Bringing New Life to an Old Supply, One Well at a Time

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ABSTRACT

In 2011, the Town of North Attleborough, MA began its second attempt to replace one of its failing groundwater supplies. Plainville Well No. 2 was constructed in 1978 with an original capacity of approximately 700 gallons per minute (gpm), and served as one of the Town's major production wells. Since the early 2000s, the well has been exhibiting a continuous loss of capacity to such a degree that the Town could only rely on this well to supply approximately 250-300 gpm due to excessive drawdown. Given the characteristics of the existing caisson well, standard well rehabilitation techniques were not effective in restoring its capacity. In 2007, the North Attleborough Department of Public Works (NADPW) began an exploratory test well program to locate and construct a new satellite replacement well as close as possible to the existing well and pump house. A satellite well was located and installed, however, it fell short of its anticipated yield. In 2011, a second exploratory test well program was completed employing a different approach for locating a new satellite well which proved to be successful. A new 675 gpm replacement well with a 36-inch Baker/Monitor pitless adapter has since been permitted, designed and constructed.

Introduction

The NADPW's public water system includes 9 wells, 3 water storage tanks, approximately 150 miles of water main and two treatment facilities including McKeon and Whiting Street. Seven of the wells are located within the Ten Mile River Basin, and the other two wells are located within the Blackstone River Basin. Plainville Well No. 2 is one of four wells that make up the Plainville Well Field which is constructed within the sand and gravel aquifer of the upper Ten Mile River Basin in Plainville, MA (Figure 1). Raw water from these wells are pumped up the Whiting Street Treatment Facility where it is treated via aeration and greensand filtration prior to being delivered into the distribution system.

Plainville Well No. 2 is a 6-foot diameter caisson well, approximately 35 feet deep and includes a 13-foot by 15-foot brick and block pump house (Figure 2). The well itself is located within the lower level of the pump house along with the discharge piping (Figure 3). The well had an original production capacity of 1 million gallons per day (MGD), but currently can provide

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Figure 1. Plainville Well Field

only about 50% of this capacity due to plugging of the well screen and aquifer zone near the screen that has occurred over its years of operation. Efforts to restore its capacity through available mechanical and chemical cleaning methods have been made with no success. The NADPW elected to proceed with locating a new satellite replacement well during the period between July 2007 and October 2008. Exploratory drilling was performed within 50 to 100 feet of the existing well to determine if subsurface conditions were suitable for construction of a replacement gravel packed well. Based on the test well results, a 12″ x 18″ diameter gravel packed well was recommended and constructed approximately 55 feet north of the existing well to a depth of 34 feet with 6 feet of 70 slot well screen (Figure 4). The new gravel packed well was constructed in a manner such that it could be used as a MassDEP-approved production well if well testing results were successful. However, after constructing and developing the new 12″ x 18″ well, the capacity of the well was observed to be only about 100 gallons per minute (gpm) which was not as expected based on previous test well results. Due to the low well yield, the sanitary seal was not installed and further testing of this well was cancelled.

Figure 2. Plainville Well No. 2 Pump House

Figure 3. 6′ Diameter Caisson Well in Pump House

Revised Approach for Improved Yield

In 2011, the NADPW revisited the possibility of constructing a satellite replacement well for Plainville Well No. 2. A different approach to selecting test well locations was employed, including the use of geophysical seismic refraction survey as recommended by Kilbridge Geological Service (KGS). A test well exploration program confined to an exploration zone located within a 250-foot radius of the existing well per MassDEP *Polices for Public Water Systems, Section 4.15* was completed by KGS from September 20 through October 20, 2011. Seven (7) 2-1/2 inch diameter steel test wells including TW-1-11 through TW-7-11 were installed (Figure 4). The selection of the test well locations was based on the results of the geophysical seismic refraction survey, delineation of wetland resource areas, proximity to the Ten Mile River, proximity to existing infrastructure, and estimated constructability.

The seismic refraction technique was used to improve the efficiency of selecting test well target locations by increasing the probability of drilling within the most saturated thickness of the aquifer near the existing well No. 2, which should provide the greatest yield. The results

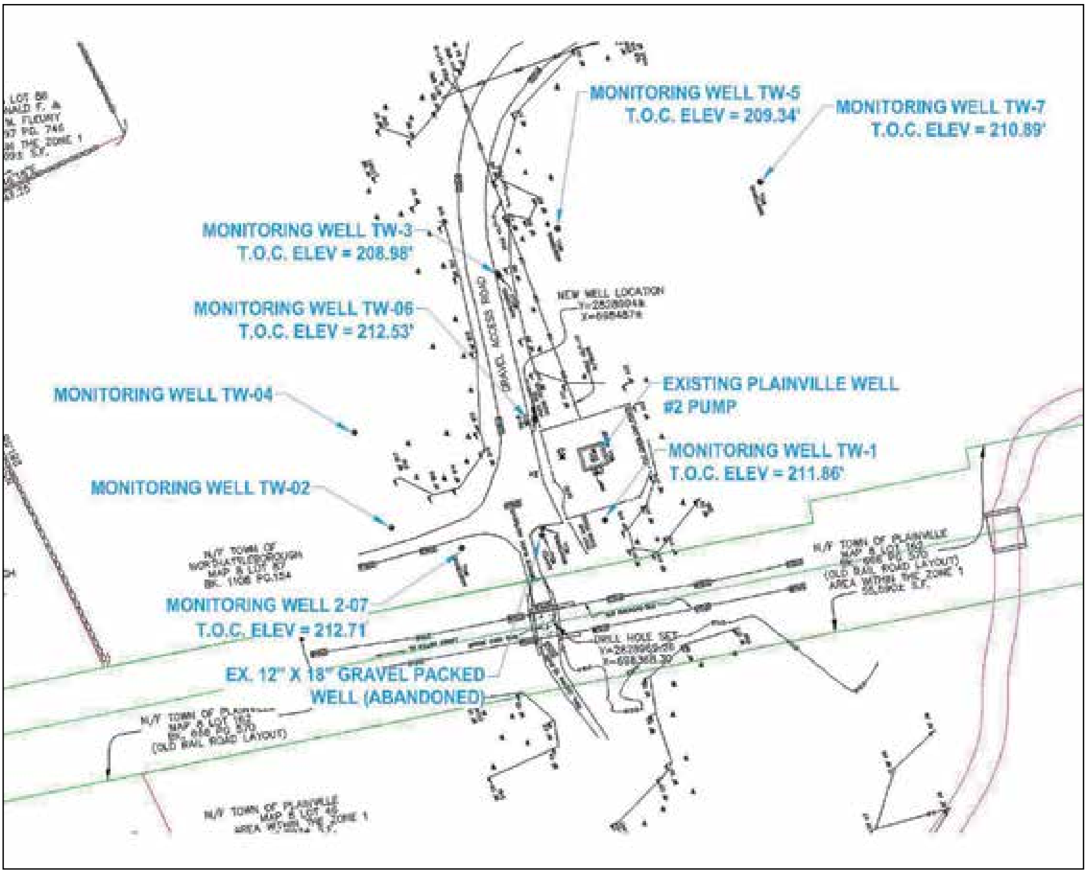

Figure 4. Plainville Well No.2 Site Plan with Test Well Locations

of the test well exploration program are summarized in Table 1. In general, depth to bedrock refusal of the installed test wells corroborated the estimated bedrock depths based on the seismic refraction profiles, with actual refusal depths generally being 5-10% less than predicted refusal depths. The shallower refusal depths encountered when drilling were due to encountering casing refusal within a dense layer of glacial till directly above the bedrock. The relative depth of bedrock interpreted along the estimated seismic profiles was successful in guiding the selection of test well locations to be along the deepest sections of seismic profiles.

Based on the results of the initial testing, three test wells were selected for performing a four hour pump test and water quality sampling including TW-3-11, TW-6-11 and TW-7-11. To conduct the pumping test, an observation well was installed two feet away from each of the three primary test wells for measuring water level drawdown while the primary test well was pumped continuously at a steady pumping rate for four hours. For each pumping test, the observation well that was installed next to each primary test well was also pumped with water level drawdown being measured in the primary test well. Potential production capacity for each test well was estimated using the pumping rate and drawdown measured during the test to calculate the specific capacity, assuming available drawdown based on the test well depth, five foot production well screen length, five foot safety zone above the top of screen, static depth below grade observed during the pumping tests, and applying a further 25-50% safety factor reduction to the calculated safe yield. The estimated yields for test wells TW-3-11, TW-6-11 and TW-7-11 are shown in Table 1.

For each pumping test, water samples were collected at the start and end of the pumping test and measured for pH, temperature, odor, specific conductance, visual clarity, total coliform, secondary contaminants, VOCs and perchlorate.

Table 1. Results of 2011 Test Well Exploration Program

Test Well	Refusal Depth (feet)	Screen Depth (feet)	Test Well Flow (gpm)	Estimated Well Yield[(1)] (gpm)	Comments
TW-1-11	39.5	32	43		Medium capacity, 40′ west of Well 2, 30′ to surface water
TW-2-11	40	35	8		Low capacity, fine sand
TW-3-11	43.5	35	100	700–800	High capacity, next to water main, 10′ to surface water
TW-4-11	44.5	26	50		Medium capacity, shallow depth, 20′ to surface water
TW-5-11	37	33	100		High capacity, good depth, 10′ to surface water
TW-6-11	44	31	90	600–700	High capacity, moderate depth, near Well 2, 30′ to surface water
TW-7-11	27	26	100	450–700	High capacity, shallow depth, furthest from surface water & Well 2

[(1)] Based on results of 4 hour pumping test performed on the test well.

Preliminary water quality results indicated that water from all three 2.5-inch diameter test well sites was acceptable to allow for considering either site as a potential satellite production well location.

Conceptual Design for Satellite Replacement Well

From the soil grain analyses conducted on the three test wells, various well screen diameters and slot openings were evaluated for both a naturally developed well and a gravel packed well to detemine the design most capable of providing the yield estimated from the pumping tests. This preliminary well screen design analysis indicated that a new satellite well screened in the aquifer formation represented by the three primary test wells TW-3-11, TW-6-11, or TW- 7-11 should be a diameter of 36 inches and should be a gravel packed well. The gravel pack diameter (outer bore hole) should be either 48 or 54 inches to provide a minimum thickness of 6 inches of gravel pack envelope around the well screen but a maximum pack thickness of nine inches.

The results of the 2011 test well exploration program were successful in identifying three favorable locations for constructing a replacement well that could meet almost 100% of the original production capacity of NADPW's existing well. All three test well locations had similar constraints related to wetlands/environmental impacts and meeting Zone 1 requirements. Taking into consideration the proximity of each test well to the existing pump house, water main and access road, test well TW-6-11 was selected as the most favorable location to construct a new replacement well (Figure 5).

Based on the results of the test well exploration program and a review of previous test well data collected for the site, it was recommended that the NADPW proceed with constructing a single 36-inch diameter gravel packed well with a target depth of 31 feet at the location of test well TW-6-11. This new well would serve as both the test well for performing the 72-hour pump test and water quality sampling required as part of the *Source Final Report,* and the actual final production well upon obtaining MassDEP approval to construct and operate. This approach would avoid having to install a smaller intermediate test well such as a 12-inch diameter well to perform the required 72-hour pump test and water quality sampling, and then replacing it with the larger production well. Although there is some inherent risk in proceeding with the design of a production well based on 2-1/2 inch test well results, it was concluded that the data collected supported this approach, which eventually saved the NADPW about $60,000 in engineering and drilling costs. It was also recommended that the new gravel

Figure 5. Test Well TW-6-11 with Observation Well

packed well be constructed using the cable tool pull down method, which is the least disturbing method of casing installation and would have the lowest risk of compacting the aquifer formation. Using a driving or rotary method for installing the well casing could potentially compact or otherwise compromise the loose properties of the aquifer sediment, thereby reducing the transmissive characteristics and production capacity of the new well.

The initial basis of design was to provide the new well with a submersible pump and pitless adapter, and use as much of the existing infrastructure as possible for adding the new well to the NADPW's water system. The existing pump station structure is in good condition, and the existing electrical and mechanical systems are serviceable. Some minor demolition and alterations will be needed to provide sufficient space to house the new variable frequency drive, pump control panel and other related equipment for operating the new well. Per the NADPW's request, the connection of the new well was to be designed so that the new well could operate alone or simultaneously to supplement the existing well, which was to be left intact. The only potential concern was that this design concept would now require the use of a 36-inch pitless adapter for the new well, which is the largest one to ever been installed and is not that common. Dewberry reviewed the conceptual design with Harmon & Co., Inc., to confirm the availability and feasibility of using a 36-inch pitless adapter for the new replacement well.

New Gravel-Packed Well Installation and Testing

Upon obtaining MassDEP approval of the test well exploration program and Pumping Test Proposal in August 2013, Dewberry and its subconsultant KGS proceeded with the work required for the design and construction of the new gravel-packed well and appurtenances. Due to the presence and proximity of wetlands resource areas, a Notice of Intent was filed with the Plainville Conservation Commission for performing construction activities related to the new satellite replacement well. An Order of Conditions (OOC) for the project was issued in January 2014 that covered the drilling, installation, development and testing of the new well along with the installation of the new pump, water main, electrical service and appurtenances.

The installation and development of a new 54″ x 36″ gravel packed well at the test well location TW-6-11 was completed by Layne Christensen Company from April to June 2014 using the cable tool pull down method as recommended. The new well was drilled to a depth of 31 feet and included: a 36″ diameter, 5-foot long stainless steel screen with a 125-slot size (Figure 6); approximately 30 feet of 36-inch diameter permanent steel casing; 12.5 feet of 9-inch thick sanitary concrete seal; and 10 feet of double gravel pack including a 3-inch thick #3 outer pack and a 6-inch 1/8″ x ½″ inner pack**.** The sanitary seal was terminated at a depth of about 6.5 feet below existing grade to allow for the future installation of the 36-inch

Figure 6. 36" Diameter Stainless Steel Well Screen

pitless adapter and connection to the existing well discharge main. The 36-inch diameter permanent casing was also extended about 4 feet above grade to accommodate the future installation of the pitless adapter. To properly install the double gravel pack, 54-inch and 48-inch temporary steel casings were used to construct the well (Figure 7).

Upon completing the installation and development of the new well, a 72-hour pump test was performed on the well from July 7-10, 2014, with recovery readings taken for 24 hours after the test. The new well was pumped continuously at a discharge rate of 675 gpm. Five existing on-site monitoring wells along with two newly installed piezometers were used for measuring drawdown and recovery during the pump test. Water quality samples were also collected at the end of the pumping test. The results of the 72-hour pump test indicated that the new 54-inch x 36-inch gravel packed well should be able to sustain a production capacity of 675 gpm, which is close to the original capacity of the existing 6' caisson well. The water quality of the new well was observed to be similar to the existing wells within the Plainville well field, with slightly high manganese (0.105 mg/L), which will be treated at the NADPW's existing greensand filtration plant at Whiting Street.

Since the location of the new gravel packed well is located within approximately 30 feet of impounded surface water, a microscopic particulate analysis (MPA) water quality test was performed during the final 24 hours of pumping. The MPA result was "Low Risk." The OOC issued for the project by the Plainville Conservation Commission authorized the NADPW to fill approximately 900 square feet of wetlands that would effectively create a setback of about 50 feet between the new well and this surface water feature. The design intent was to reproduce the same setback to this surface water feature for the new well as currently exists for the existing well to create a similar hydrogeological setting which has proven to be effective based on historical water quality. A Source

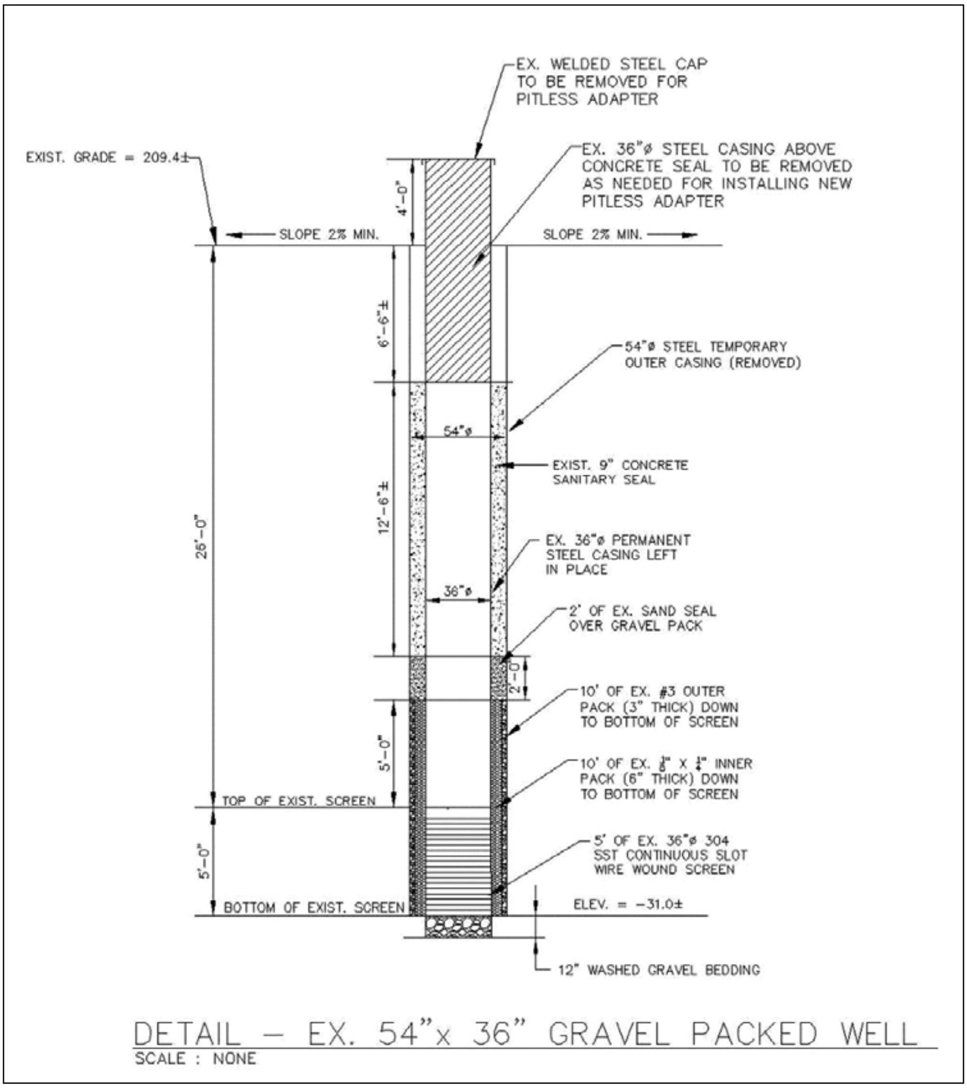

Figure 7. Schematic of 54" x 36" Gravel Packed Well

Final Report summarizing the results of the 72-hour pumping test was prepared and submitted by Dewberry and KGS in January 2015 along with a *BRP WS20: Approval to Construct a Source of 70 GPM or Greater* permit application and supporting documentation. The NADPW received MassDEP approval of the Source Final Report and for the construction of the project in March 2015.

New Pumping System

The design of the pumping system for the new gravel packed well included a 40 HP submersible pump with VFD motor, a 9-1/2 foot long, a 36-inch pitless adapter, new 8-inch ductile iron water main, new precast concrete flow chamber to house a new electromagnetic flow meter, check valve and air valve, electrical systems, process piping and instrumentation. The design also included upgrades to the existing pump station to accommodate the installation of a new VFD and new PLC-based pump control panel. A level transducer was provided within the well to continuously measure drawdown and automatically shut down the pump upon activating a low well level alarm. The existing above-grade steel casing and cap installed during the well installation was cut and removed for installing the new Baker/Monitor pitless adapter**.** The new 36-inch pitless adapter was designed to extend a minimum of 3 feet above the finished grade to ensure that the cap was above the 100-year flood elevation (Figure 8). The 36-inch pitless adapter is equipped with a 2-1/2″ screened casing vent located at the top of the cover as required per Chapter 4 of the MassDEP Guidelines for Public Water Systems. The vent was sized to accommodate the 36-inch casing (Figure 9). The connection of the new well and water main to the existing well piping system was designed so that the new precast concrete flow chamber would be common to both the new well and existing well to allow flow to be measured from either well, separate or combined (Figure 10).

New Pumping System Construction

The project was bid in August 2015 with the construction contract awarded to Barbato Construction Co., Inc. for $307,500 (Engineer's Estimate = $375,000). Construction began in October 2015. A majority of the site work, including the installation of the new submersible pump, pitless adapter, precast concrete flow chamber and water main was completed in 2016. The existing station and well remained in service throughout the construction except during the final tie-in of the water main and testing of the new well pump and VFD. Due to the heavy precipitation experienced from January through March 2016, site work activities could not begin until May when

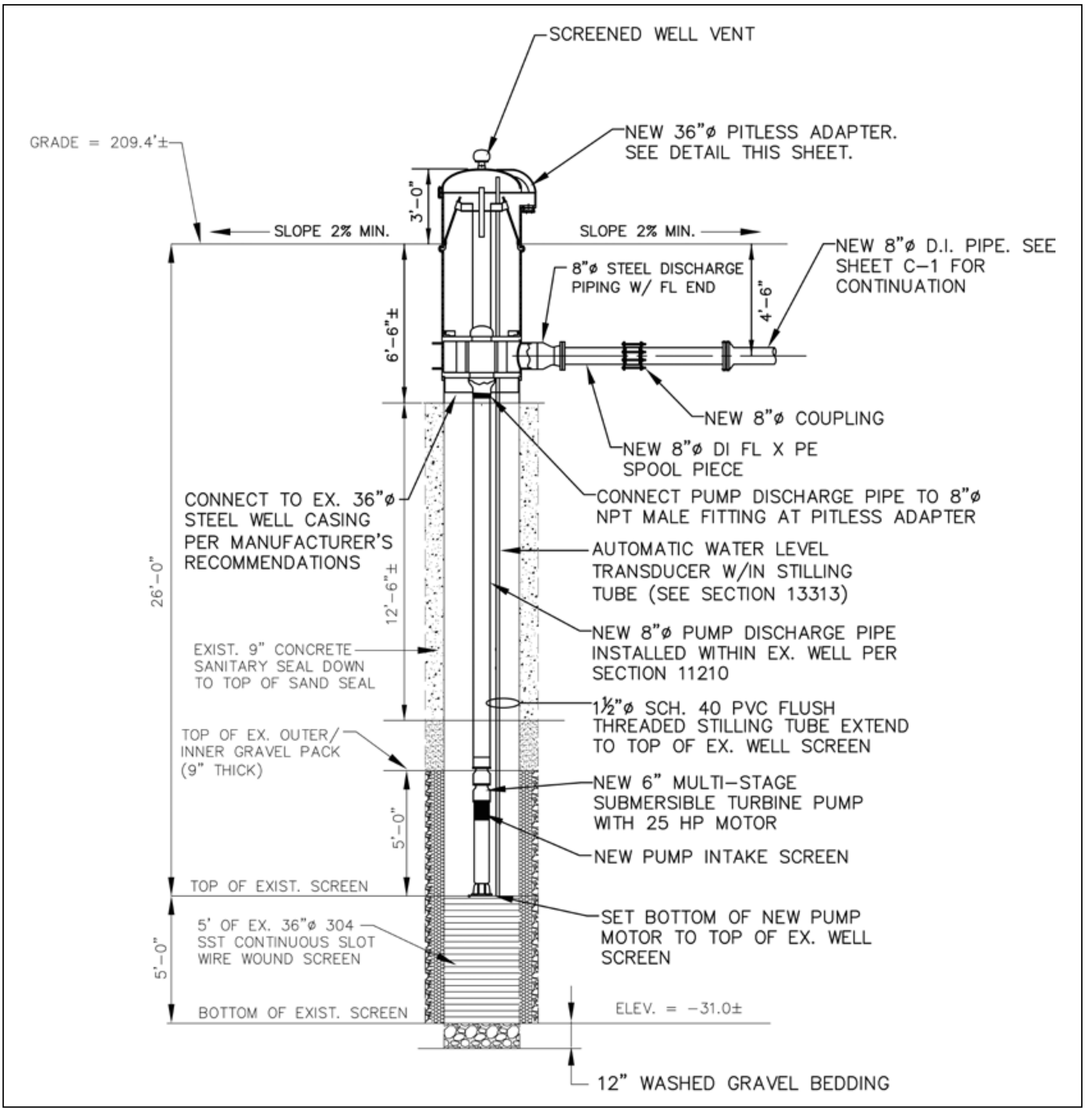

Figure 8. New Pump & Pitless Adapter in Well

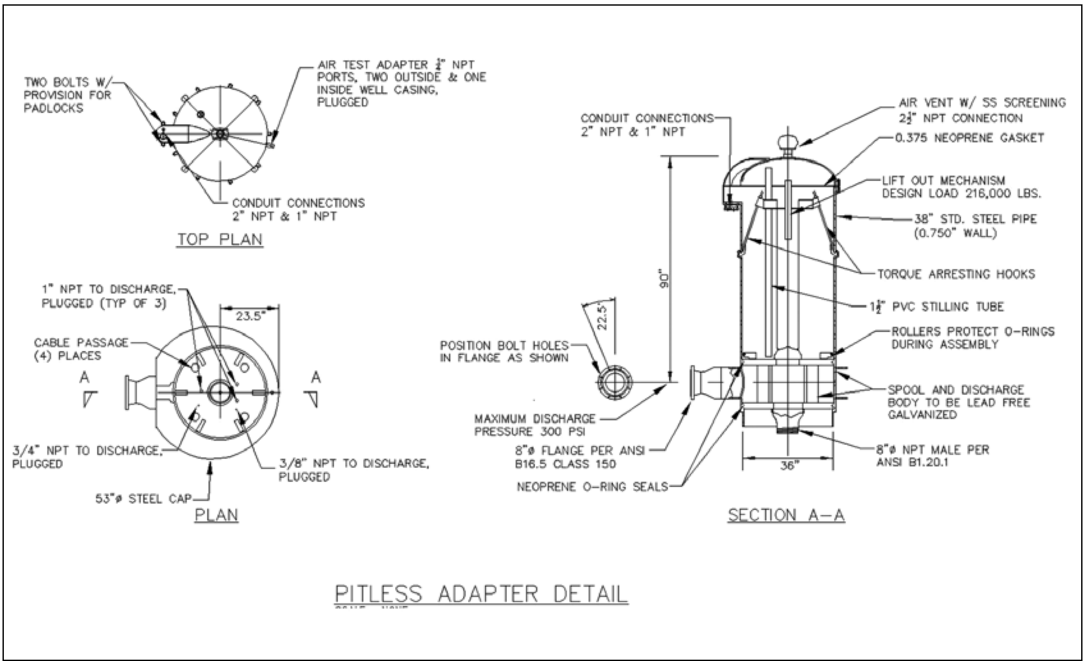

Figure 9. New 36" Baker/Monitor Pitless Adapter

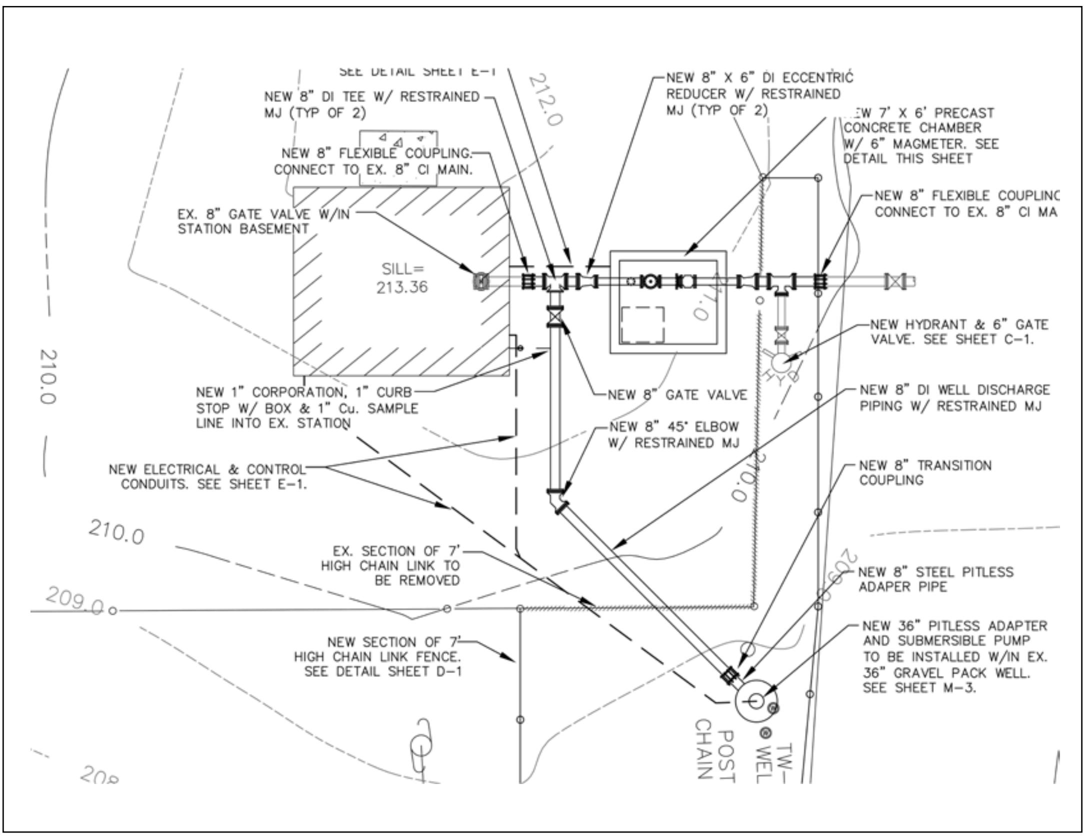

Figure 10. New Well Site Layout

Figure 11. Baker/Monitor Pitless Adapter Being Installed

Figure 12. Baker/Monitor Pitless Adapter Spool Assembly

Figure 13. Completed Baker/Monitor Pitless Adapter with Casing Vent

the high groundwater finally began to recede. Maher Services was hired by the contractor to furnish and install the 36-inch Baker/Monitor pitless adapter, submersible well pump and level transducer within the new gravel-packed well (Figures 11, 12 and 13).

The installation of the pitless adapter, exterior electrical service and water main were completed by August 2016 with the new pump, VFD, controls and final connection to the existing system completed by December 2016. The final inspection by MassDEP was performed in January 2017 and the new gravel–packed replacement well has been approved and placed into operation.

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