

APPENDIX F

SPECIFICATION FOR DRILLING AND INSTALLATION OF BEDROCK MONITORING WELL

PART 1 GENERAL

1.01 SCOPE OF WORK

- A. Furnish all labor, materials, equipment, and all other facilities and incidentals required and construct one bedrock monitoring well in the Denver Formation in western Arapahoe County to a depth of up to approximately 740 feet.
- B. Furnish all labor, materials, equipment, and all other facilities and incidentals required and develop the well.
- C. This Appendix is intended to give a general description of what is required, but does not cover all variations that may occur during well construction. This Appendix is intended to cover the successful completion and testing of the observation wells as herein specified, whether every detail is specifically mentioned or not.

1.02 RELATED WORK

- A. Refer to Appendix G, Specification for Bedrock Well Development.
- B. Refer to Appendix E, Specification for Geophysical Logging.

1.03 SUBMITTALS

- A. Submit, at least 5 days before beginning the well installation, the following:
 - 1. A complete list of construction materials and supplies including the name of the manufacturer, for the items listed below:
 - a. Casing
 - b. Well screen
 - c. Centralizers
 - d. Gravel pack
 - e. Grout(s)
 - f. Caps
 - g. Protective steel cover
 - 2. The source and location of potable water supply, written authorization of the suppliers, and method of transporting and containing the potable water.

3. The methods by which all volumetric calculations will be performed for placement of grouts and other annular completion materials in the borehole.
 4. The planned grout composition, mixing method, and equipment to be used for grouting.
- B. During drilling of each well, maintain a complete log at the well site setting forth the following:
1. The reference point for all depth measurements.
 2. The depth at which each change of formation occurs.
 3. The identification of the material of which each stratum is composed.
 4. The depth interval from which formation samples were taken.
 5. The depth at which hole diameters (bit sizes) change.
 6. Other pertinent data requested by the ENGINEER.
- C. During drilling of each well, a daily detailed driller's report shall be maintained and submitted as requested by the ENGINEER. The report shall give a complete description of number of feet drilled, number of hours on the job, shutdown due to breakdown, feet of casing set, and other pertinent data requested by the ENGINEER.
- D. During drilling of each well, formation samples shall be collected and preserved immediately after retrieval in a manner approved by the ENGINEER. Samples shall be clearly and indelibly labeled with the following information:
1. Name or number of the well.
 2. Depth interval represented by the sample.
 3. Date taken.
 4. Time taken.
- E. Upon completion of each well, submit to the ENGINEER a report to include the following:
1. The total depth of the completed well.
 2. The depth or location of any lost drilling fluid, drilling materials, or tools.
 3. The depth of the surface casing seal.
 4. The nominal hole diameter of the well bore above and below the casing seal.
 5. The amount of cement (number of bags) used for the seal.
 6. The depth and description of the well casing.
 7. The complete description (including length, diameter, slot sizes, etc.) of any well screens.

8. Other pertinent data requested by the ENGINEER.

1.04 REFERENCE STANDARDS

- A. The latest revisions of standards of AWWA, ASTM, and API shall apply as referenced herein. Standards shall include, but are not restricted to the following:
 1. American Society for Testing and Materials (ASTM)
 - a. ASTM D1784 - Standard Specification for Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds
 - b. ASTM F480 - Standard Specification for Thermoplastic Well Casing Pipe and Couplings Made in Standard Dimension Ratios (SDR), Schedule 40 and 80
 2. The latest revisions of the Office of the State Engineer's Rules and Regulations for Water Well Construction, Pump Installation and Monitoring and Observation Hole/Well Construction including any additional special provisions of Denver Basin Rules.
- B. Where reference is made to one of the above standards, the revision in effect at the time of bid opening shall apply.

1.05 QUALITY ASSURANCE

- A. The CONTRACTOR responsible for employing only competent workmen for the execution of this work and all such work shall be performed under the direct supervision of an experienced well driller who is satisfactory to the ENGINEER.
- B. The well driller shall be capable of maintaining complete and current well logs and daily notes for the well completion report, and developing and testing the wells.
- C. The OWNER may make any other investigations deemed necessary to determine the ability of the CONTRACTOR to perform the work and the CONTRACTOR shall furnish to the OWNER all such information and data for this purpose as the OWNER may request.
- D. Complete the work described in this Appendix in accordance with applicable portions of the Office of the State Engineer's Rules and Regulations for Water Well Construction, Pump Installation, and Monitoring and Observation Hole/Well Construction

1.06 DESCRIPTION OF WELLS AND SITE

- A. One 8-inch diameter PVC monitoring well will be constructed to a depth of up to approximately 740 feet and have a well screen up to 200 feet in length.
- B. The well location is anticipated to be located in the Denver Basin. The drilling site will be located on public rights-of-way or private property and will be accessible for the duration of the drilling and monitoring under agreements to be provided by the OWNER. No electrical or water service is available at the site. It is anticipated that the drilling site will be accessible to normal drilling equipment without significant grading or road construction. Upon completion of the work, the CONTRACTOR shall disperse all cuttings, debris, drilling fluid, and promptly

remove all unused materials, trash, and debris, and restore the site as nearly as possible to its original conditions.

- C. The unconsolidated alluvial deposits and bedrock formations into which the well is to be installed are known to contain stiff cohesive clays, swelling clays, and/or flowing/heaving sands at some locations. It will be the CONTRACTOR's responsibility to control these conditions to the extent necessary to permit proper construction of the well as outlined in these appendices. The above information regarding subsurface conditions is intended to assist the CONTRACTOR in bidding and the OWNER or ENGINEER does not guarantee its accuracy or that it is necessarily indicative of conditions to be encountered in drilling the well. No additional compensation will be awarded to the successful bidder for any equipment, time or and materials required to control such conditions.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. All parts and materials shall be properly protected so that no damage, deterioration, or contamination, occurs from time of shipment until installation is completed.

1.08 PERMITS

- A. The ENGINEER will acquire notifications and permits from the Colorado State Engineer to construct the monitoring wells.
- B. Any permits required to access the drilling site will be provided by the ENGINEER.
- C. The CONTRACTOR shall have all of the appropriate licenses as required by the Colorado State Board of Examiners of Water Well Construction and Pump Installation Contractors for drilling and installing monitoring wells in Type 1 aquifers by mud rotary techniques.
- D. The ENGINEER shall obtain any federal, state, or local permits required for constructing the wells, including discharging water from the site, or clearing the site.
- E. Do not perform any work on the well until access is obtained.

1.09 UNDERGROUND AND OVERHEAD UTILITIES

- A. The ENGINEER will secure information concerning the location of underground and overhead utilities at the site, prior to the start of well construction.

1.10 NOTIFICATION

- A. Supply to the ENGINEER in writing at least 10 days before mobilization, the proposed work schedule including the following:
 - 1. The starting date of the well construction.
 - 2. The anticipated completion date of the well drilling and development.
 - 3. Any anticipated work stoppage of greater than 24 hours with exception of weekends and holidays.

4. The number of well drilling rigs and personnel to be used on the project. Any change in the number of rigs and personnel shall require written notification of the ENGINEER, 48 hours prior to the change.
- B. The ENGINEER shall be notified 24 hours prior to the start of any well construction activities.
- C. No work shall be performed without completing the notification requirements specified above.

1.11 WELL ACCEPTANCE CRITERIA

- A. The well shall be developed until, in the opinion of the ENGINEER, they are:
 1. Producing water substantially free of sand and silt.
 2. Producing water completely free of drilling fluids and grout.
 3. Responsive to water level changes in the aquifer.
- B. The borehole shall be constructed and casing installed plumb and true to line. The deepest anticipated finished well depth will be 740 feet. If, in the opinion of the ENGINEER, a well might be out of plumb or alignment, it shall be tested at the CONTRACTOR's expense in accordance with AWWA A100, Sections 1-6.2 and 1-6.3.
- C. All casings, screens, grout, gravel packs, and sand caps shall be set to the depths directed by the ENGINEER.
- D. No payment for the well will be due if failure to meet all above requirements.

1.12 MEASUREMENT AND PAYMENT

- A. Payment for work performed shall be on a basis of unit and lump sum prices bid and actual work performed. The bid items are intended to cover all costs involved in completing the work specified herein. The Bidder shall include all incidental costs in the applicable unit or lump sum prices. The total respective footages paid for will not exceed the total depth of the well.

PART 2 PRODUCTS

2.01 CASING

- A. All monitoring well casing shall be new, Schedule 80, PVC pipe. Casing shall be 5-inch nominal diameter.
- B. Casing shall meet or exceed the standards according to ASTM F 480.
- C. All casing joints shall be flush threaded with O-ring seals.
- D. The steel surface casing shall be nominally 10-inch diameter, have a minimum wall thickness of 1/4-inch, and be sufficiently round and straight to permit the rotary drilling of the bedrock beneath the casing bottom to proceed without impediment. Sections of the surface casing may

be joined by welding or threaded collars. Welded joints shall be such that they are watertight and of sufficient strength to permit installation of the casing to the specified depth.

2.02 SCREEN

- A. Well screens shall be a minimum of 5-inch nominal diameter, new, mill slotted PVC. Slot size shall be 0.040-inch.
- B. Well screens shall meet or exceed the standards according to ASTM F 480.
- C. The well shall have screen up to 200 feet in length. The actual length of screen for the well will be determined in the field by the ENGINEER.

2.03 CENTRALIZERS

- A. Centralizers shall be stainless steel such as those manufactured by Johnson Manufacturing Company, or equal. The centralizers shall be of a suitable size and stiffness to properly center the well casing and screen within the borehole.

2.04 GRAVEL PACK

- A. Gravel pack material shall be clean, well-rounded size 8-12 sized silica sand as manufactured by Colorado Silica Sand Inc., or approved equal.
- B. Infiltration barrier shall consist of mortar sand or other fine-grained medium suitable to ENGINEER to prevent infiltration of grout into completion zone.

2.05 GROUT

- A. The cement/bentonite grout shall be proportioned of Type I/II (ASTM C150) neat portland cement mixed with no more than 7 gallons of water per cubic foot of cement with 5 percent bentonite additive, with an additional 3/4 gallon added per sack of cement and each 1 percent bentonite added. All other additives shall have prior approval of the ENGINEER.
- B. The bentonite grout shall consist of a high-solids bentonite grout mixed with clear water such that resulting slurry contains not less than 20 percent solids by volume and as density not less than 9.8 pound per gallon such as Volclay Grout as manufactured by the Colloid Environmental Technologies Company, or approved equal.
- C. In the event that a confining unit between two of the Denver Basin Aquifers is penetrated and backfilled, grouting across the confining unit will be in accordance with State of Colorado requirements referenced in section 1.04.

2.06 CAPS

- A. Bottom caps shall be new, 5-inch Schedule 80 PVC, attached with flush-threaded joints.
- B. Top caps will be lockable expandable plugs as manufactured by Universal Valve Model MLPP130040, or equal.

2.07 DRILLING FLUIDS

- A. Only fresh potable water shall be used in drilling fluids whether employed alone or in combination with drilling additives. Drilling additives, if required, shall be approved by the ENGINEER. Drilling with a mixture of water and unprocessed mud, clay, or other material will not be permitted. The drilling fluid shall possess such characteristics as are required to adequately maintain the walls of the hole, to prevent caving of the walls as drilling progresses, and to permit recovery of representative samples of cuttings. The use of bentonite, clay, mud, or other foreign matter that has a tendency to build a mud cake on the walls of the hole and clog or seal up the water-bearing stratum will not be permitted without prior approval of the ENGINEER.
- B. The CONTRACTOR shall supply the drill rig at all times with Standard A.P.I. drilling fluid measuring devices to measure the following properties:
 - 1. Drilling fluid weight
 - 2. Drilling fluid viscosity
 - 3. Drilling fluid sand content
 - 4. Water loss and wall cake thickness
- C. The CONTRACTOR shall maintain controlled drilling fluid characteristics during the entire operation of well construction. Solids control equipment must keep the sand content below 2 percent in the drilling fluid at all times during the drilling process. If these and other drilling fluid conditions as outlined below are exceeded, the CONTRACTOR will be required to immediately suspend further drilling until corrected.

The drilling fluid shall have the following properties in accordance with A.P.I. Code 13B (or recent modification) "Recommended Standard Procedure for Testing Drilling Fluids." In the event the CONTRACTOR cannot attain these properties, the mud shall be replaced.

- 1. Weight - a maximum to 80 pounds per cubic foot (10.0 pounds per gallon) during borehole drilling and 70 pounds per cubic foot (9.4 pounds per gallon) during gravel packing. Total solids in the drilling fluid shall at no times exceed 12 percent.
 - 2. Marsh funnel viscosity - maximum to 50 seconds during borehole drilling unless otherwise required, and a maximum of 32 seconds during gravel packing.
 - 3. Sand content of mud entering the pump - a maximum of 2 percent by volume during all aspects of drilling.
- D. The CONTRACTOR is cautioned to maintain the minimum viscosity of the drilling fluid that will raise cuttings and adequately condition the wall of the hole. The CONTRACTOR shall remove all mud cake on the wall of the hole during well development or gravel pack installation.
- E. If directed by ENGINEER all drilling fluids will be containerized. Waste drilling fluids shall not be disposed of to the ground without express permission of ENGINEER.

PART 3 EXECUTION

3.01 DRILLING AND SAMPLING

- A. The initial portion of the monitoring well shall be drilling a nominal 18-inch diameter borehole to the top of bedrock, which is estimated to be at approximately 100-foot depth, to permit installation of a steel construction casing nominally 10-inches in diameter. The drilling method used for this portion of the borehole shall be at the option of the CONTRACTOR providing the method utilized will yield a hole of sufficient diameter and stability that the steel construction casing can be set and grouted in place to the top of bedrock, as described below.
- B. After the 18-inch borehole is drilled the steel construction casing as described above in paragraph 2.01D shall be lowered into the hole to the top of bedrock. The annulus between the outside of the construction casing will be grouted from the top of bedrock to the ground surface using cement bentonite grout as described above in paragraph 2.04A. The grout shall be placed from the bottom to the top of the borehole by tremie in one continuous operation. The CONTRACTOR shall protect the bottom end of the casing such that the grout does not fill the inside of the casing.
- C. After the grout around the steel construction casing has set for a minimum of 24 hours a nominal 10-inch diameter borehole will be drilled into the bedrock from the bottom of the construction casing to a total depth of approximately 740 feet using mud rotary and coring techniques. The actual final depth of the borehole will be determined by the ENGINEER in the field. The cored intervals will be the upper 10 feet of the unweathered bedrock formation beneath the surface casing and 25 feet near the bottom of the borehole to be designated by the ENGINEER in the field.
- D. The core samples shall be nominal 2-inches in diameter (NX Core is acceptable) and preserved in appropriately sized card board boxes coated with paraffin. All coring activities will be performed under the supervision of ENGINEER, who will be given the opportunity to collect laboratory samples immediately upon retrieval, while the core is still wet. The CONTRACTOR shall make every effort during the core drilling process to insure that core recovery is maximized; including, if necessary, use of face discharge bits, controlling fluid pressure and velocity to prevent erosion of the sample, limiting the length of core runs and/or use of triple tube barrels.
- E. The CONTRACTOR shall collect and preserve samples of the drill cuttings at 5-foot intervals, or as directed otherwise by the ENGINEER in the field over the portions of the bedrock borehole that are not cored.

3.02 GEOPHYSICAL LOGGING

- A. After the borehole has been drilled and reamed to the final depth and diameter, the CONTRACTOR shall perform a geophysical log of the borehole as outlined in Appendix E.

3.03 BACKFILL, WELL CASING AND SCREEN INSTALLATION

- A. In the event that the well completion depth is above boring's total depth, backfill will be installed in the lower portion of the borehole according to standards referenced in Section 1.04.

- B. The well screen and casing shall then be assembled and lowered to the depths specified by the ENGINEER in the field. Centralizers shall be attached to the screen and casing at 40 foot intervals.

3.04 GRAVEL PACK, SAND CAP, AND CEMENT INSTALLATION

- A. Install filter via tremie until the top of the filter pack material is a minimum of 10feet above the top of the well screen as directed by the ENGINEER in the field. Placement shall be performed such that the filter pack is free from excessive amounts of cuttings, sloughed formational material or voids.
- B. Approximately 8 feet of mortar sand will be placed above the filter pack as an infiltration barrier to prevent grout from entering the zone adjacent to the well screen.
- C. The remainder of the borehole shall then be sealed using a high-solids bentonite grout as specified above in paragraph 2.05B placed by tremie. Care should be taken that the grout mixture is not over sheared.
- D. All grouting and sealing of the well shall be performed in the presence of the ENGINEER. The grouting shall be done continuously and in such a manner that will assure the filling of the annular space in one continuous operation.
- E. Take full responsibility for cementing operations, including volumes to be used and ensuring the well screens and gravel packs are not cemented or casing deformed by the heat of curing cement, if used.
- H. A protective steel cover with locking hasp will then be installed over the PVC well casing. The cover shall be set such that it extends 3 feet below the ground surface and be embedded in a 6-inch thick concrete pad that extends at least 2 feet on all sides of the protective cover and is sloped to divert water away from the well. The cover shall contain a weep hole above the concrete pad.
- I. If directed by the ENGINEER, bollards shall be installed. The bollards shall consist of 4-inch diameter steel pipe, 6 feet in length and set to a depth of 3 feet below the ground surface in a 12-inch diameter hole filled with concrete. The pipe shall then be filled with concrete rounded at the upper end and painted with high visibility weatherproof enamel paint.

3.05 WELL DEVELOPMENT

- A. The observation wells shall be developed as described in Appendix G by surging, compressed air, sand bailing, interrupted over-pumping or other methods approved by the ENGINEER.
- B. Development of the observation wells shall continue until the wells conform to the Well Acceptance Criteria as stated in paragraph 1.11 above, and the requirements of Appendix G.

3.06 WELL ABANDONMENT

- A. Well abandonment will be required in the event of failure to meet the Well Acceptance Criteria as stated in paragraph 1.11 above, or because of loss of tools, cementing well screens, gravel

packs, casing collapse, or for other cause. The CONTRACTOR shall abandon the well in accordance with the standards and procedures specified in the Colorado Rules and Regulations for Water Well Construction.

- B. The CONTRACTOR shall receive no payment for time and material for well abandonment and shall receive no compensation for the abandoned well.
- C. The CONTRACTOR shall replace the abandoned well at the unit prices outline in paragraph 1.12 above.
- D. The CONTRACTOR shall compensate the ENGINEER for the additional cost of inspection associated with the abandoned well or a borehole/well that must salvaged due to the actions of CONTRACTOR. It is understood and agreed that aside from any other liquidated or other damage per day for such delay from such time until the same is completed and accepted as herein provided; all costs of engineering and inspection on behalf of the OWNER will be charged to the CONTRACTOR hereunder and deducted from any estimate or payment otherwise due and payable to him/her from time to time. The costs of engineering and inspection shall equal to the ENGINEER's charges to the OWNER under the terms of the ENGINEER's agreement with the OWNER, which may be charged to the CONTRACTOR by the OWNER under this article.
- E. The CONTRACTOR shall receive payment for the abandonment of the observation wells as specified in the Schedule of Prices if the CONTRACTOR is authorized by the ENGINEER to abandon some or all the monitoring wells for reasons other than stated in paragraph 3.06A above. The observation wells shall be cut off approximately 3-feet below land surface and abandoned with the standards and procedures specified in the Colorado Rules and Regulations for Water Well Construction.

3.07 PROTECTION AND SITE CLEAN-UP

- A. At all times during the progress of the work, use all reasonable precautions to prevent either tampering with the wells or the entrance of foreign material.
- B. Immediately upon completion of the development remove all of the equipment, materials, and supplies from the site of the work, remove all surplus materials and debris, fill in all holes or excavations, and grade the site to elevations of the surface levels, which existed before work started. The site shall be thoroughly cleaned until approved by the ENGINEER and reseeded with a dryland grass seed mixture if directed. Failure to comply with these requirements shall give the authority of other contractors or workmen directed by the ENGINEER to enter upon the site and complete the clean up, grading, etc. The cost of this work shall be deducted from money due or to become due for construction of the wells.
- C. Depending upon the site selected for the drilling location, offsite disposal of drilling fluids and cuttings may be necessary. If required at the direction of the ENGINEER, the CONTRACTOR shall arrange for all drilling fluids and cuttings to be contained and subsequently removed from the site to an approved location. The CONTRACTOR shall furnish to the ENGINEER the name and location of the disposal site along with documentation that the site has been approved by the appropriate regulatory agencies to accept these materials, prior to hauling these wastes offsite.

END OF APPENDIX F

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Figure No. 1
Phase 2 Bedrock Monitoring Well
South Platte Decision Support System