichols Ranch Unit.

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
R-1	0-6	1.85	2.1	0.3	0.8	0.2	0.7	0.1
R-2	0-6	1.42	0.9	0.2	0.8	0.2	ND	
R-3	0-6	1.93	1.1	0.2	0.7	0.2	ND	
R-4	0-6	2.58	1.1	0.2	1.2	0.2	ND	
R-5	0-6	1.66	0.1	0.1	0.6	0.1	ND	
SS-6	0-6				0.8	0.2		
SS-7	0-6				1.3	0.2		
SS-8	0-6	1.12	0.7	0.1	0.6	0.2	ND	
SS-9	0-6				0.8	0.2		
SS-10	0-6				0.9	0.2		
SS-11	0-6	1.39	ND		0.9	0.2	ND	
SS-12	0-6				0.3	0.2		
SS-13	0-6				0.8	0.2		
SS-14	0-6				0.9	0.2		
SS-15	0-6				0.6	0.2		
SS-16	0-6				1.5	0.2		
SS-17	0-6				0.8	0.2		
SS-18	0-6				0.8	0.2		
SS-19	0-6	1.64	ND		1.4	0.2	0.1	0.1
SS-20	0-6				0.8	0.1		
SS-21	0-6				2.4	0.2		
SS-22	0-6	1.89	ND		0.9	0.1	0.8	0.6
SS-23	0-6				0.6	0.1		
SS-24	0-6				0.4	0.1		
SS-25	0-6				0.5	0.1		
SS-26	0-6				0.7	0.1		
SS-27	0-6				0.7	0.1		
SS-28	0-6				0.7	0.1		
SS-29	0-6				0.8	0.1		
SS-30	0-6				1.2	0.1		
LAS-1	0-6	0.97	ND		0.4	0.1	0.3	0.1
LAS-2	0-6	2.96	ND		0.9	0.2	0.7	0.1
LAS-3	0-6	2.58	ND		0.8	0.2	0.3	0.1
LAS-4	0-6	1.37	ND		1.0	0.2	0.7	0.1
LAS-5**	0-6	4.72	ND		26.4	3.9	0.6	0.1
LAS-6	0-6	2.19	ND		1.3	0.2	0.6	0.1
LAS-7	0-6	1.73	1.0	0.4	1.0	0.2	0.5	0.1
LAS-8	0-6	1.51	ND		1.0	0.2	0.5	0.1
Plant Site								
Center	0-12	1.43	ND		1.0	0.2	0.5	0.1
	12-24	1.22	0.5	0.4	1.0	0.2	0.4	0.1

Table 2-22 (Continued)

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
Plant Site								
Center	24-36	1.37	ND		0.7	0.2	0.6	0.1
NW	0-6	1.43	0.4	0.1	1.2	0.2	ND	
NE	0-6	1.42	0.6	0.1	0.9	0.2	ND	
SE	0-6	1.2	0.3	0.1	1.1	0.2	ND	
SW	0-6	1.45	1.0	0.2	1.0	0.2	1.1	0.6
SB-4	0-12	2.7	ND		1.0	0.1	0.5	0.1
	12-24	3.95	ND		1.0	0.1	0.6	0.1
	24-36	2.34	ND		0.8	0.1	0.4	0.1
SB-5	0-12	1.00	ND		0.7	0.1	0.4	0.1
	12-24	1.35	1.6	0.4	0.6	0.1	0.4	0.1
	24-36	1.91	0.7	0.3	0.7	0.1	0.2	0.1
SB-6	0-12	1.29	ND		0.8	0.2	0.5	0.1
	12-24	1.8	0.5	0.4	1.6	0.2	0.4	0.1
	24-36	2.05	0.4	0.4	0.8	0.2	0.5	0.1
SB-7	0-12	1.01	ND		0.8	0.1	0.3	0.1
	12-24	1.45	ND		0.9	0.2	0.4	0.1
	24-36	1.73	ND		0.9	0.2	0.6	0.1
SB-8	0-12	1.88	ND		1.1	0.2	0.7	0.1
	12-24	2.23	ND		1.0	0.1	0.7	0.1
	24-36	2.59	ND		1.0	0.1	0.5	0.1
Sample Site		Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
Surface Soil:								
Minimum		**0.97**	**0.1**		**0.3**		**0.1**	
Maximum		**4.72**	**1.1**		**26.4**		**1.1**	
Average		**1.69**	**0.7**		**0.9**		**0.6**	
Standard Deviation		**0.52**	**0.3**		**0.4**		**0.2**	
Subsurface Soil:								
Minimum		**1.00**	**0.4**		**0.6**		**0.2**	
Maximum		**3.95**	**1.6**		**1.6**		**0.7**	
Average	**0-12**	**1.55**	**ND**		**0.9**		**0.5**	
	12-24	**2.00**	**0.4**		**1.0**		**0.5**	
	24-36	**2.00**	**0.2**		**0.8**		**0.5**	

Notes: R-1: Nearest Residence. R-1 through R-4: Rn-222 and Gamma Monitoring Locations. *Reporting Limit: 0.50, SS: Surface Soil, SB: Subsurface Soil, LAS: License Area Sample, ND: Not Detected, See Exhibit D11-1 for sample site locations. **U and Ra-226 values for LAS-5 appear to be anomalies and were not used in the statistics. Radionuclide Methods are as follows: Radium 226-E903.0, Uranium-SW6020, Lead 210-NERHL-65-4, Thorium 230-E907.0

Table 2-23 Radiological Background in Sediment - Nichols Ranch Unit.

Sample Site	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
SD-1	2.1	ND		16.2	3.0	0.5	0.1
SD-2	2.02	ND		0.6	0.1	0.5	0.1
SD-3	1.84	0.7	0.3	0.7	0.1	0.5	0.1
SD-4	1.77	ND		0.7	0.1	0.4	0.1
SD-5	1.96	2.0	0.4	1.0	0.2	0.4	0.1
SD-6	0.95	ND		0.5	0.1	0.2	0.1
SD-7	3.07	0.5	0.4	1.0	0.2	0.6	0.1
SD-8	2.67	1.8	0.4	32.2	4.2	1.0	0.2
SD-9	3.03	ND		23.5	3.6	0.6	0.1
SD-10	4.02	ND		19.4	3.3	0.9	0.1
Minimum	**0.95**	**ND**		**0.5**		**0.2**	
Maximum	**4.02**	**2.0**		**32.2**		**1.0**	
Average	**2.34**	**1.3**		**9.6**		**0.6**	
Standard Deviation	**0.87**	**0.8**		**12.1**		**0.2**	

Notes:
SD: Sediment.
*Reporting Limit: 0.50.
ND: Not Detected.
See Exhibit D-11-1 for sample site locations.
Radionuclide Methods are as follows: Radium 226-E903.0, Uranium-SW6020, Lead 210-NERHL-65-4, Thorium 230-E907.0

2.9.1.4 Hank Unit Results

Table 2-24 Radiological Background in Surface and Subsurface Soil - Hank Unit provides a summary of the analyses for each sample point as well as some basic statistical measures (minimum, maximum, average and standard deviation). With just a few exceptions, the values in the table are within the expected ranges. Briefly, the average value for Ra-226 is 1.1 pCi/g, and this nearly matches the reference radium concentration of 1 pCi/g in normal soil (NCRP Report No. 78). Similarly, values for U, Th-230 and Pb-210 also fall within expected background ranges. One site, LAS-2, had the highest values for uranium (8.4 mg/kg), Pb-210 (1.2 pCi/g), Ra-226 (3.8 pCi/g) and Th-230 (2.5 pCi/g).

Table 2-24 Radiological Background in Surface and Subsurface Soil - Hank Unit.

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
R-1	0-6	1.26	3.9	0.4	1.3	0.2	0.9	0.2
R-2	0-6	1.71	ND		0.5	0.1	ND	
R-3	0-6	1.04	ND		0.4	0.1	ND	
R-4	0-6	2.77	0.3	0.2	0.3	0.1	ND	
R-5	0-6	2.46	ND		1.0	0.2	ND	
SS-6	0-6				1.5	0.1		
SS-7	0-6	2.19	ND		1.7	0.2	1.2	0.6
SS-8	0-6				1.2	0.1		
SS-9	0-6				1.1	0.1		
SS-10	0-6				2.1	0.1		
SS-11	0-6				1.1	0.1		
SS-12	0-6				1.0	0.1		
SS-13	0-6				0.9	0.1		
SS-14	0-6				1.3	0.1		
SS-15	0-6				1.1	0.1		
SS-16	0-6	1.37	ND		1.3	0.2	ND	
SS-17	0-6				1.3	0.1		
SS-18	0-6				0.8	0.1		
SS-19	0-6				0.9	0.1		
SS-20	0-6				1.2	0.1		
SS-21	0-6				1.1	0.2		
SS-22	0-6				1.3	0.2		
SS-23	0-6				0.9	0.2		
SS-24	0-6				1.1	0.2		
SS-25	0-6	1.81	ND		1.0	0.2	1.2	0.6
SS-26	0-6				0.7	0.1		
SS-27	0-6				0.7	0.1		
SS-28	0-6				0.9	0.2		
SS-29	0-6				1.1	0.2		
SS-30	0-6				1.2	0.2		
SS-31	0-6				0.7	0.2		
SS-32	0-6				1.2	0.2		
SS-33	0-6				0.9	0.2		
SS-34	0-6	2.10	ND		1.3	0.2	1.2	0.5
SS-35	0-6				1.1	0.2		
LAS-1	0-6	1.60	0.5	0.1	0.9	0.1	0.3	0.1
LAS-2**	0-6	8.40	1.2	0.1	3.8	0.1	2.5	0.1
LAS-3	0-6	1.40	ND		0.8	0.1	0.4	0.1
LAS-4	0-6	1.00	ND		0.8	0.1	0.2	0.1
LAS-5	0-6	1.60	0.6	0.1	1.1	0.1	0.5	0.1
LAS-6	0-6	1.50	ND		0.9	0.1	0.4	0.1
LAS-7	0-6	1.00	0.3	0.1	0.6	0.1	0.3	0.1
LAS-8	0-6	1.10	ND		0.6	0.1	0.5	0.1
LAS-9	0-6	1.39	ND		1.3	0.2	0.7	0.2
LAS-10	0-6	1.47	ND		1.2	0.2	0.7	0.2
LAS-11	0-6	2.35	ND		1.0	0.2	0.5	0.2
LAS-12	0-6	2.40	ND		1.3	0.1	0.6	0.1
LAS-13	0-6	1.90	ND		1.2	0.1	0.8	0.1
LAS-14	0-6	1.50	0.3	0.1	1.0	0.1	0.5	0.1
SB-4	0-12	2.30	0.9	0.1	1.6	0.1	0.9	0.1
	12-24	2.00	0.7	0.1	1.1	0.1	0.5	0.1
	24-36	1.70	ND		0.8	0.1	0.4	0.1

Table 2-24 (Continued)

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
SB-5	0-12	1.30	ND		0.9	0.1	0.5	0.1
	12-24	ND	0.7	0.1	1.1	0.1	0.4	0.1
	24-36	1.80	0.6	0.1	1.1	0.1	0.4	0.1
SB-6	0-12	1.60	0.3	0.1	1.2	0.1	0.5	0.1
	12-24	1.40	0.2	0.1	1.2	0.1	0.7	0.1
	24-36	1.60	ND		1.2		0.7	0.1
SB-7	0-12	3.11	ND		0.9	0.1	0.4	0.1
	12-24	2.33	ND		0.9	0.2	0.6	0.1
	24-36	3.62	ND		1.1	0.2	0.7	0.2
SB-8	0-12	1.43	ND		1.3	0.2	0.4	0.1
	12-24	1.42	ND		1.2	0.2	0.4	0.1
	24-36	1.60	ND		0.8	0.2	0.6	0.2
SB-9	0-12	1.13	ND		0.9	0.2	0.5	0.3
	12-24	1.30	ND		0.8	0.2	0.2	0.1
	24-36	1.43	ND		1.0	0.2	0.6	0.3
Plant Site								
Center	0-12	1.35	ND		1.0	0.2	0.5	0.1
	12-24	1.28	ND		0.9	0.2	0.7	0.1
	24-36	1.57	0.7	0.04	0.9	0.2	0.5	0.1
NW	0-6	1.83	ND		1.0	0.2	ND	
NE	0-6	2.18			1.0	0.2	0.9	0.5
SE	0-6	1.82	ND		1.2	0.2	ND	
SW	0-6	1.67	0.3	0.2	1.0	0.2	ND	
Surface Soil:								
Minimum		**1.00**	**0.3**		**0.3**		**0.2**	
Maximum		**8.40**	**0.6**		**2.1**		**1.2**	
Average		**1.73**	**0.4**		**1.0**		**0.6**	
Standard Deviation		**0.48**	**0.1**		**0.3**		**0.3**	
Subsurface Soil:								
Minimum					**0.8**		**0.2**	
Maximum					**1.6**		**0.9**	
Average	**0-12**	**1.75**	**0.2**		**1.1**		**0.5**	
	12-24	**1.39**	**0.2**		**1.0**		**0.5**	
	24-36	**1.90**	**0.2**		**0.8**		**0.6**	

Notes:
R-1: Nearest Residence. R-1, 2, 3, 4 and 5: Rn-222 and Gamma Monitoring Locations.
*Reporting Limit: 0.50.
SS: Surface Soil.
SB: Subsurface Soil.
LAS: License Area Sample.
ND: Not Detected
See Exhibit D11-2 for sample site locations.
**Values for LAS-2 appear to be anomalies and were not used in the statistics.
Radionuclide Methods are as follows: Radium 226-E903.0, Uranium-SW6020, Lead 210-NERHL-65-4, Thorium 230-E907.0

Radiological background levels were measured at 26 different sediment sample sites at the Hank Unit. Table 2-25 Radiological Background in Sediment - Hank Unit summarizes the individual values and provides basic statistical information (minimum, maximum, average and standard deviation). Sample site SD-25 has a Pb-210 value (2.5 pCi/g) that is a few times higher than normal background but the rest of the sites are typical of what one would normally expect to find.

2.9.1.5 Jane Dough Unit Results

Table 2-24A Radiological Background in Surface and Subsurface Soil - Jane Dough Unit provides a summary of the analyses for each sample point as well as some basic statistical measures (minimum, maximum, average, and standard deviation).

The average background values are typical for surface soils in the U.S., averaging less than 1 pCi/g for Ra-226, Pb-210 and Th-230. According to (NCRP Report No.78), the average value of Ra-226 reported in surface soil is 1 pCi/g. The average Ra-226 background at the Jane Dough is a little lower but similar to a mean of 1.1 pCi/g background reported in a survey covering 33 states. Not surprising, the background at the Jane Dough and in the 33-state survey are similar to the natural values reported in sandstone (0.71 pCi/g), shale (1.1 pCi/g) and igneous rock (1.3 pCi/g). Similarly, the uranium values at the Jane Dough comport with typical natural background soils, which average approximately 2 pCi/g or 3 ppm (National Council on Radiation Protection and Measurement 1984).

The averages presented in the summary table are based on 156 surface soil samples that were collected throughout the project area. Because the averages in all three unit areas are consistent, and because they compare favorably with averages reported in the literature for surface soils, it can be concluded that the soils are representative of natural background conditions.

Radiological background levels were measured at 19 different sediment sample sites in the Jane Dough Unit. Table 2-25a Radiological Background in Sediment – Jane Dough Unit summarizes the individual values and provides basic statistical information (minimum, maximum, average, and standard deviation).

Table 2-24a Radiological Baseline in Surface and Subsurface Soil: Jane Dough Unit.

Sample Site	Depth (Inches)	Uranium (mg/kg*)	Pb-210 (pCi/g)	Precision Plus/Minus	Ra-226 (pCi/g)	Precision Plus/Minus	Th-230 (pCi/g)	Precision Plus/Minus
JD-1	0-6	1.16	1.0	0.1	0.8	0.06	0.5	0.2
JD-2	0-6	1.14	0.6	0.1	0.7	0.06	0.6	0.2
JD-3	0-6	1.80	0.7	0.1	0.7	0.05	0.6	0.2
JD-4	0-6	0.69	0.4	0.1	0.4	0.04	0.4	0.2
JD-5	0-6	0.75	0.3	0.1	0.4	0.04	0.4	0.2
JD-6	0-6	2.42	0.5	0.1	1.1	0.07	0.6	0.2
JD-7	0-6	2.32	1.3	0.1	0.9	0.06	0.8	0.3
LAS-1	0-6	1.80	0.6	0.1	0.9	0.06	0.8	0.3
LAS-2	0-6				1.0	0.06		
LAS-3	0-6				0.9	0.06		
LAS-4	0-6	1.40	0.6	0.1	1.0	0.06	0.7	0.2
LAS-5	0-6				1.0	0.07		
LAS-6	0-6				0.4	0.04		
LAS-7	0-6				0.6	0.05		
LAS-8	0-6				0.9	0.06		
LAS-9	0-6				0.9	0.06		
LAS-10	0-6				0.6	0.05		
LAS-11	0-6	1.06	1.0	0.1	0.6	0.05		
LAS-12	0-6				0.8	0.06		
LAS-13	0-6	1.39	1.0	0.1	0.7	0.05	0.7	0.2
LAS-14	0-6				0.4	0.04		
SS-1	0-6	1.25	0.7	0.1	0.9	0.06	0.9	0.3
SS-2	0-6				1.1	0.07		
SS-3	0-6				0.9	0.06		
SS-4	0-6				0.8	0.06		
SS-5	0-6	1.04	1.2	0.1	0.6	0.05	0.5	0.2
SS-6	0-6				0.8	0.06		
SS-7	0-6				0.7	0.05		
SS-8	0-6				0.5	0.04		
SS-9	0-6				0.6	0.05		
SS-10	0-6				0.8	0.05		
SS-11	0-6	2.17	1.2	0.1	0.8	0.05	0.7	0.2
SS-12	0-6				2.4	0.09		
SS-13	0-6				0.3	0.03		
SS-14	0-6				0.5	0.05		
SS-15	0-6				1.5	0.08		
SS-16	0-6				0.9	0.06		
SS-17	0-6	0.88	1.2	0.1	0.6	0.04	0.6	0.2
SS-18	0-6				0.8	0.05		
SS-19	0-6				0.6	0.05		
SS-20	0-6	1.16	0.8	0.1	0.7	0.05		
SS-21	0-6				0.8	0.06		
SS-22	0-6				0.9	0.06		
SS-23	0-6				0.7	0.06		
SS-24	0-6				0.9	0.06		
SS-25	0-6				0.6	0.05		
SS-26	0-6				0.8	0.06		

Table 2-24a (continued)

Sample Site	Depth (Inches)	Uranium (mg/kg*)	Pb-210 (pCi/g)	Precision Plus/Minus	Ra-226 (pCi/g)	Precision Plus/Minus	Th-230 (pCi/g)	Precision Plus/Minus
SS-27	0-6				0.4	0.04		
SS-28	0-6				0.5	0.04		
SS-29	0-6				0.9	0.07		
SS-30	0-6				0.6	0.05		
SS-31	0-6	1.65	0.5	0.1	0.8	0.06	0.5	0.2
SS-32	0-6				1.1	0.09		
SS-33	0-6				0.7	0.05		
SS-34	0-6				0.6	0.05		
SS-35	0-6				0.6	0.06		
SS-36	0-6				1.0	0.06		
SS-37	0-6				0.6	0.05		
SS-38	0-6				0.8	0.05		
SS-39	0-6				0.7	0.05		
SS-40	0-6	1.17	1.2	0.1	0.7	0.05	0.4	0.2
SS-41	0-6				0.7	0.05		
SB-1**	0-6	1.18	0.3	0.1	0.6	0.05	0.8	0.3
	6-12	0.96	0.2	0.1	0.5	0.04	0.4	0.2
	12-24	0.78	0.2	0.1	0.4	0.04	0.3	0.1
	24-36	0.65	0.2	0.1	0.4	0.04	0.3	0.2
SB-2**	0-6				0.6	0.05		
	6-12				0.6	0.05		
	12-24				0.6	0.05		
	24-36				0.6	0.05		
SB-3**	0-6				0.7	0.05		
	6-12				0.6	0.05		
	12-24				0.6	0.05		
	24-36				0.7	0.05		
SB-4**	0-6	1.34	1.0	0.1	0.6	0.05	0.5	0.2
	6-12	1.30	0.4	0.1	1.1	0.07	0.5	0.2
	12-24	1.28	0.4	0.1	0.6	0.05	0.3	0.1
	24-36	1.13	0.5	0.1	0.6	0.04	0.5	0.2
SB-5**	0-6	1.09	0.5	0.1	0.8	0.05	0.7	0.2
	6-12	1.17	0.6	0.1	0.9	0.06	0.8	0.3
	12-24	1.29	0.8	0.1	0.9	0.06	0.6	0.2
	24-36	2.15	0.8	0.1	1.0	0.06	0.9	0.3
SB-6**	0-6				0.8	0.06		
	6-12				0.9	0.06		
	12-24				0.8	0.05		
	24-36				0.8	0.06		
SB-7**	0-6				0.7	0.05		
	6-12				0.5	0.05		
	12-24				0.6	0.06		
	24-36				0.6	0.05		
SB-8**	0-6				0.6	0.05		
	6-12				0.8	0.06		
	12-24				0.3	0.03		
	24-36				0.3	0.03		
SB-9**	0-6				0.6	0.05		
	6-12				0.5	0.05		

Table 2-24a (continued)

Sample Site	Depth (Inches)	Uranium (mg/kg*)	Pb-210 (pCi/g)	Precision Plus/Minus	Ra-226 (pCi/g)	Precision Plus/Minus	Th-230 (pCi/g)	Precision Plus/Minus
	12-24				0.5	0.05		
	24-36				0.6	0.05		
SB-10**	0-6	1.20	0.4	0.1	0.7	0.05	0.5	0.2
	6-12	1.40	0.3	0.1	0.5	0.05	0.3	0.2
	12-24	1.63	0.4	0.1	0.2	0.03	0.4	0.2
	24-36	2.18	0.5	0.1	0.3	0.04	0.3	0.2
SB-11**	0-6				0.8	0.06		
	6-12				0.8	0.06		
	12-24				0.7	0.05		
	24-36				0.7	0.06		
SB-12**	0-6				0.8	0.05		
	6-12				0.8	0.05		
	12-24				0.7	0.05		
	24-36				0.7	0.05		
SB-13**	0-6	1.35	0.6	0.1	0.8	0.06	0.6	0.2
	6-12	1.65	0.5	0.1	0.7	0.05	0.6	0.2
	12-24	2.19	0.5	0.1	0.7	0.05	0.8	0.2
	24-36	4.01	0.9	0.1	0.9	0.06	0.7	0.2
Surface Soil:								
Minimum		0.69	0.3		0.3		0.4	
Maximum		2.42	1.3		2.4		0.9	
Average		1.37	0.8		0.8		0.6	
Standard Deviation		0.46	0.3		0.3		0.1	
Subsurface Soil:								
Minimum		0.65	0.2		0.2		0.3	
Maximum		4.01	0.9		1.1		0.9	
Average 6-12		1.30	0.4		0.7		0.5	
Average 12-24		1.43	0.5		0.6		0.5	
Average 24-36		2.02	0.6		0.6		0.6	

Note:
***Reporting Limit: 0.02 mg/kg dry.**
****SB-1 to SB-13 are the 0 to 6-inch surface soil portions collected at the subsurface soil sample sites.**

Baseline radionuclides in sediments at the Jane Dough Unit are generally similar to those measured at the Hank and Nichols Units. A comparison of the averages at the three sites is provided in the table below. With regard to uranium, the averages are closely matched but the slightly higher average at Jane Dough was influenced by two anomalous values recorded at sample sites SD-11 and SD-16. As shown on Table 2-25a, these two sites have values of 8.93 mg/kg and 9.21 mg/kg, respectively. Although the Hank Unit did not have any values approaching 9 mg/kg, it had four values greater than 3 mg/kg, compared to the single 3+ value at Jane Dough. Because of this, the two averages are not far apart. Similarly, although

the Nichols Ranch Unit did not have any values approaching 9 mg/kg, it had a value over 4mg/kg and a 2.73 mg/kg value. Also because there are many fewer sample points at the Nichols Unit compared to the Jane Dough Unit (10 vs. 19), the average at the Nichols Ranch Unit is more strongly influenced by higher values.

With respect to Pb-210, the background average slightly exceeds the averages at the Hank and Nichols Units. The reason for this can be attributed to the number of samples (5 in total) that have values greater than 2 pCi/g. By comparison, the Hank and Nichols sites each had only one value greater than 2 pCi/g. It is difficult to say why the frequency of Pb-210 above 2 pCi/g is greater at the Jane Dough Unit than the Hank and Nichols Units. All three sites share a common history of land use, which includes exploration and development of shallow coal bed methane and the exploration of uranium.

Table 2-25a Radiological Background in Sediment – Jane Dough Unit.

Sample Site	Uranium (mg/kg*)	Pb-210 (pCi/g)	Precision Plus/Minus	Ra-226 (pCi/g)	Precision Plus/Minus	Th-230 (pCi/g)	Precision Plus/Minus
SD-1	1.37	1.4	0.1	0.9	0.06	0.4	0.2
SD-2	1.84	0.8	0.1	0.7	0.05	0.7	0.2
SD-3	1.57	1.7	0.1	0.8	0.06	0.5	0.2
SD-4	2.15	2.4	0.2	0.9	0.06	0.7	0.2
SD-5	1.94	2.1	0.2	1.0	0.06	0.6	0.2
SD-6	1.51	1.5	0.1	0.7	0.05	0.6	0.2
SD-7	1.62	2.4	0.2	0.8	0.05	0.9	0.3
SD-8	1.92	0.7	0.1	0.6	0.05	0.5	0.2
SD-9	2.77	1.3	0.1	0.6	0.04	0.7	0.2
SD-10	3.40	1.1	0.2	0.7	0.05	0.6	0.2
SD-11	8.93	2.0	0.2	0.7	0.05	0.4	0.2
SD-12	1.20	0.7	0.1	0.5	0.04	0.7	0.2
SD-13	1.76	1.3	0.1	0.9	0.06	0.4	0.2
SD-14	1.38	1.6	0.1	1.0	0.07	0.5	0.2
SD-15	2.10	0.8	0.1	1.1	0.07	0.6	0.2
SD-16	9.21	1.8	0.2	0.8	0.05	0.5	0.2

Table 2-25a (continued)

Sample Site	Uranium (mg/kg*)	Pb-210 (pCi/g)	Precision Plus/Minus	Ra-226 (pCi/g)	Precision Plus/Minus	Th-230 (pCi/g)	Precision Plus/Minus
SD-17	1.58	2.8	0.2	0.7	0.05	0.5	0.2
SD-18	1.49	1.3	0.1	0.7	0.05	0.5	0.2
SD-19	1.69	2.4	0.1	1.0	0.07	0.8	0.3
Minimum	1.20	0.7		0.5		0.4	
Maximum	9.21	2.8		1.1		0.9	
Average	2.60	1.6		0.8		0.6	
Standard Deviation	2.34	0.6		0.2		0.1	
Hank	2.38	1.0		1.2		0.6	
Nichols	2.34	1.3		9.6		.06	

Notes:
SD = Sediment.
***Reporting Limit: 0.02 mg/kg dry.**
See Exhibit D11-2 for sample locations.
Radionuclide methods are as follows: Radium 226-E903.0, Uranium-SW6020, Lead 210-NERHL-65-4, Thorium 230-E907.0.

2.9.2 Baseline Gamma Survey

2.9.2.1 Purpose and Procedure

The purpose of a gamma survey is the same as it is for establishing other radiological levels; namely to characterize baseline conditions. Baselines serve as a backdrop against which operational impacts can be measured.

The gamma survey that was performed for the project site differs in pattern from the survey described in Regulatory Guide 4.14. The layout of the pattern given in the guide is based on a conventional mine and mill, which have significant particulate source terms. Particulate sources at ISR facilities are negligible. Because of the vast difference between ISR and conventional mining and milling, a procedure was developed to measure baseline gamma levels in a more concentrated pattern in the areas where operational activities will occur. Since the operational areas are the most likely targets for potential impacts, these areas were given a higher degree of sampling. Referring back to the discussion in the soils section, it was noted that potential impacts

on soils and sediments from ISR operations is attributed to accidental spills from pipeline breaks or leaks.

This aspect of potential impact played a major part in the baseline sampling pattern for soils, sediments and gamma. In addition to the large number of gamma readings taken throughout the future production area and process site, readings were also taken in the drainages passing through the license area; at the nearest residence; and near the license boundary. Exhibit D11-3 (of the attached Appendix D11) Nichols Ranch Unit – Gamma Sample Location Map **and Exhibit JD-D11-2 (of the attached Appendix JD-D11) Jane Dough Unit,** shows the sample sites within and near the license boundary.

Table 2-25 Radiological Background in Sediment - Hank Unit.

Sample Site	Depth Inches	Uranium mg/kg*	Pb-210 pCi/g	Precision Plus/Minus	Ra-226 pCi/g	Precision Plus/Minus	Th-230 pCi/g	Precision Plus/Minus
SD-1		2.8	ND		1.3	0.2	0.7	0.1
SD-2		3.5	ND		1.1	0.2	0.5	0.1
SD-3		2.5	0.4	0.2	1.0	0.2	0.6	0.1
SD-4		1.3	0.5	0.2	1.1	0.2	0.6	0.1
SD-5		1.8	1.8	0.3	1.0	0.2	0.6	0.1
SD-6		1.8	0.7	0.2	1.6	0.2	0.8	0.1
SD-7		2.6	ND		1.4	0.2	0.8	0.1
SD-8		3.1	0.6	0.1	1.4	0.2	0.7	0.1
SD-9		2.7	0.9	0.1	1.6	0.2	1.0	0.2
SD-10		2.6	0.6	0.1	0.8	0.2	0.5	0.1
SD-11		2.5	ND		1.1	0.2	0.5	0.1
SD-12		2.1	ND		1.2	0.2	0.7	0.1
SD-13		1.91	ND		0.9	0.2	0.5	0.2
SD-14		2.80	ND		1.4	0.2	0.6	0.2
SD-15		2.92	ND		2.2	0.2	0.6	0.2
SD-16		2.52	ND		1.0	0.2	0.3	0.1
SD-17		1.98	ND		1.0	0.2	0.5	0.1
SD-18		3.46	ND		1.2	0.2	0.9	0.2
SD-19		2.23	ND		0.9	0.2	0.3	0.1
SD-20		1.85	ND		0.8	0.2	0.2	0.1
SD-21		2.17	ND		1.2	0.2	0.4	0.1
SD-22		3.74	ND		1.9	0.2	1.1	0.2
SD-23		1.91	ND		1.3	0.2	1.0	0.2
SD-24		2.08	ND		0.9	0.2	0.3	0.1
SD-25		1.18	2.5	0.5	1.0	0.2	0.6	0.1
SD-26		1.79	ND		1.0	0.2	0.4	0.2
Minimum		**1.18**	**ND**		**0.8**		**0.2**	
Maximum		**3.74**	**2.5**		**2.2**		**1.1**	
Average		**2.38**	**1.0**		**1.2**		**0.6**	
Standard Deviation		**0.65**	**0.7**		**0.3**		**0.2**	

Notes:
SD: Sediment.
*Reporting Limit: 0.50.
ND: Not Detected.
See Exhibit D11-2 for sample locations.
Radionuclide Methods are as follows: Radium 226-E903.0, Uranium-SW6020, Lead 210-NERHL-65-4, Thorium 230-E907.0

2.9.2.2 Survey Methodology

A Ludlum Model 19 µR Survey Meter was the instrument used in the gamma survey. The calibration date on the meter for the June 2007 survey was June 8, 2007 (Nichols Ranch and Hank Units and **and the calibration date for the September 2011 survey was September 2, 2011 (Jane Dough Unit)**. As described in the soils section of the application, a sample site map was developed prior to conducting the survey. Gamma measurements were recorded by holding the meter at waist level and slowly passing it over each soil/sediment sample point and over the area proximate to the sample location.

2.9.2.3 Nichols Ranch Unit Results

Table 2-26 summarizes the gamma readings and cross-references the gamma sites with the soil and sediment sample locations. A total of 57 gamma measurements were taken over an area of approximately 116 acres. The 116 acre-area consisted of the future production areas (113 acres) and the plant site (3.0 acres). On a per acre basis, the density of the survey was 1 reading per 2.0 acres.

As can be readily seen from Table 2-26, gamma readings are for the most part tightly grouped between 12 to 13 µR/hr. The average, minimum and maximum values are not unusual for this part of the U.S. To illustrate, the values recorded at the Nichols Ranch Unit are very much in line with earlier surveys completed at nearby North Butte. In brief, the detailed gamma survey completed at the North Butte ISL project site in 1979 was compared to a verification survey conducted by Uranerz in 1992. The mean gamma reading in the verification study was 11.7 µR/hr and the range was 11 to 13 µR/hr. These values were consistent with the North Butte survey. When compared to the average natural background range for the U.S. (8 to 15 µR/hr), it can be seen that the Nichols project site falls near the high end of the average.

There are a few sites with slightly elevated gamma levels of 15 µ R/hr. Some of the 15 µ R/hr values correspond with some of the soil and sediments sites that had elevated levels of Ra-226. For example, SS-21 has a radium value of 2.4 pCi/g; SD-8 radium is 32 pCi/g; and SD-9 radium is 23.5 pCi/g.

Table 2-26 Nichols Ranch Unit Gamma/Soil and Sediment Sample Locations.

Sample Site	μR/hr	Gamma Site
R-1 Dry Fork Ranch	13	G-54
R-2	14	G-55
R-3	12	G-56
R-4	13	G-57
SS-6 Nichols URZ	15	G-45
SS-7 Nichols URZ	15	G-40
SS-8 Nichols URZ	12	G-36
SS-9 Nichols URZ	12	G-32
SS-10 Nichols URZ	13	G-20
SS-11 Nichols URZ	13	G-17
SS-12 Nichols URZ	14	G-14
SS-13 Nichols URZ	13	G-12
SS-14 Nichols URZ	13	G-11
SS-15 Nichols URZ	13	G-8
SS-16 Nichols URZ	13	G-7
SS-17 Nichols URZ	13	G-5
SS-18 Nichols URZ	13	G-4
SS-19 Nichols URZ	14	G-1
SS-20 Nichols URZ	12	G-2
SS-21 Nichols URZ	15	G-6
SS-22 Nichols URZ	13	G-9
SS-23 Nichols URZ	12	G-13
SS-24 Nichols URZ	11	G-16
SS-25 Nichols URZ	12	G-18
SS-26 Nichols URZ	13	G-24
SS-27 Nichols URZ	13	G-33
SS-28 Nichols URZ	12	G-37
SS-29 Nichols URZ	14	G-41
SS-30 Nichols URZ	13	G-47
LAS-1 Nichols URZ	12	G-21
LAS-2 Nichols URZ	11	G-23
LAS-3 Nichols URZ	13	G-35
LAS-4 Nichols URZ	13	G-44
LAS-5 Nichols URZ	13	G-51
LAS-6 Nichols URZ	13	G-46
LAS-7 Nichols URZ	14	G-38
LAS-8 Nichols URZ	13	G-25

Table 2-26 (Continued)

Sample Site	μR/hr	Gamma Site
SB-4 Nichols URZ	12	G-3
SB-5 Nichols URZ	11	G-26
SB-6 Nichols URZ	12	G-43
SB-7 Nichols URZ	13	G-42
SB-8 Nichols URZ	13	G-22
Plant Site:		
Center	13	G-29
Northwest	13	G-27
Northeast	13	G-28
Southeast	13	G-31
Southwest	13	G-30
Minimum	**11**	
Maximum	**15**	
Average	**13**	
Standard Deviation	**1**	
SD-1 Nichols URZ	13	G-53
SD-2 Nichols URZ	13	G-10
SD-3 Nichols URZ	12	G-15
SD-4 Nichols URZ	13	G-19
SD-5 Nichols URZ	13	G-39
SD-6 Nichols URZ	11	G-34
SD-7 Nichols URZ	14	G-48
SD-8 Nichols URZ	15	G-49
SD-9 Nichols URZ	15	G-50
SD-10 Nichols URZ	13	G-52
Minimum	**11**	
Maximum	**15**	
Average	**13**	
Standard Deviation	**1**	

Notes:
R-1through R-4 are the locations of the baseline Rn-222 and Gamma monitors.
SS: Surface Soil Site.
SB: Subsurface Soil Site.
SD: Sediment Sample Site.
LAS: License Area Sample.
See Exhibits D11-1 and D11-3 for sample site locations.

Although it is well known that gamma readings taken with a general survey-type meter do not have a high degree of correspondence with chemically-measured radium content, a higher-than-background gamma reading (usually 2.5 to 3 times background) can serve as a first level screening test for detecting sites that might have elevated levels of radionuclides. In summary, the density of the survey and its consistent values provide reasonable assurance that a representative baseline was established.

2.9.2.4 Hank Unit Results

Table 2-27 summarizes the gamma readings and cross-references the gamma sites with the soil and sediment sample locations. A total of 86 gamma readings were recorded across the site (see Exhibit D11-4 [of the attached Appendix D11]). Although the survey was designed to thoroughly characterize baseline conditions in the areas where activities will occur (production areas and process facility site), it also provided background levels for sites at the license boundary, nearest residence and numerous stream courses passing through and near the site. Based on the approximate 156 acres in the production areas and the 3-acre process facility site, the resulting survey density is 1 reading per 2.0 acres.

As can be seen from Table 2-27, gamma readings do not vary significantly across the area. However, there are a few sites with elevated gamma (16 to 18 μ R/hr levels). Comparing the elevated gamma levels with the soil and sediment analyses show some correspondence. Sample site LAS-2, for example, has the highest gamma level of 18 μ R/hr and it also has the highest U (8.4 mg/kg), Pb-210 (1.2 pCi/g), Ra-226 (3.8 pCi/g) and Th-230 (2.5 pCi/g) values.

As shown below, the minimum, maximum and average values recorded at the Hank Unit compare favorably with those measured at the Nichols Ranch Unit.

	Nichols Ranch Unit (μR/hr)	Hank Unit (μR/hr)
Minimum	11	11
Maximum	15	18
Average	13	13

Table 2-27 Hank Unit Gamma/Soil and Sediment Sample Locations.

Sample Site	μR/hr	Gamma Site
R-1 Pfister Ranch Hank URZ	13	G-82
R-2	13	G-83
R-3	12	G-84
R-4	11	G-85
R-5	14	G-86
SS-6 Hank URZ	15	G-5
SS-7 Hank URZ	15	G-7
SS-8 Hank URZ	12	G-9
SS-9 Hank URZ	12	G-10
SS-10 Hank URZ	14	G-11
SS-11 Hank URZ	13	G-14
SS-12 Hank URZ	13	G-15
SS-13 Hank URZ	13	G-20
SS-14 Hank URZ	13	G-21
SS-15 Hank URZ	13	G-23
SS-16 Hank URZ	13	G-28
SS-17 Hank URZ	12	G-32
SS-18 Hank URZ	13	G-40
SS-19 Hank URZ	13	G-41
SS-20 Hank URZ	14	G-44
SS-21 Hank URZ	14	G-48
SS-22 Hank URZ	14	G-50
SS-23 Hank URZ	12	G-52
SS-24 Hank URZ	14	G-53
SS-25 Hank URZ	12	G-81
SS-26 Hank URZ	13	G-57
SS-27 Hank URZ	12	G-61
SS-28 Hank URZ	13	G-62
SS-29 Hank URZ	14	G-64
SS-30 Hank URZ	13	G-66
SS-31 Hank URZ	13	G-67
SS-32 Hank URZ	14	G-68
SS-33 Hank URZ	15	G-71
SS-34 Hank URZ	13	G-75
SS-35 Hank URZ	13	G-76
LAS-1 Hank URZ	14	G-17
LAS-2 Hank URZ	18	G-25
LAS-3 Hank URZ	13	G-18
LAS-4 Hank URZ	12	G-24
LAS-5 Hank URZ	13	G-30
LAS-6 Hank URZ	13	G-31
LAS-7 Hank URZ	11	G-46
LAS-8 Hank URZ	12	G-42

Table 2-27 (continued)

Sample Site	**µR/hr**	**Gamma Site**
LAS-9 Hank URZ	14	G-59
LAS-10 Hank URZ	13	G-47
LAS-11 Hank URZ	15	G-55
LAS-12 Hank URZ	13	G-43
LAS-13 Hank URZ	14	G-34
LAS-14 Hank URZ	14	G-29
SB-4	16	G-6
SB-5	12	G-16
SB-6	13	G-33
SB-7	14	G-51
SB-8	12	G-65
SB-9	13	G-77
Plant Site:		
Center	13	G-37
Northwest	15	G-35
Northeast	13	G-36
Southeast	13	G-39
Southwest	13	G-38
Minimum	**11**	
Maximum	**18**	
Average	**13**	
Standard Deviation	**1**	
SD-1 Hank URZ	14	G-1
SD-2 Hank URZ	16	G-3
SD-3 Hank URZ	14	G-2
SD-4 Hank URZ	11	G-4
SD-5 Hank URZ	13	G-12
SD-6 Hank URZ	13	G-13
SD-7 Hank URZ	15	G-8
SD-8 Hank URZ	15	G-19
SD-9 Hank URZ	14	G-22
SD-10 Hank URZ	14	G-27
SD-11 Hank URZ	15	G-26
SD-12 Hank URZ	14	G-80
SD-13 Hank URZ	16	G-49
SD-14 Hank URZ	13	G-45
SD-15 Hank URZ	18	G-54
SD-16 Hank URZ	17	G-58
SD17 Hank URZ	15	G-60
SD-18 Hank URZ	17	G-56
SD-19 Hank URZ	16	G-63
SD-20 Hank URZ	15	G-70
SD-21 Hank URZ	17	G-72

Table 2-27 (continued)

Sample Site	µR/hr	Gamma Site
SD-22 Hank URZ	16	G-73
SD-23 Hank URZ	14	G-69
SD-24 Hank URZ	14	G-74
SD-25 Hank URZ	13	G-79
SD-26 Hank URZ	13	G-78
Minimum	**11**	
Maximum	**18**	
Average	**15**	
Standard Deviation	**2**	

Notes:
R-1 through R-5 are the locations of the baseline Rn-222 and Gamma monitors.
SS: Surface Soil Site.
SB: Subsurface Soil Site.
SD: Sediment Sample Site.
LAS: License Area Site.
See Exhibits D11-2 and D11-4 for sample site locations.

Between the Hank Unit and the Nichols Ranch Unit, there are 143 gamma sample points. With a combined area of 275 acres (production areas and plant site areas), the overall survey density is one sample per 2.0 acres. This density, coupled with the close agreement between the measurements taken at both sites, provides a good baseline for gamma levels.

2.9.2.5 Jane Dough Unit Results

Table 2-27a provides a summary of the gamma measurements. A review of the table shows a range of 4 µR/hr (13 to 17 µR/hr) for the surface soil locations and the same 4 µR/hr range (14 to 18 µR/hr) for the sediment sample sites. The high end range for the surface soil locations is represented by a single reading of 17 µR/hr at LAS-13. Similarly, only two sediment sample locations support the 18 µR/hr top range value. Most of the values are within 14 to 16 µR/hr, and the averages for the surface soil sites and the sediment locations are 15 and 16 µR/hr, respectively. The averages at the Jane Dough Unit are a little higher but similar to the 13 µR/hr average measured at the Hank and Nichols Ranch Units.

In summary, the density of the survey and its consistent values provide reasonable assurance that a representative baseline was established.

Table 2-27A Gamma Survey Results: Jane Dough Unit.

Sample Site	Gamma (μR/hr)	Sample Site	Gamma (μR/hr)	Sample Site	Gamma (μR/hr)	Sample Site	Gamma (μR/hr)
Random 1*	14	LAS-8	15	SS-10	16	SS-26	15
Random 2*	16	LAS-9	15	SS-11	15	SS-27	16
JD-1	14	LAS-10	13	SS-12	16	SS-28	14
JD-2	14	LAS-11	16	SS-13	14	SS-29	13
JD-3	16	LAS-12	14	SS-14	15	SS-30	15
JD-4	13	LAS-13	17	SS-15	15	SS-31	13
JD-5	13	LAS-14	14	SS-16	16	SS-32	14
JD-6**	15	SS-1	14	SS-17	14	SS-33	15
JD-7**	15	SS-2	14	SS-18	14	SS-34	15
LAS-1	15	SS-3	15	SS-19	14	SS-35	16
LAS-2	16	SS-4	15	SS-20	13	SS-36	16
LAS-3	16	SS-5	15	SS-21	14	SS-37	14
LAS-4	14	SS-6	16	SS-22	15	SS-38	15
LAS-5	15	SS-7	15	SS-23	14	SS-39	16
LAS-6	14	SS-8	14	SS-24	15	SS-40	15
LAS-7	14	SS-9	14	SS-25	15	SS-41	15
SB-1	15	SD-1	15	SD-14	16	--	--
SB-2	15	SD-2	14	SD-15	14	--	--
SB-3	15	SD-3	15	SD-16	14	--	--
SB-4	15	SD-4	17	SD-17	18	--	--
SB-5	15	SD-5	15	SD-18	15	--	--
SB-6	15	SD-6	16	SD-19	16	--	--
SB-7	14	SD-7	18	--	--	--	--
SB-8	15	SD-8	15	--	--	--	--
SB-9	16	SD-9	17	--	--	--	--
SB-10	14	SD-10	17	--	--	--	--
SB-11	15	SD-11	16	--	--	--	--
SB-12	16	SD-12	15	--	--	--	--
SB-13	16	SD-13	17	--	--	--	--
Average						15	16
Minimum						13	14
Maximum						17	18

Notes:

***Random 1 and 2 are additional vegetation sample sites.**
****Nearest residences.**
JD-1 through 7: gamma exposure rate/air/vegetation sample sites.
SS: Surface Soil Site
SB: Subsurface Soil Site
SD: Sediment Sample Site
LAS: License Area Sample Site

2.9.3 Baseline Radon-222 and Direct Gamma Exposure Rates

2.9.3.1 Purpose and Procedure

As noted in the discussion on soil and sediment baseline sampling, ISR operations do not generate significant levels of particulates, but they do have Rn-222 emissions, which include radon daughter products with varying half-lives. For this reason, ambient baseline Rn-222 levels should be established. In establishing the baseline, the monitoring procedure outlined in Regulatory Guide 4.14 was followed, and it involved deploying Rn-222 detectors and gamma dosimeters at suggested locations.

2.9.3.2 Survey Methodology

The detectors that were used in the one-year monitoring program were Landauer Extra Sensitive Outdoor Rn-222 Detectors and X-9 Gamma Dosimeters. Prior to installing the detectors, the prevailing wind direction was obtained from the National Climatic Data Center for Gillette. The data covered a period from 1996 through 2005. Data from this period was compared to data from Casper and to a data collected between 1978 and 1979 by AeroVironment for Cleveland Cliffs Iron Company (CCI), who operated a meteorological station near North Butte (Pathfinder Mines Corporation, 1988). CCI's baseline data was used in support of their NRC license application for the North Butte ISL Project. A comparison of the databases showed that Casper has a stronger southwest/west-southwest/south-southwest component, while North Butte and Gillette have a component from the south/southwest/southeast. A third site, the Antelope Coal Company (ACC) meteorological station was also used in January 2009 to verify that the prevailing wind direction at the Nichols Ranch ISR Project site was from the south/southwest.

The detectors were deployed and retrieved at the same time for each location. Exposure time was on a quarterly basis. Detector locations included: (1) the nearest residence or structure that could be occupied; (2) locations at or near the license boundary; and (3) a control point to reflect background (upwind of the site). Figures 2-25 and 2-26 (see map pockets) and Exhibits D11-3

and D11-4 (of the attached Appendix D11) show the locations of the Rn-222 and gamma dosimeters.

Given that the prevailing wind direction is from the south-southwest, two monitoring stations were placed in the northern parts of both sites see previously referenced Figures 2-25 and 2-26 and Exhibits D11-3 and D11-4 (of the attached Appendix D11). In contrast, control detectors were placed in the extreme southern parts of the license areas. During operations, the downwind monitors will reflect the maximum change from baseline while the control detectors will measure the minimum change. In addition to these placements, two monitors were placed near the license boundary on the east and west side of the Hank Unit and one was placed at a nearest

residence (Dry Fork Ranch), which is approximately 1.3 mi to the southwest of the process facility location.

2.9.3.3 Nichols Ranch Unit Results

The one-year monitoring results are given in Table 2-28. A comparison of the values shows background levels to be within the expected range. When compared to historical radon levels measured over a one year period (1988-1989) at the nearby North Butte Project site, it can be seen that values at Nichols are not surprisingly different. North Butte's annualized average was 0.8 pCi/l compared to Nichols' 1.2 pCi/l average. Because radon levels are known to vary widely from place to place, the difference between 0.8 pCi/l and 1.2 pCi/l is not significant. It must also be remembered that some of difference between the two annual averages can be attributed to the detectors. Significant improvements have been made in this area over the past 10 years. As noted above, Extra Sensitive detectors were used in the monitoring program at the Nichols and Hank Units. Differences in the prevailing weather conditions at the two sites would also play a role in the background concentrations.

Table 2-28 Ambient Radon-222 Levels - Nichols Ranch Unit.

		Fourth Quarter (10/06 to 1/07) pCi/l	First Quarter (1/07 to 3/07) pCi/l	Second Quarter (4/07 to 7/07) pCi/l	Third Quarter (7/07 to 10/07) pCi/l
R-1	Nearest Residence	1.2	0.7	0.9	1.1
R-2	Upwind Control	0.9	0.8	1.1	1.7
R-3	Downwind Boundary	0.6	27.7*, 0.9**	2.3	1.4
R-4	Downwind Boundary	0.7	0.8	1.9	1.4
	Site Averages	0.9	0.8	1.6	1.4

1. *The adhesive that holds the detector within the protective housing failed and the detector was found on the ground. The anomalous value was not used in the average.
2. The annualized average for all sites combined is 1.2 pC/l.
3. The annualized average measured between 1988 and 1989 at the nearby North Butte; Project was 0.8 pCi/l.
4. The U.S. average outdoor Rn-222 level is 0.4 pCi/l (U.S. EPA).
5. **Additional reading was collected in the 4th Quarter of 2008, value was not used in average.
6. An additional monitoring site, NR-5, was added to the Nichols site in March 2009. Background levels for the past year are as follows: 3/4/009 to 6/26/09 = 1.2 pCi/l; 7/9/09 to 10/2/09=1.9 pCi/l; 102/09 to 1/4/10=0.9 pCi/l; and 1/4/10 to 4/5/10 = 0.9 pCi\l. The annualized average at NR-5 is 1.2 pCi\l, and this matches the annualized average of 1.2 pCi\l reported for sites R-1 through R-4.

Both sites have ambient radon levels that are much above the U.S. average. According to EPA, the U.S. outdoor average radon concentration is 0.4 pCi/l. The higher-than-background levels are not surprising given that with the exception of two counties, Weston and Platte, the predicted average indoor screening radon levels in Wyoming are at or above the EPA Action Level of 4 pCi/l (epa.gov/radon/zonemap). The indoor average for the U.S. is 1.3 pCi/l, and this puts Wyoming at three times the average.

Background gamma exposure rates from the one year monitoring program are summarized in Table 2-29. The averages range from 35 mrem to 48 mrem. When compared to the gamma survey results from the North Butte Project mentioned earlier, the values are similar. The North Butte quarterly averages ranged from 32.3 mrem to 39.7 mrem. To put these values into perspective, the following exposure rates are given.

- Average dose to the U.S. Public from natural sources: 300 mrem.
- Background radiation (total) in the Colorado Plateau: 75 to 140 mrem.
- Terrestrial background (Rocky Mountains): 40 mrem.
- Average dose to the public from all sources: 360 mrem.

Table 2-29 Background Gamma Exposure Rate - Nichols Ranch Unit.

		Fourth Quarter (10/06 to 1/07) mrems	First Quarter (1/07 to 3/07) mrems	Second Quarter (4/07 to 7/07) mrems	Third Quarter (7/07 to 10/07) mrems
R-1	Nearest Residence (Dry Fork Ranch)	34.7	41.1	49.3	37.4
R-2	Upwind Control (South)	36.4	41.9	48.2	38.0
R-3	Downwind Boundary (Northeast)	35.2	49.4	41.1	39.1
R-4	Downwind Boundary (Northwest)	33.6	57.6	52.8 (LP)	44.0
Site Averages		35.0	47.5	47.9	39.6

Notes: LP: Low energy photon.
Gamma exposure rate was also monitored at NR-5 for a one year period. The results are as follows: 4/1/09 to 7/10/09=51.7 mrem; 7/10/09 to 10/14/09=38.1 mrem; 10/14/09 to 1/19/10=38.0 mrem; and 1/19/10 to 4/20/10=40.9 mrem. The annualized average for NR-5 is 42.2 mrem, and this falls within the range of averages shown above for sites R-1 through R-4.

2.9.3.4 Hank Unit Results

Not unexpectedly, Rn-222 levels measured at the Hank Unit match up well with those just discussed for the Nichols Ranch Unit. The one high value (9.2 pCi/l) was caused by the detector being on the ground for some unknown period of time. This value was not used in calculating the average shown on Table 2-30. Background gamma exposure rates from the one year monitoring program are summarized in Table 2-31. The averages range from 34.4 mrem to 55 mrem. Once again these results are very similar to the Nichols Ranch Unit results and those of the historic North Butte results.

2.9.3.5 Jane Dough Unit Results

Monitoring covered a full year beginning in the third quarter of 2010 and ending in the second quarter of 2011. The results of the baseline year are summarized in Table 2-31a. A review of the table shows that the third quarter had the highest average (0.9 pCi/l) and the first quarter had the lowest average (0.3 pCi/l). It is also interesting to note that five of the seven sites had readings greater than 1.0 pCi/l during the third quarter while all of the sites had values well below 1.0 pCi/l throughout the remaining three quarters. A similar result was recorded at the Hank and Nichols Ranch Units when baseline surveys were conducted.

To illustrate, the first and third quarter averages for all five monitoring locations at the Hank and Nichols Ranch Units are summarized as follows.

Hank Unit	**Nichols Ranch Unit**
1st Quarter: 0.6 pCi/l	**1st Quarter: 0.8 pCi/l**
3rd Quarter: 1.9 pCi/l	**3rd Quarter: 1.4 pCi/l**

Although the second quarter average at the Nichols site was slightly higher than the third quarter (1.6 pCi/l vs.1.4 pCi/l), a sample location in the second quarter had a single high value of 2.3 pCi/l which raised the average. If the value had been closer to the values of 0.6 pCi/l and 1.4 pCi/l that were measured at that location during other quarters, the third quarter average would have been the highest as is was at Hank and Jane Dough. The apparent cycle of higher values occurring in the third quarter and the lower values in the

first quarter could likely be the result of weather conditions. The first quarter is usually the months of colder weather with snow cover which adds another barrier; whereas the third quarter is generally the months of warmer and drier weather. The colder months tend to suppress radon exhalation rates, while the warmer months tend to increases the emanation rate. In addition, radon exhalation rates fluctuate with wet and dry soil conditions and with changes in vegetative cover. This explanation is further supported by the fact that highest and lowest values are not found at a single site; instead, the highest and lowest values vary with the time of year.

Table 2-31a also shows the annualized average for all locations combined as being 0.6 pCi/l. This average is lower than the averages of 1.0 pCi/l and 1.2 pCi/l recorded at the Hank and Nichols Ranch Units, respectively. The range of the averages at all three units are consistent with values found in the U.S. Background radon varies considerable in the U.S. due to factors such as soil and rock types and the presence of naturally occurring uranium. The 0.6 pCi/l average measured at the Jane Dough Unit is consistent with but slightly above the U.S. average outdoor Rn-222 level of 0.4 pCi/l (U.S. EPA).

Table 2-31a Baseline Radon-222 at the Jane Dough Unit.

	Third Quarter 2010 (pCi/l)	Fourth Quarter 2010 (pCi/l)	First Quarter 2010 (pCi/l)	Second Quarter 2010 (pCi/l)	Average by Site (pCi/l)
JD-1	1.0 +/- 0.09	0.6+/-0.05	0.3 +/-0.04	0.6 +/-0.05	0.6
JD-2	1.2 +/-0.10	0.5+/-0.05	0.3 +/-0.04	0.7 +/-0.06	0.7
JD-3	0.7 +/-0.07	0.6+/-0.06	0.3 +/-0.04	0.6 +/-0.05	0.6
JD-4	0.6 +/-0.07	0.7+/-0.06	0.5 +/-0.05	0.4 +/-0.04	0.6
JD-5	1.0 +/-0.09	0.6+/-0.05	0.4 +/-0.04	0.6 +/-0.05	0.7
JD-6/NR-2*	1.1 +/-0.09	0.6+/-0.06	0.3 +/-0.04	0.7 +/-0.06	0.7
JD-7/NR-1*	1.1 +-/0.10	0.8+/-0.07	0.3 +/-0.04	0.5 +/-0.05	0.7
Average	1.0	0.6	0.3	0.6	

Background gamma exposure rates from the one year monitoring in the Jane Dough Unit are summarized in Table 2-31b. The quarterly average for all seven sites ranged from 11.3 mrem (second quarter 2011) to 45.8 mrem (fourth quarter 2010). When compared to previous baseline surveys at the Hank and Ranch Nichols Ranch, the quarterly averages for all monitoring locations ranged from 34.4 mrem to 55.0 mrem (Hank) and 35.0 mrem to 47.9 mrem (Nichols Ranch). An additional comparison can be made to values from an even earlier baseline that was developed for the nearby North Butte project. The quarterly averages from North Butte ranged from 32.3 mrem to 39.7 mrem (Pathfinder Mines Corporation 1988).

Although there is a high level of consistency between the 3rd, 4th, and 1st quarters of data from the Jane Dough Unit, the 2nd quarter is significantly below (approximately 72% lower) the 39.4 mrem average of the other three quarters combined. Also, the spread between the 11.3 mrem recorded during the second quarter at Jane Dough compared to the values from

Table 2-31b Baseline Gamma Exposure Rate at the Jane Dough Unit Air Monitoring Stations.

Sample Site	Third Quarter 2010 (mrems)	Fourth Quarter 2010 (mrems)	First Quarter 2011 (mrems)	Second Quarter 2011 (mrems)	Average by Site (mrems)
JD-1	34.7	45.0	44.5	11.0	33.8
JD-2	38.8	45.1	38.0	11.3	33.0
JD-3	33.9	46.9	34.0	10.9	31.4
JD-4	30.8	42.7	34.7	11.8	30.0
JD-5	35.0	45.9	33.0	11.5	31.4
JD-6/NR-2*	37.4	49.4	38.4	10.9	34.0
JD-7/NR-1*	36.2	45.7	38.0	11.5	32.9
Average	35.3	45.8	37.2	11.3	32.4
Nichols Ranch	39.6	35.0	47.5	47.9	42.5
Hank	41.5	34.4	55.0	50.5	45.4

Notes: *Nearest residence upwind and downwind.
Minimum detectable dose equivalent: 0.10 mrem

Hank and Nichols (50.5 mrem and 47.9 mrem, respectively) exceeds 35 mrems. Because the second quarter values at Jane Dough appear to be somewhat low, the averages shown on Table 2-31b are approximately 7 mrems too low. The ~7 mrem estimate was derived by comparing the average for all of the Jane Dough values from three quarters (39.7 mrem) and comparing this value to the 32.4 mrem average that includes the second quarter data. The 39.7 mrem value is much more consistent with the 42.5 to 45.4 mrem average recorded for Nichols Ranch and the Hank Unit.

Apart from the comparisons just noted, the average values recorded the three project sites of approximately 40 to 45 mrem/year can be put into a better perspective when compared to the following:

- **Average dose to the U.S. Public from natural sources: 300 mrem/year.**
- **Background radiation (total) in the Colorado Plateau: 75 to 140 mrem/year.**
- **Terrestrial background (Rock Mountains): 40 mrem/year.**
- **Average dose to the public from all sources: 360 mrem/year.**

As the comparison shows, the average background at the project site is very similar to terrestrial background (Rocky Mountains) of 40 mrem/year.

2.9.4 Flora and Fauna

2.9.4.1 Purpose and Procedure

The purpose of establishing baseline radiological conditions prior to initiating operations is to have a reference for comparing potential impacts. When designing a pre-operational baseline sampling program, the operational features of the activity should be kept in mind. In other words, particular attention should be given to the pathways through which contaminants could enter the environment. In developing the baseline sampling program, pathways were considered in conjunction with guidance given in Regulatory Guide 4.14.

According to Section 2.1.4 in Regulatory Guide 4.14, vegetation, food and fish samples should be collected if, in individual licensing cases, a significant pathway to man is identified. As discussed in Sections 2.9.1.1 and Section 7.3 of Chapter 7.0 of this report, pathways for radiological contaminants to enter the environment from modern ISR operations have been markedly reduced or virtually eliminated. ISR operations do not have fluid discharges nor do they generate significant particulate emissions. The main avenue for radiological constituents to enter the environment is limited to the emission of Rn-222. Because emissions are restricted to nearly-particulate-free Rn-222, significant build up of radionuclides in soil, vegetation and other media is not likely to occur. The minimal accumulation of radionuclides is supported by MILDOS modeling results, and is borne out in operational monitoring data that had been collected at various ISR facilities over the past 25 years.

Table 2-30 Ambient Radon-222 Levels - Hank Unit.

		Fourth Quarter (10/06 to 1/07) pCi/l	First Quarter (1/07 to 3/07) pCi/l	Second Quarter (4/07 to 7/07) pCi/l	Third Quarter (7/07 to 10/07) pCi/l
R-1	Nearest Residence	1.2	1.2	1.4	2.2
R-2	Downwind Boundary	0.4	0.6	0.7	3.4
R-3	Boundary	0.5	0.3	0.9	1.4
R-4	Upwind Control	0.3	9.2*, 0.6**	1.0	1.0
R-5	Boundary	0.4	0.5	0.8	1.7
Site Averages		0.6	0.6	1.0	1.9

Notes:
1. *The adhesive that holds the detector within the protective housing failed and the detector was found on the ground. The anomalous value was not used in the average.
2. The annualized average for all sites combined is 1.0 pC/l.
3. The annualized average measured between 1988 and 1989 at the nearby North Butte; Project was 0.8 pCi/l.
4. The U.S. average outdoor Rn-222 level is 0.4 pCi/l (U.S. EPA).
5. **Additional reading was collected in the 4th Quarter of 2008, value was not used in average.

Table 2-31 Background Gamma Exposure Rate - Hank Unit.

		Fourth Quarter (10/06 to 1/07) mrems	First Quarter (1/07 to 3/07) mrems	Second Quarter (4/07 to 7/07) mrems	Third Quarter (7/07 to 10/07) mrems
R-1	Nearest Residence (Pfister Ranch)	33.5	39.0	45.1	H*, 30.9**
R-2	Downwind Boundary (North)	33.5	50.0 (LP)	49.9	H *, 32.9**
R-3	Boundary (Northwest)	33.5	40.5	53.9	44.0
R-4	Upwind Control (South)	34.1	114.5 (LP)	51.8	39.1
R-5	Boundary (Southeast)	37.5	31.3	52.0	41.4
Site Averages		34.4	55.0	50.5	41.5

Notes:
*H – Not Read (Fault with dosimeter)
** Additional readings were collected in the 4th Quarter of 2008 in order to obtain 4 quarters of data.
LP- Low Energy Photon

The baseline sampling program was modified somewhat from the guidance given in Regulatory Guide 4.14. Departure from the guide is discussed in the Methods Section below. While developing the pre-operational baseline studies, it was understood through experience and through the evolution of ISR, that pathways to flora and fauna and hence to human populations are not significant. The reasons supporting this assertion were given above and are discussed in other sections of this application.

Even though potential impacts from ISR operations on flora, fauna and the food chain have been shown to be insignificant, good baseline characterizations continue to be an important part of a NRC license application. Measured baseline values can be compared to values during actual operations to validate the minimal to no-impact prediction of the MILDOS model. Additionally, having baseline data to compare with values recorded during operations, underscores the fact that modern ISR activities do not have a significant impact on human health and the environment. Following is a description of the baseline sampling program that was performed at the Nichols Ranch Unit, the Hank Unit, **and the Jane Dough Unit**.

2.9.4.2 Methods

Regulatory Guide 4.14 suggests that vegetation, crops, livestock and fish samples should be collected and analyzed for Ra-226 and Pb-210. According to the field reconnaissance, no permanent surface water exists at or immediately adjacent to the sites. Given the absence of water, fish too are absent. The sites were surveyed for the presence a crop-growing areas and none was found. Agricultural activities appear to be limited to cattle grazing. Although the guide suggests sacrificing livestock to obtain samples, it is Uranerz's opinion that this is not necessary for ISR operations. To reiterate, ISR operations do not cause significant build up of radionuclides in soil or vegetation and therefore a significant pathway for exposure does not exist. In addition, since operational monitoring will include routine sampling of vegetation, food crops (if they are grown in the area) and grazing/forage foods, a mechanism will be in place to monitor this pathway to local fauna.

Given this setting, baseline sampling included samples from grazing areas and vegetation from the nearest residences and Rn-222/gamma monitoring locations (shown on Figures 2-25 and 2-26). The vegetation sampled consisted mainly of sagebrush shrubland and mix grassland communities. Grab samples were collected in mid-August. While collecting the samples, care was taken to clip the vegetation approximately one inch above the ground to avoid mixing with surface soil. Samples were placed in large plastic bags and transported to the laboratory within 24 hours of collection. All samples were analyzed for Ra-226, Pb-210, Po-210, Th-230, Uranium, Arsenic and Selenium.

2.9.4.3 Nichols Ranch Unit Results

Table 2-32 summarizes the radiological and nonradiological (arsenic and selenium) background concentrations found in the samples. Although there is the usual variation in concentrations for the radiometric parameters, the values are within normal background ranges. The same generalization can be made for the arsenic and selenium values.

2.9.4.4 Hank Unit Results

Background values for the Hank Unit are given in Table 2-33. A comparison of the concentrations with those reported for the Nichols Ranch Unit shows a great deal of consistency. In brief, the values are not unusual for baseline conditions.

2.9.4.5 Jane Dough Unit Results

Background values for the Jane Dough Unit are given in Table 2-33a. Although there is the usual variation, the values are within normal background ranges. To illustrate the consistency in the background values, a comparison was made with the baseline previously established for the Hank and Nichols Ranch Units. As can be seen from Table 2-33b, the averages for all three sites are in close agreement.

Table 2-32 Radiological and Nonradiological Background Levels in Vegetation Nichols Ranch Unit.

Sample Location	Radiological Elements				
	Ra-226 (μCi/kg)	Pb-210 (μCi/kg)	Po-210 (μCi/kg)	Th-230 (μCi/kg)	Uranium (μCi/kg)
R-1 Dry Fork Ranch	3.7E-04	4.2E-04	9.3E-05	3.7E-06	1.1E-04
+/-	5.1E-06	2.9E-05	2.7E-05	1.8E-06	4.6E-07*
R-2 Control Upwind	8.8E-05	4.5E-04	1.5E-04	2.8E-06	6.6E-05*
+/-	6.0E-06	2.3E-05	2.3E-05	4.2E-06	3.0E-07*
R-3 Downwind NE	1.4E-04	7.5E-04	1.1E-04	3.6E-05	9.5E-05*
+/-	8.0E-06	3.0E-05	2.3E-05	4.4E-04	3.3E-07*
R-4 Downwind NW	2.7E-04	6.6E-04	9.9E-05	1.4E-04	2.4E-04*
+/-	1.1E-05	2.6E-04	2.2E-05	9.9E-06	2.8E-07*
Grazing Area	6.7E-05	4.3E-04	7.2E-05	2.4E-05	8.3E-05*
+/-	4.2E-06	1.8E-05	1.7E-05	3.6E-05	2.1E-07*

Sample Location	Non-radiological Elements			
	Arsenic (mg/kg-dry)	RL*	Selenium (mg/kg-dry)	RL*
R-1 Dry Fork Ranch	ND	0.5	ND	0.5
R-2 Control Upwind	ND	0.5	ND	0.5
R-3 Downwind NE	1.0	0.5	0.7	0.5
R-4 Downwind NW	0.7	0.5	1.3	0.5
Grazing Area	ND	0.5	1.2	0.5

Table 2-33 Radiological and Nonradiological Background Levels in Vegetation Hank Unit.

	Radiological Elements				
Sample Location	Ra-226 (µCi/kg)	Pb-210 (µCi/kg)	Po-210 (µCi/kg)	Th-230 (µCi/kg)	Uranium (µCi/kg)
R-1 Pfister Ranch	7.5E-05	4.0E-04	4.1E-05	2.3E-06	4.5E-05
+/-	5.7E-06	2.1E-05	1.3E-05	3.6E-06	2.8E-07*
R-2 Downwind	4.6E-05	5.8E-04	2.9E-05	2.0E-05	4.9E-05*
+/-	2.0E-06	2.1E-05	8.5E-06	4.5E-06	2.1E-07*
R-3 West Boundary	6.3E-05	2.5E-04	1.5E-04	6.8E-06	1.5E-05*
+/-	6.1E-06	2.1E-05	2.9E-05	2.1E-06	3.9E-07*
R-4 Control South	7.3E-05	2.6E-04	4.9E-05	2.4E-05	4.5E-05*
+/-	5.4E-06	1.8E-05	1.3E-05	4.2E-06	2.8E-07*
R-5 East Boundary	9.6E-05	5.9E-04	1.1E-04	3.5E-05	7.1E-07*
+/-	6.9E-06	2.8E-05	2.8E-05	4.9E-06	3.4E-07
Grazing Area	6.7E-05	2.5E-04	5.9E-05	8.1E-06	4.0E-05*
+/-	7.0E-06	2.4E-05	2.3E-05	2.7E-06	4.5E-07*

	Non-radiological Elements			
Sample Location	Arsenic (mg/kg-dry)	RL*	Selenium (mg/kg-dry)	RL*
R-1 Pfister Ranch	ND	0.5	0.8	0.5
R-2 Downwind	ND	0.5	0.6	0.5
R-3 West Boundary	1.0	0.5	ND	0.5
R-4 Control South	ND	0.5	ND	0.5
R-5 East Boundary	ND	0.5	1.7	0.5
Grazing Area	ND	0.5	1.0	0.5

Notes: *RL is the reporting limit for U.
+/- is the counting error.

Table 2-33a Radiological Baseline Values in Vegetation: Jane Dough Unit.

Sample Site	Uranium (µCi/kg)	Pb-210 (µCi/kg)	Ra-226 (µCi/kg)	Th-230 (µCi/kg)
JD-1	2.7E-05+/- 3.7E-07*	2.1E-04+/- 4.7E-06	4.3E-06+/- 8.9E-07	2.1E-06+/- 3.0E-06
JD-2	5.5E-05+/- 2.0E-07*	5.8E-04+/- 8.7E-06	1.1E-05+/-1.6E-06	7.4E-06+/- 4.7E-06
JD-3	5.8E-05+/- 2.0E-07*	7.4E-04+/- 1.0E-05	2.4E-05+/-2.5E-06	2.5E-05+/- 8.9E-06
JD-4	5.9E-05+/- 2.0E-07*	4.1E-04+/- 8.4E-06	8.4E-06+/-1.6E-06	5.5E-06+/- 4.7E-06
JD-5	3.4E-05+/- 2.0E-07*	2.1E-04+/- 6.7E-06	1.0E-05+/-1.6E-06	6.6E-06+/- 4.5E-06
JD-6	1.2E-05+/- 2.0E-07*	2.4E-04+/- 7.4E-06	6.9E-06+/-1.4E-06	9.4E-06+/- 6.0E-06
JD-7	5.5E-05+/- 2.0E-07*	1.9E-04+/- 8.3E-06	5.5E-06+/-1.5E-06	9.1E-06+/- 6.8E-06
Random-1	8.2E-05+/- 2.0E-07*	9.5E-04+/- 1.3E-05	1.2E-05+/-2.0E-06	3.8E-05+/- 8.8E-06
Random-2	9.7E-05+/- 2.0E-07*	6.1E-04+/- 1.0E-05	1.9E-05+/-2.3E-06	2.4E-05+/- 6.6E-06

***Reporting limit.**

Table 2-33b Comparison of Average Baseline Values: Jane Dough, Nichols Ranch and Hank Unit.

Average Baseline Values				
Mine Unit	Uranium (µCi/kg)	Pb-210 (µCi/kg)	Ra-226 (µCi/kg)	Th-230 (µCi/kg)
Jane Dough Unit	5.3E-05	4.6E-04	1.1E-05	1.5E-05
Nichols Ranch	1.2E-04	5.4E-04	1.9E-04	4.1E-05
Hank Unit	3.2E-05	3.9E-04	7.0E-05	1.6E-05

2.9.5 Radon Flux

Regulatory Guide 4.14 indicates that radon flux measurements should be conducted at eight locations within 1.5 km of the site. Because there will be no tailings impoundments or evaporation ponds at the Nichols Ranch ISR Project radon flux is not an applicable radiological parameter for baseline characterization. Radon flux measurements have not been collected in support of this project and none are planned in association with future monitoring schedules.

2.9.6 Air Particulates

2.9.6.1 Purpose and Procedure

Baseline air particulate radionuclide concentration monitoring for the Nichols Ranch ISR Project was conducted from the 2nd Quarter 2009 through the 1st Quarter 2010 (June 2009–March 2010) **and 3rd Quarter 2010 through 2nd Quarter 2011 (July 2010-June 2010), for the Nichols Ranch and Hank Units.** The continuous monitoring was conducted at 4 different locations at both the Nichols Ranch and Hank Units as depicted on Figures 2-25 and 2-26 (see map pockets) **and at seven different locations at the Jane Dough Unit, as depicted on Figure 2-26A.**

All air particulate sampling was conducted based on Regulatory Guide 4.14. Sampling locations were selected based on prevailing wind direction, CPP/Satellite plant location, practical access to samplers, and nearest residents. Each sampler was powered by solar panels with battery back-up since line power was not available.

2.9.6.2 Methods

To collect the baseline radiological air particulate data, F&J Specialty Products, Inc. Model DF-40L-AC air samplers were used (Figure 2-25). These samplers were calibrated by the manufacturer and programmed to draw approximately 30 liters per minute of air through a 47 mm glass fiber air sampling filter. Each air sampler was housed in a protective metal enclosure with the air intake/sampler filter holder assembly positioned approximately 5.0 ft above the ground surface (Figure 2-26).

Air particulate filters were collected on a weekly basis to help prevent dust loading. Once collected, the samples were composited on a quarterly basis to provide respective estimates of average radionuclide concentration as stated in Regulatory Guide 4.14. After collection, the quarterly composited batch of filters from each of the eight samplers (4 Nichols Ranch, 4 Hank, **7 Jane Dough**) were submitted to Energy Laboratories in Casper, Wyoming for analysis of Uranium (natural), Thorium 230 (Th-230), Radium 226 (Ra-226), and Lead 210 (Pb-210).

Figure 2-27 F&J Air Particulate Sampler.

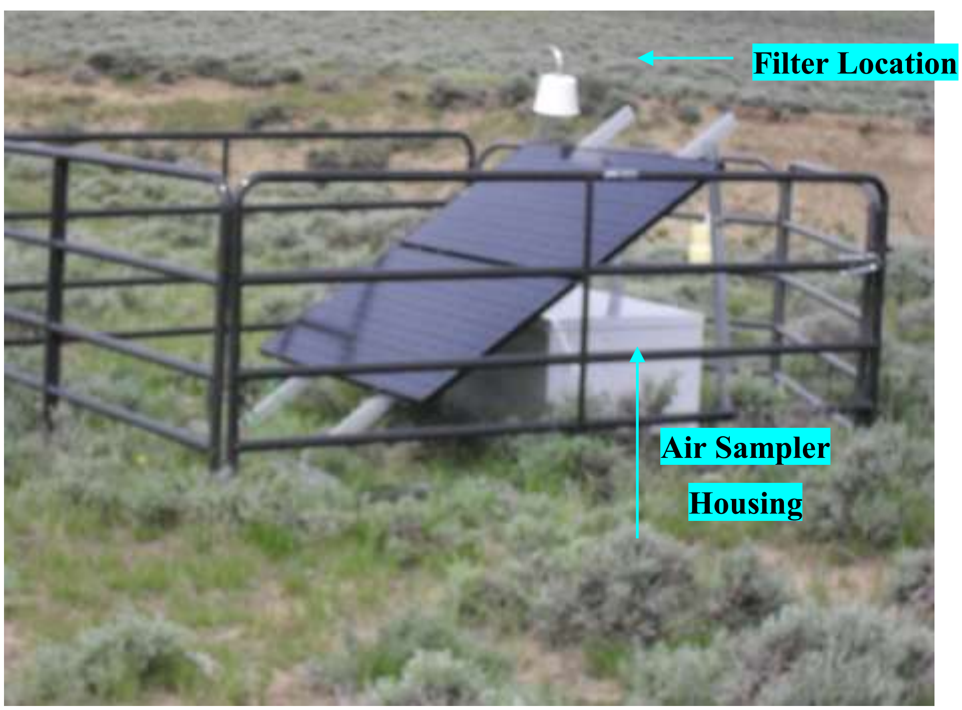

Figure 2-28 Air Particulate Sampling Station.

2.9.6.3 Results for the Nichols Ranch and Hank Unit

A summary of the baseline radiological concentration air particulate results for both the Nichols Ranch and Hank Units is provided in Table 2-33a. Tables 2-33b through 2-33e provide additional details such as lower limits of detection from Reg. Guide 4.14; counting precision and reference to figures (maps) that depict monitoring site locations. Referring again to Table 2-33a, one can see the general consistency in the baseline values between the individual monitoring locations and between the two sites (Hank and Nichols). For the most part, concentrations are quite similar for all parameters at both sites and from season to season. For example, the combined average uranium values for Hank and Nichols are as follows: second quarter = 1.51E-16; third quarter = 1.21E-16; fourth quarter = 2.12E-16; and first quarter 2010 = 6.62E-16. Two values reported for sites NR-1 and NR-3 caused the first quarter 2010 average to be higher than the previous three quarters: the reported values for NR-1 and NR-3 are 1.30E-15 and 2.69E-15, respectively. The overall consistency of uranium concentrations throughout the one-year monitoring period for both sites can be seen from the summary below.

Monitoring Period	**Hank Unit**	**Nichols Ranch Unit**
Uranium (natural) Average		
2nd Quarter 2009	1.56E-16	1.46E-16
3rd Quarter 2009	1.14E-16	1.28E-16
4th Quarter 2009	1.83E-16	2.40E-16
1st Quarter 2010	2.51E-16	1.07E-15
Annual Average	**1.76E-16**	**3.96E-16**

Units: µCi/ml

Table 2-33a Summary Comparison of Radiological Concentrations for 1 Year (Second Quarter 2009 through First Quarter 2010).

	Second Quarter 2009 Hank				Second Quarter 2009 Hank			
	HPS	**HR-1**	**HR-2**	**HR-4**	**NRPS**	**NR-1**	**NR-2**	**NR-3**
µCi/ml								
U	1.43E-16	1.36E-16	1.07E-16	2.37E-16	1.44E-16	1.59E-16	1.50E-16	1.32E-16
Th-230	1.73E-16	9.15E-17	-6.76E-16	-5.71E-17	1.46E-16	-1.55E-17	-1.32E-16	9.88E-17
Ra-226	-6.10E-17	-1.21E-17	-9.03E-17	-1.46E-16	2.86E-17	3.56E-17	2.71E-16	2.29E-17
Pb-210	8.41E-15	-1.36E-15	8.69E-15	1.18E-14	5.46E-15	1.65E-15	1.10E-15	6.44E-15
	Third Quarter 2009 Hank				**Third Quarter 2009 Nichols Ranch**			
	HPS	**HR-1**	**HR-2**	**HR-4**	**NRPS**	**NR-1**	**NR-2**	**NR-3**
µCi/ml								
U	1.27E-16	1.44E-16	1.03E-16	8.28E-17	1.50E-16	9.72E-17	1.26E-16	1.39E-16
Th-230	5.50E-18	-2.27E-17	-4.71E-17	1.49E-18	-5.60E-17	-1.47E-17	-1.09E-16	6.53E-17
Ra-226	-2.96E-17	-4.91E-17	2.12E-18	-8.76E-17	1.39E-16	-6.86E-17	-1.43E-16	-6.22E-17
Pb-210	1.28E-14	1.35E-14	1.07E-14	1.32E-14	1.28E-14	1.25E-15	9.36E-15	6.67E-15
	Fourth Quarter 2009 Hank				**Fourth Quarter 2009 Nichols Ranch**			
	HPS	**HR-1**	**HR-2**	**HR-4**	**NRPS**	**NR-1**	**NR-2**	**NR-3**
µCi/ml								
U	2.65E-16	1.93E-16	1.93E-16	8.28E-17	1.63E-16	1.80E-16	3.61E-16	2.56E-16
Th-230	-3.94E-18	2.20E-16	2.72E-16	1.49E-18	1.23E-19	8.39E-17	4.91E-17	7.21E-18
Ra-226	-5.62E-18	3.65E-17	2.62E-17	-8.76E-17	-4.98E-17	1.27E-17	5.45E-17	1.50E-17
Pb-210	6.31E-15	7.21E-15	8.06E-15	1.32E-14	3.94E-15	1.40E-14	1.12E-14	5.12E-15
	First Quarter 2010 Hank				**First Quarter 2010 Nichols Ranch**			
	HPS	**HR-1**	**HR-2**	**HR-4**	**NRPS**	**NR-1**	**NR-2**	**NR-3**
µCi/ml								
U	3.84E-16	2.66E-16	1.68E-16	1.86E-16	1.49E-16	1.30E-15	1.51E-16	2.69E-15
Th-230	-5.98E-18	1.71E-17	-7.46E-17	-3.35E-17	-2.75E-17	9.30E-18	3.58E-18	2.42E-17
Ra-226	2.47E-17	5.57E-17	8.02E-17	5.98E-17	6.50E-17	1.06E-17	8.17E-17	1.77E-17
Pb-210	1.12E-14	8.85E-15	5.33E-15	8.04E-15	1.04E-14	1.71E-14	2.01E-14	9.14E-15

Table 2-33b Baseline Radionuclide Concentrations in Air (Second Quarter 2009).

		Hank		
	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
HPS	1.43E-16	1.73E-16	-6.10E-17	8.41E-15
Counting Precision	N/A	2.17E-16	5.38E-17	9.83E-15
HR-1	1.36E-16	9.15E-17	-1.21E-17	-1.36E-15
Counting Precision	N/A	2.99E-16	6.07E-17	9.70E-15
HR-2	1.07E-16	-6.76E-16	-9.03E-17	8.69E-15
Counting Precision	N/A	4.73E-16	9.10E-17	1.67E-14
HR-4	2.37E-16	-5.71E-17	-1.46E-16	1.18E-14
Counting Precision	N/A	3.42E-16	7.78E-17	1.67E-14
		Nichols Ranch		
	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
NRPS	1.44E-16	1.46E-16	2.86E-17	5.46E-15
Counting Precision	N/A	1.70E-16	3.62E-17	5.97E-15
NR-1	1.59E-16	-1.55E-17	3.56E-17	1.65E-15
Counting Precision	N/A	1.26E-16	3.66E-17	5.93E-15
NR-2	1.50E-16	-1.32E-16	2.71E-16	1.10E-15
Counting Precision	N/A	1.01E-16	5.67E-17	5.93E-15
NR-3	1.32E-16	9.88E-17	2.29E-17	6.44E-15
Counting Precision	N/A	1.67E-16	3.62E-17	6.01E-15
Effluent Concentration 10 CFR Part 20 Appendix B, Table 2	**9.00E-14**	**3.00E-14**	**9.00E-13**	**6.00E-13**

Notes: *See Figures 2-25 and 2-26 for Monitoring Site Locations
LLD (µCi/ml): U, Th-230 and Ra-226 = 1.00E-16; Pb-210 = 2.00E-15 (Reg. Guide 4.14).

Table 2-33c Baseline Radionuclide Concentrations in Air (Third Quarter 2009).

Hank

	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
HPS	1.27E-16	5.50E-18	-2.96E-17	1.28E-14
Counting Precision	N/A	9.81E-17	7.33E-17	3.05E-15
HR-1	1.44E-16	-2.27E-17	-4.91E-17	1.35E-14
Counting Precision	N/A	8.22E-17	7.88E-17	3.07E-15
HR-2	1.03E-16	-4.71E-17	2.12E-18	1.07E-14
Counting Precision	N/A	7.52E-17	8.88E-17	3.05E-15
HR-4	8.28E-17	1.49E-18	-8.76E-17	1.32E-14
Counting Precision	N/A	7.69E-17	8.37E-17	3.07E-15

Nichols Ranch

	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
NRPS	1.50E-16	-5.60E-17	1.39E-16	1.28E-14
Counting Precision	N/A	8.60E-17	9.46E-17	3.07E-15
NR-1	9.72E-17	-1.47E-17	-6.86E-17	1.25E-15
Counting Precision	N/A	1.10E-16	7.15E-17	3.07E-15
NR-2	1.26E-16	-1.09E-16	-1.43E-16	9.36E-15
Counting Precision	N/A	7.23E-17	5.30E-17	3.03E-15
NR-3	1.39E-16	6.53E-17	-6.22E-17	6.67E-15
Counting Precision	N/A	9.90E-17	7.12E-17	3.00E-15
Effluent Concentration 10 CFR Part 20 Appendix B, Table 2	**9.00E-14**	**3.00E-14**	**9.00E-13**	**6.00E-13**

Notes: *See Figures 2-25 and 2-26 for Monitoring Site Locations
LLD (µCi/ml): U, Th-230 and Ra-226 = 1.00E-16; Pb-210 = 2.00E-15 (Reg. Guide 4.14).

Table 2-33d Baseline Radionuclide Concentrations in Air (Fourth Quarter 2009).

		Hank		
	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
HPS	2.65E-16	-3.94E-18	-5.62E-18	6.31E-15
Counting Precision	N/A	5.82E-17	2.69E-17	1.39E-15
HR-1	1.93E-16	2.20E-16	3.65E-17	7.21E-15
Counting Precision	N/A	8.40E-17	3.06E-17	1.40E-15
HR-2	1.93E-16	2.72E-16	2.62E-17	8.06E-15
Counting Precision	N/A	1.06E-16	2.96E-17	1.40E-15
HR-4	8.28E-17	1.49E-18	-8.76E-17	1.32E-14
Counting Precision	N/A	7.69E-17	8.37E-17	3.07E-15
		Nichols Ranch		
	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
NRPS	1.63E-16	1.23E-19	-4.98E-17	3.94E-15
Counting Precision	N/A	6.04E-17	2.01E-17	1.36E-15
NR-1	1.80E-16	8.39E-17	1.27E-17	1.40E-14
Counting Precision	N/A	8.39E-17	2.72E-17	1.47E-15
NR-2	3.61E-16	4.91E-17	5.45E-17	1.12E-14
Counting Precision	N/A	7.64E-17	3.72E-17	1.67E-15
NR-3	2.56E-16	7.21E-18	1.50E-17	5.12E-15
Counting Precision	N/A	6.65E-17	2.63E-17	1.37E-15
Effluent Concentration 10 CFR Part 20 Appendix B, Table 2	**9.00E-14**	**3.00E-14**	**9.00E-13**	**6.00E-13**

Notes: *See Figures 2-25 and 2-26 for Monitoring Site Locations
LLD (µCi/ml): U, Th-230 and Ra-226 = 1.00E-16; Pb-210 = 2.00E-15 (Reg. Guide 4.14).

Table 2-33e Baseline Radionuclide Concentrations in Air (First Quarter 2010).

	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Hank				
Monitoring Site*				
HPS	3.84E-16	-5.98E-18	2.47E-17	1.12E-14
Counting Precision	N/A	7.16E-17	3.79E-17	1.50E-15
HR-1	2.66E-16	1.71E-17	5.57E-17	8.85E-15
Counting Precision	N/A	6.64E-17	3.92E-17	1.47E-15
HR-2	1.68E-16	-7.46E-17	8.02E-17	5.33E-15
Counting Precision	N/A	6.16E-17	4.09E-17	1.43E-15
HR-4	1.86E-16	-3.35E-17	5.98E-17	8.04E-15
Counting Precision	N/A	6.25E-17	4.68E-17	1.69E-15
Nichols Ranch				
	U µCi/ml	Th-230 µCi/ml	Ra-226 µCi/ml	Pb-210 µCi/ml
Monitoring Site*				
NRPS	1.49E-16	-2.75E-17	6.50E-17	1.04E-14
Counting Precision	N/A	6.59E-17	4.04E-17	1.49E-15
NR-1	1.30E-15	9.30E-18	1.06E-17	1.71E-14
Counting Precision	N/A	7.30E-17	3.67E-17	1.56E-15
NR-2	1.51E-16	3.58E-18	8.17E-17	2.01E-14
Counting Precision	N/A	6.31E-17	3.92E-17	1.58E-15
NR-3	2.69E-15	2.42E-17	1.77E-17	9.14E-15
Counting Precision	N/A	7.51E-17	3.75E-17	1.47E-15
Effluent Concentration 10 CFR Part 20 Appendix B, Table 2	**9.00E-14**	**3.00E-14**	**9.00E-13**	**6.00E-13**

Notes: *See Figures 2-25 and 2-26 for Monitoring Site Locations
LLD (µCi/ml): U, Th-230 and Ra-226 = 1.00E-16; Pb-210 = 2.00E-15 (Reg. Guide 4.14).

The overall combined annual average for Hank and Nichols is 2.86E-16 μCi/ml. To add some additional perspective to this value, a comparison can be made to the average concentration of 6.52E-16 μCi/ml recorded at Energy Metals' Moore Ranch Project from February 6, 2007 through January 9, 2008. Although it is not within the scope of this report to examine reasons for regional variability in air concentrations, suffice it to say that slight differences can be expected as a result of physical site characteristics, instrument exposure period, and instrument location with respect to land use activities, to mention a few.

As previously noted, air concentrations were monitored for Th-230, Ra-226 and Pb-210. A review of the summary provided in Table 2-33a shows that Th-230 concentrations are very low. To illustrate this point, of the 32 samples collected at both sites for a one year period only 4 values (12.5%) were greater than the LLD of 1.00E-16 μCi/ml given in Reg. Guide 4.14. Moreover, the few values that were slightly above the LLD occurred as follows: once at site HPS during the 2nd Quarter of 2009; once at HR-1 and HR-2 during the 4th Quarter of 2009; and once at NRPS during the 2nd Quarter of 2009. The low Th-230 background is further illustrated by the fact that 14 samples (approximately 44% of the total values) were measured at levels well below the LLD of 1.00E-16 μCi/ml (see positive values in Table 2-33a with exponents of E-17 and E-18), and 14 values were reported with negative values. The negative values that were reported, of course, do not imply that a negative concentration exists; instead, negative values occur when a sample has fewer counts that the QC instrument blank, which sets the "zero" point. Using the reported positive numbered values, the average Th-230 concentration for the Hank/Nichols Project area is 7.33E-17 μCi/ml. To compare, the Moore Ranch Project average is 1.18E-15. In brief, 88% of the values reported for the Hank/Nichols Project area are below the LLD of 1.00E-16 μCi/ml and only 12% slightly exceed the LLD. The Moore Ranch Project shows a very similar pattern in terms of having a high percentage of the values being less than the LLD. To illustrate, 11 of the 16 values reported at the Moore Ranch Project were less than the LLD.

With respect to Ra-226 concentrations, its baseline profile is quite similar to the description provided above on Th-230: namely, only 6% of the samples have values slightly above the LLD of 1.00E-16 μCi/ml; 53% are less that the LLD (positive values with exponents of E-17 and

E-18); and 41% with negative values. Using only values equal to or above the LLD, the average Ra-226 concentration (Hank and Nichols combined) of 5.84E-17 µCi/ml. By comparison, the average concentration measured at the Moore Ranch Project of 5.29E-16 µCi/ml is somewhat lower than the value at the Hank/Nichols site, and this is consistent with the uranium values noted above. In summary, 94% of the Ra-226 values are less than the LLD and only 2 values (6% of the total number of samples) are just above the LLD. The two values that slightly exceeded the LLD were from NR-2 and NRPS.

The profile for Pb-210 is somewhat different than that for Th-230 and Ra-226 in that many more values were above the LLD of 2.00E-15 given in Reg. Guide 4.14. For example, 28 of the 32 values were greater than the LLD and only one site (HR-1) had a negative value. As can be seen in the table below, Pb-210 concentrations are very much the same at both the Hank and Nichols Ranch sites. Some variation is evident at the Hank site during the 3rd Quarter 2009 and at the Nichols Ranch site during the 1st Quarter 2010 but the overall averages are quite close. Again, for a little more perspective a comparison can be made to the nearby Moore Ranch Project, which reported an average Pb-210 concentration of 1.51E-14 µCi/ml. As with uranium and Ra-226 values, the Moore Ranch Project area also has higher Pb-210 concentrations than the Hank/Nichols Ranch Project area. Like the Hank/Nichols Ranch area, a large number of the Pb-210 values at the Moore Ranch Project were above the LLD (87%). In summary, the one year monitoring program appears to have established a representative baseline for the Hank and Nichols Ranch Project area.

Monitoring Period	**Hank Unit**	**Nichols Ranch Unit**
_Average Pb-210		
2nd Quarter 2009	9.63E-15	3.66E-15
3rd Quarter 2009	1.26E-14	7.52E-15
4th Quarter 2009	8.70E-15	8.57E-15
1st Quarter 2010	8.36E-15	1.42E-14
Annual Average	**9.82E-15**	**8.49E-15**

Units: µCi/ml

2.9.6.4 Results for the Jane Dough Hank Unit

Although one full year of monitoring is required, Uranerz has included five quarters of baseline measurements. Because of the multiple sites, multiple quarters and multiple constituents, three sets of tables are provided: the first, Table 2-33f tabulates the quarterly values by site; the second, Table 2-33g, is arranged to conveniently show quarterly comparisons; and the third, Table 2-33h, shows average air concentrations by site for each constituent throughout the monitoring period. Because of the consistency of the values over time and at each site it can be concluded that the data are representative of baseline. Additionally, the data from Jane Dough compares favorably with previously-collected data from eight locations at the Hank and Nichols Ranch Units. Lastly, and as expected, the baseline data is orders of magnitude below the 10 CFR 20 Effluent Concentration Limits of Uranium (9E-14); Pb-210 (6E13); Ra-226 (9E-13); and Th-230 (3E-14).

Table 2-33f Jane Dough Baseline Radionuclide Concentrations in Air.

		Third Quarter 2010		
Sample Site	**Uranium (µCi/ml)**	**Pb-210 (µCi/ml)**	**Ra-226 (µCi/ml)**	**Th-230 (µCi/ml)**
LLD*	1E-16	2E-15	1E-16	1E-16
JD-1	2E-16	1.1E-14	1E-17	-9E-17
Precision	N/A	1E-14	5E-17	7E-17
JD-2	2E-16	1.0E-14	3E-17	-3E-18
Precision	N/A	1E-15	3E-17	8E-17
JD-3	4E-16	1.3E-14	6E-17	-6E-17
Precision	N/A	1E-15	4E-17	8E-17
JD-4	2E-16	6.0E-15	2E-17	-1E-17
Precision	N/A	1E-15	3E-17	8E-17
JD-5	2E-16	1.4E-14	5E-17	1E-16
Precision	N/A	1E-15	4E-17	1E-16
JD-6	3E-16	9.9E-15	6E-16	7E-17
Precision	N/A	1E-15	8E-17	9E-17
JD-7	3E-16	5.0E-15	2E-16	2E-17
Precision	N/A	1E-15	6E-17	1E-15

***Lower Limit of Detection: Regulatory Guide 4.14.**

Table 2-33f Jane Dough Baseline Radionuclide Concentrations in Air Fourth Quarter 2010. (continued)

	Fourth Quarter 2010			
Sample Site	**Uranium (µCi/ml)**	**Pb-210 (µCi/ml)**	**Ra-226 (µCi/ml)**	**Th-230 (µCi/ml)**
LLD*	1E-16	2E-15	1E-16	1E-16
JD-1	1E-16	2.4E-14	1E-17	-9E-17
Precision	N/A	3E-15	6E-17	6E-17
JD-2	2E-16	2.1E-14	4E-17	-1E-16
Precision	N/A	2E-15	6E-17	7E-17
JD-3	2E-16	2.2E-14	5E-17	-1E-16
Precision	N/A	2E-15	6E-17	6E-17
JD-4	1E-16	2.3E-15	3E-17	-7E-17
Precision	N/A	3E-15	6E-17	6E-17
JD-5	2E-16	2.2E-14	5E-17	-2E-16
Precision	N/A	2E-15	6E-17	5E-16
JD-6	1E-16	2.0E-14	7E-18	-7E-17
Precision	N/A	2E-15	6E-17	7E-17
JD-7	2E-16	2.0E-15	4E-17	-3E-17
Precision	N/A	2E-15	6E-17	6E-17

***Lower Limit of Detection: Regulatory Guide 4.14.**

Table 2-33f Jane Dough Baseline Radionuclide Concentrations in Air First Quarter 2011. (continued)

	First Quarter 2011			
Sample Site	**Uranium (µCi/ml)**	**Pb-210 (µCi/ml)**	**Ra-226 (µCi/ml)**	**Th-230 (µCi/ml)**
LLD*	1E-16	2E-15	1E-16	1E-16
JD-1	1E-16	2.1E-14	-1E-17	2E-16
Precision	N/A	2E-15	6E-17	7E-17
JD-2	2E-16	1.2E-14	4E-17	1E-16
Precision	N/A	2E-15	7E-17	7E-17
JD-3	2E-16	1.3E-14	3E-17	2E-16
Precision	N/A	2E-15	6E-17	8E-17
JD-4	2E-16	1.2E-14	-4E-17	1E-16
Precision	N/A	2E-15	5E-17	7E-17
JD-5	2E-16	1.1E-14	7E-17	1E-16
Precision	N/A	2E-15	7E-17	6E-17
JD-6	2E-16	1.2E-14	2E-17	9E-17
Precision	N/A	2E-15	6E-17	6E-17
JD-7	2E-16	1.2E-14	5E-18	1E-16
Precision	N/A	2E-15	6E-17	6E-17

***Lower Limit of Detection: Regulatory Guide 4.14.**

Table 2-33f Jane Dough Baseline Radionuclide Concentrations in Air Second Quarter 2011. (continued)

		Second Quarter 2011		
Sample Site	**Uranium (µCi/ml)**	**Pb-210 (µCi/ml)**	**Ra-226 (µCi/ml)**	**Th-230 (µCi/ml)**
LLD*	1E-16	2E-15	1E-16	1E-16
JD-1	1E-16	8.7E-15	-3E-17	2E-16
Precision	N/A	1E-15	6E-17	7E-17
JD-2	2E-16	9.3E-15	2E-17	2E-16
Precision	N/A	2E-15	1E-16	9E-17
JD-3	2E-16	8.7E-15	-3E-17	2E-16
Precision	N/A	1E-15	6E-17	8E-17
JD-4	1E-16	8.9E-15	9E-17	2E-16
Precision	N/A	2E-15	5E-17	7E-17
JD-5	2E-16	9.0E-15	6E-17	2E-16
Precision	N/A	2E-15	1E-16	1E-16
JD-6	2E-16	9.0E-15	8E-17	2E-16
Precision	N/A	1E-15	1E-16	9E-17
JD-7	2E-16	8.3E-15	1E-16	2E-16
Precision	N/A	1E-15	9E-17	8E-17

***Lower Limit of Detection: Regulatory Guide 4.14.**

Table 2-33f Jane Dough Baseline Radionuclide Concentrations in Air Third Quarter 2011. (continued)

		Third Quarter 2011		
Sample Site	**Uranium (µCi/ml)**	**Pb-210 (µCi/ml)**	**Ra-226 (µCi/ml)**	**Th-230 (µCi/ml)**
LLD*	1E-16	2E-15	1E-16	1E-16
JD-1	4E-16	8.7E-15	9E-17	4E-16
Precision	N/A	4E-15	3E-16	2E-16
JD-2	4E-16	1.5E-14	5E-16	6E-16
Precision	N/A	4E-15	4E-16	2E-16
JD-3	4E-16	1.5E-14	2E-16	6E-16
Precision	N/A	4E-15	3E-16	2E-16
JD-4	4E-16	1.2E-14	3E-16	4E-16
Precision	N/A	4E-15	4E-16	2E-16
JD-5	4E-16	1.5E-14	5E-16	2E-16
Precision	N/A	4E-15	4E-16	2E-16
JD-6	8E-16	1.4E-14	8E-16	3E-16
Precision	N/A	4E-15	4E-16	2E-16
JD-7	4E-16	1.3E-15	4E-16	3E-16
Precision	N/A	4E-15	4E-16	2E-16

***Lower Limit of Detection: Regulatory Guide 4.14.**

Table 2-33g Radionuclide Air Concentrations: Quarterly Comparison.

JD-1

Sample Period	Uranium (µC/ml)	Pb-210 (µC/ml)	Ra-226 (µC/ml)	Th-230 (µC/ml)
3rd Q 2010	2E-16	1.1E-14	1E-17	-9E-17
4th Q 2010	1E-16	2.4E-14	1E-17	-9E-17
1st Q 2011	1E-16	1.2E-14	-1E-17	2E-16
2nd Q 2011	1E-16	8.7E-15	-3E-17	2E-16
3rd Q 2011	4E-16	8.7E-15	9E-17	4E-16

JD-2

Sample Period	Uranium (µC/ml)	Pb-210 (µC/ml)	Ra-226 (µC/ml)	Th-230 (µC/ml)
3rd Q 2010	2E-16	1.0E-14	3E-17	-3E-18
4th Q 2010	2E-16	2.1E-14	4E-17	-1E-16
1st Q 2011	2E-16	1.2E-14	4E-17	1E-16
2nd Q 2011	2E-16	9.3E-15	2E-17	2E-16
3rd Q 2011	4E-16	1.5E-14	5E-16	6E-16

JD-3

Sample Period	Uranium (µC/ml)	Pb-210 (µC/ml)	Ra-226 (µC/ml)	Th-230 (µC/ml)
3rd Q 2010	4E-16	1.3E-14	6E-17	-6E-17
4th Q 2010	2E-16	2.2E-14	5E-17	-1E-16
1st Q 2011	2E-16	1.3E-14	3E-17	2E-16
2nd Q 2011	2E-16	8.7E-15	-3E-17	2E-16
3rd Q 2011	4E-16	1.5E-14	2E-16	6E-16

JD-4

Sample Period	Uranium (µC/ml)	Pb-210 (µC/ml)	Ra-226 (µC/ml)	Th-230 (µC/ml)
3rd Q 2010	2E-16	6.0E-15	2E-17	-1E-17
4th Q 2010	1E-16	2.3E-14	3E-17	-7E-17
1st Q 2011	2E-16	1.2E-14	-4E-17	1E-16
2nd Q 2011	1E-16	8.9E-15	9E-17	2E-16
3rd Q 2011	4E-16	1.2E-14	3E-16	4E-16

Table 2-33g (continued)

Sample Period	Uranium (µC/ml)	Pb-210 (µC/ml)	Ra-226 (µC/ml)	Th-230 (µC/ml)
		JD-5		
3rd Q 2010	2E-16	1.4E-14	5E-16	1E-16
4th Q 2010	2E-16	2.2E-14	5E-17	-2E-17
1st Q 2011	2E-16	1.1E-14	7E-17	1E-16
2nd Q 2011	2E-16	9.0E-15	6E-17	2E-16
3rd Q 2011	4E-16	1.5E-14	5E-16	2E-16
		JD-6		
3rd Q 2010	3E-16	9.9E-15	6E-16	7E-17
4th Q 2010	1E-16	2.0E-14	7E-18	-7E-17
1st Q 2011	2E-16	1.2E-14	2E-17	9E-17
2nd Q 2011	2E-16	9.0E-15	8E-17	2E-16
3rd Q 2011	8E-16	1.4E-14	8E-16	3E-16
		JD-7		
3rd Q 2010	3E-16	9.9E-15	2E-16	2E-17
4th Q 2010	2E-16	2.0E-14	4E-17	-3E-17
1st Q 2011	2E-16	1.2E-14	5E-18	1E-16
2nd Q 2011	2E-16	8.3E-15	1E-16	2E-16
3rd Q 2011	4E-16	1.3E-14	4E-16	3E-16

Table 2-33h Average Air Concentrations Over Five Quarters of Monitoring: Jane Dough Unit.

	Uranium (µCi/kg)						Pb-210 (µCi/kg)					
Site	Q3/2010	Q4/2010	Q1/2011	Q2/2011	Q3/2011	Ave.	Q3/2010	Q4/2010	Q1/2011	Q2/2011	Q3/2011	Ave.
JD-1	2E-16	1E-16	1E-16	1E-16	4E-16	2E-16	1.1E-14	2.4E-14	1.2E-14	8.7E-15	8.7E-15	1.3E-14
JD-2	2E-16	2E-16	2E-16	2E-16	4E-16	2E-16	1.0E-14	2.1E-14	1.2E-14	9.3E-15	1.5E-14	1.4E-14
JD-3	4E-16	2E-16	2E-16	2E-16	4E-16	3E-16	1.3E-14	2.2E-14	1.3E-14	8.7E-15	1.5E-14	1.4E-14
JD-4	2E-16	1E-16	2E-16	1E-16	4E-16	2E-16	6.0E-15	2.3E-14	1.2E-14	8.9E-15	1.2E-14	1.2E-14
JD-5	2E-16	2E-16	2E-16	2E-16	4E-16	2E-16	1.4E-14	2.2E-14	1.1E-14	9.0E-15	1.5E-14	1.4E-14
JD-6	3E-16	1E-16	2E-16	2E-16	8E-16	3E-16	9.9E-15	2.0E-14	1.2E-14	9.0E-15	1.4E-14	1.3E-14
JD-7	3E-16	2E-16	2E-16	2E-16	2E-16	2E-16	9.9E-15	2.0E-14	1.2E-14	8.3E-15	1.3E-14	1.3E-14

	Ra-226 (µCi/kg)						Th-230 (µCi/kg)					
Site	Q3/2010	Q4/2010	Q1/2011	Q2/2011	Q3/2011	Ave	Q3/2010	Q4/2010	Q1/2011	Q2/2011	Q3/2011	Ave.
JD-1	1E-17	1E-17	-1E-17	-3E-17	9E-17	3E-17	-9E-17	-9E-17	2E-16	2E-16	4E-16	2E-16
JD-2	3E-17	4E-17	4E-17	2E-17	5E-16	3E-17	-3E-18	-1E-16	1E-16	2E-16	6E-16	2E-16
JD-3	6E-17	5E-17	3E-17	-3E-17	2E-16	7E-17	-6E-17	-1E-16	2E-16	2E-16	6E-16	2E-16
JD-4	2E-17	3E-17	-4E-17	9E-17	3E-16	1E-16	-1E-17	-7E-17	1E-16	2E-16	4E-16	2E-16
JD-5	5E-16	5E-17	7E-17	6E-17	5E-16	2E-16	1E-16	-2E-17	1E-16	2E-16	2E-16	1E-16
JD-6	6E-16	7E-18	2E-17	8E-17	8E-16	3E-16	7E-17	-7E-17	9E-17	2E-16	3E-16	2E-16
JD-7	2E-16	4E-17	5E-18	1E-16	4E-16	1E-16	2E-17	-3E-17	1E-16	2E-16	3E-16	1E-16

Regulatory Guide 14 Lower Limit of Detection: Uranium (1E-16); Pb-210 (2E-15); Ra-226 (1E-16); and Th-230 (1E-16). 10 CFR 20 Effluent Concentration Limits: U (9E-14); Pb-210(6E-13); Ra-226 (9E-13); and Th-230 (3E-14).
All values in the table are as reported in the laboratory reports. To allow the average to be approximated, negative values were revised to the lower limit of detection.

2.10 BACKGROUND NONRADIOLOGICAL CHARACTERISTICS

2.10.1 Nonradioactive Airborne Effluents

Nonradioactive airborne effluents associated with the Nichols Ranch ISR Project are those discussed in Section 2.5.4 Air Quality. Since the effluents will be generated during construction and operation of the Nichols Ranch ISR Project, no baseline information was collected or could be collected. Estimates of the airborne effluents associated with the operation Nichols Ranch ISR Project processing facilities, such as CO_2, HCL, H_20_2, NaOH, and Fugitive Dust, are found in Table 2-10.

2.10.2 Nonradioactive Liquid Effluents

Nonradioactive effluents will not be discharged to the environment during the operation of the Nichols Ranch ISR Project. The processing plants will be zero discharge facilities as all nonradioactive effluents will be sent to the deep disposal well. Because of this, no background information was obtained or necessary.

2.10.3 Nonradioactive Baseline Studies

Baseline studies were conducted for soils, vegetation, and groundwater for the Nichols Ranch ISR Project. All studies were conducted based upon consultation and approval of the Wyoming Department of Environmental Quality.

2.10.3.1 Soils

A baseline detailed soil inventory was conducted for the Nichols Ranch ISR Project to inventory the pre-operational soil characteristics with the project area. The attached Appendix D7 (**Nichols Ranch and Hank Units)** and **Appendix JD-D7 (Jane Dough Unit)** contains all of the information that was collected during the baseline survey. The information includes an inventory of soil types (soil map units) and soil series based on the Order 3 soil survey, a base map delineating the soil

types, physical and chemical characteristics of the topsoil for potential disturbance areas, and estimated depths of salvageable topsoil from the potential disturbance areas for future reclamation purposes.

2.10.3.2 Vegetation

Baseline vegetation studies of the Nichols Ranch ISR Project were conducted to establish a detailed inventory of the pre-operational vegetation characteristics within and adjacent to the proposed project area. The study was also use to provide baseline vegetative information for evaluating future reclamation success with the project area. The attached Appendix D8 and **Appendix JD-D8** contains all information collected during the baseline study including a description of the vegetation types and their distribution, species diversity, and composition, percent vegetative and percent total ground cover, and existing disturbances with the project area.

2.10.3.3 Groundwater

A pre-operational regional groundwater baseline water quality survey was conducted for the Nichols Ranch ISR Project. The regional groundwater quality was defined by the sampling of numerous wells in several aquifers in the area surrounding the Nichols Ranch ISR Project. The baseline study included collecting samples from the numerous regional wells once a calendar quarter for a year and having them analyzed for the constituents found in Table 2-34. These samples were collected to determine the regional groundwater characteristics in order to aid in evaluating future restoration success and for excursion detection in the event that one were to occur. The attached Appendix D6 **and Appendix JD-D6** contains detailed information on the regional baseline water quality results. Section 2.7 of this chapter also contains information regarding the results of the baseline study.

Table 2-34 Groundwater Baseline Water Quality Parameters.

Parameter*	**Analytical Method**
Alkalinity	EPA 310.1/310.2
Aluminum	EPA 200.7
Ammonia Nitrogen as N	EPA 350.1
Nitrate + Nitrite as N	EPA 353.2
Barium	EPA 200.7
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) @ 180ºF	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
Dissolved 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/SM7500-R-AD
Radium-228 (pCi/L)	SM7500-R-AD
Gross Alpha (pCi/L)	DOE RP710/CHEM-TA-GP B1/EPA 900
Gross Beta (pCi/L)	DOE RP710/CHEM-TA-GP B1/EPA 900
Uranium	DOE MM 800/EPA 200.8
Vanadium	EPA 286.1/286.2/200.7/200.8
Zinc	EPA 200.7
Gross alpha	EPA 900.0
Gross Beta	EPA 900.0

* All parameters measured in mg/L unless otherwise denoted.