Montana Bureau of Mines and Geology

Final Technical Report for NGWMN Award

G20AC00187

Miscellaneous Contribution 25

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January 2024

John I. LaFave

Montana Bureau of Mines and Geology NGWMN Final Technical Report

Award Number: G20AC00187

Agency Name: Montana Bureau of Mines and Geology

Title: Montana Bureau of Mines and Geology 2021 NGWMN Network Enhancement–West Yellowstone Well Drilling Final Report

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Term Covered: 07/15/2020–07/14/2023*
*Granted one-year COVID extension

Date of Final Report: August 31, 2023

Background

The Montana Bureau of Mines and Geology (MBMG) maintains a statewide groundwater monitoring network to collect water-level and water-quality data from about 800 wells. Many of these wells are completed in principal aquifers, including the heavily developed intermontane basin aquifers in the west (S100NRMTIB), and the less intensively developed but widely used alluvial (N100ALLUVL), Lower Tertiary (N300LTRTRY), Upper Cretaceous (N300UPCTCS), Lower Cretaceous (N300LCRTCS), and Paleozoic aquifers (N500PLOZOC) in the east (Whitehead, 1996). The MBMG became a National Groundwater Monitoring Network (NGWMN) data provider in 2015 and at the start of this project provided water-level data for 224 sites, and water-quality data for 58 sites.

In January 2020, the MBMG submitted a proposal in response to Program Announcement/Funding Opportunity G20AS00009 to complete a nested-well pair to monitor groundwater levels and quality in the basin-fill aquifer near West Yellowstone, Montana.

Description of Work Done to Support the NGWMN: Objective 5

The work performed for award G20AC00187 was under Objective 5: to drill a nested-well pair to enhance monitoring in the Northern Rocky Mountain Intermontane Basin (S100NRMTIB) principal aquifer near the town of West Yellowstone, Montana—a rapidly growing resort community on the outskirts of Yellowstone National Park, and within the Yellowstone Controlled Groundwater Area. The area is experiencing intense groundwater development, and is close to the Madison River and Yellowstone National Park. The objective was (a) to complete a well in the shallow-unconfined aquifer, and (b) the second completion depth in the deep-confined part of the basin-fill aquifer.

Site Selection

In January 2021, the MBMG met with representatives of the U.S. Forest Service (USFS) to review possible monitor well locations near West Yellowstone, Montana. A suitable site near the Smoke Jumper Base at the West Yellowstone Airport was identified (fig. 1). A USFS Special-Use Authorization permit to install and maintain two monitoring wells at the Smoke Jumper Base was signed in March 2021 (copy included in appendix A).

Contractor Selection

An “Invitation to Bid” on the well drilling was prepared by the MBMG and issued through Montana Tech Procurement on March 1, 2021; the successful bidder was Excel Pump & Well Inc., and a contract was awarded on April 12, 2021.

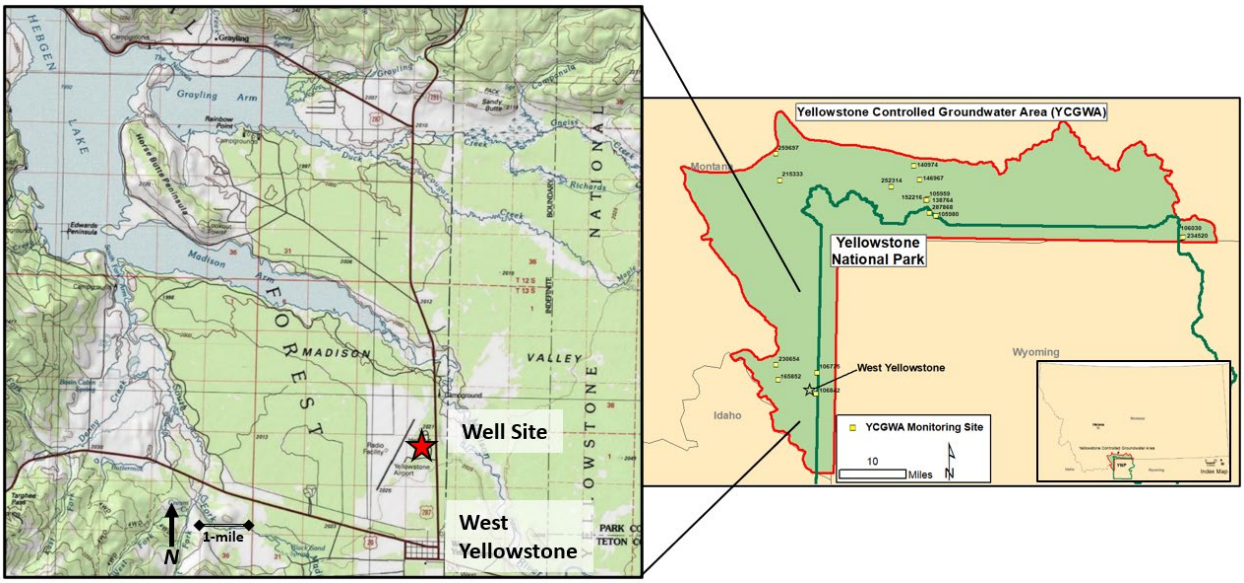


Figure 1. Location of well site approximately 2 miles north of West Yellowstone, MT.

Well Drilling

Between June and August 2021, a shallow and deep well were installed at the site using a dual rotary rig (fig. 2); cuttings were logged (fig. 3) and the drilling was supervised by the onsite MBMG hydrogeologist. The deep well was drilled first to assess the subsurface conditions and determine optimal well-screen placement for the shallow well. For both boreholes, 8-in steel outer casing was advanced to the completion depth, then the well was constructed with 4-in Schedule 40 PVC well casing and 10-ft, 20-slot well screens. Native sand and/or sand pack was placed around and up to 5 ft above the well screens and capped with bentonite. The outer steel casing was pulled back to expose the well screen. Well logs detailing the construction and lithologic information are included in appendix A.

Figure 2. The wells were drilled using a dual air rotary drilling rig.

Heaving sands encountered at about 90 ft below grade (bg) slowed the drilling process and eventually necessitated the use of drilling foam to keep sand and gravel from flowing into the drill stem.

Figure 3. Cuttings were logged onsite.

The deep well was screened from 236 to 246 ft bg below a silty-clay confining layer, and the shallow well was screened from 109.5 to 119.5 ft bg in unconfined obsidian-sand sediments. Both wells were developed until the discharge was clear and free of foam. Each well was completed with outer casing, protective posts, locking caps, and snow poles (fig. 4). After completion of all the drilling activities, the area was reseeded with a native grass seed mix.

Figure 4. Wells were completed with steel surface casing and protective posts.

Solinst Levellogger™ pressure transducers were deployed in both wells on November 30, 2021. The groundwater elevation in the deep (confined) well is generally 3 to 4 ft higher than the shallow well (fig. 5).

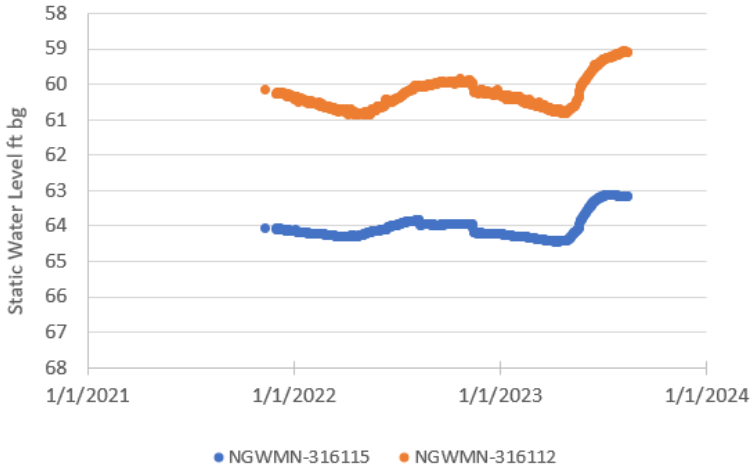


Figure 5. Hydrograph showing the water level in the deep confined aquifer is higher than in the shallow aquifer.

Each well was test-pumped at 12 gallons per minute (gpm) for 1 hr to document and assess hydraulic connection to the aquifer and determine a specific capacity (fig. 6). During the test, the pressure transducers were programmed to take readings every minute. The drawdown in both wells stabilized within about 5 min of the onset of pumping. The shallow well, MBMG-315115, recorded a drawdown of 0.56 ft for a specific capacity of 21.51 gpm/ft. The deep well, MBMG-316112, recorded a drawdown of 39.66 ft for a specific capacity of 0.30 gpm/ft.

There is a confining layer between the wells; neither well recorded any drawdown in response to the pumping of the other well.

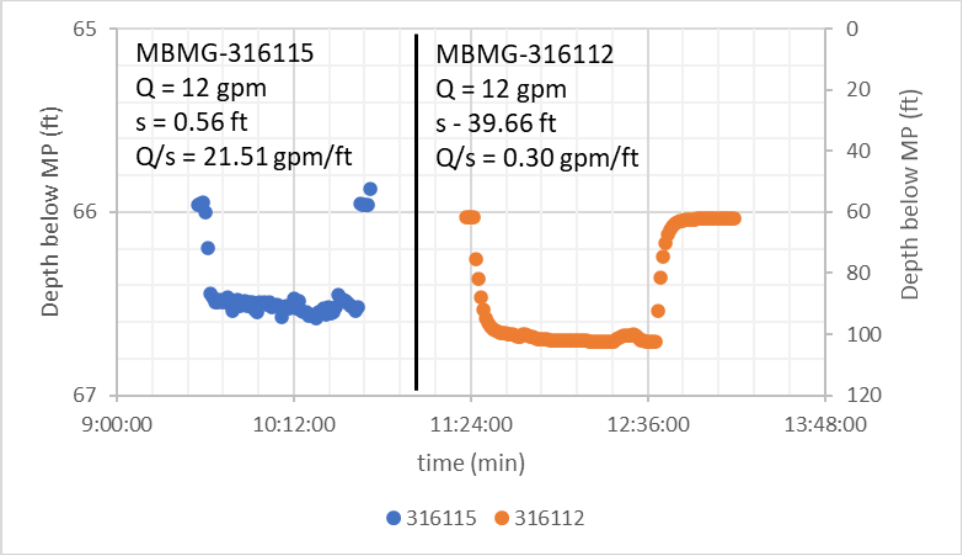


Figure 6. Results of specific capacity testing.

Water-Quality Sampling

Samples for major cations, anions, trace metals, nutrients, and stable isotopes were collected from both wells on August 15, 2022. The analytical results are included in appendix B. The water from both wells was relatively dilute; the total dissolved solids (TDS) for the deep well was 137 mg/L and for the shallow well was 119 mg/L. The sample from the deep well was slightly more enriched in sodium (fig. 7). Both samples contained arsenic: the concentration from the deep sample was 18.63 mg/L , above the 10 mg/L USEPA MCL; the concentration from the shallow sample was 6.69 mg/L.

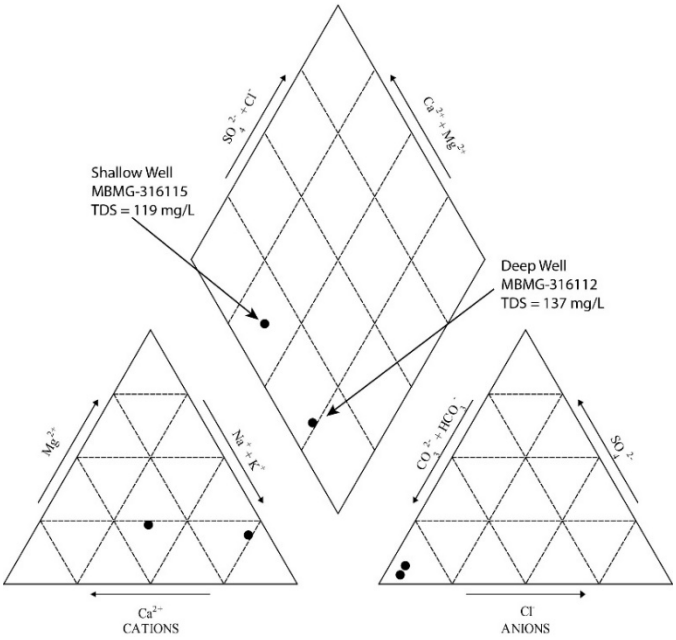


Figure 7. Piper diagram showing the deep well water quality is relatively enriched in sodium.

The wells were also sampled for stable isotopes (^{2}H and ^{18}O). The ^{18}O and ^{2}H abundances are reported as δ values, which represent the difference in parts per thousand (per mill, ‰) between the ratios of ^{18}O /^{16}O (or ^{2}H /H) to that of standard mean ocean water (SMOW); δ values are calculated by:

$$(\delta \text{ in } ‰) = (R_{sample}/R_{SMOW} - 1)*1{,}000,$$

where R is the ratio of the heavy to light isotope. Therefore, the results are interpreted relative to SMOW. A positive δ value means that the sample contains more of the heavy isotope than standard ocean water; a negative δ value means that the sample contains less.

The results are included in appendix B, and shown on figure 8. The results are consistent with the isotopic composition of meteoric waters in the Yellowstone Park region (Kharaka and others, 2002).

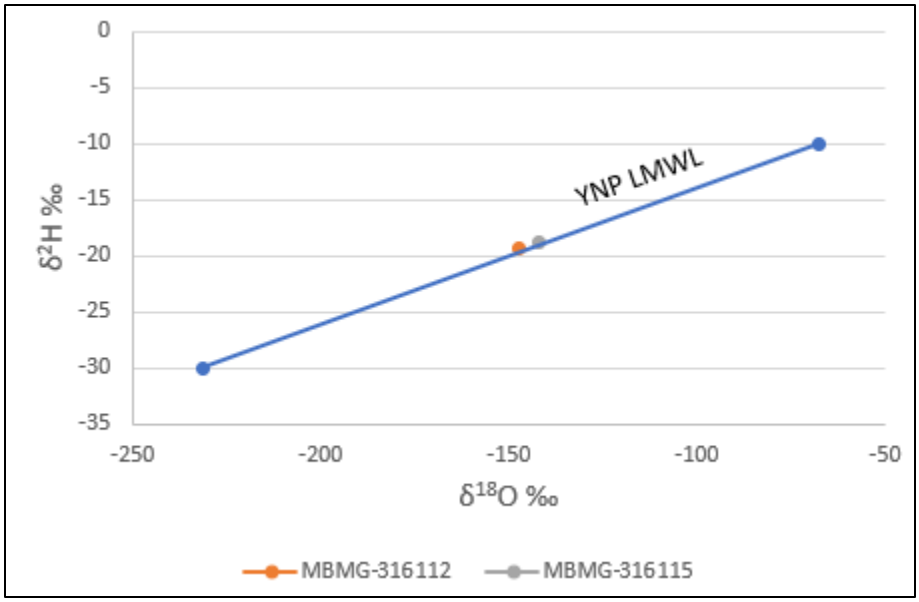


Figure 8. The stable isotope results plot along the local meteoric water line for the Yellowstone Park region.

NGWMN Registry

All site information and well construction details have been included in the Montana Bureau of Mines and Geology Ground Water Information Center database and added to the National Groundwater Monitoring Network well registry.

Agency	MBMG	MBMG
Site Name	MBMG-316115	MBMG-316112
National Aquifer Code	S100NRMTIB	S100NRMTIB
Aquifer Type	UNCONFINED	CONFINED
Water Quality Subnetwork	Yes	Yes
WQ Baseline Achieved	No	No
Water Level Subnetwork	Yes	Yes
WL Baseline Achieved	No	No
WL Well Characteristics	Background	Background
WL Well Type	Trend	Trend
WL Well Purpose	Dedicated Monitoring	Dedicated Monitoring

References

Kharaka, Y.K., Thordson, J.J., and White, L.D., 2002, Isotope and chemical compositions of meteoric and thermal waters and snow from the Great Yellowstone National Park Region: U.S. Geological Survey Open-File Report 02-194, 18 p.

Whitehead, R.L., 1996, Ground water atlas of the United States Segment 8–Montana, North Dakota, South Dakota, Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas 370-I, 24 p.

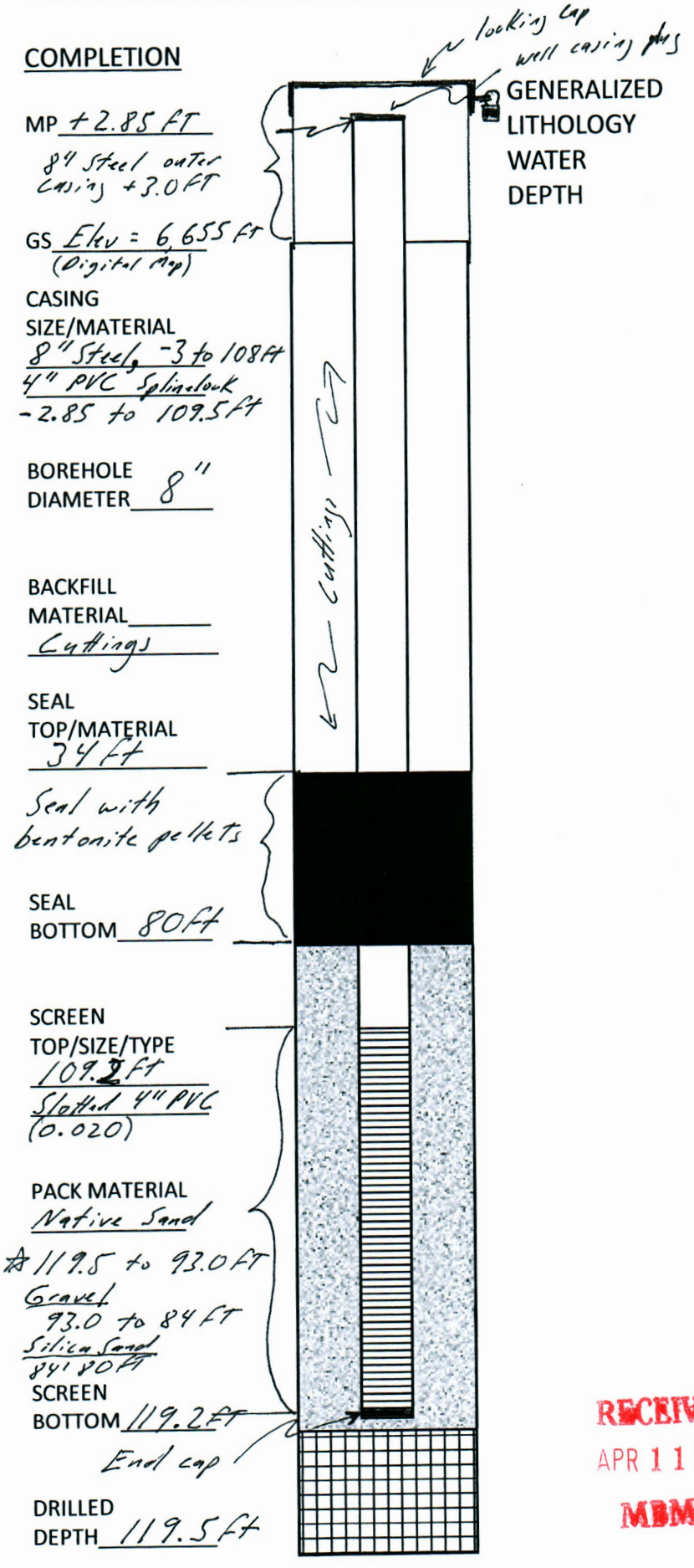
Appendix A—Well Logs and Land Use Agreement

13S 05E 22 BDBD

DEPTHS BELOW GROUND SURFACE IN FEET

MBMG
Montana Bureau of Mines and Geology

COMPLETION



MP +2.85 FT
8" Steel outer casing +3.0 FT

GS Elev = 6,655 FT
(Digital Map)

CASING SIZE/MATERIAL
8" Steel, -3 to 108 ft
4" PVC Splinelock
-2.85 to 109.5 ft

BOREHOLE DIAMETER 8"

BACKFILL MATERIAL
Cuttings

SEAL TOP/MATERIAL
34 ft

SEAL BOTTOM 80 ft

SCREEN TOP/SIZE/TYPE
109.2 ft
Slotted 4" PVC (0.020)

PACK MATERIAL
Native Sand
* 119.5 to 93.0 ft
Gravel
93.0 to 84 ft
Silica Sand
84 to 80 ft

SCREEN BOTTOM 119.2 ft

DRILLED DEPTH 119.5 ft

RECEIVED
APR 11 2022
MBMG

PROJECT
NGWMN

GWIC 316115

WELL NAME
USFS Fire Center - Shallow

LOCATION
T 13 N/(S) R 5(E)/W
S 22 TRACT
LATITUDE
44.68854°

LONGITUDE
-111.10348

DATUM/METHOD
WGS 84 Digital Map

DATE WELL STARTED
7-25-2021

DATE WELL COMPLETED
7-27-2021

RECORDED BY
Alan English (MBMG)

DRILLER/LICENSE
Colten Baertsch #756

COMPANY
Excel Pump + Well Inc.

NOTES
* Heaving sand flowed into annulus from 119.5 to 93.0 ft before filter pack could be installed around screen. Placed 9 ft of gravel on heaved sand from 93.0 to 84.0 ft to lock in native sand and prevent additional heaving.

316115

13S 05E 22 BDBD

DRILLING LOG

GWIC ID: 316115
Start Date: 7/25/2021
Finish Date: 7/26/2021
Site Name: USFS Fire Center Shallow Well
Location: Township 13 South, Range 5 East, Section 22
Latitude: 44.68861° N (Digital Map Method)
Longitude - 111.10335°
Elevation: 6656 ft MSL
Log By: Alan English, Montana Bureau of Mines and Geology

DEPTH (ft bgs)		LITHOLOGY	REMARKS
FROM	TO		
0	7	FINE-MEDIUM LT GRAY OBSIDIAN RICH SAND-SILTY W/SOME COBBLES	
7	30	MEDIUM TO COARSE LT GRAY OSIDIAN RICH SAND-SILTY, GRAVELLY	
30	53	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND-SILTY, GRAVELLY	
53	60	MEDIUM TO COARSE LT GRAY OBSIDIAN RICH SAND-GRAVELLY, SILTY	
60	62	FINE TAN SAND AND SILT	MOIST AT 60 FT
62	88	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND-SILTY, GRAVELLY	
88	91	COARSE LT GRAY OBSIDIAN RICH SAND-GRAVELLY	LITTLE WATER 89-91 FT
91	119.5	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND, SILTY, GRAVELLY-HEAVING SANDS	

316115

13S 05E 22

DEPTHS BELOW GROUND SURFACE IN FEET

MBMG
Montana Bureau of Mines and Geology

COMPLETION

MP +2.85 FT
8" steel outer casing +3 FT

GS 6,655 FT

CASING SIZE/MATERIAL
8" Steel, -3 to 236.2 FT
4" PVC Spline lock -2.85 to 235.5 FT

BOREHOLE DIAMETER 8"

BACKFILL MATERIAL
Cuttings

SEAL TOP/MATERIAL
170 FT
Seal with bentonite pellets

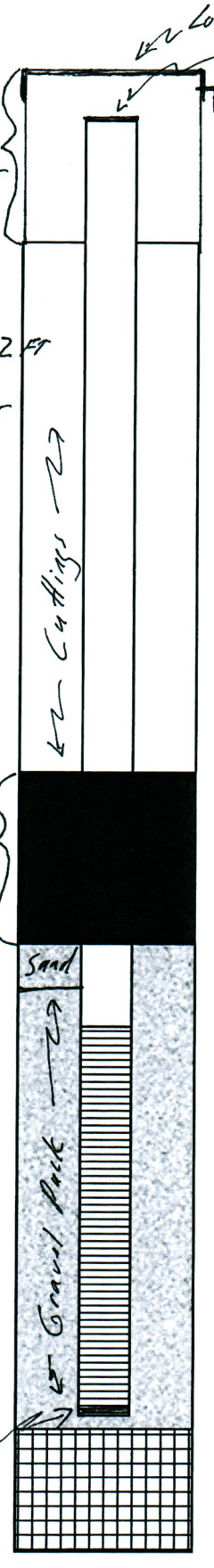
SEAL BOTTOM 220 FT

SCREEN TOP/SIZE/TYPE
235.5 FT
Slotted 4" PVC (0.020)

PACK MATERIAL
Gravel 246.0 to 227.0 FT
Silica Sand 227.0 to 220.0 FT

SCREEN BOTTOM 245.7 FT
End Cap

DRILLED DEPTH 246.0 FT



RECEIVED
APR 11 2022
MBMG

PROJECT
NGWMN

GWIC 316112

WELL NAME
USFS Fire Center - Deep

LOCATION
T 13 N/S, R 5 E/W
S 22 TRACT
LATITUDE
44.688853°

LONGITUDE
-111.10339

DATUM/METHOD
WGS 84 - Digital Map

DATE WELL STARTED
6-23-2021

DATE WELL COMPLETED
6-28-2021

RECORDED BY
Alan English (MBMG)

DRILLER/LICENSE
Colten Baertsch #756

COMPANY
Exel Pump & Well Inc.

NOTES
Only pulled steel casing back ~9.2ft because PVC casing string locked up. Stopped to avoid damaging screen & filter pack.

316112

13S 05E 22

DRILLING LOG

GWIC ID: 316112
Start Date: 6/23/2021
Finish Date: 6/28/2021
Site Name: USFS Fire Center Deep Well
Location: Township 13 South, Range 5 East, Section 22
Latitude: 44.68861° N (Digital Map Method)
Longitude - 111.10337°
Elevation: 6656 ft MSL
Log By: Alan English, Montana Bureau of Mines and Geology

DEPTH (ft bgs)		LITHOLOGY	REMARKS
FROM	TO		
0	7	FINE-MEDIUM LT GRAY OBSIDIAN RICH SAND-SILTY W/SOME COBBLES	
7	30	MEDIUM TO COARSE LT GRAY OSIDIAN RICH SAND-SILTY, GRAVELLY	
30	53	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND-SILTY, GRAVELLY	
53	60	MEDIUM TO COARSE LT GRAY OBSIDIAN RICH SAND-GRAVELLY, SILTY	
60	62	FINE TAN SAND AND SILT	MOIST AT 60 FT
62	88	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND-SILTY, GRAVELLY	
88	91	COARSE LT GRAY OBSIDIAN RICH SAND-GRAVELLY	LITTLE WATER 89-91 FT
91	127	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND, SILTY, GRAVELLY-HEAVING SANDS	
127	129	LIGHT GRAY CLAY-SILTY, SOFT	
129	134	TAN SILT, CLAYEY, SANDY, HARD	
134	135	FINE TAN SAND	
135	157	FINE TO MEDIUM LT GRAY OBSIDIAN RICH SAND, SILTY, GRAVELLY-HEAVING SANDS	
157	178	MEDIUM TO COARSE LT GRAY OBSIDIAN RICH SAND-SILTY AND GRAVELLY-HEAVING SANDS	SOME WATER AT 168 FT
178	180	BROWN CLAY-HARD	
180	188	MEDIUM LT GRAY OBSIDIAN RICH SAND-CLAYEY AND SILTY	H_2S ODOR AT 180 FT
188	193	BROWN CLAY-SILTY, WITH WOOD AND PEAT FRAGEMENTS	
193	197	MEDIUM TO COARSE LT GRAY OBSIDIAN RICH SAND,SILTY, GRAVELLY	
197	208	FINE TO MEDIUM LT GRAY OBSIDIAN SAND-SILTY-HEAVING SANDS	
208	214	FINE GREENISH-GRAY SAND-CLAYEY AND SILTY	
214	224	FINE LT GRAY OBSIDIAN RICH SAND-SILTY-HEAVING SANDS	
224	227	COARSE LT GRAY OBSIDIAN SAND-GRAVELLY	
227	228	GRAY CLAY	
228	240	MEDIUAM TO COARSE LT GRAY OBSIDIAN RICH SAND-GRAVELLY-HEAVING SANDS	WATER AT 228 FT
240	246	LIGHT GRAY GRAVEL AND COARSE SAND-SOME HEAVING, HARD GROUND AT 242 FT	MORE WATER

316112

Auth ID: GAR20
Contact ID: MT,BMG
Use Code: 942

FS-2700-23 (v. 10/09)
OMB No. 0596-0082

U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
AMENDMENT
FOR

SPECIAL-USE AUTHORIZATION

Amendment#: 1

This amendment is attached to and made a part of the GAR20 special use authorization for WATER QUALITY MONITORING STATION issued to MONTANA TECHNOLOGICAL UNIVERSITY on 11/13/2017 which is hereby amended as follows:

Amendment to existing authorization (GAR 20) for operating and maintaining water quality monitoring stations. Amendment includes the following:

1. Add to authorization monitoring of existing USFS public water supply well at Cooke Pass Administrative site/Colter Campground (T. 9 S., R. 15 E., Sec. 29) to allow for long-term groundwater monitoring. USFS will be drilling a new well in adjacent location in 2021 at which point monitoring will be moved to this location.

2. Install and maintain two groundwater monitoring wells at the Smoke Jumper Base, West Yellowstone, MT (T. 13. S., R. 5 E., sec. 22) to allow for long-term monitoring shallow and deep groundwater. The wells will be located next to each other, within a 20 'x 20' area completed at depths of approximately 80' and 240'.

3. Install and maintain two groundwater monitoring wells adjacent to the Old Stage Road, West Yellowstone, MT (T. 13 S., R. 5 E., SW1/4SE1/4 sec. 18) to allow for long-term monitoring of shallow and deep groundwater. The wells will be located next to each other, within a 20' X 20' area, completed at depths of approximately 80' and 240'.

This Amendment is accepted subject to the conditions set forth herein, and to conditions N/A to N/A attached hereto and made a part of this Amendment.

Alan English

Alan English, Hydrogeologist
Montana Bureau of Mines and Geology

3·1·2021

Date

MARY C ERICKSON
FOREST SUPERVISOR
CUSTER GALLATIN NATIONAL FOREST

Date

Appendix B—Water-Quality Results

Ground-Water Information Center Water Quality Report

Site Name: MBMG USFS SMOKE JUMPER N.W. SHALLOW WELL

Report Date: 2/14/2023

Compare to Water Quality Standards

Location Information

Sample Id/Site Id:	253882 / 316115	Sample Date:	8/15/2022 1:37:00 PM
Location (TRS):	13S 05E 22 BDBD	Agency/Sampler:	MBMG / ENGLISH, ALAN
Latitude/Longitude:	44° 41' 18" N 111° 6' 12" W	Field Number:	316115
Datum:	WGS84	Lab Date:	9/2/2022 1:03:58 PM
Altitude:	6656	Lab/Analyst:	MBMG / TIMMER, JACKIE
County/State:	GALLATIN / MT	Sample Method/Handling:	PUMPED / ru:1 ra:0 fu:2 fa:2
Site Type:	WELL	Procedure Type:	DISSOLVED
Geology:	112SNGR	Total Depth (ft):	119.5
USGS 7.5' Quad:		SWL-MP (ft):	66.74
PWS Id:		Depth Water Enters (ft):	109.2
Project:	YNPMON, YNPWYWQ, NGWMN-MONTANA		

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	11.450	0.571	Bicarbonate (HCO3)	84.130	1.379
Magnesium (Mg)	4.150	0.342	Carbonate (CO3)	0.000	0.000
Sodium (Na)	10.680	0.465	Chloride (Cl)	3.040	0.086
Potassium (K)	3.410	0.087	Sulfate (SO4)	5.430	0.113
Iron (Fe)	<0.015 U	0.000	Nitrate (as N)	0.470	0.034
Manganese (Mn)	<0.002 U	0.000	Fluoride (F)	1.640	0.086
Silica (SiO2)	38.300		Orthophosphate (as P)	<0.020 U	0.000
Total Cations		1.468	**Total Anions**		1.698

Trace Element Results (µg/L)

Aluminum (Al):	<2.000 U	Cesium (Cs):	0.330 J	Molybdenum (Mo):	3.860	Strontium (Sr):	16.660
Antimony (Sb):	0.320 J	Chromium (Cr):	<0.100 U	Nickel (Ni):	<0.100 U	Thallium (Tl):	<0.100 U
Arsenic (As):	6.690	Cobalt (Co):	<0.100 U	Niobium (Nb):	<0.100 U	Thorium (Th):	<0.100 U
Barium (Ba):	7.980	Copper (Cu):	<0.500 U	Neodymium (Nd):	<0.100 U	Tin (Sn):	<0.100 U
Beryllium (Be):	<0.100 U	Gallium (Ga):	<0.100 U	Palladium (Pd):	<0.100 U	Titanium (Ti):	<0.100 U
Boron (B):	28.790	Lanthanum (La):	<0.100 U	Praseodymium (Pr):	<0.100 U	Tungsten (W):	0.750
Bromide (Br):	<10.000 U	Lead (Pb):	<0.060 U	Rubidium (Rb):	3.920	Uranium (U):	0.280 J
Cadmium (Cd):	<0.100 U	Lithium (Li):	50.480	Silver (Ag):	<0.100 U	Vanadium (V):	6.110
Cerium (Ce):	<0.100 U	Mercury (Hg):	NR	Selenium (Se):	<0.100 U	Zinc (Zn):	0.910 J
						Zirconium (Zr):	<0.100 U

Field Chemistry and Other Analytical Results

**Total Dissolved Solids (mg/L):	118.98	Field Hardness as CaCO3 (mg/L):	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents (mg/L):	161.6	Hardness as CaCO3:	45.67	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	144.1	Field Alkalinity as CaCO3 (mg/L):	NR	PCP (µg/L):	NR
Lab Conductivity (µmhos):	144.31	Alkalinity as CaCO3 (mg/L):	68.89	Phosphorus, TD (mg/L):	0.040 J
Field pH:	8.14	Ryznar Stability Index:	9.166	Field Nitrate (mg/L):	0.000
Lab pH:	8.04	Sodium Adsorption Ratio:	0.7083	Field Dissolved O2 (mg/L):	2.580
Water Temp (°C):	7.2	Langlier Saturation Index:	-0.563	Field Chloride (mg/L):	NR
Air Temp (°C):	29.5	Nitrite (mg/L as N):	<0.010 U	Field Redox (mV):	82.8
Nitrate + Nitrite (mg/L as N)	0.400	Hydroxide (mg/L as OH):	0.000	Lab, Dissolved Organic Carbon (mg/L):	NR
Total Kjeldahl Nitrogen (mg/L as N)	NR	Lab, Dissolved Inorganic Carbon (mg/L):	NR	Lab, Total Organic Carbon (mg/L):	NR
Total Nitrogen (mg/L as N)	NR	Acidity to 4.5 (mg/L CaCO3)	NR	Acidity to 8.3 (mg/L CaCO3)	NR
As(III) (ug/L)	NR	As(V) (ug/L)	NR	Total Susp Solids (mg/L)	NR

Sample Condition: WATER CLEAR

Field Remarks:

Lab Remarks:

Notes

Explanation: **mg/L** = milligrams per Liter; **µg/L** = micrograms per Liter; **ft** = feet; **NR** = No Reading in GWIC

Qualifiers: **J** = Estimated quantity above detection limit but below reporting limit; **P** = Preserved sample; **S** = Method of standard additions; **U** = Undetected quantity below detection limit; ***** = Duplicate analysis not within control limits; ****** = Sum of Dissolved Constituents is the sum of major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO3, CO3, SO4, Cl, SiO2, NO3, F) in mg/L. Total Dissolved Solids is reported as equivalent weight of evaporation residue.

Ground-Water Information Center Water Quality Report

Site Name: MBMG USFS SMOKE JUMPER S.E. DEEP WELL

Report Date: 2/14/2023

Compare to Water Quality Standards

Location Information

Sample Id/Site Id:	253883 / 316112	Sample Date:	8/15/2022 1:46:00 PM
Location (TRS):	13S 05E 22	Agency/Sampler:	MBMG / ENGLISH, ALAN
Latitude/Longitude:	44° 41' 18" N 111° 6' 12" W	Field Number:	316112
Datum:	WGS84	Lab Date:	9/2/2022 1:03:58 PM
Altitude:		Lab/Analyst:	MBMG / TIMMER, JACKIE
County/State:	GALLATIN / MT	Sample Method/Handling:	PUMPED / ru:1 ra:0 fu:2 fa:2
Site Type:	WELL	Procedure Type:	DISSOLVED
Geology:	112SNGR	Total Depth (ft):	246
USGS 7.5' Quad:		SWL-MP (ft):	62.91
PWS Id:		Depth Water Enters (ft):	236
Project:	YNPMON, NGWMN-MONTANA		

Major Ion Results

	mg/L	meq/L		mg/L	meq/L
Calcium (Ca)	2.580	0.129	Bicarbonate (HCO3)	100.340	1.645
Magnesium (Mg)	4.220	0.347	Carbonate (CO3)	2.330	0.083
Sodium (Na)	27.440	1.194	Chloride (Cl)	3.630	0.102
Potassium (K)	4.420	0.113	Sulfate (SO4)	3.140	0.065
Iron (Fe)	0.026 J	0.000	Nitrate (as N)	<0.010 U	0.000
Manganese (Mn)	0.052	0.002	Fluoride (F)	2.750	0.145
Silica (SiO2)	38.310		Orthophosphate (as P)	0.040 J	0.000
Total Cations		1.792	**Total Anions**		2.041

Trace Element Results (µg/L)

Aluminum (Al):	18.500	Cesium (Cs):	0.260 J	Molybdenum (Mo):	5.950	Strontium (Sr):	16.580
Antimony (Sb):	<0.100 U	Chromium (Cr):	<0.100 U	Nickel (Ni):	<0.100 U	Thallium (Tl):	<0.100 U
Arsenic (As):	18.630	Cobalt (Co):	<0.100 U	Niobium (Nb):	<0.100 U	Thorium (Th):	<0.100 U
Barium (Ba):	7.490	Copper (Cu):	<0.500 U	Neodymium (Nd):	<0.100 U	Tin (Sn):	<0.100 U
Beryllium (Be):	<0.100 U	Gallium (Ga):	<0.100 U	Palladium (Pd):	<0.100 U	Titanium (Ti):	<0.100 U
Boron (B):	53.160	Lanthanum (La):	<0.100 U	Praseodymium (Pr):	<0.100 U	Tungsten (W):	2.980
Bromide (Br):	<10.000 U	Lead (Pb):	<0.060 U	Rubidium (Rb):	6.750	Uranium (U):	<0.100 U
Cadmium (Cd):	<0.100 U	Lithium (Li):	109.820	Silver (Ag):	<0.100 U	Vanadium (V):	1.870
Cerium (Ce):	<0.100 U	Mercury (Hg):	NR	Selenium (Se):	<0.100 U	Zinc (Zn):	1.060 J
						Zirconium (Zr):	<0.100 U

Field Chemistry and Other Analytical Results

**Total Dissolved Solids (mg/L):	137.08	Field Hardness as CaCO3 (mg/L):	NR	Ammonia (mg/L):	NR
**Sum of Diss. Constituents (mg/L):	187.82	Hardness as CaCO3:	23.81	T.P. Hydrocarbons (µg/L):	NR
Field Conductivity (µmhos):	171	Field Alkalinity as CaCO3 (mg/L):	NR	PCP (µg/L):	NR
Lab Conductivity (µmhos):	158.62	Alkalinity as CaCO3 (mg/L):	85.35	Phosphorus, TD (mg/L):	0.070 J
Field pH:	8.21	Ryznar Stability Index:	10.134	Field Nitrate (mg/L):	0.000
Lab pH:	8.18	Sodium Adsorption Ratio:	2.4075	Field Dissolved O2 (mg/L):	0.390
Water Temp (°C):	9.6	Langlier Saturation Index:	-0.977	Field Chloride (mg/L):	NR
Air Temp (°C):	29.5	Nitrite (mg/L as N):	<0.010 U	Field Redox (mV):	-131.9
Nitrate + Nitrite (mg/L as N)	<0.200 U	Hydroxide (mg/L as OH):	0.000	Lab, Dissolved Organic Carbon (mg/L):	NR
Total Kjeldahl Nitrogen (mg/L as N)	NR	Lab, Dissolved Inorganic Carbon (mg/L):	NR	Lab, Total Organic Carbon (mg/L):	NR
Total Nitrogen (mg/L as N)	NR	Acidity to 4.5 (mg/L CaCO3)	NR	Acidity to 8.3 (mg/L CaCO3)	NR
As(III) (ug/L)	NR	As(V) (ug/L)	NR	Total Susp Solids (mg/L)	NR

Sample Condition: SLIGHTLY CLOUDY-MILKY WHITE

Field Remarks:

Lab Remarks:

Notes

Explanation: **mg/L** = milligrams per Liter; **µg/L** = micrograms per Liter; **ft** = feet; **NR** = No Reading in GWIC

Qualifiers: **J** = Estimated quantity above detection limit but below reporting limit; **P** = Preserved sample; **S** = Method of standard additions; **U** = Undetected quantity below detection limit; ***** = Duplicate analysis not within control limits; ****** = Sum of Dissolved Constituents is the sum of major cations (Na, Ca, K, Mg, Mn, Fe) and anions (HCO3, CO3, SO4, Cl, SiO2, NO3, F) in mg/L. Total Dissolved Solids is reported as equivalent weight of evaporation residue.

Ground-Water Information Center **Isotope Tracer Report**

Site Name: MBMG USFS SMOKE JUMPER N.W. SHALLOW WELL **Report Date:** 2/14/2023

Location Information

Sample Id/Site Id:	253882 / 316115	Sample Date:	8/15/2022 1:37:00 PM
Location (TRS):	13S 05E 22 BDBD	Agency/Sampler:	MBMG / ENGLISH, ALAN
Latitude/Longitude:	44° 41' 18" N 111° 6' 12" W	Field Number:	316115
Datum:	WGS84	Lab Date:	9/2/2022 1:03:58 PM
Altitude:	6656	Lab/Analyst:	MBMG / TIMMER, JACKIE
County/State:	GALLATIN / MT	Sample Method/Handling:	PUMPED / ru:1 ra:0 fu:2 fa:2
Site Type:	WELL	Procedure Type:	DISSOLVED
Geology:	112SNGR	Total Depth (ft):	119.5
USGS 7.5' Quad:		SWL-MP (ft):	66.74
PWS Id:		Depth Water Enters (ft):	109.2
Project:	YNPMON, YNPWYWQ, NGWMN-MONTANA		

Radon (Rn_{222} - pCi/L):	NR	Argon (Ar_{39}):	NR
Carbon (C_{13}):	NR	Silicon (Si_{32}):	NR
Carbon (C_{14}):	NR	Chlorine (Cl_{36}):	NR
Tritium (H_3 - TU):	NR	Lithium (Li_6):	NR
H_3/He_3 Ratio:	NR	Krypton (Kr_{85}):	NR
Deuterium (H_2):	-141.000	Boron (B_{11})	NR
Oxygen (O_{18}):	-18.700	Strontium (Sr_{87})	NR
Sulphur (S_{34}):	NR	Chloro-fluorocarbon (CFC-11):	NR
Iodine (I_{129}):	NR	Chloro-fluorocarbon (CFC-12):	NR
Nitrogen (N_{15}):	NR	Chloro-fluorocarbon (CFC-113):	NR
Nitrogen (N15 of Nitrate):	NR	Oxygen (O_{18} of Nitrate):	NR
Sulphur (S_{34} of Sulfate):	NR	Oxygen (O_{18} of Sulfate):	NR

Sample Condition: WATER CLEAR **Notes**

Field Remarks:

Lab Remarks:

Explanation: **pCi/L** = picocuries per Liter; **TU** = Tritium Units; **NR** = No Reading in GWIC

Disclaimer

These data represent the contents of the GWIC databases at the Montana Bureau of Mines and Geology at the time and date of the retrieval. The information is considered unpublished and is subject to correction and

review on a daily basis. The MBMG warrants the accurate transmission of the data to the original end user. Retransmission of the data to other users is discouraged and the MBMG claims no responsibility if the material is retransmitted.

Ground-Water Information Center **Isotope Tracer Report**

Site Name: MBMG USFS SMOKE JUMPER S.E. DEEP WELL **Report Date:** 2/14/2023

Location Information

Sample Id/Site Id:	253883 / 316112	Sample Date:	8/15/2022 1:46:00 PM
Location (TRS):	13S 05E 22	Agency/Sampler:	MBMG / ENGLISH, ALAN
Latitude/Longitude:	44° 41' 18" N 111° 6' 12" W	Field Number:	316112
Datum:	WGS84	Lab Date:	9/2/2022 1:03:58 PM
Altitude:		Lab/Analyst:	MBMG / TIMMER, JACKIE
County/State:	GALLATIN / MT	Sample Method/Handling:	PUMPED / ru:1 ra:0 fu:2 fa:2
Site Type:	WELL	Procedure Type:	DISSOLVED
Geology:	112SNGR	Total Depth (ft):	246
USGS 7.5' Quad:		SWL-MP (ft):	62.91
PWS Id:		Depth Water Enters (ft):	236
Project:	YNPMON, NGWMN-MONTANA		

Radon (Rn_{222} - pCi/L):	NR	Argon (Ar_{39}):	NR
Carbon (C_{13}):	NR	Silicon (Si_{32}):	NR
Carbon (C_{14}):	NR	Chlorine (Cl_{36}):	NR
Tritium (H_3 - TU):	NR	Lithium (Li_6):	NR
H_3/He_3 Ratio:	NR	Krypton (Kr_{85}):	NR
Deuterium (H_2):	-147.000	Boron (B_{11})	NR
Oxygen (O_{18}):	-19.300	Strontium (Sr_{87})	NR
Sulphur (S_{34}):	NR	Chloro-fluorocarbon (CFC-11):	NR
Iodine (I_{129}):	NR	Chloro-fluorocarbon (CFC-12):	NR
Nitrogen (N_{15}):	NR	Chloro-fluorocarbon (CFC-113):	NR
Nitrogen (N15 of Nitrate):	NR	Oxygen (O_{18} of Nitrate):	NR
Sulphur (S_{34} of Sulfate):	NR	Oxygen (O_{18} of Sulfate):	NR

Sample Condition: SLIGHTLY CLOUDY-MILKY WHITE **Notes**

Field Remarks:

Lab Remarks:

Explanation: **pCi/L** = picocuries per Liter; **TU** = Tritium Units; **NR** = No Reading in GWIC