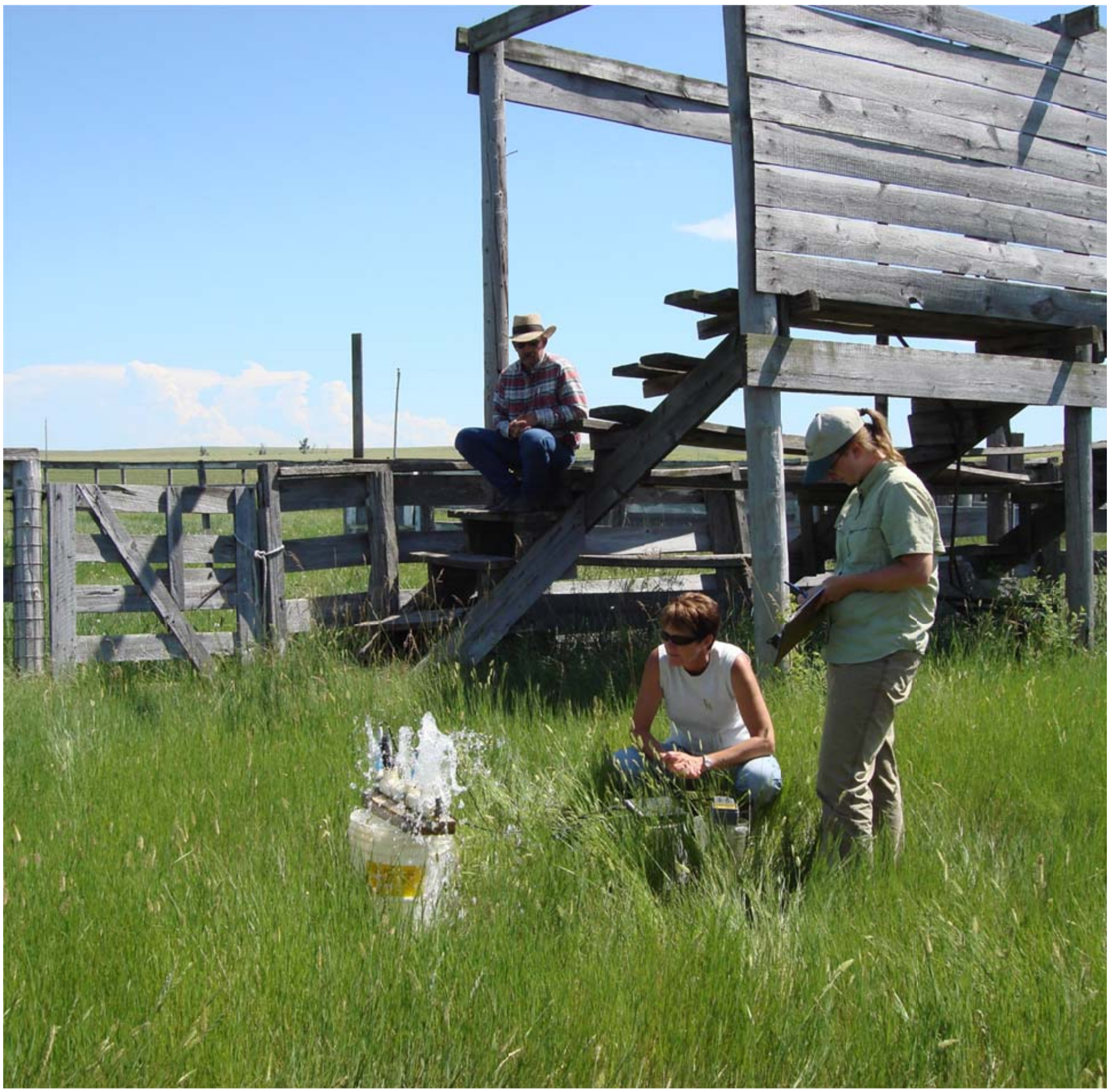
Baseline Groundwater Evaluation Near a Proposed *in situ* Leach Uranium Mine in Carter County, Montana

Elizabeth Meredith

MBMG Open File 595



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Introduction

Southern Carter County near Alzada, Montana has been identified as a potential location for *in situ* uranium development. At the time the project was initiated, uranium development looked imminent, and was expected to occur in aquifers used by local residents for their domestic water supply. *In situ* uranium mining involves the injection of a solution that dissolves uranium minerals into groundwater. The solution is then recovered in a series of pumping wells surrounding or adjacent to the injection site. The leaching solution could migrate beyond the project area if the project encounters equipment failures, aquifer heterogeneity, fractures, or improper well completions. Leaching solutions have the potential to impact domestic water supplies.

Unintended excursions from the *in situ* uranium mine would be expected to contain leaching solution with high salinity and, depending on the leaching method used, either a high or low pH compared to the groundwater. Additionally, excursions may carry soluble uranium, which would raise the radioactivity level of the water – a potential health hazard. This project established natural levels of these parameters so changes to the groundwater condition will be identifiable and natural variations are more recognizable.

To detect changes that could negatively impact the residents, a groundwater monitoring program that establishes baseline must be in place prior to *in situ* uranium production. Preceding the initiation of *in situ* uranium production, the mining company may be required to establish a local groundwater monitoring program. However, longer periods of data collection, expanded coverage area and third party monitoring have all been shown to be beneficial to all parties. To begin working toward these goals, scientists from the Montana Bureau of Mines and Geology (MBMG) in cooperation with the Carter County Conservation District, identified existing private wells that are within the proposed *in situ* uranium mining area and sampled them for baseline water quality. Defining baseline groundwater conditions is necessary to identify any changes that may occur due to future uranium production actions.

Project description

This study provided water-quality baseline data for wells in proximity to proposed uranium mining. The data collected during this study provide necessary background information for identifying changes to the groundwater resource that may occur during uranium production. Third-party data collection has been proven beneficial by building confidence among all interested parties.

Water-quality sampling was conducted in July, 2009 and July, 2010. Interested landowners were identified through mailings to owners of deep wells (900 to 3000 feet total depth) in the project area. Eleven wells were identified as being in the Lakota sandstone, the target aquifer for uranium production. Four landowners responded positively to the initial mailing and one additional interested owner was identified for the second sampling event. One shallow well was sampled because it was suspected of being influenced by the nearby Thompson Creek, which may be impacted from uranium development. In addition, a spring was identified as being of concern by a landowner and was subsequently sampled. All wells were visited and each well location recorded. One of the identified deep wells was not able to be sampled because the pump was not in working order during both of the sampling events.

Samples were analyzed for major and minor ions, trace elements such as uranium, salinity, pH, temperature, and radon concentration. All collected data are available to the public on the MBMG website (http://mbmggwic.mtech.edu) and were provided to the participants so they have a permanent record.

Water samples were collected from each well after a sufficient volume of water had been discharged to ensure that the field parameters of temperature, salinity, pH and oxidation-reduction potential remained stable for 15 minutes. Samples for major and minor constituents were filtered through 0.45 micron filters in the field and preserved with nitric and sulfuric acid as required. Samples were kept in cool, dark containers until analyzed at the Montana Bureau of Mines and Geology Analytical Laboratory at Montana Tech in Butte, Montana. Each well was also sampled for radon using sample procedures and kits put forth by the radon laboratory Air Chek, Inc. in Mills River, North Carolina. Each sampling kit provided a glass vial and a hose adapter that limits the air introduced to the sample. Samples were shipped by next day air to the North Carolina lab.

Well owners were provided with several radon sampling kits and stamped envelopes to continue sampling their well water throughout the year. Representatives from the Carter County Conservation District assisted well owners with the radon sampling.

Water chemistry and radon results were mailed to the well owners as they were completed. Water chemistry results are available on the Montana Bureau of Mines and Geology groundwater on-line database, GWIC (http://mbmggwic.mtech.edu/).

Outcomes

The results of this project include 22 detailed water chemistry analyses from 11 wells and 1 spring in proximity to proposed uranium production areas. Water chemistry analyses include all major and minor ions and trace elements (including uranium). Through a combined effort of the Carter County Conservation District, homeowners, and the Montana Bureau of Mines and Geology, 34 samples for radon analysis were collected and analyzed. All data collected for this project were provided to the well owners for their records, published in this report, and published as part of the public record on the MBMG groundwater database.

In addition to providing the citizens of Alzada important information regarding their drinking water, this project has begun to establish baseline water quality for the Lakota aquifer in this area. These analyses will provide the water users, the state of Montana, and the uranium development company the necessary information to make better informed decisions about the aquifer and to identify any impacts to this aquifer should they occur.

Results

Ground water characterization

Eleven wells were visited between July 6th and 8th 2009: 10 deep and 1 shallow (Figure 1). The pump was broken on one deep well; therefore the inventory data were limited to location information only for that well. The well owner was notified about this problem. The following year, between July 20th and 21st 2010, the Montana Bureau of Mines and Geology visited the same 11 wells, one additional deep well, and a nearby spring. The broken pump had not yet been repaired. The characteristics of the 11 working wells and one spring were inventoried. These data include location, pH, specific conductance and temperature. Most wells had a cap called a "sanitary seal", which prevented measuring water levels. Two water levels were measured in 2009: one each from a deep (GWIC ID 185488) and a shallow well (GWIC ID 251120). The shallow well's static water level was measured again in 2010.

All wells with working pumps (11 total) and the spring were sampled for water quality (analytes include all major and minor constituents) and periodically throughout the year for radon concentrations. Results from these tests are presented in Appendix A and in the following Table 1. The water chemistry (Appendix A) supports the observations of most well owners in that the water has poor or very poor taste and high iron concentrations. Factors that make the water from these wells unsuitable to drink without treatment include high salinity, pH, sodium, sulfate and iron. With the exception of the shallow well, the uranium concentrations of these waters, while some are higher than most bedrock aquifers, are below the limit the US Environmental Protection Agency (EPA) sets for safe drinking water. Most natural waters have uranium concentrations ranging from 1 to 10 ug/L (Hem, 1985) and most water sampled by the MBMG has been below the detection limit for uranium. The shallow well (GWIC ID 251120) had a uranium concentration of 38 µg/L in 2009 and 43 µg/L in 2010, which is in excess of the drinking water limit of 30 µg/L. For this reason, future sampling efforts should include shallow wells.

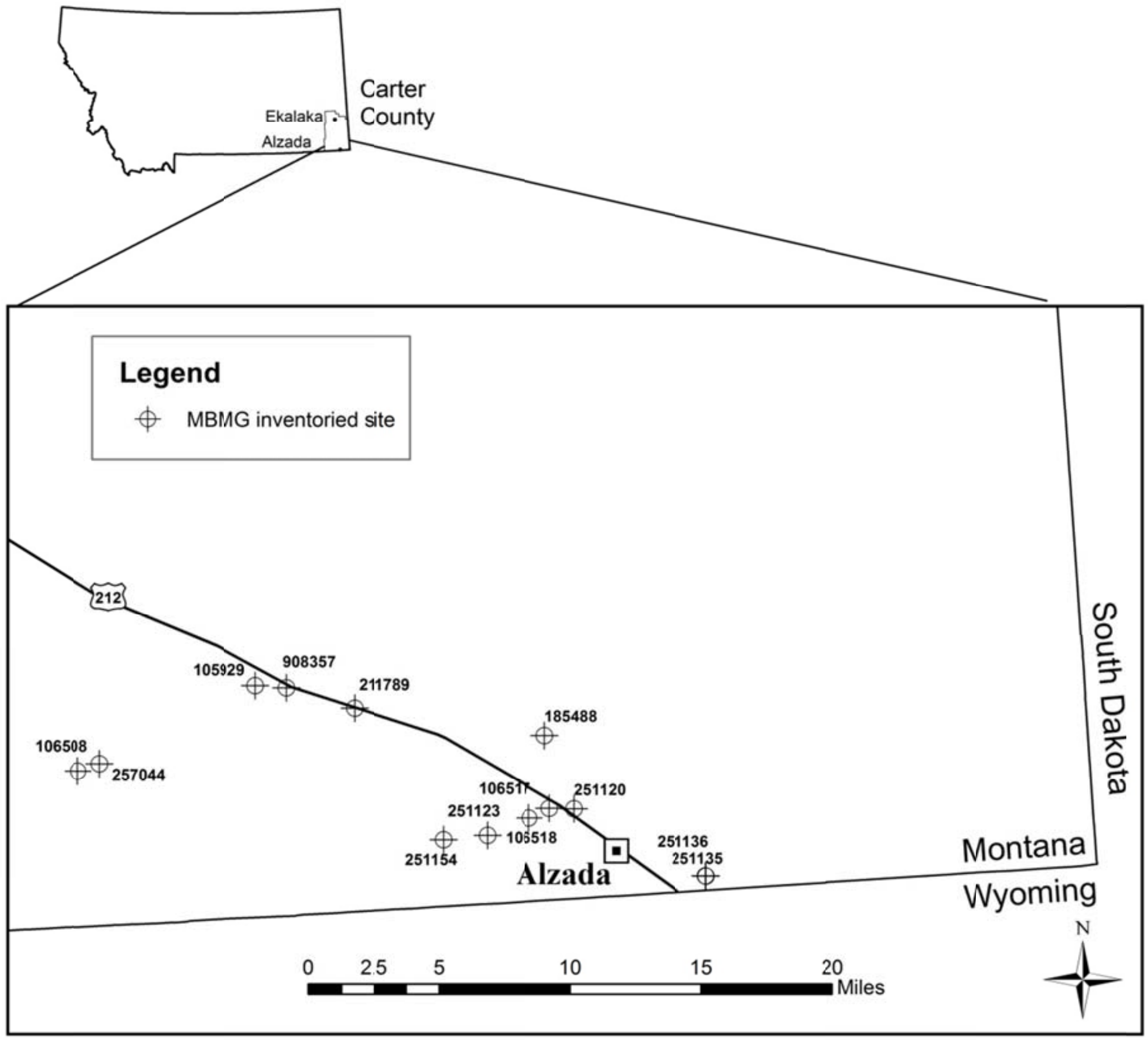

Figure 1. Location of the study site and inventoried wells.

Table 1. Summary of field parameters and radon concentrations for sampled wells and spring near Alzada, Montana

GWIC ID NUMBER*	SITE NAME	DESCRIPTION	WATER RIGHT NUMBER	NOTES	SC (uS/cm)		REDOX (mV)		TEMP (C)		pH		RADON (pCi/L)					
					2009	2010	2009	2010	2009	2010	2009	2010	Jul-09	Oct-09	Nov-09	Jan-10	Mar-10	Jul-10
106517	ARPAN	HOUSE (1)	39F 17543400		1311	1280	-344	-164	18.5	18.9	7.84	7.84	412			221	273	501
106518	ARPAN	STOCK (2)	39F 7000500		777	511	-309	-294	15.5	15.2	8.26	8.65	1022			560	542	1097
251120	ARPAN	SHALLOW (3)			2870	3160	52	73	9.3	9.2	7.27	7.33	1637			654	858	2042
251123	BARTLETT	HOUSE	39F 6934300		1204	1222	-358	-199	14.6	17.8	7.52	7.48	334	<75				88
105929	COCHRAN	ASSOCIATION	39F 276800	cistern	2080	2044	43	-75	17.7	17.1	8.69	8.98	136	701				713
185488	FLASTED	WILLOW CREEK	39F 11463700		1335	1256	-517	-70	18.2	13.3	8.76	9.36	<75	123				<75
251135	FLASTED	WEST			1127	1847	-486	-235	18.5	15.4	8.84	8.84	173					<75
251136	FLASTED	EAST		broken										<75				
106508	LANNING	HOUSE WELL	39F 71472 00			2379		-363		13.2		9.3						<75
257044	LANNING	SPRING	**			966		76		12		7.46						
908357	PILSTER	WEST (1)	39F 5488700		2030	2008	-242	-371	21.4	22.8	8.39	8.38	<75		<75			265
211789	PILSTER	EAST (2)	39F 30011318		1901	1843	-421	-330	17.8	18	8.35	8.4	117		221			238
251154	PILSTER	HOUSE (3)			1823	1803	-293	-60	16.2	16.7	7.24	7.36	258		192			243

*To find complete information on these wells go to: http://mbmggwic.mtech.edu/
Requires login ID (free). Input the GWIC ID number in the box at the bottom of the page.
**Three springs listed: 39F 100641 00, 39F 100634 00, 39F 100621 00

Radon concentrations are far below the limit the EPA suggests may be harmful to human health. The EPA uses a conversion factor of 10,000 pCi/L (picocuries per liter) in groundwater to 1 pCi/L in air. Air levels below 4 pCi/L are considered safe for healthy adults. Most wells were sampled for radon three or more times throughout the year to establish natural variation in the water. Groundwater radon levels varied from non-detectable to 2042 pCi/L; in general, radon levels were highest in the summer months. Establishing the natural variability of the radon concentration of Lakota Aquifer groundwater will help identify any increase in radioactive constituents in the water that may be mobilized during *in situ* uranium production. The concentration of radon, a daughter product of uranium radioactive decay, may be correlated to uranium concentrations in groundwater (Figure 2); however, without additional data, only a rough positive correlation can be discerned.

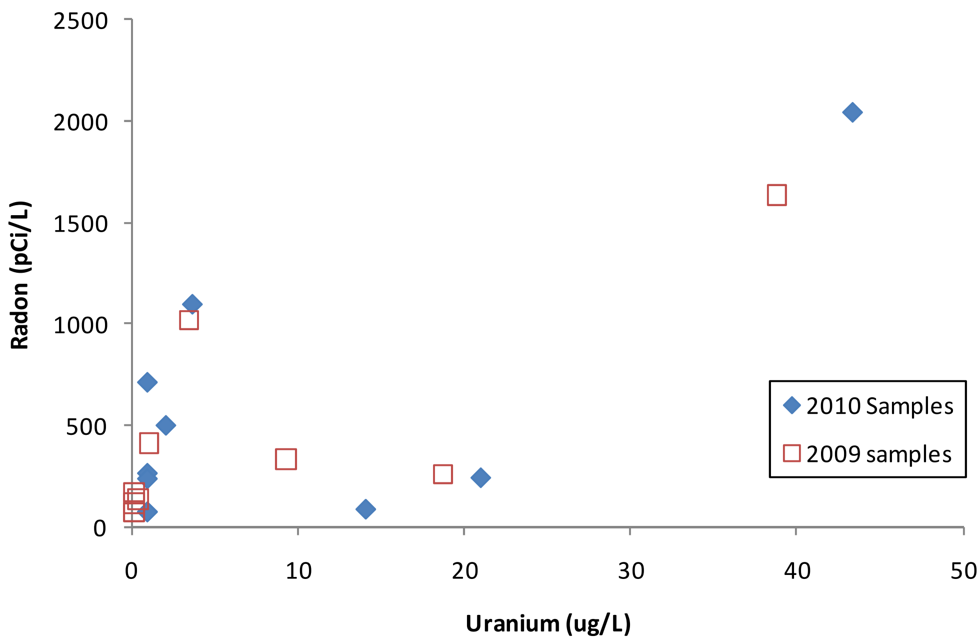

Figure 2. The relationship between uranium and radon concentrations in the sampled groundwater is not clear based upon the limited sample set collected.

Water-chemistry analyses indicate that the deep sandstone aquifer, the Lakota aquifer, used for domestic and stock water in the Alzada area generally has an elevated pH (greater than 8.0) and in some cases has pH values (greater than 9.0) that make this water undesirable for drinking without treatment. In all wells, the salinity (total dissolved solids [TDS]) of the water exceeded the recommended drinking water limit of 500 mg/L (US EPA, 2010). The relationship between specific conductance (SC), a parameter easily measured in the field, and the regulated parameter TDS (total dissolved solids), is demonstrated on Figure 3 for Alzada area groundwater. For the Alzada area, an SC of approximately 750 uS/cm corresponds to the recommended drinking water limit. Water from the deep wells all are classified as sodium-sulfate (sodium is the dominant cation, sulfate is the dominant anion). Waters having high levels of sodium but relatively lower levels of calcium and magnesium cations, can present a sodium hazard to soils if used for irrigation. The sodium adsorption ratio (SAR), which is a general indicator of a water's suitability for irrigation, of the deep groundwater ranges from 4 to 56. Depending upon the soil type being irrigated, an SAR value of less than 10 is generally preferred for irrigation.

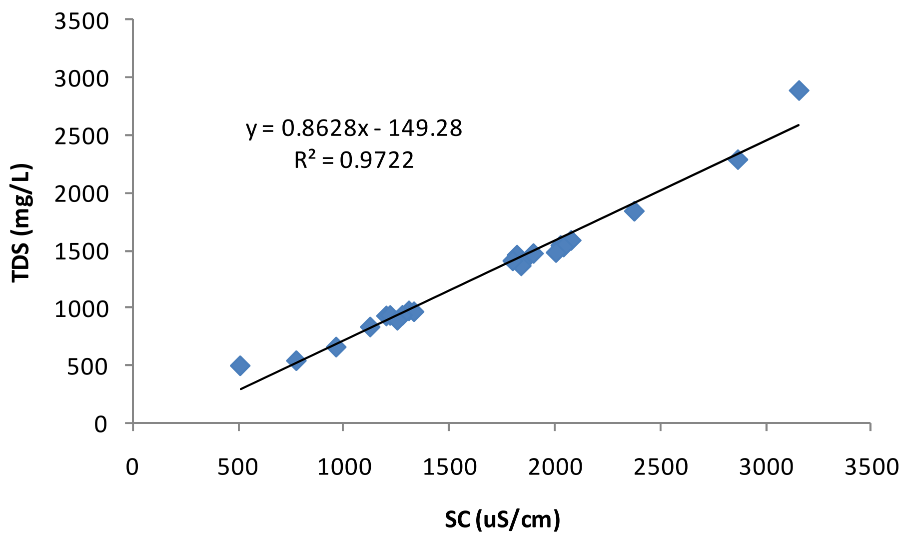

Figure 3. The close relationship between specific conductance (SC) and total dissolved solids (TDS) makes it easy to quickly evaluate whether the measured water exceeds the drinking water recommendation (500 mg/L).

No significant concentrations of trace elements or trace metals were found in the deep water samples. Most deep wells have measureable concentrations of arsenic (As), barium (Ba), boron (B), lithium (Li), strontium (Sr), molybdenum (Mo), titanium (Ti), uranium (U), and rubidium (Rb); however, none exceed drinking water standards, if a standard exists. As noted, the exception to this was the one shallow well that was sampled, which exceeded the drinking water standard for uranium. The owner was contacted specifically regarding this information. None of the samples had significant concentrations of nitrate which can indicate pollution from septic systems, fertilizers, and stockyards.

The results for water-quality analyses for each well did not change markedly between samples collected in 2009 and 2010. These samples can serve as a preliminary baseline for the groundwater in this area and indicate that the chemical constituents are relatively stable. One exception is the west Flasted well (GWIC ID 251135), which had a higher salinity and correspondingly higher cation and sulfate concentrations in the 2010 sample. Between sampling events, this well was treated for bacterial contamination and these changes may reflect those treatments.

Results dispersion

Results from the water quality testing and the radon results were sent to landowners by US Post. Each mailing included 1) a letter summarizing the results and the implications for health, 2) the analytical results from the water chemistry analysis, 3) a comparison of the results to drinking, stock and irrigation water standards, and 4) the results from radon sampling, if performed.

Data collected and interpretations are included in this report which is submitted to the Montana Department of Natural Resources and Conservation (DNRC) and will be held as a public document by the Carter County Conservation District and as an open file with the Montana Bureau of Mines and Geology.

Additionally, all data collected are available for free to the public on the Montana Bureau of Mines and Geology groundwater database, GWIC. A unique GWIC Project Code was set up for the Alzada area wells. To access these data go to the MBMG GWIC website (http://mbmggwic.mtech.edu/), sign in or create a user name, under the Navigation menu choose "Ground-Water Projects", and under Project Groups choose "Regional Water Resource Investigations". The project code "ALZADA" contains all inventory and water quality data for this project. In addition, all available data associated with a well can be accessed through its GWIC ID-number.

Project Benefits

This project benefits the public and individual well owners by providing a better understanding of the water quality and local issues surrounding the aquifer in the Alzada area in southeastern Montana. In most instances the owners received confirmation their water was safe for consumption and posed no threat from radon. By establishing the baseline water quality, including the baseline radon concentration, any changes to the system will be identifiable through additional sampling. Without these data, changes from uranium production in the area would not be definable.

Recommendations

Two samples from a particular site, while they give an indication of variability, are not sufficient to define trends in water quality. It is recommended that sampling of Lakota aquifer wells continue in the Alzada area every 1 to 2 years until at least 5 samples have been collected and analyzed prior to the initiation of uranium production. Sampling frequency should increase to seasonally immediately prior to and during uranium production, depending upon a well's proximity to production and specific aquifer characteristics such as transmissivity.

The shallow well along Thompson Creek showed unusually high levels of uranium, which exceeds the drinking water standard for human health. This well is in the Thompson Creek alluvium and the origin of the uranium, whether from the local, near-surface host rock, from the surface water, or some other source, cannot be identified. Further sampling of the shallow wells in the area and the surface water is recommended to ensure all domestic wells with potentially high uranium concentrations have been identified.

Additionally, a natural fingerprint of uranium can be used to identify the original source of uranium by using the ratio of naturally occurring isotopes of uranium U^{234}/U^{238}. A near-surface source of uranium would most likely have a very different U^{234}/U^{238} ratio than would tailings from upstream uranium mining operations where the source of uranium is a much older host rock. The U^{234}/U^{238} ratio will change with time because, while U^{234} is stable, U^{238} radioactively decays over time. Therefore, in general, an older host rock would have a higher ratio of U^{234}/U^{238} than a younger host rock.

References

Hem, John, D., 1985, Study and Interpretation of the Chemical Characteristics of Natural Water, third edition. US Geological Survey Water –Supply Paper 2254.

US Environmental Protection Agency (EPA), 2010, National Secondary Drinking Water Regulations. Available online: http://water.epa.gov/drink/contaminants/index.cfm#List accessed November 8, 2010.

Appendix A: Well information and water quality summary

Gwic Id	Site Name	Latitude	Longitude	Twn	Rng	Sec	Q Sec	County	Site Type	Depth (ft)	Comp Date	Field Number
106517	ARPAN LAWRENCE	45.04896	-104.46198	09S	59E	15	ACDD	CARTER	WELL	905	10/1/1969	ARPAN1
106518	ARPAN ROBERT	45.04426	-104.47836	09S	59E	15	CCC	CARTER	WELL	870	11/10/1988	ARPAN2
251120	ARPAN ROBERT	45.04772	-104.44285	09S	59E	14		CARTER	WELL	31.2		ARPAN3
251123	BARTLETT LINDY	45.03623	-104.51211	09S	59E	20		CARTER	WELL			BARTLET
105929	COCHRAN GRAZING ASSOC	45.12658	-104.68494	08S	57E	24	CAB	CARTER	WELL	1654	10/9/1979	COCHRAN
251135	FLASTED EVERETTE	45.00611	-104.34393	09S	60E	34		CARTER	WELL			FLASTED WEST
185488	FLASTED EVERETTE	45.08913	-104.46204	08S	59E	34	DAD	CARTER	WELL	1340	10/28/2000	WILLOW CREEK
257044	LANNING SPRING	45.08883	-104.80991	09S	56E	1		CARTER	SPRING			257044
106508	LANNING DANNY	45.085592	-104.827185	09S	56E	2	BD	CARTER	WELL	3006	12/19/1989	106508
908357	PILSTER 1-19	45.12436	-104.66112	08S	58E	19	CACA	CARTER	PETWELL			PILSTER1
211789	PILSTER RANCH	45.11079	-104.60936	08S	58E	28	ABD	CARTER	WELL	1366	5/5/2004	PILSTER2
251154	PILSTER RANCH CORP	45.0354	-104.54608	09S	59E	19		CARTER	WELL			PILSTER3

Gwic Id	Sample Date	Water Temp	Lab	Lab pH	Lab SC	Ca (mg/l)	Mg (mg/l)	Na (mg/l)	K (mg/l)	Fe (mg/l)	Mn (mg/l)	SiO2 (mg/l)	HCO3 (mg/l)	CO3 (mg/l)	SO4 (mg/l)	Cl (mg/l)
106517	7/7/2009 10:10	18.5	MBMG	7.82	1292	38.9	15.5	240	12.2	0.452	0.061	19.5	260.6	0	510.5	10.14
	7/21/2010 14:15	18.9	MBMG	7.98	1323	41.5	16.6	241	12.2	0.653	0.063	9.07	255.6	0	481.2	9.01
106518	7/7/2009 11:10	15.5	MBMG	8.12	818	30.3	14.8	130	12.1	0.48	0.019	11.5	229.1	0	231.1	<5.0
	7/21/2010 15:00	15.2	MBMG	8.33	689	30.1	14.1	124	11.3	0.732	0.025	5.53	190.3	3.42	211.8	3.64
251120	7/7/2009 12:08	9.3	MBMG	7.7	2890	302	102	404	8.17	<0.02	0.133	14.6	505.1	0	1605	23.02
	7/21/2010 15:50	9.2	MBMG	7.58	3260	324	98.3	439	9.02	<0.010	0.221	13.5	409.3	0	1775	21.52
251123	7/6/2009 14:04	14.6	MBMG	7.81	1222	75.9	30.8	171	16.2	3.66	0.243	17.9	382.6	0	426.7	<5.0
	7/20/2010 18:15	17.8	MBMG	7.81	1350	82.8	32	173	15.9	2.06	0.205	8.81	377.7	0	430.4	4.82
105929	7/7/2009 17:03	17.7	MBMG	8.15	2190	6.18	3.11	503	7.33	0.038	0.048	22.7	369.7	0	854.4	8.23
	7/20/2010 15:20	17.1	MBMG	8.69	2190	4.8	2.14	504	7.12	0.049	0.036	10.3	366.6	26.8	785.6	8.14
251135	7/8/2009 10:20	18.5	MBMG	8.45	1161	11	4.55	243	7.74	<0.010	0.017	20.1	165.9	11.6	447.6	6.18
	7/20/2010 16:50	15.4	MBMG	8.65	2050	28.7	12.5	393	5.95	0.547	0.024	8.27	180	5.61	833.5	11.18
185488	7/7/2009 15:37	18.2	MBMG	8.69	1379	11.7	6.28	291	9.38	0.041	0.021	18.5	197.2	9.6	517.8	6.21
	7/21/2010 18:00	13.3	MBMG	9.22	1298	5.18	2.71	283	8.4	0.011	0.008	2.08	223.7	19.9	456.5	6.14
257044	7/20/2010 14:10	12	MBMG	8.15	929	65.1	79.1	61.4	6.82	<0.002	<0.001	9.17	403.8	0	231.7	7.9
106508	7/20/2010 13:30	13.2	MBMG	8.8	2650	5.92	1.46	586	5.4	0.047	0.016	9.38	272.1	16.7	1073	10.29
908357	7/6/2009 16:53	21.4	MBMG	8.01	2030	3.76	1.65	467	3.84	0.372	0.057	24.3	173.2	0	950.5	6.95
	7/20/2010 16:10	22.8	MBMG	7.86	2250	3.76	1.59	469	3.73	0.402	0.061	10.8	163.5	0	904.9	7.04
211789	7/6/2009 16:32	17.8	MBMG	8.08	1854	6.99	2.44	446	6.16	0.677	0.04	22.7	229.7	0	868.3	7.06
	7/20/2010 17:15	18	MBMG	8.01	1930	6.68	2.29	437	5.8	0.741	0.04	10.3	181.8	0	807	6.94
251154	7/7/2009 18:45	16.2	MBMG	7.61	1830	91.3	35.8	309	20.4	2.16	0.263	18.4	398.5	0	781.1	5.75
	7/20/2010 19:15	16.7	MBMG	8.01	1963	88.1	35.3	305	19.8	1.17	0.244	7.71	393	0	753.7	5.42

Gwic Id	NO3-N (mg/l)	F (mg/l)	OPO4-P (mg/l)	Ag (ug/l)	Al (ug/l)	As (ug/l)	B (ug/l)	Ba (ug/l)	Be (ug/l)	Br (ug/l)	Cd (ug/l)	Co (ug/l)	Cr (ug/l)	Cu (ug/l)	Li (ug/l)	Mo (ug/l)	Ni (ug/l)	Pb (ug/l)
106517	<0.5 P	<0.5	<0.5	<0.20	<38.38	1.54	93	8.4	<1.01	<500	<0.25	<0.51	<0.20	<2.02	41	0.778	<0.51	<0.77
	<0.05	0.332	<0.05	<1.0	<10.0	1.3	86.7	7.48	<1.0	<50	<1.0	<1.0	<1.0	<2.5	36.4	<1.0	<1.0	<1.0
106518	<0.5 P	<0.5	<0.5	<0.04	<7.68	0.98	101	1.19	<0.20	<500	<0.05	<0.10	<0.04	<0.40	42.4	5.62	<0.10	<0.15
	0.062	0.434	<0.05	<0.2	<2.0	1.36	93.9	0.902	<0.2	<50	<0.2	<0.2	<0.2	<0.5	39.9	3.89	<0.2	<0.2
251120	7.32 P	<1.0	<1.0	<0.40	<76.76	<1.01	348	11.3	<2.02	<1000	<0.51	<1.01	<0.40	<4.04	186	0.778	<1.01	<1.54
	5.69	0.9	<0.25	<1.0	<10.0	<1.0	292	9.55	<1.0	<250	<1.0	<1.0	<1.0	<2.5	170	<1.0	<1.0	<1.0
251123	<0.5 P	<0.5	<0.5	<0.20	<38.38	<0.51	177	9.73	<1.01	<500	<0.25	<0.51	<0.20	<2.02	60.7	1.16	<0.51	<0.77
	<0.25	0.436	<0.25	<1.0	<10.0	<1.0	165	9.48	<1.0	<250	<1.0	<1.0	<1.0	<2.5	56.3	<1.0	<1.0	<1.0
105929	<0.5 P	0.872	<0.5	<0.20	<38.38	3.8	394	14.6	<1.01	<500	<0.25	<0.51	<0.20	5.46	52.9	1.93	<0.51	<0.77
	0.374	1.18	<0.25	<1.0	<10.0	3.24	453	14.3	<1.0	<250	<1.0	<1.0	<1.0	<2.5	52	1.95	<1.0	<1.0
251135	<0.5 P	0.731	<0.5	<0.20	<38.38	<0.51	448	15	<1.01	<500	<0.25	<0.51	<0.20	<2.02	58	4.54	<0.51	<0.77
	<0.05	1.65	<0.05	<1.0	<10.0	<1.0	361	10.3	<1.0	<50	<1.0	<1.0	<1.0	<2.5	87.6	4.76	<1.0	<1.0
185488	<0.5 P	<0.5	<0.5	<0.20	<38.38	1.38	98.2	8.03	<1.01	<500	<0.25	<0.51	<0.20	<2.02	51.3	0.919	<0.51	<0.77
	<0.05	0.406	<0.05	<1.0	<10.0	1.04	87.5	1.45	<1.0	<50	<1.0	<1.0	<1.0	<2.5	48.6	2.82	<1.0	1.48
257044	0.969	0.451	<0.05	<0.2	<2.0	0.896	146	32.9	<0.2	84	<0.2	<0.2	<0.2	0.607	78.9	1.43	<0.2	<0.2
106508	<0.25	0.479	<0.25	<1.0	<10.0	<1.0	321	14.4	<1.0	<250	<1.0	<1.0	<1.0	<2.5	57.6	1.55	<1.0	<1.0
908357	<0.5 P	<0.5	<0.5	<0.20	<38.38	1.18	77.3	9.55	<1.01	<500	<0.25	<0.51	<0.20	<2.02	41.7	0.361	<0.51	<0.77
	<0.05	0.216	<0.05	<1.0	<10.0	1.19	76.5	9.06	<1.0	<50	<1.0	<1.0	<1.0	<2.5	39.2	<1.0	<1.0	<1.0
211789	<0.5 P	<0.5	<0.5	<0.20	<38.38	2.21	122	21.2	<1.01	<500	<0.25	<0.51	<0.20	<2.02	53.9	1.12	<0.25	<0.77
	<0.05	0.404	<0.05	<1.0	<10.0	2.36	117	19.5	<1.0	<50	<1.0	<1.0	<1.0	<2.5	48.1	<1.0	<1.0	<1.0
251154	<0.5 P	<0.5	<0.5	<0.20	<38.38	6.46	183	7.37	<1.01	<500	<0.25	<0.51	<0.20	<2.02	70.6	0.555	<0.51	<0.77
	<0.05	0.269	<0.05	<1.0	<10.0	6.32	173	6.65	<1.0	<50	<1.0	<1.0	<1.0	<2.5	64.8	<1.0	<1.0	<1.0

Gwic Id	Sb (ug/l)	Se (ug/l)	Sn (ug/l)	Sr (ug/l)	Ti (ug/l)	Tl (ug/l)	U (ug/l)	V (ug/l)	Zn (ug/l)	Zr (ug/l)	Ce (ug/l)	Cs (ug/l)	Ga (ug/l)	La (ug/l)	Nb (ug/l)	Nd (ug/l)	Pd (ug/l)	Pr (ug/l)	Rb (ug/l)
106517	<0.24	<0.51	<0.21	742	5.83	<0.17	1.07	<0.51	<0.25	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.25	<0.51	<0.11	3.81
	<1.0	<1.0	<1.0	728	3.84	<1.0	2.11	<1.0	16.2	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	3.67
106518	<0.05	4.14	<0.04	506	2.36	<0.03	3.45	<0.10	38	<0.05	<0.02	<0.04	<0.05	<0.02	<0.04	<0.05	0.152	<0.02	2.87
	<0.2	3.73	<0.2	472	1.65	<0.2	3.7	<0.2	44.9	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	2.76
251120	<0.48	<1.01	<0.41	2311	19.1	<0.33	38.8	<1.01	<9.09	<0.51	<0.20	<0.42	<0.51	<0.22	<0.40	<0.52	<1.01	<0.21	2.47
	<1.0	1.52	<1.0	2600	14.6	<1.0	43.3	<1.0	59.4	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	2.87
251123	<0.24	<0.51	<0.21	1248	4.52	<0.17	9.28	<0.51	80.3	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.25	<0.51	<0.11	4.12
	<1.0	6.09	<1.0	1351	3.15	<1.0	14.1	<1.0	116	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	4.25
105929	<0.24	0.581	0.294	161	8.87	<0.17	0.398	<0.51	<4.55	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.26	<0.51	<0.11	3.09
	<1.0	<1.0	<1.0	157	6.57	<1.0	<1.0	<1.0	9.89	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	3.12
251135	<0.24	<0.51	<0.21	324	4.77	<0.17	<0.12	<0.51	<4.55	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.26	<0.51	<0.11	1.99
	<1.0	<1.0	<1.0	901	6.61	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	<2.5
185488	<0.24	<0.51	<0.21	370	5.59	<0.17	<0.12	<0.51	<4.55	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.26	<0.51	<0.11	2.04
	<1.0	<1.0	<1.0	131	3.7	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	<2.5
257044	<0.2	15	<0.2	1201	1.79	<0.2	20.8	<0.2	<1.0	<0.2	<0.2	<0.5	<0.2	<0.2	<0.2	<0.2	<0.5	<0.2	1.35
106508	<1.0	<1.0	<1.0	128	8.3	<1.0	<1.0	<1.0	<5.0	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	4.11
908357	<0.24	<0.51	<0.21	87.6	10.3	<0.17	<0.12	<0.51	<4.55	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.26	<0.51	<0.11	2.14
	<1.0	<1.0	<1.0	87.2	7.68	<1.0	<1.0	<1.0	8.94	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	<2.5
211789	<0.24	<0.26	<0.20	178	<0.51	<0.11	<0.12	<0.51	83.7	<0.25	<0.10	<0.21	<0.25	<0.11	<0.11	<0.77	53.9	1.12	<0.51
	<1.0	<1.0	<1.0	183	6.42	<1.0	<1.0	<1.0	77	<0.2	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	<2.5
251154	<0.24	<0.51	<0.21	1671	8.14	<0.17	18.7	<0.51	40	<0.25	<0.10	<0.21	<0.25	<0.11	<0.20	<0.26	0.519	<0.11	4.07
	<1.0	<1.0	<1.0	1590	6.1	<1.0	21	<1.0	67.1	<1.0	<1.0	<2.5	<1.0	<1.0	<1.0	<1.0	<2.5	<1.0	3.93

Gwic Id	Th (ug/l)	W (ug/l)	NO2-N (mg/l)	NO3+NO2-N (mg/l)	Total N as N (mg/l)
106517	<0.12	<0.25			
	<1.0	<1.0	<0.05	5.65	6.39
106518	<0.02	<0.05			
	<0.2	<0.2	<0.05	3.9	4.63
251120	<0.23	<0.51			
	<1.0	<1.0	<0.25	9.34	10.1
251123	<0.12	<0.25			
	<1.0	<1.0	<0.25	<0.2	<1.0
105929	<0.12	<0.25			
	<1.0	<1.0	0.329	<0.2	1.01
251135	<0.12	<0.25			
	<1.0	<1.0	<0.05	4.11	4.4
185488	<0.12	<0.25			
	<1.0	<1.0	<0.05	<0.2	<1.0
257044	<0.2	<0.2	<0.05	0.951	1.36
106508	<1.0	<1.0	<0.25	<0.2	1.28
908357	<0.12	<0.25			
	<1.0	<1.0	<0.05	<0.2	1.04
211789	1.93	178			
	<1.0	<1.0	<0.05	<0.2	1.47
251154	<0.12	<0.25			
	<1.0	<1.0	<0.05	<0.2	<1.0