

US EPA ARCHIVE DOCUMENT

APPENDIX B – Proposed Well Construction Procedures and Diagrams

FLORENCE COPPER, INC.
UIC PERMIT APPLICATION
FLORENCE COPPER PROJECT – PRODUCTION TEST FACILITY

ATTACHMENT L – WELL CONSTRUCTION PROCEDURES

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L.1 Introduction

This Attachment L has been prepared in support of an application (Application) by Florence Copper, Inc. (Florence Copper) to the United States Environmental Protection Agency (USEPA) for issuance of an Underground Injection Control Class III (Area) Permit (UIC Permit) for the planned Production Test Facility (PTF), to be located at the Florence Copper Project (FCP) in Pinal County, Arizona.

Florence Copper is proposing to develop the PTF in order to demonstrate the feasibility of operating an in-situ copper recovery (ISCR) facility at the FCP site. The PTF will produce a limited amount of copper from a porphyry copper oxide deposit (oxide zone) located beneath the FCP site. The PTF proposed by Florence Copper will consist of a closely spaced array of Class III injection and recovery wells that will be used to inject a dilute sulfuric acid based solution (lixiviant) into the copper oxide deposit (oxide zone) and recover the resulting copper-bearing pregnant leach solution (PLS). Details of the proposed well design are presented in Attachment M of this Application. Based on formation conditions, Florence Copper may find it necessary to construct some wells without using the well screen and filter pack shown in Attachment M. If formation conditions prove that it is necessary to construct some wells without well screen and filter pack, all other elements of the well design shown in Attachment M will be applied. This Attachment includes a description of the well construction methods that will be applied to wells constructed with or without well screen.

This Attachment describes procedures that will be used to construct the proposed Class III wells. Proposed Class III wells include four injection wells, nine recovery wells, seven observation wells, four multi-level sampling wells, one operational monitoring well, and seven supplemental monitoring wells. This Attachment does not include a description of downhole equipment that will be used during PTF operations. Downhole equipment may include submersible pumps, injection tubing, orifice plate assemblies, packer assemblies, fluid level instruments, well cleaning tools, and other equipment.

L.2 Well Construction

Well construction descriptions provided below include details of drilling, open-hole geophysics, casing and annular conductivity devices (ACDs), injection zone conductivity sensors (CS), screen and filter pack installation, cementing, cased-hole geophysics, injection interval, and proposed changes and workovers.

L.2.1 Borehole Drilling

Borehole drilling consists of drilling a relatively large diameter borehole to accommodate installation of surface casing to a depth of 20 feet, then drilling a narrower borehole from the bottom of the surface casing to the planned total depth of the well. The surface casing boring will be drilled by the auger or rotary method, and will be of a diameter of sufficient size to allow installation of the surface casing and annular seal described in Attachment M. The surface casing will be installed with the top of the surface casing above land to accommodate the mud-rotary drilling equipment. The annular seal will consist of cement grout installed in the annulus between the surface casing and the borehole, using the tremie method or displacement method. The surface annular seal will extend from the land surface to the total depth of the surface casing.

The borehole in which the well will be constructed will be drilled from the bottom of the surface casing borehole to approximately 10 feet below the bottom of the oxide zone using the direct mud rotary, reverse circulation mud rotary, or a casing advance drilling method as conditions require. The well boring will be of a diameter of sufficient size to allow installation of the well casing and annular materials described in Attachment M.

L.2.2 Open-Borehole Geophysics

Open-hole geophysical logs will be run in each boring (for all injection, recovery, observation, multi-level sampling, operational monitoring, and supplemental monitoring wells) for the purpose of depth control and detection of borehole anomalies. Geophysical tools will include caliper, gamma-ray, temperature, directional survey, and electrical logs. In addition to the geophysical logs listed above, neutron-density logs will be run in selected PTF borings.

L.2.3 Well Casing Installation

The well will consist of blank casing material in the upper part of the well from land surface to 40 feet below the top of bedrock. If well casing is to be installed in the injection zone below, it will consist of one or more screened intervals separated by blank casing segments, to the bottom of the well. Casing materials for injection and recovery wells will be designed to resist corrosion, not fail in tension, and not collapse or burst. Proposed casing materials are described in Attachment M.

During installation of the well casing and screen, the borehole will be kept full of drilling fluid and free of any obstructions detrimental to completing casing installation. The well casing and screen will be centered in the hole so as not to interfere in any way with the complete well installation. Casing installation will continue on a 24-hour per day, 7-day per week basis, until completed.

Casing centralizers will be secured to the well casing and screen at 40-foot intervals, as shown in Attachment M. The casing and screen will be hung in tension, centered in the borehole, until the filter pack and cement grout seal have been installed.

In accordance with Attachment O of this Application, wells constructed with polyvinyl chloride (PVC) or fiberglass reinforced plastic (FRP) outer casings, will have ACD devices installed. One ACD will be attached to the exterior of the well casing at a point as close as possible to the top of the Middle Fine-Grained Unit (MFGU), and no more than 20 feet above the MFGU. The ACD will consist of a pair of metal bands spaced one meter apart and connected to electrical wires which extend to the surface. The ACD will be used to demonstrate and monitor Part II mechanical integrity of the well as described in section P.5.3 of Attachment P of this Application. Refer to Attachment O, Section O.3.3, for a description of alternatives to demonstrate Part II mechanical integrity should the ACD be damaged. A schematic diagram of the ACD is included in Attachment M.

During casing installation, a suitable 2-inch diameter metal tremie pipe will be installed into the annular space between the well casing and the borehole wall. The tremie pipe will be used to place formation stabilizer materials (filter pack), such as silica sand, adjacent to screened casing intervals and to install sand and cement adjacent to blank casing intervals to form the filter pack and hydraulic seals, as described below, within the annular space between the blank casing intervals and the borehole wall. The tremie pipe will be removed from the well as construction and sealing operations are completed.

L.2.4 Filter Pack and Intermediate Seal Installation

Drilling fluid will be maintained throughout the full depth of the well to land surface, and the well casing and screen will be hung in tension until the filter material placement has been completed to the specified level, while the filter pack and intermediate seal materials are installed. During the time of placement, fluid circulation will be maintained through a swab block located inside the well screen and approximately 40 feet below the fill depth of the fill material. The swab block will be periodically reciprocated to remove fine-grained material, prevent bridging, and aid in settling the filter pack in the borehole.

Filter pack (i.e., silica sand) will be placed to continuously fill the annulus to the specified level. Filter pack will be installed by use of the tremie pipe. At no time will the bottom of the tremie pipe be located at a distance of greater than 40 feet above the interval being filled during placement. Materials will be placed to completely fill the annulus to the specified intervals. As required by formation conditions, intermediate cement seals may be installed at selected intervals within the filter pack as shown in Attachment M. Cement seals will be installed using the same tremie pipe used for installing the filter pack sand.

The tremie pipe will be moved upward during installation of these sand and cement intervals, until the filter pack is installed above the uppermost well screen interval. The level of the filter pack will be measured periodically during placement with a wireline sounder. Placement of the materials will be continuous, except when additional precautions are necessary to prevent bridging or when measurements of the level are being conducted. The quantity of materials placed in the annulus will not be less than that of the computed volume.

The same tremie pipe will then be utilized for cementing the upper portion of the well casing as described below.

L.2.5 Cementing

L.2.5.1 Cementing Characteristics for Injection and Recovery Wells

PTF injection and recovery wells will be drilled in two stages. The upper stage will consist of a boring drilled from land surface to a point at least 40 feet below the top of bedrock, in which a steel casing will be cemented in place extending from ground surface to a point at least 40 feet below the top of bedrock. The steel casing will be cemented by the plug displacement method.

The lower section of each injection and recovery boring will be drilled from the bottom of the cemented steel casing to the design depth. After well screen and annular materials have been emplaced in the lower section of the boring by tremie pipe, cementing of the upper section of the inner casing, inside the outer steel casing, from the bottom of the bedrock exclusion zone to ground surface will be accomplished by pumping a cement slurry down a tremie pipe positioned with the pipe's lower end near the bottom of the exclusion zone, forcing the cement to fill the annular space between the inner casing and outer steel casing from the bottom up to the surface.

L.2.5.2 Cementing Characteristics for Observation, Multi-Level Sampling, Operational Monitoring, and Supplemental Monitoring Wells

The observation, multi-level sampling, operational monitoring, and supplemental monitoring well borings will be of a constant diameter, drilled in a single stage, and thus cannot be grouted by the plug displacement method. Once the well casing, screen, and filter pack have been installed in the boring, cementing of the upper portion of the well casing, from the bottom of the bedrock exclusion zone (or the bottom of the design grouted interval in the case of the operational and supplemental monitoring wells) to ground surface, will be accomplished by pumping a cement slurry down a tremie pipe positioned with the pipe's lower end near the bottom of the exclusion zone, forcing the cement to fill the annular space between the borehole and casing from the bottom up to the surface.

L.2.5.3 Cementing Characteristics for All Class III Wells

Cement grout will be placed to completely fill the well annulus within the specified interval. Prior to pumping, the cement grout will be passed through a 1/2-inch slotted bar strainer in order to remove any unmixed lumps. In cases where a tremie pipe is used (observation wells, multi-level sampling wells, operational monitoring, and supplemental monitoring wells, and between the steel outer casing and inner fiberglass casing of the injection and recovery wells) during cement grout installation, the discharge end of the tremie pipe will be continuously submerged in the grout until the zone to be grouted is completely filled.

The well casing will be hung in tension until the cement grout has cured. The well casing will be filled with a fluid of sufficient density to maintain an equalization of pressures to prevent collapse of the well casing during cementing.

Cement will consist of sulfate-resistant Portland Type V cement, unless Florence Copper submits the following information to the Director regarding a Type V substitute. A suitable Type V substitute will meet the following requirements:

1. The results of an immersion test for resistance to PLS or equivalent mass samples of Type V cement and any proposed substitute.
2. A comparison of the percentage weight change between samples.
3. An acceptable substitute will experience little visual change, a weight loss or gain within 5 to 8 percent, and no significant change in compressive strength.

Upon completion of this demonstration, and subject to USEPA approval, a substitute cement that meets these criteria may be substituted for Type V cement for well construction.

Water and/or appropriate mud-breaker chemicals will be circulated through the tremie pipe prior to cementing to reduce drilling mud viscosity and assist in removal of mud from the borehole-casing annulus.

The cement slurry will be pumped at the greatest flow rate possible to promote removal of drill mud from the annular space, and enhance bonding between the cement and the casing and formation. An excess quantity of cement will be pumped into the annular space in order to verify “clean” cement slurry returns from the well prior to terminating the cementing procedure. Following installation of the cement slurry, the cement will be allowed to cure for a minimum of 24 hours before performing additional operations on the well.

L.2.6 Cased-Hole Geophysics

Cased-hole geophysical surveys will include gamma ray, temperature, and cement bond logs to be run in all injection and recovery wells over the entire length of each well after the outer steel casing has been installed and cemented to the surface. These logs will also be run in each of the steel cased operational and supplemental monitoring wells, and the FRP cased observation and multi-level sampling wells. Additional logs may be run as appropriate.

L.3 Injection Interval

Fluids will only be injected at depths greater than 40 feet below the top of the oxide zone unless Florence Copper has received written approval from the Director to expand the injection interval. To ensure that the injection interval is at least 40 feet below the top of the oxide zone, Florence Copper will case and cement all injection wells from ground surface to at least 40 feet below the top of the oxide zone. Florence Copper may develop the injection interval for each well by installing well screen and short blank casing sections through the oxide interval below the bedrock exclusion zone, or may inject into the open borehole below the bedrock exclusion zone.

L.4 Proposed Changes and Workovers

Florence Copper will give advance notice to the Director, as soon as possible, of any planned alterations or additions to the construction of permitted injection wells. Following a well workover, a demonstration of mechanical integrity will be performed prior to resuming injection activities, in accordance with UIC Permit requirements.

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ATTACHMENT M – WELL CONSTRUCTION DETAILS

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List of Exhibits

Exhibit M-1	Revised Figures Previously Provided with Comment Responses <ul style="list-style-type: none">– Revised Figure 11-2, Supplemental Monitoring Well M61-LBF Design– Revised Figure 12-1, Supplemental Monitoring Well M57-O Design– Revised Figure 12-2, Supplemental Monitoring Well M58-O Design– Revised Figure 12-3, Supplemental Monitoring Well M59-O Design– Revised Figure 12-4, Supplemental Monitoring Well M60-O Design– Revised Figure 18-2, POC Well Design Well M55-UBF– Revised Figure 18-3, POC Well Design Well M56-LBF– Figure M1-1, Operational Monitoring Well MW-01
Exhibit M-2	Selected Materials from Temporary APP Application Attachment 9, Exhibit 9A

M.1 Introduction

This Attachment M has been prepared in support of an application (Application) by Florence Copper, Inc. (Florence Copper) to the United States Environmental Protection Agency (USEPA) for issuance of an Underground Injection Control Class III (Area) Permit (UIC Permit) for the planned Production Test Facility (PTF), to be located at the Florence Copper Project (FCP) in Pinal County, Arizona. This Attachment provides details of the Class III injection well design including schematic drawings showing construction details of injection and recovery wells. In the following discussion, the Class III injection wells are referred to as injection and/or recovery wells. This Attachment does not include a description of downhole equipment that will be used during PTF operations. Downhole equipment may include submersible pumps, injection pipes, orifice plate assemblies, packer assemblies, fluid level instruments, and well cleaning tools.

M.2 Well Design

Well design details are shown on Drawings M-1 through M-5. Drawing M-1 shows details of a typical injection/recovery well. Drawing M-2 shows construction details of a typical injection/recovery well head. Drawing M-3 shows construction details of a typical observation well. Drawing M-4 shows construction details for a typical multi-level sampling well, and Drawing M-5 shows construction details for a typical supplemental monitoring well and operational monitoring well. Drawings M-6 and M-7 show details of the annular conductivity device (ACD) that will be installed on all observation wells and multi-level sampling wells constructed with polyvinyl chloride (PVC) or fiberglass reinforced plastic (FRP) well casing. Conductivity sensors (CS) (Drawings M-8 and M-9) will be attached to the screen of recovery wells, observation wells, and multi-level sampling wells to facilitate electrical resistivity profiling of the injection zone during injection and recovery.

Exhibit M-1 includes figures depicting the proposed construction details for supplemental monitoring wells M55-UBF, M56-LBF, M57-O, M58-O, M59-O, M60-O, M61-O, and operational monitoring well MW-01. Exhibit M-2 includes design documents submitted to the Arizona Department of Environmental Quality (ADEQ) in support of the application for Temporary Aquifer Protection Permit (APP) No. 106360, which has now been superseded by the description and drawings submitted with this Attachment.

M.2.1 Well Casing

The surface casing will be low carbon steel manufactured in accordance with American Society for Testing and Materials (ASTM) Specification 153-89A (1989) Grade A (or better) steel. This casing will be of a diameter sufficient to allow a minimum 2½-inch annular space between the casing wall and borehole wall to ensure that an adequate seal can be installed.

The surface casing diameter will vary based on the diameter of the planned well casing to be installed. Because of the chemical environment in which the casing will be installed, FRP, PVC, or other corrosive-resistant threaded casing will be used to complete the injection, recovery, observation, and multi-level sampling wells. These casing materials will be of sufficient grade so that they will not fail in tension and will not collapse or burst, and will be chemically resistant to the planned process related solutions.

Well screen made of PVC or other suitable material may be used in the lower portion of each injection, recovery, observation, and multi-level sampling well as necessary to keep the hole open and to provide the operational flexibility to isolate segments of the full length of the injection and recovery zone.

M.2.2 Casing Centralizers

Casing centralizer will be installed on the well casing every 40 feet along the entire well casing, including screens where applicable. The centralizers will be made of stainless steel or PVC and will be suitable for contact with process related solutions.

M.2.3 Screened Interval

The screened interval will vary in length at each well and may include one or more screened segments within the full length of the injection and recovery zone. Formation characteristics may require that wells be completed without well screen and filter pack within the injection and recovery zone. If this proves to be necessary, all other aspects of the proposed design will remain in effect. No screened interval will be installed higher than 40 feet below the Lower Basin Fill Unit (LBFU)/oxide bedrock contact.

M.2.4 Annular Seal

The annular seal will be installed from 40 feet below the LBFU/oxide bedrock contact to the surface. The annular seal material will be cement and will be installed either by the tremie method or by the displacement method as described in Attachment L.

M.2.5 Annular Conductivity Device

The ACD will be installed on PVC or FRP well casing of observation wells and multi-level sampling wells in a location that will be as close as possible to the top of the Middle Fine-Grained Unit (MFGU), and no more than 20 feet above the MFGU. It will consist of a pair of metal bands spaced 3 feet apart, and connected to electrical wires which extend to the surface. The ACD will be constructed of materials suitable for contact with the annular seal materials and the forecast process related solutions. Details of the ACD are presented in Drawings M-3 and M-4.

A CS will be strapped to the well screens of recovery, observation, and multi-level sampling wells at regular intervals to facilitate electrical resistivity profiling of the formation during injection and recovery.

M.2.6 Fluid Pressure Transducers

Each of the injection, recovery, and observation wells will be fitted with transducers for fluid level measurement. Injection wells will include two transducers installed within the well casing, with one above and one below the inflatable packer in each injection well. Recovery wells will include one transducer installed within the well casing below the packer, and a second transducer installed outside the well casing, adjacent to the screen to measure fluid pressure in the formation adjacent to the well. Observation wells will include a single transducer installed within the well casing to measure fluid levels at the edge of the PTF wellfield. Transducer installation locations and cable configuration are shown on Figures M-1, M-2 and Figure 2 of Appendix K-2.

CONDUCTIVITY SENSOR LEADS
(RECOVERY WELLS)

0 FEET

20 FEET (MIN.)

UPPER BASIN
FILL UNIT
(UBFU)

MIDDLE
FINE-GRAINED UNIT
(MFGU)

LOWER BASIN
FILL UNIT
(LBFU)

40' BEDROCK
EXCLUSION ZONE

MINIMUM 40 FEET
BELOW TOP OF
BEDROCK OXIDE UNIT

20 FEET ABOVE
BEDROCK
EXCLUSION ZONE

OXIDE
BEDROCK
UNIT

TRANSDUCER CABLE (UPPER)
(RECOVERY WELLS ONLY)

CONCRETE PAD

STEEL SURFACE CASING, CEMENTED

18-1/2-INCH MIN. BOREHOLE

CASING DIAMETER WILL BE SIZED TO
PROVIDE A MINIMUM 2-1/2-INCH ANNULUS

CASING CENTRALIZERS EVERY 40 FEET

LOW-CARBON STEEL CASING, CEMENTED

TYPE V PORTLAND CEMENT (NEAT MIX)

LOW-CARBON STEEL TO COATED STEEL
WELDED JOINT

LOW-CARBON STEEL CASING, POLYMER
COATED

FIBERGLASS REINFORCED CASING

FIBERGLASS REINFORCED TO PVC PIPE
ADAPTER

12-1/4-INCH MIN. BOREHOLE

PVC SCREEN OR OTHER APPROVED
ACID RESISTANT MATERIAL

PVC BLANK CASING OR OTHER APPROVED
ACID RESISTANT MATERIAL

SILICA SAND FILTER PACK

TYPE V CEMENT, TYPICAL

STAINLESS STEEL CASING
CENTRALIZERS EVERY 40 FEET

PVC CAP

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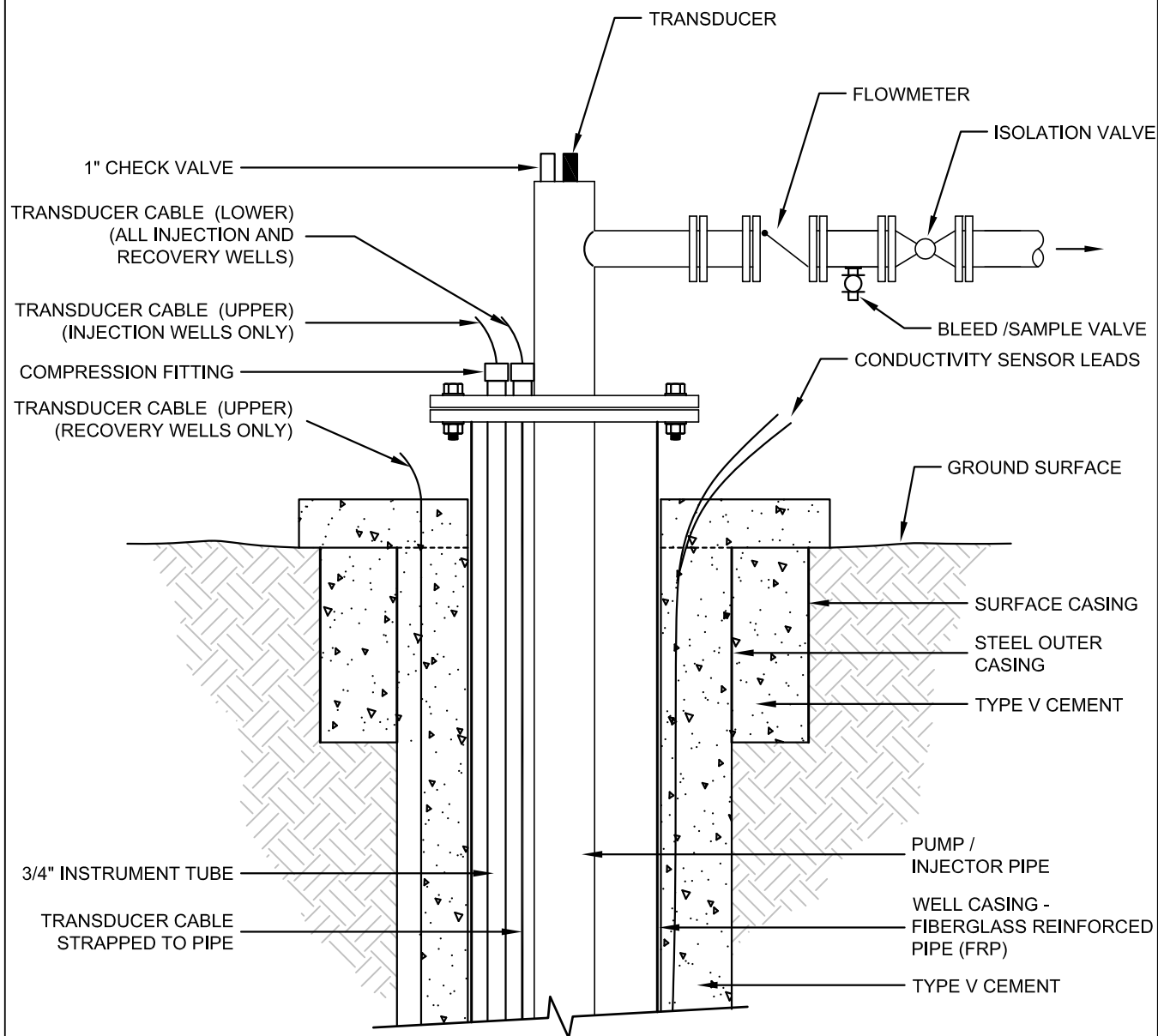
TYPICAL INJECTION/RECOVERY WELL CONSTRUCTION DIAGRAM

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DRAWING M-1

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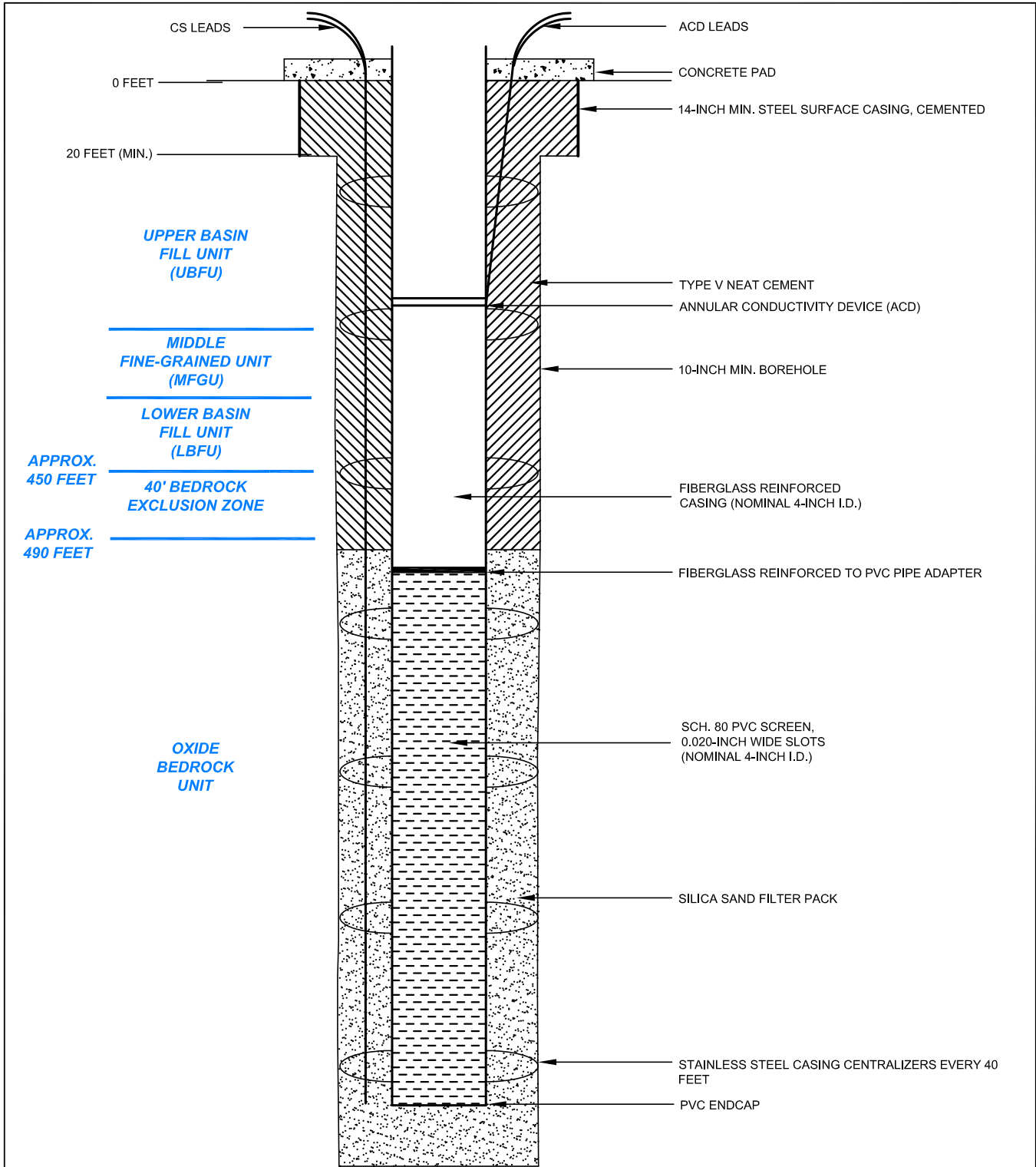
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INJECTION/RECOVERY WELL HEAD DETAIL

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DRAWING M-2



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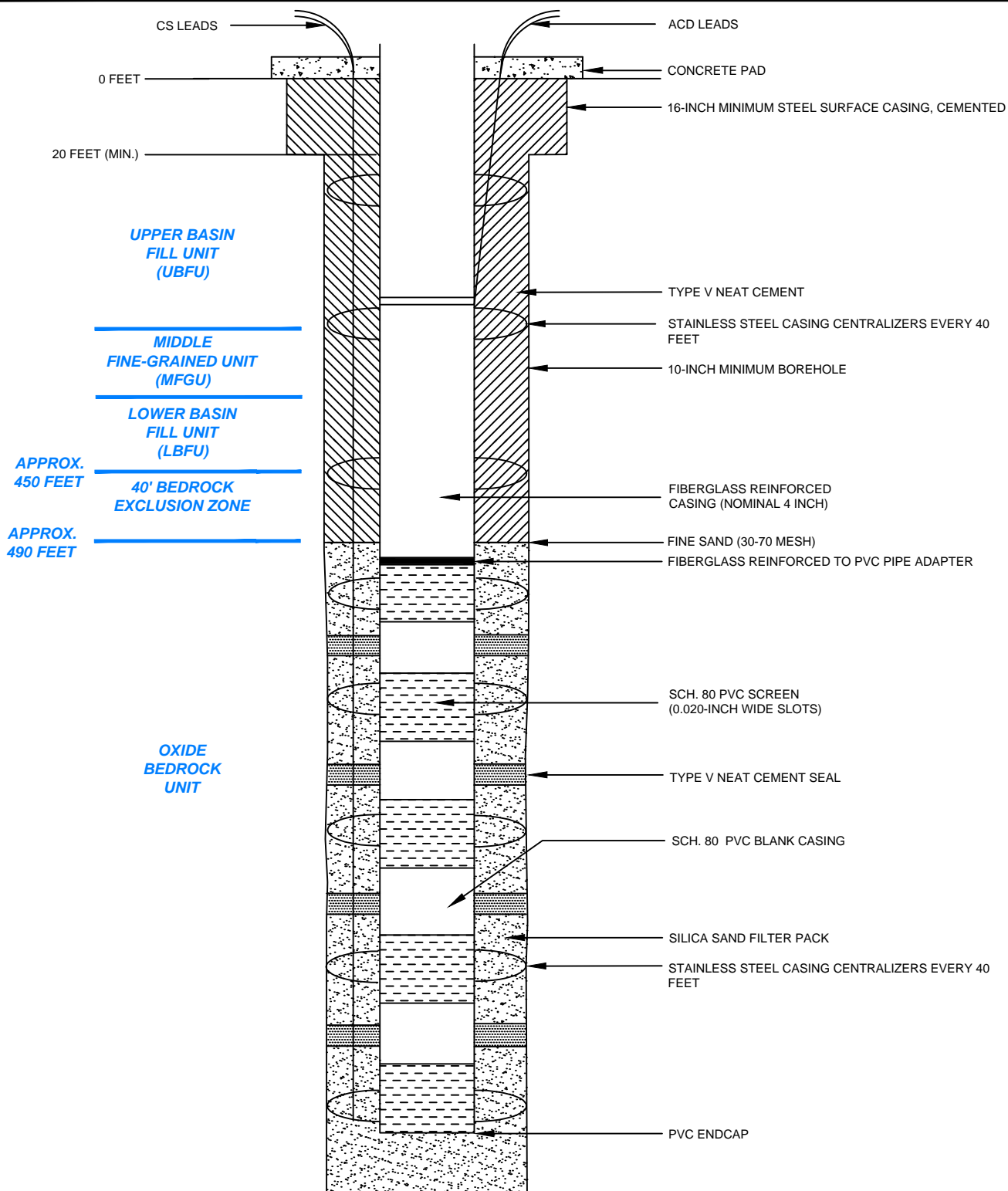
TYPICAL OBSERVATION WELL CONSTRUCTION DIAGRAM

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DRAWING M-3

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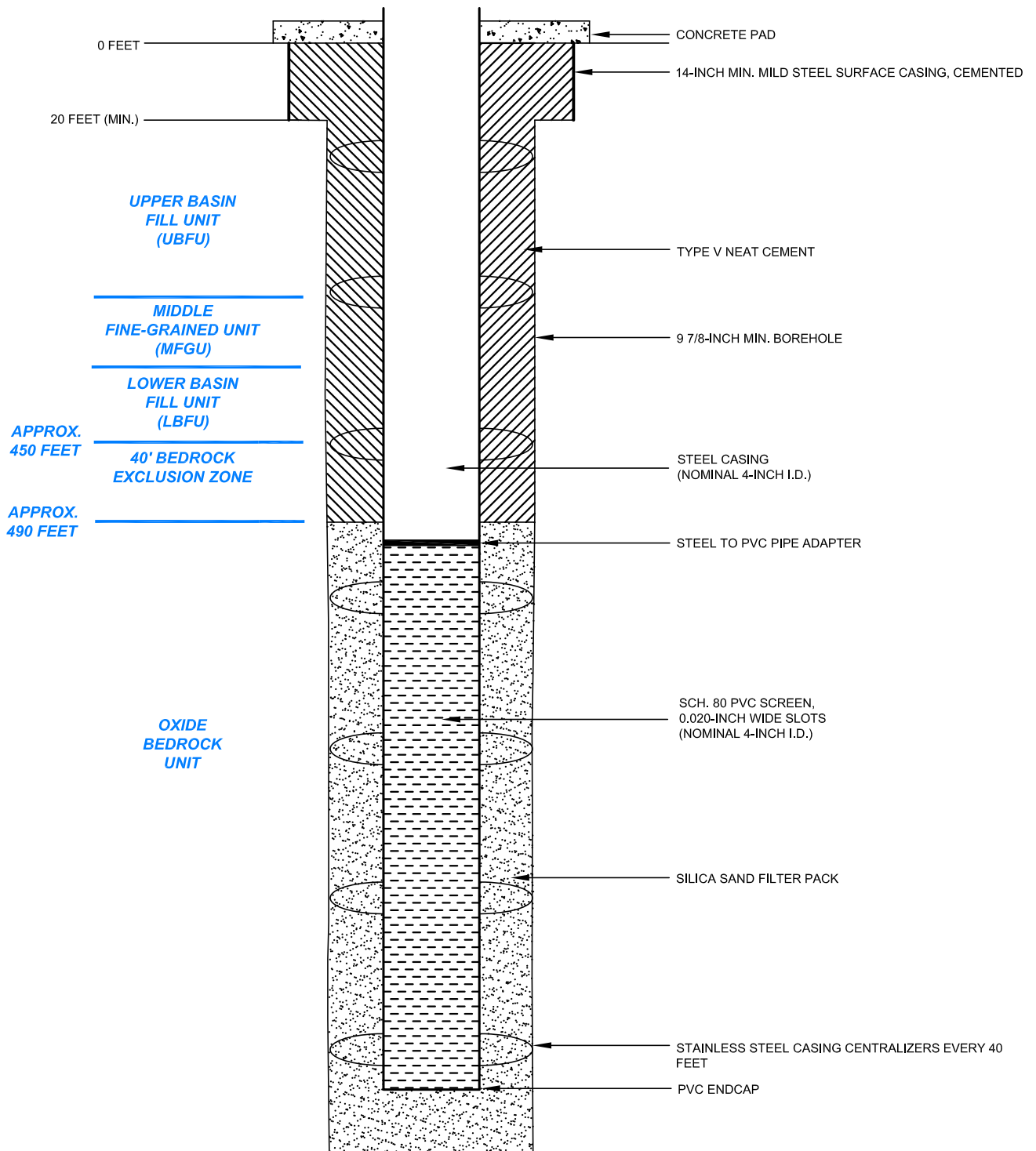
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TYPICAL MULTI-LEVEL SAMPLING WELL CONSTRUCTION DIAGRAM

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DRAWING M-4



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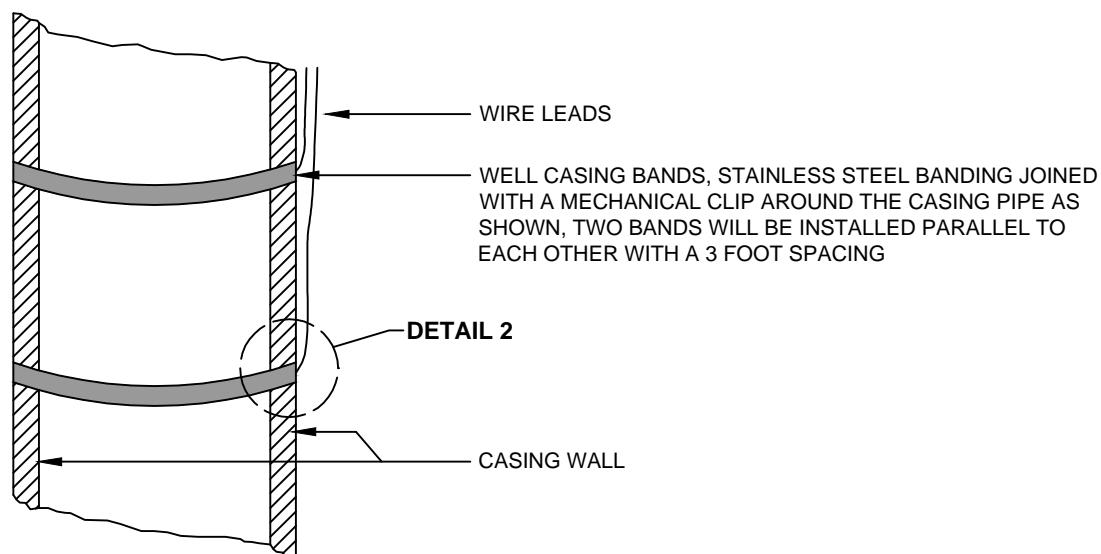
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TYPICAL SUPPLEMENTAL MONITORING WELL AND OPERATIONAL MONITORING WELL CONSTRUCTION DIAGRAM

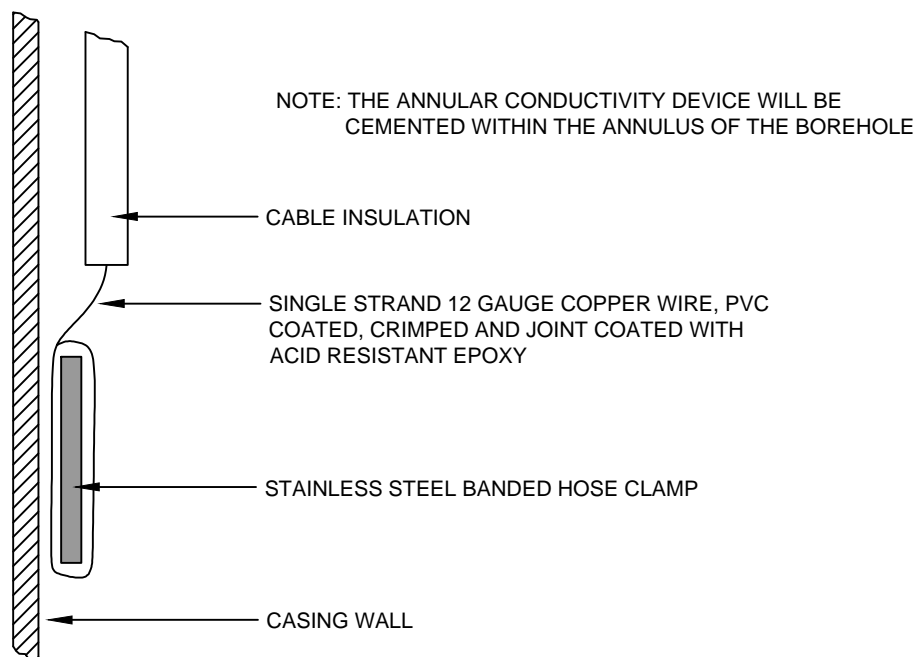
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DRAWING M-5



DRAWING M-6
ANNULAR CONDUCTIVITY DEVICE DETAIL 1
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DRAWING M-7
ANNULAR CONDUCTIVITY DEVICE DETAIL 2
NOT TO SCALE

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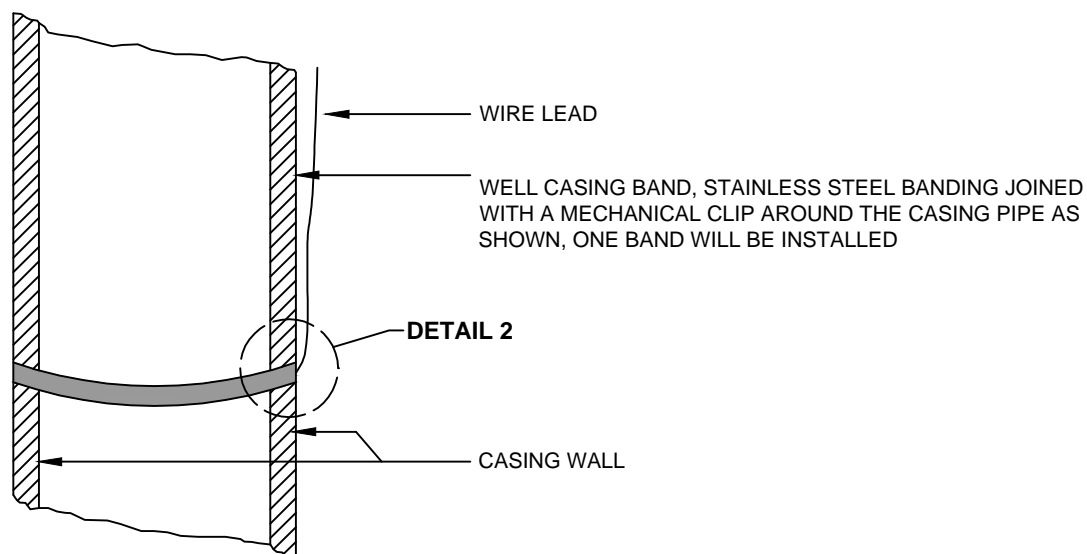
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ANNULAR CONDUCTIVITY
DEVICE DETAILS

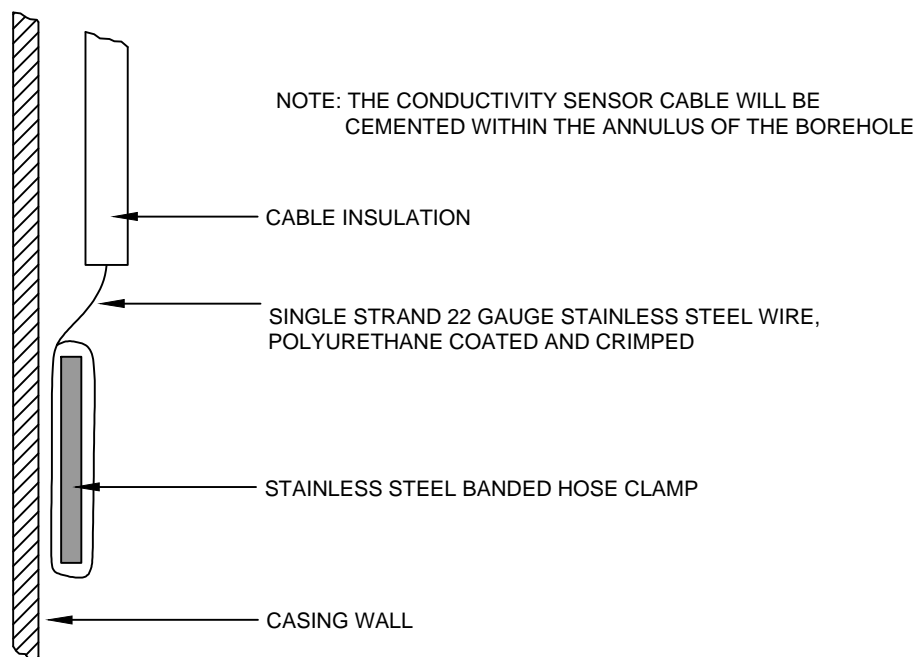
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DRAWING M-6 & M-7



DRAWING M-8
CONDUCTIVITY SENSOR DEVICE DETAIL 1
 NOT TO SCALE



DRAWING M-9
CONDUCTIVITY SENSOR DEVICE DETAIL 2
 NOT TO SCALE

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**CONDUCTIVITY SENSOR
 DEVICE DETAILS**

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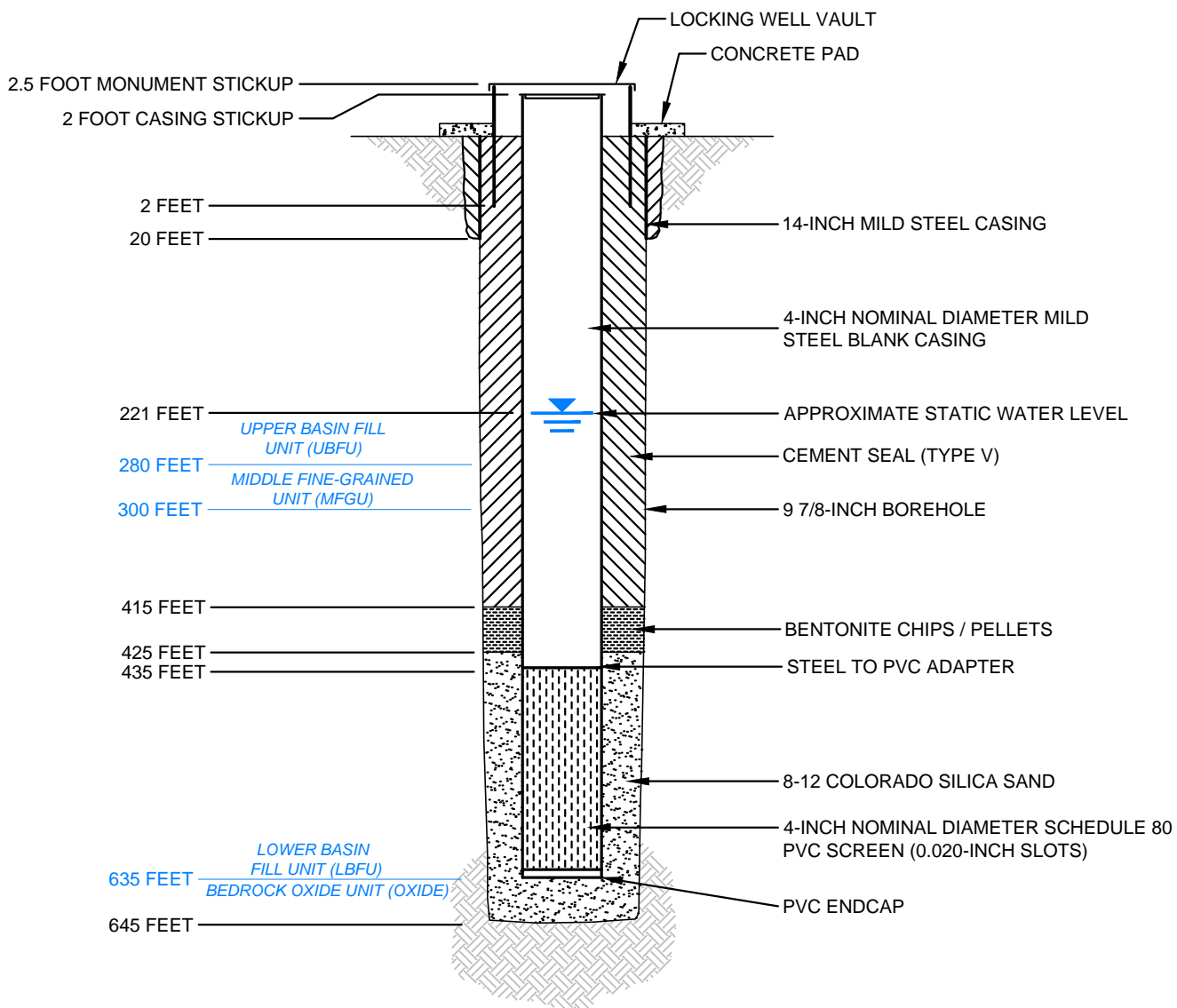
DRAWING M-8 & M-9

EXHIBIT M-1

Revised Figures Previously Provided with Comment Responses

- Revised Figure 11-2, Supplemental Monitoring Well M61-LBF Design
- Revised Figure 12-1, Supplemental Monitoring Well M57-O Design
- Revised Figure 12-2, Supplemental Monitoring Well M58-O Design
- Revised Figure 12-3, Supplemental Monitoring Well M59-O Design
- Revised Figure 12-4, Supplemental Monitoring Well M60-O Design
- Revised Figure 18-2, POC Well Design Well M55-UBF
- Revised Figure 18-3, POC Well Design Well M56-LBF
- Figure M1-1, Operational Monitoring Well MW-01 Design

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SUPPLEMENTAL MONITORING
WELL M61-LBF DESIGN (REVISED)

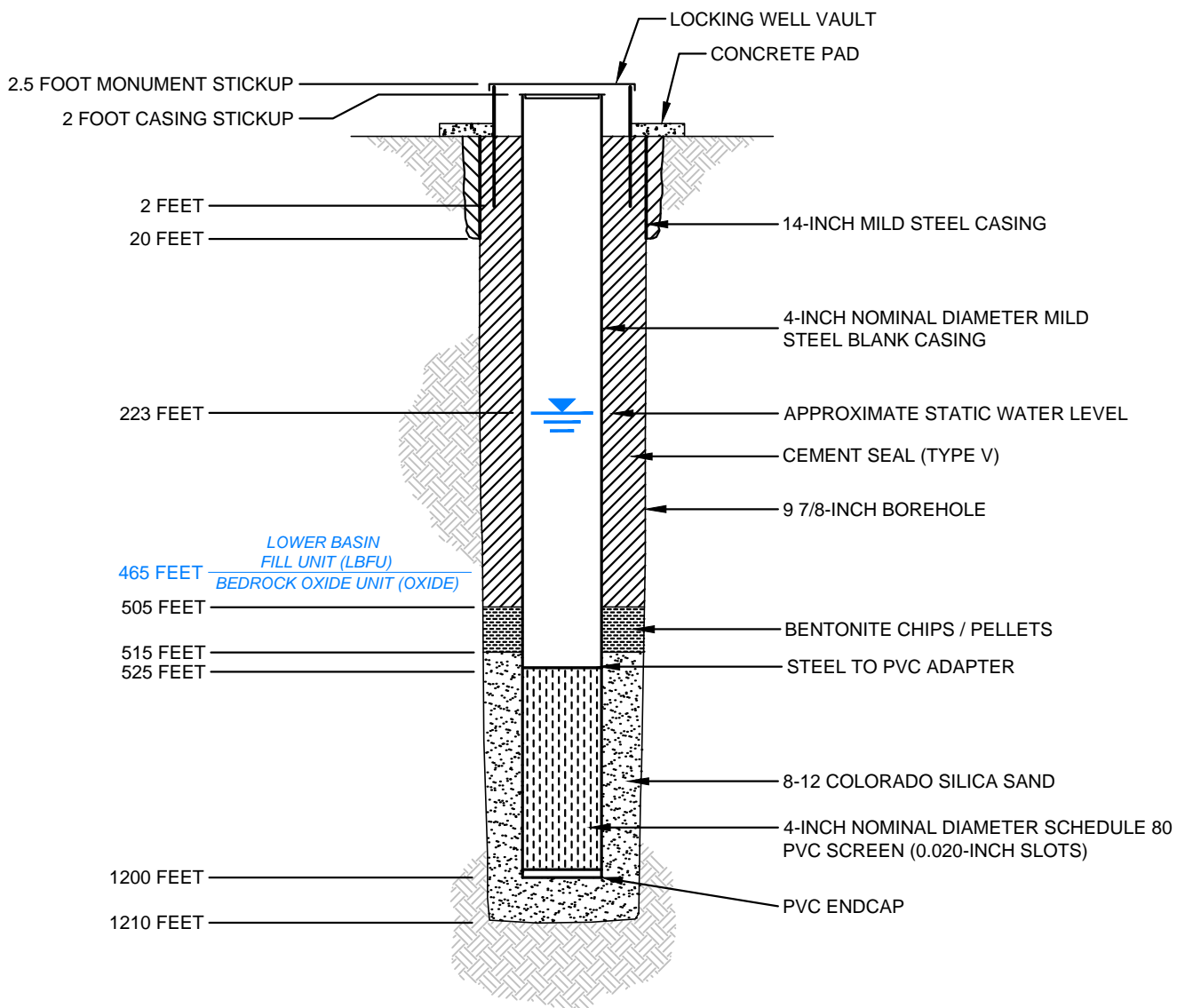


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FIGURE 11-2

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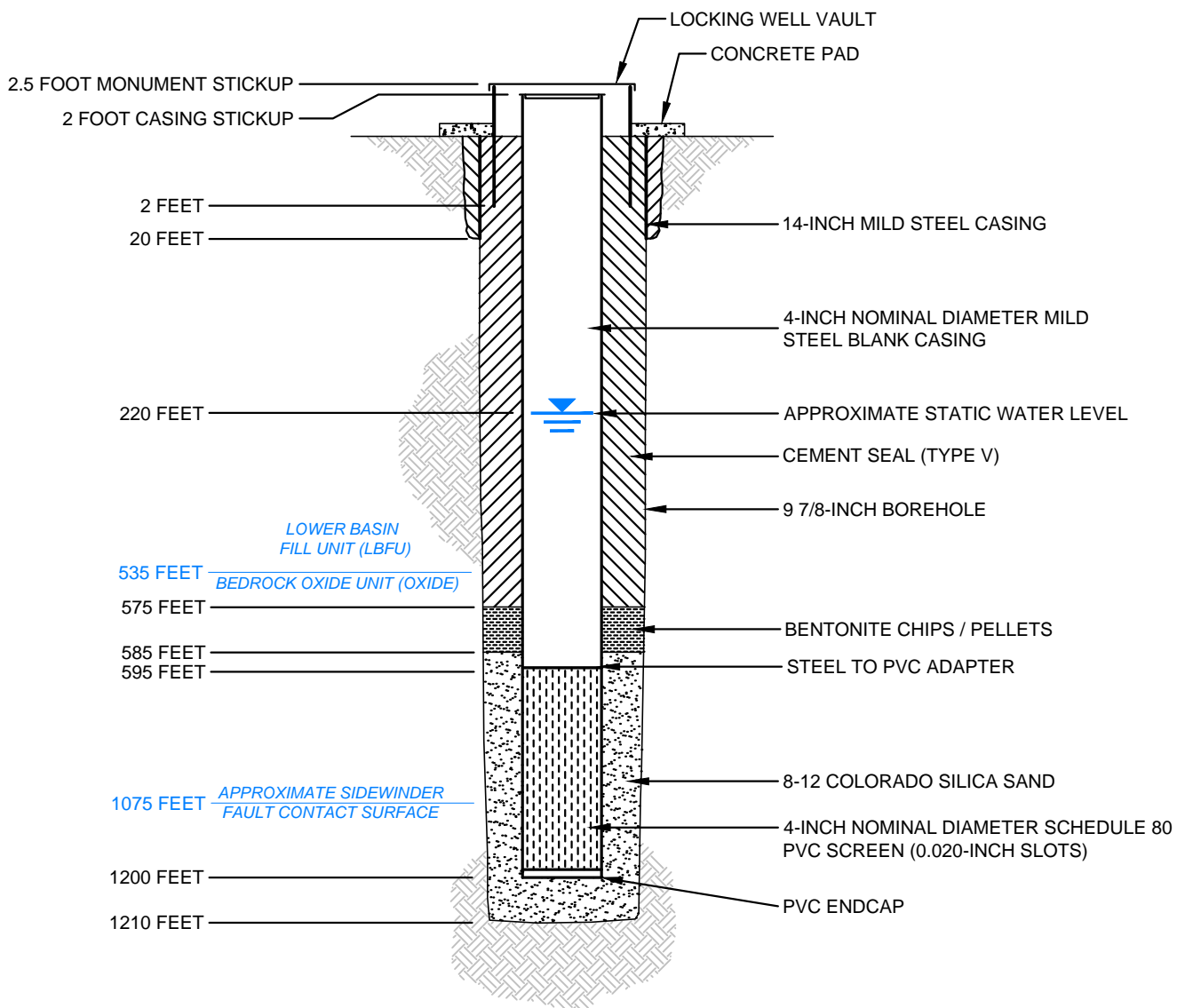
SUPPLEMENTAL MONITORING
WELL M57-O DESIGN (REVISED)

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FIGURE 12-1

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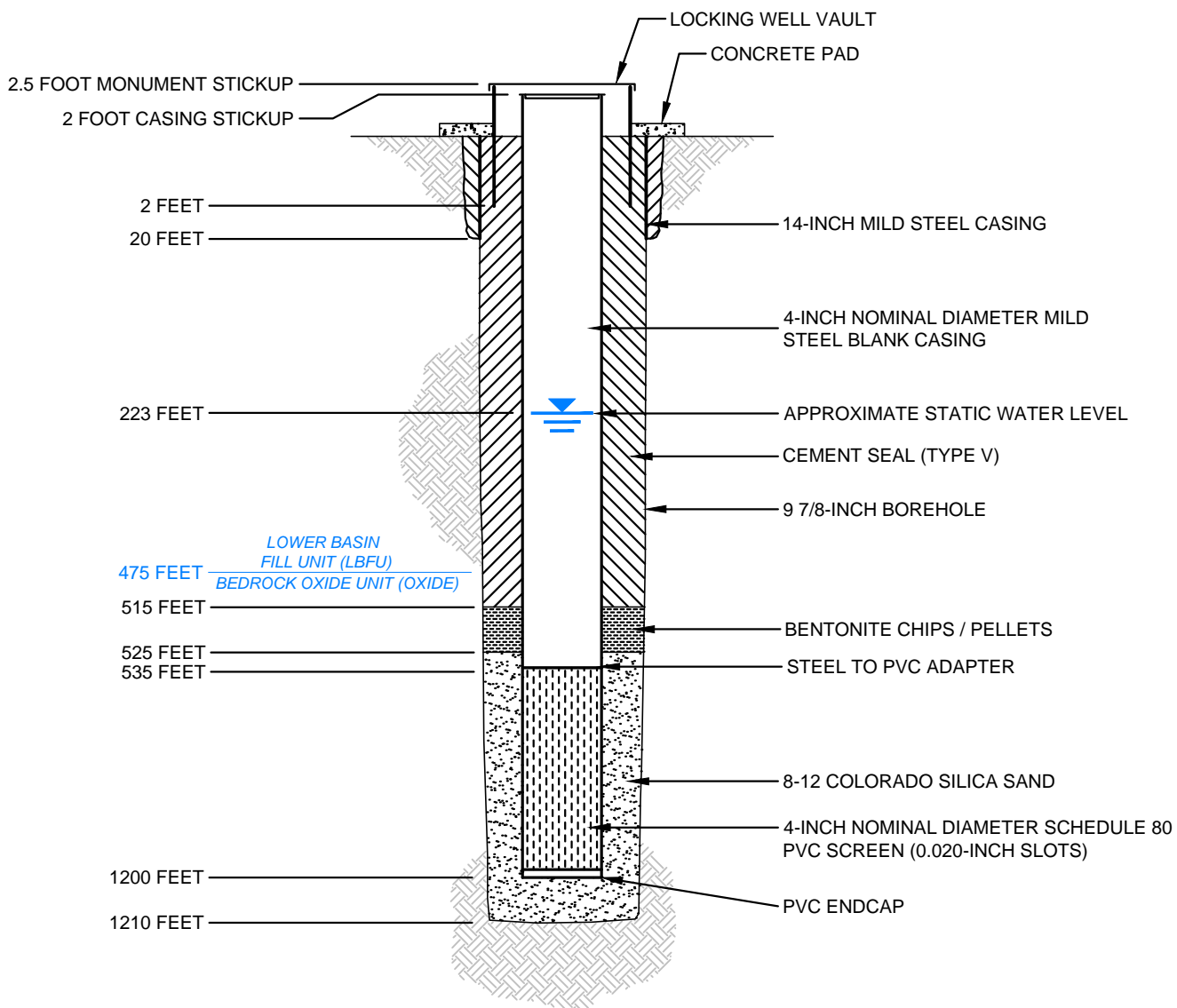
SUPPLEMENTAL MONITORING
WELL M58-O DESIGN (REVISED)

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FIGURE 12-2

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HALEY & ALDRICH

FLORENCE COPPER, INC.
FLORENCE, ARIZONA

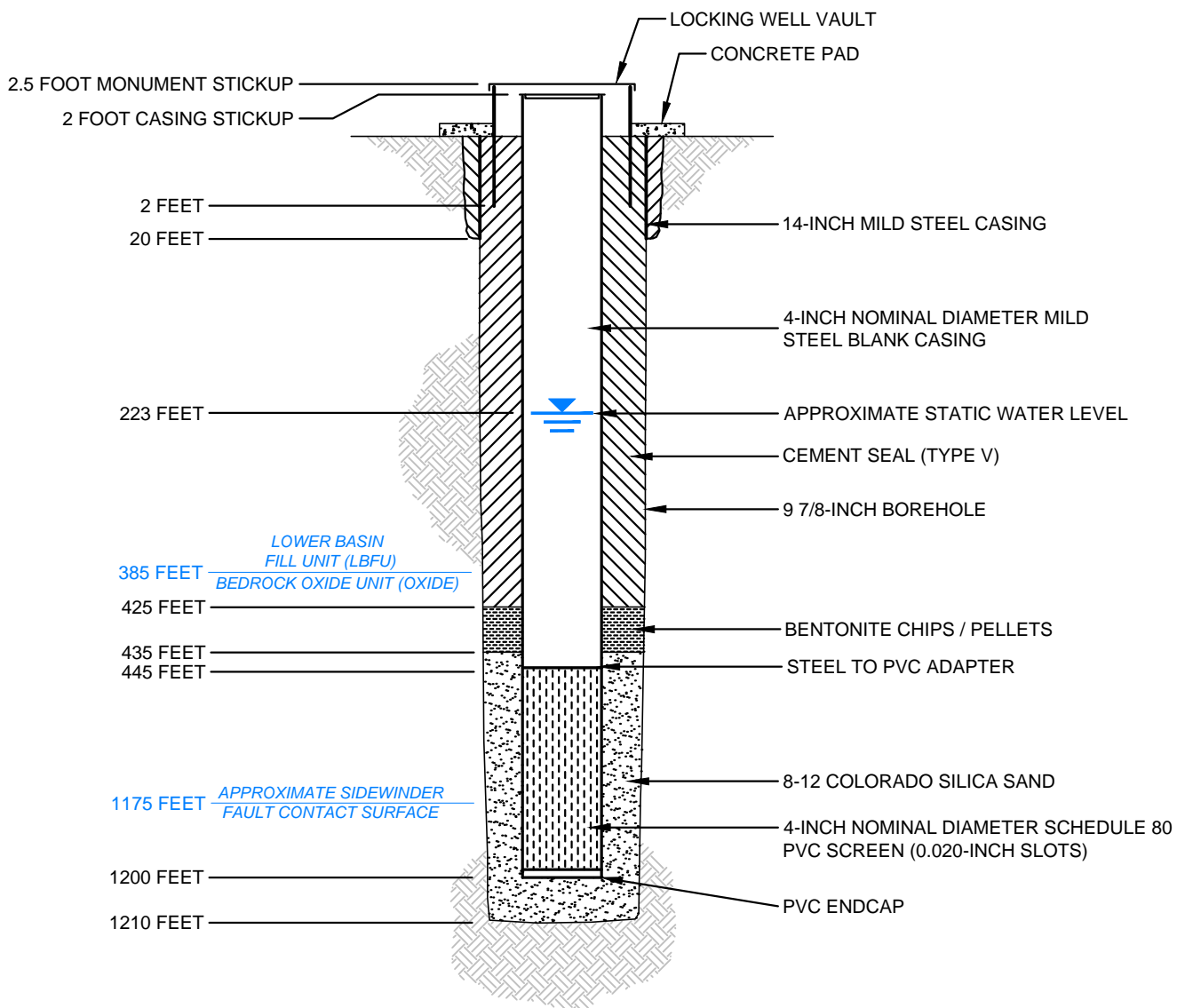
SUPPLEMENTAL MONITORING
WELL M59-O DESIGN (REVISED)

**FLORENCE
COPPER INC.**

SCALE: NOT TO SCALE
JULY 2014

FIGURE 12-3

G:\PROJECTS\CURIS RESOURCES\38706-CURIS FEASIBILITY\DRAWINGS\2014 UIC APPWELL DESIGNS\M60WELLDDESIGN.DWG



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SUPPLEMENTAL MONITORING
WELL M60-O DESIGN (REVISED)

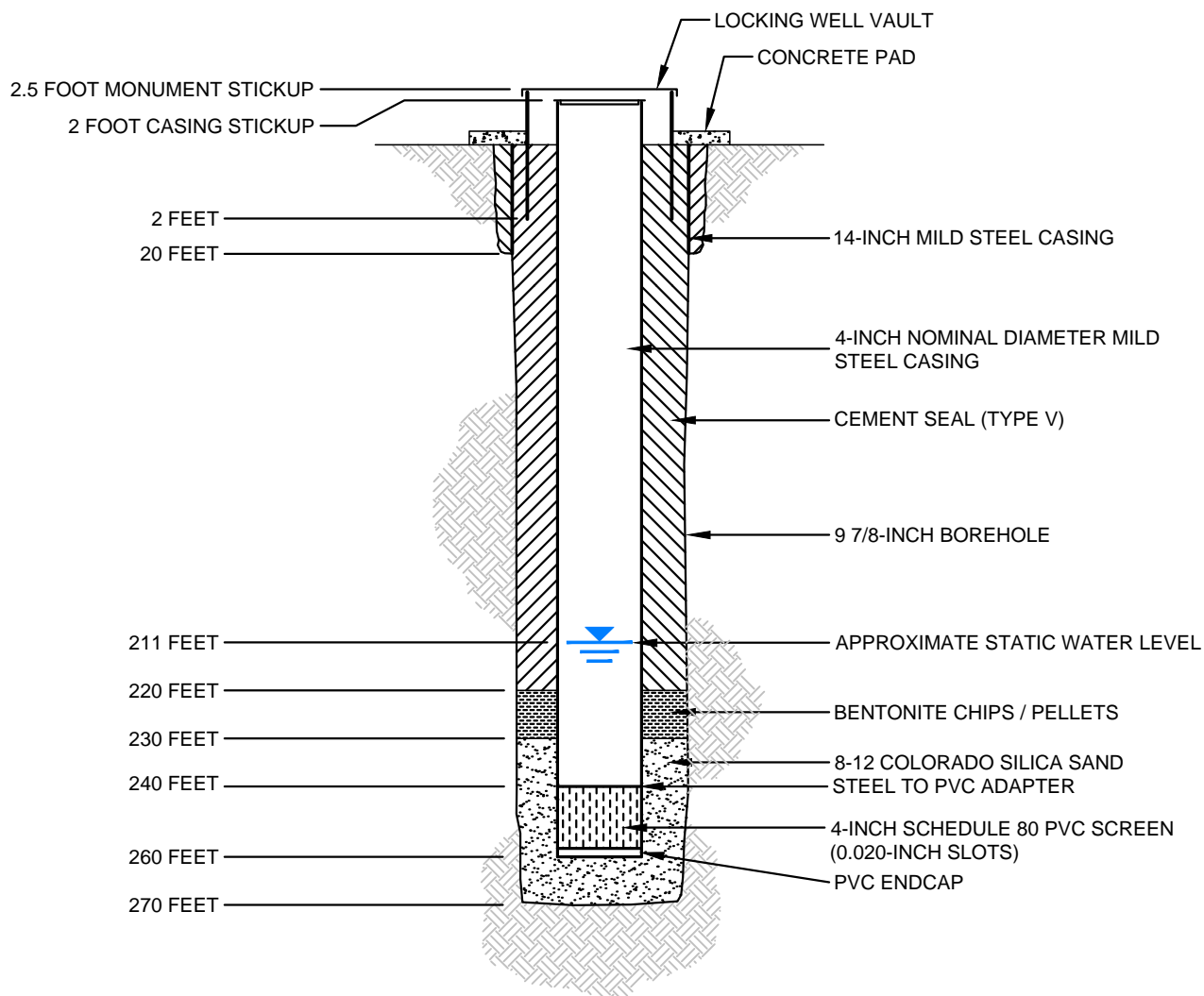


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COPPER INC.

SCALE: NOT TO SCALE
JULY 2014

FIGURE 12-4

G:\PROJECTS\CURIS RESOURCES\38706-CURIS FEASIBILITY\DRAWINGS\2014 UIC APPWELL DESIGNS\M55_M56_WELLDRAWING.DWG



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SUPPLEMENTAL MONITORING
WELL M55-UBF DESIGN (REVISED)

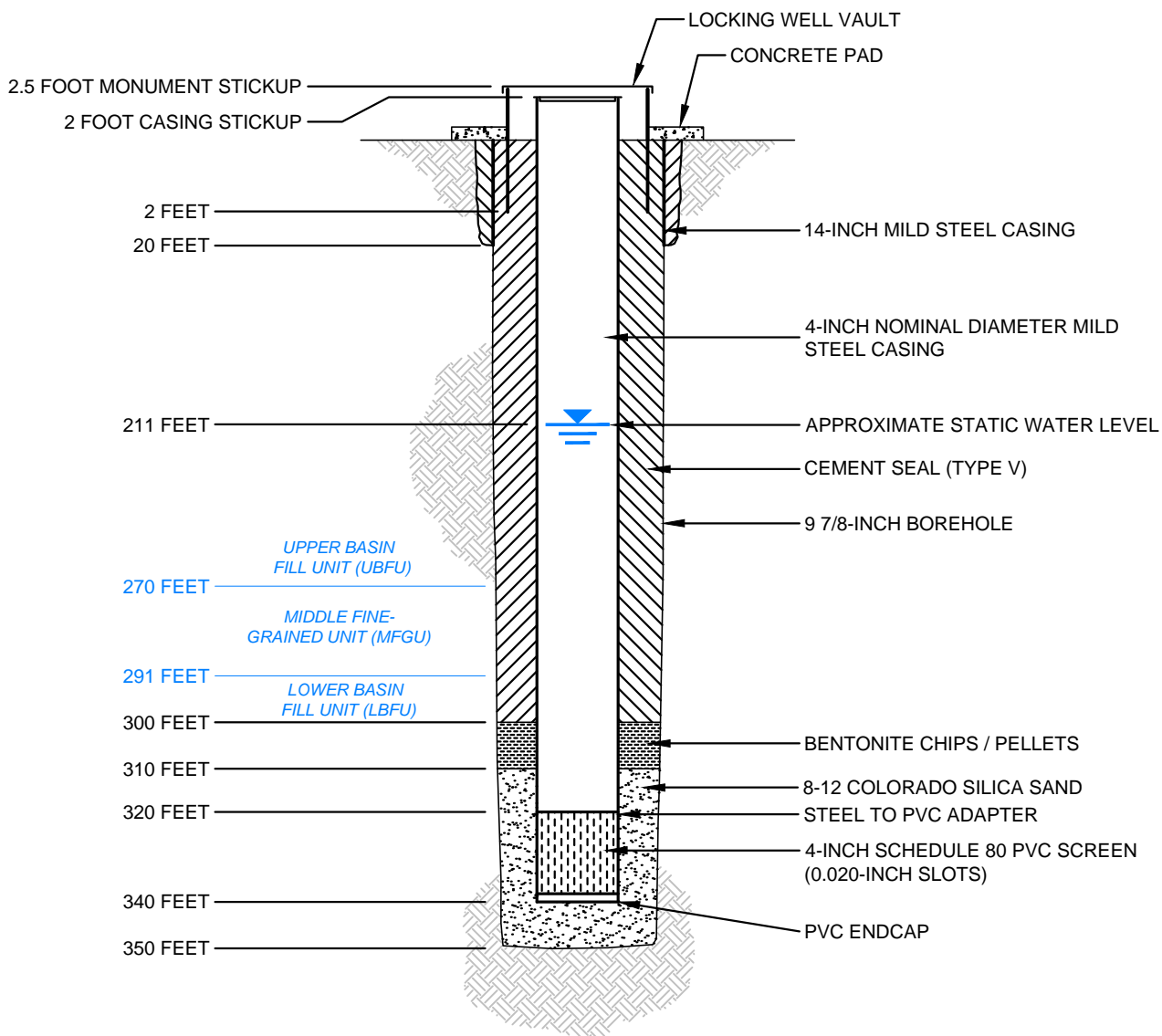


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COPPER INC.

SCALE: NOT TO SCALE
JULY 2014

FIGURE 18-2

G:\PROJECTS\CURIS RESOURCES\38706-CURIS FEASIBILITY\DRAWINGS\2014 UIC APPWELL DESIGNS\M55_M56_WELLDRAWING.DWG



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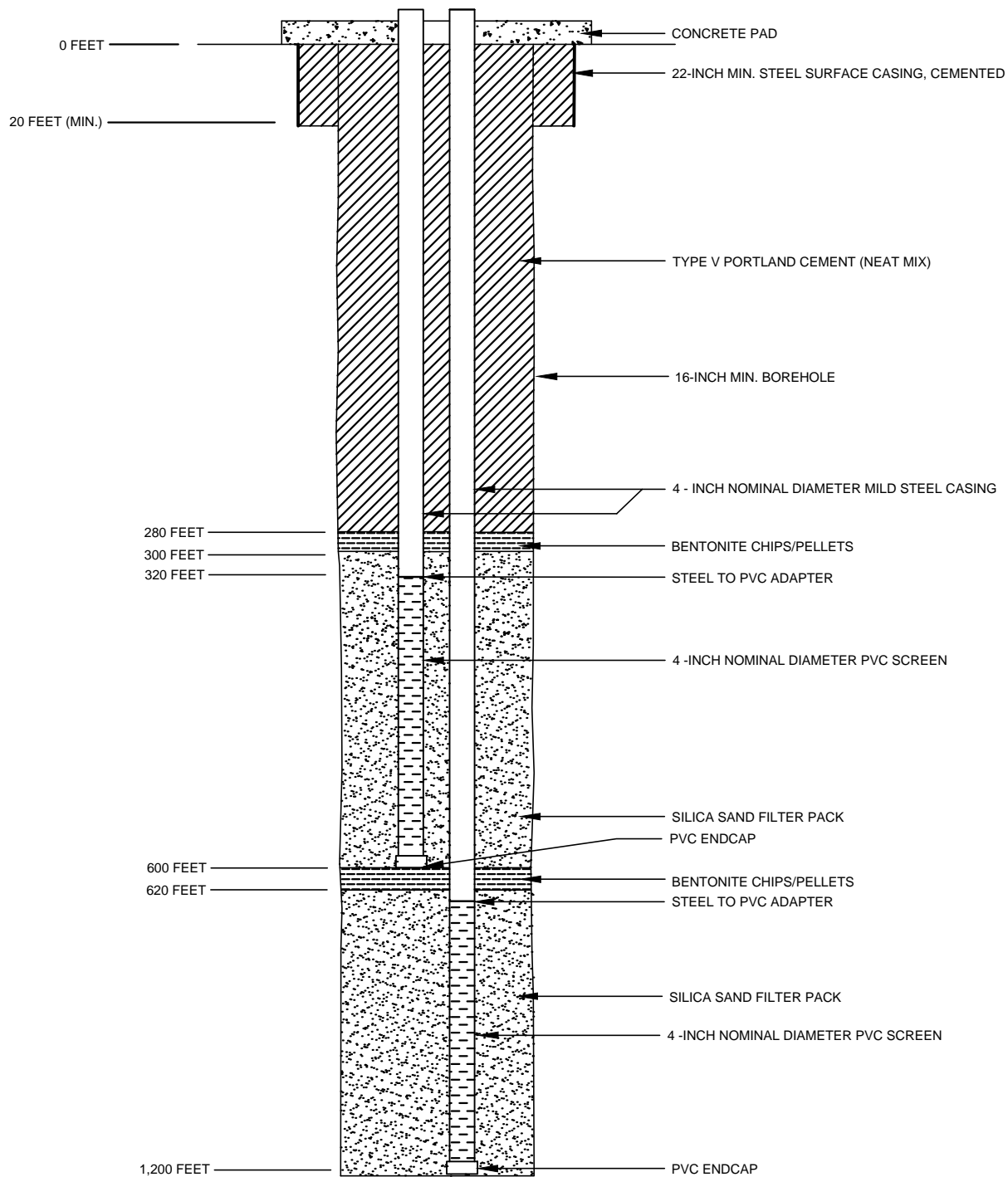
SUPPLEMENTAL MONITORING
WELL M56-LBF DESIGN (REVISED)

FLORENCE COPPER INC.

SCALE: NOT TO SCALE
JULY 2014

FIGURE 18-3

G:\PROJECTS\CURIS RESOURCES\38706-CURIS FEASIBILITY\DRAWINGS\JULY 2014 UIC APP\MW-01_WELL\DIAGRAM.DWG



NOTE: LITHOLOGIC UNIT CONTACTS WILL BE DETERMINED ONCE THE FINAL WELL LOCATION HAS BEEN APPROVED BY ARIZONA DEPARTMENT OF ENVIRONMENTAL QUALITY

HALEY & ALDRICH

FLORENCE COPPER, INC.
FLORENCE, ARIZONA

OPERATIONAL MONITORING WELL MW-01 PROPOSED DESIGN

FLORENCE COPPER INC.

SCALE: NOT TO SCALE
SEPTEMBER 2014

FIGURE M1-1