

PUMP TEST CAPACITY REPORTS



US Army Corps of Engineers



Big Bend Dam (SD01092)

Missouri River, Fort Thompson, South Dakota
Embankment, Powerhouse, and Spillway

FY20 DAM SAFETY INSTRUMENTATION REHABILITATION

ENGINEERING GEOLOGY REPORT

**Northwestern Division
Omaha District**



Status: **FINAL**
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1. INTRODUCTION

The purpose of this report is to document the results of an FY20 drilling program plan to capacity test and rehabilitate (as required) 11 relief wells at Big Bend Dam. The 11 relief wells are located near the left abutment of the dam in areas with identified risk-driving failure modes. The purpose of this work was to measure and mitigate any losses in well efficiency that may have occurred since installation of the relief wells; thereby ensuring that they continue to relieve pressures in the left abutment foundation.

1.1 Big Bend Dam Risk Assessment Status

Previous risk assessments at Big Bend Dam consist of a Screening Portfolio Risk Assessment (SPRA) conducted in 2007, a Potential Failure Mode Analysis (PFMA) performed in 2009, and a Periodic Assessment (PA) conducted in July 2019 (note that the PA is still being drafted). Both the SPRA (2007) and the PFMA (2009) identified seepage and piping in the left abutment as probably inadequate (SPRA) or as a potential failure mode (PFMA).

The PA included a risk assessment in which 54 potential failure modes (PFMs) were identified. Of these, two of the five PFMs listed as risk drivers were also in the area of the left abutment seepage as described below:

- PFM 31: Plugged left abutment relief well subdrain system between stations 120+00 and 130+00 causes blowout resulting in backward erosion piping (BEP) through the foundation alluvium.
- PFM 32: Backward erosion piping (BEP) initiating at an unfiltered exit in the relief well channel in area of historic boils between stations 119+00 and 120+00.

For both PFMs, a large inflow event causes the reservoir to reach top of active storage (TAS) at elevation 1,423 feet local project datum (LPD). High pressures (which have historically been observed during normal pool conditions) exist in the left valley bank alluvial sand. There is a continuous alluvial sand layer between the upstream reservoir and the downstream left abutment bank. Vertical gradients are sufficient to initiate BEP at the left abutment.

The two failure modes (PFM 31 and PFM 32) are differentiated by the exit locations. For PFM 31, the relief well collector subdrain system between stations 120+00 and 130+00 is either plugged or ineffective at relieving the uplift pressures. Vertical exit gradients are sufficient to blow out the relatively thin clay blanket and initiate BEP of the foundation alluvial sands. For PFM 32, the uplift pressures are sufficient to blow out the natural clay blanket in the relief well channel exposing the valley alluvium in the vicinity of stations 119+00 and 120+00. This area was identified as a potential exit location due to historic pinboils at the bottom of the relief well channel. Global gradients would be sufficient for BEP of the foundation sands.

1.2 Objectives and Justification

The objectives of the work outlined in this report were to capacity test and rehabilitate (if required) relief wells RW-65A through RW-68B. These 11 relief wells are located in the general area of two PA-identified risk-driving failure modes (PFM 31 and PFM 32). The capacity testing and rehabilitation of relief wells is part of the routine operation and maintenance procedures at the dam in accordance with EM 1110-2-1914, Design, Construction, and Maintenance of Relief Wells which states that all relief wells should be pump tested every five years to measure and mitigate any appreciable losses in well efficiency. Based on the funding received in FY20, relief wells RW-65A through RW-68B were identified as the highest priority due to their proximity to PFM31 and PFM32. None of the 11 relief wells had been tested within the last five years.

2. PROJECT BACKGROUND

Big Bend Dam is a high hazard potential dam located on the Missouri River in Buffalo and Lyman Counties, South Dakota, approximately 20 miles upstream of the city of Chamberlain. Big Bend is one of six main stem dams on the Missouri River, and was authorized by the Flood Control Act approved 22 December 1944 (Public Law 534, 78th Congress 2nd Session) as part of the general comprehensive plan for flood control, irrigation, navigation, and hydropower in the Missouri River basin. The project was constructed from 1963 to 1966.

2.1 Project Description

Big Bend Dam is a multiple purpose project consisting of a rolled earthfill embankment, hydroelectric generating power plant, spillway, and reservoir (Figure 1 and Figure 2). The reservoir has a capacity of 1,859,000 acre-feet for flood control, irrigation, conservation, navigation, power development, and other uses. Conventional outlet works structures were not constructed at Big Bend; releases are made through either the spillway or the power plant.

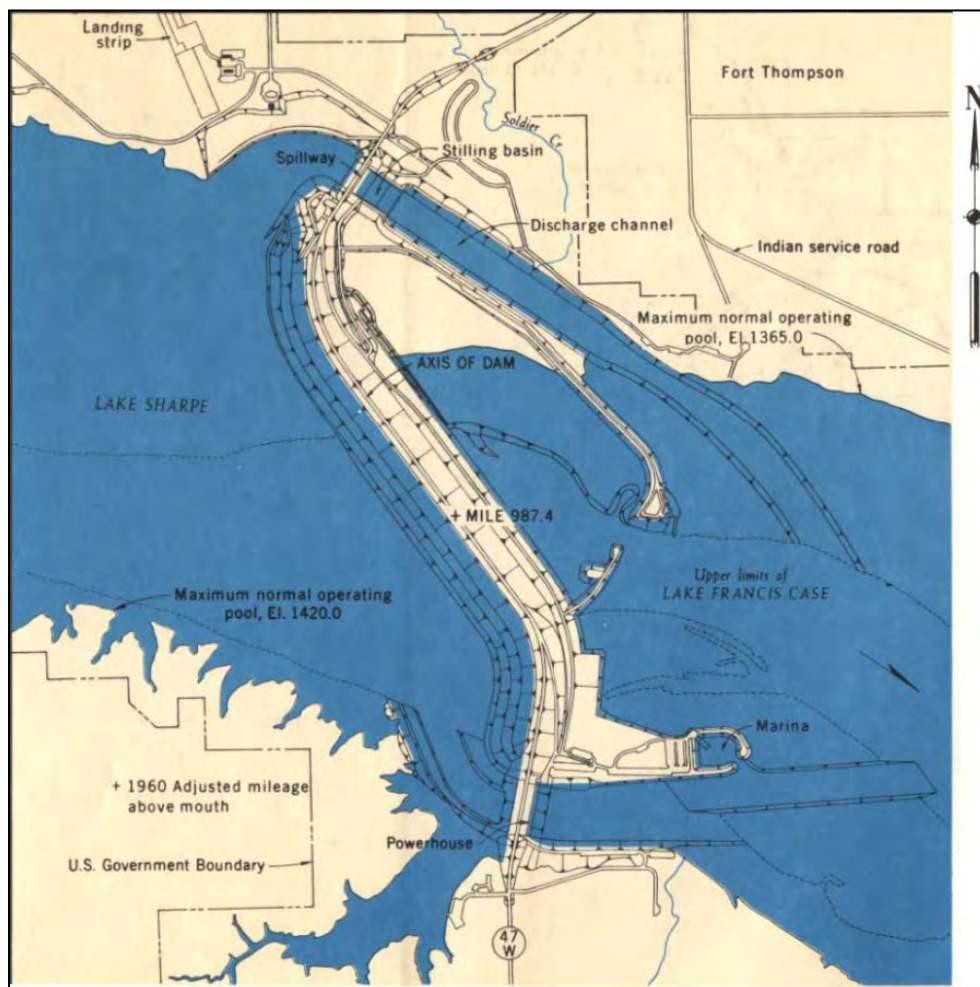


Figure 1: Project feature map



Figure 2: Aerial photo showing project features

2.1.1 Embankment

The rolled, zoned (Figure 3), earth-filled embankment is 10,570 feet long with a maximum height of 95 feet above the river channel and a crest width of 50 feet. The maximum width at the base of the embankment is 1,200 feet. The embankment makes a gentle S curve across the valley. The embankment was built upon dredged or dumped underwater pervious fill. A central impervious core extends from the pervious fill to five feet below the top of the dam. This core extends through the length of the embankment and transitions into a massive impervious section at the spillway and powerhouse tie-ins. The core is flanked on the downstream side by a pervious zone that ties into either the pervious downstream embankment fill or a horizontal downstream pervious blanket to provide drainage for seepage through the core. The top five feet of the embankment crest is composed of pervious fill connected to the downstream pervious drain to provide a frost-free base for the highway surface across the embankment.

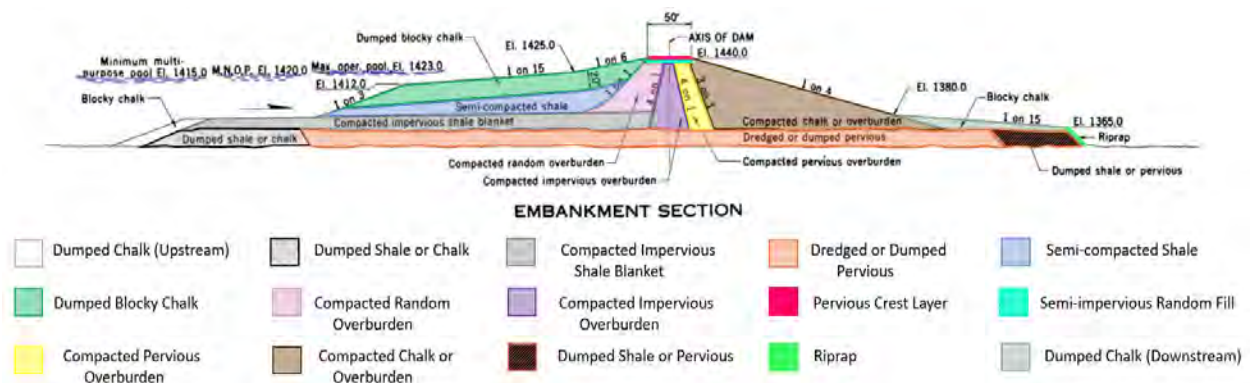


Figure 3: General embankment section

A minimum 10-foot-thick impervious blanket ties into the central impervious core and extends upstream 425 to 540 feet throughout the major portion of the embankment. Near the powerhouse area the blanket is thickened and excavated into bedrock and forms an impervious toe trench that prevents excessive seepage in the powerhouse area.

In the left abutment area near the spillway (Figure 4), a minimum 20-foot-thick upstream blanket is present over a portion of the right slope of the spillway approach channel. Above the upstream impervious blanket, the embankment is composed of a massive compacted shale section that is protected by 20 feet of dumped chalk. The downstream fill section consists primarily of random fill with a berm section of dumped chalk. The right abutment section, located between the right side of the powerhouse and the natural abutment ground surface, has 1V on 3H side slopes and is composed of random fill materials obtained from the right bank excavations.

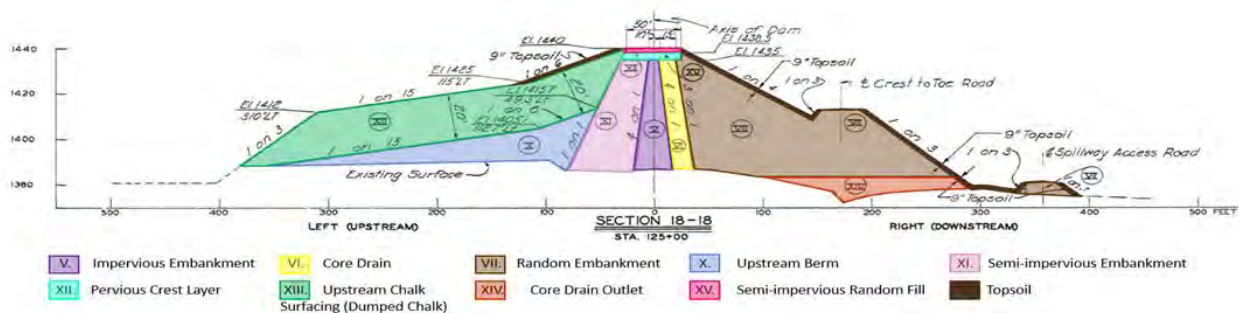


Figure 4: Left abutment embankment typical section (station 125+00)

2.1.2 Seepage Control Measures

Seepage through the embankment is controlled primarily by the impervious core, impervious upstream blanket, and the pervious drain section on the downstream side of the impervious core. Underseepage control is provided by the upstream impervious blanket, the chalk berm sections, the pervious blanket, and by pressure relief wells along the downstream toe of the embankment. Due to the relatively low head at Big Bend Dam and to the other underseepage control methods provided, a positive cutoff through the foundation sand was not determined to be necessary.

2.1.2.1 Pressure Relief Wells

The original system of pressure relief wells was installed in 1963 and extends a distance of 7,125 feet along the toe of the dam (Figure 2). The system was comprised of 68 relief wells spaced at intervals varying from 75 to 225 feet. The wells were installed to provide relief from any excess hydrostatic uplift pressures that may develop in the valley alluvial sands beneath the downstream impervious natural clay blanket. Between 2009 and 2012, the relief well system was modified with 35 additional relief wells. The current system has a total of 103 relief wells and extends a distance of 7,425 feet along the toe of the dam. The additional wells were installed between existing wells through the valley and in the left abutment. Spacing between the relief wells ranges from 35 to 200 feet.

3. FY20 DAM SAFETY INSTRUMENTATION FIELD WORK

The FY20 dam safety instrumentation field effort at Big Bend Dam was conducted in two phases from May 4 through May 21, 2020 and from June 15 through June 20, 2020 by the U.S. Army Corps of Engineers (USACE), Omaha District drill crew. The primary goal of this investigation was to rehabilitate and capacity test instrumentation to relieve uplift pressures at Big Bend Dam. Specific tasks included the inspection, capacity testing, and rehabilitation of relief wells RW-65A through RW-68B as discussed in

the following sections. Maps with the instrument locations are included as Appendix A. Field forms are included as Appendix B.

Intrusive activities into, in close proximity to, or through embankment dams and their foundations may pose significant risk to the structures if not implemented properly. To mitigate these risks, all drilling and sampling was conducted in accordance with EM 1110-1-1804, Geotechnical Investigations (1 January 2001); ER 1110-1-1807, Drilling in Earth Embankment Dams and Levees (31 July 2014); EM 1110-2-1914, Design, Construction, and Maintenance of Relief Wells (29 May 1992), the drilling program plan, and specific guidance as referenced in these sections.

3.1 Relief Well Construction Details

A total of 11 relief wells in the left abutment area were capacity tested and rehabilitated for this effort. Construction details for the relief wells are provided in the following sections. Three of the relief wells (RW-66, RW-67, and RW-68) are original wood-stave project relief wells constructed in 1963. Eight of the relief wells are stainless steel Muni-Pak™ wells installed in 2010 and 2012. Relief well construction details are summarized in Table 1. Locations are shown on Figures A-1 and A-2 in Appendix A.

3.1.1 Original Project Relief Wells (1963)

The original project relief wells (RW-66, RW-67, and RW-68) consist of a gravel-packed, eight-inch-diameter, slotted, wood stave well screen attached to an eight-inch-diameter plastic riser pipe. Access to the well is through a corrugated metal well pit covered with a steel cover. Discharge of the well is either into the relief well channel or into the relief well collector pipe. The screen slots are 3/16-inch wide with 30 square inches of slotting per lineal foot of screen. Construction details are provided on Figure 5. Locations are shown on Figures A-1 and A-2 in Appendix A.

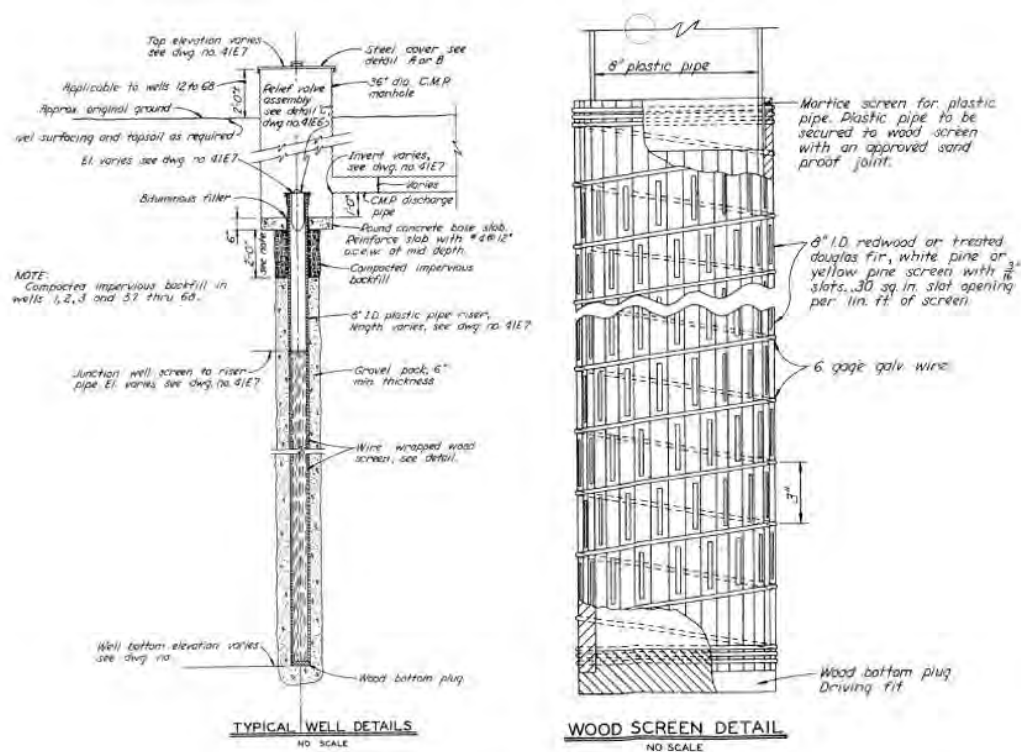


Figure 5: Typical construction details for original project relief wells

3.1.2 2010 Relief Wells

The relief wells installed in 2010 (RW-65A, RW-66A, RW-66B, and RW-67A) consist of 50-slot Muni-Pak™ stainless steel well screens with a five-inch-diameter inner screen and a seven-inch-diameter outer screen. The riser consists of five-inch-diameter, Schedule-80, PVC flush-treaded pipe.

3.1.3 2012 Relief Wells

The relief wells installed in 2012 (RW-66C, RW-67B, RW-68A, and RW-68B) consist of 40-slot Muni-Pak™ stainless steel well screens with a five-inch-diameter inner screen and a seven-inch-diameter outer screen. The riser consists of five-inch-diameter, stainless steel flush-treaded pipe.

Table 1: Construction details for relief wells to be capacity tested in FY20

Relief Well Designation	Year Installed	Bottom Depth (ft bgs) ¹	Screen Interval (ft bgs) ¹	Construction Material
RW-65A	2010	80.1	30.1-79.8	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 80 PVC riser
RW-66	1963	80.0	25.0-80.0	8-inch ID wire-wrapped wood-stave screen, 8-inch plastic riser pipe
RW-66A	2010	81.4	31.4-81.1	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 80 PVC riser
RW-66B	2010	82.4	32.4-82.1	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 80 PVC riser
RW-66C	2012	82.0	36.5-81.5	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 40 stainless steel riser
RW-67	1963	84.7	22.4-84.7	8-inch ID wire-wrapped wood-stave screen, 8-inch plastic riser pipe
RW-67A	2010	82.3	32.3-82.0	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 80 PVC riser
RW-67B	2012	83.0	37.0-82.0	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 40 stainless steel riser
RW-68	1963	87.1	26.5-87.1	8-inch ID wire-wrapped wood-stave screen, 8-inch plastic riser pipe
RW-68A	2012	89.0	47.9-87.9	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 40 stainless steel riser
RW-68B	2012	90.0	48.6-88.6	5x7-inch ID Muni-Pak pre-packed stainless steel screen, 5-inch Schedule 40 stainless steel riser

¹All depths are below ground surface.

3.2 Relief Well Inspection

Prior to capacity testing and/or rehabilitative efforts, each of the relief wells was sounded for depth and the results compared to the original as-built design depths as described in the following sections and summarized in Table 2. All of the wells were noted to be in good condition with sediment accumulations less than 2.6 feet.

Table 2: Relief well inspection and sediment removal summary

Relief Well Designation	As-Built Bottom Depth (ft bgs)	Sounded Depth May 2020 (ft btoc)	Top of outer casing stick-up (ft ags)	Sounded Depth May 2020 (ft bgs)	Depth of Sediment (ft)	Condition/Comments
RW-65A	80.1	82.3	1.3	81.0	-0.9	Top of well riser pipe is 5.6 feet below top of outer casing or 4.3 feet below ground surface. Good condition.
RW-66	80.0	81.3	2.4	78.9	1.1	Top of well riser pipe is 5.2 feet below top of outer casing or 2.8 feet below ground surface. Good condition.
RW-66A	81.4	83.2	1.5	81.7	-0.3	Top of well riser pipe is 5.2 feet below top of outer casing or 3.7 feet below ground surface. Good condition.
RW-66B	82.4	83.0	0.7	82.3	0.1	Top of well riser pipe is 4.8 feet below top of outer casing or 4.1 feet below ground surface. Good condition.
RW-66C	82.0	83.3	1.5	81.8	0.2	Top of well riser pipe is 7.8 feet below top of outer casing or 6.3 feet below ground surface. Good condition.
RW-67	84.7	85.4	1.8	83.6	1.1	Top of well riser pipe is 8.3 feet below top of outer casing or 6.5 feet below ground surface. Good condition.
RW-67A	82.3	82.4	0.5	81.9	0.4	Top of well riser pipe is 4.9 feet below top of outer casing or 4.4 feet below ground surface. Good condition.
RW-67B	83.0	83.8	1.1	82.7	0.3	Top of well riser pipe is 6.1 feet below top of outer casing or 5.0 feet below ground surface. Good condition.
RW-68	87.1	85.4	0.9	84.5	2.6	Top of well riser pipe is 9.3 feet below top of outer casing or 8.4 feet below ground surface. Good condition.
RW-68A	89.0	90.9	1.8	89.1	-0.1	Top of well riser pipe is 8.9 feet below top of outer casing or 7.1 feet below ground surface. Good condition.
RW-68B	90.0	89.7	1.6	88.1	1.9	Top of well riser pipe is 8.2 feet below top of outer casing or 6.6 feet below ground surface. Good condition.

ft = feet, bgs = below ground surface, btoc = below top of outer casing, ags = above ground surface

3.2.1 Pre-capacity procedures

Typically, relief well outfall pipes are shut or packered off during capacity testing to allow the static water levels to equilibrate prior to the measurement of drawdown. At Big Bend, none of the eleven relief well outfalls are equipped with shut-off valves to stop flow. Three of the eleven wells (RW-66, RW-66A, and RW-66B) discharge into the relief well channel. The outfalls for the other eight relief wells flow into collector pipes or other relief wells/manholes as noted in Table 3. A field sketch showing the configuration of the outfalls and collector pipes from relief well RW-64B to RW-67 is provided as Figure 6.

Table 3: Manhole and outfall information

Relief Well Designation	Outfall/manhole details	Notes
RW-65A	RW-65A flows into the manhole for RW-65 which discharges into the relief well channel.	No packer or sump pump needed. Drawdown measured from top of flowing water level.
RW-66	Outfalls directly into the relief well channel - outfall invert at elevation 1362.92 ft.	Manhole filled with algae/gunk. Removed with sump pump prior to testing. Drawdown measured from top of flowing water level.
RW-66A	Outfalls directly into the relief well channel - outfall invert at elevation 1365.32 ft.	Manhole filled with algae/gunk. Removed with sump pump prior to testing. Drawdown measured from top of flowing water level.
RW-66B	Outfalls directly into the relief well channel - outfall invert at elevation 1365.94 ft.	Outfall for RW-66C was packered off during capacity testing on RW-66B to keep water from flowing into well during test. Drawdown measured from top of flowing water level.
RW-66C	RW-66C flows into the manhole for RW-66B.	Groundwater was observed flowing up from ground around well riser pipe during capacity testing. Sump used to dewater manhole for RW-66C to prevent water from flowing into well during test. Drawdown measured from top of flowing water level.
RW-67	Outfalls into MH-2.	Manhole filled with algae/gunk. Removed with sump pump prior to testing. Drawdown measured from top of flowing water level. Water barely flowing from top of casing.
RW-67A	Outfalls into MH-2.	Manhole filled with algae/gunk. Removed with sump pump prior to testing. Drawdown measured from top of flowing water level. Water barely flowing from top of casing.
RW-67B	RW-67B flows into RW-67A which outfalls into MH-2.	Groundwater was observed flowing up from ground around well riser pipe during capacity testing. Manhole filled with algae/gunk. Removed with sump pump prior to testing. Drawdown measured from top of flowing water level.
RW-68	In series to the collector drain.	No packer or sump pump needed. Drawdown measured from top of flowing water level.
RW-68A	Outfalls into the collector drain.	Groundwater was observed flowing up from ground around well riser pipe during capacity testing. Drawdown measured from top of flowing water level.
RW-68B	Outfalls into the collector drain.	Manhole filled with algae/gunk. Removed with sump pump prior to testing. Drawdown measured from top of flowing water level.

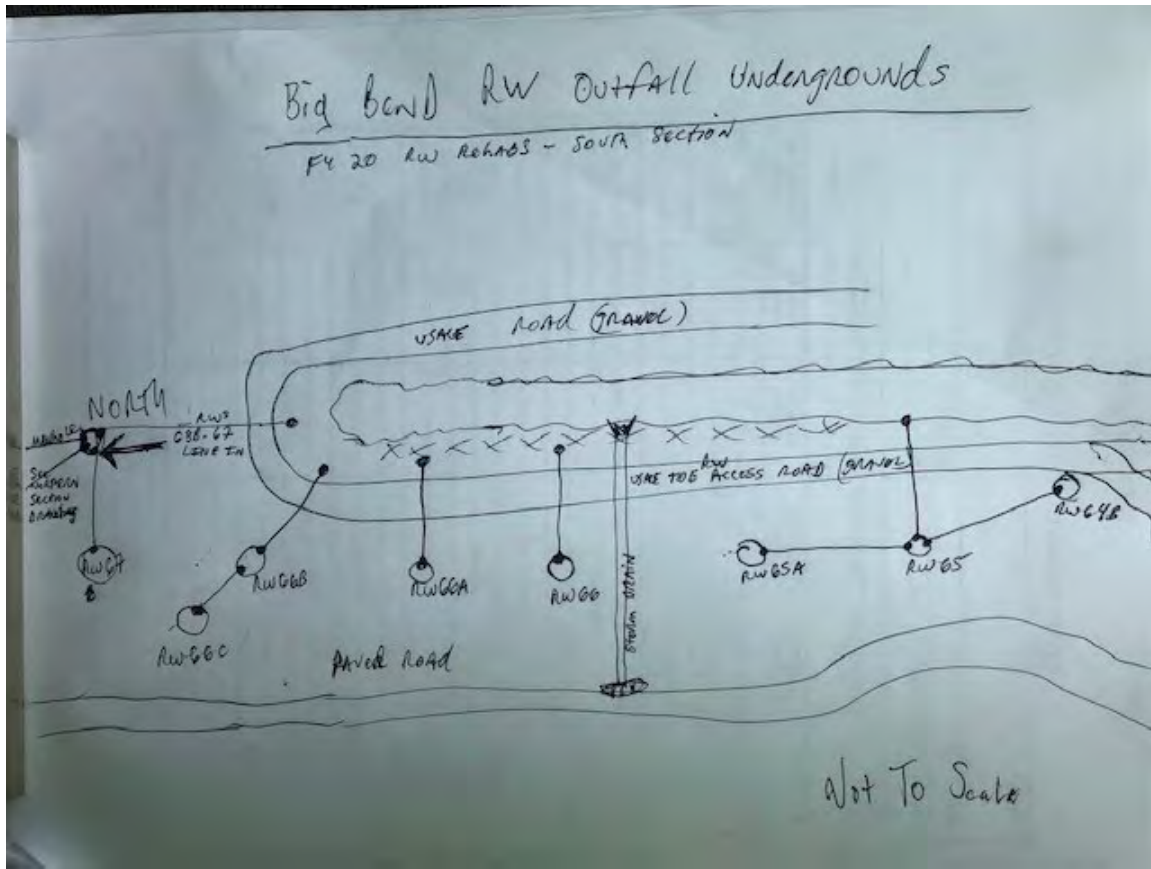


Figure 6: Field sketch showing the configuration of the outfalls, collector pipes, and manholes (relief wells RW-64B to RW-67). Not to scale.

Further complicating the testing, all relief well riser pipes were cut off below ground surface near the depths of the outfalls and completed to the surface with 36-inch diameter outer casings placed over the wells (Figure 7). For this reason, the drawdown was measured from the existing water levels in all relief wells (typically near the base of each outfall). Because the drawdown readings were taken from flowing conditions, the measured drawdown is less than what it would be under static conditions. Because of this, the specific capacity measured from the outfall will be higher (less drawdown at the same pumping rate) than what would be recorded under static conditions. It should be noted, however, that the original capacity tests on the newer wells were also performed after the outfalls were installed and under flowing conditions.

As shown in Table 3, sump pumps were required in several of the relief well manholes due to algae/debris that had accumulated in the bottom of the vaults. The growth had to be removed with a sump pump prior to testing to avoid drawing the material into the well during testing and rehabilitation. Groundwater was also observed to be flowing around the outside of the riser pipe at the base of the vault in three of the relief wells, RW-66C, RW-67B, and RW-68A. It appears that the seal between the bottom of the vault and the riser pipe has been compromised in these three wells and groundwater is flowing up through the seal.



Figure 7: Photograph of biological materials in manhole for relief well RW-67A



Figure 8: Groundwater flowing around well riser pipe at base of manhole vault during capacity testing in relief well RW-67B

3.3 Capacity Testing

Once the initial inspection was made (note that no sediment was required to be removed), the 11 relief wells were capacity tested. The capacity tests were performed using a five-inch-diameter submersible pump. Each relief well was pumped to achieve a drawdown similar to the original pumping rates/drawdowns for a minimum of two hours unless rapid drawdown was obtained (RW-67 and RW-67A). Where rapid drawdown was obtained at a very low pumping rate (~1 gpm), the test was stopped and the well was identified for rehabilitation. The pump inlet was placed the minimum required distance below the water level in the relief well to obtain adequate drawdown, yet remain above the top of the well screen. Flow was determined by the use of an in-line flow meter and bucket and stopwatch. Recharge was monitored immediately after pumping until the water level recovered to 95% of the measured pre-pumping static water level. Pre-rehabilitation capacity test data is summarized in Table 4. All data was recorded on the Capacity Test Data Form (Appendix B). The results were compared to the original pump test results obtained after installation (if available) to determine if the wells have experienced diminished capacity and to compare to the post-rehabilitation capacity testing to measure the effectiveness of the rehabilitative efforts as discussed in Section 3.5.

Table 4: Initial Capacity Test Results

Relief Well Designation	2020 Pre-Rehab Pumping Rate (gpm)	2020 Pre-Rehab Drawdown (ft)	2020 Pre-Rehab Specific Capacity (gpm/ft of drawdown)	2020 Pre-Rehab Approx. Recovery Time (>95%)	Original Specific Capacity (gpm/ft of drawdown)
RW-65A	13.3	15.9	0.8	1 minute	17/13.6 (1.3)
RW-66	23.3	16.2	1.4	2 minutes, 30 seconds	24.4/6.1 (4.0)
RW-66A	32.5	18.8	1.7	40 seconds	61/10.3 (5.9)
RW-66B	12.7	18.0	0.7	40 seconds	24/17.7 (1.4)
RW-66C	20.3	18.0	1.1	1 minute, 10 seconds	23/12.3 (1.9)
					33/17.8 (1.9)
					49/26.9 (1.8)
RW-67	1	>10	NA	Not measured (slow recovery)	46.3/5.9 (7.8)
RW-67A	1	>10	NA	20 minutes	NA
RW-67B	12.2	17.0	0.7	2 minutes, 30 seconds	23/12.1 (1.9)
					35/18.7 (1.9)
					49/28.2 (1.7)
RW-68	10.1	9.8	1.0	3 minutes, 20 seconds	7.2
RW-68A	21.2	11.4	1.9	40 seconds	23.5/1.7 (13.8)
					33.6/4.0 (8.4)
					45.7/7.4 (6.2)

Relief Well Designation	2020 Pre-Rehab Pumping Rate (gpm)	2020 Pre-Rehab Drawdown (ft)	2020 Pre-Rehab Specific Capacity (gpm/ft of drawdown)	2020 Pre-Rehab Approx. Recovery Time (>95%)	Original Specific Capacity (gpm/ft of drawdown)
RW-68B	9.2	18.8	0.5	4 minutes	20.5/14.6 (1.4)
					31.2/19.5 (1.6)
					41.4/30.8 (1.3)

3.4 Mechanical Rehabilitation

After the initial capacity tests were completed, the wells were mechanically cleaned to remove as much biomass, mineral scale, and sediment from each well as possible. In accordance with EM 1110-2-1914, the wells were only to be mechanically rehabilitated if determined to be below 80 percent of the original capacity (all tested wells met the guideline for rehabilitation). Most relief wells undergo some loss in specific capacity primarily due to the slow movement of foundation fines into the filter pack with a corresponding reduction in permeability. The mechanical rehabilitation was conducted on wells with diminished capacity to remove any debris and break apart any materials that may be obstructing the well screens.

Chemical treatment was not utilized for this field effort. The process of mechanical rehabilitation continued until the water was generally free and clear of fines. All relief wells were sounded before and after rehabilitation and those depths were compared to the as-builts to ensure that all sediment was removed after the rehabilitation process. Significant amounts of sediment (between 2 and 4 feet) were only observed to be entering the well through the screen from the surrounding material/filter pack during development in relief wells RW-68A and RW-68B (mostly fines and fine sand). The steps for the mechanical rehabilitation are described in the following sections.

3.4.1.1 Scrubbing and Airlifting

The initial phase of mechanical rehabilitation consisted of mechanically scrubbing the entire length of each well with a nylon brush to remove bio-foul and mineral scale within the well casing and screen. Before any actual scrubbing was initiated, a pre-pass test was conducted which consisted of the brush assembly being slowly lowered the entire length of the well to determine if the brush assembly would pass without binding or encountering obstructions. No unknown obstructions were encountered in any of the relief wells. Brushing was performed with stroke lengths of no more than five feet. Pertinent details of the brushing process were recorded on the attached Relief Well Rehabilitation Forms. Once brushing was complete, the water column in the well was pumped utilizing an airlift method until the well was clear of biomass and sediment (note that none of the wells was noted to contain significant bio-mass or mineral scaling).

3.4.1.2 Surging and Airlifting (Stainless Steel Wells)

At the completion of brushing and airlifting, the stainless steel relief wells were surged with a Q-water development tool (with built-in relief valve) to attempt to break up any bridged fines around the filter pack and increase the capacity of the well. Each well screen was surged in sections with the stroke length not exceeding 10 feet with a stroke rate of no more than 4 feet/second. Each 10-foot length of rehabilitation zone proceeded for 15 minutes. Most of the material that entered the wells was noted to be fines and fine sand, as shown in Figure 9. Relief wells RW-68A and RW-68B had significant amounts of sand in the discharge, as shown in Figure 10. Once surging was complete, the water column in the well was pumped utilizing an airlift method until the well was clear of biomass and sediment. After airlifting was complete, the bottom depth was measured to confirm that all material at the bottom of the well from surging has been removed.



Figure 9: Airlifted material (post-surge) from relief well RW-67A



Figure 10: Airlifted material (post-surge) from relief well-68A

3.4.1.3 Airlift Surging and Airlifting (Wood-Stave Wells)

Because the wood-stave wells are more than 50 years old and more fragile/susceptible to collapse, surge blocks were not utilized for these wells (RW-66, RW-67, and RW-68). Instead, the wells were rehabilitated by creating a surging action with the airlift mechanism by alternately drawing the water column down to a depth just above the top of the screen and shutting the air off allowing the well to recharge. This process continued until the recharge improved enough to allow continuous pumping at which time continuous airlifting was conducted until the water was free and clear of fines.



Figure 11: Initial discharge water at the start of post-surge airlifting (RW-68)



Figure 12: Final discharge water at the end of post-surge airlifting (RW-68)

3.4.2 Post-Rehabilitation Capacity Testing

Once the mechanical rehabilitation was complete, the relief wells were again tested for capacity utilizing the steps identified in Section 3.3. All data was recorded on the Capacity Test Data Form (attached).

Table 5: Final Capacity Test Results

Relief Well Designation	2020 Post-Rehab Pumping Rate (gpm)	2020 Post-Rehab Drawdown (ft)	2020 Post-Rehab Specific Capacity (gpm/ft of drawdown)	2020 Recovery Time (>95%)	Original Specific Capacity (gpm/ft of drawdown)
RW-65A	26.3	9.3	2.8	15 seconds	17/13.6 (1.3)
RW-66	29.9	13.5	2.2	90 seconds	24.4/6.1 (4.0)
RW-66A	59.5	15.7	3.8	20 seconds	61/10.3 (5.9)
RW-66B	28.7	10.2	2.8	20 seconds	24/17.7 (1.4)
RW-66C	32.7	10.1	3.2	20 seconds	23/12.3 (1.9)
					33/17.8 (1.9)
					49/26.9 (1.8)
RW-67	14	10.3	1.4	2 minutes, 30 seconds	46.3/5.9 (7.8)
RW-67A	14.5	13.6	1.1	45 seconds	NA
RW-67B	20.7	10.8	1.9	40 seconds	23/12.1 (1.9)
					35/18.7 (1.9)
					49/28.2 (1.7)
RW-68	16.0	8.8	1.8	1 minute, 45 seconds	7.2
RW-68A	33	26.5	1.2	2 minutes	23.5/1.7 (13.8)
					33.6/4.0 (8.4)
					45.7/7.4 (6.2)
RW-68B	16.2	20.0	0.8	2 minutes, 15 seconds	20.5/14.6 (1.4)
					31.2/19.5 (1.6)
					41.4/30.8 (1.3)

3.5 Summary of Results and Recommendations

A summary of the results of the relief well rehabilitation and capacity testing are include in Table 6 along with recommendations for each well based on the testing.

Table 6: Summary and Recommendations

Relief Well Designation	Baseline Specific Capacity (gpm/ft of drawdown)	2020 Pre-Rehab Specific Capacity (gpm/ft of drawdown)	2020 Post-Rehab Specific Capacity (gpm/ft of drawdown)	Comments	Recommendation
RW-65A	17/13.6 (1.3)	13.3/15.9 (0.8)	26.3/9.3 (2.8)	Specific capacity increased from 0.8 to 2.8 gpm/ft drawdown after rehabilitation. Recovery improved from 60 seconds to 15 seconds.	Relief well is currently at ~215% of original capacity. Relief well should be capacity tested again in five years and rehabilitated as required.
RW-66	24.4/6.1 (4.0)	23.3/16.2 (1.4)	29.9/13.5 (2.2)	Specific capacity increased from 1.4 to 2.2 gpm/ft drawdown after rehabilitation. Recovery improved from 150 seconds to 90 seconds.	Relief well is currently at ~55% of original capacity. Relief well should be evaluated and considered for abandonment and replacement (if determined to be necessary) due to its age and the decrease in capacity. If not replaced, relief well should be capacity tested again in five years and rehabilitated as required.
RW-66A	61/10.3 (5.9)	32.5/18.8 (1.7)	59.5/15.7 (3.8)	Specific capacity increased from 1.7 to 3.8 gpm/ft drawdown after rehabilitation. Recovery improved from 40 seconds to 20 seconds.	Relief well is currently at ~64% of original capacity but is still higher than surrounding wells. Relief well should be capacity tested again in five years and rehabilitated as required.
RW-66B	24/17.7 (1.4)	12.7/18.0 (0.7)	28.7/10.2 (2.8)	Specific capacity increased from 0.7 to 2.8 gpm/ft drawdown after rehabilitation. Recovery improved from 40 seconds to 20 seconds.	Relief well is currently at ~200% of original capacity. Relief well should be capacity tested again in five years and rehabilitated as required.
RW-66C	23/12.3 (1.9)	20.3/18.0 (1.1)	32.7/10.1 (3.2)	Specific capacity increased from 1.1 to 3.2 gpm/ft drawdown after rehabilitation. Recovery improved from 70 seconds to 20 seconds.	Relief well is currently at ~170% of original capacity. Relief well should be capacity tested again in five years and rehabilitated as required. Repair leak around outside of pipe (bottom of vault).
	33/17.8 (1.9)				
	49/26.9 (1.8)				
RW-67	46.3/5.9 (7.8)	1 gpm/drawdown below screen	14.0/10.3 (1.4)	Specific capacity increased from drawdown into screen at 1 gpm to 1.4 gpm/ft drawdown after rehabilitation. Recovery 150 seconds after rehabilitation (not measured after pre-rehab test).	Relief well responded to rehabilitation; however, it is currently at only 18% of original capacity. Relief well should be evaluated and considered for abandonment and replacement (if determined to be necessary) due to its age and the decrease in capacity. If not replaced, relief well should be capacity tested again in five years and rehabilitated as required.

Relief Well Designation	Baseline Specific Capacity (gpm/ft of drawdown)	2020 Pre-Rehab Specific Capacity (gpm/ft of drawdown)	2020 Post-Rehab Specific Capacity (gpm/ft of drawdown)	Comments	Recommendation
RW-67A	NA	<1 gpm/drawdown below screen	14.5/13.6 (1.1)	Specific capacity increased from drawdown below top of screen at 1 gpm to 1.1 gpm/ft after rehabilitation (note the initial capacity could not be measured due to immediate drawdown). Recovery improved significantly from 20 minutes to 45 seconds.	Original capacity data is not available for this relief well due to immediate drawdown below top of screen occurring during initial test (and also during the pre-rehabilitation test). Relief well responded to rehabilitation and is currently at 1.1 gpm/ft capacity. Relief well should be capacity tested again in five years and rehabilitated as required.
RW-67B	23/12.1 (1.9)	12.2/17.0 (0.7)	20.7/10.8 (1.9)	Specific capacity increased from 0.7 to 1.9 gpm/ft drawdown after rehabilitation. Recovery improved from 150 seconds to 45 seconds.	Relief well is currently at ~100% of original capacity. Relief well should be capacity tested again in five years and rehabilitated as required. Repair leak around outside of pipe (bottom of vault).
	35/18.7 (1.9)				
	49/28.2 (1.7)				
RW-68	7.2	10.1/9.8 (1.0)	16/8.8 (1.8)	Specific capacity increased from 1.0 to 1.8 gpm/ft drawdown after rehabilitation. Recovery improved from 200 seconds to 105 seconds.	Relief well is currently at ~25% of original capacity. Relief well should be evaluated and considered for abandonment and replacement (if determined to be necessary) due to its age and the decrease in capacity. If not replaced, relief well should be capacity tested again in five years and rehabilitated as required.
RW-68A	23.5/1.7 (13.8)	21.2/11.4 (1.9)	33/26.5 (1.2)	Specific capacity decreased from 1.9 to 1.2 gpm/ft drawdown after rehabilitation. Recovery decreased from 40 seconds to 120 seconds. More substantial sediment was drawn into the well during pumping than other relief wells tested.	Relief well is currently at ~10% of original capacity and had significant sediment drawn in during testing. Relief well design should be investigated and the well should be considered for abandonment, redesign, and replacement. If not replaced, relief well should be capacity tested again in five years and rehabilitated as required. Repair leak around outside of pipe (bottom of vault).
	33.6/4.0 (8.4)				
	45.7/7.4 (6.2)				
RW-68B	20.5/14.6 (1.4)	9.2/18.8 (0.5)	16.2/20.0 (0.8)	Specific capacity increased from 0.5 to 0.8 gpm/ft drawdown after rehabilitation. Four feet of sediment was drawn into the well during post-surge airlifting. Recovery improved slightly from 150 seconds to 135 seconds.	Relief well is currently at ~50% of original capacity and had significant sediment drawn in during testing. Relief well design should be investigated and the well should be considered for abandonment, redesign, and replacement. If not replaced, relief well should be capacity tested again in five years and rehabilitated as required.
	31.2/19.5 (1.6)				
	41.4/30.8 (1.3)				

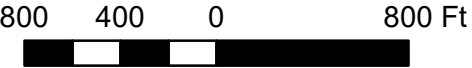
Appendix A: Location Maps



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

LEGEND

- Relief Wells Rehabilitated and Capacity Tested (FY20)
- Relief Wells not Rehabilitated or Capacity Tested (FY20)



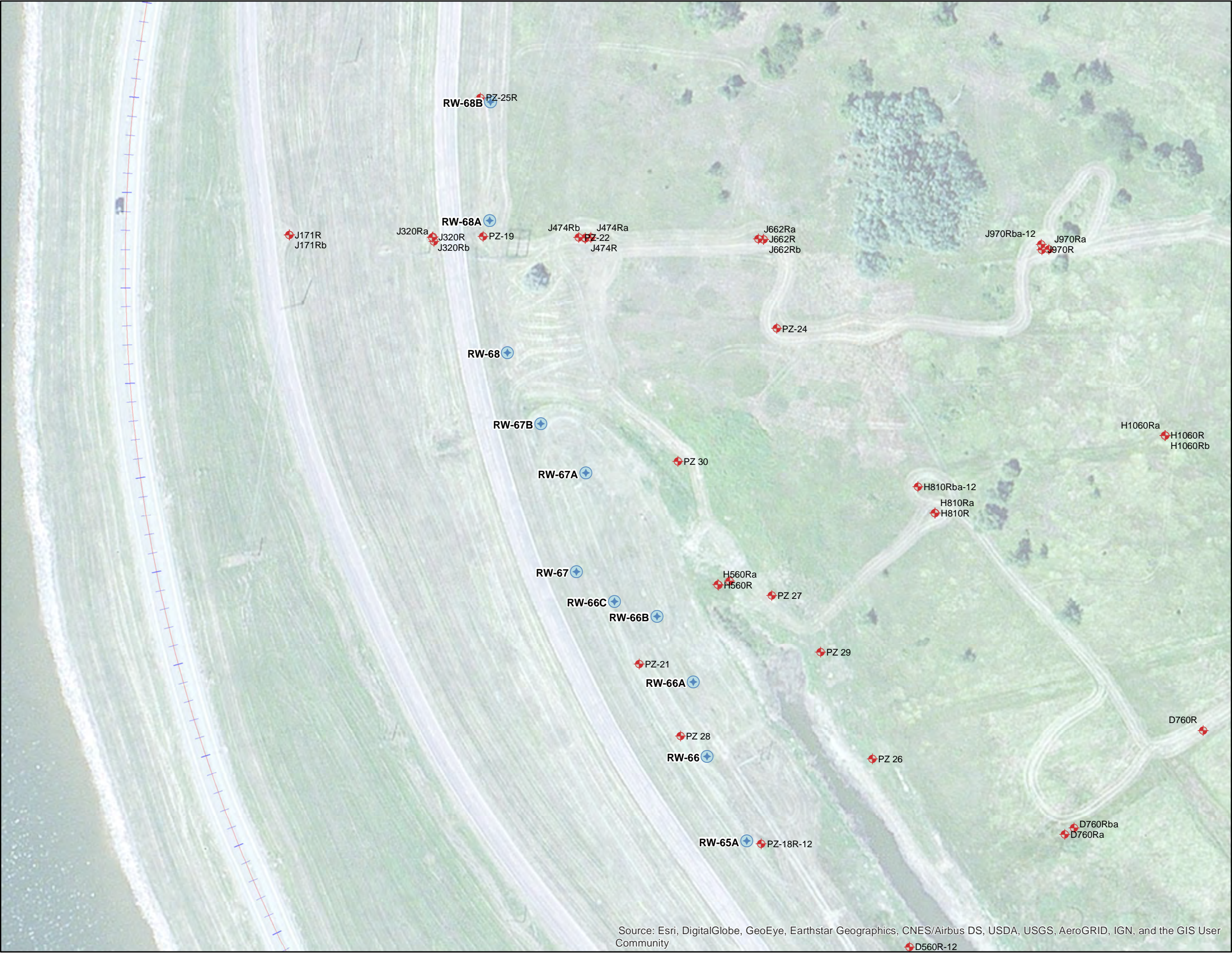
 **U.S. Army Corps of Engineers
Omaha District**

Big Bend Dam
Buffalo and Lyman Counties, SD

Relief Well Location Map

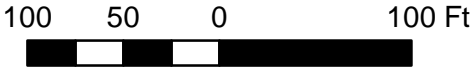
March 2020


FIGURE A1



LEGEND

- Relief Wells to be Rehabilitated and Capacity Tested (FY20)
- Existing Piezometer



 U.S. Army Corps of Engineers Omaha District	
Big Bend Dam Buffalo and Lyman Counties, SD	
Relief Well Rehabilitation Location Map	
March 2020	FIGURE A2

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Appendix B: Field Forms

RW65A -
INITIAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: F420 Big Bend Dam Dam Safety Instrumentation RW Rehab	Date: 5/12/20
	Well ID: RW65A
Location: Big Bend Dam, SD	Initial Depth of Well: 82.25
Monitoring Instrument: 200ft Test Well Water Level Indicator	Weather: 45° cloudy, windy
Static Water Level ² : 5.63 Inside TLOC	Measured By: R. Zygowicz

Free Flowing over TOIC

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1300	21.06		13.3	
30 sec		21.06		13.3	water clear at
1 min		21.07		13.3	start
1 min 30 sec		21.06		13.3	removed orange
2 min		21.06		13.3	algae/scum from
2 min 30 sec		21.05			manhole around
3 min		21.05			TOIC with sump
4 min		21.03			pump prior to
5 min		21.02			start of initial
6 min		21.01			capacity test.
7 min		21.01			
8 min		21.02			
9 min		21.01			
10 min		21.00			
11 min		21.00			
12 min		20.99			
13 min		20.97			
14 min		20.97			
15 min		20.95			
20 min		21.80		13.4	
25 min		21.81		13.4	
30 min	1330	21.76		13.3	
35 min		21.53		13.3	
40 min		21.66		13.3	
45 min		21.63		13.3	
50 min		21.62		13.3	
55 min		21.61		13.3	
1 hr	1400	21.61		13.3	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

TLOC stick up = 1.3' A.G.S

TOIC stick up from bottom of vault = 1.3'
water free flowing over TOIC, but beneath TOIC inside of TLOC.

TOIC from TLOC = 5.64'

NO PACKER needed, NO sump pump needed

Depth of manhole from TLOC = 6.9 ft
water clear at start

dtw from TLOC prepumping = 5.63'

Previous
CAP =
17 gpm / 13.6 DD

RW 65A
- INITIATE

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: FY20 OAM Safety Enhancement RW Rehab	Date: 5/12/20
Location: Big Bend DAM, SD	Well ID: RW 65A

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min		21.61		13.3	
1 hr 20 min		21.60			
1 hr 30 min		21.59			
1 hr 40 min		21.55			
1 hr 50 min		21.53			
2 hr	1500	21.46		↓	
2 hr 30 min	1530	21.48		13.3	Ended test at 2 hrs 30 min - constant pumping rate of 13.3 gpm
3 hr					
3 hr 30 min					
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1531	21.48		REL →	30 sec = 10.6' min = 6.1'
5 min					
10 min					Rec to TOIC overflow in 1:06
15 min					
20 min					
25 min					DTB AT END INITIATE
30 min					= 82.2 ft
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments: Rapid Recovery post INITIAL CAPACITY
water clear AT END

RWGSA

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam FY20 Dam Safety Instrumentation RWS
 RELIEF WELL: RWGSA
 INSPECTOR: R. Zygowicz

OPENED: DATE <u>5/13/20</u> TIME <u>0800</u>	CLOSED: DATE <u>5/13/20</u> TIME _____
Water Level (TOC) _____ ft	Water Level (TOC) _____ ft
Well Depth (TOC) <u>82.20</u> ft	Well Depth (TOC) <u>81.69</u> ft
Design Depth (TOC) _____ ft	Design Depth (TOC) _____ ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
	Total Water Removed _____ gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

RWGSA good condition
outflow is directed toward & into RWGS vault
No packer necessary at this time
overflowing to EC at this time

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: - No Bailing Required -
 METHOD: Utilized airlift/ vacuum

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments:

RW 65 A

STEP 1. SCRUB 5"

EQUIPMENT: NYLON WALL SCREEN BRUSH, MITE E MITE RIG CABLE

METHOD: MANUALLY BRUSHING OF SCREEN UTILIZING RIG CABLE

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	P	5	25		water clear at start
2.					BECAME GREY & OPAQUE WHEN
3.					BRUSHED
4.					
5.					

Comments:

performed brushing sequence as described in the OPP/AT.

STEP 2. PUMP/AIRLIFT

EQUIPMENT: SULLAIR 375H CA3 AIR COMPRESSOR, 2" & 1" PVC PIPE, 2" DISCHARGE HOSE

METHOD: AIR-LIFT/VACUUM UTILIZING AIR COMPRESSOR & PVC PIPING

PRE-PUMP WATER LEVEL: 5.63 WITHIN LOC DTB = 82.2

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	opaque grey	clear light grey tint	30 min	600		opaque grey at start, trace sand clear w/ stirrer
2.						grey tint at end
3.						
4.						
5.						

Comments:

RW65A

STEP 3. SURGE

EQUIPMENT: Q WATER TOOL Surge Block

METHOD: MANUAL SURGING LENGTH OF SCREEN UTILIZING DRILL RIG CABLE

PRE-SURGE WATER LEVEL: 5.63 INSIDE LOC

Cycle	Pre-Pass Test (Pass/Fail)	Surge Length (ft)	Surge Speed (strokes per minute)	Time Spent Surging	Bottom Depth After Surging (ft TOC)	Remarks
1.	P	10	7-10	75 min	81.5	surged 10 ft length for 15 min
2.						
3.						
4.						Depth to Bottom post surge
5.						0.75 Above pre surge

Comments:

Surged the RW65A according to DPP INSTRUCTIONS

Water flowing over TOC visibly increased post surging

STEP 4. PUMP/AIRLIFT

EQUIPMENT: SULLAIR 375H CA3 TRAILERED AIR COMPRESSOR, 2" & 1" PVC PIPE, ARLINE

METHOD: AIRLIFT/VACUUM UTILIZING AIR COMPRESSOR

PRE-PUMP WATER LEVEL: 5.63 FROM TOC

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	gray opaque with fine gray sand	clear NO sand	60 min	22 gal then 22 gal 21300	81.7	fine gray sand coming up at start
2.						END WATER - clear
3.						NO sand coming up
4.						
5.						

Comments:

~~TOC~~
~~water over visible increased post~~

post AIRLIFT dec from 18.5 b TOC = 34 sec
AIRLIFTING continued UNTIL clear water and NO sand lifting

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: F420 Big Bend DAM DAM SAFETY INSTRUMENTATION RW REHABS	Date: 5/13/20
Location: Big Bend Dam, SD	Well ID: RW 65A
Monitoring Instrument: Testwell 200ft Water Level Indicator	Initial Depth of Well: 81.7' From TLOC
Static Water Level ² : Free Flowing Above TOIC 5.60 from TLOC	Weather: 40-50° cloudy, Windy
	Measured By: R. Zygowicz

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1326	5.6062		14.2 0	
30 sec		6.62		* 14.2	
1 min		6.69		14.0	
1 min 30 sec		6.75		14.0	
2 min		7.81		16.8	Water clear
2 min 30 sec		8.01		16.8	At start of
3 min		8.40		16.67	pumping for
4 min		11.24		24.3	firm drawdown
5 min		13.00		24.3	
6 min		13.27		24.3	
7 min		13.32		24.3	
8 min		13.33		24.3	
9 min		13.34		24.3	
10 min		13.35		24.3	
11 min		13.36		24.3	
12 min		13.38		24.3	
13 min		13.40		24.3	
14 min		13.41		24.3	
15 min		13.43		24.3	
20 min		13.45		24.3	
25 min		14.85		26.4	
30 min		14.84		26.4	
35 min		14.84		26.4	
40 min		14.86		26.4	
45 min		14.88		26.4	
50 min		14.92		26.4	
55 min		14.88		26.4	
1 hr	1426	14.89		26.4	

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

~~Due to the nature of this RW, water level was established before timer start.~~ DRAW DOWN

TOIC = 5.55 below TLOC

TLOC AGS = 1.40

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

F420

Project: Big Bend Dam Safety Ints, RW,	Date: 5/13/20
Location: Big Bend Dam, SD	Well ID: RW 65A

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1436	14.89		26.4	
1 hr 20 min		14.89		26.4	
1 hr 30 min		14.88		26.4	
1 hr 40 min		14.84		26.4	
1 hr 50 min		14.89		26.4	
2 hr	1526	14.90		26.4	
2 hr 30 min	1556	14.92		26.4	2:15 = 14.91
3 hr					
3 hr 30 min					
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1557	14.92	+14.92	—	RECOVERY OVER TOIC IN 20 seconds
5 min					
10 min					
15 min					
20 min					
25 min					
30 min					
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

FINAL
 VERY RAPID REC post capacity test
 post capacity:
 D+W TOIC = 5.52
 Inside vault 5.54
 D+B = 81.69

switch to 26.4
 D+B post capacity: 81.69
 D+W: TOIC = 5.52
 Inside vault 5.54
 81.69

RW 66 - Initial

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend DAM FY 20 DAM SAFETY INSTRUMENTATION RW REHABS	Date: 5/14/20
Location: Big Bend DAM, SD	Well ID: RW 66
Monitoring Instrument: Test Well 200 ft Water Level Indicator	Initial Depth of Well: 81.25
Static Water Level ² : DWT from TLOC = 4.90 DWTIC = 5.22	Weather: 60° SUNNY
	Measured By: R. Zygowicz

RW is free flowing over TOIC

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	0910	18.10		21.1	
30 sec		20.71		21.1	
1 min		22.85		21.1	
1 min 30 sec		23.35		22.1	
2 min		23.55		22.1	
2 min 30 sec		23.40		22.1	water clear at
3 min		23.35		22.1	start
4 min		22.98		22.1	
5 min		22.49		22.1	
6 min		22.20		22.1	
7 min		21.90		22.1	8" INNER CASING
8 min		21.66		22.1	pumped out vault
9 min		21.50		22.1	with sump pump &
10 min		21.63		23.1	clear algae &
11 min		21.90		23.4	lower inner LOC
12 min		22.07		23.4	water level to below
13 min		22.14		23.4	TOIC
14 min		22.00		23.0	
15 min		21.90		22.7	
20 min		21.77		22.7	
25 min		21.66		23.2	
30 min		21.58		23.3	
35 min		21.49		23.3	
40 min		21.41		23.3	
45 min		21.35		23.3	
50 min		21.25		23.3	
55 min		21.15		23.3	
1 hr	1010	21.16		23.3	

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

previous provided D+B = 80.0'
Screen 25-80'
D+B = 6.1 / 24.4 gpm

OUT Fall ~ 3.75 gpm
Set pump at 24 ft
NOT PAULERED

D+B
Light = 81.2
Heavy = 81.25

Depth to
D+B = 5.22

pumped out vault with sump pump prior to start in order to lower vault DWT to below TOIC

RW 66 - INITIAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend FY 20 DAM Safety INST	Date: 5/14/20
Location: Big Bend Dam, SD	Well ID: RW 66

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1080	21.05		23.3	
1 hr 20 min		21.01		23.3	
1 hr 30 min		20.96		23.3	
1 hr 40 min		20.91		23.3	
1 hr 50 min		20.88		23.3	
2 hr	1110	20.80		23.3	2:15 = 20.76
2 hr 30 min	1140	20.72		23.3	
3 hr					
3 hr 30 min					Began slightly
4 hr					increasing water level
4 hr 30 min					after constant rate
5 hr					of pumping 23.3 gpm
5 hr 30 min					for 10 min
6 hr					could not rise any
6 hr 30 min					pump any more due
7 hr					to flow meter limitations
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1141	20.70			0:30 = 15.58 1:00 = 11.75
5 min					full rec to TOIC
10 min					IN: 2 min 39 sec
15 min					1:30 = 9.33
20 min					2 min = 7.11
25 min					2:35 = 5.60
30 min					2:39
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

RW 66

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam FY20 RW Rehab + Repair
 RELIEF WELL: RW 66
 INSPECTOR: R. Zygowski

OPENED: DATE <u>6/20/20</u> TIME <u>0800</u>	CLOSED: DATE <u>6/20/20</u> TIME _____
Water Level (TOC) <u>IN VAULT = TOIC = 5.20</u> ft	Water Level (TOC) <u>5.20</u> ft
Well Depth (TOC) <u>81.23</u> ft	Well Depth (TOC) <u>81.54</u> ft
Design Depth (TOC) _____ ft	Design Depth (TOC) _____ ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
<u>OTOIC = 5.20</u> <u>water flowing over top</u>	Total Water Removed _____ gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

8" Riser. A wood STAVE RW. Generally OK condition.
Removed Algae from large outer well vault with sump pump.
This RW has a straight discharge line into the RW channel.
5" TOIC submerged when RW is flowing.
36" outer casing stuck up = 2.45' (North side)
At well vault bottom = 5.90'
Removed

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: NA
 METHOD: NA

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments:

No Bailing Required in This RW

RW 66

STEP 1. SCRUBEQUIPMENT: Mite E mite Drill Rig, 8" Nylon Well Screen BrushMETHOD: MANUAL SCRUBBING utilizing DRILL RIG CABLE

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	P	5	22	81.20 LT 81.30 HV	water "clouded" up during brushing
2.					
3.					
4.					
5.					

Comments:

passed PREPASS, SCRUBBED 2 min/5 ft of screen (25-80 ft) - NO ISSUES during & after scrubbing.

20.157

15.3

1:12.5

1:30.3

2 = 3.85

2:10 FULL REC

STEP 2. PUMP/AIRLIFTEQUIPMENT: SULLAIR 375 TRAILERED Air compressor, 1" & 2" pvc pipingMETHOD: AIRLIFT/VACUUM utilizing compressor & pvc piping systemPRE-PUMP WATER LEVEL: 4.92 IN 36" VENT. 5.20 flowing over TOC

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	Black & grey opaque with fine sand	Clear NO FINE very slight greenish tint	100 min	~3000	81.5 LT 81.55 HV	some sand on bottom of RW
2.						but did not work removal ^{overall}
3.						IN AN Aggressive manner
4.						
5.						

Comments:

Extended AIRLIFT/VACUUM. Began by airlifting water down to just ABOVE screen and shut off air for RW recharge. Performed this procedure 5x. Then began AIRLIFT/VAC rate of ~30 gpm. Actual drawdown for this was ~15 ft

NO surge on 2nd AIRLIFT for this WORKSTATE RW
2 of 2

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam FY20 RW Rehab & Repair	Date: 6/20/20
	Well ID: RW66
Location: Big Bend Dam, SD	Initial Depth of Well: 81.50
Monitoring Instrument: TEST Well 200ft Water Level Indicator	Weather: 65° mostly cloudy
Static Water Level ² : 5.89 - Flowing over Top of Inner Casing (5")	Measured By: R. Zygowicz

DWIV = 4.90

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1148	5.89			
30 sec		18.52	18.52	29.9	
1 min		18.50		29.9	
1 min 30 sec		18.51		29.9	
2 min		18.52		29.9	
2 min 30 sec		18.53		29.9	Due to the Design Build & Nature of this RW, the pump rate & drawdown were established before initiating timer.
3 min		18.54		29.9	
4 min		18.56			
5 min		18.57			
6 min		18.58			
7 min		18.59			
8 min		18.60			
9 min		18.61			
10 min	1158	18.63			
11 min		18.64			
12 min		18.65			
13 min		18.65			
14 min		18.66			
15 min		18.67		↓	
20 min		18.70		29.8	
25 min		18.71		29.8	
30 min	1218	18.72		29.8	
35 min		18.72		29.8	
40 min		18.73		29.8	
45 min		18.73		29.8	
50 min		18.70		29.8	
55 min		18.69		29.8	
1 hr	1248	18.69		29.8	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

$$\begin{array}{r} 18.90 \\ 5.19 \\ \hline 13.41 \end{array}$$

$$\begin{array}{r} 18.70 \\ 5.19 \\ \hline 13.51 \end{array}$$

to IC = 5.20 ft

36" well vault stuck up 2.45 ft AJS

observed
 No leaking at bottom of well/vault
 and casing 5" riser interface

RW 66 - FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: <u>Big Bend Dam FY20 RWS</u>	Date: <u>6/20/20</u>
Location: <u>Big Bend Dam, SD</u>	Well ID: <u>RW 66</u>

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1258	18.70		29.8	
1 hr 20 min		18.72		29.8	
1 hr 30 min	1318	18.73		29.8	
1 hr 40 min		18.73		29.8	
1 hr 50 min		18.75		29.8	
2 hr	1348	18.75		29.8	
2 hr 30 min	—	—	—	—	Ended test at 2 hrs
3 hr					constant rate of 29.8 gpm
3 hr 30 min					~ 13.5 ft draw down
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1349	18.75			Rec =
5 min					30: 13.49
10 min					1 min 8.41
15 min					1:30 6.00
20 min					2 min NA
25 min					2:30 NA
30 min					3 min NA
35 min					4 min NA
40 min					
45 min					
50 min					
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

18.73
5.00
13.54

TOIC = 5.20 ft

FULL Rec At 1:43

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam SAFETY INSTRUM. FY 20	Date: 5/6/20
	Well ID: RW 66B
Location: Big Bend Dam, SD	Initial Depth of Well: 81.12'
Monitoring Instrument: TESTWELL WATER LEVEL INDICATOR - 200 FT	Weather: 45° SUNNY
Static Water Level ² : 4.2 PUMP IN START	Measured By: R-2490W1C2

Need to (MINUS 1.65) = 4.3

Elapsed Time	Actual Time	Depth ↓ To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1425	24.35			
30 sec		24.39		12.70	
1 min		24.41			
1 min 30 sec		24.41			
2 min		24.44			
2 min 30 sec		24.44			
3 min		24.45		12.70	
4 min		24.45			
5 min		24.47		12.80	
6 min		24.46			
7 min		24.46			
8 min		24.47			
9 min		24.47		12.70	
10 min		24.48		12.70	
11 min		24.47			
12 min		24.47		12.70	
13 min		24.45			
14 min		24.47			
15 min		24.47		12.70	
20 min		24.46		12.70	
25 min		24.48			
30 min		24.47		12.7	
35 min		24.47		12.7	
40 min		24.46		12.7	
45 min		24.41		12.7	
50 min		24.39		12.7	
55 min		24.38		12.70	
1 hr		24.37		12.70	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

MEASURED FROM TOP OF LARGE OUTER RW CASING:
 TOP OF OUTFALL PIPE = 4.2 ft
 TOP OF INFLOW PIPE = 4.0 ft
 TOP OF 5" RW INNER CASING = 5.0 ft
 DTH = 4.2 ft

349 gpm
 DD =

5.8
 24.45
 5.95
 18.50

5.8
 1.5
 4.3

1.65
 minus
 from

5.95
 11.65
 4.80

RW 66B INITIAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: <u>FY 20 Big Bend Dam Safety Dist.</u>	Date: <u>5/6/20</u>
Location: <u>Big Bend Dam, SD</u>	Well ID: <u>RW 66B</u>

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min		24.34		12.70	
1 hr 20 min		24.33		12.70	
1 hr 30 min		24.32		12.70	
1 hr 40 min		24.30		12.70	
1 hr 50 min		24.30		12.70	
2 hr		24.29		12.70	
2 hr 30 min		24.27		12.70	
3 hr					Ended At 2:30
3 hr 30 min					4 hr min
4 hr					
4 hr 30 min					DONOT FORGET
5 hr					SUBTRACT
5 hr 30 min					1.65
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	24.27			1 MIN = 13.00	
5 min				1:30 = 8.33	
10 min				2 MIN = 6.45	
15 min				NEED MINUS 1.65	
20 min					
25 min					
30 min					
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

24.33
1.65
22.68

→ Rapid Recovery ~ 2 min
 During test → needed sump pump to drain surrounding
 large outer casing due to INFLTRATION
 along 8" connecting pipe to RW 66B. PACKED
 RW 66B AT OUT FLOW FROM INSIDE ITS ALSO
 E.O.C.

22.68
4.30
18.38

FULL 6.45
 REC 1.45
 IN 5.00
 ~ 2 MIN

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam FY 20 RW Rehab

RELIEF WELL: RW 66B

INSPECTOR: R. Zygowicz

OPENED: DATE <u>5/7/20</u> TIME <u>0800</u>	CLOSED: DATE _____ TIME _____
Water Level (TOC) <u>4.3 Inside Manhole</u> ft	Water Level (TOC) _____ ft
Well Depth (TOC) <u>83.18 from</u> ft	Well Depth (TOC) <u>82.95</u> ft
Design Depth (TOC) <u>82.15</u> ft	Design Depth (TOC) _____ ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
<u>Rim of LOC</u>	Total Water Removed _____ gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

LOC = Large outside casing

* Re MEASURE to C of INNER CASING
from top of
LARGE
CASING

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: NONE - performed INITIAL CAPACITY TEST

METHOD: _____

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments:

DTW 4.36
At toC (inner) = 4.77'
from Rim of LOC

STEP 1. SCRUBEQUIPMENT: Might E mite Drill Rig cable 5" Nylon BrushMETHOD: MANUAL SCRUBBING UTILIZING RIG CABLE + W/ SCREEN BRUSH

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	PASS	5	2.5	82.85	ST 1304 ET 1345
2.					
3.					
4.					
5.					

Comments:

Scrubbed each 5 ft ^{screen} interval for 2.5 minutes
 water at start of brushing - clear
 As brushing proceeded, water became gray & opaque, turbid

STEP 2. PUMP/AIRLIFTEQUIPMENT: Sullair model # 375 H CA3 filtered air compressorMETHOD: Airlift utilizing compressor + PVC pipePRE-PUMP WATER LEVEL: DW = 4.4 D+B = 82.85
_{INSIDE LOC}

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	opaque, gray turbid	clearer not opaque slight gray tint	1 hr	5 well vial	82.95	water cleared + 0.1' removed from bottom
2.						
3.						
4.						
5.						

Comments:

85 GAL removed
 from bottom
 ~ 5 gal / 8 sec
 85 GAL = 1 W/V

RW66B

STEP 3. SURGEEQUIPMENT: RWATER TOOL 5" Surge Block, Mite E MiteMETHOD: MANUAL SURGING VIA DRILL M/C CABLEPRE-SURGE WATER LEVEL: 4.1 from TOC of LOC

Cycle	Pre-Pass Test (Pass/Fail)	Surge Length (ft)	Surge Speed (strokes per minute)	Time Spent Surging	Bottom Depth After Surging (ft TOC)	Remarks
1.	PASS	10	7-10	1:15	82.7	water became grey & slushy while surging 82.95 start
2.						
3.						
4.						
5.						

Comments:

Surged with 2 RWS/4 on RWATER TOOL
 Vented surge block for less aggressive surging

STEP 4. PUMP/AIRLIFTEQUIPMENT: SULLAIR MAILER AIR COMPRESSOR PVC AIRLIFT/VIEDRIVEMETHOD: STRAIGHT AIRLIFTPRE-PUMP WATER LEVEL: 4.77 TOC INNER WATER LEVEL =

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	grey opaque		1035-11:05 40 MIN	5 GAL/8 sec		grey opaque to clear fine grey sand at bottom removed until no action
2.						
3.						
4.						
5.						

Comments:

Packaged the outfall pipe from RW66C
 in order to isolate RW66B for post surging AIRLIFT
 & CAPACITY test.

42 sec fill RWC
 AS 42
 ~15.5 ft

5 gal / 8 sec ~35 gpm
 fine grey sand removed from
 bottom
 1 W = 85 GAL

15.28

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend DAM safety FY20 Instrumentation RW Rehab	Date: 5/8/20
Location: Big Bend DAM, SD	Well ID: RW66B
Monitoring Instrument: Testwell 200ft Water Level Indicator	Initial Depth of Well: 8
Static Water Level ² : 4.77 TOC INNER casing	Weather: 55° SUNNY
	Measured By: R. Zygowicz

This RW Flows over TOC (inner 5") at static level. Draw inside LOC = 4.3

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	11:56	12.50		29	
30 sec		13.55			
1 min		13.78			
1 min 30 sec		14.10			
2 min		14.25			
2 min 30 sec		14.32		↓	
3 min		14.41		29	
4 min		14.45		29	
5 min		14.55		29	
6 min		14.60		29	
7 min		14.64		29.5	
8 min		14.67			
9 min		14.69		29.5	
10 min		14.74		29.5	
11 min		14.77		29.5	
12 min		14.79			
13 min		14.80			
14 min		14.82		29.5	
15 min		14.85			
20 min		14.46		28.8	
25 min		14.48		28.8	
30 min		14.49		28.7	
35 min		14.52		28.7	
40 min		14.49		28.7	
45 min		14.50		28.7	
50 min		14.51		28.7	
55 min		14.52		28.7	
1 hr		14.53		28.7	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

LOC = Large Outer Casing - Top of Large Outer Casing = +LOC

TOIC = Top of Inner 5" Casing

RW 66B - FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend Dam Safety FY 20	Date: 5/8/20
Location: Big Bend Dam	Well ID: RW 66B

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min		14.55		28.7	
1 hr 20 min		14.58		28.7	
1 hr 30 min		14.60		28.7	
1 hr 40 min		14.61		28.7	
1 hr 50 min		14.63		28.7	
2 hr		14.65		28.7	
2 hr 30 min	1428	14.68		28.7	Ended test at 2.5 hours - reached constant rate drawdown for 2 hrs
3 hr					
3 hr 30 min					
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	14.35	14.69			Full rec to over flowing
5 min					INT TOC IN 22 sec
10 min					From 14.69' OTW At Start of Recovery
15 min					
20 min					
25 min					
30 min					
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

Rapid Recharge from Final Capacity Test.

Post Final Capacity Test:

Post Packer Removal: OTW from TLOC = 4.33

TORC = 4.77.

OTB from TLOC = 82.95' Hard bottom

RW66C - INITIAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: FY 20 Big Bend DAM Safety Instrumentation RW Rehab	Date: 5/8/20
Location: Big Bend Dam, SD	Well ID: RW66C
Monitoring Instrument: test well 200ft water level indicator	Initial Depth of Well:
Static Water Level ² : frac flowing over to IC measured from TLOC: DTW =	Weather: 55° SUNNY
	Measured By: R. Zygowicz

Depth to top of INNER 5" CASING =

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1612	24.70		20.3	
30 sec		24.40		20.3	
1 min		24.36		20.3	Due to the
1 min 30 sec		24.34			build design of
2 min		24.35		20.3	this RW, Manhole, &
2 min 30 sec		24.37			Drainage system,
3 min		24.41			The drawdown
4 min		24.41			was initiated &
5 min		24.35		20.3	brought to a stable
6 min		24.31			rate to begin
7 min		24.33			test
8 min		24.34			
9 min		24.38		20.3	Packaged off inflowing
10 min		24.35			Drain pipe
11 min		24.39		20.3	utilized sump pump
12 min		24.42			to prevent water that
13 min		24.43			was infiltrating around
14 min		24.45		20.3	The INNER 5" casing
15 min		24.45		20.3	stuck up from
20 min		24.48			topping the top of
25 min		24.51		20.3	the INNER casing
30 min		24.49			
35 min		24.52			
40 min		24.56			
45 min		24.57		20.3	
50 min		24.59		20.3	
55 min		24.62		20.3	
1 hr		24.60		20.3	

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

Pre test
From } DTW 6.56
TLOC } TOIC = 7.77
DTA = 83.25

Previous: 33 gpm / 17.8' DD
Bottom of pump at 35' from TLOC
TOIC from bottom of well valve = ~ 1.8 ft

RW 66 C -
INITIAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: FY20 Big Bend DAM Safety Instrumentation RW Rehab	Date: 5/8/20
Location: Big Bend DAM, SD	Well ID: RW66C

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min		20.52		20.3	
1 hr 20 min		24.54		20.3	
1 hr 30 min		24.56		20.3	
1 hr 40 min		24.57		20.3	
1 hr 50 min		24.57		20.3	
2 hr		24.60		20.3	Ended INITIAL
2 hr 30 min		24.63		20.3	Test at 2 hrs with
3 hr					A constant rate of
3 hr 30 min					20.3 gpm and drawdown
4 hr					~ 24.5 ft from TLOC
4 hr 30 min					2:15 24.62 TLOC top of large outer casing
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	184	24.64			30 sec = 14.55
5 min					1:00 8.35
10 min					1:21 overflowed
15 min					TLOC
20 min					
25 min					
30 min					
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments: END DTB = 83.3

RW 66C

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam F420 RWS
 RELIEF WELL: RW 66C
 INSPECTOR: A. Lygowski

OPENED: DATE <u>5/8/20</u> TIME _____	CLOSED: DATE <u>5/8/20</u> TIME _____
Water Level (TOC) _____ ft	Water Level (TOC) _____ ft
Well Depth (TOC) <u>83.22</u> ft	Well Depth (TOC) <u>83.25</u> ft
Design Depth (TOC) _____ ft	Design Depth (TOC) _____ ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
	Total Water Removed _____ gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

RW IN good condition

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: No Bailing Required - utilized Airlifting
 METHOD: _____

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments:

RW 66C

STEP 1. SCRUBEQUIPMENT: 5' E mite Drill rig cable, 5" NYLON BRUSHMETHOD: MANUAL SCRUBBING UTILIZING BRUSH & RIG CABLE

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	PASS	5 ft	2.5 pass	83.23	water at start - clear
2.					water at end - gray, opaque
3.					
4.					
5.					

Comments:

St: 0835

Et: 0905

brushed 5 ft sections 2.5 minutes each
for length of screen as per Project Geologist.

STEP 2. PUMP/AIRLIFTEQUIPMENT: SULLAIRMETHOD: AIRLIFT/VACUUMING WITH COMPRESSOR & PVC PIPEPRE-PUMP WATER LEVEL: AT TOC

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	gray opaque	clear	St: 1000 Et 1045	209 gal	83.25	start water gray tint slightly opaque trace fine gray sand END WATER - clear no fines
2.						
3.						
4.						
5.						

Comments:

789 gal = 1 WV

rec from AIRLIFT 50 sec

RW 66 C

STEP 3. SURGE

EQUIPMENT:

Q WATER TOOL 5" SURGE BLOCK, MITE E MITE RIG ^{TRACK}

METHOD:

MANUAL SURGING VIA DRILL RIG CABLE

PRE-SURGE WATER LEVEL:

7.7 overflying AT TOIC

Cycle	Pre-Pass Test (Pass/Fail)	Surge Length (ft)	Surge Speed (strokes per minute)	Time Spent Surging	Bottom Depth After Surging (ft TOC)	Remarks
1.	PASS	10	7-10	70 MIN	83.15	water clear AT
2.						start of surging
3.						opaque gray AT END
4.						
5.						

Comments:

MEASUREMENTS ARE FROM THE TOP OF THE LARGE OCEAN CASING

STEP 4. PUMP/AIRLIFT

EQUIPMENT:

SULLAIR ^{timbered} air compressor

METHOD:

AIRLIFT/VACUUM USING 2" & 1" PVC PIPING

PRE-PUMP WATER LEVEL:

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	gray opaque	clear slight gray tint	90 MIN	30gpm		start: gray, opaque trace sand, fine gray IN Bottom of Bucket
2.		not opaque				
3.						End: clear slight gray tint, no sand
4.						
5.						

Comments:

AFTER 90 MIN OF CONTINUOUS AIRLIFT/pumping water did not clear completely - slight gray tint BUT not opaque.

RW66C -
FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam FY20 DAM Safety Instrumentation	Date: 5/12/20
	Well ID: RW66C
Location: Big Bend Dam, SD	Initial Depth of Well: 83.25
Monitoring Instrument: test well 200ft water level indicator	Weather: 40° cloudy
Static Water Level ² : 6.70 From TLOC static is above 5" casing	Measured By: R. Zygowicz

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	0852	16.63		32.8	
30 sec		16.62			
1 min		16.63			
1 min 30 sec		16.64			
2 min		16.65			
2 min 30 sec		16.66			
3 min		16.66			
4 min		16.67			
5 min		16.65		32.7	water at start clear
6 min		16.65		32.7	slight pump tint
7 min		16.66		32.7	not opaque
8 min		16.65		32.7	water at end = clear
9 min		16.65		32.7	
10 min		16.67		32	
11 min		16.66		32.7	
12 min		16.67		32.7	
13 min		16.67		32.7	
14 min		16.68		32.7	
15 min		16.70		32.7	
20 min		16.71		32.7	
25 min		16.71		32.7	
30 min		16.70		32.7	
35 min		16.72		32.7	
40 min		16.76		32.7	
45 min		16.75		32.7	
50 min		16.75			
55 min		16.76			
1 hr	0952	16.75		32.7	

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

TLOC = 1.5' ABOVE GROUND SURFACE

DB post final capacity =

TLOC = 1.5' AGS
TOP OF LARGE OUTER CASING

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project:	Date: 5/12/20
Location: Big Bend Dam, SD	Well ID: RW66C

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1002	16.76		32.7	
1 hr 20 min		16.77		32.7	
1 hr 30 min		16.77		32.7	
1 hr 40 min		16.78		32.7	
1 hr 50 min		16.77		32.7	
2 hr	1052	16.79		32.7	1107:
2 hr 30 min					2:15 = 16.80
3 hr					test ended AT 2 hrs 15 min
3 hr 30 min					- 2 hrs constant drawdown
4 hr					AT 32.7 gpm
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1109	16.79			FULL REC to
5 min					over flowing
10 min					TO IC IN 21 sec
15 min					
20 min					
25 min					
30 min					
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

VERY RAPID FULL RECOVERY

FROM TLOC; ATW AT CLOS = 6.71

CLOSING ATB = 83.25'

RW 67

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam FY 20 RW Rehab + Repair
 RELIEF WELL: RW67
 INSPECTOR: R. Zygowicz

OPENED: DATE <u>6/19/20</u> TIME <u>0830</u>	CLOSED: DATE <u>6/19/20</u> TIME _____
Water Level (TOC) <u>8.23</u> ft	Water Level (TOC) _____ ft
Well Depth (TOC) <u>85.53</u> ft	Well Depth (TOC) <u>85.55</u> ft
Design Depth (TOC) _____ ft	Design Depth (TOC) _____ ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
	Total Water Removed <u>500</u> gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

A wood STAVE R.W
Fairly good condition
TOC is corroded + IRREGULAR SURFACED
Low Flowing upon opening

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: NA NO BAILING Required
 METHOD: _____

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments:

No Bailing Required

RW 67

STEP 1. SCRUBEQUIPMENT: Might E might Drill Rig, 8" Nylon Wall Screen BrushMETHOD: MANUAL SCRUBBING UTILIZING DRILL RIG CABLE

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	P	5	24	85.82 LF 85.52 HV	scrubbed from
2.					22-84.5 ft
3.					2 min/5 ft
4.					
5.					

Comments:

utilized a gentle scrubbing of the wood stake RW

STEP 2. PUMP/AIRLIFTEQUIPMENT: SULLAIR 375 TRAILORED AIR COMPRESSOR, 1" & 2" PVC PIPEMETHOD: AIRLIFT/VACUUMED FROM JUST ABOVE BOTTOM OF RW USING COMPRESSED AIRPRE-PUMP WATER LEVEL: 8.23

OAB = 85.52

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	black opaque little fine sand	clear NO SAND	60 min 7X42	1200	85.55 LF 85.50 HV	DRAINED RW 7 times & Allowed to Recharge After each AIRLIFT. A constant lift rate of 16 gpm at 14 ft. Actual draw down for 60 min
2.						
3.						
4.						
5.						

Comments:

* For this low flowing RW, air lifted/vacuumed the water out of the RW until the water level dropped to just above screen, shut off air & allowed to recharge. Repeated this procedure until water cleared.

Full Rec from 25 ft @ 3:25

MANUAL
NO Surging performed on the wood stake RW.

RW 67

STEP 3. SURGEEQUIPMENT: NAMETHOD: NA

PRE-SURGE WATER LEVEL: _____

Cycle	Pre-Pass Test (Pass/Fail)	Surge Length (ft)	Surge Speed (strokes per minute)	Time Spent Surging	Bottom Depth After Surging (ft TOC)	Remarks
1.						
2.						
3.						
4.						
5.						

Comments: 2nd surge not performed

Note: Design of Discharge pipe allows water to flow back from main discharge line into well vault when well vault is damaged.

Well vault floor has a leak at TOC/floor surface on North side of inner casing riser. These conditions do not affect the RW water level during draw down

STEP 4. PUMP/AIRLIFTEQUIPMENT: NAMETHOD: NA

PRE-PUMP WATER LEVEL: _____

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.						
2.						
3.						
4.						
5.						

Comments: 2nd Airlift not performed

RW 67 - FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend DAM FY 20 RW REHAB & REPAIR	Date: 6/19/20
	Well ID: RW 67
Location: Big Bend DAM, SD	Initial Depth of Well: 85.55
Monitoring Instrument: Testwell 200ft Water Level Indicator	Weather: 75° SUNNY
Static Water Level ² : 81.22	Measured By: R. Zygowicz

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1229	8.22			
30 sec		18.50	X	14.0	
1 min		18.46		14.0	
1 min 30 sec		18.45		14.0	
2 min		18.44		14.0	
2 min 30 sec		18.44		14.0	
3 min		18.44		14.0	DUE TO THE DESIGN BUILD & NATURE OF THIS RW, THE DRAWDOWN & gpm WMS STABILIZED BEFORE INITIATING TIMING.
4 min		18.44		14.0	
5 min		18.43		14.0	
6 min		18.43		14.0	
7 min		18.43		14.0	
8 min		18.44		14.0	
9 min		18.44		↓	
10 min	1239	18.45		↓	
11 min		18.45		14.0	
12 min		18.45		↓	
13 min		18.46		↓	
14 min		18.46		14.0	
15 min		18.47		↑	
20 min		18.49		↓	
25 min		18.51		↓	
30 min	1259	18.52		14.0	
35 min		18.52		↓	
40 min		18.53		↓	
45 min		18.53		↓	
50 min		18.53		14.0	
55 min		18.54		↓	
1 hr	1329	18.54		14.0	

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments: OBSERVING WELL VAULT/CASING INTERFACE ON BOTTOM OF WELL VAULT LEADING ON NORTH SIDE OF INNER 5" CASING. DOES NOT AFFECT/INFILTRATE DURING DRAWDOWN TESTING.

DTWIV = 8.30

RW 67 - FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend Dam RW R+R	Date: 6/19/20
Location: Big Bend Dam, SD	Well ID: RW 67

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	13:39	18.56		14.0	
1 hr 20 min		18.55		14.0	
1 hr 30 min		18.57		14.0	
1 hr 40 min		18.57		14.0	
1 hr 50 min		18.58		14.0	
2 hr	14:29	18.59		14.0	END TEST AT
2 hr 30 min					2 hrs AS PER PROJECT 600.
3 hr					CONSTANT RATE OF
3 hr 30 min					14 gpm with ~ 10.3 ft draw down
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	14:30	18.59			
5 min					30 15.05
10 min					2 min 13.11
15 min					1:30 11:23
20 min					2 min 9.80
25 min					2:30 8.51
30 min					FULL REC
35 min					OVER TO FC
40 min					IN 2:42
45 min					
50 min					
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

LARGE WELL VAVL4 D_{4W} = 8.30
 D_{4W} IN 5" = 8.22

P+D 85.57 ft
 85.60 HV

RW 68 -
IN 1712

CONSTANT-RATE PUMPING TEST DATA FORM

Project: Big Bend Dam FY20 Dam Safety Instrumentation for Rebar		Date: 5/21/20
Location: Big Bend Dam, SO		Weather: 63° - Rainy, Cloudy
Monitoring Instrument: water level test well 2044 Indicator		Measured By: R. Zygowicz

HW
Static 9.38 IN
8" INNER CASING
outer
36"
VAULT:
9.64

	Pumping Well ID	Piezometer ID	Piezometer ID	Piezometer ID	Comments
Time	Depth To Water ²	Depth To Water ²	Depth To Water ²	Depth To Water ²	Pumping Rate ³ (GPM)
0 ¹	0905	9.34			9.6
15 sec		19.85			9.6
30 sec		19.84			9.6
45 sec		19.83			9.6
1 min 30 sec		19.81			9.6
2 min		19.80			9.6
3 min		19.78			9.6
4 min		19.75			9.6
5 min		19.70			9.6
6 min		19.75			10.0
7 min		19.78			10.1
8 min		19.90			10.1
9 min		19.92			10.1
10 min		19.95			10.1
12 min		19.95	Due to Design & Build of this Rev, The water was		10.1
15 min		19.95			10.1
20 min		19.86	Drawn down to a		10.1
25 min		19.81	stable level & timer		10.1
30 min		19.78	was started.		10.1
35 min		19.63			10.1
40 min		19.55			10.1
45 min		19.54			10.1
50 min		19.50			10.1
55 min		19.54			10.1
1 hr	1015	19.44			10.1

11 - 19.95 10.0
12 - 19.95 10.0
13 - 19.94 10.0
14 - 19.91
15 - 19.90
DTB = 85.4'

From TLOC: 18/24 13
DTBVC = 9.32 DTBV = 10.9'
DTWAV = 9.64 DTOTC = 9.33
TLOC = 09 ft Age from north side

19.9
9.3
10.6
DT = 10.6
G 10.6 gpm

RW68 Initial

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend Dam Safety RWS	Date: 5/21/20
Location: Big Bend Dam, SD	Well ID: RW68

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1025	19.46		10.1	
1 hr 20 min		19.41		10.1	
1 hr 30 min	1045	19.31		10.1	water clear at
1 hr 40 min		19.25		10.1	start
1 hr 50 min		19.19		10.1	
2 hr	1115	19.15		10.1	
2 hr 30 min	1145	19.08		10.1	
3 hr					ended test at
3 hr 30 min					2 hrs 30 min
4 hr					
4 hr 30 min					
5 hr					water clear at end
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					

RECOVERY					
0 min	1147	19.07			Rec = 30 sec = 16.42
5 min	1147				1 min = 14.36
10 min					
15 min					15.30 11.30
20 min					
25 min					2 min = 11.95
30 min					2:30 10.91
35 min					3 10.03
40 min					
45 min					
50 min					
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

(Riser #4)
clean out access

underground discharge pipe

RW68B

RW68A

RW68

2

RW67B

RW67

manhole

Discharge Channel

ROAD

South

- NOT TO SCALE -

North
N manhole

RW 68

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam Aug 20 RW Rehab + Repairs
 RELIEF WELL: RW 68
 INSPECTOR: R. ZYGOWICZ

OPENED: DATE <u>6/18/20</u> TIME <u>1000</u>	CLOSED: DATE <u>6/18/20</u> TIME _____
Water Level (TOC) <u>9.39</u> ft	Water Level (TOC) _____ ft
Well Depth (TOC) <u>85.45</u> ft	Well Depth (TOC) <u>85-80</u> ft
Design Depth (TOC) _____ ft	Design Depth (TOC) _____ ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
	Total Water Removed <u>900</u> gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

old wood stake RW
TOC uneven, irregular surface - ^{but} does not affect function
of the RW
RW TOP ABOVE WATER IN VAULT, FUNCTIONING WELL

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: NA
 METHOD: _____

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments: NO BAILING REQUIRED

RW 68

STEP 1. SCRUBEQUIPMENT: light mix track rig, 8' NYLON ~~black~~ screen brush ris cableMETHOD: MANUAL SCRUBBING of screen length using ris cable

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	P	5	15	85.38	light brushing
2.					
3.					
4.					
5.					

Comments:

Brush passed entire length
 Scrubbed 1:30 per 5 ft
 Brush removed with trace amount of stringy
 algae-like material on brush ends

STEP 2. PUMP/AIRLIFTEQUIPMENT: 1" ID PVC, SULLAIR 375H CA3 ~~horizontal~~ AIR COMPRESSORMETHOD: Airlift/VACUUM using PVC PIPING & AIR COMPRESSORPRE-PUMP WATER LEVEL: 9.39 - WATER FLOWING OVER TOC

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	BLACK OPAQUE	clear very very	~ 60 min	900	85.45 ft 85.60 ft	BLACK OPAQUE AT START (H/L) SINK FLOW WATER CLEAR AS LIFTED
2.		slight greenish tint				clear at end
3.						No sand
4.						
5.						

Comments:

this RW was not surged & only brush & airlift cycle performed for this rehab

Note: → For the Pump/Airlift/VACUUM cycle on this RW, the procedure established ^{2 of 3} was, due to low original flow, to amplify the RW until water level dropped to just above the screen, shut off air until full recharge & repeat this sequence.

RW 68-
FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam FY20 RW Rehab + Repair		Date: 6/18/20
Location: Big Bend Dam, SD		Well ID: RW68
Monitoring Instrument: Testwell 200ft Water Level Indicator		Initial Depth of Well: 85.45
Static Water Level ² : 9.32 - Flowing over Top		Weather: 65° p. Cloudy
		Measured By: R. Zygowicz

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1316	9.32			
30 sec		14.81		14.9	
1 min		15.21			
1 min 30 sec		15.54			
2 min		15.82			
2 min 30 sec		16.03			
3 min		16.23			
4 min		16.44			
5 min		16.66			
6 min		16.72			
7 min		16.87		14.9	
8 min		17.11		16.1	
9 min		17.43			
10 min	1326	17.69			
11 min		17.84		16.1	
12 min		17.95			
13 min		18.02			
14 min		18.06			
15 min		18.10			
20 min		18.16		16.1	
25 min		18.18		16.0	
30 min	1346	18.14		16.0	
35 min		18.12		16.0	
40 min		18.12		16.0	
45 min		18.12		16.0	
50 min		18.12		16.0	
55 min		18.12		16.0	
1 hr	1416	18.13		16.0	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

RW68-FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend Dam, SD RWS	Date: 6/18/20
Location: Big Bend Dam, SD	Well ID: RW68

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1426	18.13		16.0	
1 hr 20 min	1436	18.14		16.0	
1 hr 30 min		18.14		16.0	
1 hr 40 min		18.15		16.0	
1 hr 50 min		18.15		16.0	
2 hr	1516	18.16		16.0	ENDED TEST
2 hr 30 min					At 2 hrs as per Project Geo.
3 hr					CONSTANT RATE 16.0 gpm
3 hr 30 min					with ~ 8.7 - 8.8 ft draw down
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min		18.16			0:30 14.41
5 min					1 min 14.79
10 min					1:30 10.20
15 min					2 min 9.32
20 min					2:30 NA
25 min					
30 min					Full Rec to TOJC IN: 2:00
35 min					
40 min					At 9.32' Flowing over TOJC
45 min					
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

Ag's Stick up of TLOC = 1.0 ft (North side)

RW68A -
INITIAL

CONSTANT-RATE PUMPING TEST DATA FORM

Project: Big Bend DAM FY20 DAM SAFETY INSTRUMENTATION RW REHABS		Date: 5/21/20
Location: Big Bend DAM, SD		Weather: 65° cloudy
Monitoring Instrument: Test Well 200 ft water level indicator		Measured By: R. Zygowicz

	Pumping Well ID	Piezometer ID	Piezometer ID	Piezometer ID	Comments
Time	Depth To Water ²	Depth To Water ²	Depth To Water ²	Depth To Water ²	Pumping Rate ³ (GPM)
1313					
0 ¹	8.84				
15 sec					
30 sec	19.74				21.20
1 min	19.82				21.2
1 min 30 sec	19.82				21.2
2 min	19.82		28.30 = 19.82		21.2
3 min	19.81				21.2
4 min	19.81				21.2
5 min	19.81				21.2
6 min	19.82				21.2
7 min	19.82				21.2
8 min	19.81				21.2
9 min	19.82				21.2
10 min	19.82				21.2
12 min	19.82				21.2
15 min	19.84				21.2
20 min	19.88				21.2
25 min	19.89				21.2
30 min	19.90				21.2
35 min	19.91				21.2
40 min	19.98				21.2
45 min	19.98				21.2
50 min	19.97				21.2
55 min	19.97				21.2
1413 1 hr	19.98				21.2

1343

TABLE
89.0 DIB
78-88
SCRW
4.0 00
33.6 SPM

HMIN=19.83 D TOIC=8.85

Bmin=19.83 D4W2V=8.64

14 min=19.84 D4BV=10.1

15 min 19.84

TLOC=1.75 ft AGS (North side)

D+B = 90.85 LT

90.49 HV

D4WTOIC=8.84

* Large
VARIETY floor has water
upwelling around base of
INNER 5" CASING especially
at NW side

RW68A -
INITIAL

CONSTANT-RATE PUMPING TEST DATA FORM (Cont. Page)

Project: <u>BBDSE RWRs</u>	Date: <u>5/21/20</u>
Location: <u>BBD, SD</u>	

	Pumping Well ID	Piezometer ID	Piezometer ID	Piezometer ID	Comments
Time	Depth To Water ²	Depth To Water ²	Depth To Water ²	Depth To Water ²	Pumping Rate ³ (GPM)
1 hr 10 min	1423	19.99			21.2
1 hr 20 min		19.99			21.2
1 hr 30 min	1493	20.00			21.2
1 hr 40 min		20.01			21.2
1 hr 50 min		20.04			21.2
2 hr	1513	20.05			21.2
2 hr 10 min					
2 hr 20 min					
2 hr 30 min					
2 hr 40 min					
2 hr 50 min					
3 hr					
3 hr 10 min					
3 hr 20 min					
3 hr 30 min					
3 hr 40 min					
3 hr 50 min					
4 hr					
4 hr 10 min	1515 ACTUAL TIME	DTW			
4 hr 20 min	30 sec 1546 1515	14.44			
4 hr 30 min	1 MIN				
4 hr 40 min	1:30				
4 hr 50 min	2 MIN				
5 hr	2:30				
5 hr 10 min	3 MIN				
5 hr 20 min					
5 hr 30 min					
5 hr 40 min					
5 hr 50 min					

Ended at 2 hrs
constant rate was 21.2
with D.O. ~ 16-11.5 ft

RECOVERY

seconds until
water flowing over
TOIC = 46 sec

DTW TOIC = 8.85
DTW TOIC = 8.84

very rapid rec to TOIC over flowing

RELIEF WELL REHABILITATION LOG

RW 68A

PROJECT NAME: Big Bend Dam RW Rehab Repair FY20
RELIEF WELL: RW 68A
INSPECTOR: P. Zygowicz

OPENED: DATE <u>6/12/20</u> TIME _____	CLOSED: DATE <u>6/12/20</u> TIME _____
Water Level (TOC) <u>8.84</u> ft	Water Level (TOC) <u>8.83</u> ft
Well Depth (TOC) <u>90.85</u> ft	Well Depth (TOC) <u>90.9</u> ft
Design Depth (TOC) <u>89.0</u> ft	Design Depth (TOC) <u>8</u> ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
	Total Water Removed <u>6000</u> gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

DTWIN = 8.64 water infiltrating around
DTBV = 10.1 top of inner casing/ well vault
DTIC = 8.85 bottom interface
DTW =
TLOC = 1.75 ft AGS

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: NA
METHOD: NA

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments: no Bailing required in this RW

RW68A

STEP 1. SCRUB

EQUIPMENT: 5" NYLON BRUSH, MITE E MITE DRILL RIG
 METHOD: MANUAL SCRUBBING UTILIZING BRUSH + RIG CABLE

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	P	5 ft	25	90.6	
2.					
3.					
4.					
5.					

Comments:

BRUSHED SCREEN AS PER DPP
 40 FT SCREEN

STEP 2. PUMP/AIRLIFT

EQUIPMENT: SULLAIR, MAINTAINED AIR COMPRESSOR, 1" + 2" PVC PIPING
 METHOD: AIRLIFT / VACUUM BOTTOM
 PRE-PUMP WATER LEVEL: 8.83

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	BLACK, GRAY OPAQUE	CLEAN	30 MIN	1500	90.9	
2.						
3.						
4.						
5.						

Comments:

WATER BLACK / DARK GRAY OPAQUE AT START
 TRACE SAND THEN CLEARED

RW 68A

STEP 3. SURGE

EQUIPMENT:

METHOD:

PRE-SURGE WATER LEVEL:

Cycle	Pre-Pass Test (Pass/Fail)	Surge Length (ft)	Surge Speed (strokes per minute)	Time Spent Surging	Bottom Depth After Surging (ft TOC)	Remarks
1.	P	10	6-10	60 min	88-6	appears to have drawn in sand
2.						
3.						
4.						
5.						

Comments:

surged RW AS PER DPP
some sand DRAW into RW

STEP 4. PUMP/AIRLIFT

EQUIPMENT:

METHOD:

PRE-PUMP WATER LEVEL:

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	black/grey opaque	clear - no fine	115 min	4900	90.9	GREY OPAQUE AT START WITH SILT & SAND water clear AT END - very slight greenish tint
2.	with sand					
3.						
4.						
5.						

Comments:

airlifted out some sand from bottom of RW, pumping around 42 gpm
Extended airlift/vacuum until water cleared
AND NO FINEs, cleared sand from bottom of RW

RW68A - FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam, SD FY 20 RW Rehab + Repair	Date: 6/15/20
	Well ID: RW68A
Location: Big Bend Dam, SD	Initial Depth of Well:
Monitoring Instrument: Testwell 200ft Water Level Indicator	Weather: mostly cloudy 75-80°
Static Water Level ² : 8.79	Measured By: R. Zygowicz

Flowing over TOIC

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	10/0	8.79			
30 sec		33.82		33.2	
1 min		33.99		33.1	
1 min 30 sec		34.05		33.1	
2 min		34.06		33.1	
2 min 30 sec		34.08		33.1	
3 min		34.11		33.1	
4 min		34.11		33.1	
5 min		34.13		33.1	
6 min		34.18		33.1	
7 min		34.19		33.1	
8 min		34.20		33.1	
9 min		34.20		33.1	
10 min		34.21		33.1	
11 min		34.22		33.1	
12 min		34.24		33.1	
13 min		34.26		33.1	
14 min		34.26		33.1	
15 min		34.28		33.1	
20 min		34.35		33.0	
25 min		34.39		33.0	
30 min		34.42		33.0	
35 min		34.43		33.0	
40 min		34.41		33.0	
45 min		34.72		33.0	
50 min		34.65		33.0	
55 min		34.68		33.0	
1 hr	1/10	34.65		33.0	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

$$D_{TOIC} = 8.79$$

$$D_{WV} = 8.66$$

$$D_B = 90.8$$

$$\frac{34.1}{8.8} = 26.3$$

* LEAKS AROUND ~~TOIC~~ ^{INNER CASING AT} Bottom of VAVLT

RW 68A-FINAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend DAM RW Rehab	Date: 6/15/20
Location: Big Bend DAM, SD	Well ID: RW 68A

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min		34.68		33.0	
1 hr 20 min		34.79		33.0	
1 hr 30 min		34.87		33.0	
1 hr 40 min		34.88		33.0	
1 hr 50 min		34.93		33.0	
2 hr	1210	34.97		33.0	2:15 = 33.0
2 hr 30 min	1240	35.09		33.0	
3 hr					
3 hr 30 min					
4 hr					Ended test
4 hr 30 min					At 2 hrs 30 min
5 hr					constant rate 33.0 gpm
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1241	35.10			18.85
5 min					0:30 13.57
10 min					1 min 13.57 1:30 10.41
15 min					2 min 8.93 2:30 NA
20 min					3 min NA Full Rec IN
25 min					OTOC 8.79 2:26
30 min					
35 min					
40 min					
45 min					
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

Closing DB = 90.75

RW68B - INITIAL

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam Fy20 RW Rehab + Repair	Date: 6/15/20
Location: Big Bend Dam, SD	Well ID: RW68B
Monitoring Instrument: TEST WELL 200 FT WATER LEVEL INDICATOR	Initial Depth of Well: 89.7
Static Water Level ² : 8.22 Flowing over top of TLOC	Weather: 90° SUNNY
	Measured By: R. Zygowicz

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1358	8.22		✓	
30 sec		26.00	9.20	9.20	
1 min		27.79		9.2	
1 min 30 sec		27.72		9.2	
2 min		27.71		9.2	
2 min 30 sec		27.70		9.2	
3 min		27.69		9.2	
4 min		27.65		9.2	pump capacity test INITIATED AFTER STABILIZING DUE TO RW DESIGN BUILD & NATURE OF RW
5 min		27.61		9.2	
6 min		27.57		9.2	
7 min		27.55			
8 min		27.56			
9 min		27.55			
10 min		27.53			
11 min		27.82			
12 min		27.51			
13 min		27.50			
14 min		27.49			
15 min		27.46			
20 min		27.42			
25 min		27.45			
30 min		27.40			
35 min		27.45			
40 min		27.40			
45 min		27.33			
50 min		27.20			
55 min		27.20		9.2	
1 hr	1458	27.16		9.2	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

TLOC stuck up = 1.55 (north side) measurements taken from TLOC

D+OIC = 8.22

D+WVB = 10.15

D+B = 89.73 WVB
89.7 LT

D+WVB VML4 = 8.16

previous
31 gpm / 19.500
90 D+B
SCAN = 48.6 - 88.6

Set pump at 40 ft

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend Dam F920 RWS	Date: 6/15/20
Location: Big Bend Dam, SD	Well ID: RW68B

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1508	27.15		9.2	
1 hr 20 min		27.11		9.2	
1 hr 30 min	1528	27.05		9.2	
1 hr 40 min		27.01		9.2	
1 hr 50 min		26.99		9.2	
2 hr	1558	26.96		9.2	
2 hr 30 min					ENDED TEST AT 2 HRS
3 hr					CONSTANT RATE OF 9.2 gpm
3 hr 30 min					STABILIZED ~ 27 FT
4 hr					
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min	1600	26.95			Rec = 0.30 20.02
5 min					4 MIN 17.03
10 min					1:30 15.05
15 min					2 MIN 13.51
20 min					2:30 11.20
25 min					3 MIN 10.20
30 min					3:30 10.50
35 min					4 MIN 9.90
40 min					4:30 9.35
45 min					TOFC Flowing over
50 min					AT 9 MIN 30 SEC
55 min					
1 hr					

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

D+B at End = 89.59 light probe
89.75 heavy probe

RW 68B

RELIEF WELL REHABILITATION LOG

PROJECT NAME: Big Bend Dam FY20 RW Rehab + Repair
 RELIEF WELL: RW 68B
 INSPECTOR: A. Zago w/c2

OPENED: DATE <u>6/15/20</u> TIME _____	CLOSED: DATE <u>6/16/20</u> TIME _____
Water Level (TOC) <u>8.18</u> ft	Water Level (TOC) <u>8.16</u> ft
Well Depth (TOC) <u>89.7</u> ft	Well Depth (TOC) <u>90.85</u> ft
Design Depth (TOC) <u>90.0</u> ft	Design Depth (TOC) <u>90.0</u> ft
Est. Sed. In Well _____ ft	Est. Sed. In Well _____ ft
	Total Water Removed <u>2600</u> gals

Relief Well Condition (note general condition and record any damage/obstructions/issues):

DTW IV = 8.18
DTW VB = 10.15
DTW IC = 8.22
36" stick up TLOC = 1.55' North side
NGS

Instructions: Record scrubbing, pumping, and surging information for each cycle of rehabilitation (i.e. Cycle 1 should consist of one full cycle of scrubbing, pumping, and surging). Repeat for each additional cycle required until relief well is fully rehabilitated.

PRE-REHABILITATION BAILING (IF REQUIRED)

EQUIPMENT: NA
 METHOD: NA

Initial Bottom Depth (ft TOC)	Amount of Material in Well Pre-Bail (ft)	Ending Bottom Depth (ft TOC)	Amount of Material in Well Post-Bail (ft)	Remarks (Type of Material Removed)

Comments:

NO BAILING REQUIRED IN THIS RW

6/16/20

RW 68 B

STEP 1. SCRUB

EQUIPMENT:

METHOD:

5" NYLON WELL SCREEN BRUSH MITE E MITE DRILL RIG
 Utilized Drill Rig CABLE & BRUSH to MANUALLY BRUSH SCREEN

Cycle	Pre-Pass Test (Pass/Fail)	Stroke Length (ft)	Time Spent Scrubbing (minutes)	Bottom Depth After Scrubbing (ft TOC)	Remarks
1.	P	5	25	89.1	
2.					
3.					
4.					
5.					

Comments:

WATER CLEAR AT START THEN BECAME
 GRAY WITH SCRUBBING
 SCRUBBED RW AS PER DPR

STEP 2. PUMP/AIRLIFT

EQUIPMENT:

METHOD:

PRE-PUMP WATER LEVEL:

SULLAIR TRAILORED AIRCOMPRESSOR, 1" & 2" PVC PIPING

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	black/gray opaque with sand	clear slight greenish tint	60 min	900	90.55	
2.						
3.						
4.						
5.						

Comments:

WATER GRAY/OPAQUE WITH SAND & SILT
 CLEARED AFTER 1 hr

RW 68B

STEP 3. SURGE

EQUIPMENT: QWERTY TOOL 5" Surge Block, mite E mite Drill Ry
 METHOD: MANUAL SURGING USING DRILL Ry CABLE
 PRE-SURGE WATER LEVEL: 8.18

Cycle	Pre-Pass Test (Pass/Fail)	Surge Length (ft)	Surge Speed (strokes per minute)	Time Spent Surging	Bottom Depth After Surging (ft TOC)	Remarks
1.	P	10	6-10	1 Hr	86.5	Draw in considerable sand with surging
2.						
3.						
4.						
5.						

Comments:

Surged RW As per DPP
measurements reveal sand DRAWN INTO RW Bottom

STEP 4. PUMP/AIRLIFT

EQUIPMENT: SULLAIR 375HCA3 TRAILER AIR compressor, 1" & 2" PVC PIPING
 METHOD: AIRLIFT/VACUUM RW UTILIZING COMPRESSOR
 PRE-PUMP WATER LEVEL: 8.16

Cycle	Water Clarity/Turbidity (NTUs)		Time Spent Pumping	Water Removed (gallons)	Bottom Depth After Pumping (ft TOC)	Remarks
	Start of Pumping	End of Pumping				
1.	gray/black opaque	clear slight	110	1650	90.8	very dark gray with sand at start then cleaned - no fines
2.	with sand & silt	greenish tint				
3.						
4.						
5.						

Comments:

Airlifted out considerable amount of sand & silt
water cleaned after extended AIRLIFT pumping
no fines at end

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM

Project: Big Bend Dam FY20 RW Rehab + Repairs		Date: 6/16/20
		Well ID: RW68B
Location: Big Bend Dam, SD		Initial Depth of Well: 90.6
Monitoring Instrument: Test Well 200ft Water Level Indicator		Weather: 85° Sunny Windy
Static Water Level ² : 8.22 Flowing over Toile		Measured By: R. Zygowicz

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
0 sec	1355	28.10		16.4	
30 sec		28.10		16.4	
1 min		28.01		16.4	
1 min 30 sec		28.02		16.4	
2 min		28.03		16.4	
2 min 30 sec		28.04		16.4	
3 min		28.05		16.4	
4 min		28.03		16.4	
5 min		28.04		16.4	
6 min		28.05		16.4	
7 min		28.06		16.4	
8 min		28.04		16.4	
9 min		28.03		16.4	
10 min	1405	28.05		16.4	
11 min		28.06		16.4	
12 min		28.07		16.4	
13 min		28.08		16.4	
14 min		28.05		16.4	
15 min		28.04		16.4	
20 min		28.14		16.4	
25 min		28.18		16.4	
30 min	1425	28.25		16.2	
35 min		28.23		16.2	
40 min		28.20		16.2	
45 min		28.15		16.2	
50 min		28.16		16.2	
55 min		28.15		16.2	
1 hr	1455	28.17		16.2	

All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

tot =
18 ft 00 / 9.2 gpm
Previous
19.5 ft / 9.1 gpm

RELIEF WELL CONSTANT RATE CAPACITY TEST DATA FORM (Cont.)

Project: Big Bend Dam RW REHABS	Date: 6/16/20
Location: Big Bend Dam, SD	Well ID: RW68B

Elapsed Time	Actual Time	Depth To Water ¹	Water Level Change ¹	Pumping Rate (gpm)	Comments
1 hr 10 min	1505	28.49		16.2	
1 hr 20 min		28.22		16.2	
1 hr 30 min	1525	28.29		16.2	
1 hr 40 min		28.30		16.2	
1 hr 50 min		28.32		16.2	
2 hr	1605	28.34		16.2	
2 hr 30 min	1635	28.42		16.2	ENDED TEST AT
3 hr					2 hrs 30 min
3 hr 30 min					16.2 gpm
4 hr					for 2 hrs
4 hr 30 min					
5 hr					
5 hr 30 min					
6 hr					
6 hr 30 min					
7 hr					
7 hr 30 min					
8 hr					
RECOVERY					
0 min		28.43			REC:
5 min		15.10			30 sec 19.12
10 min					1 min 15.10
15 min					1 min 30 12.72
20 min					2 min 10.91
25 min					2:30 8.45
30 min					3:25 OVER TOP OF
35 min					INNER
40 min					CASING
45 min					AT 3:25
50 min					
55 min					
1 hr					

¹All measurements in 0.01 feet. ²Static water level recorded prior to capacity/drawdown test.

Comments:

NO LEAKAGE OBSERVED AT INNER 5" CASING
+ 36" WELL VAULT INTERFACE OR FLANGE ON BOTTOM
OF WELL VAULT

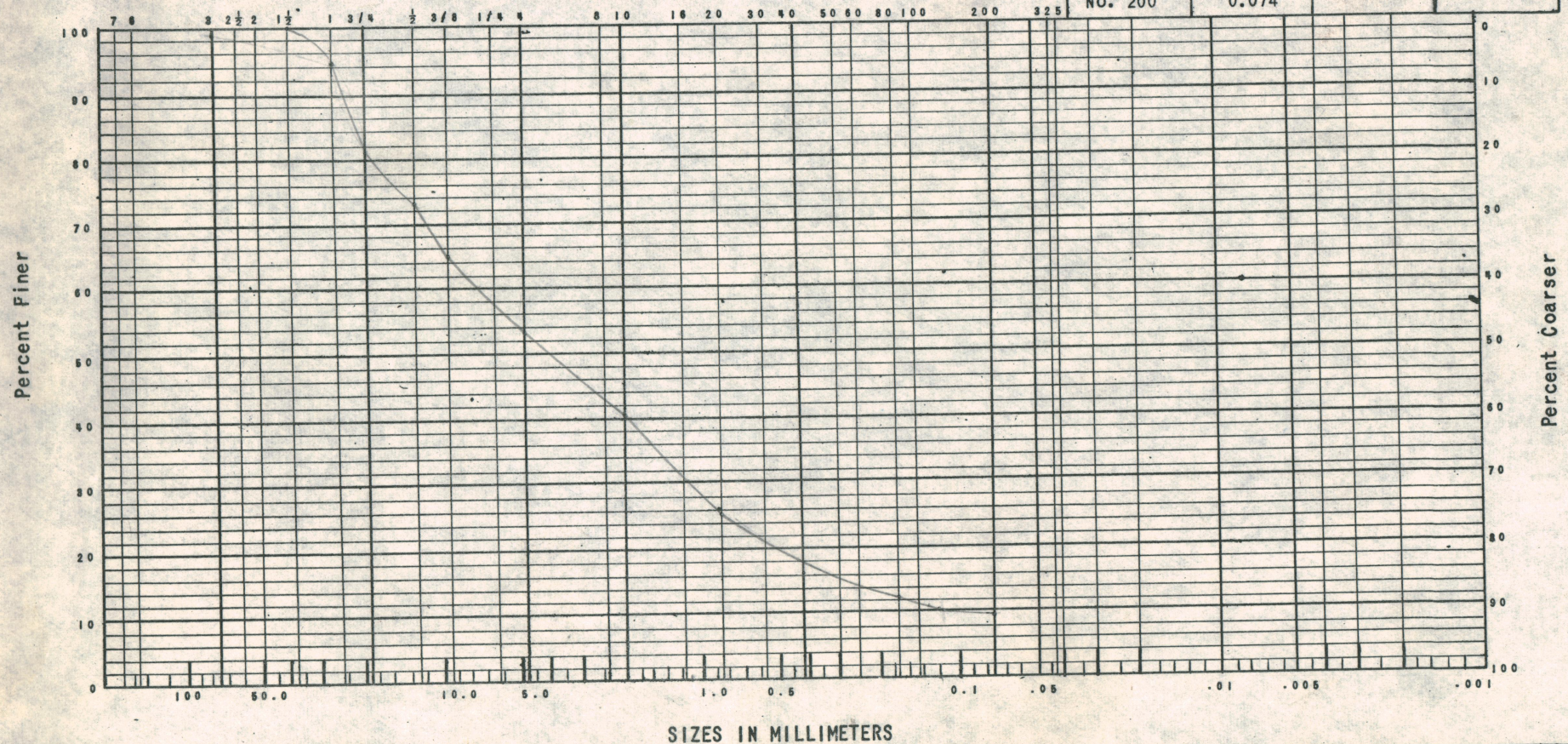
DTB AT END

GEOTECHNICAL LAB REPORTS

Report #4

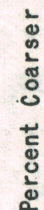
BOTTOM OF HOLE:
47 ft. to Bottom.

MECHANICAL ANALYSIS

O. C. E. SOIL CLASSIFICATIONU. S. STANDARD SIEVE SIZES

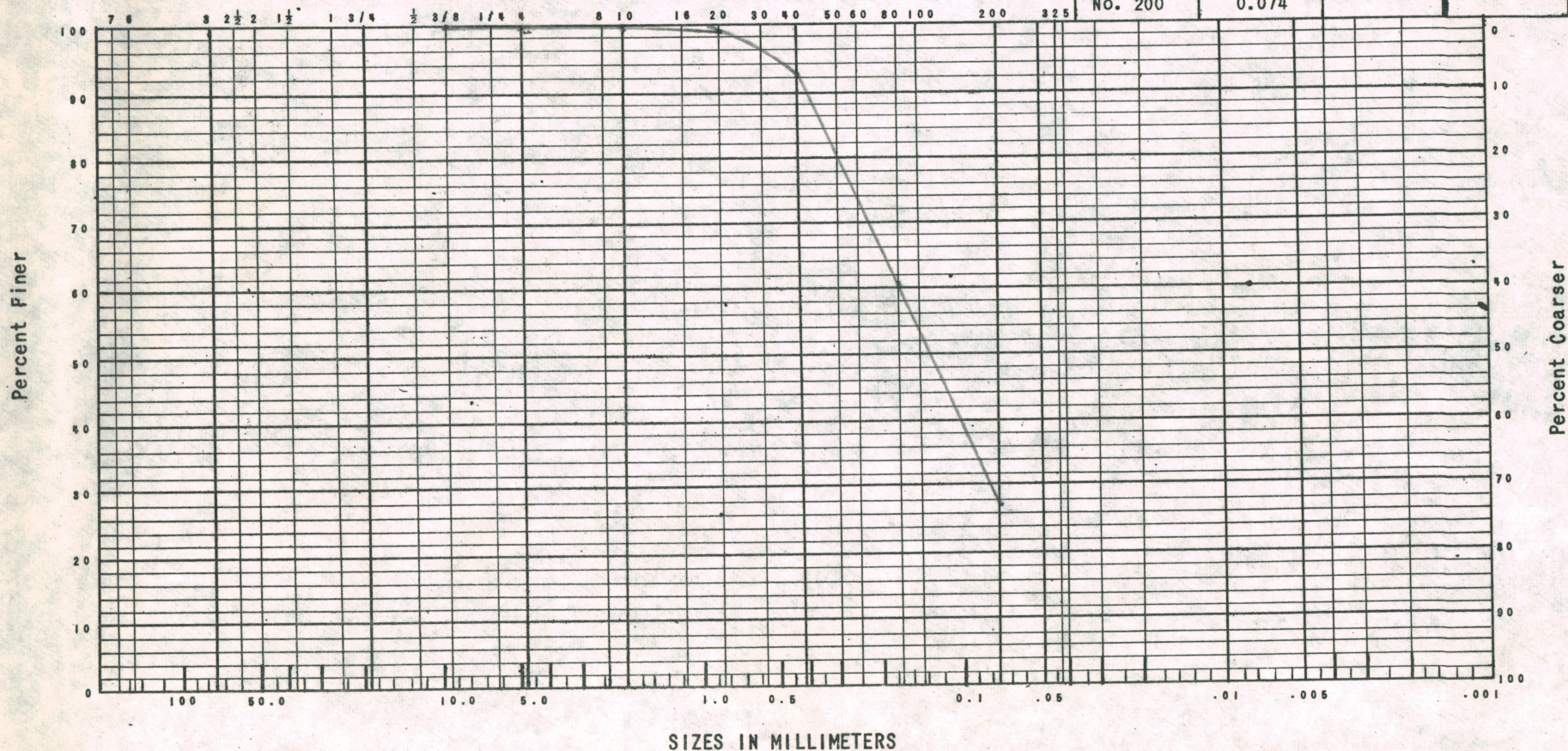
MECHANICAL ANALYSIS

O. C. E. SOIL CLASSIFICATION

U. S. STANDARD SIEVE SIZES

CORPS OF ENGINEERS
MISSOURI RIVER DIVISION LABORATORY
OMAHA, NEBRASKA

MECHANICAL ANALYSIS							U. S. Standard Sieve		Total Wt. Coarser	Percent Coarser
							No.	Size (mm)		
Project:		MRD Lab. No.:					3 inch	76.2		
Location Sampled: <i>JAR D-10-46</i>							1 1/2 inch	38.1		
							3/4 inch	19.1		
							Pan			
Pan No.		Time	Hyd. Rdg.	Temp. C.	Corr. Rdg.	% Finer	Total			
Init. Wt. of Sample		1 min.					3/8 inch	9.52		
Gum Arabic		4 min.					No. 4	4.76		
Hyd. Cyl. No.		20 min.					Pan			
Return Dish No.		120 min.					Total			
O. C. E. SOIL CLASSIFICATION							No. 10	2.00		
Cobbles	Gravel		Sand			Fines	No. 20	0.84		
	Coarse	Fine	Coarse	Medium	Fine		No. 40	0.42		
							No. 80	0.177		
							No. 200	0.074		



SPECIAL INSPECTIONS

1998 BRAUN INTECH PIEZOMETER REHAB AND RESPONSE TEST REPORT

BRAUNTM
INTERTEC

*Engineers and Scientists
Serving the Built and
Natural Environments*

**Piezometer Rehabilitation and Response Tests
Big Bend Dam, South Dakota
Contract No. DACW45-96-D-0004
Delivery Order No. 7**

Prepared for

**Department of the Army
Corps of Engineers, Omaha District**

Project No. DACW-45-9607
May 18, 1998

Braun Intertec Corporation

BRAUNSM
INTERTEC

Braun Intertec Corporation
6875 Washington Avenue South
P O Box 39108
Minneapolis, Minnesota 55439-0108
612-941-5600 Fax. 942-4844

*Engineers and Scientists Serving
the Built and Natural Environments®*

May 18, 1998

Project No. DACW-45-9607

Department of the Army
Corps of Engineers, Omaha District
Attn: CENWO-ED-GH (Skeen)
215 North 17th Street
Omaha, NE 68102-4978


Dear Mr. Skeen:

Re: Contract No. DACA45-96-D-0004, Delivery Order No. 7

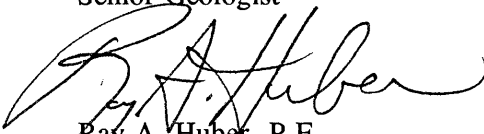
Braun Intertec Corporation has completed piezometer rehabilitation and response tests at the Big Bend Dam in South Dakota. Our observations, results and conclusions are provided in the attached report.

We appreciate the opportunity to provide our services to you. Should you have any questions regarding this report or the project, please call Pat Terhaar at (612) 683-8756 or Ray Huber at (612) 942-4831.

Sincerely,



Patricia M. Terhaar, PG
Senior Geologist



Ray A. Huber, P.E.
Vice President

Attachment:
Report

A. Introduction

As a result of extremely high Lake Francis Case tailwaters, 55 piezometers on the down stream side of Big Bend Dam, South Dakota were submerged. The piezometers required rehabilitation and response testing to assure and confirm that they were working properly for their intended purpose of determining the groundwater piezometric elevation under areas of the dam.

On December 9, 1997 Braun Intertec Corporation (Braun Intertec) was authorized by the U.S. Army Corps of Engineers (USACE) Omaha District Office to complete piezometer rehabilitation and response tests at the Big Bend Dam. This work was carried out under Contract No. DACA45-96-D-0004, Delivery Order No. 7.

B. Scope of Work

The scope of work for this project was provided to Braun Intertec by the USACE in a Scope of Services document dated November 14, 1997. The following tasks were carried out by Braun Intertec.

- Elevation data for Lake Sharp and the Lake Francis Case tailwater for the period of piezometer rehabilitation was obtained from the Big Bend Project Office.
- Prior to rehabilitating each piezometer, the depth to water and depth of the piezometer were measured and recorded to the nearest hundredth of a foot. The condition of the piezometer was also recorded. For piezometers having a protective outer casing, depth measurements were made from the top of the well riser pipe (inner casing or TOR), except in some instances where the riser pipe was considerably lower than the outer casing. In those instances, the measurements were made from the top of the protective casing and are noted as TOC on the field data forms.
- Sediment was removed from each piezometer using compressed air. Plastic tubing was lowered into the piezometer 1 to 2 inches above the base. Compressed air was blown through the tubing, gradually increasing the pressure until it was sufficient to eject water and sediment from the top of the pipe. An up and down surging motion was used on the tube until the water appeared clear and free of sediment. Potable water was added as necessary to remove all of the sediment.

- Following rehabilitation, all water (to the degree possible) was removed from the piezometer with compressed air. A recovery rate (response) test was then performed by measuring and recording water levels in the piezometer at specified intervals as indicated on the Piezometer Test Data Forms in Appendix A.
- After completion of the response testing, the final water level and depth of the piezometer were measured and recorded.
- The recovery rate test data were analyzed using the aquifer test analysis computer program AQTESOLV, developed by Geraghty and Miller, Inc. An estimate of hydraulic conductivity was obtained for the aquifer in the vicinity of each piezometer at the horizon of the well screen.

C. Deviations

The following deviations to the proposed scope of work occurred.

- A post-response testing piezometer depth was not measured on the following wells: D-760-RB, PZ-2, PZ-2A, PZ-4, PZ-6, PZ-8, PZ-8A, H810-RB-A, and H1060-RA.
- Piezometer F560-RB was damaged prior to our arrival at the site. We were able to repair this piezometer by reattaching the riser pipe; however, the lock ring remained broken and a new cap is needed.
- Ten of the piezometers contained diesel fuel. According to the Big Bend Project Office, the diesel fuel was added several years ago to keep the water in the piezometers from freezing. Based on information provided to us, at one time the thickness of diesel fuel in the piezometers ranged from 1 to 7 feet. At the direction of the Project Office, wearing protective clothing, Braun Intertec personnel used compressed air to eject the diesel fuel along with the water onto the ground surface.
- Due to malfunction of one of the water level tapes, we used a water level tape borrowed from the Big Bend Project Office for some of the response test measurements in three of the piezometers. Since the borrowed water level tape was marked only in 1-foot increments, we were only able to take measurements to the nearest tenth of a foot using a ruler held against the water level tape.

- A piece of PVC pipe was inadvertently dropped down PZ-5, but was later retrieved.
- The depth of a piezometer outside of the flooded area, E130-RB, was measured and assessed for the presence of sediment as a comparison to the wells in the flooded area. A noticeable thickness of sediment was observed. We were not able to determine the thickness of the sediment without knowing the constructed depth of the piezometer, but the feel of the water level probe at the base of the well was similar to many of the rehabilitated wells.
- Two piezometers (PZ-2A and PZ-8A) were dry when initially checked and remained dry after rehabilitation. Therefore, response tests could not be performed. Piezometers B480-R and PZ-22 initially had water but remained dry after rehabilitation, and piezometers PZ-11A and PZ-14A had very little recovery. D760-RB-A, J970-RB-A and PZ-25R had a very fast recovery, with most of the recovery occurring before measurements could be made. Therefore, hydraulic conductivity values were not calculated for any of these wells.
- Six piezometers (see Table 1) had ice which prevented us from obtaining an accurate initial water level measurement. Likewise, ten piezometers contained diesel fuel, which did not allow an accurate initial water level measurement.

None of the deviations described above prevented us from achieving the goal of removing the sediment in the piezometers that resulted from flooding. With the exception of the dry piezometers and the ones showing very little recovery, none of the deviations are believed to have affected the recovery rate test results.

D. Results and Conclusions

Table 1 provides a summary of water level measurements, well depth measurements and well conditions. General field notes and completed Piezometer Response Test Data Forms for each of the piezometers are contained in Appendix A. Well depths measured after the response testing are indicated in the comments column. On most of the forms a notation of H (hard) or S (soft) was used to indicate whether sediment was felt (i.e., H indicates that no sediment was felt).

As shown in Table 1, the initial depths measured by Braun Intertec agreed fairly well with the depth measurements made in August 1997 except for in piezometers F560-RB, PZ-2 PZ-2A and PZ-21. The likely cause of this discrepancy for PZ-2 and PZ-21 is that the August measurements were made relative to the top of protective casing while our December 1997 measurements were made from the top of riser. The August depth of F560-RB was nearly 1 foot deeper than in December indicating additional sediment entered the well after August, or an inaccurate measurement was made. The August depth for PZ-2A was approximately 0.5 feet greater than the December measurement; however, the well was dry in December and no sediment was felt.

Sediment was generally felt prior to rehabilitation in the piezometers unless otherwise noted in the comments section of Table 1. Fourteen of the piezometers exhibited an increase in measured depth greater than 0.1 feet after rehabilitation. Of these, five had an increase greater than 1 foot; these are listed below.

<u>Piezometer</u>	<u>Feet</u>
F560-RB	1.33
H1060-RB	0.95
H1310-RB	2.20
J474-RB	0.64
J662-RB	0.63

With the exception of F560-RB, clear, sediment-free water was obtained from all of the wells at the end of rehabilitation and prior to the response testing. Piezometer F560-RB was flushed for one hour without achieving clear water. An additional well volume of water was removed prior to response testing; however, sediment was still present. This was the piezometer that required repair prior to rehabilitation. A white precipitate believed to be scaling was observed in the water removed from some of the piezometers.

At the end of the response testing, a small amount of sediment could be felt using the water level probe at the base of many of the piezometers. This sediment is believed to have come into the piezometer through the screen during water level recovery. That this sediment originated from the formation rather than from the flooding is supported by the fact that a piezometer we checked outside of the flooded area (E130-RB) also contained sediment. The transport of fines from the formation through the screen would not be unexpected for driven wells such as these.

The post-rehabilitation depth for piezometers J970-RB-A and J1220-RA was about 0.1 feet less than measured prior to rehabilitation, suggesting sediment entered the piezometer through the screen during rehabilitation. Piezometer PZ-19 exhibited a greater than 1-foot decrease in depth which appears to be related to formation sand entering the piezometer as further discussed below.

Hydraulic conductivity values obtained from the recovery test data are provided in Table 1, and data for each well are presented graphically in Appendix C. Hydraulic conductivity values ranged from a high of $3.29\text{E-}02$ cm/sec in PZ-4 to a low of $1.76\text{E-}08$ cm/sec in J662-RA.

Water elevations for Lake Sharp and the Lake Francis Case tailwater are provided on the data sheets in Appendix B under the columns headed EL and TW, respectively. A graph of this data is also included in Appendix B. Although fluctuations in the lake levels may have influenced the water levels during the recovery rate tests, we do not believe the results would have been significantly affected. Fluctuations in the recovery rates are more likely to be a result of variables such as measurement and equipment accuracy, and these generally even out during data analysis.

All of the wells appeared to be in good condition with the following exceptions:

- The riser pipe for F560-RB was broken and had to be repaired, as previously discussed.
- A partial obstruction was encountered at a depth of 14 feet in PZ-11A. This may be the result of a damaged screen. Resistance to the water level probe was observed in PZ-11 at a depth of about 47.4 feet.
- The riser pipe for B480-R was bent slightly, but was still fully accessible.
- The protective casing for PZ-17 was found lying on the ground next to the piezometer. The piezometer was still fully functional.
- Fine- to medium-grained sand was observed in the water ejected from PZ-19. This sediment was considerably coarser than the sediment observed in the other wells, and a greater amount of sediment appeared to be present at the base of the piezometer after response testing. Although sediment-free water was obtained from the piezometer upon completion of the rehabilitation, it is possible that the screen is damaged.

As confirmed with Mr. Dave Kane of the Big Bend Project Office, no site restoration was necessary after completion of the work.

E. General

In performing its services, Braun Intertec used that degree of care and skill ordinarily exercised under similar circumstances by reputable members of its profession practicing in the same locality. No other warranty is made or intended.

Table 1
Summary of Piezometer Rehabilitation Data

Piezometer	USACE Depth ¹	Initial Depth ²	Final Depth ³	Water Level ⁴	Condition	K ⁵ cm/sec	Comments
B480-R	13.1	13.1	13.11	5.33	Good	IR	No sediment felt with probe prior to rehabilitation.
C480-R	20.6	20.71	20.71	17.81	Good	3.57E-05	No sediment felt with probe prior to rehabilitation.
D760-RA	44.7	44.77	44.78	4.70	Good	5.94E-06	Sediment felt with probe after rehabilitation.
D760-RB-A	84.6	84.62	NM ⁷	4.56	Good	NA ¹²	No sediment felt with probe prior to rehabilitation. Ice in well at 4'4" after rehabilitation.
D1160-RB	82.6	82.82	83.12	5.03	Fair to good	1.15E-06	Sediment felt after rehabilitation. Well in general good condition but poor seal in annular space around well.
F560-RA	49.2	49.25	49.28	5.50	Good	5.18E-05	Sediment felt with probe after rehabilitation.
F560-RB	82.9	81.98	83.31	6.59	Damaged	3.99E-06	Well repaired prior to rehabilitation. Well flushed for 1 hour using 40 gallons water. Did not clear. Sediment felt after rehabilitation.
F760-RA	52.1	52.14	52.17	7.05	Good	7.87E-04	Sediment felt with probe after rehabilitation.
F760-RB	82.9	82.93	83.18	6.10	Good	6.96E-05	Sediment felt with probe after rehabilitation.
F960-RA	36.4	36.42	36.43	8.12	Good	6.20E-04	Sediment felt with probe after rehabilitation.
F960-RB	84	84.06	84.07	8.29	Good	9.50E-04	Sediment felt with probe after rehabilitation.
G680-RA	34	34.04	34.27	4.28	Good	4.64E-04	Sediment felt with probe after rehabilitation.
G680-RB	83.3	83.26	83.28	4.46	Good	3.79E-05	Sediment felt with probe after rehabilitation.
G880-RA	43.6	43.68	43.93	ice at 2.22	Good	3.71E-06	No sediment felt with probe after rehabilitation.
G880-RB	81.8	81.73	82.18	4.93	Good	7.16E-05	Sediment felt with probe after rehabilitation.
H560-RA	34.2	34.32	34.32	DF ⁸ at 7.60	Good	6.40E-05	No sediment felt with probe after rehabilitation. Diesel fuel in well.
H560-RB	87.7	87.56	87.56	3.63	Good	7.01E-07	Sediment felt with probe after rehabilitation. No lock on well.
H810-RA	35.5	35.62	35.70	DF at 5.96	Good	2.27E-05	Small amount of sediment felt with probe after rehabilitation. Diesel fuel in well.
H810-RB-A	86.9	86.9	NM	ice at 2.85	Good	8.79E-04	
H1060-RA	38.2	38.33	NM	6.19	Good	2.70E-05	
H1060-RB	83.5	83.51	84.46	ice at 3.33	Good	1.84E-05	Sediment felt with probe after rehabilitation.
H1310-RB	82.9	82.87	85.07	4.52	Good	3.53E-05	
J474-RA	42.4	42.40	42.40	DF at 5.0	Good	5.59E-05	Sediment felt with probe after rehabilitation. Diesel fuel in well.

Table 1 (Continued)

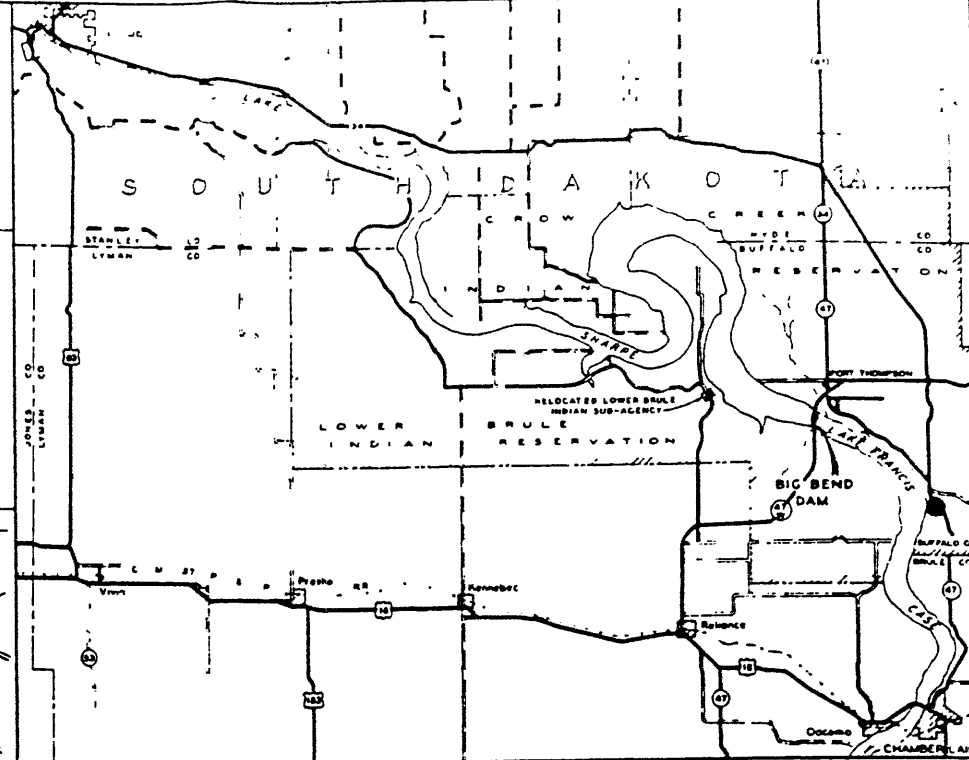
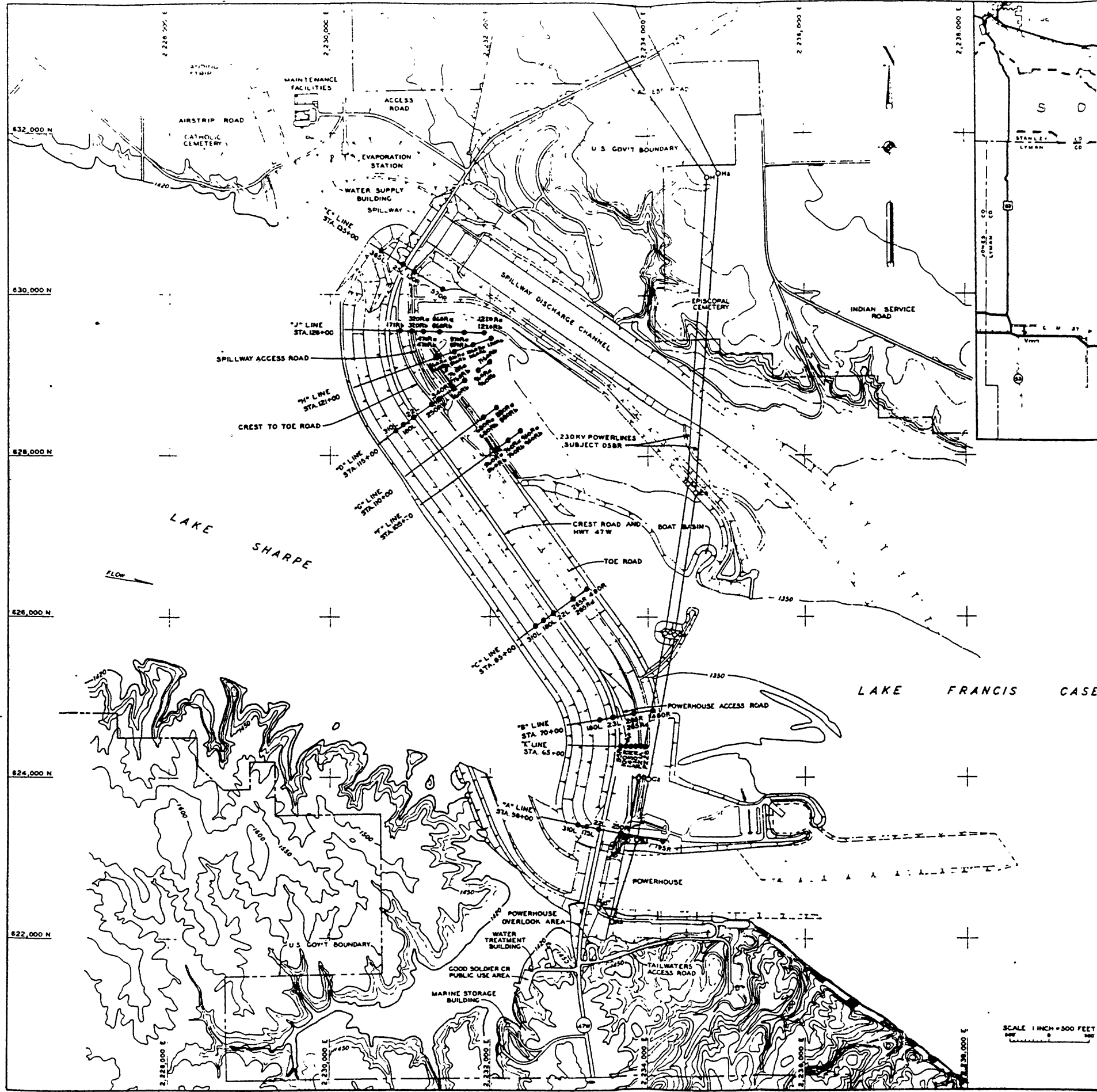
Piezometer	USACE Depth ¹	Initial Depth ²	Final Depth ³	Water Level ⁴	Condition	K ⁵ cm/sec	Comments
J474-RB	91.7	91.67	92.31	3.25	Good	5.84 E-07	Sediment felt with probe after rehabilitation. Diesel odor in well but free product not observed.
J662-RA	25.6	25.76	25.77	DF at 6.00	Good	1.76E-08	No sediment felt with probe after rehabilitation. Diesel fuel in well.
J662-RB	91.2	91.22	91.85	4.63	Good	1.86E-05	Sediment felt with probe after rehabilitation.
J970-RA	42.93	42.76	42.78	DF at 6.52	Good	1.85E-08	No sediment felt with probe after rehabilitation. Diesel fuel in well.
J970-RB-A	82.5	82.46	82.35	DF at 4.70	Good	NA	Sediment felt with probe after rehabilitation. Diesel fuel in well.
J1220-RA	38.2	38.36	38.28	2.68	Good	5.00E-07	
J1220-RB	83.8	83.88	84.00	0.74	Good	4.82E-08	Sediment felt with probe after rehabilitation.
PZ-2	40.7	39.90 ⁹	NM	5.91	Good	5.84E-08	No sediment felt in well prior to rehabilitation.
PZ-2A	14.9	14.36	NM	dry	Good	dry	No sediment felt in well prior to rehabilitation.
PZ-3	42.3	42.36 ¹⁰	42.36	18.11 ¹⁰	Good	2.04E-04	No sediment felt with probe after rehabilitation.
PZ-4	39	38.98	NM	14.89	Good	3.29E-02	No sediment felt prior to or after rehabilitation.
PZ-5	40.1	40.12	40.36	16.38	Good	1.23E-05	Sediment felt with probe after rehabilitation.
PZ-6	40.0	39.80	NM	12.45	Good	5.54E-08	No sediment felt with probe prior to rehabilitation.
PZ-7	41.2	41.22 ¹⁰	41.22	ice at 2.82 ¹⁰	Good	2.28E-07	No sediment felt with probe after rehabilitation.
PZ-8	40.2	40.10	NM	17.36	Good	5.06E-5	
PZ-8A	17.2	17.27	NM	dry	Good	dry	
PZ-9R	47.6	47.61	47.61	19.09	Good	2.97E-04	
PZ-10	49.8	49.77	49.84	19.21	Good	7.52E-06	No sediment felt prior to or after rehabilitation.
PZ-11	50.37	50.27	50.30	15.88	Good?	4.74E-07	Sediment felt in well after rehabilitation. Well in good condition at surface but appears to have partial obstruction at 47.35 feet.
PZ-11A	16.3	16.24	16.25	15.63	Fair	IR ⁶	Sediment felt with probe after rehabilitation. Partial obstruction at 14 feet. Possible screen damage?
PZ-12	50	50.03 ¹⁰	50.04	17.25 ¹⁰	Good	2.03E-06	No sediment felt prior to or after rehabilitation.
PZ-13	51	51.03 ¹⁰	51.04	17.11 ¹⁰	Good	4.72E-05	No sediment felt prior to or after rehabilitation.
PZ-14	48	48.08 ¹⁰	48.13	15.60 ¹⁰	Good	4.42E-05	

Table 1 (Continued)

Piezometer	USACE Depth ¹	Initial Depth ²	Final Depth ³	Water Level ⁴	Condition	K ⁵ cm/sec	Comments
PZ-14A	16.4	16.60 ¹⁰	16.60	ice at 3.59 ¹⁰	Good	IR	No sediment felt with probe prior to rehabilitation.
PZ-15R	49.4	49.45	49.47	11.60	Good	9.30E-05	Sediment felt with probe after rehabilitation.
PZ-16	38.5	38.62	38.74	6.12	Good	2.33E-05	Sediment felt with probe after rehabilitation.
PZ-17	42.8	42.82	42.96	ice at 6.09	Damaged	7.87E-06	7' riser stickup. Protective casing on ground. No lock. Sheen on water flushed from well.
PZ-19	41.6	41.60	40.53	DF at 6.11	Damaged?	9.40E-05	Well in good condition at surface but may be damaged below the surface, allowing formation sand to enter well. Well depth after removing water and prior to recovery was 42.08. Diesel fuel in well.
PZ-21	29.6	29.10 ¹¹	29.10	3.17	Good	3.27E-06	Diesel fuel reportedly added to well previously; however, no odor or free product was observed.
PZ-22	14.6	14.60	14.71	DF at 7.08	Good	IR	No sediment felt with probe after rehabilitation. Diesel fuel in well.
PZ-24	27.9	28.01	28.01	DF at 7.40	Good	4.59E-05	No sediment felt with probe after rehabilitation. Diesel fuel in well. Strong odor after 24 hours.
PZ-25R	44.3	44.24	44.24	DF at 6.10	Good	NA	No sediment felt with probe after rehabilitation. Diesel fuel in well.

Notes: All depths in feet. All Braun Intertec measurements made from top of riser except as noted.

1. Measured by USACE in August, 1997.
2. Measured prior to rehabilitation.
3. Measured post rehabilitation.
4. Measured prior to rehabilitation.
5. Hydraulic Conductivity
6. Inadequate or no recovery
7. Not measured.
8. Unknown thickness of diesel fuel on top of water in well.
9. Top of riser 0.80 ft below top of protective casing; this is the likely cause of the discrepancy relative to USACE depth.
10. Measurement made from top of protective casing.
11. Top of riser 0.58 feet below top of protective casing; this is the likely cause of the discrepancy relative to USACE depth.
12. Not analyzed. Very fast recovery. Most of recovery occurred before measurements could be made.

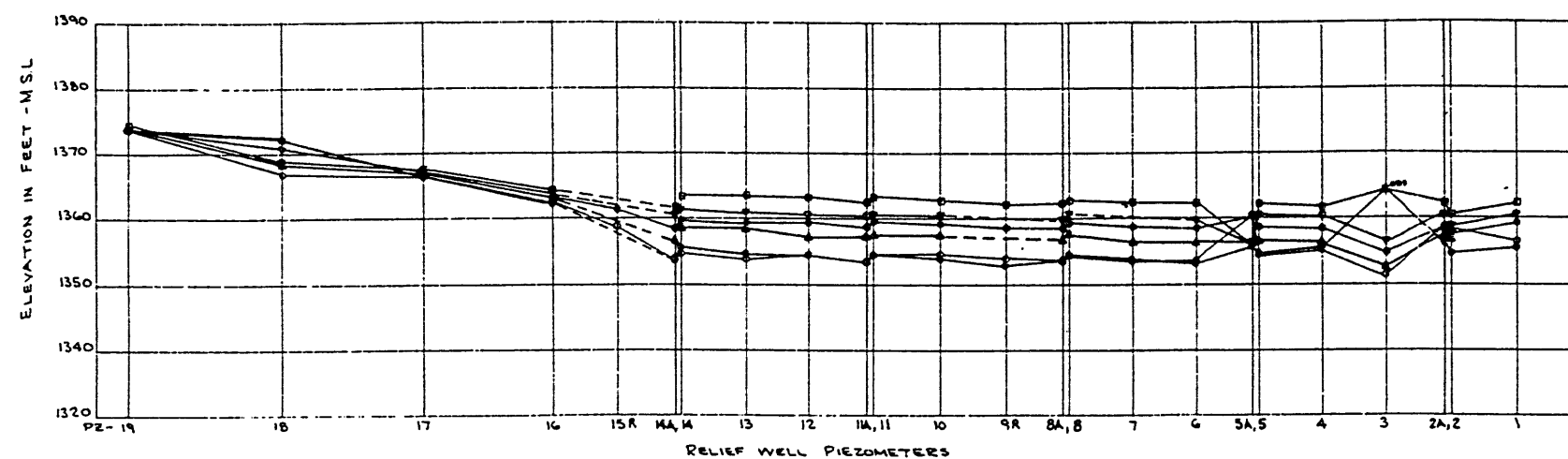
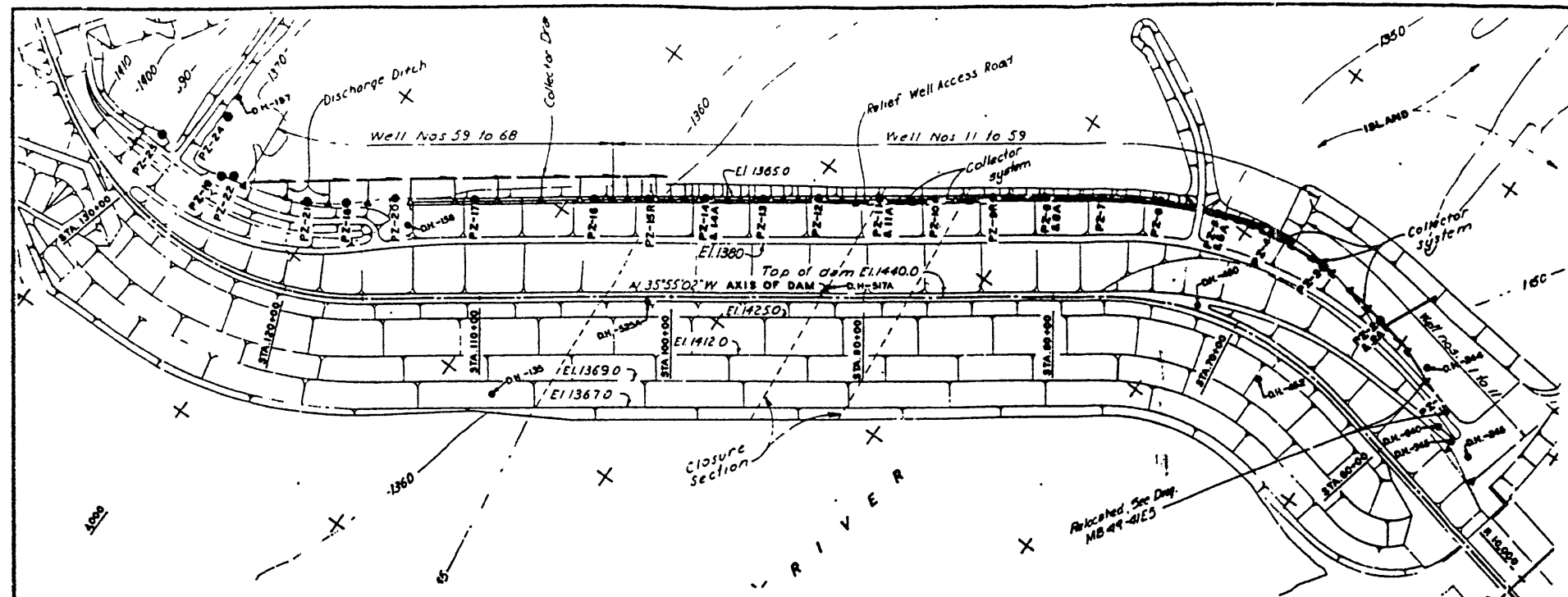


VICINITY MAP
SCALE IN MILES
0 1 2 3 4 5 6 7 8 9 10

LEGEND:
● PIEZOMETER

THIS DRAWING HAS BEEN REDUCED TO
THREE-FOURTHS THE ORIGINAL SCALE

DATE		REVISIONS		MADE	APPROVED
U. S. ARMY ENGINEER DISTRICT, OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA					
DESIGNED BY		CHECKED BY		DATE	
DRAWN BY		APPROVED BY		SEP 1980	
PROJECT NO.		SHEET NO.		DRAWING NUMBER	
SHEET OF		SCALE AS SHOWN		SPEC. NO.	
B. P. Landreth		Charles L. Hopp		B. P. Landreth	
S. C. E. DISTRICT ENGINEER		CHIEF, ENGINEERING DIVISION		S. C. E. DISTRICT ENGINEER	



LEGEND:

- FEB. 28 '75
- MAY 17 '75
- MAY 12 '76
- APR. '77
- NOV. '78
- MAY '79

THIS DRAWING HAS BEEN REDUCED TO
THREE-EIGHTHS THE ORIGINAL SCALE.



THIS PLAN ACCOMPANIES CONTRACT NO.
RESERVATION NO.

DATE	DESCRIPTION	MADE	APPROVED
REVISIONS			
U. S. ARMY ENGINEER DISTRICT, OMAHA CORPS OF ENGINEERS OMAHA, NEBRASKA			
DESIGNED BY	MISSOURI RIVER BIG BEND DAM EMBANKMENT		
DRAWN BY	RELIEF WELL PIEZOMETERS		
CHECKED BY	DATE: June '79		
APPROVED BY	CHIEF ENGINEER DISTRICT		
APPROVED BY	CHIEF OF BRIGADE		
APPROVED BY	CHIEF OF DISTRICT		

①

12-12-97

~~CHIXX 77 1988~~ ~~A~~

CHAMBERLAIN, SOUTH DAKOTA

WEATHER: CLEAR, SUNNY, 8°F, NW WIND @ 10 mph

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN.

TASK: PIEZOMETER RESTORATION - RECOVERY RATE TEST

TIME: 7:00 AM

7:00 Prep equipment. PURCHASE FLOOD LIGHT FOR EVENING WORK.

7:00 ARRIVE ON SITE. DISCUSS WORK PLAN, ACCESS, HOURS OF OPERATION, STORAGE, SAFETY ISSUES WITH DAVE KANE AND ANN GRAJATT.

7:30 START SET-UP ON PZ-4. B 430R.

6:39 WL TAPES HAVING DIFFICULTY IN READING PZ-5.
PZ-5 RECHARGES V. QUICKLY FROM ELEVATION(S) ABOVE
BOTTOM OF WELL.

LEAVE SITE AT 6:45. ~~A~~

WELLS COMPLETED: PZ-4, PZ-7, PZ-6, PZ-8, PZ-8A, B 430R
FLUSHED PZ-5

note: Problem w/ PZ-5 related to faulty water
level tape. PZ-5 retested 12/19/97.

pmj
3/12/98

12-13-97

CHAMBERLAIN, SOUTH DAKOTA

WEATHER: CLEAR, 20°F, W WIND 5-10 MPH

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TECH)

TASK: PIEZOMETER REDEVELOPMENT

ARRIVE ON SITE @ 7:00 AM

7:00 ARRIVE OF DAM STORAGE TO GET COMPRESSOR &
125 G POTABLE WATER.

7:50 SET UP ON PZ-5. WILL EVACUATE WELL AND
TRY FOR RECOVERY RATE TEST. WATER RECHARGES
VERY FAST AND ENTERS WELL FROM ELEVATION
HIGHER THAN BOTTOM OF WELL. LEAKAGE INTO
WELL CAUSES CONTINUOUS AUDIBLE SOUNDING OF
WL TAPES MAKING RECOVERY RATE TEST VERY DIFFICULT.

see note
previous
page 2.

8:15 WELL FLUSHED w/ 3 WELL VOLUMES, WATER CLEAR, NO SEDIMENT
FELT IN WELL BOTTOM.

9:15 ALL WELLS BEING EVACUATED w/ AT LEAST 2 VOLUMES
OF WATER AND BLOWN WITH AIR @ 100 PSI. WATER
IS CLEAR OF SEDIMENT BEFORE BEGINNING EVACUATION
AND RECOVERY RATE TEST.

10:55 B 480-R WELL DRY AFTER 24 HOURS

11:38 PZ-4 WATER LEVEL AT 15.06. THIS
VALUE IS LOWER THAN RECORDED
AFTER 2 ^{HOURS} ~~HOURS~~ DAM MAY BE
HOLDING BACK WATER. CHECK
w/ CORP ON WATER LEVEL
RESPONSES DURING FLUCUATION/RELEASES
FROM DAM.

122

12-14-97

(4)

CHAMBERLAIN, S. DAKOTA

WEATHER: CLEAR SKY, 5° F, CALM WINDS

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TECH)

TASK: MW REDEVELOPMENT

ARRIVE ON SITE @ 7:00 AM

7:00 GET COMPRESSOR & 100 G POTABLE WATER

7:30 SET UP ON PZ-13.

7:45 ALL WELLS WILL BE FLUSHED W/ MINIMUM 2⁺ RISER PIPE WELL VOLUMES REGARDLESS OF WELL CONDITION AND WILL BE EVACUATED USING 100 PSI COMPRESSED AIR.

10:00 PZ-13, PZ-14, PZ-14A WELLS EVACUATED. SET UP ON PZ-15R

1:00 PZ-16 EVACUATED. SET UP ON F 560-RA.
WELL F 560-RB DAMAGED. RISER PIPE COMPLETELY REMOVED UPON ARRIVAL AT F 560-RA / F 560-RB PAIR. RISER PIPE LOCKED BUT LAYING ON GROUND ADJACENT TO F 560-RA.
20 MINUTES TO CLEAN RISER, DIG OUT WELL OPENING AND RECONSTRUCT WELL. WELL NEEDS NEW WELL CAP, LOCK. RING IS BROKEN.

2:30 3 WELL VOLUMES FLUSHED FROM F 560-RB. CLEAR WATER NOT YET OBSERVED. LEAVE TO GET 125 G POTABLE WATER. GROUND SURFACE MOIST AND MUDDY - DIFFICULT TO TRAVERSE
✓ TRUCK & COMPRESSOR.

2:50 Return to F 560-RB

3:00 PURGED ONE ADDITIONAL WELL VOLUME FROM F 560-RB
STARTED RECOVERY RATE TEST.

F 560-RA AND EVACUATED, WAITING ON 2 HOUR READINGS
WELLS COMPLETED: PZ-13, PZ-14, PZ-14A, PZ-15R, PZ-16, F 560 RA,
LEAVE SITE 6:30 F 560 RB, F 760 RA

ΔACW-

CHAMBERLAIN, S. DAKOTA

WEATHER: CLEAR, 17°F, CALM WINDS

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TECH)

TASK: PIEZOMETER DEVELOPMENT

ARRIVE ON SITE AT 7:00 AM

7:05 GET 125 G WATER & COMPRESSOR FROM STORAGE AREA

8:30 CALL GREG SCALLON REQUEST ADDITIONAL PVC TO REPLACE BROKEN FITTINGS AND REQUEST A TAPER TAP TO ASSIST IN REMOVAL OF BROKEN SECTION OF PVC IN PZ-5.

9:00 DAVID KANE, TECHNICAL SUPPORT CHIEF, CORP OF ENGINEERS ON SITE TO CHECK PROGRESS. MR. KANE WILL PROVIDE HOURLY READINGS FOR LAKE FRANCIS AND LAKE SHARP FOR EACH DAY.

9:30 SET UP ON F 760 RB.

10:30 CALL P. TERHAAR, P.M., TO INFORM HER OF PROGRESS & CONDITION OF PZ-5 AND REPAIRED WELL F 560 RB.

11:00 CALL P. TERHAAR, P.M., THEN DAVID KACHEK, OMAHA CORP OF ENGINEERS. NEITHER INDIVIDUAL AVAILABLE. DID NOT LEAVE MESSAGES DUE TO STATIC ON CELL PHONE AND BREAKUP ON CONNECTION.

11:45 WATER LEVEL TAPE MALFUNCTIONS. ORDER REPLACEMENT TAPE. OVERNIGHT DELIVERY WILL BE TO D.A.M.

4:00 ATTEMPT TO REMOVE PVC FROM PZ-5

5:00 REMOVAL ATTEMPT UNSUCCESSFUL

5:30 LEAVE SITE.

WELLS COMPLETED: G 880 RA, G 880 RB, F 960 RA, F 960 RB, F 760 RB

DACW-45-9607
CHAMBERLAIN, S. DAKOTA

12-16-97

(6)

WEATHER: CLEAR, SUNNY, 26° F
GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TECH)
TASK: PIEZOMETER DEVELOPMENT
ARRIVE ON SITE: 9:30

9:30 SPOKE TO ANN GRAVATT, CORP OF ENGINEERS, ABOUT
DELIVERY OF WATER LEVEL TAPE AND ADDITIONAL PVC TO CORP
OFFICE, EITHER TODAY OR TOMMOROW. ALSO SPOKE WITH DALE LUNDQUIST,
ARRIVING

CORP OF ENGINEERS, IN CHAMBERLAIN ABOUT SAME ARRIVAL DATES.
A. INFORM ANN GRAVATT ABOUT MINOR RUTS NEAR F 560 RA
& F 560 RB. SITE RESTORATION IS NOT NECESSARY SINCE THE AREA
IS SCHEDULED FOR RAKING & SEEDING IN SPRING (PER A. GRAVATT)
SHE WILL INFORM DAVID KANE OF ISSUE.

1:41 DAVE KANE ON SITE. DISCUSS LOCAL GEOLOGY
W/DAVE TO DETERMINE WHY SOME WELLS HAVE
SEDIMENT IN 24 HOURS AFTER BEING CLEAN.
DAVE INDICATED THAT THE NATIVE SOILS CONSIST OF
SHALES & CLAYS, THESE COULD PROVIDE FINES ENTERING
INTO PIEZOMETER SCREENS. DISCUSS THE DELIVERY
OF WELL MATERIALS & WL TAPE. DISCUSS LAKE ELEVATION
LEVELS - DAVE WILL PROVIDE ALL FROM THE POWERHOUSE,
AND SEND WEEKEND LEVELS TO BRAUN INTERTEC CORPORATION
MENDOTA HEIGHTS OFFICE. DISCUSS MALFUNCTIONING
WL TAPE AND PZ-5.

1:55 DAVE LEAVES SITE. CONTINUE PIEZOMETER DEVELOPMENT.

2:00 DAVE KANE DELIVERS PVC & HAZCO WL TAPE ON-SITE.
START PIEZOMETER D 760 RB W/NEW EQUIPMENT. MORALE
IS HIGH!

WELLS COMPLETED: J 1220 RB, J 1220 RA, D 1160 RB, D 760 RB, D 760 RA
G 680 RA, G 680 RB

7:00 Leave Site

12-17-97

7

DACW-95-9607

CHAMBERLAIN, S. DAKOTA

WEATHER: PARTLY CLOUDY, 15°F, W WIND 9+ 10 mph

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TECH)

TASK: WELL DEVELOPMENT

ARRIVE ON SITE: 0730

7:40 FILL DEVELOPMENT TANK W/ 125 G POTABLE WATER. GET COMPRESSOR

7:50 MOBILIZE TO DAM. SET UP ON H 1310 RB.

10:30 MOBILE FOR 2ND TANK OF POTABLE WATER (125 G).

12:10 CALL PAT TERHAAR, P.M., TO INFORM HER OF DIESEL FUEL PUT IN VARIOUS WELLS TO PREVENT ICE. CONCERN WITH CROSS CONTAMINATION OF WELLS AND EFFECTS ON SAMPLING EQUIP. & PERSONNEL. SHE WILL CONTACT CORP.

3:30 MEASURE WELL DEPTH OF PIEZOMETER E 130 RB.

THIS WELL IS LOCATED ALONG EASTERLY BERM ON DOWNSIDE WALL OF DAM. THIS WELL WAS OUTSIDE OF FLOOD AREA AND ABOVE ELEVATIONS OF PIEZOMETERS REQUIRING REDEVELOPMENT. THIS WAS MEASURED TO COMPARE SEDIMENT LEVEL IN A WELL OUTSIDE THE FLOOD AREA. WELL DEPTH WAS 77.35 FEET WITH NOTICEABLE SEDIMENT THICKNESS AT THE BASE OF THE WELL.

6:00 LEAVE SITE

WELLS COMPLETED: J 474 RB, J 662 RB, H 810 RB-A
H 1060 RA, H 1060 RB, H 1310 RD

12-18-97

(9)

DACW-45-9607

CHAMBERLAIN, S. DAKOTA

WEATHER: OVERCAST, 33° F

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TRCN)

TASK: PIEZOMETER DEVELOPMENT

ARRIVE ON SITE @ 7:00

7:10 GET COMPRESSOR } 125 G POTABLE WATER

7:30 SET UP ON PZ-17.

13 PIEZOMETERS REMAINING, 9 HAVE VARYING AMOUNTS OF DIESEL FUEL IN THEM. CORP ADDED DIESEL TO PREVENT FREEZING IN PIEZOMETERS.

THESE WELLS WILL NOT BE DEVELOPED UNTIL OK'D BY P.M., PAT TERHAAR AND PROPER EQUIPMENT IS ACQUIRED. 4 PZ'S SCHEDULED FOR TODAY.

10:30 DISCUSS PZ'S w/DIESEL ON WATER w/ PAT TERHAAR.

SHE INDICATED THAT THE CORP DEVELOPED PZ'S w/DIESEL BY "STANDING BACK" WHILE EVACUATING WELLS. SHE INDICATED THAT WE SHOULD GET APPROPRIATE PROTECTIVE CLOTHING AND EQUIP FOR FIELD PERSONNEL. WE ARE OK TO BEGIN DEVELOPING FREE PRODUCT PZ'S. END OF PHONE CONVERSATION.

10:45 SECOND PHONE CONVERSATION w/P.M. PAT TERHAAR.

INFORM HER OF PROPOSED DAILY ACTIVITIES:

- ① MOBILIZE TO TOWN TO ACQUIRE PROTECTIVE MATERIALS AND ADDITIONAL EQUIPMENT FOR EVACUATION OF DIESEL.
- ② 24 HOUR READINGS FROM PREVIOUS DAY WILL BE TAKEN EARLY AND LATE, AND DATA EXTRAPOLATED BACK.
- ③ EVACUATION OF DIESEL WILL REQUIRE SOLVENTS TO CLEAN EQUIPMENT. THIS STEP WILL POSSIBLY INCREASE FIELD TIME SIGNIFICANTLY. INCREASE IN SCOPE OF WORK DUE TO FAILURE OF CORP OF ENGINEERS TO PROVIDE NECESSARY AND RELEVANT INFORMATION REGARDING CONDITION OF WELLS PRIOR TO BIDDING OF PROTECT.

4:15 REMOVED PVC FROM PZ-5

4:24 TAKE 24 HR + WATER LEVELS

WELLS COMPLETED: PZ-17

4:30 LEAVE SITE.

12-19-97

9

DACW-45-9607

CHAMBERLAIN, S. DAKOTA

WEATHER: OVERCAST, 33°F, NW WIND @ 10-20 mph

GEOLOGIST: SCOTT JOHNSON, CHAS RASMUSSEN (TEXT)

TASK: PIEZOMETER DEVELOPMENT AND DIESEL REMOVAL

ARRIVE ON SITE @ 7:00

7:10 PICK UP COMPRESSOR & FILL WATER TANK
WITH 125 G POTABLE WATER

7:45 SET UP ON PZ-5

10:00 DAVE KANE, CORP OF ENGINEERS, ON SITE. PROVIDES
HOURLY WL DATA OF PAST EIGHT DAYS FOR LAKE SHARPE &
LAKE FRANCIS CASE. WILL MAIL WL DATA FOR WEEKEND
TO BIRANN INTERTEC CORPORATION ON MONDAY. DAVE HAS
NO CONCERNS W/ANY RUTS IN THE LOWLAND (FLOODED) AREA.
HE INDICATED THE AREA HAS TALL GRASSES AND WILL BE
RAKED & RESEED IN THE SPRING.

6:00 LEAVE SITE

WELLS COMPLETED: PZ-24, J 662 RA, PZ-22, J 474 RA,
PZ-21, H 560 RA, H 560 RB, PZ-5

12-20-97

(10)

DACW - 45-9607

CHAMBERLAIN, S. DAKOTA

WEATHER: CLEAR, SUNNY, 15° F, S WIND at 15 mph

GEOLOGIST: SCOTT JOHNSON, CHRIS RASMUSSEN (TECH)

TASK: PIEZOMETER DEVELOPMENT

ARRIVE ON SITE: 7:00 AM

7:15 GET COMPRESSOR & 125 G POTABLE WATER

8:00 START 24 hour WL CHECK AT PZ-5. MOBILIZE
TO EAST END OF DAM. SET UP ON J 970 RA & RB


WELLS COMPLETED: PZ-10, J 970 RA, J 970 RB-A,
H 810 RA, PZ-19, PZ-25R

ALL WELLS COMPLETED - 24 READING ONLY ON 12-21-97.

LEAVE SITE @ 3:00

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-12-97
	PIEZ. ID: B480-R
LOCATION: Big Bend Dam, SD.	Depth of Piez: 13.1
Monitoring Instrument:	Weather: CLEAR, SUNNY, 8°F NW WIND AT 10 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
10:50 0	TOC	13.11 (DRY)			
15 Sec	TOC				
30 Sec	TOC				
45 sec	TOC				
1 min	TOC				
2 min	TOC				
3 min	TOC				
4 min	TOC				
5 min	TOC				
10 min	TOC				
15 min	TOC				
20 min	TOC				
25 min	TOC				
30 min	TOC				
11:50 1 hour	TOC	13.11			DRY
12:50 2 hour	TOC	13.11			DRY
10:50 24 hour	TOC	13.11			DRY 13.11
Static Water Level ² : 5.33			Measured by: 		


¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. RISER bent slightly to NORTH. WL TAPE PROBE AUDIBLE HEARD CONTACT STEEL AT BOTTOM OF WELL. NO SEDIMENT OBSERVED OF PROBE. ADDED 3 WELL VOLUMES OF WATER. WATER CLEAR AFTER 1ST WELL VOLUME.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-13-97
	PIEZ. ID: C 480-R
LOCATION: Big Bend Dam, SD.	Depth of Piez: 20.71
Monitoring Instrument: SOLONIST	Weather: CLEAR, SUNNY, 20°F, NW WIND @ 10 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC				
15 Sec	TOC	20.70	1348.00	—	
30 Sec	TOC	20.65	1348.05	0.05	
45 sec	TOC	20.63	1348.07	0.02	
1 min	TOC	20.62	1348.08	0.01	
2 min	TOC	20.57	1348.13	0.08	
3 min	TOC	20.53	1348.17	0.04	
4 min	TOC	20.50	1348.20	0.03	
5 min	TOC	20.46	1348.24	0.04	
10 min	TOC	20.29	1348.41	0.17	
15 min	TOC	20.14	1348.56	0.15	
20 min	TOC	20.00	1348.70	0.14	
25 min	TOC	19.89	1348.81	0.11	
30 min	TOC	19.75	1348.95	0.14	
1 hour	TOC	19.18	1349.52	0.57	
2 hour	TOC	18.31	1350.39	0.87	
24 hour	TOC	18.57	1350.13	-0.26	20.71 w2 water let out Nov 12-13-97
Static Water Level ² : 17.81			Measured by: 		

¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. WL TAPE FROM 1000/FEET CONTACTING BOTTOM OF WELL. NO INTERFERENCE ON TAPE FROM AFTER REMOVAL FROM WELL. ADDED 2 WELL VOLUMES BEFORE WATER FLUSHED CLEAR

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-16-97
	PIEZ. ID: D 760 RA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 44.77
Monitoring Instrument: Rocktest (1 ft intervals)	Weather: CLEAR, SUNNY, 28°F SW WIND at 5 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
1:00 0	TOC	44	1328.5	—	
15 Sec	TOC	44	1328.5	0	
30 Sec	TOC	39.95	1332.55	4.05	
45 sec	TOC	39.95	1332.55	0	
1 min	TOC	44	1328.5		
2 min	TOC	43.5	—		
3 min	TOC	43.5	1329		
4 min	TOC	43.5	1329	0	
5 min	TOC	43.3	1329.2	0.2	
10 min	TOC	42.8	1329.7	0.5	
15 min	TOC	—	—		
20 min	TOC	41.40	1331.1		
25 min	TOC	40.90	1331.6	0.5	
1:30 30 min	TOC	40.30	1332.2	0.6	
2:00 1 hour	TOC	37.60	1334.4	2.7	
3:00 2 hour	TOC	32.45	1340.05	5.15	HAZCO TAPE
1:00 24 hour	TOC	4.99	1347.51	27.46	44.78 (5)
Static Water Level ² : 4.70				Measured by: <i>[Signature]</i>	

¹ All measurements in 0.01 feet.² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. NO SEDIMENT IN WELL, FLUSHED 1/5 WELL VOLUMES - CLEAR. WHITE precipitate in water during flushing.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-16-97
	PIEZ. ID: D 760 RBA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 84.62
Monitoring Instrument: HAZCO	Weather: CLEAR, Sunny, 37° F SW wind at 5 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	9.80 5.60	1364.74	—	
15 Sec	TOC	5.14	1365.60	0.86	
30 Sec	TOC	4.84	1365.90	0.5	
45 sec	TOC	4.70	1366.04	1.14	
1 min	TOC	4.64	1366.1461	0.06	
2 min	TOC	4.60	1366.14	0.04	
3 min	TOC	4.58 4.56	1366.15	0.04	
4 min	TOC	4.56	1366.18	0	
5 min	TOC	4.56	1366.18	0	
10 min	TOC	4.56	1366.18	0	
15 min	TOC	4.56	1366.18	0	
20 min	TOC	4.56	1366.18	0	
25 min	TOC	4.56	1366.18	0	
30 min	TOC	4.53	1366.21	0.03	HAZCO TAP
1 hour	TOC	4.53	1366.21	0	
2 hour	TOC	4.53	1366.21	0	
24 hour	TOC	4.53	1366.21	0	ICE in well at 4.4"
Static Water Level ² : 4.56				Measured by: JCK	

¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD SHAPE. NO SEDIMENT FELT IN BOTTOM OF WELL. FLUSHED 2/3 well volume - white precipitate flushed out, WATER CLEAR.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-16-97
	PIEZ. ID: D 1160 RB
LOCATION: Big Bend Dam, SD.	Depth of Piez: 82.82
Monitoring Instrument: HAZCO	Weather: CLEAR, 50.0°F, 27°F SOUTH WIND at 5 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	83.02	1287.72	—	
15 Sec	TOC	82.92	1287.82	0.1	
30 Sec	TOC	82.87	1287.87	0.05	
45 sec	TOC	82.82	1287.92	0.05	
1 min	TOC	82.80	1287.94	0.02	
2 min	TOC	82.66	1288.08	0.14	
3 min	TOC	82.52	1288.22	0.14	
4 min	TOC	82.43	1288.31	0.09	
5 min	TOC	82.35	1288.39	0.08	
10 min	TOC	82.00	1288.74	0.35	
15 min	TOC	81.75	1288.99	0.25	
20 min	TOC	81.55	1289.19	0.2	
25 min	TOC	81.33	1289.41	0.22	
30 min	TOC	81.14	1289.60	0.19	
1 hour	TOC	80.00	1290.74	1.14	
2 hour	TOC	77.90	1292.84	2.1	
24 hour	TOC	43.69	1327.05	34.21	83.12 (s)
Static Water Level ² : 5.03				Measured by: <i>AF</i>	

¹ All measurements in 0.01 feet.


² Static water level recorded prior to piezometer rehabilitation.

FAIR

Additional Comments: WELL IN GOOD CONDITION. SEDIMENT FELT IN BOTTOM OF WELL. WATER EMINATING FROM GROUND SURFACE WHERE PIPE ENTERS - LOOK FOR RISING OR POSSIBLE ANNULAR SPACE TO DEPTH. WHITE PRECIPITATE FLUSHED FROM WELL. WELL SHOULD BE INSPECTED.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-14-97
	PIEZ. ID: F-560-RA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 49.25
Monitoring Instrument: SOLO NIST	Weather: SUNNY, CLEAR, 30 °F S WIND at 5 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	47.95	1320.81	—	
15 Sec	TOC	47.53	1321.23	0.42	
30 Sec	TOC	47.39	1321.37	0.14	
45 sec	TOC	47.18	1321.58	0.21	
1 min	TOC	46.98	1321.78	0.2	
2 min	TOC	46.51	1322.25	0.47	
3 min	TOC	45.48	1323.28	0.93	
4 min	TOC	44.71	1324.05	0.77	
5 min	TOC	44.06	1324.70	0.65	
10 min	TOC	40.23	1328.53	3.83	
15 min	TOC	37.50	1331.20	2.73	
20 min	TOC	34.75	1334.01	2.75	
25 min	TOC	31.72	1337.04	3.03	
30 min	TOC	29.80	1338.96	1.92	
1 hour	TOC	22.27	1346.49	7.53	
2 hour	TOC	10.74	1358.02	11.53	
24 hour	TOC	5.50	1363.20	5.24	49.28 s
Static Water Level ² : 5.50			Measured by: 		

¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: Riser pipe bent slightly, otherwise, well in good condition. FLUSHED WITH THREE WELL VOLUMES.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-14-97
	PIEZ. ID: F-560-RB
LOCATION: Big Bend Dam, SD.	Depth of Piez: 81.98
Monitoring Instrument: SOLOMIST	Weather: Sunny, Clear, 20°F 5 wind at 5 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	82.41	1287.11	—	
15 Sec	TOC	82.35	1287.17	0.06	
30 Sec	TOC	82.32	1287.20	0.03	
45 sec	TOC	82.27	1287.26	0.05	
1 min	TOC	82.21	1287.31	0.06	83.30 Bottom
2 min	TOC	82.05	1287.47	0.16	
3 min	TOC	81.93	1287.59	0.12	
4 min	TOC	81.82	1287.70	0.11	
5 min	TOC	81.71	1287.81	0.11	
10 min	TOC	80.98	1288.54	0.73	
15 min	TOC	80.55	1288.97	0.43	
20 min	TOC	80.02	1289.50	0.53	
25 min	TOC	79.46	1290.06	0.56	
30 min	TOC	78.95	1290.57	0.51	
1 hour	TOC	76.09	1293.43	2.86	
2 hour	TOC	70.32	1299.2	5.27	
24 hour	TOC	12.47	1357.05	58.35	83.31 (S)
Static Water Level ² : 6.59			Measured by: CR 3		


¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: See field notes - well damaged upon arrival
 Flushed well for 1 hr. using 40 gallons H₂O - water not clear after
 1 hr. Flushed w/ 1 more well volume and started recovery rate test.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-14-97
	PIEZ. ID: F 760 RA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 52.14
Monitoring Instrument: SOLOMIST	Weather: CLEAR SUNNY, 20°F CALM WIND

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	34.80	1334.44	—	
15 Sec	TOC	32.80	1336.44	2.00	
30 Sec	TOC	30.60	1338.64	2.20	
45 sec	TOC	29.00	1340.24	1.6	
1 min	TOC	27.18	1342.06	1.82	
2 min	TOC	22.20	1347.04	4.98	
3 min	TOC	17.61	1351.63	4.59	
4 min	TOC	14.78	1354.46	2.83	
5 min	TOC	12.63	1356.61	2.15	
10 min	TOC	7.50	1361.74	5.13	
15 min	TOC	7.15	1362.09	0.35	
20 min	TOC	7.05	1362.19	0.1	52.17 well depth (5)
25 min	TOC	7.05	1362.19	0	
30 min	TOC	7.05	1362.19	0	
1 hour	TOC	7.05	1362.19	0	
2 hour	TOC	7.05	1362.19	0	
24 hour	TOC	7.05	1362.19	0	
Static Water Level ² : 7.05			Measured by: 		

¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. SEDIMENT CONTACTED AT BASE OF WELL. SEDIMENT ON TIP OF WL TUBE AFTER REMOVE FROM WELL, FLUSHED WITH TWO WELL VOLUMES - CLEAR WATER, SOME WHITE PRECIPITATE. FOLR

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-15-97
	PIEZ. ID: F 760 RB
LOCATION: Big Bend Dam, SD.	Depth of Piez: 82.93
Monitoring Instrument: SOUNIST	Weather: PARTLY CLOUDY, 17°F N WIND AT 5 mph

10:00

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	78.11	1290.18	—	
15 Sec	TOC	77.46	1290.83	0.65	
30 Sec	TOC	76	—	—	
45 sec	TOC	76.70	1291.59		
1 min	TOC	76.35	1291.94	0.35	
2 min 30 SEC	TOC	73.88	1294.41	2.47	
3 min	TOC	73.17	1295.12	0.71	
4 min	TOC	72.20	1296.09	4.03	
5 min	TOC	69.80	1298.49	7.4	
10 min	TOC	61.15	1307.14	8.65	
15 min	TOC	55.65	1312.64	5.5	
20 min	TOC	49.24	1319.05	6.41	
25 min	TOC	42.00	1326.29	7.24	
30 min	TOC	38.25	1330.04	3.75	
1 hour	TOC	12.92	1355.31	25.33	
2 hour	TOC	6.97	1361.32	5.95	
24 hour	TOC	6.11	1362.18	0.86	83.18 (S)
Static Water Level ² : 6.10				Measured by: CS	

¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. SEDIMENT FELT ON WEL
TAPE PROBE AT BOTTOM OF WELL. FLOUED W/ 3 WELL VOLUMES POTABLE
WATER.

11:00

12:00

10:00

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-15-97
	PIEZ. ID: F 960 RA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 36.42
Monitoring Instrument: SOLONIST	Weather: P cloudy, 17°F N wind at 5

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
11:40 0	TOC	30.70	1338.52	—	
15 Sec	TOC	29.10	1340.12	1.6	
30 Sec	TOC	28.00	1341.22	1.1	
45 sec	TOC	26.65	1342.57	1.35	
1 min	TOC	25.87	1343.35	0.78	
2 min	TOC	21.31	1347.91	4.56	
3 min	TOC	19.02	1350.20	2.29	
4 min	TOC	16.28	1352.94	2.74	
5 min	TOC	14.30	1354.92	1.98	
10 min	TOC	8.97	1360.25	5.33	
15 min	TOC	8.18	1361.04	0.79	
20 min	TOC	8.12	1361.10	0.06	
25 min	TOC	8.12	1361.10	0	
30 min	TOC	8.12	1361.10	0	
12:40 1 hour	TOC	8.12	1361.10	0	
1:40 2 hour	TOC	8.13	1361.09	-0.01	
11:40 24 hour	TOC	8.15	1361.07	-0.02	36.43 (#)
Static Water Level ² : 8.12				Measured by: <i>[Signature]</i>	

¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. SEDIMENT FELT IN WELL.
 FLUSHED 1/3 WELL VOLUMES - WATER CLEAR.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-15-97
	PIEZ. ID: F 960 RB
LOCATION: Big Bend Dam, SD.	Depth of Piez: 84.06
Monitoring Instrument: SOLONIST	Weather: P. CLOUD 17°F N. WIND @ 5 mph

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
11:05 0	TOC	60.10	1309.3	—	
15 Sec	TOC	57.22	1312.18	2.88	
30 Sec	TOC	55.40	1314.00	1.82	
45 sec	TOC	53.70	1315.70	1.70	
1 min	TOC	52.40	1317.00	1.3	
2 min 30 sec	TOC	42.65	1326.75	9.75	
3 min	TOC	40.00	1329.40	2.65	
4 min	TOC	34.90	1334.50	5.1	
5 min	TOC	29.10	1340.30	5.8	
10 min	TOC	13.60	1355.80	15.5	
15 min	TOC	8.65	1360.75	4.95	
20 min	TOC	8.31	1361.09	0.34	
25 min	TOC	8.30	1361.10	0.01	
30 min	TOC	8.31	1361.09	-0.01	
12:05 1 hour	TOC	8.31	1361.09	0	
2:05 2:05 2 hour	TOC	8.31	1361.09	0	
11:05 24 hour	TOC	8.37	1361.03	-0.06	84.07 s
Static Water Level ² : 8.29			Measured by: <i>[Signature]</i>		

¹ All measurements in 0.01 feet.


² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. SEDIMENT FELT IN WELL. FLUSHED WITH THREE WELL VOLUMES.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-16-97
	PIEZ. ID: G 680 RA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 34.04
Monitoring Instrument: Rock-test (1 ft intervals)	Weather: BCLMR, Sunny, 20°F W wind at 5 mph

11:56

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	27.3	1342.42	—	
15 Sec	TOC	25.4	1344.32	1.9	
30 Sec	TOC	24.7	1345.02	0.7	
45 sec	TOC	23.3	1346.42	1.4	
1 min	TOC	22.7	1347.02	0.6	
2 min	TOC	19.7	1350.82	3.8	
3 min	TOC	16.5	1353.22	2.4	
4 min	TOC	14.81	1354.91	1.69	
5 min	TOC	12.5	1357.22	2.31	
10 min	TOC	7.00	1362.72	5.5	
15 min	TOC	5.22	1364.50	1.78	
20 min	TOC	4.75	1364.97	0.47	
25 min	TOC	4.50	1365.22	0.25	
30 min	TOC	4.40	1365.32	0.1	
1 hour	TOC	4.40	1365.32	0	
2 hour	TOC	4.33	1365.39	0.07	
24 hour	TOC	4.26	1365.46	0.07	34.21 (5)
Static Water Level ² : 4.28				Measured by: 	

12:50

1:50

11:56


¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. SEDIMENT IN BOTTOM OF WELL. 5 WELL VOLUMES ADDED - CLEAR. WHITE PRECIPITATE FLUSHED FROM WELLS.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-10-97
	PIEZ. ID: G 680 RB
LOCATION: Big Bend Dam, SD.	Depth of Piez: 83.26
Monitoring Instrument: Roc-test (1 ft intervals)	Weather: CLEAR, SUNNY, 27°F CALM WINDS

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	78	1291.95	—	
15 Sec	TOC	77	1292.95	1.0	
30 Sec	TOC	76.8	1293.15	0.2	
45 sec	TOC	76.6	1293.35	0.2	
1 min	TOC	76.15	1293.80	0.45	
2 min	TOC	75.5	1294.45	0.65	
3 min	TOC	74.3	1295.65	1.2	
4 min	TOC	73.1	1296.85	1.2	
5 min	TOC	72.1	1297.85	1.0	
10 min	TOC	64.80	1305.15	7.3	
15 min	TOC	62.10	1307.85	2.7	
20 min	TOC	59.00	1310.95	3.1	
25 min	TOC	58.50	1315.45	4.5	
30 min	TOC	50.50	1319.45	4.0	
1 hour	TOC	29.60	1340.35	20.9	
2 hour	TOC	14.56	1355.39	15.04	
24 hour	TOC	4.43	1365.52	10.13	83.28 (5)
Static Water Level ² : 4.46				Measured by: 	


¹ All measurements in 0.01 feet.

² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. Sediment in Bottom OF WELL. FLUSHED w/5 well volumes - water clear. WHITE PRECIPITATE FLUSHED FROM WELLS

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test	DATE: 12-15-97
	PIEZ. ID: G 880 RA
LOCATION: Big Bend Dam, SD.	Depth of Piez: 43.68
Monitoring Instrument: Solonist	Weather: Sunny, Clear, 30° F CALM WINDS


TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	43.80	1325.15	—	
15 Sec	TOC	43.76	1325.19	0.04	
30 Sec	TOC	43.74	1325.21	0.02	
45 sec	TOC	43.70	1325.25	0.04	
1 min	TOC	43.70	1325.25	0	
2 min	TOC	43.60	1325.35	0.1	
3 min	TOC	43.52	1325.43	0.08	
4 min	TOC	43.46	1325.49	0.06	
5 min	TOC	43.39	1325.56	0.07	
10 min	TOC	43.00	1325.95	0.39	
15 min	TOC	42.65	1326.30	0.35	
20 min	TOC	42.31	1326.64	0.34	
25 min	TOC	41.75	1327.20	0.56	
30 min	TOC	41.50	1327.45	0.25	
1 hour	TOC	39.78	1329.17	1.72	
2 hour	TOC	36.60	1332.35	3.18	
24 hour	TOC	4.76	1364.19	31.84	43.93 (H)
Static Water Level ² : 2.22 (ice)				Measured by: 	

¹ All measurements in 0.01 feet.² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. ICE IN WELL AT 55" TOR.
FLUSHED WELL W/3 VOLUMES - CLEAR.

Attachment 3. Piezometer Response Test Data Form

PROJECT: Big Bend Piezometer Rehabilitation and Response Test		DATE: 12-15-97
		PIEZ. ID: G 880 RB
LOCATION: Big Bend Dam, SD.		Depth of Piez: 81.73
Monitoring Instrument: SOLONIST		Weather: CLEAR, SUNNY, 20°F, CHILL WINDS

TIME	MEASURE POINT	DEPTH TO WATER ¹	ELEV.	W.L. RESPONSE (Change) ¹	COMMENTS
0	TOC	78.00	1291.95	—	
15 Sec	TOC	77.40	1292.55	0.6	
30 Sec	TOC	77.10	1292.85	0.3	
45 sec	TOC	76.65	1293.30	0.45	
1 min	TOC	76.32	1293.63	0.33	
2 min	TOC	74.31	1295.64	2.01	
3 min	TOC	73.22	1296.73	1.09	
4 min	TOC	71.79	1298.16	1.43	
5 min	TOC	70.22	1299.73	1.57	
10 min	TOC	63.01	1306.94	7.21	
15 min	TOC	57.30	1312.65	5.71	
20 min	TOC	51.36	1318.59	5.94	
25 min	TOC	45.85	1324.10	5.51	
30 min	TOC	42.05	1328.45	4.35	
1 hour	TOC	22.15	1347.8	19.35	
2 hour	TOC	6.59	1363.36	15.56	
24 hour	TOC	4.93	1365.02	10.63	82.18 (5)
Static Water Level ² : 4.93				Measured by: 	

¹ All measurements in 0.01 feet.² Static water level recorded prior to piezometer rehabilitation.

Additional Comments: WELL IN GOOD CONDITION. FLUSHED w/4 gal volume POTABLE WATER - CLEAR.