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EXECUTIVE SUMMARY

TO	Otter Tail Power Company	
DATE	September 6th, 2017	
SUBJECT	Executive Summary	
PROJECT	Production Well – Astoria Site	BAI No. 22392.00.30

Otter Tail Power Company is an investor-owned electric utility based out of Fergus Falls, Minnesota. Otter Tail Power is proposing to develop a natural gas-fired energy conversion facility in the vicinity of Astoria, South Dakota. Property has been secured for the facility and the intent was to install a production well on the property to provide water for the process and for 3 to 5 plant employees. On May 12, 2017 the SD DENR authorized Thein Well to install a test well on the property. This test well is now proposed to be used as a production well.

A site was selected in the southeast corner of the property for Thein to drill a well. Thein maintained drilling logs throughout the drilling process and the aquifer formation was determined by collecting samples throughout. This log is included in Appendix A of this report and is summarized in the following table.

Table 1: Test Bore

Geological Material	From	To
Top Soil	0	3
Clay	3	51
Sand Med	51	52
Clay	52	58
Sand Med	58	61
Clay	61	64
Gravel Course Med	64	67
Rock	67	73
Clay	73	103
Gravel	103	106
Sandy Clay	106	177
Clay	177	186
Clay/Sand Layers	186	192
Sand Med	192	196
Clay/Few Sand	196	251
Sand Med	251	255
Clay/Sandy Soft	255	296
Sand	296	298
Clay	298	307
Sand/Rock	307	315
Clay/Sandy	315	336
Gravel	336	340
Clay w/ Sand &	340	416
Gravel Fine	416	418

Geological Material	From	To
Clay	418	436
Sandy Clay	436	440
Clay w/ Sand Layers	440	451
Sand w/ Clay Layers	451	461
Clay	461	465
Sand	465	467
Clay	467	471
Sand w/ Clay Layers	471	473
Clay	473	506
Clay w/ Sand	506	526
Shale	526	556
Clay	556	561
Shale	561	572
Clay	572	615
Sand	615	617
Clay	617	618
Sand	618	619
Clay	619	621
Sand	621	623
Clay	623	625
Sandstone w/ Sand	625	646
Sand Med/Fine	646	672
Clay	672	678
Sandstone	678	679

As indicated on the bore log, a good layer of sand/gravel was found from 625 feet to 678 feet, providing 53 feet of good water bearing material. Thein reamed out the bore hole and installed a 5-inch casing, including 60 feet of well screen, and gravel pack. A cross section of the Otter Tail Power production well is illustrated in Figure 3.

After the casing, screen, and gravel pack were installed, Thein proceeded to develop the well. Thein developed the well over a 12-hour period. Upon completion of the well development, Thein installed a temporary pump so the well could be test pumped to determine drawdown and recharge characteristics

of the aquifer. The well was test pumped for eight (8) hours at 65 gpm and the drawdown and recharge information is summarized in Table 2. The static water elevation was 269.71 feet below grade.

Table 2: Test Pumping

PUMPING TEST					RECOVERY			
Time	Time (min)	Pumping Level	Draw Down	GPM	Time	Time (min)	Water Level	Draw Down
7:31 AM	1	282.71	-13.0	65	3:35 PM	5	270.71	-1
7:35 AM	5	282	-12.29	65	3:45 PM	15	270.33	-0.62
7:40 AM	10	282.41	-12.7	65	5:30 PM	120	270	-0.29
7:45 AM	15	282.58	-12.87	65				
7:50 AM	20	252.62	-12.91	65				
7:55 AM	25	282.62	-12.91	65				
8:00 AM	30	282.66	-12.95	65				
8:15 AM	45	282.91	-13.2	65				
8:30 AM	60	283	-13.29	65				
8:45 AM	75	283	-13.29	65				
9:00 AM	90	283.1	-13.39	65				
9:30 AM	120	283.21	-13.5	65				
10:00 AM	150	283.29	-13.58	65				
10:30 AM	180	283.41	-13.7	65				
11:00 AM	210	283.5	-13.79	65				
11:30 AM	240	283.45	-13.74	65				
12:00 PM	270	283.54	-13.83	65				
12:30 PM	300	283.62	-13.91	65				
1:00 PM	330	283.66	-13.95	65				
1:30 PM	360	283.75	-14.04	65				
2:00 PM	390	283.79	-14.08	65				
2:30 PM	420	283.83	-14.12	65				
3:00 PM	450	283.9	-14.19	65				
3:30 PM	480	283.91	-14.2	65				

As shown in the table, the water level immediately dropped 13 feet upon starting the test pump, but then stabilized to within approximately an additional one foot over the course of the 8-hour pumping period. The stabilization of the water level indicates the aquifer is recharging to maintain the pumping needs. In addition, the aquifer quickly recovered once the pump was turned off, returning to within one foot of static within 5 minutes.

Water samples were grabbed while test pumping and delivered to the Water & Environmental Engineering Research Center at SDSU for analysis. The water quality characteristics are shown in Table 3.

Table 3: Water Quality Analysis

Water Quality Characteristic	Otter Tail Well	Maximum Contaminant Level Primary Stds+	Maximum Contaminant Level Secondary Stds++
pH*	7.309	-	-
Temperature (°C)*	14.1	-	-
Alkalinity (mg/l as $CaCO_3$)	475	-	-
Nitrate (mg/l as N)	0.153	10	-
Total Suspended Solids (mg/l)	13	-	-
Total Dissolved Solids (mg/l)	1689	-	500
Volatile Suspended Solids (mg/l)	12	-	-
Conductivity (uS/cm)	2270	-	-
E. Coli (mpn/100 ml)	<1	0	-
Chloride (mg/l as Cl)	8.8	-	250
Sulfate (as SO_4)	1216	-	250
Total Hardness (mg/l as $CaCO_3$)	723	-	-
Calcium Hardness (mg/l as $CaCO_3$)	415	-	-
Aluminum (mg/l)	not present	-	0.05 -0.2
Barium (mg/l)	0.010	2	-
Boron (mg/l)	1.35	-	-
Cadmium (mg/l)	not present	0.005	-
Calcium (mg/l)	377.1	-	-
Chromium (mg/l)	not present	0.1	-
Copper (mg/l)	not present	1.3	-
Iron (mg/l)	2.51	-	0.3
Lead (mg/l)	not present	0.015	-
Manganese (mg/l)	2.28	-	0.05

Table 3: Water Quality Analysis (continued)

Water Quality Characteristic	Otter Tail Well	Maximum Contaminant Level Primary Stds[+]	Maximum Contaminant Level Secondary Stds[++]
Magnesium (mg/l)	200	-	-
Molybdenum (mg/l)	not present	-	-
Nickel (mg/l)	not present	-	-
Phosphorus (mg/l)	0.486	-	-
Potassium (mg/l)	36.5	-	-
Sodium (mg/l)	745	-	-
Silver (mg/l)	not present	-	0.10
Vanadium (mg/l)	0.016239	-	-
Zinc (mg/l)	0.000612	-	5
Tin (mg/l)	0.152	-	-
Strontium (mg/l)	3.40	-	-
Thallium (mg/l)	1.08	0.002	-
Cobalt (mg/l)	0.30	-	-
Lithium (mg/l)	0.02	-	-

[*]pH and temperature were completed on-site by a Banner staff engineer.

[+]National Primary Drinking Water Regulations (NPDWR) are legally enforceable primary standards and treatment techniques that apply to public water systems. Primary standards and treatment techniques protect public health by limiting the levels of contaminants in drinking water by listing a maximum contaminant level (MCL).

[++]National Secondary Drinking Water Regulations (NSDWR) are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply with the standard. However, states may choose to adopt them as enforceable standards.

PREPARED BY Kristin Bisgard, P.E. – Project Manager