2016

SYNOPTIC GROUNDWATER SAMPLING ON THE ASHLAND RANGER DISTRICT

MBMG Open-File Report 670

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Cover image: All photos by Clay Schwartz. Large photo: Stag Rock. Smaller photos: parameter monitoring during purging, Spring Creek Pipeline well, and North Fork Spring.

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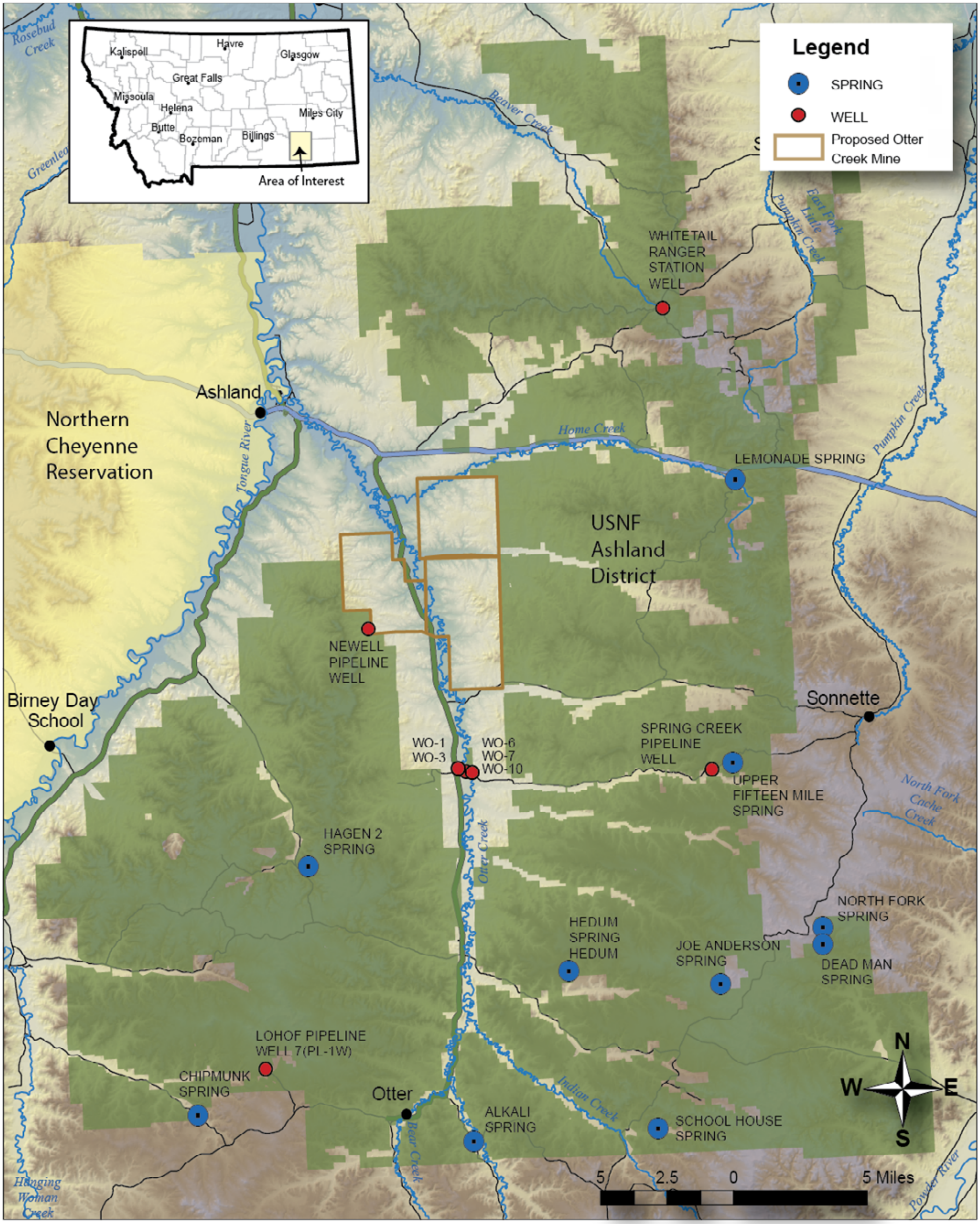

Figure 1. Location of sampled sites and proposed coal mine.

ABSTRACT

During the falls of 2014 and 2015, the Montana Bureau of Mines and Geology (MBMG) and the U.S. Forest Service (USFS) collaborated on a synoptic groundwater sampling program on the Ashland Ranger District of the Custer National Forest. The agencies selected twenty wells and springs that are near the location of a potential coal mine or had not previously been sampled.

The chemistry of most samples were either sodium bicarbonate (mature groundwater usually in coals and sandstone) or sodium sulfate (young water generally in alluvium and sandstone). Alluvial water along Otter Creek was also sodium sulfate type, indicating recharge from bedrock. Two springs (Hagen 2 and Joe Anderson) and one well (Whitetail Ranger Station) produced low-salinity magnesium bicarbonate water, likely from a local clinker recharge. Water from Hedum Spring had a unique magnesium sulfate composition, high salinity, and high levels of several trace elements of concern for drinking and stockwater. Isotope ratios of oxygen and hydrogen show that most springs receive recharge from colder precipitation or higher elevations than do wells that produce groundwater from regional flow systems.

INTRODUCTION

In the semi-arid Powder River Basin of southeastern Montana, local ecosystems, wildlife populations, and livestock grazing depend upon the available water resources. Inventoried groundwater resources on the Ashland Ranger District include 284 springs with a total discharge of over 250 gpm; 34 wells, 24 of which are completed in sandstone and/or coals of the Fort Union Formation; and 25 groundwater-dependent stream segments with a combined flow of about 400 gpm (Wheaton and others, 2008a). Coal aquifers are an important water source for stock and wildlife on the Ashland Ranger District and throughout the Powder River Basin.

The U.S. Forest Service Ashland Ranger District of the Custer–Gallatin National Forest is surrounded by potential and ongoing coal-related development, including a proposed coal mine along Otter Creek and upgradient coalbed-methane fields. Both the coal mine and coalbed-methane production have the potential to impact the groundwater and springs that supply stock and wildlife water and contribute to surface-water flows on the District. Coal mining disrupts the hydrologic function of the coal by the necessary dewatering for coal production, its ultimate removal, and finally its replacement by spoils fill. Coalbed-methane development requires the groundwater level to be drawn down in coals in order to produce methane gas.

The MBMG characterized the current state of groundwater in order to be able to identify future changes to groundwater on the District. Twenty groundwater sites, 10 wells and 10 springs, were sampled during fall 2014 and 2015 (appendix A). By sampling these sites in the fall, near the low point in the hydrologic cycle, the effects of variability due to local precipitation are minimized. Large amounts of precipitation can lower or raise the salinity or change the chemistry of locally recharged aquifers, but such a sample could not be replicated. The results from this synoptic sampling effort provide a snapshot of the current state of water quality on the district, including natural variation over the course of the 2-year study.

The MBMG and USFS chose sample locations from the set of wells and springs that make up the MBMG groundwater monitoring network on the Ashland Ranger District. Springs and wells that did not have a long history of sampling and wells near the proposed coal mine (the WO set of monitoring wells) were selected (fig. 1; table 1; a full description of sample sites and locations is in appendix A).

Table 1. Sample sites.

Springs	Wells
Upper Fifteen Mile	WO-1
Hedum	WO-2
Joe Anderson	WO-3
North Fork	WO-6
Deadman	WO-7
School House	WO-10
Alkali	Whitetail Ranger Station
Chipmunk	Newell Pipeline
Hagen -2	Spring Creek Pipeline
Lemonade (Musgrove)	Lohof Pipeline

METHODS

The MBMG collected samples from all wells but one after purging three casing volumes of water. The exception was the Spring Creek Pipeline Well, which was sampled at the well head in 2015, but could only be sampled from the holding tank in 2014. During purging, field parameters of salinity (specific conductance, SC), temperature, and pH were measured to ensure that field parameters had stabilized to within 10 percent. Samples from developed springs were collected as close as possible to the discharge point and prior to entering holding impoundments.

All samples were filtered, preserved, and stored according to laboratory protocol. Samples were analyzed for major and minor inorganic constituents (appendix B) and isotopes of oxygen and hydrogen (appendix C) at the MBMG Analytical Laboratory in Butte, Montana.

At each site a field inventory was completed in 2014 that included an updated location by navigational GPS, descriptive directions, and photographs. Site photographs are available as digital files and selected photographs are included in appendix D. All water-level measurements, field parameters (SC, T, pH), geochemistry results, and information on sample locations are available from the Groundwater Information Center Database (GWIC) maintained by the MBMG: http://mbmggwic.mtech.edu/.

Project-specific information is collected under the Project Code USFSOTTER within the coal and CBM-related project category: http://mbmggwic.mtech.edu/sqlserver/v11/menus/menuProject.asp?mygroup=CBM&.

RESULTS

MAJOR ION CHEMISTRY

Geochemical evolution in Powder River Basin groundwater is driven by physical and biological processes that control the relative abundance of constituents. Sulfate in groundwater is generated through dissolution of gypsum ($CaSO_4$) and epsomite ($MgSO_4$) in soils by infiltrating precipitation in recharge areas. In aquifers where pyrite (FeS_2) is present, iron and sulfate can increase due to oxidation; excess sulfate can precipitate as gypsum. A high percentage of sodium in groundwater is primarily driven by cation exchange of calcium and magnesium for sodium on clays. As water moves down a flow path, sulfate-reducing bacteria decrease sulfate concentrations and increase the relative bicarbonate concentration (Brinck and others, 2008). Magnesium in Powder River Basin groundwater is generated through dedolomitization, which dissolves dolomite and gypsum to precipitate calcite and aqueous magnesium sulfate (Clark, 1995):

$$CaMg(CO_3)_2 + CaSO_4 \Rightarrow 2CaCO_3 + MgSO_4 \text{ (aq)}.$$

Major cations (positively charged ions) in groundwater are calcium, magnesium, sodium, and potassium, and to a lesser degree iron, manganese, and silica. Major anions (negatively charged ions) are bicarbonate, carbonate, chloride, and sulfate and to a lesser degree nitrate, fluoride, and phosphate. These elements are usually measured in milligrams per liter (mg/L). The major ion chemistry, presented as percentage composition on a trilinear plot (fig. 2), shows several distinct water types present on the District.

Magnesium-bicarbonate or magnesium-sulfate water comes from sites near recharge sources such as clinker outcrops (marked as Recharge in fig. 2). The sulfate in some of these waters may be attributable to recharge sources where epsomite or gypsum is present in soils, or pyrite is present in clinker. Most of the water is an "Intermediate" sodium-sulfate type found in sandstone aquifers. This water is from deeper in the flow system, where microbial activity has not fully reduced the sulfate, than the magnesium-bicarbonate/sulfate "Recharge" water. "Transitional" waters plot between the "Intermediate" and "Mature" sodium-bicarbonate type waters typified by coal aquifers (fig. 2). The Intermediate, Transitional, and Mature chemistries are from deep in the flow system, distant from recharge sources.

Another way to compare the geochemistry of the sites is with Stiff diagrams, which display absolute concentrations of the major ions. In addition to the water type shown by the shape of the diagram, the size of the plot increases with increased salinity or the dissolved constituent concentration. The water types magnesium bicarbonate or magnesium sulfate (Recharge, fig. 3), sodium sulfate (Intermediate, fig. 4), and a sodium-bicarbonate (Transitional and Mature, fig. 5), displayed as Stiff diagrams, show the geochemical progression with distance from recharge. For a description of environmental factors influencing water chemistry in the Powder River Basin, see Brinck and others (2008).

Mineral species that drive groundwater-quality reactions in recharge areas are highly variable in the Powder River Basin. Infiltrating precipitation is slightly acidic and oxygenated. Minerals in the shallow systems reflect the geologic depositional environments and salts from ongoing dissolution/precipitation and oxidation/reduction reactions. The result is highly variable groundwater quality in recharge areas (fig. 3). Further along the flow path, the reaction options are somewhat more limited; groundwater quality is dominated by a consistent

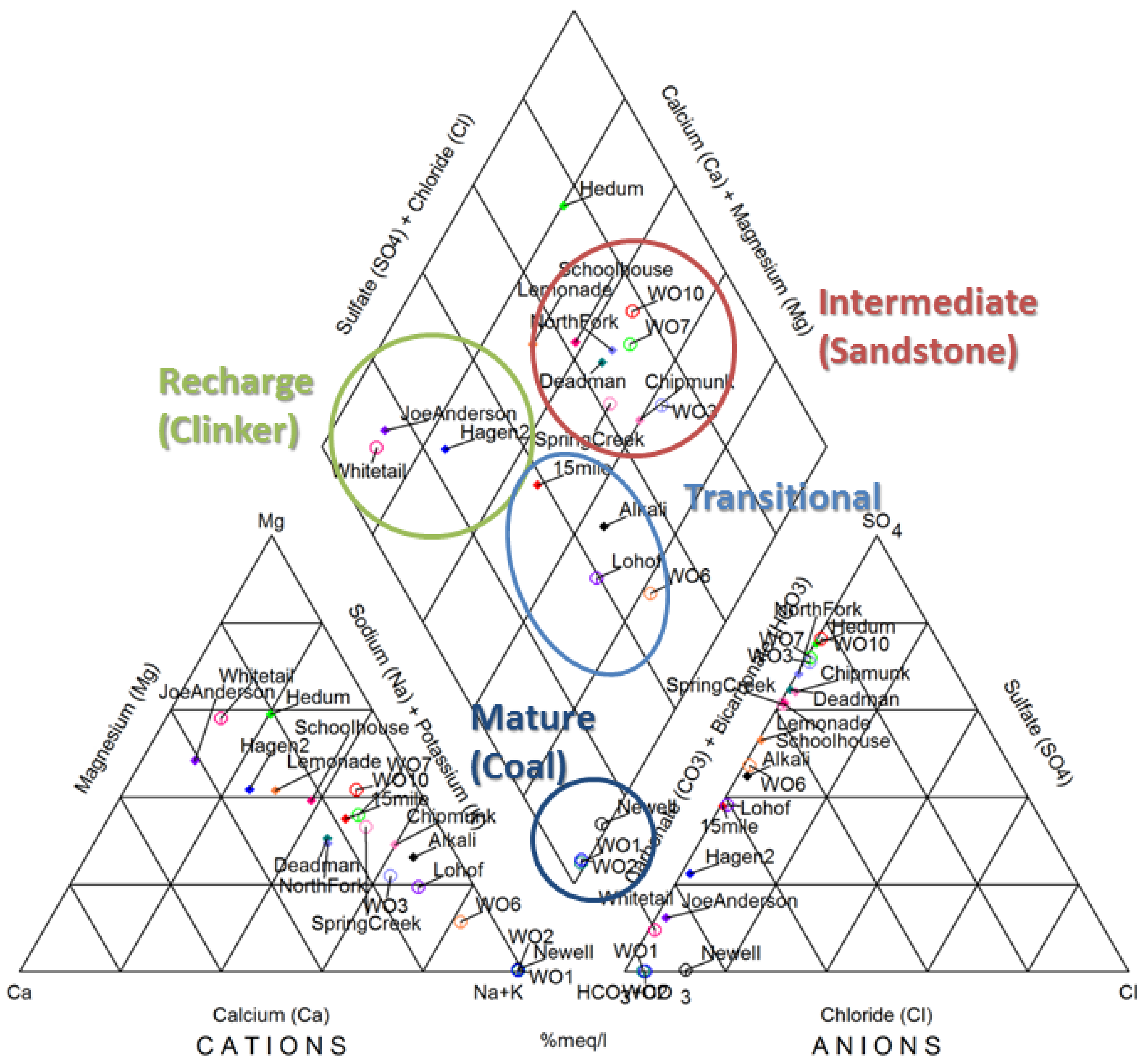

Figure 2. Recharge, Intermediate, Transitional, and Mature groundwater types within the Ashland Ranger District displayed on a trilinear plot.

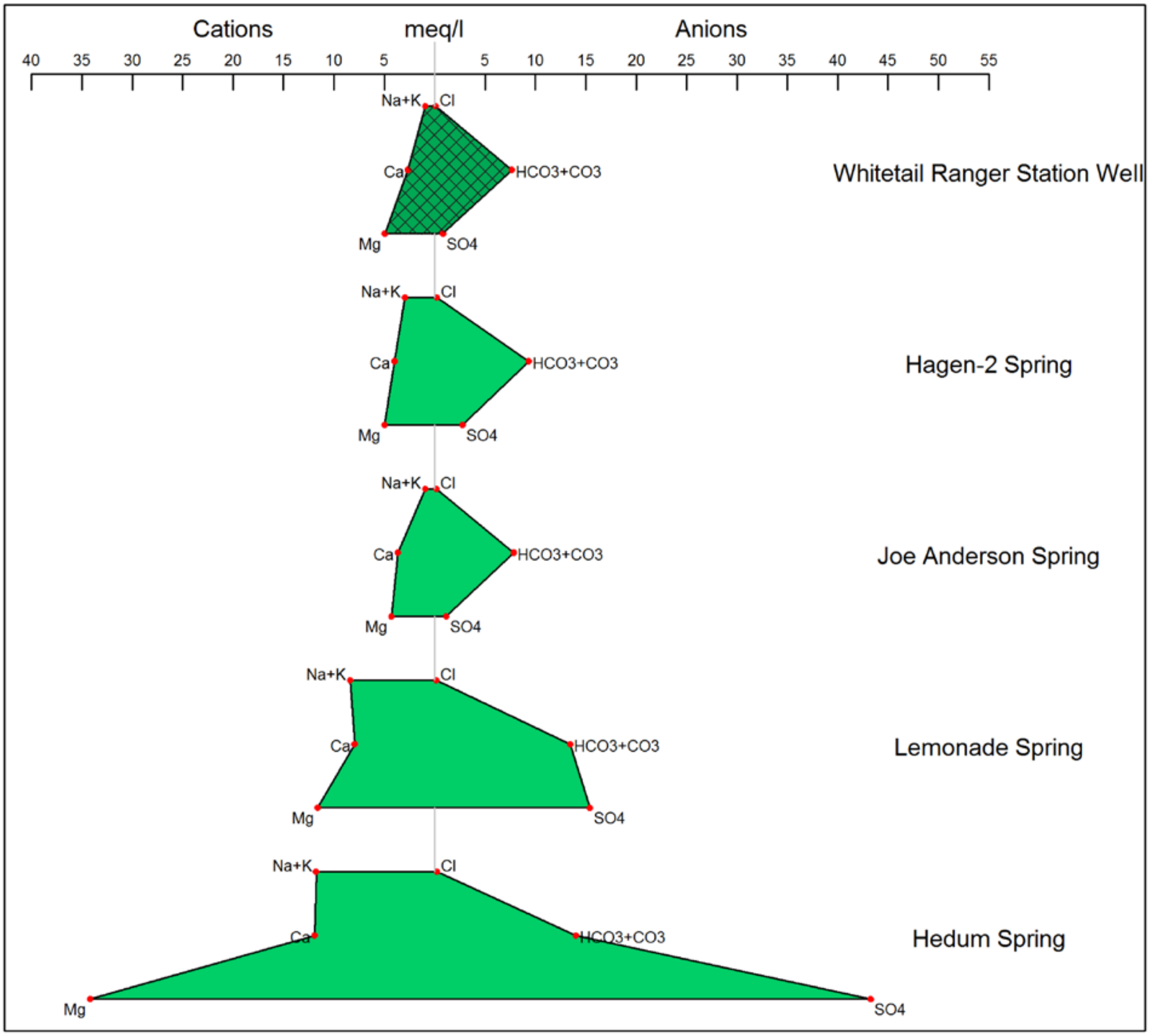

Figure 3. Stiff diagrams of magnesium-bicarbonate or magnesium-sulfate type Recharge water from wells and springs sampled in 2015. Lighter colors are springs, darker/hatched colors are wells. Water from Lemonade Spring likely has a transitional chemistry between Recharge waters and Intermediate sodium-sulfate type waters.

and predictable suite of constituents, sodium sulfate, and concentration (salinity) is the highest variable (fig. 4). At even further distances along the flow path, the reactions options are more limited and dominated by microbial activity and the resultant groundwater quality is characteristically predictable as sodium bicarbonate (fig. 5).

Clinker aquifers generally have low-salinity magnesium-bicarbonate water such as that found in the Whitetail Ranger Station well, Hagen 2 Spring, and Joe Anderson Spring (fig. 3). However, while Hedum Spring is likely locally recharged and near clinker outcrops, its magnesium-sulfate water is markedly different from water discharged by the other clinker springs (fig. 3). Clinker forms when heat from naturally burning coalbeds metamorphoses overlying rock layers. Minerals in clinker that may be available for dissolution depend on the original rock composition and the temperature of melting.

The Whitetail Ranger Station well belongs to the MBMG Coalbed Methane Monitoring network as well as the MBMG statewide monitoring network, but previously had no recorded information on the aquifer source. Because the water chemistry in the Whitetail Ranger Station well closely matches the chemistry of water from the Hagen 2 and Joe Anderson Springs, known to discharge from clinker aquifers, the Whitetail Ranger Station

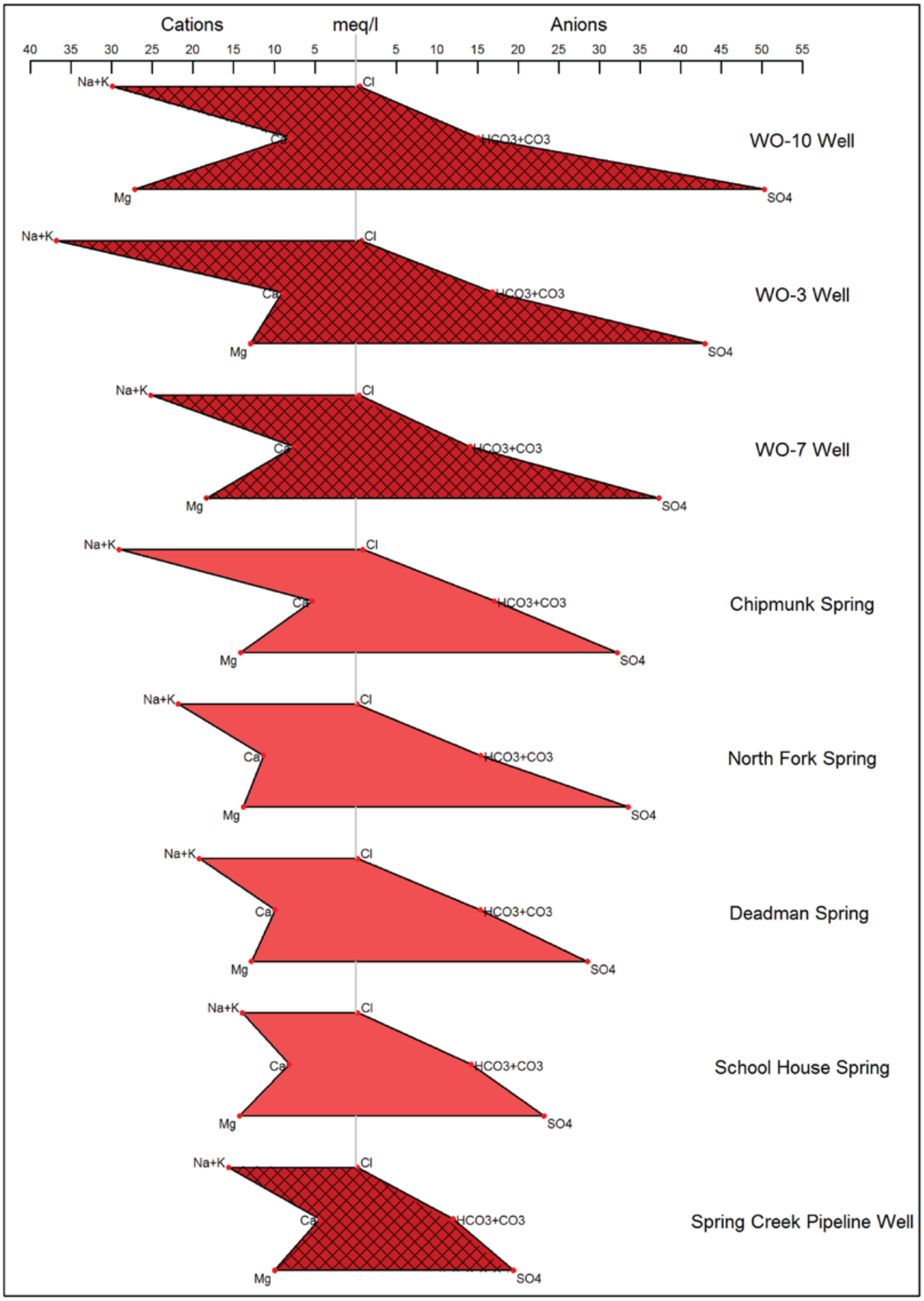

Figure 4. Stiff diagrams for Intermediate, sodium-sulfate type waters produced by wells and springs sampled in 2015. ighter colors are springs, darker/hatched colors are wells.

well is also likely recharged locally. Because of the localized recharge source, the Whitetail Ranger Station well is potentially subject to local climatic variability (e.g., drought).

Because sodium-sulfate type groundwater is found in both Otter Creek alluvium and the nearby sandstone aquifers (fig. 4), the recharge to the alluvial aquifers comes, at least in part, from the sandstone aquifers. Precipitation, often considered to be a major source of recharge to alluvial aquifers, is a low-salinity recharge source—but water from alluvial well WO-10 exceeds 4,000 mg/L. Therefore Otter Creek alluvial groundwater, as measured in wells WO-3, WO-7, and WO-10, has only a small component of vertical infiltration of recent precipitation and a large component of water from bedrock recharge.

Mixing of waters from different aquifers can be illustrated using Stiff diagrams. Coal aquifers, reduced sodium-bicarbonate type water (including those containing methane), are depicted by diagrams for wells WO-1, WO-2, and the Newell Pipeline well in figure 5. Water with increasingly more magnesium and sulfate, as shown by diagrams for the Lohoff Pipeline well, well WO-6, Alkali Spring, and Upper Fifteen Mile Spring, has not been

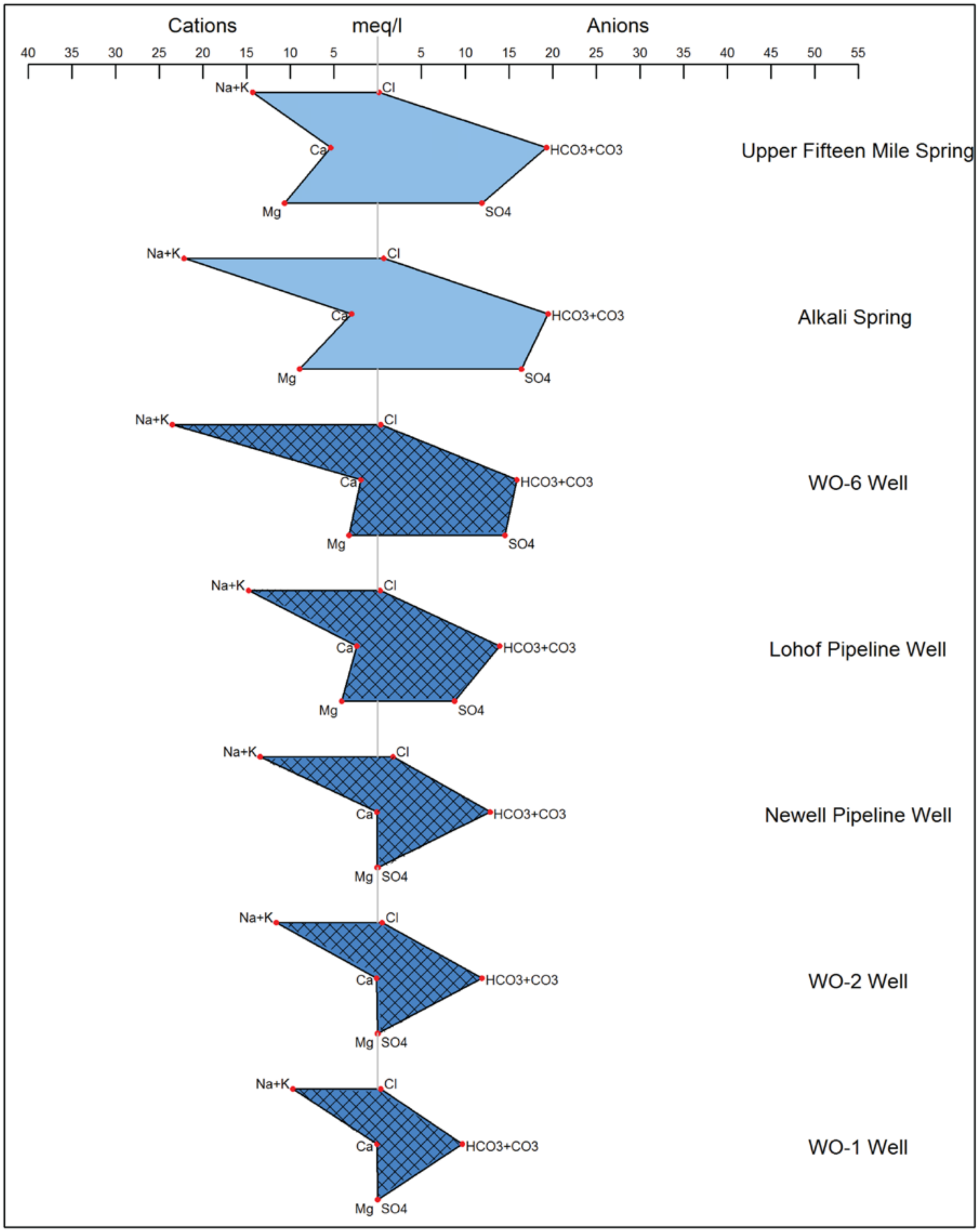

Figure 5. Stiff diagrams of Transitional and Mature sodium-bicarbonate wells and springs sampled in 2015. Lighter colors are springs, darker/hatched colors are wells. Samples that contain measurable sulfate are transitional between the geochemistry of the Intermediate and Mature water.

fully microbially reduced or may be mixtures of mature water, including coal aquifer water, and recently recharged water (Transitional water in figure 2).

Although no water-quality samples from Otter Creek were collected during this project, chemistry from samples collected by the MBMG in 2013 from six locations are shown in figure 6. Otter Creek has been sampled by the MBMG under a couple of previous programs, most recently an MBMG Groundwater Investigation Program (GWIP) study on bedrock recharge to Powder River Basin streams. The six locations are between the towns of Otter (confluence of Bear Creek and Otter Creek) and Ashland, Montana. Otter Creek is chemically similar to the alluvial groundwater (fig. 4), but has slightly lower total dissolved solids. The stream's chemistry is consistent except for the sample collected at Ashland Bridge, which likely includes water from the Home Creek tributary.

TRACE ELEMENT CHEMISTRY

Trace elements are those that are at significantly lower concentrations than major ions, usually measured in micrograms per liter (µg/L). These are predominantly metals, and several are considered hazardous to human health above certain levels. Some trace elements are of concern in drinking water because of secondary standards of taste, smell, or appearance.

Aluminum was found intermittently in several wells, where one of four samples had measurable concentrations. The secondary drinking water standard for aluminum ranges from 50 to 200 µg/L; however, fish and aquatic life are more sensitive and the aquatic life criteria (EPA, 2015) limits aluminum to 87 µg/L for chronic conditions and 750 µg/L for acute conditions (for waters between pH 6.5 and 9.0). In this sample set, detectable aluminum concentrations at seven sites were (in µg/L): Lemonade Spring (two detections, 42 and 81), Hagen 2 Spring (one detection, 9.3), Joe Anderson Spring (one detection, 13), WO-1 (two detections, 70 and 22), WO-2 (two detections, 90 and 4.1), WO-3 (one detection, 50), and WO-7 (one detection, 30). The analytical detection limit for aluminum in this dataset varied from 4.0 from 150 µg/L, depending upon the analytical equipment used and the sample salinity.

Other water-quality standards that were exceeded in some samples were for lead and cadmium. Lead has a primary drinking water standard of 15 µg/L for humans and 50 µg/L for stock. Lead was detected twice; once in WO-3 (40 µg/L) and once in North Fork Spring (105 µg/L). The analytical detection limit for lead in the data varied from 0.06 to 40 µg/L, depending upon the equipment and the sample salinity. Because the detection limit varied, lead concentrations in some samples could exceed the primary drinking water standard yet still be reported as below detection.

The primary drinking water standard for cadmium, 5 µg/L, was approached in one sample from Chipmunk Spring, which had a concentration of 4.5 µg/L in June 2009.

The MBMG sampled Hedum Spring four times from 2013 to 2015. The water has consistently violated several primary drinking water standards: Nitrate as N (drinking water standard 10 mg/L) ranged from 9.5 to 11 mg/L; arsenic (drinking water standard 10 µg/L) ranged from 10 to 13 µg/L, selenium (drinking water standard 50 µg/L; irrigation standard 20 µg/L) ranged from 22 to 31 µg/L, and uranium (drinking water standard 30 µg/L) ranged from 25 to 48 µg/L. The nitrate is likely from cattle using the surrounding landscape, but nitrate isotope analyses would be required to define the source. The sources of the other trace elements are unknown; perhaps they are associated with local clinker geochemistry. Elevated arsenic concentrations are found in some groundwater near the Tongue River and there are elevated uranium concentrations in some groundwater near the Powder River; however, the co-occurrence of all these metals is unusual and deserves further study.

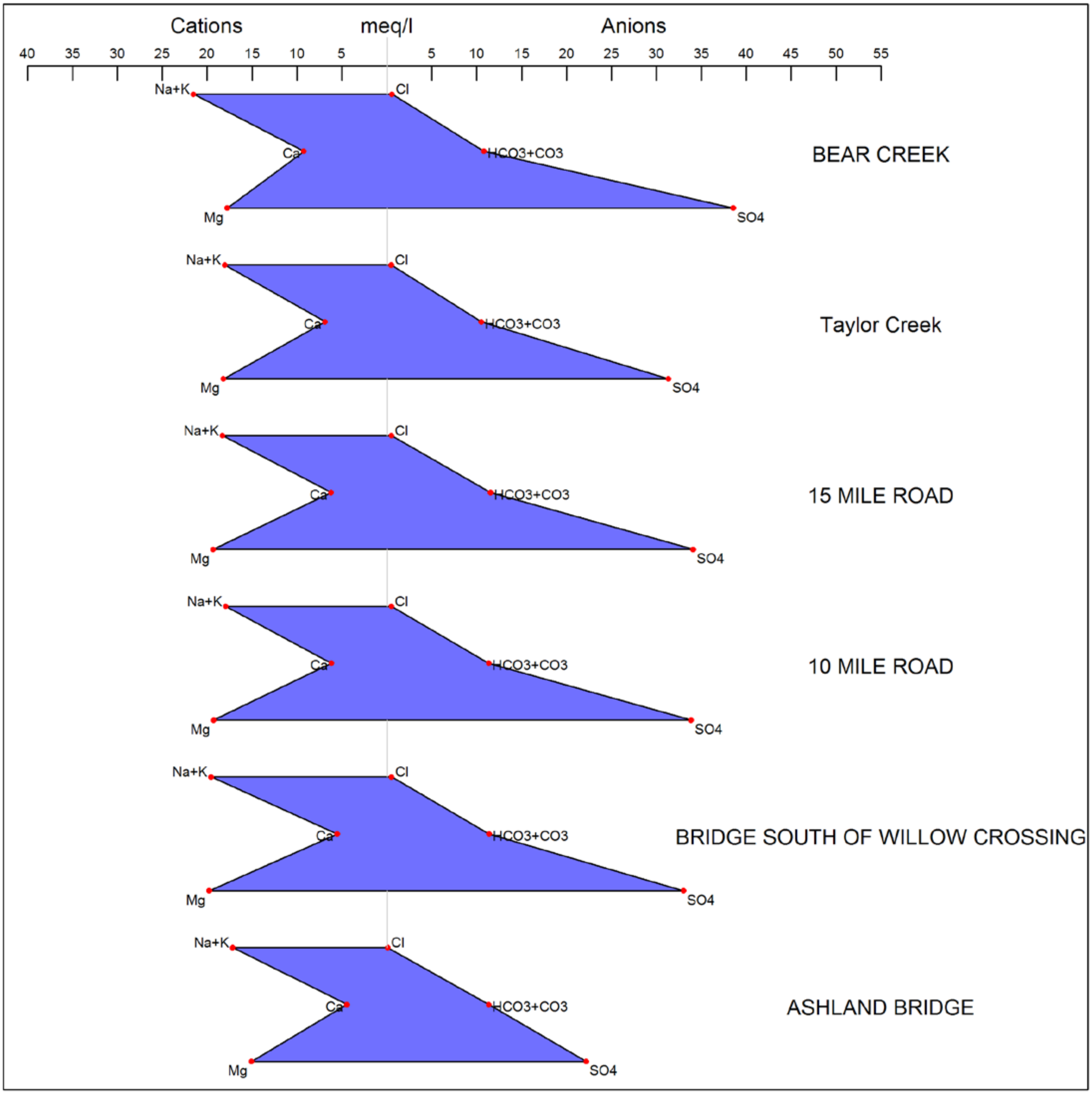

Figure 6. Otter Creek water quality in December 2013 from Bear Creek downstream to Ashland. Labels reflect the closest landmark. The stream water chemistry is similar to that of the alluvial aquifer (WO samples on figure 4). Otter Creek gains water along the sampled reach near the WO monitoring wells (Meredith and Kuzara, 2015).

SODIUM ADSORPTION RATIO

The recommended sodium level for irrigation water use depends on the soil type and balance of sodium to the other cations in the water. The potential sodium hazard to soils is reported as the Sodium Adsorption Ratio (SAR), which is the ratio of sodium to calcium and magnesium in millequivalents per Liter (meq/L). As a rule of thumb, an SAR that exceeds 10 is considered potentially harmful to soils. The samples that were near or exceeded 10 were from the sodium-bicarbonate type wells and springs (fig. 5). The exception was water from the Upper Fifteen Mile Spring, which had enough magnesium to lower the SAR to around 5. Additionally, among the sodium-sulfate waters depicted in figure 4, Chipmunk Spring and monitoring well WO-3 were near the 10 SAR limit. Water from the other sodium-sulfate wells and springs in figure 4 had a balance of magnesium and sodium that resulted in SAR values below 10.

ISOTOPE RESULTS

All of the samples were analyzed for isotopes of oxygen and hydrogen. Oxygen and hydrogen isotope ratios in water are reported in terms of their divergence from the average ocean water ratio (VSMOW). Divergences of individual sample results from VSMOW are delta (δ) values. The more negative the delta value, lower the ratio of heavy to light isotopes (Clark and Fritz, 1997). Isotope ratios of groundwater are an average of the annual precipitation; more negative values are associated with colder or higher elevation precipitation. The Ashland District isotope data are displayed in figure 7 in reference to the Global Meteoric Water Line (GMWL), a summary of average precipitation isotope values.

In general, water from the springs have more negative delta values, meaning that it contains less of the heavy isotopes (^{18}O and ^{2}H) than does water collected from wells (squares versus circles in figure 7). Water from the springs appears to have a large component of local recharge such as snowmelt and early spring rain on clinker-capped ridges. Wells from deep sources (sample depths range from 40 to 325 ft) have a relatively large component of regional recharge from low-elevation precipitation.

Exceptions to the general pattern are water samples from Joe Anderson Spring and the Lohof Pipeline well. The geochemistry of Joe Anderson Spring water is similar to that of other low-salinity clinker-recharged springs; there is no evidence that the water has undergone significant alteration (evaporation, water/rock interaction, hydrothermal, etc.). Although the surface lithology at the spring is the Fort Union Formation, the water does not display the typical geochemistry associated with sandstone or coal. However, Joe Anderson Spring is near

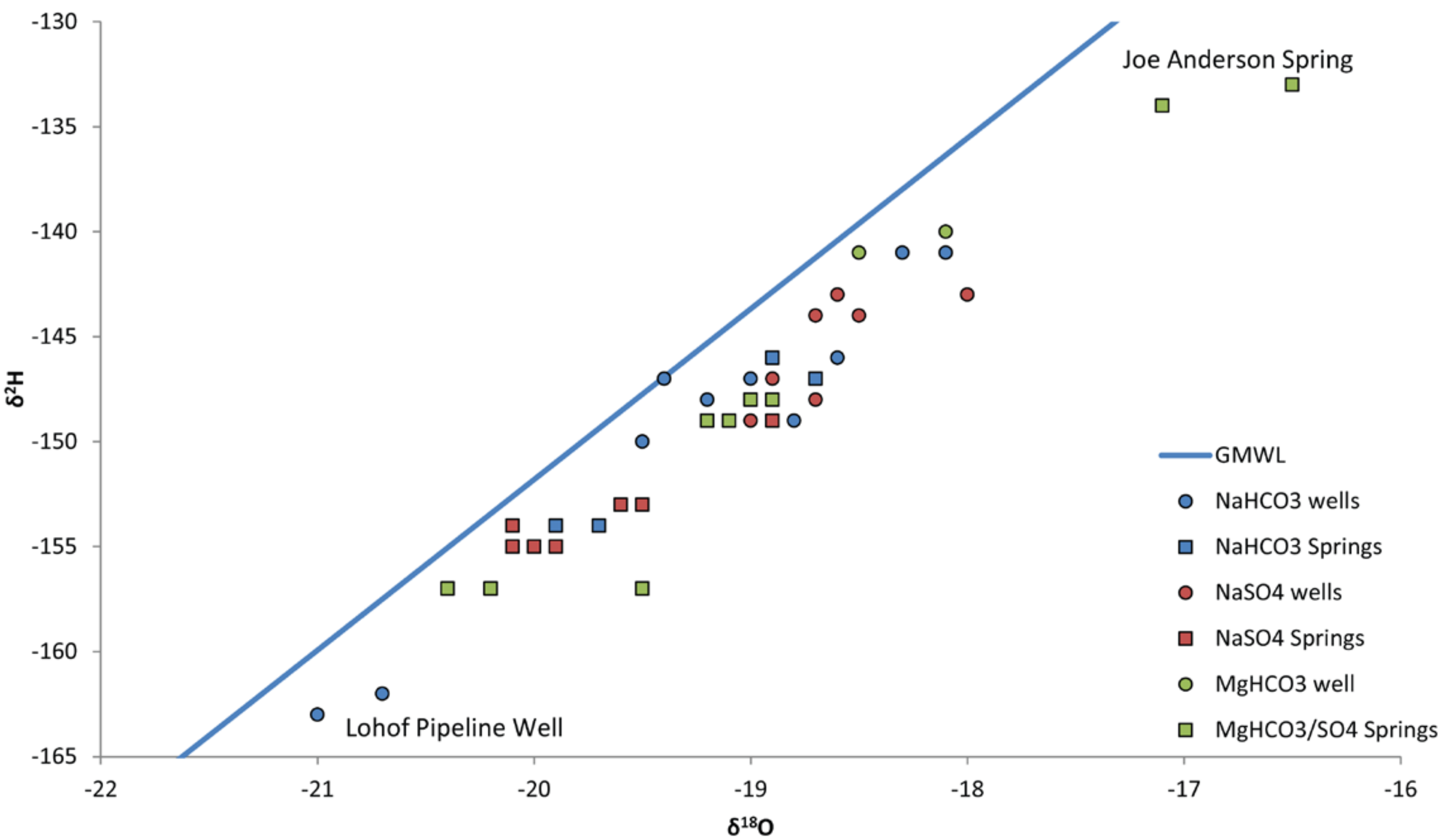

Figure 7. Oxygen and hydrogen isotope values for groundwater collected during the synoptic sampling program.

some clinker-capped ridges that may be a local source for most of its discharge. For this reason it would be expected to plot near the other sampled springs.

Water from the Lohof Pipeline well is isotopically the lightest in the dataset. The Stiff diagram in figure 5 for this water shows that it is not as mature as water from coal aquifers produced by well WO-2 or the Newell Pipeline Well; note that the sulfate has not been fully reduced. However, water from the Lohoff Pipeline well is geochemically unlike Recharge water as shown in figure 3.

CONCLUSIONS AND RECOMMENDATIONS

The synoptic sampling project produced a valuable dataset to help understand the current condition of water on the Ashland Ranger District. The dataset's value would be increased by placing it into the context of all the surface-water and groundwater samples collected by the MBMG, U.S. Geological Survey, and Arch Coal Company.

The 40 samples collected by the MBMG during this project allowed differentiation of local and regional recharge sources, identification of likely aquifers for previously unclassified wells, and finding potential mixing between aquifers. Merging these data with all of the regional water-quality data would only improve the delineation of regional and local flow paths, aquifer mixing, and important recharge sources. The implication for land management, which prioritizes water management, is apparent.

The dataset would be improved by adding tritium age-data. Alkali Spring is the only groundwater source on the District in the MBMG database that has been sampled for tritium (Wheaton and others, 2008b). The spring discharge contained no measureable tritium, indicating a water age of greater than 60 years. The data from this project provide guidance for selecting sites for tritium samples. Priorities would include Hedum Spring, because of its unique water chemistry, Joe Anderson Spring, because its chemistry does not match its isotopic fingerprint, and at least one alluvial well, such as WO-10, because the alluvial water chemistry along Otter Creek is similar to Intermediate water from sandstone, but has the potential to be recently and locally recharged. Additionally, further characterization of the alluvium near the future mine site would help regulatory agencies understand the recharge sources for the alluvium.

Future sampling will discover changes to the groundwater resources of the District. The current set of analyses provides a good foundation for baseline conditions; therefore, sampling can occur less frequently and as funding allows. However, once mining operations begin, a rigorous and frequent monitoring program (for quantity and quality) must be implemented.

ACKNOWLEDGMENTS

We received exceptional cooperation from landowners along Otter Creek. The MBMG would like to thank everyone who cooperated including Ray Smith, Pat Lohof, Jackie Musgrave, Rodger Gaskill, Thane Thomas, and the USFS staff of the Ashland Ranger District.

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APPENDIX A

Appendix A - Sample Locations

	Gwic Id	Site Name	Latitude	Longitude	Twn	Rng	Sec	Q Sec	County	Aquifer	Td	Date
Wells	183564	USDA FOREST SERVICE * WHITETAIL RANGER STATION	45.64031	-105.97647	02S	47E	19	CDCA	POWDER RIVER	125TGRV	60	
	7589	USDA FOREST SERVICE - NEWELL PIPELINE WELL	45.47266	-106.21484	04S	45E	19	DADD	POWDER RIVER	125KNCB	325	4/20/1958
	205082	USDA FOREST SERVICE- SPRING CREEK PIPELINE WELL	45.3882	-105.954533	05S	47E	20	ACAC	POWDER RIVER	125TGRV	50	
	144969	LOHOF PIPELINE WELL	45.23543	-106.30815	07S	44E	14	ABD	ROSEBUD	125TGRV	225	5/25/1992
	7780	MBMG WELL * WO-1	45.39473	-106.15033	05S	45E	23	BBAA	POWDER RIVER	125KNUB	172	11/2/1979
	7781	MBMG WELL * WO-2	45.39469	-106.15035	05S	45E	23	BBAA	POWDER RIVER	125LKCB	112	11/6/1979
	7782	MBMGWELL * WO-3	45.39461	-106.15035	05S	45E	23	BBAA	POWDER RIVER	125KNOB	66	11/6/1979
	7777	MBMG WELL * WO-6	45.3922	-106.139433	05S	45E	23	ABDA	POWDER RIVER	125LKCB	82	11/8/1979
	7778	MBMG WELL * WO-7	45.3922	-106.139484	05S	45E	23	ABDA	POWDER RIVER	110ALVM	40	11/9/1979
	7775	MBMG WELL * WO-10	45.39264	-106.14404	05S	45E	23	ABCB	POWDER RIVER	110ALVM	43	11/27/1979
Springs	197607	USDA FOREST SERVICE-* UPPER 15 MILE	45.391367	-105.938383	05S	47E	21	DCDC	POWDER RIVER	125TGRV		
	205004	USDA FOREST SERVICE * HAGEN-2	45.34491	-106.26941	06S	45E	6	ACDC	POWDER RIVER	125FRUN		
	199568	USDA FOREST SERVICE * HEDUM	45.28217	-106.07167	06S	46E	26	CDBA	POWDER RIVER	125TGRV		
	205011	USDA FOREST SERVICE * JOE ANDERSON	45.2714	-105.95539	06S	47E	34	CABA	POWDER RIVER	125TGRV		
	205010	USDA FOREST SERVICE * NORTH FORK	45.29944	-105.87417	06S	48E	20	BDCA	POWDER RIVER	125TGRV		
	199572	USDA FOREST SERVICE * DEADMAN	45.29024	-105.87501	06S	48E	29	BABB	POWDER RIVER	125TGRV		
	205049	USDA FOREST SERVICE * CHIPMUNK	45.21185	-106.36177	07S	44E	21	CCBB	ROSEBUD	125TGRV		
	197452	USDA FOREST SERVICE * ALKALI	45.191383	-106.150667	07S	46E	31	BACD	POWDER RIVER	125TGRV		
	205041	USDA FOREST SERVICE * SCHOOL HOUSE	45.1944	-106.0081	07S	47E	32	BABA	POWDER RIVER	125TGRV		
	198766	MUSGROVE - LEMONADE SPRING	45.54543	-105.92625	03S	47E	28	ACAA	POWDER RIVER	125TGRV		

APPENDIX B-1

Appendix B1: Groundwater Quality, Wells

Gwic Id	Site Name	Aquifer	Sample Date	Water Temp	Fld pH	Fld SC	Lab pH	Lab SC	Ca (mg/l)	Mg (mg/l)
7589	USDA FOREST SERVICE - NEWELL PIPELINE WELL	125KNCB	6/26/1975 11:20	13		3850	8.02	3681.2	9.1	6.3
			10/6/2014 10:41	18.4	8.66	1189	8.56	1297.99	2.25	1.07
			9/23/2015 13:32	21.4		1208	8.42	1336.06	2.13	0.99
144969	LOHOF PIPELINE WELL * BOYCE WELL	125TGRV	10/1/2014 10:55	11.7	7.74	1922	7.68	1954.8	47.65	49.83
			9/23/2015 10:15	12	7.36	1732	7.47	2055.57	47.66	50.19
183564	USDA FOREST SERVICE * WHITETAIL RANGER STATION	125TGRV	4/26/2005 15:45	6.8	8.74	1310	7.3	708	48.3	53.3
			9/30/2014 9:52	9	7.08	1142	7.06	707.52	49.97	59.7
			9/22/2015 9:54	8.9	6.8	704	6.96	752.14	52.87	60.12
205082	USDA FOREST SERVICE- SPRING CREEK PIPELINE WELL	125TGRV	10/2/2014 10:38	15.9	7.8	2540	7.68	2633.6	94.75	128.34
			9/23/2015 17:00	17.6		2457	7.48	2713.25	88.25	121.03
7780	MBMG MONITORING WELL * WO-1	125KNUB	10/22/1980 10:40	1.2	8.45	860	8.26	909	2	0.4
			10/6/2014 14:45	12.7	8.84	847	8.67	911.64	1.65	0.32
			9/24/2015 9:46	13.1		845	7.11	5426.27	181.41	157.06
7781	MBMG MONITORING WELL * WO-2	125LKCB	10/25/1980 16:30	12	8.5	1070	8.18	1103	2.8	0.6
			2/16/2011 11:26	12	8.73	980	8.49	922	2.26	0.503
			10/16/2013 13:49	12.2	8.64	819	8.27	993.38	2.34	0.52
			10/7/2014 8:25	12	8.63	1019	8.04	1084.42	2.33	0.5
			9/24/2015 9:50	12.8		894	8.42	1148.08	2.27	0.49
7782	MBMG MONITORING WELL * WO-3	125KNOB	10/21/1980 15:30	11.5	6.9	3400	7.57	3344	107	83.9
			10/6/2014 15:05	12.3	7.21	4230	7.14	4641.16	175.62	175.34
			9/24/2015 9:51	12.9		4800	8.46	933.86	1.56	0.31
7777	MBMG MONITORING WELL * WO-6	125LKCB	10/23/1980 13:30	11	7.6	1775	8.48	1845	16.8	13.6
			10/6/2014 12:00	11.5	8.3	2401	8.18	2597.7	36.56	37.06
			9/24/2015 7:16	10.7		2485	8.07	2788.44	38.73	39.86
7778	MBMG MONITORING WELL * WO-7	110ALVM	10/24/1980 11:20	11	7.1	3350	7.81	3293	126	175
			10/6/2014 12:01	10.5	7.43	3634	7.3	3940.82	148.2	217.98
			9/24/2015 7:18	10.2		3950	7.22	4328.91	151.99	223.15
7775	MBMG MONITORING WELL * WO-10	110ALVM	10/21/1980 13:00	9	7.3	4600	8.14	4439	155	292
			2/15/1983 12:10	9.5	7.59	4200	7.79	4136	141	276
			10/8/1988 16:30	10	7.57	3800	7.75	4142	137	259
			8/18/2006 8:58	10.6	7.52	4228	7.71	4140	145	277
			10/2/2014 13:22	9.2	7.81	4750	7.39	4767.56	162.36	328.39
			9/23/2015 14:55	10.1		4842	7.57	5634.34	160.66	330.14

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B1: Groundwater Quality, Wells

Gwic Id	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)	NO3-N (mg/l)	F (mg/l)	OPO4-P (mg/l)	Ag (ug/l)	Al (ug/l)	As (ug/l)
7589	1027.5	5.7	<.01	0.01	7.4	2498	0	200	10.8	1.4	1.2				
	332.65	1.63	<0.038 U	<0.005 U	8.59	790.62	0	4.17	57.31	<0.010 U	2.79	0.020 J	<0.250 U	<5.000 U	<0.250 U
	308.27	1.57	<0.038 U	0.007 J	8.9	751.15	16.53	2.66	61.93	<0.010 U	2.64	0.020 J	<0.250 U	<5.000 U	<0.250 U
144969	358.29	8.18	0.257	0.017 J	10.46	828.26	0	431.2	9.89	0.05	0.83	<0.020 U	<0.250 U	<5.000 U	<0.250 U
	334.62	8.74	0.335	0.027 J	11.31	851.18	0	422.9	9.91	<0.010 U	0.83	<0.020 U	<0.250 U	<5.000 U	<0.250 U
183564	19.4	7.76	0.025	0.04	14.7	428.5	0	34.4	3.02	<0.5 P	1.49	<0.05	<1	<10	1.13
	17.42	7.59	<0.038 U	0.006 J	16.62	460.3	0	43.39	3.74	0.030 J	1.73	<0.020 U	<0.250 U	6.320 J	0.600 J
	16.72	7.88	<0.015 U	0.007 J	17.29	467.4	0	39.53	3.55	0.06	1.66	<0.020 U	<0.100 U	<2.000 U	0.59
205082	401.88	7.31	<0.075 U	<0.010 U	9.15	746.43	0	974.3	7.74	0.3	0.41	<0.020 U	<0.500 U	<10.000 U	<0.500 U
	354.82	7.75	<0.038 U	0.012 J	9.01	733.56	0	933.4	7.62	0.32	0.41	<0.020 U	<0.250 U	<5.000 U	<0.250 U
7780	224	3	0.006	0.002	8.1	583	0	1.5	13.3	0.01	1.9		4	70	
	232.42	1.18	<0.015 U	<0.002 U	7.28	601.35	1.08	<0.500 U	13.36	0.030 J	2.24	0.040 J	<0.100 U	22.31	<0.100 U
	837.26	15.14	6.407	0.169 J	9.78	1029.86	0	2065	25.94	<0.050 U	0.61	<0.100 U	<1.000 U	<20.000 U	<1.000 U
7781	275	1.5	0.011	0.006	7.7	710	0	3	18.9	0.12	2.59		3	90	
	264	1.51	0.01	0.004	6.21	650.3	16.21	<2.5	14.98	<0.05	2.27	<0.1	<0.2	4.06	<0.2
	259.8	1.57	<0.015 U	0.004 J	6.85	679.19	4.89	1.500 J	17.49	<0.010 U	2.58	0.11	<0.100 U	<2.000 U	<0.100 U
	268.74	1.32	<0.038 U	<0.005 U	6.97	727.9	0	0.820 J	16.98	<0.010 U	2.92	0.030 J	<0.250 U	<5.000 U	<0.250 U
	265.71	1.52	<0.015 U	0.006 J	7.16	700.88	13.29	0.570 J	17.84	<0.010 U	2.81	0.030 J	<0.100 U	4.400 J	<0.100 U
7782	613	11.5	0.91	0.075	8.8	921	0	1210	24.6	0.01	1.22		6	50	
	741.13	15.47	5.619	0.104 J	9.2	1065.43	0	1909	22.98	<0.050 U	0.91	<0.100 U	<1.000 U	<20.000 U	<1.000 U
	222.15	1.32	<0.015 U	0.003 J	7.51	562.22	14.22	0.520 J	12.85	<0.010 U	1.96	0.040 J	<0.100 U	<2.000 U	<0.100 U
7777	405	3.8	0.006	0.003	9.4	784	0	290	15.7	0.34	1.55		<2.	<30.	
	547.02	5.47	<0.038 U	<0.005 U	9.86	894.57	0	683.1	11.99	0.05	1.51	<0.020 U	<0.250 U	<5.000 U	<0.250 U
	536.23	6.16	<0.038 U	0.005 J	10.6	970.41	0	699.7	12.22	<0.010 U	1.42	<0.020 U	<0.250 U	<5.000 U	<0.250 U
7778	449	14.1	0.17	0.053	12.4	798	0	1283	21.6	0.01	0.85		<2.	30	
	594.83	15.57	<0.150 U	0.038 J	12.17	872.45	0	1781	13.71	0.41	0.53	<0.100 U	<1.000 U	<20.000 U	<1.000 U
	569.78	16.02	<0.150 U	0.058 J	12.71	860.62	0	1794	15.52	0.57	0.53	<0.100 U	<1.000 U	<20.000 U	<1.000 U
7775	613	22.6	5.23	0.99	24.4	859	0	2170	22	0.04	1.08		<2.	<30.	
	590	22.4	4.62	0.84	25.3	797	0	2030	12.2	0.04	1				
	564	22.3	5.04	0.81	26.8	708	0	2010	14.4	0.02	0.1	0.1	<2.	<30.	
	547	23.4	5.67	0.948	27.7	885.7	0	1995	<25.0	<2.5 P	<2.5	<2.5	<10	<100	<10
	656.01	23.01	5.338	0.958	25.67	901.14	0	2548	17.13	<0.050 U	1.02	<0.100 U	<1.000 U	<20.000 U	2.390 J
	673.54	23.85	5.688	0.911	26.93	921.19	0	2416	18.31	<0.050 U	0.9	<0.100 U	3.630 J	<20.000 U	2.590 J

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B1: Groundwater Quality, Wells

Gwic Id	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)	Sb (ug/l)	Se (ug/l)
7589	117.91	118.25	<0.250 U	291	<0.250 U	<0.250 U	<0.250 U	<1.250 U	19.440 J	0.790 J	<0.250 U	<0.150 U	<0.250 U	<0.250 U
	113.9	103.41	<0.250 U	427	<0.250 U	<0.250 U	<0.250 U	<1.250 U	23.070 J	1.53	<0.250 U	<0.150 U	<0.250 U	<0.250 U
144969	206.31	10.73	<0.250 U	64	<0.250 U	<0.250 U	<0.250 U	<1.250 U	159.76	<0.250 U	<0.250 U	<0.150 U	<0.250 U	<0.250 U
	206.01	10.75	<0.250 U	<10.000 U	<0.250 U	<0.250 U	<0.250 U	<1.250 U	198.37	0.540 J	<0.250 U	<0.150 U	<0.250 U	<0.250 U
183564	257	82.6	<2	67	<1	<2	3.5	7.21	61.9	<10	<2	2.12	<2	<1
	228.82	95.74	<0.250 U	<10.000 U	<0.250 U	<0.250 U	<0.250 U	1.330 J	56.01	4.56	0.760 J	<0.150 U	<0.250 U	<0.250 U
	202.81	106.77	<0.100 U	<10.000 U	<0.100 U	0.210 J	<0.100 U	1.320 J	77.44	5.35	0.290 J	<0.060 U	<0.100 U	0.54
205082	176.09	11.96	<0.500 U	<10.000 U	<0.500 U	<0.500 U	<0.500 U	4.150 J	142.73	1.020 J	<0.500 U	<0.300 U	<0.500 U	<0.500 U
	178.44	13.74	<0.250 U	202	<0.250 U	<0.250 U	<0.250 U	7.81	198.95	1.61	1.240 J	<0.150 U	<0.250 U	1.34
7780	180				<2.		<2.	4	22	<20.	<10.	<40.		
	100.77	60	<0.100 U	77	<0.100 U	<0.100 U	<0.100 U	<0.500 U	19.04	1.12	<0.100 U	<0.060 U	<0.100 U	<0.100 U
	462.48	11.98	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U	347.89	<1.000 U	<1.000 U	<0.600 U	<1.000 U	<1.000 U
7781	150				<2.		4	6	26	<20.	<10.	<40.		
	96.1	104	<0.2	131	<0.2	<0.2	<0.2	<0.5	16.5	0.653	<0.2	<0.2	<0.2	0.324
	104.81	93.16	<0.100 U	134	<0.100 U	<0.100 U	<0.100 U	<0.040 U	20.6	0.69	<0.100 U	<0.060 U	<0.100 U	0.340 J
	106.35	96.5	<0.250 U	127	<0.250 U	<0.250 U	<0.250 U	1.260 J	22.890 J	0.590 J	<0.250 U	<0.150 U	<0.250 U	<0.250 U
	99.01	93.79	<0.100 U	163	<0.100 U	<0.100 U	<0.100 U	<0.500 U	29.59	0.84	<0.100 U	<0.060 U	<0.100 U	<0.100 U
7782	480				<2.		6	27	160	<20.	<10.	40		
	692.48	14.99	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U	274.98	<1.000 U	<1.000 U	<0.600 U	<1.000 U	<1.000 U
	108.98	60.23	<0.100 U	227	<0.100 U	<0.100 U	<0.100 U	<0.500 U	25.14	1.25	<0.100 U	<0.060 U	<0.100 U	<0.100 U
7777	190				<2.		<2.	<2.	38	<20.	<10.	<40.		
	140.86	24.19	<0.250 U	54	<0.250 U	<0.250 U	<0.250 U	<1.250 U	71.5	<0.250 U	<0.250 U	<0.150 U	<0.250 U	<0.250 U
	144.74	22.16	<0.250 U	92	<0.250 U	<0.250 U	2.02	<1.250 U	99.82	<0.250 U	<0.250 U	<0.150 U	<0.250 U	<0.250 U
7778	480				<2.		5	27	140	<20.	<10.	<40.		
	479.28	11.88	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U	170.54	<1.000 U	<1.000 U	<0.600 U	<1.000 U	<1.000 U
	471.15	13.7	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U	233.66	<1.000 U	<1.000 U	<0.600 U	<1.000 U	<1.000 U
7775	490				<2.		14	33	130	30	20	90		
	460			<100.	<2.		<2.	<2.	130	<20.	<10.			
	427	<20	<20	<2500	<10	<20	<20	<20	164	<100	<20	<20	<20	<10
	411.53	17.6	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	5.160 J	142.33	5.35	<1.000 U	<0.600 U	<1.000 U	<1.000 U
	399.01	16.39	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U	200.01	7.55	<1.000 U	<0.600 U	<1.000 U	<1.000 U

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B1: Groundwater Quality, Wells

Gwic Id	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)
7589	0.780 J	116.2	1.69	<0.250 U	<0.250 U	<0.250 U	<1.250 U	<0.250 U	<0.250 U	<0.250 U	4.11	<0.250 U	0.540 J	<0.250 U
	3.11	135.09	1.82	<0.250 U	<0.250 U	<0.250 U	<1.250 U	<0.250 U	<0.250 U	<0.250 U	7.04	<0.250 U	<0.250 U	<0.250 U
144969	<0.250 U	1358.86	50.52	<0.250 U	<0.250 U	<0.250 U	4.200 J	<0.250 U	<0.250 U	<0.250 U	<0.250 U	<0.250 U	<0.250 U	<0.250 U
	<0.250 U	1402.35	41.47	<0.250 U	<0.250 U	<0.250 U	5.32	<0.250 U	<0.250 U	<0.250 U	0.610 J	<0.250 U	<0.250 U	<0.250 U
183564		1560	<1	<5	1.78	<5	50.2	<2						
	<0.250 U	1331.85	31.28	<0.250 U	1.63	3.05	4.740 J	<0.250 U	<0.250 U	<0.250 U	3.36	<0.250 U	<0.250 U	<0.250 U
	0.180 J	1429.36	24.9	<0.100 U	3.55	9.64	1.480 J	<0.100 U	<0.100 U	<0.100 U	7.03	<0.100 U	<0.100 U	<0.100 U
205082	<0.500 U	1749.08	113.2	<0.500 U	6.04	<0.500 U	3.630 J	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U
	<0.250 U	1874.97	86.85	<0.250 U	11.49	1.210 J	1.260 J	<0.250 U	<0.250 U	<0.250 U	0.820 J	<0.250 U	<0.250 U	<0.250 U
7780		64	4			3	9	6						
	0.260 J	62.48	1.09	<0.100 U	<0.100 U	<0.100 U	<0.500 U	<0.100 U	<0.100 U	<0.100 U	2.07	<0.100 U	<0.100 U	<0.100 U
	<1.000 U	6603.56	682.43	<1.000 U	<1.000 U	<1.000 U	6.350 J	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U
7781		110	11			<1.	<4.	<4.						
	<0.5	121	<0.2	<0.2	<0.2	<0.2	0.519	0.197	<0.2	<0.5	<0.2	<0.2	<0.5	<0.2
	<0.100 U	115.83	<0.100 U	<0.100 U	<0.100 U	<0.100 U	0.740 J	<0.100 U	<0.100 U	<0.100 U	<0.100 U	<0.100 U	<0.100 U	<0.100 U
	<0.250 U	100.2	1.51	<0.250 U	<0.250 U	<0.250 U	<1.250 U	<0.250 U	<0.250 U	<0.250 U	3.44	<0.250 U	<0.250 U	<0.250 U
	0.320 J	106.89	8.12	<0.100 U	<0.100 U	<0.100 U	<0.500 U	<0.100 U	<0.100 U	<0.100 U	6.22	<0.100 U	<0.100 U	<0.100 U
7782		3640	19			3	11	4						
	<1.000 U	6134.59	216.61	<1.000 U	<1.000 U	<1.000 U	13.370 J	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U
	0.400 J	65.02	1.33	<0.100 U	<0.100 U	<0.100 U	<0.500 U	<0.100 U	<0.100 U	<0.100 U	4.12	<0.100 U	<0.100 U	<0.100 U
7777		680	<1.			<1.	5	4						
	1.130 J	1325.55	60.29	<0.250 U	<0.250 U	<0.250 U	<1.250 U	<0.250 U	<0.250 U	<0.250 U	0.770 J	<0.250 U	<0.250 U	<0.250 U
	0.370 J	1456.69	121.52	<0.250 U	<0.250 U	<0.250 U	<1.250 U	<0.250 U	<0.250 U	<0.250 U	1.32	<0.250 U	<0.250 U	<0.250 U
7778		2890	19			6	27	<4.						
	<1.000 U	3478.07	202.88	<1.000 U	9.06	<1.000 U	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	2.740 J	<1.000 U
	<1.000 U	3946.62	515.25	<1.000 U	17.9	2.800 J	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U
7775		2570	19			15	11	<4.						
		2510	4			<1.	<3.	<4.						
		3336	<10	<50	11.6	<50	<20	<20						
	<1.000 U	2878.83	238.6	<1.000 U	12.14	<1.000 U	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	3.250 J	<1.000 U
	<1.000 U	2879.54	657.67	<1.000 U	20.59	<1.000 U	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B1: Groundwater Quality, Wells

Gwic Id	Pd (ug/l)	Pr (ug/l)	Rb (ug/l)	Th (ug/l)	W (ug/l)	NO2-N (mg/l)	NO3+NO2-N (mg/l)	Total N as N (mg/l)	Total Dissolved Solids (mg/l)	Sum Dissolved Constituents (mg/l)	Hardness (mg/l)	Alkalinity	SAR
									2499.9419	3767.4	48.6535	2048.7872	64.1282
7589	<0.250 U	<0.250 U	1.56	<0.250 U	<0.250 U	<0.010 U	<0.200 U	<1.000 U	800.9752	1202.32	10.0224	648.7553	45.77
	<0.250 U	<0.250 U	3.03	<0.250 U	0.650 J	<0.010 U	<0.200 U	<1.000 U	777.0707	1158.12	9.3934	644.3027	43.7281
144969	1.38	<0.250 U	9.88	<0.250 U	<0.250 U	<0.010 U	<0.200 U	4.19	1323.3618	1743.48	324.0823	679.1016	8.6528
	1.48	<0.250 U	19.31	<0.250 U	<0.250 U	<0.010 U	<0.200 U	4.17	1306.0668	1737.855	325.5891	697.9655	8.0782
									392.987	610.657	339.9879	351.8534	0.4484
183564	1.42	<0.250 U	7.57	<0.250 U	<0.250 U	<0.010 U	<0.200 U	<1.000 U	427.271	660.67	370.5003	377.2787	0.3843
	1.1	<0.100 U	16.18	<0.100 U	0.370 J	<0.010 U	<0.200 U	<1.000 U	431.0393	667.99	379.4703	383.0199	0.3797
205082	1.730 J	<0.500 U	3.5	<0.500 U	<0.500 U	<0.010 U	0.31	<1.000 U	1990.5777	2369.09	764.8382	611.8476	6.3247
	1.64	<0.250 U	7.72	<0.250 U	<0.250 U	0.06	0.26	<1.000 U	1883.8644	2256.288	718.5197	602.0055	5.7624
									541.6751	837.483	6.6404	478.1597	37.826
7780	<0.100 U	<0.100 U	1.07	<0.100 U	0.230 J	<0.010 U	<0.200 U	<1.000 U	554.0511	858.992	5.4372	494.5907	43.2954
	4.820 J	<1.000 U	17.03	<1.000 U	<1.000 U	0.28	<0.200 U	2.89	3805.8592	4328.47	1099.4397	844.7761	10.9837
									663.2497	1023.496	9.4612	582.3214	38.9043
	<0.5	<0.2	1.53	<0.2	<0.2	<0.05	<0.2 P	<1.0 P	627.965	957.768	7.7136	559.7975	41.3632
7781	<0.100 U	<0.100 U	1.68	<0.100 U	<0.100 U	<0.010 U	<0.200 U	<1.000 U	631.3428	975.86	7.9833	565.2356	40.0424
	<0.250 U	<0.250 U	1.33	<0.250 U	<0.250 U	<0.010 U	<0.200 U	<1.000 U	658.4507	1027.83	7.876	597.0845	41.7098
	<0.100 U	<0.100 U	2.55	<0.100 U	<0.100 U	<0.010 U	<0.200 U	<1.000 U	657.0802	1012.76	7.685	596.6225	41.7539
									2515.6826	2982.988	612.5114	755.3775	10.7774
7782	6.35	<1.000 U	8.62	<1.000 U	<1.000 U	<0.050 U	<0.200 U	2.87	3579.5905	4119.96	1160.2226	873.4821	9.4657
	<0.100 U	<0.100 U	2.22	<0.100 U	0.360 J	<0.010 U	<0.200 U	<1.000 U	538.7173	823.87	5.1713	484.2866	42.4809
									1142.6119	1540.405	97.9272	643.0141	17.8079
7777	1.38	<0.250 U	3.63	<0.250 U	<0.250 U	<0.010 U	<0.200 U	1.14	1773.5067	2227.62	243.8293	734.053	15.2422
	1.33	<0.250 U	7.48	<0.250 U	<0.250 U	<0.010 U	<0.200 U	1.49	1822.4225	2314.59	260.7726	795.5659	14.4423
									2475.1874	2880.084	1034.922	654.4965	6.0728
7778	3.630 J	<1.000 U	4.380 J	<1.000 U	<1.000 U	<0.050 U	0.43	<1.000 U	3214.7366	3657.18	1267.2611	715.1891	7.2724
	3.440 J	<1.000 U	10.14	<1.000 U	<1.000 U	<0.050 U	0.43	<1.000 U	3210.2779	3647.14	1298.0044	706.1672	6.8839
									3729.1967	4165.044	1588.907	704.5269	6.6912
									3495.6108	3900	1488.093	653.6763	6.6547
7775									3387.7685	3747	1408.133	580.6811	6.5396
									3458.4532	3908	1502.197	726.6715	6.1407
	3.050 J	<1.000 U	16.58	<1.000 U	<1.000 U	<0.050 U	<0.200 U	1.05	4211.5924	4668.75	1757.0662	738.9741	6.8093
	2.230 J	<1.000 U	32.1	<1.000 U	<1.000 U	0.31	<0.200 U	1.17	4111.4946	4578.8	1760.0243	755.3775	6.9902

Samples collected under the 2014/2015 Synoptic Sampling Program

APPENDIX B-2

Appendix B2: Water Quality, Springs

Gwic Id	Site Name	Aquifer	Sample Date	Water Temp	Fld pH	Fld SC	Lab pH	Lab SC	Ca (mg/l)
197452	USDA FOREST SERVICE- ALKALI SPRING	125TGRV	5/1/2007 17:30	9.6	7.9	1881	7.67	2650	55.8
			10/3/2007 12:15	11.9	7.5	2621	7.81	2620	56
			5/21/2008 14:07	10.1	7.83	2728	7.76	2720	57.1
			10/30/2008 18:10	9.7	7.63	2630	7.81	2620	60.6
			10/1/2014 13:58	11.2	7.62	2860	7.6	2954.53	62.31
			9/23/2015 11:40	12.4		2876	7.4	3147.14	59.74
197607	USDA FOREST SERVICE- UPPER FIFTEEN MILE SPRING	125TGRV	1/26/2006 11:30	3.9	6.95	2599	7.48	2350	112
			8/18/2006 11:00	18.5	7.03	2360	7.28	2310	106
			10/2/2014 10:05	13.6	7.23	2400	7.28	2478.37	114.67
			9/23/2015 18:00	16.8		2446	7.11	2615.6	108.11
198766	MUSGROVE - LEMONADE SPRING	125TGRV	10/21/2003 14:45				7.43	2060	154
			9/30/2014 12:09	10.7	7.22	890	6.98	2224.11	159.14
			9/22/2015 11:00	11.2	6.82	2227	6.87	2354.09	159.26
199568	USDA FOREST SERVICE- HEDUM SPRING	125TGRV	4/19/2013 12:11	5.4	7.29	3994	7.36	4090	218.35
			11/20/2013 14:40	6.3	7.33	3999	7.49	4430	235.96
			10/1/2014 16:30	9.6	7.62	3870	7.53	3892.96	227.44
			9/22/2015 17:50	11.3	7.08	3940	7.24	4239.18	239
199572	USDA FOREST SERVICE- DEAD MAN SPRING	125TGRV	6/5/2012 17:26	10.4	6.83	3537	7.01	3280	275.55
			9/30/2014 14:50	11.4	7.18		7.2	3431.38	204.4
			9/22/2015 13:40	16	6.87	3349	7.1	3595.09	198.6
205004	USDA FOREST SERVICE- HAGEN 2 SPRING	125FRUN	5/3/2011 12:53	8	7.69	1014	7.6	899.9	81.89
			10/7/2014 12:00				7.78	1058.89	83.32
			9/24/2015 16:00	18.6		845	7.97	1086.72	79.85
205010	USDA FOREST SERVICE- NORTH FORK SPRING	125TGRV	6/5/2012 17:08	9.9	6.91	3538	7.11	3420	205.3
			9/30/2014 15:35	10.4	7.2		7.27	3785.48	221.64
			9/22/2015 12:35	12.1	6.82	3666	7.03	3977.07	227.23
205011	USDA FOREST SERVICE- JOE ANDERSON SPRING	125TGRV	5/4/2011 15:29	8.5	8.32	622	8.17	579.2	70.63
			9/30/2014 16:55	12	8.2		7.93	752.31	73.01
			9/22/2015 14:30	13.8	7.49	755	7.79	791.16	72.98
205041	USDA FOREST SERVICE- SCHOOL HOUSE SPRING	125TGRV	10/21/2003 11:45	11.1	6.81	2656	7.49	2660	157
			9/30/2014 18:00	11	7.2		7.18	3026.22	166.98
			9/22/2015 15:40	12.6	6.98	2922	7.03	3064.03	163.78
205049	USDA FOREST SERVICE- CHIPMUNK SPRING	125TGRV	10/20/2003 16:00	11.7	7.27	3468	8.08	3390	95.2
			6/19/2009 11:14	13.2	7.51	3492	7.89	3510	105
			10/13/2009 14:14	7.6	7.69	3550	7.86	3680	106
			5/19/2010 11:30				7.94	3700	103
			9/13/2010 14:00	13.3	7.38	3767	7.88	3910	108
			10/1/2014 10:00	10.9	7.64	3930	7.59	4006.36	114.66
			9/23/2015 8:30	12.7	7.3	3816	7.37	4109.96	106.9

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B2: Water Quality, Springs

Gwic Id	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)	NO3-N (mg/l)	F (mg/l)
197452	94.3	485	9.19	0.066	0.02	10.3	1022.4	0	644	21.6	<1.0	1.61
	96.2	523	7.92	0.06	0.02	9.73	1190.7	0	782	18.3	<1.0 P	1.49
	95.5	496	8.89	0.092	0.034	7.38	1030.5	0	639	20.6	<1.0 P	1.45
	103	555	9.07	<0.018	<0.003	9.96	1085.8	0	692.5	22.3	<0.5 P	1.55
	110.18	528.58	8.76	0.124 J	0.028 J	9.23	1169.06	0	797.5	23.06	0.16	1.74
	108.54	504.34	8.84	0.189 J	0.049 J	9.86	1189.16	0	788.9	24.4	0.23	1.69
197607	130	335	8.85	0.013	0.01	11.1	1127.3	0	544	5.15	<0.5 P	0.726
	113	299	10.5	0.009	0.008	13.5	1045.1	0	515	5.16	<0.5 P	0.782
	133.68	332.39	9.76	<0.038 U	0.005 J	12.11	1216.18	0	577.9	4.78	0.23	0.77
	129.42	323.47	9.77	0.088 J	0.012 J	12.31	1178.88	0	571.9	4.9	0.24	0.71
198766	134	149	8	0.088	0.03	13.2	723.9	0	653	<10.0	<0.5 P	<1.0
	149	185.6	8.25	0.147	0.026 J	12.92	818.51	0	839.6	5.29	0.06	0.29
	140.93	187.87	8.62	0.111 J	0.033 J	13.48	821.23	0	739.2	5.44	<0.010 U	0.31
199568	434.95	266.8	53.83	<0.150 U	<0.020 U	18.44	776.13	0	2155	7.62	10.03	1.17
	408.47	257.75	47.57	<0.150 U	<0.020 U	24.57	815.18	0	2061	7.97	9.53	1.13
	399.03	235.1	45.44	<0.150 U	<0.020 U	23.95	811.61	0	2040	7.03	9.86	1.17
	415.37	242.84	46.61	<0.150 U	<0.020 U	24.32	855.11	0	2078	8.18	11.36	1.28
199572	221.25	367.37	8.18	0.476	0.090 J	12.42	553.5	0	1787	14.28	<0.010 U	0.28
	166.3	447.29	8.3	<0.075 U	0.068 J	11.16	903.59	0	1478	8.2	0.230 J	0.4
	155.71	437.2	8	0.152 J	0.152 J	11.44	937.66	0	1371	8.67	0.4	0.62
205004	66.28	73.57	5.72	<2.00 U	<0.001 U	14.77	529.66	0	159.8	8.25	0.15	0.78
	61.73	65.46	5.79	<0.038 U	0.045 J	17.85	594.83	0	152.9	8.23	0.050 J	1.05
	60.33	63.97	6.34	0.035 J	0.068	18.09	569.94	0	133.4	7.52	0.07	1.05
205010	157.38	509.42	8.72	1.396	0.213 J	10.65	829.28	0	1552	4.64	0.07	0.27
	171.41	523.12	8.96	1.665	0.224 J	11.39	947.54	0	1666	5	<0.050 U	0.34
	167.75	495.62	9.96	1.791	0.314 J	13.54	940.66	0	1611	6.36	<0.050 U	0.4
205011	50.73	18.5	3.91	0.017	0.006	12.28	388.16	0	69.01	3.68	<0.05 U	0.33
	53.05	19.34	4.45	0.033 J	0.057	18.48	485.29	0	51.6	7.69	0.030 J	0.43
	52.22	18.53	5.39	0.031 J	0.050 J	19.18	479.06	0	54.63	6.51	0.09	0.46
205041	147	308	8.95	0.699	0.126	14.2	809.3	0	1019	6.97	<0.5 P	<0.5
	182.82	326.59	9.54	0.458	0.162 J	15.01	866.72	0	1040	8.57	0.150 J	0.58
	173.55	314	10.35	0.471	0.279	15.73	868.25	0	1114	10.42	0.12	0.63
205049	132	583	10.7	0.046	<0.005	12	965	0	1282	24.4	<0.5 P	4.89
	155	617	12	0.194	<0.007	14.6	1093.9	0	1505	29.01	0.547 P	1.14
	149	640	11.4	<0.010	<0.001	13.1	971.1	0	1504	26.87	0.508 P	1.7
	156	632	11.6	<0.072	<0.003	10.7	871.1	0	1480	29.49	0.22 P	1.48
	169	698	12.7	<0.195	<0.010	13.2	968.7	0	1569	29.66	0.479	1.42
	190.51	678.56	13.08	<0.150 U	<0.020 U	13.75	1041.18	0	1641	31.97	0.4	1.45
	171.88	662.3	11.09	<0.150 U	<0.020 U	13.46	1042.58	0	1547	31.77	0.42	1.56

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B2: Water Quality, Springs

Gwic Id	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)
197452	<0.5	<2.5	<5	<1.0	223	10.8	<0.5	<500	<0.5	<0.5	<0.5	<1.0
	<1.0	<0.5	<2.0	0.476	180	12.2	<0.1	<1000	<0.1	0.133	<0.1	<0.2
	<0.10	<2.5	<10.0	<1.0	234	7.84	<0.5	<200	<0.5	<0.5	<0.5	<1.0
	<1.0	<0.53	<26.3	<2.89	9.57	64.6	<1.48	<2500	<1.25	0.715	<0.61	31.2
	<0.020 U	<0.500 U	<10.000 U	<0.500 U	210.22	10.99	<0.500 U	121	<0.500 U	<0.500 U	<0.500 U	<2.500 U
	<0.020 U	<0.500 U	<10.000 U	<0.500 U	209.46	12.15	<0.500 U	173	<0.500 U	<0.500 U	<0.500 U	<2.500 U
197607	<0.5	<5	<30	<5	379	11.9	<2	<500	<1	<2	<10	<5
	<0.5	<5	<30	<5	547	16.5	<2	<500	<1	<2	<10	<5
	<0.020 U	<0.250 U	<5.000 U	<0.250 U	457	15.84	<0.250 U	<10.000 U	<0.250 U	<0.250 U	<0.250 U	<1.250 U
	<0.020 U	<0.250 U	<5.000 U	<0.250 U	490.82	16.64	<0.250 U	<10.000 U	<0.250 U	<0.250 U	<0.250 U	<1.250 U
198766	<1.0	<5	41.7	<5	231	15.5	<10	<1000	<5	<10	11.4	<10
	<0.020 U	<0.100 U	<2.000 U	0.61	235.4	18.86	<0.100 U	<10.000 U	<0.100 U	0.430 J	<0.100 U	<0.500 U
	<0.020 U	<0.250 U	81.33	0.780 J	239	17.77	<0.250 U	<10.000 U	<0.250 U	0.660 J	<0.250 U	<1.250 U
199568	0.270 J	<1.000 U	<4.000 U	13.44	663.95	21.15	<1.000 U	<50.000 U	<1.000 U	<1.000 U	8.64	<0.400 U
	<0.100 U	<1.000 U	<20.000 U	12.99	491.62	20.49	<1.000 U	<50.000 U	<1.000 U	<1.000 U	4.560 J	<5.000 U
	<0.100 U	<1.000 U	<20.000 U	10.94	615.01	20.49	<1.000 U	<50.000 U	<1.000 U	<1.000 U	7.96	<5.000 U
	<0.100 U	<1.000 U	<20.000 U	10.22	656.05	19.39	<1.000 U	<50.000 U	<1.000 U	<1.000 U	9.24	<5.000 U
199572	<0.020 U	<1.000 U	<4.000 U	<1.000 U	105.28	19.59	<1.000 U	<10.000 U	<1.000 U	<1.000 U	<1.000 U	1.290 J
	<0.100 U	<0.500 U	<10.000 U	<0.500 U	120.48	14.33	<0.500 U	<50.000 U	<0.500 U	<0.500 U	<0.500 U	2.830 J
	<0.100 U	<0.500 U	<10.000 U	<0.500 U	117.22	16.02	<0.500 U	<50.000 U	<0.500 U	1.130 J	<0.500 U	<2.500 U
205004	<0.10 U	<0.50 U	9.32	0.1400 J	97.76	35.59	<0.50 U	93	<0.50 U	<0.50 U	<0.50 U	0.1500 J
	<0.020 U	<0.250 U	<5.000 U	0.850 J	152.82	57.38	<0.250 U	58	<0.250 U	0.640 J	<0.250 U	1.290 J
	<0.020 U	<0.100 U	<2.000 U	1.55	175.9	55.04	<0.100 U	199	<0.100 U	2.02	<0.100 U	0.680 J
205010	<0.020 U	<1.000 U	<4.000 U	<1.000 U	110.27	11.18	<1.000 U	<10.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U
	<0.100 U	<1.000 U	<20.000 U	<1.000 U	107.07	11.8	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U
	<0.100 U	<1.000 U	<20.000 U	<1.000 U	107.26	13.9	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U
205011	<0.10 U	<0.50 U	12.9	0.2100 J	23.57	215.31	<0.50 U	<50.00 U	0.4800 J	<0.50 U	0.2300 J	0.54
	<0.020 U	<0.100 U	<2.000 U	0.59	34.87	204.95	<0.100 U	<10.000 U	<0.100 U	0.230 J	<0.100 U	<0.500 U
	<0.020 U	<0.100 U	<2.000 U	0.61	38.7	211.65	<0.100 U	<10.000 U	<0.100 U	0.330 J	<0.100 U	<0.500 U
205041	<0.5	<5	<150	<5	238	10.5	<10	<500	<5	<5	<10	<10
	<0.100 U	<0.500 U	<10.000 U	<0.500 U	232.17	12.5	<0.500 U	<50.000 U	<0.500 U	<0.500 U	<0.500 U	<2.500 U
	<0.020 U	<0.500 U	<10.000 U	<0.500 U	218.21	13.81	<0.500 U	250	<0.500 U	1.380 J	<0.500 U	<2.500 U
205049	<0.5	<10	<150	<10	<300	<20	<20	<500	<10	<20	<20	<20
	<1.0	<4.42	<16.55	<6.42	348	15.2	<13.24	<1000	4.47	<4.37	<6.63	<7.42
	<1.0	<0.5	<37.8	0.348	290	15.7	<0.9	<1000	<0.5	<0.3	<0.5	<2.0
	<0.25	<2.0	<23.2	<4.0	325	15.4	<2.0	261	<1.0	<1.0	<3.0	<9.1
	<0.5	<2.0	<20.0	<1.8	316	18.2	<2.0	276	<2.0	<1.8	<2.0	<5.0
	<0.100 U	<1.000 U	<20.000 U	<1.000 U	375.57	16.87	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U
	<0.100 U	<1.000 U	<20.000 U	<1.000 U	370.94	15.05	<1.000 U	<50.000 U	<1.000 U	<1.000 U	<1.000 U	<5.000 U

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B2: Water Quality, Springs

Gwic Id	Li (ug/l)	Mo (ug/l)	Ni (ug/l)	Pb (ug/l)	Sb (ug/l)	Se (ug/l)	Sn (ug/l)	Sr (ug/l)	Ti (ug/l)	Tl (ug/l)	U (ug/l)	V (ug/l)
197452	162	<5	<0.5	<1.0	<0.5	<2.5		1488	<1	<0.5	0.637	<0.5
	150	<1.0	0.762	<0.2	<0.1	0.827		1489	<1.0	327	0.788	<0.1
	168	<5.0	<0.5	<1.0	<0.5	<2.5	<0.5	1564	<5.0	<0.5	0.389	<0.5
	726	1.4	<0.98	<0.53	<0.50	<4.56	13.5	1557	31.7	<0.12	3.83	<0.54
	150.58	<0.500 U	<0.500 U	<0.300 U	<0.500 U	<0.500 U	<0.500 U	1282.85	83.4	<0.500 U	<0.500 U	<0.500 U
	215.82	<0.500 U	<0.500 U	<0.300 U	<0.500 U	<0.500 U	<0.500 U	1403.23	304.48	<0.500 U	1.540 J	1.060 J
197607	175	<10	<2	<10	<10	<5		2038	<1	<25	5.26	<10
	195	<10	<2	<10	<10	<5		2136	<10	<25	5.73	<10
	173.01	<0.250 U	0.690 J	<0.150 U	<0.250 U	<0.250 U	<0.250 U	1860.85	98.53	<0.250 U	4.95	<0.250 U
	230.73	<0.250 U	0.830 J	<0.150 U	<0.250 U	<0.250 U	0.930 J	2020.84	88.09	<0.250 U	10.38	1.35
198766	127	<50	<10	<10	<10	<5		2931	<1	<25	8.68	<25
	112.99	0.210 J	0.71	<0.060 U	<0.100 U	<0.100 U	<0.100 U	2514.58	128.47	<0.100 U	3.3	<0.100 U
	157.86	0.780 J	1.080 J	<0.150 U	<0.250 U	<0.250 U	<0.250 U	2557.83	98.89	<0.250 U	4.6	0.620 J
199568	377	19.28	1.850 J	<0.600 U	<1.000 U	30.68	<1.000 U	3706.42	29.61	<1.000 U	30.49	108.65
	270.46	20.47	3.670 J	<0.600 U	<1.000 U	27.09	<1.000 U	3594.92	11.72	<1.000 U	25.43	68.82
	377.63	17.53	<1.000 U	<0.600 U	<1.000 U	21.93	<1.000 U	3122.86	250.45	<1.000 U	27.94	114.17
	542.55	22.36	<1.000 U	<0.600 U	<1.000 U	4.800 J	1.140 J	3125.22	187.08	<1.000 U	47.98	293.4
199572	121.89	<1.000 U	3.760 J	<0.400 U	<1.000 U	4.660 J	<1.000 U	4952.65	15.68	<1.000 U	1.810 J	<1.000 U
	144.64	<0.500 U	<0.500 U	<0.300 U	<0.500 U	<0.500 U	<0.500 U	3988.87	200.07	<0.500 U	1.280 J	<0.500 U
	206.04	<0.500 U	3.82	<0.300 U	<0.500 U	<0.500 U	<0.500 U	4040.35	185.4	<0.500 U	2.450 J	1.610 J
205004	52.79	1.02	0.4900 J	<0.20 U	<0.50 U	1.1	<0.50 U	1619.99	1.27	<0.50 U	3.95	0.2600 J
	71.65	1.59	1.050 J	<0.150 U	<0.250 U	<0.250 U	7.43	1520.89	60	<0.250 U	3.35	<0.250 U
	110.08	2.35	1.37	0.4	<0.100 U	0.400 J	3.2	1640.46	47.45	<0.100 U	6.44	0.69
205010	148.44	<1.000 U	2.840 J	<0.400 U	<1.000 U	5.91	<1.000 U	4261.24	15.7	<1.000 U	<1.000 U	<1.000 U
	148.17	<1.000 U	<1.000 U	<0.600 U	<1.000 U	<1.000 U	<1.000 U	4046.12	230.06	<1.000 U	<1.000 U	<1.000 U
	206.35	<1.000 U	<1.000 U	104.55	<1.000 U	<1.000 U	<1.000 U	4286.76	197.17	<1.000 U	<1.000 U	<1.000 U
205011	20.63	0.78	0.52	0.22	<0.50 U	<0.50 U	<0.50 U	649.58	0.63	<0.50 U	0.83	<0.50 U
	32.31	0.410 J	0.63	<0.060 U	<0.100 U	<0.100 U	<0.100 U	607.87	45.42	<0.100 U	0.53	<0.100 U
	49.92	0.58	1.28	<0.060 U	<0.100 U	<0.100 U	<0.100 U	648.18	41.53	<0.100 U	1.17	0.480 J
205041	174	<50	<10	<10	<10	<5		2929	<5	<25	6.16	<25
	169.11	<0.500 U	1.260 J	<0.300 U	<0.500 U	<0.500 U	<0.500 U	2364.39	165.57	<0.500 U	3.79	<0.500 U
	218.43	1.360 J	1.580 J	<0.300 U	<0.500 U	<0.500 U	<0.500 U	2347.82	114.49	<0.500 U	4.71	<0.500 U
205049	189	<100	<20	<20	<20	<10		2765	<5	<50	8.5	<50
	186	<4.64	<7.10	<7.29	<5.41	<8.27	<5.24	2709	14.4	<7.64	7.73	<5.95
	161	1.35	<0.6	<2.0	<0.5	1.71	<0.5	2788	15.6	<0.5	8.98	<0.4
	67.3	<3.0	<3.0	<5.1	<4.0	<3.0	<1.0	2657	17.1	<2.0	8.88	<2.0
	156	<2.0	<1.8	<2.0	<2.0	<1.8	<2.0	3030	10.3	<2.0	7.18	<2.0
	167.34	<1.000 U	<1.000 U	<0.600 U	<1.000 U	<1.000 U	<1.000 U	2494.37	165.6	<1.000 U	11.37	<1.000 U
	216.26	3.260 J	<1.000 U	<0.600 U	<1.000 U	<1.000 U	<1.000 U	2424.85	461.16	<1.000 U	17.49	2.040 J

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B2: Water Quality, Springs

Gwic Id	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)	Th (ug/l)
197452	<1.0	<0.5										
	0.45	0.287										
	23.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.59	<0.5	3.59	<0.25
	36.3	1.82	0.5	<0.34	<0.61	<0.50	<0.37	<0.76	14.6	0.332	30	<0.47
	2.880 J	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	1.570 J	<0.500 U	1.410 J	<0.500 U	4.42	<0.500 U
	<2.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	1.480 J	<0.500 U	9.72	<0.500 U
197607	<2	<2										
	2.16	<2										
	4.760 J	<0.250 U	<0.250 U	<0.250 U	<0.250 U	<0.250 U	<0.250 U	<0.250 U	1.91	<0.250 U	5.17	<0.250 U
	4.730 J	<0.250 U	<0.250 U	<0.250 U	1.010 J	<0.250 U	<0.250 U	<0.250 U	1.87	<0.250 U	12.02	<0.250 U
198766	3.68											
	3.49	<0.100 U	<0.100 U	<0.100 U	0.52	<0.100 U	<0.100 U	<0.100 U	2.66	<0.100 U	2.69	<0.100 U
	6	<0.250 U	<0.250 U	<0.250 U	1.030 J	<0.250 U	<0.250 U	<0.250 U	2.07	<0.250 U	5.43	<0.250 U
199568	<0.500 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	42.88	<1.000 U
	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	47.52	<1.000 U
	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	3.260 J	<1.000 U	39.81	<1.000 U
	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	2.280 J	<1.000 U	83.34	<1.000 U
199572	<2.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	2.040 J	<1.000 U	6.86	<1.000 U
	7.820 J	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	4.11	<0.500 U	6.69	<0.500 U
	<2.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	3.65	<0.500 U	14.32	<0.500 U
205004	2.41	<0.50 U	<0.50 U	<0.50 U	<0.50 U	<0.50 U	<0.50 U	<0.50 U	0.72	<0.50 U	3.08	<0.50 U
	5.96	<0.250 U	<0.250 U	<0.250 U	1.97	<0.250 U	0.850 J	<0.250 U	1.62	<0.250 U	2.91	<0.250 U
	5.1	<0.100 U	<0.100 U	<0.100 U	3.72	<0.100 U	<0.100 U	<0.100 U	1.43	<0.100 U	7	<0.100 U
205010	<2.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	1.760 J	<1.000 U	7.84	<1.000 U
	6.010 J	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	4.450 J	<1.000 U	6.96	<1.000 U
	34.36	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	3.810 J	<1.000 U	15	<1.000 U
205011	245.02	1.53	<0.50 U	<0.50 U	<0.50 U	<0.50 U	<0.50 U	<0.50 U	0.4500 J	<0.50 U	0.69	0.1200 J
	0.710 J	<0.100 U	<0.100 U	<0.100 U	6.77	<0.100 U	0.360 J	<0.100 U	0.85	<0.100 U	0.75	<0.100 U
	<0.500 U	<0.100 U	<0.100 U	<0.100 U	14.23	<0.100 U	<0.100 U	<0.100 U	0.55	<0.100 U	1.66	<0.100 U
205041	<10	<10										
	<2.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	2.66	<0.500 U	6.25	<0.500 U
	<2.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	<0.500 U	1.720 J	<0.500 U	12.22	<0.500 U
205049	<20	<10										
	<29.51	<3.82	<6.91	<5.42	<7.26	<6.49	<5.21	<8.02	<4.09	<7.10	8.79	<7.36
	<4.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.927	<0.5	9.14	<0.5
	<11.1	3.66	<1.0	<1.0	<1.0	<1.0	<2.0	<1.0	<9.1	<1.0	7.44	<1.0
	<10.0	<1.8	<2.0	<5.0	<1.8	<2.0	<1.7	<2.0	<5.0	<2.0	10.9	<2.0
	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	2.560 J	<1.000 U	8.2	<1.000 U
	<5.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	<1.000 U	2.190 J	<1.000 U	16.2	<1.000 U

Samples collected under the 2014/2015 Synoptic Sampling Program

Appendix B2: Water Quality, Springs

wic Id	W (ug/l)	NO2-N (mg/l)	NO3+NO2-N (mg/l)	Total N as N (mg/l)	TDS (mg/l)	Sum Diss. Const. (mg/l)	Hardness (mg/l)	Alkalinity	SAR
					1825.5483	2344.1	527.4714	838.2148	9.1883
					2080.8995	2685.2	535.7912	976.8237	9.831
.97452	<2.5				1833.5048	2356.623	535.6567	845.5963	9.3246
	<0.57				1989.6424	2540.667	575.2662	890.7057	10.0682
	<0.500 U	<0.010 U	<0.200 U	<1.000 U	2118.3521	2711.49	609.0889	958.7799	9.3263
	<0.500 U	<0.010 U	<0.200 U	1.02	2091.9943	2695.28	595.9214	975.1833	8.9831
					1702.1724	2274	814.744	924.3327	5.1066
.97607					1578.7803	2109.002	729.79	857.0787	4.8159
	<0.250 U	<0.010 U	0.24	<1.000 U	1785.3648	2402.35	836.5579	997.3279	4.9945
	<0.250 U	<0.010 U	0.22	<1.000 U	1741.3182	2339.53	802.6434	966.9816	4.9607
					1467.6962	1835.046	936.082	593.8038	2.119
.98766	<0.100 U	<0.010 U	<0.200 U	<1.000 U	1763.5913	2179.143	1010.6566	671.72	2.5458
	<0.250 U	<0.010 U	<0.200 U	<1.000 U	1658.7105	2075.277	977.7401	673.3604	2.6161
	<1.000 U	<0.050 U	9.3	9.67	3548.566	3942.3	2335.4742	636.4527	2.4039
.99568	<1.000 U	<0.050 U	10.1	10.1	3456.9078	3870.43	2270.4546	668.4394	2.3559
	<1.000 U	<0.050 U	9.68	10.5	3388.47	3800.47	2210.3252	665.9789	2.1749
	2.190 J	<0.050 U	10.1	11.7	3487.5523	3921.37	2306.4459	701.2462	2.2015
	<1.000 U	<0.010 U	<0.200 U	2.78	2957.7064	3238.8	1598.7133	454.3747	3.9938
.99572	<0.500 U	<0.050 U	0.25	2.03	2768.0202	3226.7	1194.8776	741.4346	5.6267
	<0.500 U	0.25	0.35	2.07	2653.379	3129.31	1136.8066	769.3204	5.6396
	<0.50 U	<0.05 U	<0.20 U	<1.00 U	673.2647	942.181	477.2878	434.6906	1.4738
05004	<0.250 U	<0.010 U	<0.200 U	<1.000 U	689.1594	991.056	462.1307	488.0017	1.3157
	<0.100 U	<0.010 U	<0.200 U	<1.000 U	650.9732	940.185	447.7037	467.4975	1.3161
	<1.000 U	<0.010 U	<0.200 U	5.5	2858.0544	3278.68	1160.4102	679.9218	6.5016
05010	<1.000 U	<0.050 U	<0.200 U	3.08	3076.0451	3557.05	1258.9586	777.5221	6.4137
	<1.000 U	<0.050 U	<0.200 U	3.05	2997.5608	3475.014	1257.8523	771.7809	6.0852
	<0.50 U	<0.05 U	<0.20 U	<1.00 U	420.752	617.619	385.1678	318.2263	0.4213
05011	<0.100 U	<0.010 U	<0.200 U	<1.000 U	465.9763	712.06	400.6598	397.7829	0.413
	<0.100 U	<0.010 U	<0.200 U	<1.000 U	466.1606	709.2	397.1686	392.8619	0.4148
					2060.5222	2471	997.081	663.5183	4.2442
05041	<0.500 U	<0.050 U	<0.200 U	2.4	2178.8936	2618.8	1169.4362	711.0883	4.1607
	<0.500 U	0.040 J	<0.200 U	1.51	2229.9162	2670.33	1123.2905	711.9084	4.0765
					2619.5695	3109.2	781.0264	791.465	9.0768
	<8.59				2977.9163	3533	900.165	897.2671	8.9479
	<0.5				2930.3251	3423	877.966	796.386	9.3981
05049	<2.0				2853.064	3295	899.287	714.3689	9.1699
	<2.0	<0.25	0.407 P	<1.0 P	3078.3399	3570	965.28	794.7457	9.7752
	<1.000 U	<0.050 U	0.4	<1.000 U	3197.9779	3726.17	1070.4452	853.798	9.0299
	<1.000 U	<0.050 U	0.31	<1.000 U	3059.5731	3588.78	974.3874	855.4384	9.2276

Samples collected under the 2014/2015 Synoptic Sampling Program

APPENDIX C

Appendix C: Isotope Results

	Gwic Id	Site Name	Sample Date	^{18}O	^{2}H
Wells	7589	USDA FOREST SERVICE - NEWELL PIPELINE WELL	10/6/2014 10:41	-18.3	-141
			9/23/2015 13:32	-18.1	-141
	144969	LOHOF PIPELINE WELL * BOYCE WELL	10/1/2014 10:55	-21	-163
			9/23/2015 10:15	-20.7	-162
	183564	USDA FOREST SERVICE * WHITETAIL RANGER STATION	9/30/2014 9:52	-18.5	-141
			9/22/2015 9:54	-18.1	-140
	205082	USDA FOREST SERVICE- SPRING CREEK PIPELINE WELL	10/2/2014 10:38	-18.7	-144
			9/23/2015 17:00	-18.5	-144
	7780	MBMG MONITORING WELL * WO-1	10/6/2014 14:45	-19.2	-148
			9/24/2015 9:46	-18.8	-149
	7781	MBMG MONITORING WELL * WO-2	10/16/2013 13:49	-19.5	-150
			10/7/2014 8:25	-19.4	-147
			9/24/2015 9:50	-19	-147
	7782	MBMG MONITORING WELL * WO-3	10/6/2014 15:05	-19	-149
			9/24/2015 9:51	-18.9	-147
	7777	MBMG MONITORING WELL * WO-6	10/6/2014 12:00	-18.9	-147
			9/24/2015 7:16	-18.6	-146
	7778	MBMG MONITORING WELL * WO-7	10/6/2014 12:01	-18.7	-148
			9/24/2015 7:18	-18.7	-148
	7775	MBMG MONITORING WELL * WO-10	10/2/2014 13:22	-18.6	-143
			9/23/2015 14:55	-18	143
Springs	197452	USDA FOREST SERVICE * ALKALI	10/1/2014 13:58	-18.9	-146
			9/23/2015 11:40	-18.7	-147
	197607	USDA FOREST SERVICE * UPPER 15 MILE	10/2/2014 10:05	-19.9	-154
			9/23/2015 18:00	-19.7	-154
	198766	MUSGROVE - LEMONADE SPRING	9/30/2014 12:09	-19.2	-149
			9/22/2015 11:00	-19.1	-149
	199568	USDA FOREST SERVICE * HEDUM	11/20/2013 14:40	-19.5	-157
			10/1/2014 16:30	-20.4	-157
			9/22/2015 17:50	-20.2	-157
	199572	USDA FOREST SERVICE * DEADMAN	9/30/2014 14:50	-20.1	-155
			9/22/2015 13:40	-20	-155
	205004	USDA FOREST SERVICE * HAGEN-2	10/7/2014 12:00	-19	-148
			9/24/2015 16:00	-18.9	-148
	205010	USDA FOREST SERVICE * NORTH FORK	9/30/2014 15:35	-20.1	-154
			9/22/2015 12:35	-19.9	-155
	205011	USDA FOREST SERVICE * JOE ANDERSON	9/30/2014 16:55	-17.1	-134
			9/22/2015 14:30	-16.5	-133
	205041	USDA FOREST SERVICE * SCHOOL HOUSE	9/30/2014 18:00	-19.6	-153
			9/22/2015 15:40	-19.5	-153
	205049	USDA FOREST SERVICE * CHIPMUNK	10/1/2014 10:00	-19.1	-149
			9/23/2015 8:30	-18.9	-149

APPENDIX D

GWIC ID: 7589, Site Name: Newell Creek Pipeline Well

GWIC ID: 144969, Site Name: Lohoff Qtr Circle V Pipeline Well

GWIC ID: 7780, Site Name: WO-1

GWIC ID: 7781, Site Name: WO-2

GWIC ID: 7782, Site Name: WO-3

GWIC ID: 7777, Site Name: WO-6

GWIC ID: 7778, Site Name: WO-7

GWIC ID: 7775, Site Name: WO-10

GW IC ID: 184564, Site Name: Whitetail Cabin USFS

GWIC ID: 197452, Site Name: Alkali Spring

GWIC ID: 197607, Site Name: Upper 15 Mile Spring

GWIC ID: 198766, Site Name: Lemonade Spring

GWIC ID: 199568, Site Name: Hedum Spring

GWID ID: 199572, Site Name: Deadman’s Spring

GWIC ID: 205004, Site Name: Hagen 2 Spring

GWIC ID: 205010, Site Name: North Fork Spring

GWIC ID: 205011, Site Name: Joe Anderson Spring

GWIC ID: 205041, Site Name: School House Spring

GWIC ID: 205049, Site Name: Chipmunk Spring

GWIC ID: 205082, Site Name: Spring Creek Pipeline Well