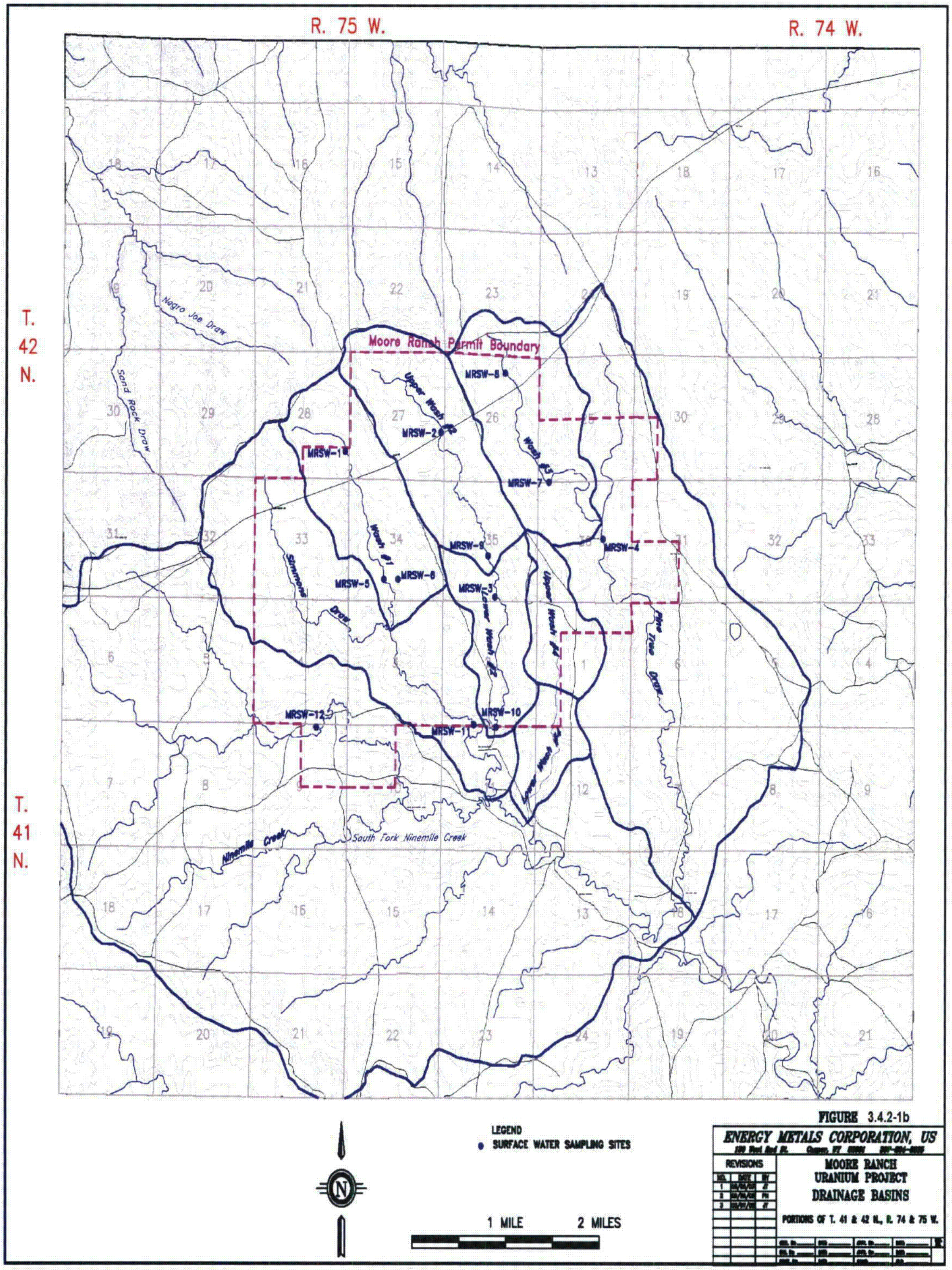

FIGURE 3.4.2-1b

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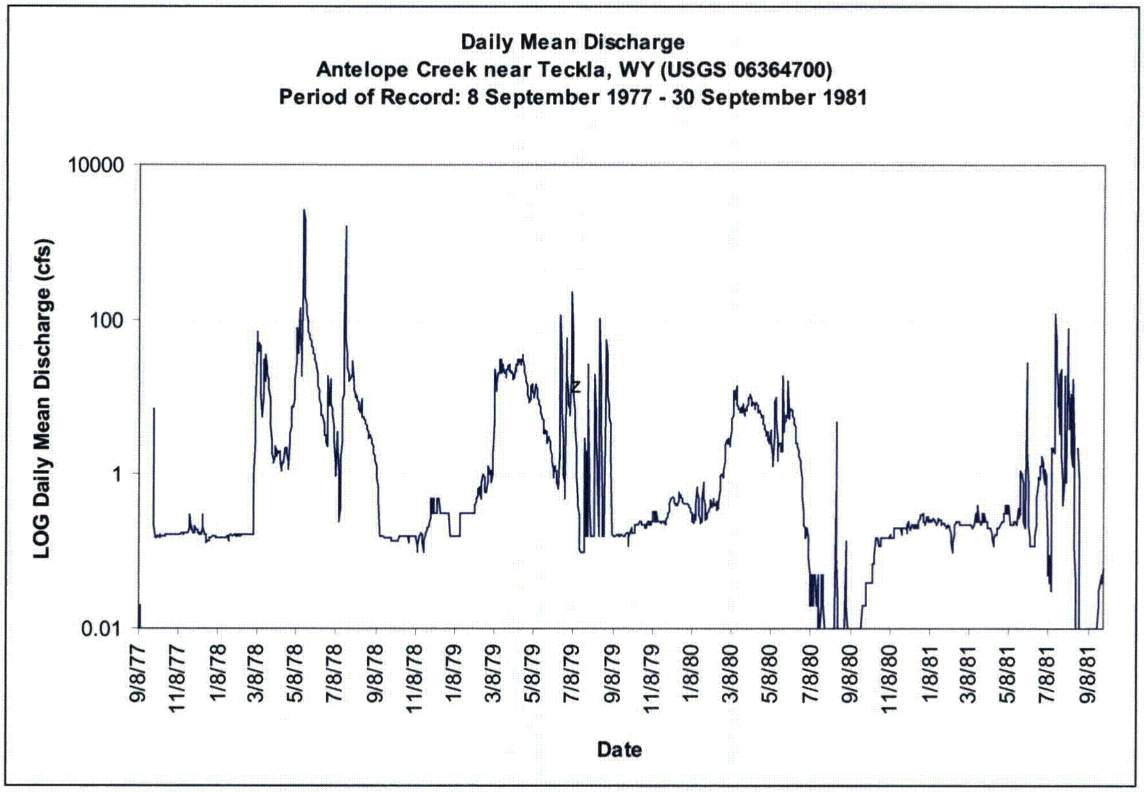
URANIUM PROJECT
DRAINAGE BASINS

PORTIONS OF T. 41 & 42 N., R. 74 & 75 W.

Figure 3.4.2-2 Daily Mean Discharge for Antelope Creek near the Town of Teckla

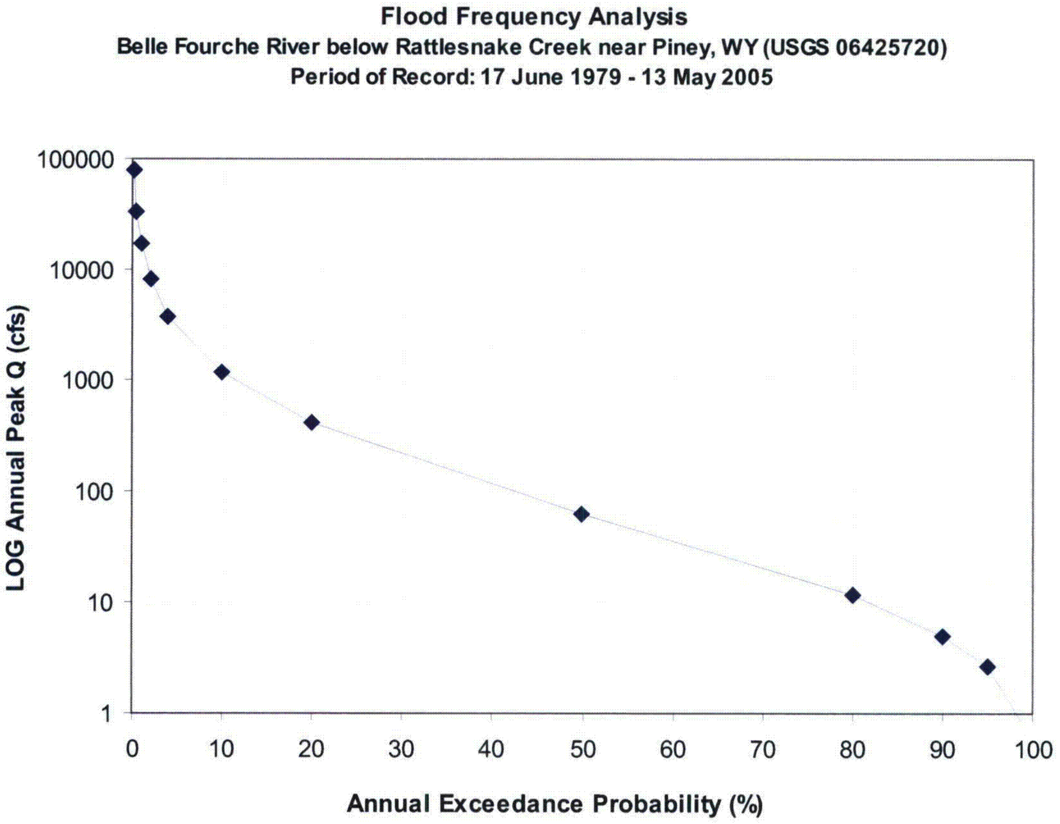


Analysis of daily mean discharge for the Powder River above Burger Draw near Buffalo, WY (USGS 06313590) from June 12, 2003 through June 28, 2007 revealed an average flow of 127 cfs and a median flow of 100 cfs. Daily mean discharge ranged from a minimum of 0.03 cfs to a maximum of 3,050 cfs, which occurred on May 7, 2007. Analysis of annual peak instantaneous discharge for the period of June 18, 2003 to May 12, 2005 revealed an average of 2,360 cfs and a median of 2,200 cfs. Annual instantaneous peaks flows ranged from 1,140 cfs to 3,740 cfs, which was recorded on May 12, 2005 (USGS 2007). Flood frequency data analysis was not possible due to the limited record of annual peak instantaneous data.

Analysis of daily mean discharge for the Belle Fourche River below Rattlesnake Creek near Piney, WY (USGS 06425720) revealed an average flow of 9.0 cfs and a median flow of 0.3 cfs. Daily mean discharge ranged from 0 cfs to 2,740 cfs, which was recorded on December 28, 2003. Analysis of annual instantaneous peak discharge from June 17, 1979 to May 13, 2005 indicated a mean peak flow of 357 cfs and a median peak flow of 36 cfs. Annual instantaneous peak discharges ranged from 4 cfs to 1,300 cfs, which was recorded on June 17, 1979 (USGS 2007).

Flood frequency analysis was performed using the USGS standard method, in which a log-Pearson Type III frequency distribution is fit to the logarithms of the peak flow cumulative distribution. Parameters of the log-Pearson Type III were estimated from the logarithmic peak flows (mean, standard deviation, and coefficient of skewness) with adjustments for low and high outliers, historic peaks and generalized skew (Riggs 1968). Log-Pearson III flood frequency analysis revealed a flood that has the probability of occurring once every 10 years, has a magnitude of about 1,100 cfs. Similarly, a flood that has the probability of occurring once every 100 years has a magnitude of 12,000 cfs (Figure 3.4.2-3).

Figure 3.4.2-3 Flood Frequency Analysis for Belle Fourche River near Piney, Wyoming



Antelope Creek has a drainage area of 980 square miles with an approximate channel length of 62 miles and an average gradient of 0.006 (ft/ft). The elevation at Antelope Creek's headwaters is approximately 6,225 feet above mean sea level (msl), and 4,400 feet at its confluence with the South Cheyenne River. The U.S. Geological Survey has a stream gaging station on Antelope Creek approximately ten miles upstream from its mouth. The drainage area is 959 square miles, at the gage.

Ninemile Creek has a total drainage area of 63 square miles, a channel length of approximately 20 miles, and an average channel gradient of 0.006 (ft/ft). The elevation difference from headwaters to mouth is 610 feet with a maximum basin elevation of approximately 5,500 feet above msl. The channel length within this area is approximately 10.5 miles with an average gradient of 0.007 (ft/ft).

Simmons Draw is a Ninemile Creek tributary flowing southeasterly through the project (Figure 3.4.2-4). Its total drainage area is 8.1 square miles. The channel length is 6.8 miles with an average gradient of 0.007 (ft/ft). Total basin elevation difference is 260 feet with a maximum elevation of approximately 5,475 feet above msl.

Pine Tree Draw, with a drainage area of 8.2 square miles, flows from the north into Ninemile Creek on the eastern edge of the project area (Figure 3.4.2-4). The channel length is approximately 7.6 miles, and the average gradient is 0.009 (ft/ft). The maximum basin elevation approaches 5,470 feet above msl, and the minimum is approximately 5,110 feet.

Simmons Draw has two tributaries which flow in a predominantly southerly direction in the project area. These tributaries are labeled Washes Nos. 1 and 2 on Figure 3.4.2-4. Wash No. 2 is further subdivided into Upper Wash No. 2 and Lower Wash No. 2 based on the channel reach being upstream and downstream of the proposed mining Pit 35N. Wash No. 4, which is tributary to Ninemile Creek, is also further divided into Upper Wash No. 4 and Lower Wash No. 4 at the location of the proposed mill tailings evaporation pond dam.

Wash No. 1 has a drainage area of 1.7 square miles, a channel length of 2.8 miles, and an average channel gradient of 0.014 (ft/ft). The basin elevation difference is approximately 205 feet with a maximum elevation of 5,475 feet above msl.

Upper Wash No. 2 and Lower Wash No. 2 have drainage areas of 1.9 and 0.95 square miles, respectively. Their respective channel lengths are 3.1 and 2.2 miles with average gradients of 0.012 and 0.007 (ft/ft).

The drainage areas of Upper Wash No. 4 and Lower Wash No. 4 are 0.70 and 0.53 square miles respectively. Channel lengths are 0.46 and 1.3 miles with respective gradients of 0.017 and 0.013 (ft/ft).

Wash No. 3 (Figure 3.4.2-4) drains into Pine Tree Draw from the northwest in Section 36 of T42N-R75W. Its drainage area is 1.8 square miles, the channel length and average gradient are 3.2 miles and 0.014 (ft/ft), respectively, and the basin elevation difference is approximately 230 feet. The maximum basin elevation is approximately 5,480 feet above msl.

Drainage basin characteristics for Antelope Creek, Ninemile Creek, and all of the tributaries relevant to the Moore Ranch project area are summarized in Table 3.4.2-1.

Table 3.4.2-1 Drainage Basin Characteristics for the Moore Ranch Project Area

Drainage Basin	Drainage Area (mi^2)	Channel Length (mi)	Elevation Differences (ft)	Channel (ft/mi)	Gradient (ft/ft)
Antelope Creek (total)	980	62	1,825	29.4	0.006
Antelope Creek (at USGS gage)	959	52	1,775	34.1	0.006
Ninemile Creek (Total)	63	20	610	30.5	0.006
Ninemile Creek (@ 1-7)	34	10.5	390	37.1	0.007
Pine Tree Draw	8.2	7.6	370	48.9	0.0009
Simmons Draw	8.1	6.8	260	38.2	0.0007
Wash No. 1	1.7	2.8	205	73.2	0.014
Upper Wash No. 2	1.9	3.1	190	61.3	0.012
Lower Wash No. 2	0.95	2.2	80	36.4	0.007
Wash No. 3	1.8	3.2	230	71.9	0.014
Upper Wash No. 4	0.70	0.46	130	90.2	0.017
Lower Wash No. 4	0.53	1.3	90	69.2	0.013

Site Surface Water Runoff

Surface water runoff from precipitation (rain and snowmelt) at the Moore Ranch ISR facilities will flow from the facilities area to natural drainages. Precipitation runoff is not expected to significantly exceed natural condition, as the increase in runoff from some areas (e.g., building roofs) will be balanced by the decrease in runoff from other areas (flat, gravel parking lots, etc.). Figure 3.4.2-1a shows the reduced slopes anticipated in the vicinity of the restricted, fenced area around the plant site as compared to the natural landform slopes. Additionally, Figure 3.4.2-1a shows the location of the Central Plant area in relation to the location of the nearest natural drainages and wetlands and shows that none of the runoff will flow directly into either artificial or natural streams or wetlands. The potential for contamination of surface-water runoff is also minimal because the processing plant and shop buildings are self-contained and all exterior chemical and fuel tanks will have a means of secondary containment. The Second Tributary to the Simmons Draw, located to the east of the Plant is a natural intermittent stream.

Peak flood estimates for each of the drainage basins within and directly adjacent to the Moore Ranch Project area were previously calculated and presented to the NRC in the Environmental Report for the Sand Rock Mill Project, Docket No. 40-8743 (1980) and subsequent Draft Environmental Statement prepared by the NRC (1982). Those documents were referenced to provide the following runoff estimates. These estimates are considered valid.

In those reports, three techniques were utilized for estimating flood flows and volumes ephemeral basins for different recurrence intervals as described below.

- Lowham (1976) presented a basin characteristics technique whereby peak flow was related to drainage area with consideration of different regions in the state. Lowham's regression equations can be used for basins with drainage areas between 5 and 5,300 square miles. However, using a graphical approach, his technique can be used for basins slightly less than one square mile in area.

- For small basins (approximately 10 square miles and less) Craig and Rankl (1977) developed basin characteristics regression equations which utilize other basin parameters in addition to drainage area to compute peak flows and flood volumes (Craig and Rankl, “Analysis of Runoff from Small Drainages in Wyoming, US Geological Survey, Open-File Report 77-727, 1977).

- Also, for small basins, the U.S. Soil Conservation Service (SCS) has developed a technique to estimate peak flows and flood volumes. These techniques are published in their Engineering Field Manual (1969). The SCS technique utilizes peak rainfall values published by the U.S. Weather Bureau and then takes into consideration soil and vegetation characteristics and basin slope and drainage area to make the flood flow and volume estimates.

The technique presented in Lowham (1976) has since been superseded by Lowham, 1988, and subsequently by Miller, 2003. Therefore, the flood estimates calculated from the techniques in Lowham (1976) are not considered valid and are not presented in this report. The methods used in Craig and Rankl (1977) for analysis for small drainage basins in Wyoming (later published in Craig and Rankl, “Analysis of Runoff from Small Drainages in Wyoming, US Geological Survey, Water Supply Paper 2056, 1978) and the SCS method are considered valid techniques for estimating runoff as described WDEQ-LQD Guideline 8.

Table 3.4.2-2 presents flood flow and volume estimates for the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year events. For comparison purposes, values obtained by utilizing the two techniques described above are tabulated.

Values listed in Table 3.4.2-2 under the SCS method were obtained using curve number 75 and 24-hour duration precipitation values from Miller and others (1973). Table 3.4.2-3 shows precipitation for selected recurrence intervals for different duration periods.

Table 3.4.2-2 Peak Flood Discharge Estimates for 5-, 10-, 25-, 50-, and 100-Year Recurrence Intervals for Drainages within the Moore Ranch Project Boundary

Drainage	Drainage Area (mi^2)	Craig and Rank's Method (CFS)					SCS Method (CFS)				
		5-year	10-year	25-year	50-year	100-year	5-year	10-year	25-year	50-year	100-year
Ninemile Creek	63	4,700	6,900	9,800	14,000	18,000					
Pine Tree Draw	8.2	1,100	1,600	2,200	3,100	3,900					
Simmons Draw	8.1	1,400	2,000	2,600	3,600	4,500					
Wash No. 1	1.7	410	580	770	1,100	1,310	150	250	350	450	550
Upper Wash No. 2	1.9	480	670	890	1,200	1,500	160	260	370	480	580
Lower Wash No. 2	0.95	500	640	770	990	1,200	100	150	240	310	360
Wash No. 3	1.8	400	560	760	1,000	1,300	160	260	360	470	570
Upper Wash No. 4	0.7	260	360	460	610	740	85	140	190	250	300
Lower Wash No. 4	0.53	270	350	440	570	670	70	110	150	210	250

Reference: Conoco, Inc. 1980. Environmental Report for the Sand Rock Mill Project, Campbell County, Wyoming, Docket No. 40-8743. July, 1980.

More recent peak discharge evaluations for similar drainages in the Powder River Basin were conducted to evaluate the performance of reconstructed stream channel reclamation at coal mines (Western Water Consultants, 1995). Rainfall-runoff simulations were based on the SCS triangular hydrograph method to estimate flood discharges for 10 and 100-year events. Flood discharge values calculated for drainage areas in Campbell County of similar size are shown to be relatively similar to 100-year flood discharge values for drainages within the Moore Ranch project area using the SCS method. Table 3.4.2-4 shows a comparison of the Moore Ranch 100-year flood estimates and 100-year flood estimates from similar size drainage basins evaluated in the Western Water Consultants, 1995 report.

Table 3.4.2-3 Precipitation Values For Selected Recurrence Intervals and Durations in the Moore Ranch Project Area (Inches)

Duration	**2-Yr**	**5-Yr**	**10-Yr**	**25-Yr**	**50-Yr**	**100-Yr**	**500-Yr**	**Duration**
5-Min	.25	.35	.42	.52	.59	.66	.83	5-Min
10-Min	.38	.54	.65	.80	.92	1.03	1.29	10-Min
15-Min	.48	.69	.83	1.01	1.16	1.30	1.64	15-Min
30-Min	.67	.95	1.14	1.40	1.61	1.81	2.27	30-Min
1-Hour	.85	1.21	1.45	1.78	2.03	2.29	2.87	1-Hour
2-Hour	.95	1.33	1.59	1.94	2.22	2.49	3.12	2-Hour
3-Hour	1.03	1.44	1.71	2.09	2.38	2.67	3.33	3-Hour
6-Hour	1.25	1.71	2.01	2.44	3.47	3.10	3.86	6-Hour
12-Hour	1.47	2.00	2.35	2.84	3.22	3.60	4.47	12-Hour
24-Hour	1.70	2.29	2.69	3.24	3.67	4.10	5.09	24-Hour

Table 3.4.2-4 Comparison of Moore Ranch Project SCS Method 100-year Flood Estimates with Recent Flood Estimates for Similar Size Drainage Basins in Campbell County

Drainage	Area (Square Miles)	SCS Method 100-year Peak Discharge (cfs)	Drainage	Area (Square Miles)	SCS Method 100-year Peak Discharge (cfs)
Wash No. 1	1.7	550	Russel Draw	1.8	590
Upper Wash No. 2	1.9	580	Russel Draw	1.8	590
Lower Wash No. 2	0.95	360	HA Creek Tributary	1.03	351
Wash No. 3	1.8	570	Russel Draw	1.8	590
Upper Wash No. 4	0.70	300	Lone Tree Prong	0.68	279
Lower Wash No. 4	0.53	250	School Creek	0.49	260

3.4.2.2 Flooding Potential For Facility Areas

Figures 3.5.5-2 and 3.5.5-8 show surface water features within the Moore Ranch Project Area in relation to proposed facilities and wellfields. Figures 1.2-4 also show the facilities in relation to surrounding topography. The satellite processing area and wellfields are located well above any surface water features that would be inundated during flooding events, and also located in a manner that insignificant runon will occur from upgradient sources. Runoff in these areas will consist primarily of overland sheet flow. The satellite plant and facilities area will be graded and sloped to direct precipitation runoff away from building foundations in all directions to a storm water conveyance system. Potential runon will also be intercepted and directed around the satellite plant area. The stormwater conveyance system will be designed to pass the 50-year flood. Due to the location of Wellfield 1 and the satellite plant area related to the surrounding topography, impacts from flooding are expected to be minimal. The stream channel in Upper and Lower Wash No. 2 is located near the center portion of Wellfield 2. The previous hydrologic analysis conducted by Conoco determined representative channel cross sections for Upper and Lower Wash No. 2 and water crest heights for 100-year and 5-year floods (see Appendix A5 for previous hydrologic analysis conducted by Conoco). Channel cross sections for Upper Wash No. 2 in the vicinity of Wellfield 2 (approximately 650 feet upstream) show a channel inundation depth of approximately 2.9 feet at a velocity of 7.4 ft/second. As shown Figure 3.5.5-8, the channel widens somewhat through Wellfield 2, so the water depth and velocity in the channel during a 100-year flood through Wellfield 2 is anticipated to be less than 2.9 feet and 7.4 ft/second. However, due to the ephemeral nature of the drainages in the area, this channel typically contains no flow.

3.4.2.3 Surface Water Quality

No streams within the Antelope Creek Basin are listed on the US EPA Section 303(d) list, which categories impaired surface water bodies. The Upper Powder River Basin is listed on the Section 303(d) list for chloride and selenium from the South Fork of the Powder River to an undetermined distance downstream below Sussex, WY. The Upper Belle Fourche River Basin is listed on the Section 303(d) list for ammonia and total residual chlorine downstream of the Hulett Wastewater Treatment Plant (US EPA 2007).

According to the Wyoming Department of Environmental Quality (WY DEQ), Antelope Creek is classified as a 3B surface water, meaning its designated use is for recreation, other aquatic life, wildlife, agriculture, industry, and scenic value. The North Fork of the Powder River is classified as a 2AB surface water, which means its designated use is for drinking water, game and non-game fisheries, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic value. The Upper Belle Fourche River is classified as a 2ABWW surface water, and its associated designated uses are drinking water, game and non-game fisheries, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic value (WY DEQ 2001).

Water quality data were available from only one USGS stream gage (06364700) located on Antelope Creek near Teckla, WY from October 3, 1977 through September 7, 2005. Water quality data analyses revealed a mean temperature of 10.4 degrees Celsius (°C) and a range from 0 to 30 °C. Mean dissolved oxygen was 7.8 milligrams/liter (mg/l) and ranged from 2.8 to 11.7 mg/L. Total nitrogen averaged 0.55 mg/L and ranged from 0.21 to 1.8 mg/l. Mean ammonia as nitrogen concentrations were 0.04 mg/L and ranged from 0 to 0.13 mg/l. Nitrite plus nitrate as nitrogen averaged 0.04 mg/L, with a range from 0 to 0.29 mg/l. Average phosphate was 0.03 mg/L and average selenium (water filtered) was 0.56 mg/l (USGS 2007). EMC has conducted surface water quality sampling at 12 monitoring locations at the Moore Ranch site. Sampling was performed on a quarterly basis since last quarter 2006.

Within the Moore Ranch Project Area, surface water samples were collected from 9 sampling locations (all locations are existing stock ponds or areas in drainages where ponding occurs) at upstream and downstream locations from proposed mining areas during late fall of 2006, early spring of 2007, and late spring of 2007. Locations of these sample sites are shown on Figure 3.4.2-4. No surface water was available for sites MRSW-10 and MRSW-11 for sampling during these periods. The following summarizes the efforts to sample MRSW-10 and MRSW-11 through 2009:

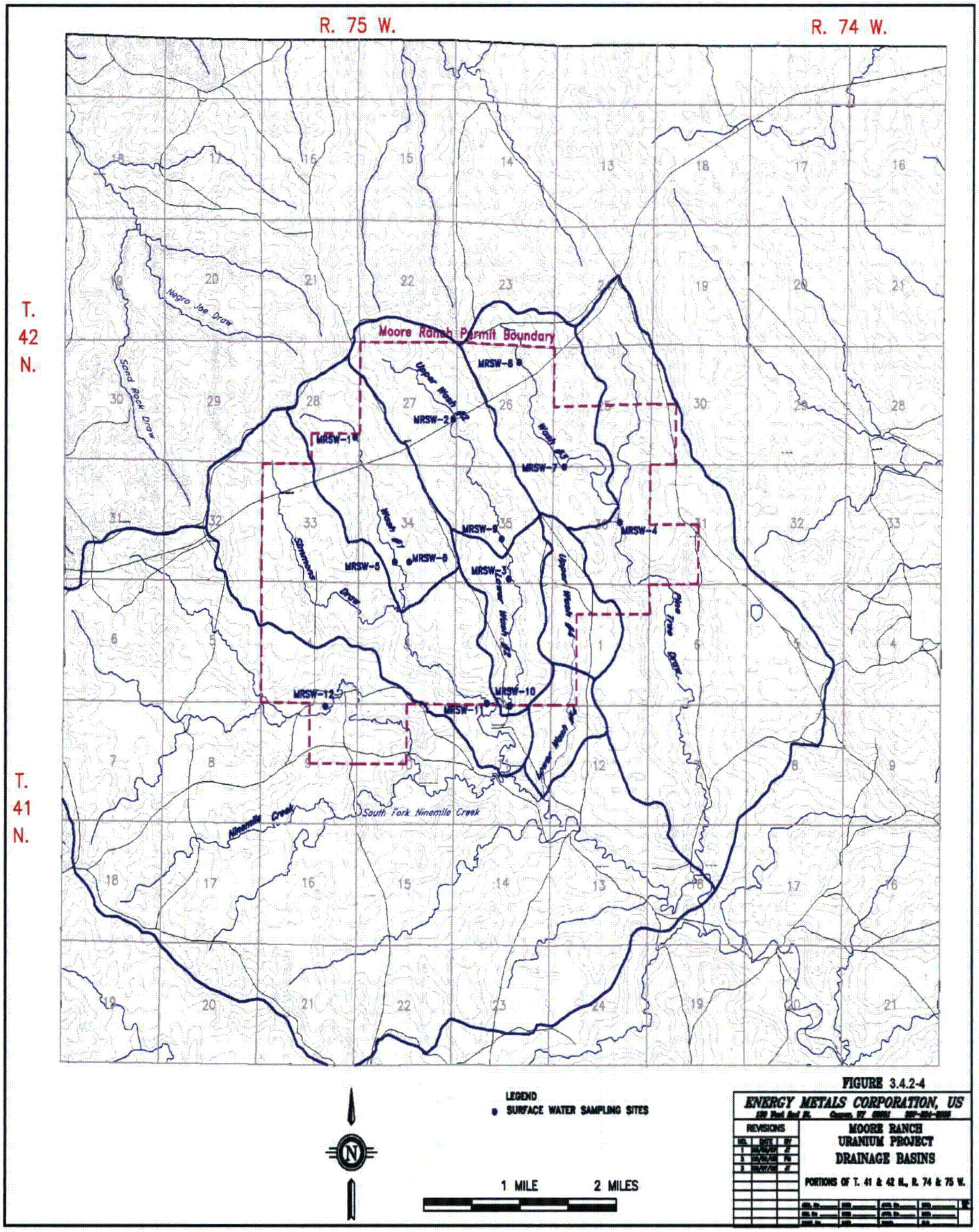
Date Site Visited	MRSW-10	MRSW-11
10/25/2006	Dry	Dry
3/23/2007	Dry	Dry
7/8/2008	Sample Collected	Dry
10/23/2008	Dry	Dry
2/9/2009	Dry	Sample Collected
3/11/2009	Dry	Sample Collected
4/22/2009	Dry	Sample Collected
7/23/2009	Dry	Sample Collected

Water quality data collected from theses surface water sites is summarized in Tables 3.4.2-5 through 3.4.2-15, overall average concentrations are shown in Table 3.4.2-15c, and seasonal averages are shown in Table 3.4.2-15b. Detection limit values were used for non-detectable results for calculation purposes. (Tables 3.4.2-5 through 3.4.2-15 are at the end of this section).

In general, surface water contained in the ponds at the sampling locations will exhibit typical saline characteristics of coal-bed methane surface discharge (higher values for conductivity, TDS, and bicarbonate) during summer and fall months. Sampling data shows that surface water quality changes during spring months when dilution occurs from snow melt or heavy precipitation events. Significantly higher values for bicarbonate, carbonate, chloride, conductivity, fluoride, TDS, gross alpha, gross beta, nitrogen, arsenic, potassium, magnesium, sodium, occurred during the fall sampling when the surface water contained was largely comprised of CBM discharge. Values for these parameters were typically the lowest during the samples taken in late March, which were taken soon after a large snowmelt event. Samples taken in June, while showing slightly higher concentrations than the March sampling, were also significantly lower than the fall sample due to the influence of spring runoff water contained in the ponds. Another round of surface water samples will be collected in the third quarter of 2007 (late summer) at locations with available water. It is anticipated that water quality from these samples will resemble results from the samples taken in the fall of 2006.

Average water quality during the fall sampling exceeded Wyoming Class I (domestic use) for TDS, pH, and iron, and just slightly exceeded Class II (agriculture use) and Class III (livestock use) for pH. Averages for the other sampling periods also exceeded all class of use standards for pH. Overall averages for all sample rounds combined also exceed all class of use standards for pH and the Class I standard for TDS. The data tables also show lead average values for the fall and overall averages above the Class I standard, however these values are inaccurately high due to the use of a detection limit of 0.05 mg/L for the fall of 2006 samples in the calculations. This detection limit in itself exceeds the Class I standard of 0.015 mg/L. Sample results for the next two sample rounds show much lower results below the Class I standard. Also, one value for Pb-210activity at MRSW-1 for the fall of 2006 shows and extremely high anomalous value of 170 pCi/L, and as a result, was believed to be lab error and excluded from the average calculations.

Figure 3.4.2-4


R. 75 W.
R. 74 W.
T. 42 N.
T. 41 N.
Moore Ranch Permit Boundary
Negro Joe Draw
Sand Rock Draw
Simmons Draw
Upper Wash #2
Wash #3
Wash #1
Lower Wash #2
Upper Wash #4
Lower Wash #4
Pine Tree Draw
Ninemile Creek
South Fork Ninemile Creek
MRSW-1
MRSW-2
MRSW-3
MRSW-4
MRSW-5
MRSW-6
MRSW-7
MRSW-8
MRSW-9
MRSW-10
MRSW-11
MRSW-12
LEGEND
SURFACE WATER SAMPLING SITES
N
1 MILE
2 MILES
FIGURE 3.4.2-4
ENERGY METALS CORPORATION, US
REVISIONS
NO.
DATE
BY
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URANIUM PROJECT
DRAINAGE BASINS
PORTIONS OF T. 41 & 42 N., R. 74 & 75 W.

Table 3.4.2-5

Table 3.4.2-5 Water Quality Data from MRSW-1

	MRSW-1										
Parameters	**11/3/2006**	**3/23/2007**	**6/15/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/27/2009**	**Average**
Bicarbonate as HCO3, mg/L	1140	814	391				187	269	290	514	515
Carbonate as CO3, mg/L	19	43	50				8	18	168	208	73
Chloride, mg/L	10	3	3				<1	<1	2	7	4
Conductivity, umhos/cm	1940	1260	714				308	434	914	1280	979
Fluoride, mg/L	0.5	0.7	0.4				0.1	0.2	0.4	0.6	0.4
pH, s.u.	8.48	9.06	9.44				8.64	8.76	9.88	9.74	9.14
Solids, Total Dissolved TDS @ 180 C, mg/L	1160	772	472			78	221	270	590	771	542
Solids, Total Suspended TSS @ 105 C, mg/l		19.3		9	4	46	5	20	11	16	16
Sulfate, mg/L	39	<1.0	2				3	3	<1	3	7
Turbidity, NTU				15.5	8.1	22.3	9.2	23.5	17.5	14.1	15.7
Gross Alpha, pci/L (dissolved)	6.8	1					**<1.6**	4.5	**<4.3**	**<5.4**	3.9
Gross Beta, pci/L (dissolved)	21.8	10.3					4.2	4.9	8.7	12.2	10.4
Lead 210, pci/L (dissolved)	170*	**<1.0**	**<1.0**				**<2.8**	**<3.1**	**<2.2**	**<1.4**	<1.9
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<0.7**	**<0.8**	**<0.8**	**<0.6**	<0.84
Radium 226, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.12**	**<0.13**	0.32	**<0.22**	<0.20
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<1.5**	**<1.3**	**<1**	**<2.2**	<1.3
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.5**	**<0.6**	**<0.4**	**<0.2**	<0.4
Nitrogen, Ammonia as N, mg/L	0.15	0.08	0.12				<0.05	<0.05	<0.05	0.07	0.08
Nitrogen, Nitrate+Nitrite as N, mg/L	0.8	<0.1	<0.1				<0.05	<0.05	0.02	<0.1	<0.17
Aluminum, mg/L (dissolved)		<0.1	1.1				<0.1	0.4	0.4	<0.1	0.31
Arsenic, mg/L (dissolved)	0.002	0.002	0.006				0.002	0.002	0.008	0.006	0.004
Barium, mg/L (dissolved)	0.5	0.5	<0.1				0.2	0.3	0.1	0.2	0.3
Boron, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005				<0.005	<0.005	<0.005	<0.005	<0.005
Calcium, mg/L	43	13	7				12	18	9	10	16
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05
Copper, mg/L (dissolved)	<0.01	<0.01	<0.01				0.01	<0.01	<0.01	<0.01	<0.01
Iron, mg/L (dissolved)	0.07	0.07	0.6				0.05	0.26	0.22	0.08	0.19
Lead, mg/L (dissolved)	<0.05	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.05
Magnesium, mg/L	56	35	14				9	13	23	33	26
Manganese, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05
Potassium, mg/L	17	11	7				7	5	11	12	10
Selenium, mg/L (dissolved)	<0.001	<0.001	<0.002				<0.001	<0.001	<0.001	<0.001	<0.001
Silica, mg/L	4.7	2.3	8.4				4.3	5.2	6.5	0.5	4.6
Sodium, mg/L	355	243	133				43	68	186	273	186
Uranium, mg/L (dissolved)	0.0052	0.0007	0.0006				0.0003	<0.0003	0.0004	0.0008	0.0012
Vanadium, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	0.03	<0.01	<0.01	<0.01
Iron, TOTAL mg/L	0.26	0.38	1.31				0.36	1.62	0.96	0.54	0.78
Manganese, TOTAL mg/L	<0.01	0.02	0.04				<0.01	0.03	0.03	<0.01	0.02
Lead 210, suspended pci/L	**<2.0**	**<1.0**	**<1.0**				**<3.9**	**<5.7**	**<3.8**	**<0.9**	<2.6
Polonium 210 suspended, pci/L	**<2.0**	**<1.0**	**<1.0**				**<0.5**	**<0.4**	**<0.5**	**<0.3**	<0.9
Radium 226 suspended, pci/L	**<0.4**	**<0.2**	**<0.2**				**<0.3**	0.2	**<0.09**	**<0.1**	<0.2
Thorium 230 suspended, pci/L	**<0.4**	**<0.2**	**<0.2**				**<0.3**	**<0.3**	**<0.05**	0.05	<0.2
Uranium suspended, pci/L	**<0.0003**	**<0.0003**	**<0.0003**				**<0.0003**	**0.0004**	**<0.0003**	0.0036	<0.0003

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

* Anomalous value considered analytical error.

Sampled Feature Type: Stock Pond

Surface Water State Permit # P12608

Table 3.4.2-6

Table 3.4.2-6 Water Quality Data from MRSW-2

	MRSW-2										
Parameters	**10/25/2006**	**3/23/2007**	**6/15/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/27/2009**	**Average**
Bicarbonate as HCO3, mg/L	1010	748	532				283	180	107	78	420
Carbonate as CO3, mg/L	52	22	33				6	6	68	86	39
Chloride, mg/L	9	3	2				2	<1	1	2	3
Conductivity, umhos/cm	1520	1120	870				448	274	401	439	725
Fluoride, mg/L	0.7	0.6	0.4				0.2	0.1	0.2	0.2	0.3
pH, s.u.	8.96	8.8	9.13				8.61	8.59	10	10.6	9.24
Solids, Total Dissolved TDS @ 180 C, mg/L	996	672	520			119	308	167	279	274	417
Solids, Total Suspended TSS @ 105 C, mg/L		20		8	24	14	5	8	57	36	22
Sulfate, mg/L	1	<1.0	10				3	1	5	12	5
Turbidity, NTU				10.1	14.3	6.7	5.1	4.9	29.7	43.3	16.3
Gross Alpha, pci/L (dissolved)	3	1.5					<2.0	4.4	<2.2	<2.0	2.6
Gross Beta, pci/L (dissolved)	14	9.7					6.6	4.9	6.1	4.5	7.6
Lead 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<2.8**	**<3.1**	**<2.2**	**<1.4**	<1.8
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<0.8**	**<0.5**	**<0.4**	**<1.3**	<1.0
Radium 226, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.12**	**<0.12**	0.28	**<0.16**	<0.2
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<1.7**	**<1.2**	**<1.1**	**<1.4**	<1.2
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.2**	**<0.3**	**<0.3**	**<0.2**	<0.2
Nitrogen, Ammonia as N, mg/L	0.17	<0.05	<0.05				<0.05	<0.05	0.06	<0.05	<0.07
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1	<0.1	<0.1				<0.05	<0.05	0.02	<0.1	<0.07
Aluminum, mg/L (dissolved)		<0.1	0.1				<0.1	<0.1	0.4	1.3	0.35
Arsenic, mg/L (dissolved)	0.002	0.002	0.003				0.003	<0.001	0.006	0.008	0.004
Barium, mg/L (dissolved)	0.8	0.5	0.1				0.2	0.2	<0.1	<0.1	0.3
Boron, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005				<0.005	<0.005	<0.005	<0.005	<0.005
Calcium, mg/L	18	22	11				15	15	9	8	14
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05
Copper, mg/L (dissolved)	<0.01	0.05	<0.01				0.01	<0.01	<0.01	<0.01	<0.02
Iron, mg/L (dissolved)	0.07	0.15	0.11				0.08	0.06	0.29	0.76	0.22
Lead, mg/L (dissolved)	<0.05	0.007	<0.01				0.003	<0.001	<0.001	0.001	<0.012
Magnesium, mg/L	43	28	20				10	7	7	6	17
Manganese, mg/L (dissolved)	0.01	0.02	<0.01				<0.01	<0.01	<0.01	0.02	<0.02
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05
Potassium, mg/L	14	10	7				9	4	7	6	8
Selenium, mg/L (dissolved)	<0.001	<0.001	<0.002				<0.001	<0.001	<0.001	<0.001	<0.001
Silica, mg/L	3.8	3	0.9				5.9	5.7	7.5	4.8	4.5
Sodium, mg/L	349	208	157				75	47	67	75	140
Uranium, mg/L (dissolved)	0.0003	0.0005	0.0006				<0.0003	<0.0003	0.0004	0.0005	0.0005
Vanadium, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/L (dissolved)	<0.01	0.02	0.02				<0.01	0.02	<0.01	<0.01	0.02
Iron, TOTAL mg/L	0.07	0.04	0.36				0.2	0.21	2.4	1.63	0.70
Manganese, TOTAL mg/L	<0.01	<0.01	0.02				0.01	<0.01	0.04	0.03	0.02
Lead 210, suspended pci/L	**<1.0**	**<1.0**	**<1.0**				**<4.1**	5.8	**<4.0**	**<0.9**	<2.6
Polonium 210 suspended, pci/L	**<1.0**	**<1.0**	**<1.0**				**<0.5**	**<0.5**	0.3	1.8	<1.0
Radium 226 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.4**	**<0.2**	**<0.1**	**<0.1**	<0.2
Thorium 230 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.3**	**<0.2**	**<0.05**	0.05	<0.2
Uranium suspended, pci/L	**<0.0003**	**<0.0003**	**<0.0003**				0.0006	**<0.0003**	**<0.0003**	0.0006	<0.0004

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Stock Pond

Surface Water State Permit # P14037S

Table 3.4.2-7

Table 3.4.2-7 Water Quality Data from MRSW-3

	MRSW-3										
Parameters	**10/25/2006**	**3/22/2007**	**6/13/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/22/2009**	**Average**
Bicarbonate as HCO3, mg/L	358	92	33				69	71	15	DRY	125
Carbonate as CO3, mg/L	8	9	4				<1	<1	11		5
Chloride, mg/L	11	2	<1.0				<1	<1	5		3
Conductivity, umhos/cm	928	544	609				168	125	1260		475
Fluoride, mg/L	0.9	0.2	0.4				<0.1	<0.1	0.2		0.3
pH, s.u.	8.6	9.25	9.45				7.82	7.99	10.5		8.62
Solids, Total Dissolved TDS @ 180 C, mg/L	560	364	414			96	161	95	924		373
Solids, Total Suspended TSS @ 105 C, mg/L		5.5		5	118	10	<1	<4	8		22
Sulfate, mg/L	214	189	254				20	14	562		138
Turbidity, NTU		(Deleted)		4.2	16.2	8.2	3	5.6	6.8		7.3
Gross Alpha, pci/L (dissolved)	12.7	7.9					2.1	3.9	4.8		6.3
Gross Beta, pci/L (dissolved)	13.5	9.7					3.6	5.6	7.8		8.1
Lead 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<2.8**	**<3.1**	**<2.2**		<1.9
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<0.6**	**<0.5**	**<0.7**		<1.0
Radium 226, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.12**	**<0.11**	0.47		<0.2
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**	1.9				**<1.4**	**<1.1**	**<1.3**		<1.1
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.3**	**<0.4**	**<0.5**		<0.3
Nitrogen, Ammonia as N, mg/L	0.09	0.06	0.09				<0.05	<0.05	<0.05		0.07
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1	<0.1	<0.1				<0.05	<0.05	<0.01		<0.1
Aluminum, mg/L (dissolved)		<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Arsenic, mg/L (dissolved)	0.002	0.002	0.003				<0.001	<0.001	0.003		0.002
Barium, mg/L (dissolved)	0.1	<0.1	<0.1				<0.1	<0.1	0.1		<0.1
Boron, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005				<0.005	<0.005	<0.005		<0.005
Calcium, mg/L	42	60	48				18	124	111		58
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05		<0.05
Copper, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01		<0.01
Iron, mg/L (dissolved)	0.16	<0.03	0.05				0.07	0.1	<0.03		0.08
Lead, mg/L (dissolved)	<0.05	<0.001	<0.001				<0.001	<0.001	<0.001		<0.05
Magnesium, mg/L	18	13	18				4	34	20		17
Manganese, mg/L (dissolved)	<0.01	<0.01	<0.01				0.01	<0.01	<0.01		<0.01
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	DRY	<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05		<0.05
Potassium, mg/L	8	8	4				8	4	10		6
Selenium, mg/L (dissolved)	<0.001	0.001	<0.001				<0.001	<0.001	<0.001		<0.001
Silica, mg/L	2.9	8.3	3.2				3.2	4.2	0.2		4.4
Sodium, mg/L	173	32	46				7	17	113		55
Uranium, mg/L (dissolved)	0.013	0.0119	0.0043				0.0014	0.0013	0.0028		0.0064
Vanadium, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Zinc, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01		<0.01
Iron, TOTAL mg/L	0.33	0.1	0.12				0.11	0.3	0.39		0.23
Manganese, TOTAL mg/L	0.01	0.03	0.01				0.03	<0.01	0.04		0.02
Lead 210, suspended pci/L	**<1.0**	**<1.0**	**<1.0**				**<4.0**	6	**<3.9**		<2.8
Polonium 210 suspended, pci/L	**<1.0**	**<1.0**	**<1.0**				**<0.4**	**<0.5**	**<0.3**		<0.7
Radium 226 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.4**	0.2	**<0.1**		<0.2
Thorium 230 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.3**	**<0.1**	**<0.04**		<0.2
Uranium suspended, pci/L	**<0.0003**	**<0.0003**	**<0.0003**				**<0.0003**	**<0.0003**	0.0006		<0.0004

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Stock Pond

Surface Water State Permit # P14038S

Table 3.4.2-8

Table 3.4.2-8 Water Quality Data from MRSW-4

	MRSW-4										
Parameters	**10/25/2006**	**3/22/2007**	**6/13/2007**	**7/8/2008**	**10/23/2008**	**2/9/2008**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/26/2009**	**Average**
Bicarbonate as HCO3, mg/L	363	156	77				119	238	124	269	192
Carbonate as CO3, mg/L	24	23	15				<1	<1	67	47	25
Chloride, mg/L	23	7	2				2	6	8	13	9
Conductivity, umhos/cm	1500	792	968				324	700	811	1050	878
Fluoride, mg/L	0.6	0.5	0.4				0.1	0.1	0.2	0.3	0.3
pH, s.u.	9.06	9.41	9.63				8	8.22	9.82	9.18	9.05
Solids, Total Dissolved TDS @ 180 C, mg/L	984	504	644			170	277	447	840	681	568
Solids, Total Suspended TSS @ 105 C, mg/l		17		6	5	10	2	7	16	<4	8
Sulfate, mg/L	461	230	360				72	175	175	242	245
Turbidity, NTU				2.5	6.9	9.6	4.5	3.2	3.7	7.3	5.4
Gross Alpha, pci/L (dissolved)	5.6	2.5					1.9	7	<3.3	4.2	4.1
Gross Beta, pci/L (dissolved)	11.9	7.6					6.6	7.6	7.6	12.2	8.9
Lead 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<2.8**	**<3.1**	**<2.2**	**<1.4**	<1.8
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				4.6	**<0.7**	**<0.7**	**<1.1**	<1.5
Radium 226, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.13**	**<0.11**	0.22	0.5	<0.3
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<1.6**	**<1.1**	**<1.1**	**<1.4**	<1.2
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.3**	**<0.3**	**<0.3**	**<0.2**	<0.3
Nitrogen, Ammonia as N, mg/L	0.52	0.2	0.09				<0.05	<0.05	<0.05	<0.05	0.14
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1	<0.1	<0.1				<0.05	<0.05	0.02	<0.1	<0.08
Aluminum, mg/L (dissolved)		<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, mg/L (dissolved)	0.006	0.006	0.005				0.003	0.002	0.007	0.004	0.005
Barium, mg/L (dissolved)	0.2	<0.1	<0.1				<0.1	0.1	<0.1	<0.1	<0.1
Boron, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005				<0.005	<0.005	<0.005	<0.005	<0.005
Calcium, mg/L	24	26	27				24	56	18	26	29
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05
Copper, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	0.34	<0.01	<0.01	<0.06
Iron, mg/L (dissolved)	0.32	<0.03	<0.03				0.19	0.06	0.04	<0.03	0.10
Lead, mg/L (dissolved)	<0.05	<0.001	<0.001				<0.001	0.075	<0.001	<0.001	<0.019
Magnesium, mg/L	25	18	24				9	22	29	37	23
Manganese, mg/L (dissolved)	0.02	0.02	0.02				0.08	<0.01	0.04	<0.01	0.03
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05
Potassium, mg/L	10	8	7				10	8	12	14	10
Selenium, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001
Silica, mg/L	3.8	12.8	3.7				7.9	14.4	0.5	0.6	6.2
Sodium, mg/L	320	114	133				31	62	114	151	132
Uranium, mg/L (dissolved)	0.0069	0.0034	0.0028				0.0016	0.0036	0.0024	0.0041	0.0035
Vanadium, mg/L(dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/L (dissolved)	<0.01	<0.01	<0.01				0.02	1.72	<0.01	<0.01	<0.30
Iron, TOTAL mg/L	0.4	0.07	0.11				0.31	0.28	0.11	0.32	0.26
Manganese, TOTAL mg/L	0.02	0.12	0.05				0.15	0.07	0.1	0.03	0.08
Lead 210, suspended pci/L	**<1.0**	**<1.0**	**<1.0**				**<4.2**	7.1	**<3.8**	**<0.9**	<2.8
Polonium 210 suspended, pci/L	**<1.0**	**<1.0**	**<1.0**				**<0.5**	**<0.5**	**<0.3**	**<0.3**	<0.7
Radium 226 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.3**	**<0.2**	**<0.1**	**<0.1**	<0.2
Thorium 230 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.3**	**<0.2**	**<0.05**	0.1	<0.2
Uranium suspended, pci/L	**<0.0003**	**<0.0003**	**<0.0003**				0.0004	**<0.0003**	**<0.0003**	0.0038	<0.0008

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Stock Pond

Surface Water State Permit # P14039S

Table 3.4.2-9

Table 3.4.2-9 Water Quality Data from MRSW-5

	MRSW-5										
Parameters	**11/3/2006**	**3/22/2007**	**6/15/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/27/2009**	**Average**
Bicarbonate as HCO3, mg/L	1410	924	858	DRY	DRY		240	233	DRY	DRY	733
Carbonate as CO3, mg/L	155	24	11				<1	12			41
Chloride, mg/L	6	7	10				<1	4			6
Conductivity, umhos/cm	2560	1450	1520				397	638			1313
Fluoride, mg/L	1.2	0.5	0.4				0.2	0.2			0.5
pH, s.u.	9.29	8.66	8.46				8.35	8.51			8.65
Solids, Total Dissolved TDS @ 180 C, mg/L	1590	890	998			172	270	384			717
Solids, Total Suspended TSS @ 105 C, mg/l		9.5				10	88	68			44
Sulfate, mg/L	9	20	157				5	134			65
Turbidity, NTU						7.4	41.4	51.9			34
Gross Alpha, pci/L (dissolved)	11	2.4					<1.8	7.8			5.6
Gross Beta, pci/L (dissolved)	32.7	11					4	4.1			13
Lead 210, pci/L (dissolved)	9.9	**<1.0**	**<1.0**				**<2.8**	**<3.1**			<3.6
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<0.4**	**<0.7**			<1.0
Radium 226, pci/L (dissolved)	**<0.2**	1.5	2.3				**<0.12**	0.15			0.85
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<1.9**	**<1.2**			<1.2
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.8**	**<0.2**			<0.3
Nitrogen, Ammonia as N, mg/L	0.27	0.15	0.19				<0.05	<0.05			0.14
Nitrogen, Nitrate+Nitrite as N, mg/L	0.9	<0.1	<0.1				<0.05	<0.05			<0.24
Aluminum, mg/L (dissolved)		<0.1	<0.1				<0.1	<0.1			<0.1
Arsenic, mg/L (dissolved)	0.008	0.003	0.004				0.004	0.002			0.004
Barium, mg/L (dissolved)	0.5	0.5	0.3				0.2	0.4			0.4
Boron, mg/L (dissolved)	0.1	<0.1	<0.1				<0.1	<0.1			<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005				<0.005	<0.005			<0.005
Calcium, mg/L	9	45	41				26	50			32
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05			<0.05
Copper, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	0.05			<0.01
Iron, mg/L (dissolved)	0.92	0.05	0.08				0.06	0.09			0.24
Lead, mg/L (dissolved)	<0.05	<0.001	<0.001				<0.001	0.007			<0.05
Magnesium, mg/L	73	39	50				10	26			40
Manganese, mg/L (dissolved)	0.02	<0.01	0.03				0.14	<0.01			0.04
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001			<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1			<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05			<0.05
Potassium, mg/L	22	12	13	DRY	DRY		7	5	DRY	DRY	12
Selenium, mg/L (dissolved)	<0.001	<0.001	0.004				<0.001	<0.001			<0.002
Silica, mg/L	9.3	5.2	8.1				13	7			8.5
Sodium, mg/L	559	255	230				41	55			228
Uranium, mg/L (dissolved)	0.001	0.0029	0.0027				0.0031	0.0026			0.0025
Vanadium, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1			<0.1
Zinc, mg/L (dissolved)	<0.01	<0.01	0.01				0.01	0.12			0.03
Iron, TOTAL mg/L	1.11	0.11	0.12				1.65	2.72			1.14
Manganese, TOTAL mg/L	0.05	0.01	0.06				0.33	0.14			0.12
Lead 210, suspended pci/L	**<2.0**	**<1.0**	**<1.0**				**<4.8**	**<5.0**			<2.6
Polonium 210 suspended, pci/L	**<2.0**	**<1.0**	**<1.0**				1.5	0.5			1.2
Radium 226 suspended, pci/L	**<0.4**	**<0.2**	**<0.2**				**<0.4**	**0.3**			<0.3
Thorium 230 suspended, pci/L	**<0.4**	**<0.2**	**<0.2**				**<0.3**	**<0.2**			<0.3
Uranium suspended, pci/L	**<0.0003**	**<0.0003**	**<0.0003**				**<0.0003**	**<0.0003**			<0.0003

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Ponding in Drainage Area

Surface Water State Permit # N/A

Table 3.4.2-10

Table 3.4.2-10 Water Quality Data from MRSW-6

	MRSW-6									
Parameters	**3/22/2007**	**6/15/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/23/2009**	**10/26/2009**	**Average**
Bicarbonate as HCO3, mg/L	351	563		DRY		804	635	752	DRY	621
Carbonate as CO3, mg/L	7	114				12	35	240		82
Chloride, mg/L	2	3				4	4	8		4
Conductivity, umhos/cm	538	1140				1240	1020	1850		1158
Fluoride, mg/L	0.3	0.7				0.4	0.4	0.6		0.5
pH, s.u.	8.52	9.64				8.57	8.65	9.54		8.98
Solids, Total Dissolved TDS @ 180 C, mg/L	326	754			78	740	591	1250		623
Solids, Total Suspended TSS @ 105 C, mg/L	46		6		10	14	10	128		36
Sulfate, mg/L	10	2				2	1	49		13
Turbidity, NTU			4.2		5.9	6.8	2.4	127		29.3
Gross Alpha, pci/L (dissolved)	1.1					<4.2	9.8	<8.6		5.9
Gross Beta, pci/L (dissolved)	6.9					7.1	5.1	14.3		8.4
Lead 210, pci/L (dissolved)	**<1.0**	**<1.0**				**<5.6**	**<3.1**	**<2.3**		<2.6
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**				**<0.7**	**<0.7**	0.6		<0.8
Radium 226, pci/L (dissolved)	**<0.2**	1.5				0.14	0.16	**<0.18**		0.43
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**				**<2.0**	**<1.2**	**<1.1**		<1.3
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**				**<0.8**	**<0.2**	**<0.6**		<0.4
Nitrogen, Ammonia as N, mg/L	0.13	0.15				<0.05	<0.05	<0.05		0.09
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1	<0.1				<0.05	<0.05	0.02		<0.1
Aluminum, mg/L (dissolved)	0.4	1				<0.1	<0.1	0.3		0.4
Arsenic, mg/L (dissolved)	0.002	0.006				0.002	0.002	0.003		0.003
Barium, mg/L (dissolved)	0.4	0.2				1.2	0.6	0.3		0.54
Boron, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005				<0.005	<0.005	<0.005		<0.005
Calcium, mg/L	26	9				55	29	15		31
Chromium, mg/L (dissolved)	<0.05	<0.05				<0.05	<0.05	<0.05		<0.05
Copper, mg/L (dissolved)	<0.01	<0.01				<0.01	<0.01	<0.01		<0.01
Iron, mg/L (dissolved)	0.21	0.44				<0.03	<0.03	0.14		0.17
Lead, mg/L (dissolved)	<0.001	0.001				<0.001	<0.001	<0.001		<0.001
Magnesium, mg/L	10	15				26	22	46		24
Manganese, mg/L (dissolved)	<0.01	0.02				<0.01	<0.01	<0.01		<0.02
Mercury, mg/L (dissolved)	<0.001	<0.001				<0.001	<0.001	<0.001	DRY	<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05				<0.05	<0.05	<0.05		<0.05
Potassium, mg/L	7	6		DRY		11	8	17		10
Selenium, mg/L (dissolved)	<0.001	<0.002				<0.001	<0.001	<0.001		<0.002
Silica, mg/L	9.5	5.6				17.7	18.4	10.4		12.3
Sodium, mg/L	77	232				198	167	436		222
Uranium, mg/L (dissolved)	<0.0003	0.0003				0.0005	<0.0003	<0.0003		0.0003
Vanadium, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Zinc, mg/L (dissolved)	<0.01	0.01				<0.01	0.06	<0.01		0.02
Iron, TOTAL mg/L	0.51	0.72				0.19	0.21	3.9		1.11
Manganese, TOTAL mg/L	0.02	0.04				<0.01	0.01	0.05		0.03
Lead 210, suspended pci/L	**<1.0**	**<1.0**				**<4.1**	**<3.9**	**<3.6**		<2.7
Polonium 210 suspended, pci/L	**<1.0**	**<1.0**				**<0.4**	**<0.2**	0.7		<1.0
Radium 226 suspended, pci/L	**<0.2**	0.4				**<0.3**	**<0.2**	0.2		0.3
Thorium 230 suspended, pci/L	**<0.2**	**<0.2**				**<0.3**	**<0.2**	0.08		<0.2
Uranium suspended, pci/L	**<0.0003**	**<0.0003**				0.0005	**<0.0003**	**<0.0003**		0.0003

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Water present at 10/25/06 sampling event however to muddy to get access to pond to collect sample.

Sampled Feature Type: Ponding in Drainage Area

Surface Water State Permit # N/A

Table 3.4.2-11

Table 3.4.2-11 Water Quality Data from MRSW-7

	MRSW-7										
Parameters	**10/25/2006**	**3/23/2007**	**6/13/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/23/2009**	**10/22/2009**	**Average**
Bicarbonate as HCO3, mg/L	809	DRY	520				DRY	DRY	DRY	DRY	665
Carbonate as CO3, mg/L	12		22								17
Chloride, mg/L	9		2								6
Conductivity, umhos/cm	1120		837								979
Fluoride, mg/L	0.5		0.5								0.5
pH, s.u.	8.42		8.96								8.69
Solids, Total Dissolved TDS @ 180 C, mg/L	706		586			508					600
Solids, Total Suspended TSS @ 105 C, mg/L				13	7	42					21
Sulfate, mg/L	23		3								13
Turbidity, NTU				2.3	1.6	7.6					3.8
Gross Alpha, pci/L (dissolved)	5.4										5.4
Gross Beta, pci/L (dissolved)	13.1										13.1
Lead 210, pci/L (dissolved)	**<1.0**		**<1.0**								<1.0
Polonium 210, pci/L (dissolved)	**<1.0**		**<1.0**								<1.0
Radium 226, pci/L (dissolved)	**<0.2**		**<0.2**								<0.2
Radium 228, pci/L (dissolved)	**<1.0**		**<1.0**								<1.0
Thorium 230, pci/L (dissolved)	**<0.2**		**<0.2**								<0.2
Nitrogen, Ammonia as N, mg/L	0.1		0.08								0.09
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1		<0.1								<0.1
Aluminum, mg/L (dissolved)			0.5								0.5
Arsenic, mg/L (dissolved)	0.003		0.004								0.004
Barium, mg/L (dissolved)	0.5		0.3								0.4
Boron, mg/L (dissolved)	<0.1		<0.1								<0.1
Cadmium, mg/L (dissolved)	<0.005		<0.005								<0.005
Calcium, mg/L	27		15								21
Chromium, mg/L (dissolved)	<0.05		<0.05								<0.05
Copper, mg/L (dissolved)	<0.01		<0.01								<0.01
Iron, mg/L (dissolved)	0.7		0.59								0.65
Lead, mg/L (dissolved)	<0.05		<0.001								<0.001
Magnesium, mg/L	18		10								14
Manganese, mg/L (dissolved)	0.02		0.01								0.02
Mercury, mg/L (dissolved)	<0.001		<0.001								<0.001
Molybdenum, mg/L (dissolved)	<0.1		<0.1								<0.1
Nickel, mg/L (dissolved)	<0.05		<0.05								<0.05
Selenium, mg/L (dissolved)	<0.001	DRY	<0.001				DRY	DRY	DRY	DRY	<0.001
Potassium, mg/L	10		7								9
Silica, mg/L	8.4		7.5								8
Sodium, mg/L	263		173								218
Uranium, mg/L (dissolved)	0.0006		0.0004								0.0005
Vanadium, mg/L (dissolved)	<0.1		<0.1								<0.1
Zinc, mg/L (dissolved)	<0.01		<0.01								<0.01
Iron, TOTAL mg/L	0.64		0.73								0.69
Manganese, TOTAL mg/L	<0.01		0.04								0.03
Lead 210, suspended pci/L	**<1.0**		**<1.0**								<1.0
Polonium 210 suspended, pci/L	**<1.0**		**<1.0**								<1.0
Radium 226 suspended, pci/L	**<0.2**		**<0.2**								<0.2
Thorium 230 suspended, pci/L	**<0.2**		**<0.2**								<0.2
Uranium suspended, pci/L	0.0007		**<0.0003**								<0.0003

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Drainage Area

Surface Water State Permit # N/A

Table 3.4.2-12

Table 3.4.2-12 Water Quality Data from MRSW-8

	MRSW-8										
Parameters	**10/25/2006**	**3/23/2007**	**6/13/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/27/2009**	**Average**
Bicarbonate as HCO3, mg/L	420	458	327		DRY		458	327	225	DRY	369
Carbonate as CO3, mg/L	1670	44	26				7	21	170		323
Chloride, mg/L	21	2	<1.0				<1	<1	2		5
Conductivity, umhos/cm	3220	796	569				710	611	918		1137
Fluoride, mg/L	2.2	0.6	0.4				0.4	0.3	0.6		0.8
pH, s.u.	9.65	9.32	9.23				8.59	8.68	10.1		9.26
Solids, Total Dissolved TDS @ 180 C, mg/L	2190	508	354			266	493	345	1040		853
Solids, Total Suspended TSS @ 105 C, mg/L		24		84		34	12	53	259		78
Sulfate, mg/L	10	<1.0	14				4	16	18		11
Turbidity, NTU				155		13.7	12.6	35.9	540		151.4
Gross Alpha, pci/L (dissolved)	4.3	2.4					<3.0	5.1	21.7		7.3
Gross Beta, pci/L (dissolved)	20.9	10.1					7.2	5.1	21.5		13
Lead 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<2.8**	**<4.1**	**<2.2**		<2.1
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<0.6**	**<0.7**	**<1.1**		<1.0
Radium 226, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				0.12	0.11	1.4		0.36
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**	**<1.0**				**<1.5**	**<1**	**<1.2**		<1.0
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.2**				**<0.2**	**<0.2**	0.7		<0.3
Nitrogen, Ammonia as N, mg/L	0.86	0.09	<0.05				0.13	<0.05	<0.05		0.21
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1	<0.1	<0.1				0.08	<0.05	0.03		<0.08
Aluminum, mg/L (dissolved)		0.1	0.2				<0.1	<0.1	0.6		0.2
Arsenic, mg/L (dissolved)	0.025	0.005	0.004				0.003	0.002	0.019		0.01
Barium, mg/L (dissolved)	0.6	0.1	0.1				0.2	0.1	<0.1		0.2
Boron, mg/L (dissolved)	0.1	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005				<0.005	<0.005	<0.005		<0.005
Calcium, mg/L	6	13	11				20	17	9		13
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05		<0.05
Copper, mg/L (dissolved)	<0.01	<0.01	<0.01				<0.01	<0.01	0.01		<0.01
Iron, mg/L (dissolved)	0.48	0.09	0.39				0.08	0.09	0.78		0.32
Lead, mg/L (dissolved)	<0.05	<0.001	<0.001				<0.001	0.001	0.002		<0.009
Magnesium, mg/L	53	15	11				12	9	9		18
Manganese, mg/L (dissolved)	0.02	<0.01	<0.01				<0.01	<0.01	0.02		<0.02
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001		<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05		<0.05
Potassium, mg/L	19	10	7				9	7	9	DRY	10
Selenium, mg/L (dissolved)	0.002	0.001	0.001		DRY		<0.001	<0.001	<0.001		0.001
Silica, mg/L	6.1	7.1	3.7				7.8	5.5	7.5		6.3
Sodium, mg/L	842	158	106				121	97	198		254
Uranium, mg/L (dissolved)	0.004	0.0009	0.001				0.0006	<0.0003	0.0014		0.0014
Vanadium, mg/L (dissolved)	<0.1	<0.1	<0.1				<0.1	<0.1	<0.1		<0.1
Zinc, mg/L (dissolved)	<0.01	<0.01	<0.01				0.11	0.05	0.01		0.03
Iron, TOTAL mg/L	0.2	0.86	0.63				0.58	1.69	24.1		4.68
Manganese, TOTAL mg/L	<0.01	0.01	0.02				0.02	0.02	0.27		0.09
Lead 210, suspended pci/L	6.3	**<1.0**	**<1.0**				**<6.1**	**<3.9**	**<4.3**		<3.8
Polonium 210 suspended, pci/L	**<1.0**	**<1.0**	**<1.0**				**<0.9**	**<0.3**	0.8		<1.0
Radium 226 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.5**	**<0.1**	0.5		<0.3
Thorium 230 suspended, pci/L	**<0.2**	**<0.2**	**<0.2**				**<0.4**	**<0.2**	0.3		<0.3
Uranium suspended, pci/L	0.0004	**<0.0003**	**<0.0003**				0.0004	<0.0003	0.0004		0.0004

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Stock Pond

Surface Water State Permit # P14043S

Table 3.4.2-13

Table 3.4.2-13 Water Quality Data from MRSW-9

	MRSW-9									
Parameters	**3/22/2007**	**6/13/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/22/2009**	**Average**
Bicarbonate as HCO3, mg/L	131	67		DRY		45	71	DRY	DRY	79
Carbonate as CO3, mg/L	15	12				<1	<1			7
Chloride, mg/L	<1.0	<1.0				<1	<1			<1
Conductivity, umhos/cm	259	148				75	96			145
Fluoride, mg/L	0.2	0.2				<0.1	<0.1			0.2
pH, s.u.	9.32	9.16				7.39	8.94			9
Solids, Total Dissolved TDS @ 180 C, mg/L	148	96			88	74	64			94
Solids, Total Suspended TSS @ 105 C, mg/L	8		67		12	2	<4			19
Sulfate, mg/L	2	5				3	5			4
Turbidity, NTU			99.4		7.5	4.6	6			29.4
Gross Alpha, pci/L (dissolved)	1.7					**<1.2**	3.7			2.2
Gross Beta, pci/L (dissolved)	3.9					**<2.7**	2.8			3.1
Lead 210, pci/L (dissolved)	8.6	**<1.0**				**<2.8**	**<3.1**			3.9
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**				**<0.7**	**<0.6**			<1.0
Radium 226, pci/L (dissolved)	**<0.2**	**<0.2**				**<0.13**	**<0.17**			<0.2
Radium 228, pci/L (dissolved)	**<1.0**	**<1.0**				**<1.7**	**<1.3**			<1.3
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**				**<0.4**	**<0.3**			<0.3
Nitrogen, Ammonia as N, mg/L	0.05	<0.05				<0.05	<0.05			<0.05
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.1	<0.1				<0.05	<0.05			<0.1
Aluminum, mg/L (dissolved)	<0.1	0.3				<0.1	<0.1			<0.2
Arsenic, mg/L (dissolved)	0.002	0.002				0.001	0.001			0.002
Barium, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1			<0.1
Boron, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1			<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005				<0.005	<0.005			<0.005
Calcium, mg/L	13	15				6	12			12
Chromium, mg/L (dissolved)	<0.05	<0.05				<0.05	<0.05			<0.05
Copper, mg/L (dissolved)	<0.01	<0.01				<0.01	<0.01			<0.01
Iron, mg/L (dissolved)	0.03	0.19				<0.03	0.03			0.07
Lead, mg/L (dissolved)	<0.001	<0.001				<0.001	<0.001			<0.001
Magnesium, mg/L	5	4				2	3			4
Manganese, mg/L (dissolved)	<0.01	<0.01				<0.01	<0.01			<0.01
Mercury, mg/L (dissolved)	<0.001	<0.001				<0.001	<0.001			<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1			<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05				<0.05	<0.05			<0.05
Potassium, mg/L	6	3		DRY		5	3	DRY	DRY	4
Selenium, mg/L (dissolved)	<0.001	<0.001				<0.001	<0.001			<0.001
Silica, mg/L	6.9	3.4				3.3	4.4			4.5
Sodium, mg/L	36	8				4	8			14
Uranium, mg/L (dissolved)	0.0016	0.0018				<0.0003	0.0006			0.0011
Vanadium, mg/L (dissolved)	<0.1	<0.1				<0.1	<0.1			<0.1
Zinc, mg/L (dissolved)	<0.01	<0.01				<0.01	<0.01			<0.01
Iron, TOTAL mg/L	0.08	0.89				0.26	0.28			0.38
Manganese, TOTAL mg/L	<0.01	0.08				0.01	<0.01			0.03
Lead 210, suspended pci/L	**<1.0**	**<1.0**				**<4.1**	**<3.8**			<2.5
Polonium 210 suspended, pci/L	**<1.0**	**<1.0**				**<0.3**	**<0.4**			<1.0
Radium 226 suspended, pci/L	**<0.2**	**<0.2**				**<0.4**	**<0.1**			<0.2
Thorium 230 suspended, pci/L	**<0.2**	**<0.2**				**<0.2**	**<0.2**			<0.2
Uranium suspended, pci/L	**<0.0003**	**<0.0003**				**<0.0003**	0.0005			<0.0004

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Pond

Surface Water State Permit # N/A

Table 3.4.2-14

Table 3.4.2-14 Water Quality Data from MRSW-10

	MRSW-10										
Parameters	**10/25/2006**	**3/23/2007**	**6/14/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/27/2009**	**10/22/2009**	**Average**
Bicarbonate as HCO3, mg/L	DRY	DRY	DRY		DRY		DRY	DRY	DRY	DRY	
Carbonate as CO3, mg/L											
Chloride, mg/L											
Conductivity, umhos/cm											
Fluoride, mg/L											
pH, s.u.											
Solids, Total Dissolved TDS @ 180 C, mg/L						85					85
Solids, Total Suspended TSS @ 105 C, mg/L				160		14					87
Sulfate, mg/L											
Turbidity, NTU				130		7.8					68.9
Gross Alpha, pci/L (dissolved)											
Gross Beta, pci/L (dissolved)											
Lead 210, pci/L (dissolved)											
Polonium 210, pci/L (dissolved)											
Radium 226, pci/L (dissolved)											
Radium 228, pci/L (dissolved)											
Thorium 230, pci/L (dissolved)											
Nitrogen, Ammonia as N, mg/L											
Nitrogen, Nitrate+Nitrite as N, mg/L											
Aluminum, mg/L (dissolved)											
Arsenic, mg/L (dissolved)											
Barium, mg/L (dissolved)											
Boron, mg/L (dissolved)											
Cadmium, mg/L (dissolved)											
Calcium, mg/L											
Chromium, mg/L (dissolved)											
Copper, mg/L (dissolved)											
Iron, mg/L (dissolved)											
Lead, mg/L (dissolved)											
Magnesium, mg/L											
Manganese, mg/L (dissolved)											
Mercury, mg/L (dissolved)											
Molybdenum, mg/L (dissolved)											
Nickel, mg/L (dissolved)											
Potassium, mg/L	DRY	DRY	DRY		DRY		DRY	DRY	DRY	DRY	
Selenium, mg/L (dissolved)											
Silica, mg/L (dissolved)											
Sodium, mg/L											
Uranium, mg/L (dissolved)											
Vanadium, mg/L (dissolved)											
Zinc, mg/L (dissolved)											
Iron, TOTAL mg/L											
Manganese, TOTAL mg/L											
Lead 210, suspended pci/L											
Polonium 210 suspended, pci/L											
Radium 226 suspended, pci/L											
Thorium 230 suspended, pci/L											
Uranium suspended, pci/L											

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Ponding in Drainage Area

Surface Water State Permit # N/A

Table 3.4.2-15

Table 3.4.2-15 Water Quality Data from MRSW-11

	MRSW-11										
Parameters	**10/25/2006**	**3/23/2007**	**6/14/2007**	**7/8/2008**	**10/23/2008**	**2/9/2009**	**3/11/2009**	**4/22/2009**	**7/23/2009**	**10/26/2009**	**Average**
Bicarbonate as HCO3, mg/L	DRY	DRY	DRY	DRY	DRY		67	147	492	451	289
Carbonate as CO3, mg/L							<1	<1	<5	<5	<3
Chloride, mg/L							<1	<1	3	4	<3
Conductivity, umhos/cm							131	211	742	683	442
Fluoride, mg/L							<0.1	<0.1	0.1	0.2	<0.2
pH, s.u.							7.77	7.9	7.99	8.09	7.94
Solids, Total Dissolved TDS @ 180 C, mg/L						134	136	159	532	390	270
Solids, Total Suspended TSS @ 105 C, mg/L						28	8	6	6	30	16
Sulfate, mg/L							3	2	1	15	5
Turbidity, NTU						13.6	2.9	1.6	12.3	17	9.5
Gross Alpha, pci/L (dissolved)							**<1.3**	5.7	**<4.5**	**<3.2**	<4.1
Gross Beta, pci/L (dissolved)							7.6	9.3	20.5	17.3	13.7
Lead 210, pci/L (dissolved)							**<2.8**	**<5.6**	**<2.3**	**<1.4**	<3.1
Polonium 210, pci/L (dissolved)							**<0.9**	**<0.6**	**<0.6**	**<0.7**	<0.7
Radium 226, pci/L (dissolved)							**<0.12**	**<0.17**	0.2	**<0.18**	<0.2
Radium 228, pci/L (dissolved)							**<1.5**	**<1.3**	**<1.2**	**<1.5**	<1.4
Thorium 230, pci/L (dissolved)							**<0.4**	**<0.2**	**<0.4**	**<0.2**	<0.3
Nitrogen, Ammonia as N, mg/L							<0.05	<0.05	0.05	<0.05	<0.05
Nitrogen, Nitrate+Nitrite as N, mg/L							<0.05	<0.05	0.02	<0.1	<0.04
Aluminum, mg/L (dissolved)							<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic, mg/L (dissolved)							<0.001	0.001	0.007	0.003	0.003
Barium, mg/L (dissolved)							<0.1	<0.1	<0.1	<0.1	<0.1
Boron, mg/L (dissolved)							<0.1	<0.1	<0.1	<0.1	<0.1
Cadmium, mg/L (dissolved)							<0.005	<0.005	<0.005	<0.005	<0.005
Calcium, mg/L							13	35	110	79	59
Chromium, mg/L (dissolved)							<0.05	<0.05	<0.05	<0.05	<0.05
Copper, mg/L (dissolved)							<0.01	0.01	<0.01	<0.01	<0.01
Iron, mg/L (dissolved)							0.04	<0.03	0.11	0.05	0.06
Lead, mg/L (dissolved)							<0.001	0.004	<0.001	<0.001	<0.002
Magnesium, mg/L							3	5	29	31	17
Manganese, mg/L (dissolved)							<0.01	<0.01	0.75	0.06	<0.21
Mercury, mg/L (dissolved)							<0.001	<0.001	<0.001	<0.001	<0.001
Molybdenum, mg/L (dissolved)							<0.1	<0.1	<0.1	<0.1	<0.1
Nickel, mg/L (dissolved)							<0.05	<0.05	<0.05	<0.05	<0.05
Potassium, mg/L							9	9	25	22	16
Selenium, mg/L (dissolved)	DRY	DRY	DRY	DRY	DRY		<0.001	<0.001	<0.001	<0.001	<0.001
Silica, mg/L							6.6	15.4	28.8	9.4	15.1
Sodium, mg/L							2	4	6	7	5
Uranium, mg/L (dissolved)							<0.0003	<0.0003	0.0005	0.0023	<0.0009
Vanadium, mg/L (dissolved)							<0.1	<0.1	<0.1	<0.1	<0.1
Zinc, mg/L (dissolved)							<0.01	0.22	<0.01	<0.01	<0.07
Iron, TOTAL mg/L							0.11	0.06	1.62	0.51	0.58
Manganese, TOTAL mg/L							0.02	0.05	0.93	0.08	0.27
Lead 210, suspended pci/L							**<4.2**	**<3.8**	**<3.6**	**<0.9**	<3.2
Polonium 210 suspended, pci/L							**<0.4**	**<0.4**	**<0.4**	**<0.3**	<0.4
Radium 226 suspended, pci/L							**<0.4**	**<0.1**	**<0.07**	0.2	<0.2
Thorium 230 suspended, pci/L							**<0.2**	**<0.1**	**<0.07**	**<0.06**	<0.2
Uranium suspended, pci/L							**<0.0003**	**<0.0003**	**<0.0003**	**<0.0003**	<0.0003

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Radionuclides. These values were used in the development of the average concentrations.

Sampled Feature Type: Ponding in Drainage Area

Surface Water State Permit # N/A

Table 3.4.2-15a

Table 3.4.2-15a Water Quality Data from MRSW-12

	MRSW-12						
Parameters	**7/8/2008**	**10/23/2008**	**2/9/2009**	**4/22/2009**	**7/23/2009**	**10/22/2009**	**Average**
Bicarbonate as HCO3, mg/L	101	524	43	61	561	DRY	258
Carbonate as CO3, mg/L	<1	41	<1	<1	70		23
Chloride, mg/L	<1	9	<1	1	15		5
Conductivity, umhos/cm	182	935	38	318	1090		513
Fluoride, mg/L	<0.1	0.7	<0.1	<0.1	0.9		0.4
pH, s.u.	6.49	8.85	7.07	7.51	8.93		7.77
Solids, Total Dissolved TDS @ 180 C, mg/L	170	542	70	199	697		336
Solids, Total Suspended TSS @ 105 C, mg/L	242	17	12	<4	46		64
Sulfate, mg/L	1	3	7	111	8		26
Turbidity, NTU	64.1	7	5.8	1.8	29.8		22
Gross Alpha, pci/L (dissolved)	**<1.1**	4	**<1.1**	5.1	**<5.0**		<3.3
Gross Beta, pci/L (dissolved)	12.6	3.9	5.1	3.6	13.4		7.7
Lead 210, pci/L (dissolved)	**<9.2**	**<4.8**	**<3.6**	**<3.1**	**<2.3**		<4.6
Polonium 210, pci/L (dissolved)	**<1.0**	**<1.0**	**<0.7**	**<0.6**	**<0.6**		<0.8
Radium 226, pci/L (dissolved)	0.2	1.3	**<0.3**	**<0.16**	**<0.23**		<0.4
Radium 228, pci/L (dissolved)	**<1.1**	**<1.3**	**<1.5**	**<1.2**	**<1.5**		<1.3
Thorium 230, pci/L (dissolved)	**<0.2**	**<0.2**	**<0.5**	**<0.3**	**<0.8**		<0.4
Nitrogen, Ammonia as N, mg/L	<0.05	0.06	<0.05	<0.05	<0.05		<0.05
Nitrogen, Nitrate+Nitrite as N, mg/L	<0.05	0.7	0.12	<0.05	0.01		0.19
Aluminum, mg/L (dissolved)	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1
Arsenic, mg/L (dissolved)	0.002	<0.001	0.002	<0.001	0.004		0.002
Barium, mg/L (dissolved)	<0.1	0.5	<0.1	<0.1	0.4		0.2
Boron, mg/L (dissolved)	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1
Cadmium, mg/L (dissolved)	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005
Calcium, mg/L	18	26	9	30	19		20
Chromium, mg/L (dissolved)	<0.05	<0.05	<0.05	<0.05	<0.05		<0.05
Copper, mg/L (dissolved)	<0.01	<0.01	<0.01	0.12	<0.01		<0.03
Iron, mg/L (dissolved)	0.9	<0.03	0.06	0.07	0.18		0.25
Lead, mg/L (dissolved)	<0.001	<0.001	<0.001	0.026	<0.001		<0.006
Magnesium, mg/L	5	17	2	14	19		11
Manganese, mg/L (dissolved)	0.35	<0.01	<0.01	0.03	0.02		0.08
Mercury, mg/L (dissolved)	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001
Molybdenum, mg/L (dissolved)	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1
Nickel, mg/L (dissolved)	<0.05	<0.05	<0.05	<0.05	<0.05		<0.05
Potassium, mg/L	18	8	5	4	15	DRY	10
Selenium, mg/L (dissolved)	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001
Silica, mg/L	22.5	7.1	6.5	5.4	1.3		8.6
Sodium, mg/L	2	172	1	13	237		85
Uranium, mg/L (dissolved)	<0.0003	<0.0003	0.0004	0.0019	0.0024		0.0011
Vanadium, mg/L (dissolved)	<0.1	<0.1	<0.1	<0.1	<0.1		<0.1
Zinc, mg/L (dissolved)	<0.01	0.01	0.06	0.76	<0.01		0.17
Iron, TOTAL mg/L	4.16	0.44	0.29	0.34	0.87		1.22
Manganese, TOTAL mg/L	0.4	<0.01	<0.02	0.04	0.03		0.1
Lead 210, suspended pci/L	**<11.2**	**<7.3**	**<5.8**	**<3.9**	**<3.7**		<6.4
Polonium 210 suspended, pci/L	1.7	**<0.2**	1.1	**<0.3**	**<0.3**		<0.8
Radium 226 suspended, pci/L	0.7	**<0.5**	0.8	**<0.1**	0.07		0.4
Thorium 230 suspended, pci/L	0.6	**<0.2**	0.2	0.2	**<0.07**		<0.3
Uranium suspended, pci/L	**<0.0003**	**<0.0003**	0.0005	**<0.0003**	**<0.0003**		<0.0003

Bolded values represent MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) for Rac the development of the average concentrations.

Sampled Feature Type: Ponding in Drainage Area

Surface Water State Permit # N/A

Table 3.4.2-15b

Table 3.4.2-15b Water Quality Data - Surface Water - Seasonal Averages

Parameter	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
Bicarbonate as HCO3, mg/L	333	295	296	612
Carbonate as CO3, mg/L	13	20	89	194
Chloride, mg/L	2	2	5	10
Conductivity, umhos/cm	589	621	908	1431
Fluoride, mg/L	0.3	0.3	0.4	0.7
pH, s.u.	8.51	8.78	9.25	9.08
Solids, Total Dissolved TDS @ 180 C, mg/L	301	398	702	904
Solids, Total Suspended TSS @105 C, mg/L	18	18	63	26
Sulfate, mg/L	32	67	91	86
Turbidity, NTU	9.8	14	70	14
Gross Alpha, pci/L (dissolved)	2.3	5.7	6.2	6.2
Gross Beta, pci/L (dissolved)	6.9	5.3	12.5	14.8
Lead 210, pci/L (dissolved)	2.6	2.3	3.0	2.3
Polonium 210, pci/L (dissolved)	1.0	0.8	0.7	1.0
Radium 226, pci/L (dissolved)	0.2	0.3	0.4	0.3
Radium 228, pci/L (dissolved)	1.4	1.1	1.2	1.2
Thorium 230, pci/L (dissolved)	0.3	0.3	0.5	0.2
Nitrogen, Ammonia as N, mg/L	0.08	0.07	0.05	0.20
Nitrogen, Nitrate+Nitrite as N, mg/L	0.08	0.07	0.03	0.28
Aluminum, mg/L (dissolved)	0.1	0.3	0.2	0.3
Arsenic, mg/L (dissolved)	0.003	0.003	0.007	0.006
Barium, mg/L (dissolved)	0.3	0.2	0.2	0.4
Boron, mg/L (dissolved)	0.1	0.1	0.1	0.1
Cadmium, mg/L (dissolved)	0.005	0.005	0.005	0.005
Calcium, mg/L	23	33	35	27
Chromium, mg/L (dissolved)	0.05	0.05	0.05	0.05
Copper, mg/L (dissolved)	0.01	0.04	0.01	0.01
Iron, mg/L (dissolved)	0.08	0.15	0.21	0.25
Lead, mg/L (dissolved)	0.001	0.007	0.001	0.030
Magnesium, mg/L	14	17	21	34
Manganese, mg/L (dissolved)	0.02	0.01	0.14	0.02
Mercury, mg/L (dissolved)	0.001	0.001	0.001	0.001
Molybdenum, mg/L (dissolved)	0.1	0.1	0.1	0.1
Nickel, mg/L (dissolved)	0.05	0.05	0.05	0.05
Potassium, mg/L	9	6	14	14
Selenium, mg/L (dissolved)	0.001	0.001	0.001	0.001
Silica, mg/L	7.3	6.8	9.5	4.8
Sodium, mg/L	91	92	151	295
Uranium, mg/L (dissolved)	0.0017	0.0014	0.0012	0.0033
Vanadium, mg/L (dissolved)	0.1	0.1	0.1	0.1
Zinc, mg/L (dissolved)	0.02	0.16	0.01	0.01
Iron, TOTAL mg/L	0.35	0.67	4.3	0.54
Manganese, TOTAL mg/L	0.05	0.04	0.21	0.02
Lead 210, suspended pci/L	3.0	3.0	3.8	2.1
Polonium 210 suspended, pci/L	0.8	0.7	0.6	1.0
Radium 226 suspended, pci/L	0.3	0.2	0.3	0.2
Thorium 230 suspended, pci/L	0.2	0.2	0.1	0.2
Uranium suspended, pci/L	0.0004	0.0003	0.0003	0.0009

The MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) values were used in the development of the average concentrations for Radionuclides when the reported results were less than the MDC's and RL's.

Table 3.4.2-15c

Table 3.4.2-15c Water Quality Data - Surface Water - Average Concentrations

Parameter	Overall Average
Bicarbonate as HCO3, mg/L	384
Carbonate as CO3, mg/L	79
Chloride, mg/L	5
Conductivity, umhos/cm	887
Fluoride, mg/L	0.4
pH, s.u.	8.91
Solids, Total Dissolved TDS @ 180 C, mg/L	576
Solids, Total Suspended TSS @ 105 C, mg/L	31
Sulfate, mg/L	69
Turbidity, NTU	27
Gross Alpha, pci/L (dissolved)	5.1
Gross Beta, pci/L (dissolved)	9.9
Lead 210, pci/L (dissolved)	2.0
Polonium 210, pci/L (dissolved)	0.9
Radium 226, pci/L (dissolved)	0.3
Radium 228, pci/L (dissolved)	1.2
Thorium 230, pci/L (dissolved)	0.3
Nitrogen, Ammonia as N, mg/L	0.10
Nitrogen, Nitrate+Nitrite as N, mg/L	0.12
Aluminum, mg/L (dissolved)	0.2
Arsenic, mg/L (dissolved)	0.005
Barium, mg/L (dissolved)	0.3
Boron, mg/L (dissolved)	0.1
Cadmium, mg/L (dissolved)	0.005
Calcium, mg/L	30
Chromium, mg/L (dissolved)	0.05
Copper, mg/L (dissolved)	0.02
Iron, mg/L (dissolved)	0.17
Lead, mg/L (dissolved)	0.010
Magnesium, mg/L	22
Manganese, mg/L (dissolved)	0.05
Mercury, mg/L (dissolved)	0.001
Molybdenum, mg/L (dissolved)	0.1
Nickel, mg/L (dissolved)	0.05
Potassium, mg/L	10.8
Selenium, mg/L (dissolved)	0.001
Silica, mg/L	7.1
Sodium, mg/L	157
Uranium, mg/L (dissolved)	0.0019
Vanadium, mg/L (dissolved)	0.1
Zinc, mg/L (dissolved)	0.05
Iron, TOTAL mg/L	1.47
Manganese, TOTAL mg/L	0.08
Lead 210, suspended pci/L	2.8
Polonium 210 suspended, pci/L	0.8
Radium 226 suspended, pci/L	0.3
Thorium 230 suspended, pci/L	0.2
Uranium suspended, pci/L	0.0005

The MDC's (Minimum Detectable Concentration) and RL's (Analyte reporting limit) values were used in the development of the average concentrations for Radionuclides when the reported results were less than the MDC's and RL's.

3.4.2.4 Surface Control Structures

Several small dams and ponds exist within and downstream of the project that provide a level of control and storage of surface water. During normal runoff conditions, these ponds will contain all upgradient runoff. Many of these water features may contain higher levels of water after spring runoff or after large precipitation events but are generally reduced to small, isolated pools or are completely dry by the end of the summer. Relatively small amounts of surface discharge from coal-bed methane operations may also maintain small pools of water in these ponds during dry summer months.

Installation of Wellfield 2 monitor, injection, and production wells in main ephemeral stream channels will be avoided if possible. If it is necessary to install a well within the high water marks of a ephemeral channel, then adequate structural wellhead protection will be installed to protect the wells during potential flood conditions. Wellhead protection could include concrete berms, or reinforced steel/concrete well covers, etc. Properly sized culverts will be used for secondary access roads crossing across small drainages. Efforts will be made to construct secondary access roads to avoid crossing major drainages. However, if crossing a major drainage is required, then adequately sized culverts will be utilized and embankments will be protected from erosion using adequate best management practices (rip rap, rock, etc.) in accordance with WDEQ-LQD Rules and Regulations, Chapter 3. Culverts across significant drainages will be designed to pass the 25-year peak runoff event using head available at the entrance. The minimum culvert size of 18" will be utilized to divert drainage from roads or for crossing small drains or swayles. Crossings for major drainages will be constructed at or near right angles.

3.4.2.5 Surface Water Impacts From CBM Discharges

Currently, three Wyoming Pollutant Discharge Elimination System (WYPDES) permits exist within or adjacent to the license area. The following Table 3.4.2-16 summarizes these permits.

Table 3.4.2-16 WYPDES Permits in or near the Moore Ranch Project

WYPDES Permit	Facility Name	Operator
WY0040436	East Pine Tree Unit	Devon Energy Production Company
WY0051217	Palm Tree Project	Bill Barrett Corporation (BBC)
WY0055131	BBC Pine Tree Area	Bill Barrett Corporation (BBC)

Outfalls permitted under the three WYPDES permits are presented on Figure 2.7.1-2.

Table 3.4.2-17 provides the WYPDES effluent limitations for Devon's East Pine Tree Unit CBM Facility (WY0040436), Bill Barrett Corporation's (BBC) Palm Tree Project CBM Facility (WY0051217) and BBC Pine Tree Area Permit (WY0055131).

Table 3.4.2-17 WYPDES Effluent Limitations for Permits in or near the Moore Ranch Project

Devon – East Pine Tree Unit (Outfalls 001-002, 004-015, 017-030)[1]	
Effluent Characteristic	**Daily Maximum**
Chlorides, mg/L	46
Dissolved Iron, µg/L	1000
pH, su	6.5 – 9.0
Sodium Adsorption Ratio	10
Specific Conductance, micromhos/cm	2000
Total Recoverable Arsenic, µg/L	2.4
Total Recoverable Barium, µg/L	1800
Total Dissolved Solids, mg/L	5000
Total Flow[4], MGD	0.68
BBC – Palm Tree Project (Outfalls 001 - 025)[2]	
Effluent Characteristic	**Daily Maximum**
Chlorides, mg/L	46
Dissolved Iron, µg/L	1000
pH, su	6.5 – 9.0
Sodium Adsorption Ratio	10
Specific Conductance, mircromhos/cm	2000
Total Recoverable Arsenic, µg/L	3.0
Total Recoverable Barium, µg/L	1800
Total Flow[4], MGD	5.3
BBC – BBC Pine Tree Area (Outfalls 004 - 008)[3]	
Chlorides, mg/L	46
Dissolved Iron, µg/L	1000
pH, su	6.5 – 9.0
Sodium Adsorption Ratio	10
Specific Conductance, micromhos/cm	2000
Total Recoverable Arsenic, µg/L	3.0
Total Recoverable Barium, µg/L	1800
Total Flow[4], MGD	1.02

[1] Devon's East Pine Tree Unit permit (WY0040436), effective August 30, 2007.

[2] BBC's Palm Tree Project permit (WY0051217), effective February 4, 2008.

[3] BBC's BBC Pine Tree Area permit (WT0055131), effective October 4, 2007.

[4] Total flow is for all outfalls permitted under each permit number, in million gallons per day.

Table 3.4.2-18 provides a list of reservoirs permitted through the Wyoming State Engineers Office (WSEO) within the license area that may be impacted by CBM produced water discharge. The reservoir locations are depicted on Figure 3.4.2-5.

Figure 3.4.2-5

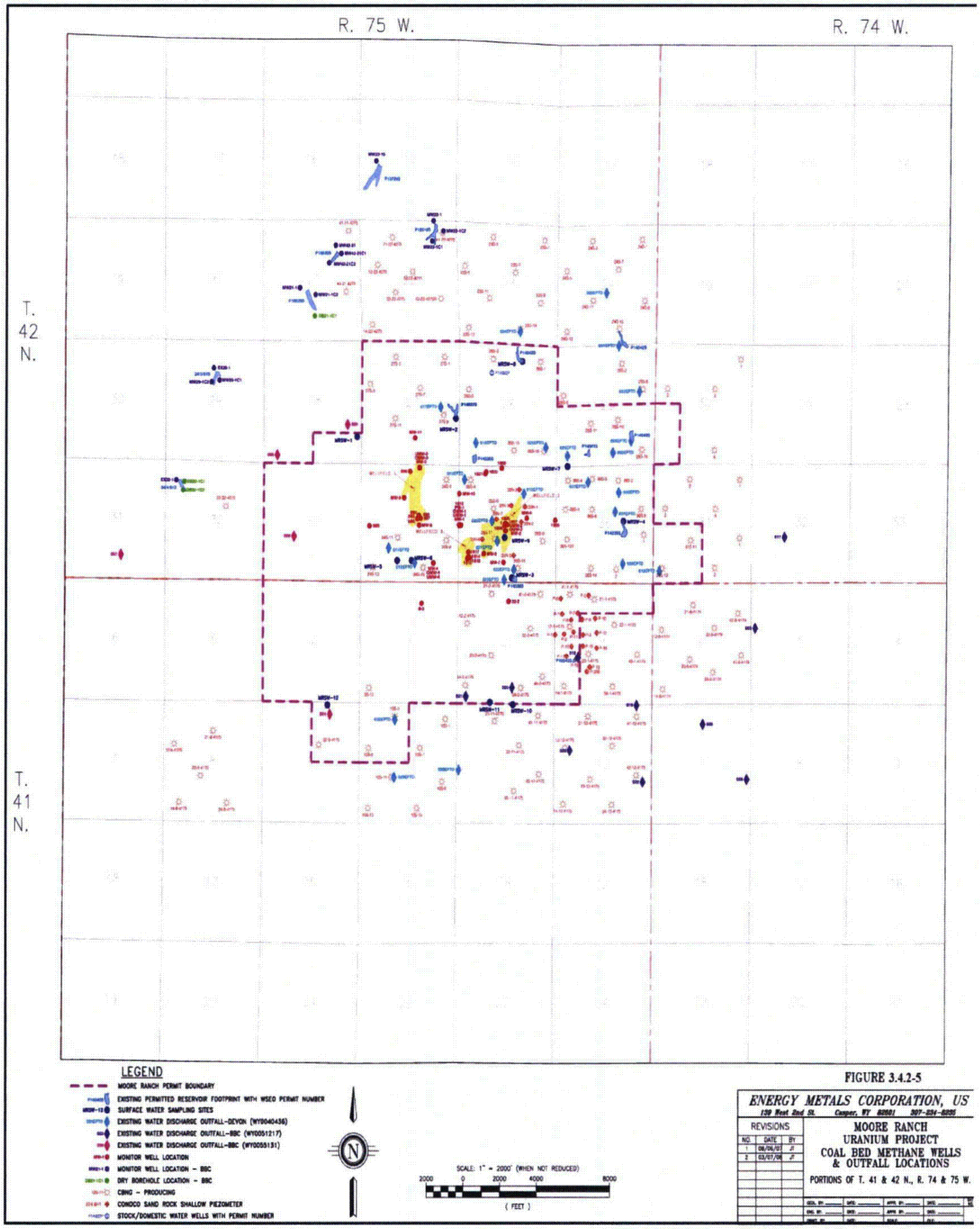
R. 75 W.
R. 74 W.
T. 42 N.
T. 41 N.
LEGEND
MOORE RANCH PERMIT BOUNDARY
EXISTING PERMITTED RESERVOIR FOOTPRINT WITH WSEO PERMIT NUMBER
SURFACE WATER SAMPLING SITES
EXISTING WATER DISCHARGE OUTFALL-DEVON (WY0040436)
EXISTING WATER DISCHARGE OUTFALL-BBC (WY0051217)
EXISTING WATER DISCHARGE OUTFALL-BBC (WY0055131)
MONITOR WELL LOCATION
MONITOR WELL LOCATION - BBC
DRY BOREHOLE LOCATION - BBC
CBNG - PRODUCING
CONOCO SAND ROCK SHALLOW PIEZOMETER
STOCK/DOMESTIC WATER WELLS WITH PERMIT NUMBER
N
SCALE: 1" = 2000' (WHEN NOT REDUCED)
2000
0
2000
4000
8000
(FEET)
FIGURE 3.4.2-5
ENERGY METALS CORPORATION, US
139 West 2nd St. Casper, WY 82601 307-234-8235
REVISIONS
NO.
DATE
BY
1
08/06/07
JT
2
03/07/08
JT
MOORE RANCH
URANIUM PROJECT
COAL BED METHANE WELLS
& OUTFALL LOCATIONS
PORTIONS OF T. 41 & 42 N., R. 74 & 75 W.

Table 3.4.2-18 WSEO Permitted Reservoirs with the Moore Ranch License Area

SEO Permit No.	Qtr-Qtr	Section	Township	Range
P16543S	NWSW	1	41N	75W
P14042S	NWNE	25	42N	75W
P14041S	SESW	25	42N	75W
P14040S	SWSE	25	42N	75W
P14043S	NWNE	26	42N	75W
P14036S	SWSW	26	42N	75W
P14037S	NESE	27	42N	75W
P14038S	SWSE	35	42N	75W
P14039S	NWSE	36	42N	75W

Table 3.4.2-19 provides a list of the discharge points located within the license area. These discharge points are also presented on Figure 3.4.2-5 as are a number of others outside of the license area.

Table 3.4.2-19 CBM WYPDES Permits and Outfall Locations Within or Upstream of the Moore Ranch Project

Company	Permit #	Outfall #	Qtr-Qtr	Sec	Twp	Rng	Latitude	Longitude
Devon	WY0040436	001 EPTD	NWNE	25	T42N	R75W	43.59012	-105.81289
		002 EPTD	SENE	25	T42N	R75W	43.58458	-105.80856
		004 EPTD	SESE	25	T42N	R75W	43.5806	-105.8100
		005 EPTD	SWSE	25	T42N	R75W	43.5769	-105.8122
		006 EPTD	NWNE	36	T42N	R75W	43.5719	-105.8117
		007 EPTD	SWNE	36	T42N	R75W	43.5694	-105.8122
		008 EPTD	SESE	36	T42N	R75W	43.5639	-105.8008
		009 EPTD	NESW	24	T42N	R75W	43.59653	-105.81550
		010 EPTD	SWSW	31	T42N	R74W	43.5626	-105.8043
		011 EPTD	NESW	34	T42N	R75W	43.5647	-105.8586
		012 EPTD	SWSE	34	T42N	R75W	43.5647	-105.8547
		017 EPTD	NESE	27	T42N	R75W	43.5814	-105.8465
		019 EPTD	NWNW	35	T42N	R75W	43.5743	-105.8430
		020 EPTD	SENW	35	T42N	R75W	43.5688	-105.8374
		021 EPTD	NESW	35	T42N	R75W	43.5657	-105.8259
		022 EPTD	SWSE	35	T42N	R75W	43.5628	-105.8345
		023 EPTD	SWSE	35	T42N	R75W	43.5623	-105.8345
		024 EPTD	SWSE	23	T42N	R75W	43.59174	-105.83319
		025 EPTD	SESE	26	T42N	R75W	43.5775	-105.8261
		026 EPTD	SWSW	25	T42N	R75W	43.5763	-105.8227
		027 EPTD	NENW	36	T42N	R75W	43.5738	-105.8176
		030 EPTD	NENW	10	T41N	R75W	43.5442	-105.8581
BBC	WY0051217	018	NWSW	1	T41N	R75W	43.55252	-105.82161
		020	SWSE	2	T41N	R75W	43.54840	-105.83423
		021	SWSW	2	T41N	R75W	43.54722	-105.84404
BBC	WY0055131	004	NWNE	9	T41N	R75W	43.54492	-105.87229
		005	NESE	28	T42N	R75W	43.58020	-105.86910
		006	SWSW	28	T42N	R75W	43.57640	-105.88350
		007	SWSE	31	T42N	R75W	43.56395	-105.91549
		008	NESW	33	T42N	R75W	43.56641	-105.87995

*Shading indicates outfalls that are upstream of Moore Ranch License Area

Discharge data and WYPDES permit limits for outfalls located within the license area are provided in the tables on the following pages. Data provided in response to RAI 2-5.b on the Moore Ranch Technical Report indicates that infiltration to the 72 Sand has not occurred to date.

A conservative annual declination rate of 5% is assumed for future CBM discharge based on Devon's East Pine Tree Unit (WY0040436) historic data, as presented in the following Tables 3.4.2-20 through 3.4.2-23. All three WYPDES permits will be up for renewal in early 2009 with an expiration date in 2014. Personal communications with permit holders indicates that the permits will not likely be renewed in 2014. Flow from Devon's WY0040436 outfalls is anticipated to be less than 0.006 MGD by 2013. Based on historic CBM water discharge data within the license area, water quality will not vary significantly as CBM water production declines.

Table 3.4.2-20 Historic and Projected Discharge Rates at CBM Discharge Points (Devon – East Pine Tree Unit, WY0040436)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2012	2014
MAXIMUM FLOW (MGD)	0.1006	0.0694	0.0572	0.0302	0.0183	0.0111	0.0092	0.0120	0.0114	0.0108	0.0103	0.0093	0.0084
AVERAGE FLOW (MGD)	0.0895	0.0615	0.0388	0.0243	0.0143	0.0078	0.0078	0.0082	0.0078	0.0074	0.0070	0.0063	0.0057
ANNUAL DECLINE		36.0%	35.2%	11.1%	11.1%	17.4%	5.9%	5.9%	5.0%	5.0%	5.0%	5.0%	5.0%

Table 3.4.2-21 BBC Pine Tree Area (WY0055131) Average Water Quality and Discharge Rates

PARAMETER	UNIT	PERMIT LIMIT[1]	OUTFALL				
			004	005	006	007	008
Total Flow (MGD) - MAX	MGD	1.02	0.0042	0.0261	0.0146	No Dis	No Dis
Total Flow (MGD) - AVG	MGD		0.0028	0.0197	0.0124	No Dis	No Dis
Bicarbonate	mg/L		952	1293	1126	No Dis	No Dis
Dissolved Calcium	me/L		74	82	73	No Dis	No Dis
Dissolved Magnesium	me/L		26	33	34	No Dis	No Dis
Dissolved Sodium	me/L		222	305	197	No Dis	No Dis
pH	SU	6.5-9.0	7.57	7.55	7.43	No Dis	No Dis
Sodium Adsorption Ratio	Calculated	10	5.7	7.6	6.0	No Dis	No Dis
Specific Conductance	micromhos/cm	2000	1350	1686	1415	No Dis	No Dis
Total Alkalinity	mg/L as CaCO3		780	1059	922	No Dis	No Dis
Chlorides	mg/L	46	10.3	6.9	6.8	No Dis	No Dis
Dissolved Iron	ug/L	1000	160	1257	570	No Dis	No Dis
Total Recoverable Arsenic	ug/L	3	0.67	1.73	1.60	No Dis	No Dis
Total Recoverable Barium	ug/L	1800	1050	2023	1157	No Dis	No Dis
Dissolved Cadmium	ug/L		0.1	ND	N/A	No Dis	No Dis
Dissolved Manganese	ug/L		97	104.5	84.5	No Dis	No Dis
Fluorides	mg/L		0.56	0.90	0.66	No Dis	No Dis
Potassium	mg/L		9	12.3	12.4	No Dis	No Dis
Sulfates	mg/L		2.6	3	7.5	No Dis	No Dis
Total Petroleum Hydrocarbons	mg/L		1	ND	ND	No Dis	No Dis
Total Radium 226	pCi/L		0.6	1.05	0.4	No Dis	No Dis

[1] – Data is provided for outfalls within and flowing through the license area.

[2] - Permit Limit set for all outfalls discharging under Permit WY0051217 (total number outfalls is 25)

N/A - Was not monitored, No Dis – No discharge reported, ND – Reported as non-detect by laboratory

Table 3.4.2-22 Devon East Pine Tree Unit (WY0040436) WYPDES Average Water Quality and Discharge Rates[1]

PARAMETER	UNIT	PERMIT LIMIT[2]	OUTFALL																			
			004	005	006	007	008	010	011	012	013	017	018	019	020	021	022	023	025	026	027	030
Flow - MAX	MGD	0.68	0.0443	0.0239	0.0109	0.0213	0.0256	0.0348	0.0283	0.0290	No Dis	0.0414	No Dis	0.0183	0.0086	0.0041	0.0066	No Dis	0.0130	0.0057	0.0032	0.0175
Flow - AVG	MGD		0.0367	0.0150	0.0096	0.0206	0.0232	0.0266	0.0217	0.0135	No Dis	0.0291	No Dis	0.0158	0.0076	0.0021	0.0044	No Dis	0.0108	0.0046	0.0021	0.0139
Alkalinity	mg/L		468	615	762	670	663	572	1217	995	No Dis	997	No Dis	602	702	498	434	No Dis	796	302	407	617
Total Recoverable Arsenic	ug/L	2.4	0.8	1.4	0.9	1.6	1.3	1.4	2.6	1.4	No Dis	5.6	No Dis	0.5	2.1	2.0	0.6	No Dis	0.6	1.6	1.1	1.8
Total Recoverable Barium	ug/L	1800	628	1032	1092	902	883	486	2476	1694	No Dis	1433	No Dis	577	925	600	421	No Dis	1153	296	360	980
Bicarbonate	mg/L		660	741	921	817	804	695	1471	1190	No Dis	1211	No Dis	723	828	605	517	No Dis	960	365	496	741
Calcium	mg/L		29	42	52	51	46	36	131	103	No Dis	88	No Dis	55	54	36	28	No Dis	68	17	26	59
Chlorides	mg/L	46	10	9	9	10	9	10	8	11	No Dis	5	No Dis	5	5	7	8	No Dis	6	9	No Dis	9
Dissolved Iron	ug/L	1000	189	482	1043	1089	60	671	380	174	No Dis	353	No Dis	467	351	1060	90	No Dis	498	892	905	0
Dissolved Cadmium	ug/L		N/A	N/A	N/A	N/A	N/A	N/A	0.6	0.6	No Dis	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1820
Dissolved Manganese	ug/L		109	50	66	176	50	143	117	114	No Dis	77	No Dis	48	70	61	30	No Dis	88	119	74	57
Fluorides	mg/L		0.6	0.5	0.5	0.7	1.4	0.7	0.6	0.5	No Dis	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.7
Magnesium	mg/L		8	9	16	11	13	9	44	29	No Dis	32	No Dis	16	14	8	6	No Dis	16	4	5	19
pH	SU	6.5 – 9.0	7.81	7.87	7.76	7.69	7.81	7.64	7.44	7.62	No Dis	7.55	No Dis	7.51	7.34	7.05	7.60	No Dis	7.16	7.66	7.22	7.84
Potassium	mg/L		5	6	7	7	7	6	15	11	No Dis	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	9
Sodium	mg/L		146	215	256	221	231	199	305	274	No Dis	298	No Dis	209	232	180	160	No Dis	255	117	153	178
Sodium Adsorption Ratio	Calculated	10	7.6	7.9	8.0	7.6	7.9	8.1	5.9	6.2	No Dis	7.0	No Dis	6.4	7.2	7.1	6.9	No Dis	7.2	6.7	7.2	5.1
Specific Conductance	umhos/ cm	2000	859	1093	1348	1204	1175	1008	2068	1665	No Dis	1684	No Dis	1145	1186	912	798	No Dis	1316	585	735	1076
Sulfates	mg/L		13	2	4	3	2	2	5	2	No Dis	1	No Dis	40	1	1	8	No Dis	16	9	ND	2
Total Petroleum Hydrocarbons	mg/L		0.7	1.0	1.0	0.7	1.0	0.5	1.0	1.0	No Dis	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.0
Total Radium 226	pCi/L		0.5	0.3	0.5	0.3	0.3	0.3	0.8	0.6	No Dis	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5

[1] – Data is provided for outfalls within the license area.

[2] - Permit Limit set for all outfalls discharging under Permit WY0040436 (total number outfalls is 30)

N/A - Was not monitored, No Dis – No discharge reported, ND – Reported as non-detect by laboratory

Table 3.4.2-23 BBC Palm Tree Project (WY0051217) Average Water Quality and Discharge Rates

PARAMETER	UNIT	PERMIT LIMIT[1]	OUTFALL		
			018	020	021
Total Flow (MGD) - MAX	MGD	5.3	0.0403	0.0079	0.0083
Total Flow (MGD) - AVG	MGD		0.0147	0.0079	0.0083
Bicarbonate	mg/L		723	744	674
Dissolved Calcium	me/L		5.72	7.89	11.78
Dissolved Magnesium	me/L		1.97	2.14	2.96
Dissolved Sodium	me/L		40.30	43.88	48.96
pH	SU	6.5-9.0	8.03	8.03	7.94
Sodium Adsorption Ratio	Calculated	10	7.9	7.4	6.4
Specific Conductance	micromhos/cm	2000	880	1052	967
Total Alkalinity	mg/L as CaCO3		449	615	555
Chlorides	mg/L	46	9	8	9
Dissolved Iron	ug/L	1000	1810	1514	2020
Dissolved Manganese	ug/L		63	119	66
Sulfates	mg/L		18	1	ND
Total Recoverable Arsenic	ug/L	3	0.8	1.0	1.6
Total Recoverable Barium	ug/L	1800	608	713	832
Total Petroleum Hydrocarbons	mg/L		ND	ND	ND
Total Radium 226	pCi/L		0.36	0.47	0.23

[1] – Data is provided for outfalls within and flowing through the license area.

[2] - Permit Limit set for all outfalls discharging under Permit WY0051217 (total number outfalls is 25)

ND – Reported as non-detect by laboratory

The seasonal variability of surface water quality apparent during baseline characterization (see Section 3.4.2.2) is largely due to the influence from Devon Energy's outfalls permitted under WY0040436. The lack of water at MRSW-10 and MRSW-11 indicates that Bill Barrett's discharges upstream infiltrate into the shallow alluvial system and do not directly contribute to surface hydrological features within the license area. Assessment of surface water quality in light of the contributions from CBM water discharges present at or upstream of monitoring sites must account for the seasonal variability present in the area. Following permit renewals in 2008, WYPDES permits WY0040436, WY0051217 and WY0055131 will be active into 2014.

3.4.3 Groundwater

This section describes the regional and local groundwater hydrology, including: hydrostratigraphy, groundwater flow patterns, hydraulic gradient and aquifer parameters. The discussion is based on information from investigations performed within the Powder River Basin, data presented in previous applications/reports for the Moore Ranch Site, and the geologic information presented in Section 3.3. Regional and site hydrogeology and baseline water quality conditions are discussed in the following Sections. (For ease of review the figures for this section are contained at the end of the section).

3.4.3.1 Regional Hydrogeology

The Moore Ranch site is located in the southwestern portion of the Powder River Basin, approximately 20 miles east of the north-flowing Powder River and approximately 50 miles north of Casper, Wyoming. Moore Ranch lies within the Northern Great Plains Aquifer System (USGS 1996). The Northern Great Plains Aquifer System contains overlapping aquifers in the Lower Tertiary, Upper and Lower Cretaceous, and Upper and Lower Paleozoic rocks. Figure 3.4.3-1 provides a generalized stratigraphic column of the hydrostratigraphic units of the Northern Great Plains Aquifer System. The Eocene Wasatch Formation, the stratigraphic unit that hosts the uranium mineralization of the Moore Ranch project, crops out over most of the License area (and most of the central portion of the Powder River Basin). The Oligocene White River Formation, which is commonly found in outcrop along the fringes of the Powder River Basin, has been eroded away in the Moore Ranch area. Occasional surficial deposits of the White River Formation are encountered in the vicinity of Pumpkin Buttes (north of the site), but these deposits are not a significant source of groundwater. Furthermore, Rankl and Lowry (1990) state that water from Quaternary alluvium in the Powder River Basin has not been developed extensively because better quality water occurs in the underlying Lower Tertiary and Upper Cretaceous (Wasatch-Fox Hills) sequence and large yields are generally not possible.

The Lower Tertiary aquifers are found within the Wasatch and Fort Union Formations, and the Upper Cretaceous aquifers are found within the Lance Formation and the Fox Hills Sandstone. The Lower Tertiary-Upper Cretaceous aquifer sequence (Wasatch to Fox Hills Sandstone) is about 1,350 feet thick in southeastern Montana and thickens to at least 7,000 feet in Converse County (south of the Moore Ranch Site) (Taylor 1968). The Lewis Shale is a regional aquitard that separates the Upper Cretaceous aquifers from the Lower Cretaceous aquifers.

The Lower Cretaceous aquifers include the Mesa Verde, Frontier and Cloverly Formations. Several regional aquitards are interlayered between these Cretaceous aquifers, including the Cody, Mowry and Thermopolis Shales. Figure 3.4.3-1 shows the stratigraphic relationship of the Lower Teritiary, Upper and Lower Cretaceous aquifers and the regional aquitards for the western portion of the Powder River Basin.

Historical studies have stated that regional groundwater systems (e.g., the Wasatch, Fort Union, and deeper aquifers) generally flow to the northern portion of the Powder River Basin and discharge via unknown locations in Montana (Lowry & Wilson, 1986, and Rankl & Lowry, 1990). A generalized potentiometric surface map for the Lower Tertiary units of the Northern Great Plains Aquifer system is shown in Figure 3.4.3-2. The hydraulic communication between the aquifer systems has been reported to vary from none to direct. Groundwater flow direction in sediments near outcrop areas generally has been characterized as toward the center of the Powder River Basin.

On a semi-regional scale, ground-water flow occurs to the north-northwest, and the gradient is on the order of 0.004 to 0.006 ft/ft. This ground-water flow direction is consistent with results of numerous studies (Honea, 1974; Morris & Bahr, 1975; NRC, 1978; Rose, 1971). In the vicinity of Moore Ranch, flow in the shallow groundwater system is north to northwesterly, toward the Powder River.

Regional recharge to the Lower Tertiary aquifers in the vicinity of the Moore Ranch Project generally occurs at the formation outcrops along the western and southern edges of the Powder River Basin, associated with the Casper Arch and Laramie Mountain uplifts. Some recharge to the shallower aquifer systems is also derived from localized infiltration of precipitation. As described under the section on geology, sands that contain the uranium mineralization at Moore Ranch (70 Sand) crop out within a mile to the southeast of the License Area. These outcrops are localized recharge zones for the Wasatch aquifers within the Moore Ranch License Area.

For purposes of this application, only hydrogeologic units of Lower Tertiary/Upper Cretaceous age are described with respect to general hydrologic properties and potential for groundwater supply. Units deeper than the Fox Hills Sandstone and beneath the Lewis Shale are generally too deep to economically develop for water supply or have elevated TDS concentration that renders them unusable for consumption. Exceptions to this can be found along the edges of the basin, where Lower Cretaceous and older stratigraphic units are found in outcrop. Near outcrop areas, Lower Cretaceous and Paleozoic units can provide relatively good quality water. In particular, the Mesaverde Formation, Frontier Formation, Madison Limestone and Tensleep Sandstone can produce large quantities of relatively good quality water. However those outcrop locations are tens of miles from the Moore Ranch site. In the vicinity of Moore Ranch, the Lower Cretaceous and Paleozoic rocks are separated from the Wasatch Formation by over 5,000 feet of sediments.

Units younger than Lower Tertiary are typically not present within the vicinity of Moore Ranch and therefore are of no significance with respect to groundwater supply. Hydrologic units of interest within the southwest Powder River Basin are shown on the stratigraphic column in Figure 3.4.3-1 from deepest to shallowest:

- Lewis Shale (Late Cretaceous)
- Fox Hills Sandstone (Late Cretaceous)
- Lance Formation (Late Cretaceous)
- Fort Union Formation (Paleocene)
- Wasatch Formation (Eocene)

Discussion of the regional characteristics for each of these hydrostratigraphic units is provided below.

Lewis Shale

The Lewis Shale underlies the Fox Hills Sandstone and is generally considered the major aquitard between the Upper and Lower Cretaceous aquifer systems in the Powder River Basin. This unit is described by Hodson et al. (1973) as predominately shale with sandy shale zones and lenses of fine-grained sandstone. Thickness of this unit is approximately 450 to 500 feet in the southwest part of the basin. Small quantities of water may be available from the thin sandstone beds within this unit near the margins of the basin. However most of this formation does not yield water (Hodson 1973).

Fox Hills Sandstone

The Fox Hills Sandstone is the basal aquifer unit within the Lower Tertiary/Upper Cretaceous aquifer sequence in the Powder River Basin. The Fox Hills Sandstone consists of fine to medium grained sandstone beds deposited in a marine environment. The Fox Hills Sandstone is described by Weimer (1961) as a lithogenetic unit consisting of a series of individual sands bodies, sometimes several miles wide and hundreds of miles long. The Fox Hills Sandstone has been recognized in the northwestern part of the basin, but is generally poorly developed and unmapped along the western side of the basin (Gill 1966). The Fox Hills Sandstone is approximately 700 feet thick in the west part of the basin (Horn 1955) but is often undifferentiated from the overlying Lance Formation in west and northwest parts of the basin (Hose 1955).

Because of the disconnected nature of the individual sand bodies, hydraulic head data is not sufficient to define a potentiometric surface for a specific horizon within the Fox Hills Sandstone (Rankl 1990). Wells completed in the Fox Hills Sandstone have yields that typically range from 5 to 50 gallons per minute. Locally, this formation can yield over 200 gallons per minute, although lower yields are typically available in the western portion of the basin (Hodson 1973). Flowing artesian conditions (75 gpm) were present in a well in Campbell County, completed at a depth of 2,000 feet.

Lance Formation

Overlying the Fox Hills Sandstone is the Lance Formation. The Lance Formation consists predominately of very fine-to fine-grained lenticular, clayey, calcareous sandstone. Shale, coal and lignite beds are present within the formation, which has a typical thickness of 1,000 to 3,000 feet (Conoco 1982). Wells completed in the Lance Formation generally yield less than 20 gpm and most wells are drilled in outcrop areas for domestic and stock purposes. Because few wells are completed in this formation out toward the center of the basin, potentiometric surface data are limited. It is assumed that the direction of groundwater flow is generally to the north, similar to that of the overlying Fort Union and Wasatch Formations.

Fort Union Formation

The Paleocene Fort Union Formation is stratigraphically between the Lance Formation and the overlying Wasatch Formation, reaching a maximum thickness of approximately 3,500 feet within the Powder River Basin. The Fort Union Formation is described as continental and shallow non-marine deposits of sandstone, carbonaceous shale and coal. Outcrops of the Fort Union Formation encircle most of the basin and the beds dip basinward. This formation is a major source of coal within the Powder River Basin and the United States and is extensively exploited for coal bed methane reserves.

Water is generally produced from sandstone, jointed coal and clinker beds with maximum yields on the order of 150 gpm. Specific capacity determined from wells completed in the Fort Union Formation within the Powder River Basin are generally less than 1 gpm per foot of drawdown (Lowery 1966, and Whitcomb 1964).

The hydraulic gradient of the Fort Union and Wasatch aquifers in the vicinity of Moore Ranch is reported as 0.0014 ft/ft to the north-northwest by Conoco (1982).

Wasatch Formation

The Wasatch Formation is described as an arkosic fine- to coarse-grained sandstone with siltstone, claystone and coals. The Wasatch Formation was deposited as a mixture of alluvial, fluvial and paludal environments. The contact between the Fort Union Formation and the Wasatch Formation is gradational in the vicinity of Moore Ranch and is generally arbitrarily set at the top of the thicker coals or thick sequence of clays and silts (Conoco 1982). The boundary between the two formations was considered by Conoco to be the top of the Roland Coal. Maximum total thickness of the Wasatch Formation is greater than 1,000 feet (800 to 1,100 feet in the License Area). In the southern portion of the Powder River Basin, the Wasatch Formation generally dips to the northwest at 1.0 to 2½ degrees. The sandstones that contain the uranium mineralization are generally coarse cross-bedded arkosic sand deposited in a high-energy fluvial environment. Individual channel sand units are generally oriented northward.

There are commonly multiple water-bearing sands within the Wasatch Formation. Groundwater within the Wasatch aquifers is typically under confined (artesian) conditions, although locally unconfined conditions exist. Hodson et al (1973) reported that wells completed in the Wasatch typically yield 10 to 50 gpm in the north part of the basin but yields are generally greater in the south part of the basin with yields as high as 500 gpm possible. Specific capacities of wells completed in the Wasatch Formation are usually greater than for wells completed in the underlying aquifers. Specific capacities of 4 to 15 gpm/ft of drawdown were reported by Hodson et al. (1973).

As reported by Rankl and Lowry, most data available to describe aquifers in the Wasatch /Fox Hills sequence are from stock and domestic wells that are generally completed in small intervals of single formations at depths of less than 500 feet. There is large topographic relief in the area and because these wells are completed in sandstone aquifers at differing depths, hydraulic head data are generally not representative of a single continuous stratigraphic horizon and are not sufficient to provide potentiometric surfaces extending over great distances. The overall groundwater flow system in the shallow aquifers in the vicinity of Moore Ranch is toward the Powder River to the north-northwest. However, the aquifer systems are often locally controlled by stratigraphy and topography and attempts to confidently extend potentiometric surface data for any significant distance is difficult.

3.4.3.2 Site Hydrogeology

Groundwater

EMC has been collecting lithologic, water level, water quality, and pump test data as part of its ongoing evaluation of hydrologic conditions at the Moore Ranch Project. In addition to recent data acquisition, historic data collected for Conoco (1982) was used to support this evaluation. Drilling and installation of borings and monitor wells is ongoing in order to provide additional data to further refine the site hydrologic conceptual model. Water level measurements, both historic and recent, provide data to assess potentiometric surface, hydraulic gradients and inferred groundwater flow directions for the aquifers of interest at the Moore Ranch Project, at least on a localized scale. Recently completed pump tests by EMC and Petrotek Engineering Corporation (PEC 2008) as well as the pump tests conducted by Conoco (1982), were used to evaluate hydrologic properties of the aquifers of interest and to assess hydraulic characteristics of the confining units.

Figure 3.4.3-3 shows the monitor wells (current and historic) that were used in the site hydrologic evaluation. Table 3.4.3-1 (at the end of this section) provides data for those wells to the extent available.

Hydrostratigraphic Units

EMC has adopted the nomenclature used by Conoco (1982) for the hydrostratigraphic units of interest within the Moore Ranch Project. Sands above the Roland Coal are numbered, increasing upward. The 40 and 50 Sands are regionally extensive sands that are considered significant aquifers. The primary Production Zone is identified as the 70 Sand. The 70 Sand is bounded above and below by areally extensive confining units. with some localized exceptions, as will be discussed. Overlying the upper confining unit is the 72 Sand. The 72 Sand is considered the overlying aquifer to the Production Zone. The 72 Sand is the shallowest occurrence of groundwater across most of the Permit Area. However, localized perched groundwater conditions have been observed in the sand that overlies the 72 Sand, designated as the 80 Sand. The 80 Sand is present in outcrop over portions of the License Area. Beneath the lower confining unit is the 68 Sand. Although the 68 Sand is considered the underlying aquifer to the Production Zone, it is in communication with the 70 Sand in localized areas of the License Area, most notably in a small portion of proposed Wellfield 2. The 68 Sand also appears to coalesce with the underlying 60 Sand in portions of the License Area. Figure 3.4.3-4 depicts the hydrostratigraphic relationship of these units.

A brief description of each hydrostratigraphic unit follows, from shallowest to deepest.

80 Sand (Shallowest Occurrence of Groundwater in the License Area)

The uppermost sand unit within the permit area is the 80 Sand. The 80 Sand is present at the surface across portions of the site, reaching a maximum thickness of nearly 100 feet. The 80 Sand pinches out toward the south-southeast. The extent of saturated conditions in the 80 Sand within the permit area appears very limited. Three monitor wells (OMW-5, OMW-6 and OMW-7B) were recently installed specifically targeting the 80 Sand interval (Figure 2). Only one of these locations, OMW-7B (located in the north central portion of proposed Wellfield 2), contains sufficient water to allow for water quality sampling or pump testing. The groundwater at location OMW-7B is present under unconfined conditions and is most likely perched above the 72 Sand.

72 Sand (Overlying Aquifer)

The 72 Sand (Overburden above the 70 Sand) consists of a 50- to 250-foot thick sequence of clays, silts, discontinuous sandstones and alluvial sediments. The alluvial sediments are limited to the low-lying areas of surface drainages. A lignite marker bed, designated the "E" coal, is present across the site below the 72 Sand. As previously described, the 72 Sands are discontinuous, and when saturated, generally represent perched water conditions. Figure 3.3-12 is an isopach of the overburden thickness in the vicinity of the ore bodies. The 70 Sand is considered the uppermost continuous water-bearing unit within the License area.

The first potential aquifer overlying the Production Zone is the 72 Sand. The top of the 72 Sand occurs at depths of approximately 30 to 200 ft bgs within the Moore Ranch License Area. The total thickness of the sand ranges from 5 to 90 feet. This sand is discontinuous across the License area, pinching out to the west-southwest. The 72 Sand is unsaturated over the southern portion of the License Area. In areas that saturated conditions exist within the 72 Sand, this unit is considered the overlying aquifer to the Production Zone aquifer. Maximum saturated thickness observed within the License Area is approximately 60 feet. In some areas where the 72 sand is saturated, it is a perched aquifer system.

Upper Mudstone, E Coal and Lower Mudstone-Upper Confining Unit

Underlying the 72 Sand is a sequence of mudstone, shale and lignite. A persistent, laterally extensive lignite seam was identified by Conoco as the E Coal. The E Coal is located a few feet above the top of the 70 Sand and is a consistent marker bed for the License Area. The units above and below the E Coal were designated by Conoco as the Upper and Lower Mudstone, respectively. The sequence of Upper Mudstone, E Coal and Lower Mudstone are collectively considered the Upper Confining Unit to the Production Zone. Although the E Coal has some intrinsic permeability, its limited thickness (typically 3 feet or less) and limited extent of saturation precludes its use as a source of groundwater supply.

In some instances, saturated conditions have been found to exist in wells completed in shallower sands above areas where the upper portion of the 70 Sand is unsaturated indicating that, at least locally, perched water is present above the 70 Sand.

70 Sand (Production Zone Aquifer)

The 70 Sand contains uranium mineralization and is the Production Zone at the Moore Ranch Project. The total thickness of the 70 Sand ranges from 40 to 120 feet, but is typically 60 to 80 feet, (Figure 3.3-9*)*. The top of the 70 Sand ranges from approximately 100 to 330 ft bgs within the Moore Ranch License Area. This hydrostratigraphic unit is a really extensive (except to the south where it crops out) and dips to the northwest at less than one degree. The 70 Sand is present in outcrop or under a thin veneer of alluvium and topsoil just south of the License area over large portions of section 11 and 12 of T41N and R75W and Sections 6 and 7 of T41N and R74W. The area of 70 Sand outcrop is a recharge zone for the Production zone aquifer. Water entering the 70 Sand in this recharge area would flow north-northwest across the License Area.

Groundwater occurs in the 70 Sand under both confined and unconfined conditions. Data indicate that the potentiometric surface in the 70 Sand is close to the top of the sand itself (approximately 100 to 150 feet below ground surface). Confined conditions predominate in the northern portion of the Permit Area becoming unconfined to the south. Groundwater flow direction, based on the potentiometric data, is generally to the north. There is adequate hydrostratigraphic confinement between the production sand and/or the overlying/underlying sands over most of the site. In an eastern portion of Wellfield #2, the 70 Sand aquifer occurs under unconfined conditions and for the most part has adequate hydrostratigraphic confinement between the 70 Sand and overlying/underlying sands. However, lack of hydrostratigraphic confinement between the 70 Sand and the underlying 68 Sand occurs in the eastern/northeastern part of Wellfield #2. Additional mine-unit scale testing will provide data necessary to validate the approach for mining and monitoring this section of Wellfield #2. In the south part of the License Area, the 70 Sand is the shallowest occurrence of groundwater (although perched conditions may exist locally in some of the overlying sands and coals). The underlying aquifer to the 70 Sand is the 68 Sand.

Lower Confining Unit

Beneath the 70 Sand is a sequence of clays and silts ranging from 0 to 50 feet thick. The clay/silt sequence is absent in the area of monitor well UMW-2 where the 70 and 68 Sands coalesce.

68 Sand (Underlying Aquifer)

The first sand underlying the 70 Sand is identified as the 68 Sand. This unit is typically 40 to 60 feet thick but can reach over 75 feet in thickness (Figure 2.6-8). The 68 Sand appears to be laterally extensive across the permit area but coalesces with the 70 Sand at some locations, most importantly within portions of proposed Wellfield 2. Water levels in the 68 Sand monitor wells indicate this unit is under confining conditions across the site.

Unnamed Shale Unit

The unnamed shale at the base of the 68 Sand has not yet been fully characterized. This unit is generally 5 to 30 feet thick.

60 Sand

The 60 Sand is generally the first sand unit underlying the 68 Sand. In areas where the 70 and 68 Sand coalesce as one aquifer, the 60 Sand is considered the underlying aquifer to the Production Zone aquifer. The 60 Sand is approximately 100 feet thick and is continuous throughout the area. It is separated from the underlying 58 Sand by 5 to 70 feet of shale or mudstone with some interspersed sandstone lenses. Three additional monitor wells have been drilled and completed in the 60 Sand within the project area. The location of the wells are shown on Figure 3.4.3-3.

Deeper Wasatch Sands

Several deeper sands that are included in the Wasatch Formation are present beneath the License Area. The geologic cross sections described and included in Section 3.3 indicate, in descending order, the 58, 50, 40, 30, 20 and 10 Sands. Beneath the 10 Sand is the Roland Coal that is considered the top of the Fort Union Formation. Data from these deeper Wasatch Formation Sands are limited because these hydrostratigraphic units are not anticipated to be impacted by ISR activities at Moore Ranch and therefore have not been extensively characterized as part of this License application. The 40 and 50 Sands were considered by Conoco (1982) to be locally significant aquifers. However these hydrostratigraphic units are separated from the Production Zone aquifer by over 250 feet of section which includes the 68 Sand, the 60 Sand and the 58 Sand. The 68 Sand is the underlying aquifer across most of the site with the exception of areas where the 68 and 70 Sands coalesce. In those areas, the 60 Sand is considered the underlying aquifer. The 58 Sand is present between the 60 Sand and the 50 Sand. It is not anticipated that ISR activities will impact the 40 or 50 Sand within the License Area or areas downgradient. Monitor wells have been completed within the 58, 50 and 40 Sands along the southern portion of the License Area.

Potentiometric Surface, Groundwater Flow Direction and Hydraulic Gradient

The EMC hydrologic evaluation of the Moore Ranch Project included measurement of water levels in monitor wells completed in the 70 Sand (Production Zone), the overlying aquifer (72 Sand) and the underlying aquifer (68 Sand) to assess the potentiometric surface, groundwater flow direction and hydraulic gradient of those units. Additional historic water level data were available from the Conoco hydrologic evaluation of the site (1982). Water levels have also been measured in monitor wells completed in the 80, 60, 58, 50 and 40 Sands. Table 3.4.3-2 (at the end of this section) lists water level data recorded for the site monitor wells.

The potentiometric surface for the 70 Sand production zone is shown on Figures 3.4.3-5a through 3.4.3-5e. The figures show a consistent hydraulic gradient toward the north throughout the period of measurement (February 2007 through March 2008) with the exception of the July 2007 potentiometric surface map. The potentiometric surface in July 2007 (Figure 3.4.3-5c), indicates a depression at baseline monitor well MW8. Hydrographs have also been prepared for all of the baseline monitor wells completed within the 70 Sand that illustrate water level fluctuations since the wells were installed in 2006 The 70 Sand monitor wells on the west side of the License Area are shown on Figure 3.4.3-5f and on the east side on Figure 3.4.3-5g. Water level fluctuations are generally less than a few feet with the exception of monitor well MW8. MW8 showed a decrease of almost 20 feet in two measurements in July 2007 and then rebounded to previous levels. No direct cause has been identified for the decrease although it is suspected that the low water level is the result of slow recovery after purging the well prior to a sampling event. A potentiometric map was also constructed for the July 2007 data without including the MW8 measurement (Figure 3.4.3-5h). The results of the mapping indicate that the depression around MW8 is localized and does not impact the other baseline monitor wells. Water level data used to develop the potentiometric surface maps and the hydrographs are included in Table 3.4.3-2. Based on those data, the direction of groundwater flow within the 70 Sand is predominantly to the north, generally consistent with the regional flow system. The horizontal hydraulic gradient calculated from this data is approximately 0.0040 ft/ft (21.1 ft/mile).

Potentiometric maps of the 72 Sand were developed (Figures 3.4.3-6a through 3.4.3-6e). The figures illustrate that the potentiometric surface is relatively stable throughout the period of measurement (February 2007 through March 2008). Water levels collected from the overlying aquifer (72 Sand) indicate a similar northerly groundwater flow direction as for the 70 Sand aquifer, The horizontal hydraulic gradient calculated from the data for the 72 Sand aquifer is approximately 0.0039 ft/ft (20.4 ft/mile). Hydrographs of the 72 Sand baseline monitor wells indicate minimal change in the water level elevations within that hydrostratigraphic unit since the wells were installed in 2006 (Figure 3.4.3-6f). Water level data used to develop the hydrographs are included in Table 3.4.3-2. Saturated thickness of the 72 Sand ranges from 10 feet at OMW2 to over 50 feet at OMW1.

Potentiometric surface maps for the 68 Sand were also prepared (Figures 3.4.3-7a through 3.4.3-7e). The maps show that the horizontal hydraulic gradient is consistently toward the northwest, however the magnitude of the gradient varies. Changes in the horizontal hydraulic gradient are predominately caused by large fluctuations in water levels that occur in 68 Sand monitor well UMW3. Additional monitoring of that well was performed by EMC and is described in detail later in this section. Although the general direction of groundwater flow is also to the north, the horizontal hydraulic gradient calculated for the 68 Sand (0.0005 ft/ft [2.6 ft/mi]), is much flatter than for the 70 and 72 Sands. Hydrographs have been prepared for the 68 Sand baseline monitor wells showing water level changes over time for each well [Figure 3.4.3-7f]. With the exception of well UMW3, water levels remain relatively stable during the period of measurement (February 2007 through March 2008). Water level data used to develop the potentiometric surface maps and the hydrographs are included in Table 3.4.3-2.

Three monitor wells were installed in the 60 Sand during the spring of 2008. A potentiometric surface map of the 60 Sand is presented in Figure 3.4.3-8.

Vertical hydraulic gradients were determined by measuring water levels in closely grouped wells completed in different hydrostratigraphic units. Figure 3.4.3-9a shows the location of the well groups used for the assessment of vertical hydraulic gradients. Table 3.4.3-3 summarizes the calculated vertical gradients between the 72, 70, 68, and 60 Sand aquifers. The potentiometric surface of the 70 Sand ranges from 50 to 60 feet lower than the potentiometric surface of the overlying 72 Sand at the grouped wells, suggesting that the Overlying aquifer and the Production Zone aquifer are not in hydraulic communication. Vertical hydraulic gradients range from approximately 0.6 to 0.9 ft/ft between the 72 and 70 Sand aquifers and consistently indicate decreasing hydraulic head with depth (downward potential). A downward potential is indicative of an area of recharge, as opposed to an upward potential that is normally indicative of an area of groundwater discharge.

Hydrographs were constructed illustrating the hydraulic relationship between the 70 and 72 Sands at each of the four monitor well clusters (Figures 3.4.3-9b through 3.4.3-9e). Water level data used to develop the hydrographs are included in Table 3.4.3-2. The large difference in heads between the hydrostratigraphic units demonstrates a lack of hydraulic communication between them. Available data indicate the 72 Sand is a perched aquifer system in the southern portion of the License Area. The uppermost portion of the 70 Sand is unsaturated across the southern portion of the site. This unsaturated zone between the 70 Sand and the 72 Sand hydrostratigraphic units provides a buffer that will prevent hydraulic communication between the sands during production and restoration activities. Furthermore, the production and restoration phases of the project will be operated under a net bleed (overpumpage), resulting in declining water levels within the 70 Sand that will further separate the 72 and 70 Sands hydraulically.

Hydrographs illustrating the hydraulic relationship between the 68 and 70 Sands at each of the four well clusters were also developed and are shown on Figures 3.4.3-10a through 3.4.3-10d. Water levels between the MW1/UMW1 and MW2/UMW2 well clusters are very similar and no clear vertical hydraulic gradient predominates. The data are consistent with isopach maps that indicate the absence of the underlying shale between the 70 and 68 Sands in the central portion of Wellfield 2 and therefore possible hydraulic communication between those units. At the MW4/UMW4 well group there is a distinct downward hydraulic gradient between the 70 and 68 Sands with water levels in the 70 Sand monitor wells consistently 8 to 10 feet greater than in the 68 Sand monitor wells. In the area of the MW4 well group, the shale unit between the 70 and 68 Sand is 25 to 40 feet thick. The thickness of the shale unit, coupled with the large head difference indicates that the 68 and 70 Sand aquifers are not in direct hydraulic communication at this location. The hydraulic relationship between the 70 and 68 Sands at the MW3/UMW3 well pair is not clear because of the large fluctuations in water levels at UMW3. Figure-3.4.3-10e shows additional water level monitoring that has been conducted at monitor well UMW3. Water level data used to develop the potentiometric surface maps and the hydrographs are included in 3.4.3-2.

The cause for the large fluctuation in water levels in the 68 Sand at well UMW3 is unknown. Well UMW-3 experienced steady drawdown from February of 2007 through July 2007. Approximately 25 feet of water level decline was observed during that period. None of the other underlying 68 Sand wells in the project area showed this declining trend and only showed fluctuations of a few feet. From July 2007 until October 2007, water levels showed a gradual recovery in UMW3 only to drop off sharply again. The decrease in water levels in October 2007 was in response to a sampling event in which the well was purged prior to sampling. Almost two months following the sampling event, water levels in the well were still almost 18 ft lower than the pre-sample level (Figure 3.4.3-10e). This slow recovery indicates that the 68 Sand in the vicinity of UMW3 has a relatively low transmissivity or that there is significant skin damage in the well. The water level in UMW3 returned to static levels around February 2008. An August 2009 measurement at UMW3 indicates that the water level at that well is anomalously high.

The cause of the earlier declining trend in well UMW3 is unknown and was not replicated in other wells Additional investigation indicates that the drawdown observed in the water levels of UMW-3 from February through July of 2007 does not correspond with production from nearby CBNG wells. Production from the six closest wells was ongoing through both drawdown and subsequent recovery of the water levels in UMW-3. Water production from the CBNG wells in March 2008 was more than 5,780 bbls/day (WOGCC, 2008), while the water levels in UMW-3 stabilized in February 2008. The majority of produced water has come from the 34S-1 (NENE, Section 34, T42N, R75W) and 35S-4 wells (NWNW, Section 35, T42N, R75W). Impacts to the monitor well due to CBNG production seems highly unlikely given this scenario.

Water levels at two 60 sand monitor wells were compared to levels in overlying wells in August 2009. The water levels indicate a downward hydraulic gradient between the 60 and overlying 68 and 70 Sands (Table 3.4.3-3).

Aquifer Properties

Hydrologic properties for the Wasatch aquifers within the Moore Ranch Project area are estimated from historic and recent pumping tests. Dames & Moore conducted an initial investigation (1978) for Conoco of the hydrologic properties within three delineated ore bodies. The ore bodies were designated by Conoco as the 34 (located in Section 34 T42N, R75W) and 35N (located in the north portion of Section 35, T42N, R75W) and 35S (located in the south portion of Section 35, T42N, R75W). Conoco performed additional hydrologic evaluation in 1982 to determine the feasibility of in-situ and/or open pit production of those uranium ore bodies.

EMC conducted pump tests in 2007 and 2008 to evaluate hydrologic properties of the Production Zone aquifer (70 Sand). Results of the hydrologic testing are summarized below.

Additional hydrologic testing was performed in August 2009 to evaluate hydrologic properties of the other hydrostratigraphic units that could be potentially impacted by ISR operations including the shallowest occurrence of groundwater (80 Sand), the overlying aquifer (72 Sand), the underlying aquifer (68 Sand) and the unit underlying the area where the 70 and 68 Sands coalesce (60 Sand). Results of those tests will be provided in a supplemental hydrologic testing report.

Historic Pump Tests

A series of aquifer tests were conducted on the Moore Ranch project from 1977 through 1980 to assess hydraulic characteristics of the Production Zone as well as overlying and underlying hydrostratigraphic units. Initial testing was performed by Wyoming Water Resources Research Institute (WWRI). Dames & Moore's assessment of the initial testing was that the results were unsatisfactory because of improperly developed wells, inadequate water level measurements and inappropriate analysis methods (Dames & Moore, 1978). Conoco redeveloped the wells using airlift pumping. Data collected during development of the wells were analyzed by Conoco to determine aquifer characteristics; additional pump tests also were conducted and analyzed by Conoco. A summary of the Conoco tests that were conducted to assess conditions within the ore bodies at Moore Ranch is presented below (See Appendix A5 for Historic hydrologic analysis by Conoco). Information on the pumping wells and observation wells utilized in the pump tests are provided in Table 3.4.3-1 and the locations of the wells are shown on Figure 3.4.3-9.

- A pumping test was conducted on 8/17/77 at well 885 with wells 886, 887 and 888 as observation wells. These wells are located within the 34orebody. Well 885 was pumped for 1 day (1440 minutes) at a rate of 3.4 gallons per minute (gpm). Observation wells 886, 887 and 888 were located 64, 115 and 50 feet, respectively, from the pumping well. Drawdown in the observation wells at end of test for 886, 887 and 888 were 0.74, 0.76 and 1.94 feet, respectively. All wells are completed within the 70 Sand except for well 887, which is completed in the 68 Sand. The response of well 887 during the pumping test indicates the possibility that there is hydraulic communication between the 70 and 68 Sands in the vicinity of the 34orebody. The Conoco Mine License Application states that the seal between the sands in well 887 was questionable.

- The previously described wells were redeveloped using airlift methods. Recovery following redevelopment was recorded at wells 886 and 887. The effective pumping rate was 2 gpm for 886 and 0.1 gpm for 887 with 0.7 and 12 feet of drawdown, respectively.

- A pumping test was conducted within the 35N orebody on 6/25/78. Well 1 was pumped at 3.5 gpm for 140 minutes. Observation wells 1805 and 1806, located 36 and 73 feet, respectively from the pumping well, had measured drawdown of 0.71 and 0.54 feet at the end of the test. The pumping well and the observation wells are all completed within the 70 Sand.

- A second pumping test was conducted at Well 1 on 6/25/78 to evaluate hydraulic communication with the 68 Sand within the 35N orebody. Well 1 was pumped at 2.5 gpm for 170 minutes. Observation well 1807 is located 111 feet from pumping well and completed within the 68 Sand. Drawdown of 0.37 feet was measured at well 1807 at the conclusion of the pumping test. The test results indicate that there may be hydraulic communication between the 70 and 68 Sand within the Wellfield 2 orebody. However, the Conoco Mine License Application indicates the results are inconclusive based on concerns regarding the integrity of the well completion in 1807.

- Well 1814, located within the 35S orebody, was pumped at 19 gpm for 1140 minutes beginning on 12/1/78. A maximum drawdown of 1.87 feet was measured at well 1816, located 55 feet from pumping well. Both the pumping and observation wells are completed within the 70 Sand.

- Well 1823 was pumped for 70 minutes at 1.7 gpm on 5/22/80. Well 1823 is located within the 35S orebody and is completed in the 68 Sand. Over 6 feet of drawdown was measured in that well during the test. Water levels were also measured in observation well 1816 during the test. Well 1816 is located 70 feet from 1823 and completed in the 70 Sand. Water levels in well 1816 showed a slight increase during the pumping test, indicating a possible lack of hydraulic communication in that area between the 68 and 70 Sands.

- Well 1814, located in the 35S orebody, was pumped at an average rate of 16.8 gpm over 3,100 minutes, beginning on 8/13/80. Maximum drawdown at the pumping well was 32 feet. The maximum drawdown in the well occurred approximately 1170 minutes into test. The pumping rate gradually decreased after that time (from 17.1 gpm to 15.8 gpm) and the water levels showed slight recovery during the latter portion of the test. Water levels were recorded during the test at observation wells 1816, 1815, 1817, and 1823, located 34.5, 89, 228 and 75 feet from the pumping well, respectively. All of the wells are completed in the 70 Sand except for 1823, which is completed in the 68 Sand. Maximum drawdown measured in the 70 Sand observation wells was 2.87 feet (1816), 1.3 feet (1815) and 0.2 ft (1817). Water levels in well 1823 did not show any drawdown, again indicating hydraulic separation between the 68 and 70 Sand in this portion of the license area.

Results of the tests were variable with the highest transmissivity and hydraulic conductivity values determined for the 35S orebody. The results from the aquifer tests are summarized in Table 3.4.3-4. Based on internal review of the data by PEC, representative values are presented in the table along with the range.

Table 3.4.3-4 Summary of Conoco Pump Test Results – 68 and 70 Sand
Moore Ranch Project

	Range of Values	*Representative Value*
34-Orebody		
Transmissivity (T; ft^2/d)	23 to 240	110

Hydraulic Conductivity (k; ft/day)	0.38 to 4.0	1.9
Net Sand Thickness (h; ft)	60	60
Storativity (S)	5.3×10^{-6} to 2.9×10^{-3}	9.8×10^{-4}
35N-Orebody		
Transmissivity (T; ft^2/d)	112 to 297	165
Hydraulic Conductivity (k; ft/day)	0.95 to 1.52	1.4 ft/d
Net Sand Thickness (h; ft)	80	80
Storativity (S)	8.0×10^{-5} to 5.2×10^{-4}	2.5×10^{-4}
35S-Orebody		
Transmissivity (T; ft^2/d)	374 to 735 ft^2/d	555
Hydraulic Conductivity (k; ft/day)	9.35 to 18.3	13.8
Net Sand Thickness (h; ft)	40	40
Storativity (S)	3.2×10^{-4} to 4.3×10^{-3}	1.4×10^{-3}
Specific Yield	0.01 to 0.058	0.032

Note: The 70 Sand is only partially saturated in the vicinity of the 35 N and 35S ore-bodies

Additional testing was performed by Conoco in an area to the southeast that was selected as a potential site for evaporation ponds. The purpose of that testing was primarily to assess hydraulic characteristics of the near-surface soils with respect to suitability for pond placement.

Limited data (e.g., laboratory analyses or detailed pump test data) regarding the vertical hydraulic conductivity of the confining units are available for the Moore Ranch Project Area. However, the data from other ISR operations in the Powder River Basin (COGEMA Mining Corporation and Power Resources Inc) appear to be reasonably analogous to Moore Ranch. In this regard, the COGEMA and PRI data indicate the vertical hydraulic conductivity of clays/shales in the Wasatch is on the order of 10^{-7} to 10^{-11} cm/sec (10^{-4} to 10^{-7} ft/d).

EMC did not analyze the data from the Conoco pump tests and only reported the results of the analyses performed by Conoco. The raw data from the Conoco pump tests were unavailable for additional analysis.

2007 Pump Tests

EMC conducted three pump tests in 2007 to evaluate aquifer properties of the 70 Sand. The initial pump test plan called for a single pump test.

The limited historic data (Conoco) suggested it might be possible to test the entire Moore Ranch Project Area in one test (e.g., by pumping from only one well). For this reason, the pumping well (PW-1) was centrally located between the ore bodies and installed specifically for use as a pumping well. However, based on the results from the first test that indicated greater than anticipated transmissivity and hydraulic conductivity, two additional pump tests were conducted. Table 3.4.3-1 provides basic well information for the pumping wells and observation wells used in the tests. Table 3.4.3-5 summarizes the pump test parameters. The location of pumping wells and observation wells are provided in Figure 3.4.3.10. Details regarding the pump test procedures and results are provided in Appendix A1.

The data collected from the 2007 pump tests was suitable for general scoping purposes to determine if ISR methods could be successfully applied at the site. However, the data collected from the 2007 pump tests were not conducive to detailed analysis of aquifer properties because of the limited radius of influence and the strong impacts that barometric changes had on water level data during the tests.

In the test at well PW1, drawdown was observed at observation well MW1 located approximately 109 feet from the pumping well. However, that test was not run under a constant rate, making analysis of the data collected during the test more qualitative than quantitative.

During the MW2 pump test, drawdown was observed at well 1805, completed within the 70 Sand at a distance of 346 feet from the pumping well. That well was analyzed using the Neuman method of analysis that is suitable for delayed yield response typical of unconfined aquifers. Results of the unconfined analysis of well 1805 are included in Figure 3.4.3-13.

The pump test that was performed at well MW3 resulted in no discernible drawdown at any of the monitor locations. The closest 70 Sand monitor well to the pumping well was more than 1,300 feet away.

Table 3.4.3-5 Summary of Moore Ranch 2007 Pump Test Parameters

Test No.	*Pumping Well*	*Duration (minutes)*	*Duration (days)*	*Flow Rate (gpm)*	*Comments*
1	PW-1	13,275	9.2	16.5	20.6' drawdown in PW1; only other response observed was in MW-1 (distance of 109')
2	MW-2	1,465	1.0	26.0	19.4' drawdown in MW-2; response in Well 1805 (70 Sand, distance of 346'); UMW-2 (68 Sand; distance of 10'), 1807 (68 Sand; distance of 252')
3	MW-3	5,535	3.8	14.4	17.8' drawdown in MW-3; no response in any other monitor wells

Transmissivity (T) results from the analysis of the 2007 pump test data for the 70 Sand range from 329 to 724 ft^2/d, with an average value of 538 ft^2/d. Based on an average thickness of 71 feet, the average hydraulic conductivity (K) is 7.5 ft/d. Assuming a water viscosity of 1.35 cp (50 degrees F) and a density of 1.0, this equates to a permeability of approximately 2,000 millidarcies (md). No storativity values were determined because two of the tests were run under unconfined conditions and the third test did not include an observation well completed within the pumped aquifer. Details of the methods of analysis of the 2007 pump tests and the results are discussed in Appendix A1. Table 3.4.3-6 provides a summary of the aquifer properties estimated from the recent pump test results.

Table 3.4.3-6 Summary of Aquifer Properties Estimated From Recent Pump Test Results

Pump Test	Representative Value
Central Location Between Wellfields 1 and 2 (PW-1 Test)	
Transmissivity (T; ft2/d)	542
Hydraulic Conductivity (k; ft/day)	8.4
Net Sand Thickness (h; ft)	64
Wellfield 1 Test (MW-3)	
Transmissivity (T; ft2/d)	329
Hydraulic Conductivity (k; ft/day)	4.6
Net Sand Thickness (h; ft)	72
Wellfield 2 Test (MW-2)	
Transmissivity (T; ft2/d)	640
Hydraulic Conductivity (k; ft/day)	8.2
Net Sand Thickness (h; ft)	78

All results are with respect to the Production Zone Aquifer (70 Sand)

No water-level change of significance was observed in the overlying OMW-1 or underlying UMW-1 completions as a result of pumping the PW-1 well completed in the 70 Sand. The UMW-1/OMW-1 wells are located approximately 109 feet from PW-1. No changes of significance were observed in the overlying monitor well during the MW-2 pump test. Well OMW-2 declined slightly during the pumping period, however, the decline continued during recovery. Underlying completions UMW-2 and 1807 (completed in the 68 Sand 252 feet distant) directly responded to pumping, which is expected as the 70 and 68 Sands coalesce in that area.

No significant change in water level was observed in OMW-3 (overlying completion) during the MW-3 pump test. The underlying well (UMW-3) declined steadily during the background monitoring, pumping, and recovery periods (Appendix A1, Figure 5-15). The declining trend in UMW-3 continued through July of 2007, followed by a recovery trend until October 2007. In October 2007, UMW3 was purged prior to sampling. The water level was lowered as a result of the purging and took several months to recover to static levels. As discussed previously, the cause of the decline is not known; however, long-term monitoring data clearly indicate that the decline was not a result of the MW-3 pump test and has not had an impact on water levels in MW-3.

As previously discussed, the potentiometric surface of the overlying 72 Sand is approximately 50 feet higher than the 70 Sand. This difference in potentiometric surfaces supports the testing data that demonstrate isolation between the 72 and 70 Sands. Hydrographs illustrating the hydraulic relationship between the 70 and 72 Sands are attached (Figures 3.4.3-11a through 3.4.3-11d). Water level data used to develop the hydrographs are included in Table 3.4.3-2. The large difference in heads between the hydrostratigraphic units demonstrates a lack of hydraulic communication between them. Available data indicates the 72 Sand is a perched aquifer system. The uppermost portion of the 70 Sand is unsaturated across much of the site. This unsaturated zone between the 70 Sand and the 72 Sand hydrostratigraphic units provides a buffer that will prevent hydraulic communication between the sands during production and restoration activities. Furthermore, the production and restoration phases of the project will be operated under a net bleed (overpumpage), resulting in declining water levels within the 70 Sand that will further separate the 72 and 70 Sands hydraulically.

The difference in potentiometric surface between the 68 and 70 Sand is variable across the site, indicating a downward gradient in some areas and upward gradient in others. There is very little difference in potentiometric heads in the vicinity of MW-2/UMW-2 where coalescing of the 68 and 70 Sands occurs.

The test results demonstrate that:

- The 70 Sand monitor wells located in the near proximity to the pumping well are in communication, indicating that the 70 Sand Production Zone has hydraulic continuity. While communication was not exhibited over the entire area, geologic information clearly shows that the 70 Sand is a contiguous sand body across Moore Ranch Project Area. Additional (mine unit) scale testing required by NRC and WDEQ will demonstrate communication throughout each mine unit between the pumping well(s) and the monitor well ring;
- To adequately stress the 70 Sand, future pump tests will require multiple pumped wells. Results of a numerical model simulation indicate that it will take numerous pumping tests to demonstrate hydraulic communication with all wells in the monitor well ring (Numerical Modeling of Groundwater Conditions Related to Insitu Recovery at the Moore Ranch Uranium Project, Wyoming, Petrotek Engineering

Corporation, 2008). The hydrologic testing to be conducted to complete the requirements of the wellfield data package will be designed in such a way as to: 1) adequately characterize the aquifer properties of the production zone aquifer; 2) indicate hydraulic communication between the production zone and the monitor well ring; 3) identify confinement or lack of confinement with overlying and underlying aquifers; and 4) and identify hydrologic boundaries within the production zone aquifer..

- Within the proposed Wellfield areas the 70 Sand has been adequately characterized with respect to hydrogeologic conditions within the test area at the Moore Ranch Project Area;
- Adequate confinement exists between the 70 Sand Production Zone and the overlying 72 Sand in the areas of the proposed wellfields for ISR operation;
- Adequate confinement exists between the 70 Sand Production Zone and the underlying 68 Sand in the area of proposed Wellfield 1. Where the 68 and 70 Sands coalesce in the center of Section 35 (proposed Wellfield 2) mining operations will be designed to account for this variation in geology and mine-unit scale testing will demonstrate the validity of the recommended approach(s); and,
- Sufficient testing has been conducted to date at Moore Ranch to proceed with a Class III UIC license application and a NRC license application.

2008 Pump Test Results

EMC and PEC conducted a pump test in 2008 designed to replicate operational conditions for the 70 Sand. A 5-spot pattern was installed within proposed Wellfield 2. The test included a central extraction well, four injectors spaced 100 feet apart, and several additional observation wells at distances of 10, 30, 40 and 70 feet from the extraction well. Boring logs and water level data confirmed that the wells included in the 5 Spot Pump Test were all within the unconfined portion of the 70 Sand. The initial phase of the test included only pumping from the extraction well. The well was pumped at a rate of 22.3 gpm for nearly 4 days. Drawdown in the extraction well at the end of the test was approximately 21 ft. Drawdown at the four corner injection wells (without injection) was between 3.7 and 4.1 ft. After completion of the first phase of the test, water levels were allowed to recover to near static conditions and then an injection/extraction phase was conducted where water pumped from the extraction well was injected into the injection wells. The extraction rate was 20 gpm. The extracted water was equally partitioned between the 4 injection wells (5 gpm per well) for a period of 2 days. Then, two of the wells were shut-in and the 20 gpm of extracted water was injected equally into only two wells (10 gpm each). After 1 day, a third injection well was shut-in and all of the extracted water was injected into a single well for a period of 1 day. The single injection well was able to accept all 20 gpm of the extracted groundwater.

The pumping, injection and observation wells were instrumented to allow continuous monitoring during all phases of the test. The data collected from the test was analyzed using a variety of analytical methods including Theis, Cooper-Jacob, Neuman (delayed yield) and Theis recovery. Results of the analyses indicate that the Neuman (delayed yield, unconfined conditions) method provided the best fit to the data. Furthermore, analytical results using the Neuman method were typically only 60 to 70 percent of the value determined using the standard Theis method. Data and analysis from the test are provided in Appendix A2 (Technical Memorandum "5 Spot Pump Test, Results, Analysis and Modeling, Moore Ranch Uranium Project" (Petrotek 2008a) that is attached. The analytical results reported in that report are considered the most representative of site conditions and provide the basis for additional calculations and modeling pertaining to production and restoration operations. Adjustments to aquifer property data and calculations dependent on those aquifer properties will be made as that data becomes available throughout the project.

Recently acquired field data from a 5 Spot Pump Test provides reliable and representative aquifer characterization of the 70 Sand. Data and analysis from the test are provided in Appendix A2. The results of the pump test were used to construct and validate numerical models that will be used to design future pumps tests that will adequately demonstrate hydraulic communication within the production zone. Results of the modeling indicate that multiple pumping tests will be required to demonstrate hydraulic communication across the production zone. A preliminary simulation of such a pump test and full description of the model development and model simulations is provided in the Appendix A4 report "Numerical Modeling of Groundwater Conditions Related to Insitu Recovery at the Moore Ranch Uranium Project, Wyoming" (Petrotek 2008b).

The recently completed 5-Spot Pump Test provided sufficient information to adequately characterize the 70 Sand aquifer system in an area where it is predominately under unconfined conditions. The aquifer characterization data has been incorporated into numerical models that will be used to assist in the design of wellfield development, production and restoration. The 5 Spot Pump Test demonstrated that the aquifer is very responsive to pumping. For example, during the first phase of the 5-Spot Pump Test with pumping occurring at a single extraction well at a rate of 21.7 gpm, drawdown of over 2 feet occurred at all wells within the test area within 1 day. The maximum distance from the pumping wells to the wells on the exterior of the pattern was 71 feet. Using parameters determined from the 5-Spot test (transmissivity of 300 ft2/d, and a specific yield of 0.028), the calculated drawdown at a distance of 500 feet from the pumping well would be approximately 0.5 feet after 10 days of pumping at 22 gpm (Figure 3.4.3-13). The data indicate that a cone of influence could rapidly extended out to a monitor well ring 500 feet from the mined ore zone and that an excursion could be reversed within a relatively short period of time. Additional model simulations will be performed to further refine the methods that would be employed to recover an excursion and to determine the time frame that recovery could be accomplished.

Also, an additional pump test was performed on the historic Conoco well 885 in the summer of 2008. In 1977, Conoco pumped well 885 at a rate of 3.4 gpm for a period of 1 day (a total of 4,900 gallons). During the test, Conoco reported drawdown in an underlying monitoring well (887) of 0.76 feet. The underlying well was reported to be a distance of 119 feet from the pumping well. Conoco stated in its report that the well seal was suspect. Drawdown was also measured at two other 70 Sand monitor wells, 886 and 888, reported to be 64 and 50 ft, respectively from the pumping well. The drawdown in those wells was reported as 0.74 and 1.95 ft, respectively. Note that the well locations reported in the Conoco Permit to Mine Application indicate that the distance from the pumping well to 887, 886 and 885 are actually 159, 161 and 12 feet respectively.

In an attempt to verify the hydraulic communication reported by Conoco, EMC conducted a pump test at well 885 on 6/4/08. Well 885 was pumped at a rate of approximately 15.6 gpm for a period of 20 hours (18,600 gallons). This test provided a significantly larger hydraulic stress to the 70 Sand than the Conoco test. The underlying monitor well (887) showed no response due to pumping of the production zone well (885). There was an unexplained and abrupt shift in the water level at well 887 halfway into the test. However, the shift does not appear to be related to the pumping test because it was a sharp instantaneous rise in water level of 0.1 feet approximately 11 hours into the test. No drawdown was observed during the duration of the test. Drawdown in well 885 was 17.4 feet at the end of the test. Drawdown at 70 Sand monitor well 888 at the end of the test was 2.6 ft. There was no drawdown indicated at location 886 during the test. A map showing the location of the pumping well and monitor wells and plots of the water level data collected during the test are attached. Based on the results of the test, EMC has demonstrated there is no communication between the 70 Sand and 68 Sand in the vicinity of the 885 monitor well. Results of this test can be found in Appendix A3 and the historic testing performed by Conoco can be found in Appendix A5.

2009 Pump Test Results

A series of short term pump tests were conducted in August 2009 to evaluate hydrologic properties of the 72, 68 and 60 Sand aquifers. The tests were conducted in areas where well clusters are located in order to allow assessment of hydraulic communication between the pumped aquifer and overlying and underlying units. One of the well clusters is located within Wellfield 1 and includes monitor wells MW-3 (70 Sand), OMW-3 (72 Sand), UMW-3 (68 Sand) and UMW-11 (60 Sand). The other well cluster is located within Wellfield 2 and includes monitor wells MW-2 (70 Sand), OMW-2 (72 Sand), UMW-2 (68 Sand) and UMW-10 (60 Sand).

Two short term pump tests were conducted in the 72 Sand at monitor wells OMW-2 and OMW-3 in August 2009. Wells completed in the underlying aquifer were monitored during the tests. The OMW-3 pump test was repeated three times because of the short duration of the tests. The pumping rate ranged from 0.91 to 0.94 gpm for the tests and the length of the tests ranged from 15 to 31 minutes. Total drawdown in the well was rapidly stabilized at 0.6 feet for each test. No response was observed in the underlying 70 Sand monitor well (MW-3) during the test. Estimated transmissivity for the 72 Sand from the OMW-3 test is 280 to 300 ft^2/d. Well OMW-2 was pumped for 33 minutes at 0.84 gpm. The test was terminated when the flow dropped below the pressure transducer. There was less than 10 feet of water column in the well at the start of the test. Total drawdown in the well was 7.1 feet at the end of the test. No response was observed in the underlying 70 Sand monitor well (MW-2) during the test. The transmissivity of the 72 sand at OWW-2 was not estimated because the test was terminated before the casing storage was withdrawn.

Two short term pump tests were conducted in the 68 Sand at monitor wells UMW-2 and UMW-3 in August 2009. Well UMW-2 is located within Wellfield 2 in the area where the 68 and 70 Sands coalesce. Wells completed in the overlying and underlying aquifers were monitored during the tests. Well UMW-2 was pumped for 112 minutes at 1.1 gpm. Total drawdown in the well was 63.5 feet at the end of the test. No response was observed in either the overlying 70 Sand monitor well (MW-2) or the underlying 60 Sand monitor well (UMW10). Estimated transmissivity from the UMW-2 test is 0.5 to 0.7 ft^2/d. Well UMW-3 was pumped for 20 minutes at 0.8 gpm. Total drawdown in the well was 21.3 feet at the end of the test. The test was terminated because the water level fell below the level of the transducer. No response was observed in either the overlying 70 Sand monitor well (MW-3) or the underlying 60 Sand monitor well (UMW11). Transmissivity was not estimated from the UMW-3 test because the test did not run long enough to exceed the casing storage in the well. It can be reasonably assumed that the transmissivity of the 68 Sand in the vicinity of UMW-3 is of the same magnitude as that estimated at UMW-2, both of which are significantly lower than the transmissivity of the 70 Sand aquifer.

Two short term pump tests were conducted in the 60 Sand at monitor wells UMW-10 and UMW-11 in August 2009. Wells completed in the overlying aquifer (68 Sand) were monitored during the tests. Well UMW-10 was pumped for 26 minutes at 5.4 gpm. Total drawdown in the well was approximately 85 feet at the end of the test. No response was observed in the overlying 68 Sand monitor well (UMW-2). Estimated transmissivity from the UMW-10 test is 2.4 ft^2/d. Well UMW-11 was pumped for 141 minutes at 2.1 gpm. Total drawdown in the well was approximately 75 feet at the end of the test. No response was observed in the overlying 70 Sand monitor well (UMW-3) during the test. Estimated transmissivity from the UMW-11 test is 1.4 ft^2/d. Note that the transmissivity calculated from both 60 Sand pump tests is significantly lower than the transmissivity of the 70 Sand aquifer. A Technical Memorandum: Evaluation of Potential Impacts to the 68 Sand from ISR Production in Wellfield 2, Moore Ranch Uranium Projects, Wyoming, is presented Appendix A6.

3.4.3.3 Groundwater Quality

EMC has installed a monitor well network to evaluate pre-mining baseline conditions within the License Area. The location of the monitor wells are shown on Figure 3.4.3-12. Four well groups or clusters were constructed, each including a completion in the Production Zone aquifer (70 sand), the overlying aquifer (72 Sand), and the underlying aquifer (68 Sand). In addition to the well groups, four wells completed in the 70 Sand are included in the baseline water quality monitoring network. Three monitor wells have also been installed in the 60 Sand which underlies the 68 Sand. One of those 60 Sand monitor wells is located in the area where the 68 and 70 Sands coalesce. A row of monitor wells completed in the 58, 50 and 40 Sands was installed in the southern portion of the License Area. Three wells were also installed in the 80 Sand that overlies the 72 Sand. Only one of those 80 Sand monitor wells contains sufficient water for sampling. Table 3.4.3-10 provides a summary of well construction information. The parameters included in the EMC Monitoring Program are listed in Table 3.4.3-11.

Three of the original Conoco wells, 8-3, 1808, and 885, and 4 private stock wells were also included in the monitoring program. These wells are not a part of the baseline monitoring program. Water quality from these wells are used only for comparison to historical water quality collected by Conoco. Monitor wells 8-3 and 1808 are completed across both the 70 and 68 Sands. Monitor well 885 is only completed across the 70 Sand.

Information regarding site water quality is primarily derived from studies conducted by Conoco (1982) and from baseline monitoring of the Moore Ranch Project by EMC. Conoco began a baseline groundwater monitoring program in 1978 as part of its Mine Permit Application for the Sand Rock Project. EMC initiated a baseline groundwater monitoring program in 2007 to collect data required for the Permit to Mine and NRC License Applications for the Moore Ranch Uranium Project. Some of the historic Conoco baseline wells were either completed across multiple sands or are of questionable well construction/integrity. Those wells of questionable construction or that are completed across multiple sands are not considered as part of the baseline water quality for purposes of obtaining a license. Data from those wells are included for discussion of background water quality for informational purposes only.

Regional Water Quality

Water quality within the Powder River Basin ranges from very poor to excellent. Groundwater in the near surface, more permeable aquifers is generally of better quality than groundwater in deeper and less permeable aquifers. However, significant regional aquifers are present at depth that can provide relatively good quality water. In particular, the Mesaverde Formation, Frontier Formation, Madison Limestone and Tensleep Sandstone can produce large quantities of acceptable quality water. But overall, water quality tends to degrade moving into the deeper portions of the Powder River Basin.

Sources of water quality data include the historic USGS WATSTOR data system (now replaced by the National Water Information System), the Wyoming Water Resources Research Institute (WWRI) data system (WRDS) and compilations by various authors including Hodson (1971 and 1974), Larson and Daddow (1984), Crawford (1941), Crawford and Davis (1962) and Wells (1979).

Water quality from the Madison Limestone illustrates the downgradient, basinward increase in TDS levels. Springs from Madison outcrops along the west side of the basin generally yield calcium bicarbonate type water containing less than 500 mg/l TDS. Further into the basin, groundwater within the Madison aquifer becomes progressively more saline with TDS values rapidly exceeding 3,000 mg/l. Groundwater transitions to a sodium sulfate, sodium-chloride water type with distance from recharge areas. TDS concentrations rapidly increase in Western Converse County, possibly related to the structural complexity along the north flank of the Laramie Mountains (Feathers 1981).

Similarly, in the western half of the Powder River Basin, water quality from outcrop areas of the Tensleep Formation is generally below 500 mg/l TDS. Low TDS waters tend to be predominately magnesium to calcium-bicarbonate type. Higher TDS samples generally are associated with higher sodium sulfate or sodium chloride levels. (Feathers 1981)

A study conducted by Lowry et al (1986) that included the Powder River Basin as well as upstream parts of the Belle Fourche and Cheyenne River basins, reported that 84 percent of wells and springs reviewed exceeded the USEPA secondary drinking water standard for TDS (500 mg/l) and approximately 55 percent of the samples exceeded 1,000 mg/l. The sample set included 693 wells and springs. The average TDS concentration (in mg/l) reported in the study by formation is shown in Table 3.4.3-7.

Table 3.4.3-7 Total Dissolved Concentration by Formation, Powder River Basin (after Lowry et al 1986)

Formation	Average	Min	Max	No of Samples
Alluvium	2,128	106	6,610	38
Wasatch Formation	1,298	227	8,200	191
Fort Union Formation	1,464	209	5,620	257
Fox Hills/Hells Creek Formations	1,100	340	5,450	73
Lance Formation	1,218	251	2,850	31
Tensleep Sandstone*	874	230	6,820	15
Madison Group	1,503	65	3,240	25

* Most of the Tensleep Sandstone samples were collected from springs and near formation outcrop areas

The study noted that the dominant factor affecting TDS concentration within an aquifer is most likely the length of the flow path from recharge to discharge. Wells close to recharge areas generally have the lowest TDS levels and wells farthest from the recharge areas tend to have the highest TDS levels. Only 8 percent of the samples exceeded 3,000 mg/l.

Total dissolved solids levels within the Fox Hills Sandstone are generally higher in the western side of the basin than the eastern side, ranging between 1,000 and 2,000 mg/l. No water type is prevalent. TDS values from the Lance Formation range from about 200 to more than 2,000 mg/l but are typically between 500 and 1,500 mg/l (Hodson 1973).

Water quality for the Fort Union aquifer is described by Hodson (1973) as having TDS values ranging from 200 to more than 3,000 mg/l, but typically is between 500 and 1,500 mg/l. Water type for the Fort Union is predominately sodium bicarbonate to sodium sulfate.

Within the Wasatch, TDS ranges from less than 200 to more than 8,000 mg/l but typically ranges between 500 and 1500 mg/l. Sodium sulfate and sodium bicarbonate are the dominant water types for the Wasatch aquifer system.

The study by Lowry (1986) indicated that manganese levels exceeded the USEPA secondary drinking water standard (SDWS) of 50 µg/l in 43 percent of the 257 samples reviewed. Iron concentrations exceeded the USEPA SDWS (0.3 mg/l) in over 15 percent of the 366 samples reviewed. Selenium levels exceeded USEPA Maximum Contaminant Level (MCL) of 0.05 mg/l, in a small percentage of the wells (2.5 percent). Lead levels exceeded the MCL of 0.015 mg/l in 3.6 percent of the samples. There was no breakdown of the sample groups by formation reported in the study.

Radionuclide data for the Powder River Basin are sparse outside of the uranium mining areas. Feathers and others (1981) reported uranium ranging from 0.5 to over 10,000 µg/l for 96 samples collected from mine monitor wells completed in the Wasatch Formation. Radium-226 samples from the same sample group ranged from 0.2 to 173 pCi/l. Samples from five non-mining locations indicated uranium levels at or below 0.6 µg/l and radium-226 levels at or below 0.8 pCi/l.

Uranium levels from 31 samples from mine monitor wells completed in the Fort Union Formation ranged from 5 to 3,550 µg/l (Feathers 1981). The radium-226 concentration in those same wells ranged from 3.7 to 954 pCi/l. Samples from non-mine wells completed in the Fort Union Formation were generally low in uranium and radium-226 concentration. Samples from Lance and Fox Hills wells were much lower than those completed in the Wasatch and Fort Union mine wells but were similar to the non-mine wells for those formations.

Near Moore Ranch, hydrostratigraphic units deeper than the Fox Hills Sandstone are generally too deep to be economically developed for water supply or have elevated TDS concentrations that renders them unusable for consumption. At Moore Ranch, the Lower Cretaceous and Paleozoic aquifers are separated from the Wasatch aquifer by over 5,000 feet of sediments.

Site Baseline Water Quality

Information regarding site water quality is primarily derived from studies conducted by Conoco (1982) and from ongoing exploration and delineation of the Moore Ranch Project by EMC. Conoco began a baseline groundwater monitoring program in 1978 as part of its Mine License Application for the Sand Rock Project. EMC has initiated a baseline groundwater monitoring program to collect data required for the Permit to Mine and NRC License Applications for the Moore Ranch Uranium Project

Groundwater Monitoring Network and Parameters

Historic Network/Parameters

Conoco installed monitor wells within the License Area that were completed in the Production Zone aquifer (70 Sand), the underlying aquifer (68 Sand), the 40-50 Sand, and the Roland Coal. The locations of the Conoco monitor wells that were sampled for water quality are shown on Figure 3.4.3.-11. Table 3.4.3-8 provides construction details for the Conoco monitor wells used in the initial baseline analysis for the area. The parameters included in the Conoco Monitoring Program are listed in Table 3.4.3-9.

Based on the data provided in the Conoco Mine License Application (1982), many of the wells were only sampled once. However, five of the wells, 1, 8-3, 893, 1808 and 1814, were sampled at least four times from November 1978 through April 1980. Two of the wells that were sampled multiple times by Conoco (1808 and 8-3) and one well (885) that was only sampled once, were also included in recent sampling rounds by EMC. The initial monitoring performed by Conoco, and the continuation of monitoring of some of the original wells, provides an extensive background record of water quality that supplements the current baseline sampling program. Wells 1808 and 8-3 are completed across multiple sands and are not used to establish baseline conditions for the License Area but are provided for informational purposes only.

Conoco also collected groundwater samples from eleven private wells within and near the License Area. Six of the wells have State Engineers Groundwater Permit Numbers, four did not and one of the locations is Pine Tree Spring. Of the six that have permit numbers, three are listed as domestic-stock wells, two are listed as stock wells and one is listed as a domestic-industrial well (Continental Oil -Permit No.12299)..The locations of most of those wells are also shown on Figure 3.4.3-11. Several of the private wells are located over two miles outside the License area and are not shown on the figure. The private wells were sampled for the same parameters as the Conoco monitor wells (Table 3.4.3-9). Construction details on the private wells were generally unavailable. Therefore, the private wells are not considered for purposes of establishing baseline conditions. However, some of these private wells have also been included in the current sampling program to provide an assessment of water quality of groundwater that is being utilized in the vicinity of the License Area and to identify if changes in water quality at those locations may occur.

Table 3.4.3-9 Conoco Baseline Water Quality Monitoring Parameters

Major Ions	**Trace Constituents**	**Radionuclides**
Calcium	Aluminum	Radium-226
Magnesium	Ammonia	Uranium
Potassium	Arsenic	Polonium-210
Sodium	Barium	Lead-210
Bicarbonate	Berylium	Thorium-230
Chloride	Boron	
Carbonate	Cadmium	
Sulfate	Chromium	
Nitrate (Total)	Copper	
	Fluoride	
	Iron	
General Water Chemistry	Lead	
Total Dissolved Solids	Manganese	
pH (field and laboratory measured)	Mercury	
Conductivity(field and lab measured)	Molybdenum	
Temperature (field measured)	Nickel	
	Selenium	
	Vanadium	
	Zinc	

EMC has installed a monitor well network to evaluate pre-mining baseline conditions within the License area. Four well groups were constructed, each including a completion in the Production Zone aquifer, the overlying aquifer, and the underlying aquifer. In addition to the well groups, four new wells completed in the 70 Sand are included in the baseline water quality monitoring network. Three monitor wells have also been installed in the 60 Sand which underlies the 68 Sand. One of those 60 Sand monitor wells is located in the area where the 68 and 70 Sands coalesce. A row of monitor wells completed in the 58, 50 and 40 Sands was installed in the southern portion of the License Area. Three wells were also installed in the 80 Sand that overlies the 72 Sand. Only one of those 80 Sand monitor wells contains sufficient water for sampling.

Table 3.4.3-10 provides a summary of well construction information. The locations of wells included in the current monitoring network are shown on Figure 3.4.3-12. The parameters included in the EMC Monitoring Program are listed in Table 3.4.3-11.

Three of the original Conoco wells, 8-3, 1808, and 885, and 4 stock wells were also included in the monitoring program. Monitor wells 8-3 and 1808 are completed across both the 70 and 68 Sands. Monitor well 885 is only completed across the 70 Sand. These wells are not a part of the baseline monitoring program. Water quality from these wells are used only for comparison to historical water quality collected by Conoco.

This baseline analysis is intended to evaluate the overall quality of groundwater that is moving beneath the License Area under normal pre-mining conditions and does not provide the final basis for establishing restoration criteria for the individual mine units. The mine unit baseline water quality assessment and restoration goals will be provided to the WDEQ with the first Mine Unit Wellfield Plan Data Package.

Four rounds of water sampling have been completed in the baseline monitor well for the Production Zone aquifer (70 Sand), the overlying aquifer (72 Sand) and the underlying aquifer (68 Sand). An initial water sampling round has been completed in the 80, 60, 58, 50, and 40 sand monitor wells in May 2009. Additional sampling events are planned for those wells in order to fully assess seasonal and other potential impacts to groundwater quality.

Four stock wells located within the License Area were also sampled by EMC to establish pre-mining groundwater quality. Three of the wells (T-1, P'-9, and P'-11) were previously sampled under the Conoco monitoring program (1978-1980). The locations of the four wells are shown on Figure 3.4.3-12. EMC recently replaced the pumps in those wells and was able to gather the following information.

- Stock Well #1 (formerly referred to as T-1). Pump is set 180' below surface in steel casing. Water right associated with this well is License No. 12299. Well may be completed within the 70 Sand based on depth of pump.
- Stock Well #2 (formerly referred to as P'11). Pump is set 260' below surface in steel casing. Well is most likely completed in the 68 sand.
- Stock Well #3 (formerly referred to as P'9). Pump is set 120' below surface in steel casing. Well is most likely completed in the 70 Sand.

- Stock Well #4 (formerly referred to as P'26). Pump is set 141' below surface in steel casing. Total depth of the well is 158 ft. Water right associated with well is License No. 14682. Well is likely completed above the 70 Sand, probably within the 72 sand.

Again, because of the uncertainty in the completion intervals in these wells, the water samples collected from these private stock wells do not represent baseline water quality for the License Application and are only provided for informational purposes and to assess possible changes in water quality during ISR operations.

Table 3.4.3-11 EMC Baseline Water Quality Monitoring Parameters

Major Ions	**Trace Constituents**	**Radionuclides**
Calcium (dissolved)	Aluminum (dissolved)	Gross Alpha (dissolved)
Magnesium (dissolved)	Ammonia (as N)	Gross Beta (dissolved)
Potassium (dissolved)	Arsenic (dissolved)	Lead-210 (dissolved and suspended)
Sodium (dissolved)	Barium (dissolved)	Polonium-210 (dissolved and suspended)
Bicarbonate (total)	Beryllium (dissolved)	Radium-226 (dissolved and suspended)
Chloride (total)	Boron (dissolved)	Radium-228 (dissolved and suspended)
Carbonate (total)	Cadmium (dissolved)	Thorium-230 (dissolved and suspended)
Sulfate (total)	Chromium (dissolved)	Uranium (dissolved and suspended)
Nitrate + Nitrite (as N)	Copper (dissolved)	
Silica (dissolved)	Fluoride	
	Iron (dissolved and total)	
	Lead (dissolved)	
General Water Chemistry	Manganese (dissolved and total)	
Total Dissolved Solids (@180 F)	Mercury (dissolved)	
pH (field and laboratory measured)	Molybdenum (dissolved)	
Conductivity(field and lab measured)	Nickel (dissolved)	
Temperature (field measured)	Selenium (dissolved)	
	Vanadium (dissolved)	
	Zinc (dissolved)	

Groundwater Quality Sampling Results

Results of the Conoco monitoring programs are summarized in Tables 3.4.3-12 and 3.4.3-12a. The Conoco data are provided as background water quality and are not intended as baseline characterization. Results of the EMC baseline monitoring program (72, 70, and 68 Sands) are summarized in Table 3.4.3-13 and 3.4.3-13a. Results of additional EMC groundwater monitoring from non-baseline wells (deeper Wasatch sands, the 80 Sand, private wells and wells with unknown or multiple horizon completions) are included in Table 3.4.3-13. Overall water quality determined from the monitoring programs indicates a predominately calcium sulfate to calcium bicarbonate water, although significant differences are apparent between the Production Zone and overlying and underlying aquifers. Figure 3.4.3-13a is a Piper diagram of the average ion concentration for each of the monitor wells included in the EMC baseline sampling program (completed in the 68 through 72 Sands). Groundwater within the Production Zone aquifer is generally a calcium sulfate type. The overlying monitor wells exhibit a generally calcium sulfate type water with the exception of OMW3, which is a calcium bicarbonate type. The underlying monitor wells are more variable, ranging from calcium-to-sodium-sulfate and calcium-to-sodium-bicarbonate. Chloride and carbonate are generally very low in all of the wells. A Piper Diagram for the non-baseline wells included in the EMC monitoring program (including wells completed across multiple sands or sands other than the 72, 70 and 68 Sands) is shown on Figure 3.4.3-13b.

Figure 3.4.3-14 is a Piper diagram for the average ion concentration for each of the aquifers (including a category for those wells screened in both the 68 and 70 Sands) for the EMC groundwater monitoring program. Historic and current data from the wells completed in the 40, 50, 58, 60, and 80 Sands and the Roland Coal are also included on the diagram for reference. The Roland coal sample is clearly a sodium bicarbonate water type. The typical 68 Sand (underlying aquifer) water type appears more like the 40-50 Sand and Roland Coal type water than the 70 (Production zone) and 72 Sands (overlying aquifer). A Stiff diagram of the water quality for the different aquifers shows the transition with depth from a calcium sulfate water to a sodium bicarbonate water (Figure 3.4.3-15)

Table 3.4.3-16 is a summary of the analytical results for the current EMC baseline monitoring for wells completed in the Production Zone and the overlying and underlying aquifers. Recent sampling from the 80 Sand (1 well) and the 60 Sand (3 wells) are also included. Wells that are screened across multiple aquifers or that are of unknown completion intervals are not included in the table. The results are compared to WDEQ Class I Standards and USEPA MCLs.

As shown on the table, over half of the samples exceeded the WDEQ Class I standard for TDS (500 mg/l), with the greatest proportion of exceedences occurring in samples from the Production Zone aquifer. Figure 3.4.3-16 shows the distribution of TDS in the Production

Zone and the overlying and underlying aquifers. The range of TDS within wells completed in either the Production Zone or the underlying or overlying aquifers was 240 to 1350 mg/l with an average of 654 mg/l. The single 80 Sand monitor well and one of the 60 Sand monitor wells also exceeded the TDS standard.

Well 8-3, which is not included in the table because it is completed across both the Production Zone and the underlying aquifers, had an average TDS value of 2,380 mg/l over the two recent sampling events.

Similarly, almost half of the Production Zone samples exceeded the WDEQ Class I standard for sulfate of 250 mg/l (Figure 3.4.3-17). Sulfate ranged from 65 to 743 mg/l with an average of 307 mg/l for the wells included in the baseline monitoring. One of the 60 Sand monitor wells exceeded the sulfate standard. Sulfate ranged from 79 to 743 mg/l with an average of 301.6 mg/l. The highest sulfate value was found in well 8-3 (1,430 mg/l) which, again, was not included in the table because the well is completed across both the Production Zone and underlying aquifer.

Ammonia, iron, manganese, and selenium were the only trace minerals to exceed standards in the baseline wells. The ammonia WDEQ Class I standard of 0.05 mg/l was exceeded at two overlying monitor wells (OMW1 and OMW2). Iron exceeded the WDEQ Class I standard (0.3 mg/l) in one underlying well (UMW4), one overlying monitor well (OMW4), and two Production Zone monitor wells (MW11 and PW-1) and at well 8-3. Iron ranged from below detection to 3.34 mg/l. Manganese slightly exceeded the WDEQ Class I standard (0.05 mg/l) in two Production Zone monitor wells (885 and MW-4) and two overlying monitor well (OMW2 and OMW4). The selenium standard (0.05 mg/l for WDEQ Class I and EPA MCL) was exceeded in two wells in the underlying aquifer (UMW2 and UMW4) and two wells in the Production zone aquifer (MW2 and MW7). The selenium standard was exceeded in all three of the 60 Sand monitor wells.

The majority of the samples collected from the Production Zone and underlying aquifers exceeded the USEPA MCLs for uranium (0.03 mg/l). Most of the samples from the 70 Sand (Production Zone) exceeded the Wyoming Class I and USEPA MCL standards for radium 226+228 (5 pCi/l). Two of the 68 Sand (underlying aquifer) wells exceeded the radium 226+228 standards (UMW2 and UMW4). None of the samples from the overlying monitor wells exceeded the standard for uranium and only one exceeded the radium standard (OMW3). Figure 3.4.3-18 shows the distribution of uranium within the three aquifers. Uranium ranged from below detection (<0.0003) to 0.864 mg/l. Radium 226 distribution is shown in Figure 3.4.3-19. The average uranium concentration for the Production Zone aquifer was 0.16 mg/l, over five times the USEPA MCL. For the 68 Sand aquifer, uranium concentration averaged 0.056 mg/l. The uranium standard was exceeded in all three of the 60 Sand monitor wells.

Radium 226 ranged from below detection (<0.2) to 335 pCi/l with an average of 57 pCi/l. Radium-228 values were much lower, ranging from below detection (<1.0) to 9.5 pCi/l. The combined radium 226+228 concentration in the Production Zone aquifer averaged 97 pCi/l, over an order of magnitude greater than the Wyoming Class I Standard or the USEPA MCL.

In summary, general water quality in the shallow Wasatch aquifers within the Moore Ranch License area commonly exceeds WDEQ Class I standards for TDS and SO_4. In addition to TDS and sulfate groundwater quality standards, many of the monitor wells fail to meet Class I (Drinking), II (Agricultural) or III (Livestock) WDEQ classification standards for radium, gross alpha and selenium as well as USEPA Drinking water standards for uranium. The projected class of use, based on water quality is shown in following table.

Table 3.4.3.16 Projected Class of Use Based on Monitor Well Water Quality Moore Ranch License Area

		STANDARDS EXCEEDED				Projected Class of Use
	Completion Interval	WDEQ Class I	WDEQ Class II	WDEQ Class III	USEPA MCL	
Well ID						
UMW-9	60 Sand	Se, g. alpha	Se, g. alpha	Se, g. alpha	Se, g. alpha, U	Class VI
UMW-10	60 Sand	Se, pH	Se, pH	Se	Se, U	Class VI
UMW-11	60 Sand	SO4, TDS, pH, Se, g. alpha	SO4, Se, g. alpha	Se, g. alpha	Se, g. alpha, U	Class VI
UMW-1	68 Sand	pH	pH	pH	None	Class VI
UMW-2	68 Sand	pH, Se, Ra	pH, Se, Ra	pH, Se, Ra	Se, Ra	Class VI
UMW-3	68 Sand	TDS. Ra	Ra	Ra	Ra	Class VI
UMW-4	68 Sand	Se	Se	Se	Se, U	Class VI
MW-2	70 Sand	SO4, TDS, Ra	SO4, Ra	Ra	Ra, U	Class VI
MW-3	70 Sand	TDS, g. alpha, Ra	G. alpha, Ra	G. alpha, Ra	G. alpha, Ra, U	Class VI
MW-4	70 Sand	SO4, TDS, g. alpha, Ra	G. alpha, Ra	G. alpha, Ra	G. alpha, Ra, U	Class VI
MW-6	70 Sand	None	None	None	None	Class I
MW-7	70 Sand	Se, g alpha	Se, g. alpha	Se, g. alpha	Se, g. alpha, U	Class VI
MW-9	70 Sand	SO4, TDS, Se, g alpha, Ra	SO4, Se, g alpha, Ra	Se, g alpha, Ra	Se, g alpha, Ra, U	Class VI
MW-11	70 Sand	SO4, TDS, Fe, g. alpha, Ra	SO4, g. alpha, Ra	g. alpha, Ra	g. alpha, Ra U	Class VI
PW-1	70 Sand	SO4, TDS, Fe, g. alpha, Ra	SO4, g. alpha, Ra	g. alpha, Ra	g. alpha, Ra U	Class VI
885	70 Sand	SO4, TDS, Mn, g. alpha, Ra	SO4, g. alpha, Ra	g. alpha, Ra	g. alpha, Ra U	Class VI
1808	68-70 Sand	SO4, TDS, Mn, Ra	SO4, Ra	Ra	Ra	Class VI
8-3	68-70 Sand	SO4, TDS, Fe, Mn	SO4, TDS,	None	None	Class III
OMW-1	72 Sand	pH	None	pH	None	Class II
OMW-2	72 Sand	SO4, TDS, Mn	SO4	None	None	Class III
OMW-3	72 Sand	None	None	None	None	Class I
OMW-4	72 Sand	SO4, TDS, Fe, Mn	SO4, Mn	None	None	Class III
OMW-7B	80 Sand	TDS. g. alpha	g. alpha	g. alpha	g. alpha	Class VI
Stockwell #1	70?	SO4, TDS, Fe, Mn	SO4, Mn	None	None	Class III
Stockwell #2	68?	SO4, TDS, Fe,	SO4, Mn	None	None	Class III

Table 3.4.3.16 Projected Class of Use Based on Monitor Well Water Quality Moore Ranch License Area

		STANDARDS EXCEEDED				Projected Class of Use
	Completion Interval	WDEQ Class I	WDEQ Class II	WDEQ Class III	USEPA MCL	
Well ID						
		Mn				
Stockwell #3	70?	SO4, TDS, Fe, Mn, g. alpha	SO4, TDS, Mn, g. alpha	g. alpha	g. alpha	Class VI
Stockwell #4	72?	None	None	None	None	Class I

A set of figures has been prepared that identifies the projected WDEQ class of use (from Table 3.4.3.16) for the 60 through 80 Sands within the project area, based on the available monitor well water quality data (Figure 3.4.3-20a through 20d). A separate figure is presented that indicates the projected class of use of four private un-permitted stock wells within the License Area that have been sampled by EMC (Figure 3.4.3-20e). The completion zones for these wells are estimated from pump depths and projection from site cross sections. Also included on the figure is the projected class of use for two Conoco monitor wells that are completed across multiple aquifers.

Radionuclides radium-226 and uranium are elevated above EPA MCLs in the majority of the samples collected from the Production Zone aquifer and the underlying aquifer. The average radium 226-228 concentration in the production zone is an order of magnitude greater than the USEPA MCL. Elevated concentration of these constituents is consistent with the presence of uranium ore-bodies. Current data collected from wells included in the previous baseline monitoring by Conoco show relatively consistent results with the previous data showing consistent water quality for the past 25 years (with the exception of the three anomalous values and potential causes for well 8-3 as previously described).

The only permitted domestic well within the License Area is identified as an industrial, domestic well for the Rio Algom Mining Corp (P12299W). That well is projected as being completed in the 58 or 60 Sand interval. There are no occupied residences within the License Area. The nearest other permitted domestic wells are located approximately two miles to the east of the License Area. These wells are hydraulically upgradient or cross-gradient to the License Area.

There are numerous permitted and un-permitted stock wells located within the License Area. Water quality data are unavailable from SEO records for any of the permitted stock wells within the two-mile radius of the Moore Ranch License Area. EMC collected water quality from four stock wells within the Permit Area that are not permitted. Water quality data from those wells indicate that one of the wells meets all WDEQ Class I and USEPA MCL standards for general chemistry, inorganics and radionuclides Two of the wells meet Class III standards (but not Class I) making them suitable for livestock purposes, consistent with their current use. The fourth stock well exceeds the WDEQ Class III standard for gross alpha, making the Wyoming groundwater classification of this well as Class VI, unsuitable for drinking water, agricultural or livestock uses. EMC has no control over the use of these private wells and can only inform the well owner that the water quality is unsuitable for the wells intended use.

As shown in Table 3.4.3.16, the all but one of the 60, 68 and 70 Sand monitor wells exceed Class I, II and III standards for gross alpha and radium and the USEPA MCL for uranium. Many of those wells also exceed selenium standards for Class I, II and III water. All of the 72 sand monitor wells meet the Class III water quality standards. These water quality trends are consistent with the presence of uranium mineralization beneath the 72 Sands within the Moore Ranch License Area.

3.4.3.4 Groundwater Impacts from CBM Discharge

Between 1979 and 1981 Conoco installed 35 piezometers in section 35, T42N, R75W and section 1, T41N, R75W as part of an evaluation of proposed mine tailings and evaporation pond sites. The piezometers were installed in discrete lithologic units (silts, sands, coals and alluvium) contained in the 72 sand aquifer. Two of these piezometers were completed near OMW-2 in sandy sections of the aquifer. The measured water elevations for both wells are similar to the elevations measured currently in the 72 sand. Data from the piezometers and monitor well OMW-2 are presented in Table 3.4.3-17. While saturated thickness levels are below those currently measured in OMW-2, this is likely a relic of completion methods versus quantity of water in the formation. Of the 35 piezometers completed for Conoco's Appendix D-5, only two lacked groundwater. EMC believes the presence of water in the 72 sand in 1979-1980 (some 21 years prior to CBM development) indicates that the aquifer has been historically present in the area and is not the result of CBM development. Additionally, Stockwell #4P14682P, located in the SENW quarter of section 26, T42N, R75W and completed in the 72 sand aquifer has been a source of livestock water since the early sixties.

Table 3.4.3-17 Shallow Tailings Area Piezometer Characteristics

Well/Piezometer I.D.	Total Depth	Depth to Water (Ft)	Saturated Thickness (Ft)	Static Water Elevation (Ft. AMSL)	Water Level Date
OMW-2	**78**	**67.62**	**10.38**	**5244.88**	**2/9/2007**
35N-6	**90**	**86.87**	**3.13**	**5236.5**	**5/15/1980**
35N-7C	**84**	**82.09**	**1.91**	**5229.3**	**5/15/1980**

As noted previously in this section, the groundwater within the 72 sands is of the calcium-sulfate type. Shallow groundwater monitoring associated with CBM water storage facilities in the area also indicates calcium-sulfate type water under baseline conditions (WDEQ-WQD, Sheridan Office, 2008). Groundwater quality data from three monitor wells installed by methane producers in sections 4, 15 and 22 of T42N, R75W, are also of the calcium-sulfate type (MW4-2, MW23-15 and MW22-1). These three wells are under water table conditions and have not received any infiltration from water produced during coal-bed development because they were installed prior to the discharge of CBM produced water. Based on elevation relationships, it is highly likely that the wells in sections 15 and 22 are installed in the 72 sand aquifer. Similarly, the groundwater encountered in piezometers 35N-6 and 35N-7C (Conoco, 1981) is of the calcium-sulfate type. Both of these piezometers were completed in sandy portions of the 72 sand aquifer.

Shallow aquifer systems which have received CBM water typically display an evolution from calcium-sulfate to sodium-bicarbonate type (WDEQ-WQD, Sheridan Office, 2008). CBM water within this area is of the sodium-bicarbonate type. Data from a monitor well (MWAL21-20-1) installed in a shallow alluvial system located in the NENW of section 20, T43N, R77W have been included on the Piper diagrams (Figures 3.4.3-10). These data show the influence from infiltration of CBM water as sodium and bicarbonate become the dominant ions in the shallow groundwater. The evolution from a calcium-sulfate based water type to sodium-bicarbonate occurred along with a decrease in total dissolved solids. Although groundwater in OMW-3 is somewhat atypical because of the significant presence of the bicarbonate ion, bicarbonate concentrations are far below those observed from nearby CBNG outfalls and the dominant cation remains calcium versus the prevalent sodium from CBNG discharges.

Comparison of the ambient water quality measured in the 72 sand to data from a system being altered by infiltration indicates that the 72 sand has not received infiltration from nearby discharges. The potential for the water quality of the 72 sand to be impacted by infiltrating CBM discharges was evaluated through a basic linear velocity analysis using conservative estimates to delineate; 1) minimum travel time for CBM produced water to infiltrate from the surface through the overlying silts and clays to the top of the sandy portion of the 72 aquifer, and 2) minimum travel time between infiltration into the sandstone (either underlying an impoundment or recharge directly into a sandstone outcrop) to the closest monitoring point. The basic assumptions that were made lead to exceedingly conservative velocities and travel times (see Table 3.4.3-18). Fundamentally, utilizing conservative values for thickness, hydraulic conductivity and porosity it is theoretically possible for the 72 sand to receive water during the lifespan of the Moore Ranch Project. Infiltration into outcrops or subcrops of the 72 sand to where it could potentially reach monitoring locations is less likely, with travel times on the order of tens to hundreds of thousands of years.