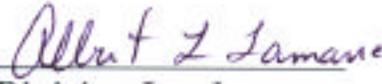


LLNL Environmental Restoration Division (ERD)
Standard Operating Procedure (SOP)

ERD SOP 1.4: Well Installation—Revision: 4

	AUTHOR(S): J. Valett*	
	APPROVALS:	Date
	 Division Leader	<u>10/23/00</u>
	 Hydrogeology Group Leader	<u>10/18/00</u>
	CONCURRENCE:	Date
	 QA Implementation Coordinator	<u>10/16/00</u>

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1.0 PURPOSE

The purpose of this SOP is to ensure proper well design and installation. Wells provide a means of collecting representative ground water samples and water-level data from a distinct water-bearing zone. Wells can also be used to extract contaminated ground water, or reinject treated ground water.

2.0 APPLICABILITY

This procedure is applicable for all personnel performing well installation operations, and shall be fully reviewed prior to conducting these activities.

3.0 REFERENCES

- 3.1 Department of Water Resources (1991), *California Well Standards: State of California*, Resources Agency, Bulletin 74-90.
- 3.2 Driscoll, F. G. (1986), *Ground Water and Wells*, Johnson Division, St. Paul, Minnesota.
- 3.3 U.S. Environmental Protection Agency (1987), *A Compendium of Superfund Field Operations Methods*, EPA/540/p-87/001.

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- 3.4 California Environmental Protection Agency, Department of Toxic Substances Control (1994), *Monitoring Well Design and Construction for Hydrogeologic Characterization*.
- 3.5 American Society of Testing and Materials (1990), *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers*, ASTM Standard D5092-90.

4.0 DEFINITIONS

See SOP Glossary.

5.0 RESPONSIBILITIES

5.1 Division Leader

The Division Leader's responsibility is to ensure that all activities performed by ERD at the Livermore Site and Site 300 are performed safely and comply with all pertinent regulations and procedures, and provide the necessary equipment and resources to accomplish the tasks described in this procedure.

5.2 Hydrogeology Group Leader (HGL)

The HGL's responsibility is to ensure that proper procedures are followed for activities (i.e., drilling, borehole logging and sampling, monitor well installations and development).

5.3 Drilling Supervisor (DS)

The DS schedules all drilling related activities and coordinates the drilling contractor schedules and equipment needs and the progress of drilling activities daily.

5.4 Drilling Coordinator (DC)

The DC provides the interface between the DS, Subproject Leader (SL), Hydrogeologist (HG), and the field activities and is responsible for coordinating the well completion activities with the Drilling Geologist.

5.5 Drilling Geologist (DG)

The DG is responsible for overseeing and documenting well completion activities safely and correctly per the Drilling Work Plan, and applicable operational and safety procedures, and to inform the DC and SL of any nonconformances.

5.6 Subproject Leader (SL)

The SL is responsible for the overall investigation, planning, assessment, and remediation within a study area, including decisions regarding borehole depths and well specifications.

5.7 Hydrogeologist (HG)

The HG is responsible for arranging the review of borehole and geophysical logs and assisting the SL with determining target zone for completion.

6.0 PROCEDURES

Well installations create permanent access for collecting ground water samples, measuring aquifer characteristics, and extracting ground water or reinjecting treated water. Wells should only minimally alter the medium being sampled.

6.1 Preparation

- 6.1.1 Perform the applicable preparation activities described in SOP 4.1, “Instructions for Field Personnel.”
- 6.1.2 Review drilling workplan for preliminary well completion information. After drilling, analysis, and logging, the original objectives may change. The SL may change how the well is to be completed. This change will be communicated to the DG by the SL.
- 6.1.3 Obtain necessary items listed in the Drilling Geologist Equipment Checklist (Attachment A) and obtain appropriate personal protective equipment (PPE) for site activities per SOP 4.1, “General Instructions for Field Personnel.”
- 6.1.4 Ensure that no foreign materials are introduced into the borehole without the DS’s approval. Use of solvents, glues, oil, or cleaners in the borehole is prohibited. Mud stabilization additives may be allowed in certain situations. The DS may grant such approval after communication with the appropriate regulatory agencies. Verify that any water source to be used is analyte-free.
- 6.1.5 Decontaminate all equipment and well casing, screen, centralizers, etc. prior to monitor well installation per SOP 4.5, “General Equipment Decontamination.” It is not necessary to decontaminate pre-cleaned well casing, screen, and centralizers supplied in factory-sealed containers, unless exposed to possible contamination.

6.2 Operation

- 6.2.1 Record the following on the Borehole/Well Construction Log (SOP 1.2, Attachment A) and the Monitoring Well As-Built Report (Attachment B):
 - A. Depth from surface grade of the following:
 - 1. Bottom of the boring,
 - 2. Overdrill (bottom) seal,
 - 3. Well casing and screen,
 - 4. Filter pack,
 - 5. Fine filter pack,
 - 6. Bentonite seal,
 - 7. Grout,
 - 8. Cave-in (slough),
 - 9. Centralizers, and
 - 10. Conductor casing, if permanent.

Note: Does not include wellhead completion specifications.

- B. Composition of the grout, seals, and filter pack.
- C. Casing/screen material and casing/screen inside diameter.
- D. Screen slot size and the anticipated wellhead completion.
- E. Type and amount of supplies used for well construction.

11. Drill all boreholes at least 4 in. greater in diameter than the outer diameter of the casing to be installed (minimum required work space in annulus is 2 in.). When setting a conductor casing, it is preferable to complete the casing a foot or more into the underlying clay or other fine-grained unit, if present. Bottom seals and the conductor casing annulus seal should be placed using Type I/II cement/2% bentonite grout or bentonite chips as directed by the SL or DS. Approved grout accelerators, such as Cal Seal, are permitted for bottom and conductor casing annulus seals to decrease setting times.

Note: Due to failure to reach specified depths, loss of tools, inadvertent contamination, or any other cause approved by the DS or SL, the well or borehole should be abandoned as discussed in SOP 1.7, "Well Closures."

6.2.3 Use Schedule 40 (or Schedule 80 at Site 300) PVC casing with 0.020-in. screen slot size for wells installed exclusively as monitor wells unless instructed otherwise by the DS or SL. If the well is installed to perform as an injection, extraction, or production well, the DS, in concert with the HG, DG, and SL, will determine the filter pack and screen slot size based on lithologic descriptions on the Borehole/Well Construction Log as per SOP 1.1, "Field Borehole Logging," interpretation of geophysical logs as performed per SOP 1.6, "Borehole Geophysical Logging," and if available, sieve analyses of the lithology in the screened interval. In addition, these personnel will determine the casing material (generally Schedule 40 or Schedule 80 PVC, stainless steel, or low carbon steel) based on site-specific conditions such as water quality, installation objectives, required tensile and compressive strengths, and the required life expectancy of the well.

6.2.4 Use plastic centralizers on all well installations unless the casing is being installed through hollow-stem augers. Fasten centralizers to the well casing by mechanical fasteners radially spaced about the casing at 120 or 90° degrees. Install centralizers at the top and bottom of the screened casing and on the blank casing at 5 to 10 ft below ground surface (Attachment C). Provide a description of the centralizer fastening device and the locations on the Borehole/Well Construction Log and Monitoring Well As-Built Report.

6.2.5 Place a filter pack in the annulus adjacent to the well screen in all monitor wells. The filter pack limits the transmission of sand and fines from the formation to the well, and stabilizes the formation. The filter pack should not extend within 5 ft of any water-bearing zone other than the one to be monitored. Well design should be modified to allow for a sufficient filter pack without threat of interconnecting water-bearing zones.

- A. Fill the annulus between the well screen and borehole wall with washed Lonestar Lapis Luster #3 Monterey-type sand (or an equivalent 8 × 20 U.S. standard sieve size or filter pack approved by the DS) extending a minimum of 1 ft above the screen before swabbing. A cap should be placed over the top of the well casing before pouring the sand down the annulus to prevent sand from entering the casing.

- B. When determined by the DS or SL, the filter pack is emplaced using a tremie pipe. For this, install a sand slurry composed of sand and potable water through the tremie pipe into the annulus throughout the entire screened interval and over the top of the screen. Continuously tag the depth of the filter pack to ensure that bridging does not occur.
 - C. Compact the filter pack by making a few passes with a bailer prior to the installation of the bentonite seal. Fully cover the screen after the sand has settled with sufficient filter material. Install at least 2 ft of sand above the top of a 5- to 10-ft-long screen. Increase the minimum filter pack thickness by approximately 1 ft for each additional 10 ft of screen. Cover the #3 sand with a minimum 1-ft layer of finer-grained Lonestar Lapis Luster Monterey-type sand #0/30 (or equivalent). The #0/30 sand is not added until it is verified that the #3 sand extends above the screen as discussed above. Attachment C displays a typical installation using the #0/30 sand.
 - D. Ascertain the depth of the top of the sand after compaction using a weighted tape or tremie pipe recorded by the DG.
- 6.2.6 Place a bentonite seal between the filter pack and grout to prevent infiltration of cement into the filter pack and the well. The bentonite should not be added until it is determined that there has been no settling of the filter pack. The steps below discuss the use of bentonite. Attachment B displays a typical installation using bentonite. A fine sand (#0/30) may be used on top of the bentonite seal if conditions warrant as determined by the driller and DG and approved by the DS.
- A. Fill the annulus between well casing and borehole with a bentonite seal at least 3 ft thick (vertically) in the interval between the fine sand above the filter pack and the grout seal. Bentonite seal thickness may be increased by an extra foot for each additional 50 ft of depth for deep wells (200 ft or more).
 - B. Use uncoated bentonite pellets with a minimum purity of 90% sodium montmorillonite (with no additives and certified by the National Sanitation Foundations (NSF) to ANSI/NSF Standard 60, Drinking Water Treatment Chemicals - Health Effects) and a minimum dry bulk density of 75 lb/cu ft for 1/2-in. pellets. Place a cap over the top of the well casing and slowly pour the bentonite pellets directly down the annulus. Pour the pellets from different points around the casing to ensure even distribution in the annulus. Test the borehole for bridging of the bentonite during application. Bentonite chips, certified to ANSI/NSF Standard 60, may be used to reduce bridging problems and costs. Add enough approved clean water, usually 10 to 20 gal, to completely hydrate the bentonite.
 - C. Tag the top of the bentonite seal with a tremie pipe or a weighted tape to verify that the proper thickness of seal has been placed in the annulus.
 - D. Allow at least 45 min for the bentonite pellets to hydrate prior to placing grout. Allow 1.5 h for bentonite chips to hydrate prior to placing grout.
- 6.2.7 Fill the well annulus with grout from the top of the bentonite seal to the surface. Only Type I/II [American Society for Testing and Materials (ASTM C-150)] cement without accelerator additives may be used, unless otherwise specified by the DS. Place the grout in the well annulus as follows:
- A. Completely fill the annulus between the well casing and borehole wall.

- B. Place the grout with a tremie pipe unless the borehole is dry and does not exceed a depth of 30 ft. The tremie pipe typically used is 1.25-in. PVC. The tremie pipe must have a “J” tube on the lower end.
 - C. Pump the grout through this pipe to the bottom of the open annulus until undiluted grout flows from the annulus at the ground surface. Deeper annular depths and larger diameter boreholes may require large amounts of grout. In these cases, set grout in 100 to 150-gal lifts, allowing sufficient time for the grout mix to set between lifts. Use approved accelerators such as Cal-Seal, to decrease setting times only with approval of the DS. Certain subsurface/borehole conditions may require an initial small lift of grout (<15 ft) to prevent rupturing the bentonite seal. The DG should check with the DC, SL, and DS on each completion.
 - D. The grout should consist of a neat cement mix composed of 2 lb of commercial bentonite powder, certified to ANSI/NSF Standard 60, and approximately 6.5 gal of water added per 94-lb bag of cement. Only grout mixed with approved water should be used.
 - E. After the grout has set (about 72 h), fill any depression in the grout due to settlement with a grout mix similar to that described above.
 - F. The DG shall write with an indelible marker, the well ID number, screened interval, and total depth on the well casing and cap.
- 6.2.8 Install a protective stove pipe or a below-grade vault around all monitor wells. This will normally be done at a later date by LLNL technicians. Prior to installation, the DG should ensure temporary wellhead protection by placing barriers around the well. The minimum elements in the protection design should include:
- A. Protective stove pipe (above grade).
 - 1. Install a minimum 2 ft × 2 ft, 3-in.-thick concrete pad, such that surface drainage is diverted away from the wellhead.
 - 2. Secure a metal stovepipe to the concrete pad. The stovepipe must keep precipitation out of the well and is secured by a padlock. The exact height of the top of the well casing and stove pipe is recorded and reported to the Data Management Team (DMT) and Sampling Coordinator (SC), as appropriate.
 - 3. Place the well identification label on the protective casing.
 - B. Vault (installed below grade when wells are located in streets, parking lots, or sidewalks).
 - 1. Install the vault so that surface drainage is diverted away from the vault.
 - 2. The lid of the vault must keep fluids out of the vault and have a key locking system.
 - 3. Install a traffic-rated vault for installations in streets or parking lots.

6.3 Post Operation

- 6.3.1 Perform post-work activities described in SOP 4.1, Section 6.3.

- 6.3.2 Return the site to its original condition, using best reasonable efforts, and notify the DC that the well is completed and is ready for surveying and pump installation. Following development, submit the completed Well Specification Form (Attachment D) to the DC and SC.
- 6.3.3 The DC or SL will arrange to have the LLNL Survey Team survey the cement pad or the edge of the vault to the nearest 0.01 ft. A shiny, metal well identification tag (shiner) is attached to the survey location (concrete pad or edge of vault) by the Survey Team with the well ID stamped on the tag. A copy of the survey data is distributed to the DC, DMT, and SC.
- 6.3.4 Deliver original copies of Borehole/Well Construction Log, Well Development Form, Field Logbook, and all other relevant forms and information to the Quality Control Reviewer for review. After the review, edit documents and copy and distribute files.

7.0 QUALITY ASSURANCE RECORDS

- 7.1 Borehole/Well Construction Log
- 7.2 Document Control Logbook
- 7.3 Monitoring Well As-Built Report
- 7.4 Well Specifications Form

8.0 ATTACHMENTS

- Attachment A—Drilling Geologist Equipment Checklist
- Attachment B—Monitoring Well As-Built Report
- Attachment C—Typical Monitor Well
- Attachment D—Well Specifications Form

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Attachment A

Drilling Geologist Equipment Checklist

Drilling Geologist Equipment Checklist

- ___ 300-ft weighted tape
- ___ Any applicable permits (i.e., excavation, utility clearance, burn permits)
- ___ Applicable documents (i.e., SSP, OSPs, SOPs, work plan, sample plan, etc.)
- ___ Appropriate clothing (i.e., coveralls, steel-toed safety shoes, gloves)
- ___ Barricades/traffic cones
- ___ Buckets and brushes
- ___ Caution tape
- ___ Company ID sign for vehicle
- ___ Cooler with ice
- ___ Core boxes, marking pens
- ___ Deionized water
- ___ Detergents (Alconox, Liquinox)
- ___ Disposable Teflon or polyethylene bailers
- ___ Document control logbook
- ___ Field forms (i.e., borehole/well constructions form, daily field report forms)
- ___ Field notebook
- ___ Fire extinguisher
- ___ First aid kit
- ___ Glass jar
- ___ Grain-size sieves
- ___ Hard hat
- ___ Hearing protection
- ___ Imhoff cone
- ___ Measuring wheel
- ___ Munsell soil/rock color chart
- ___ Nitrile or latex sampling gloves
- ___ pH paper
- ___ PID or FID, or gamma/beta meter if required
- ___ Rock hammer
- ___ Safety glasses
- ___ Sample containers/labels
- ___ Signs listing responsible persons, restricted entry, hearing protection/hard hat/safety glasses/safety shoes required
- ___ Soil sample tubes
- ___ Steel measuring tape with engineering scale
- ___ Steel spatula
- ___ Stopwatch or watch with second hand
- ___ String
- ___ Teflon tape (4 in. wide)
- ___ Water-level meter
- ___ Zip-Loc plastic bags

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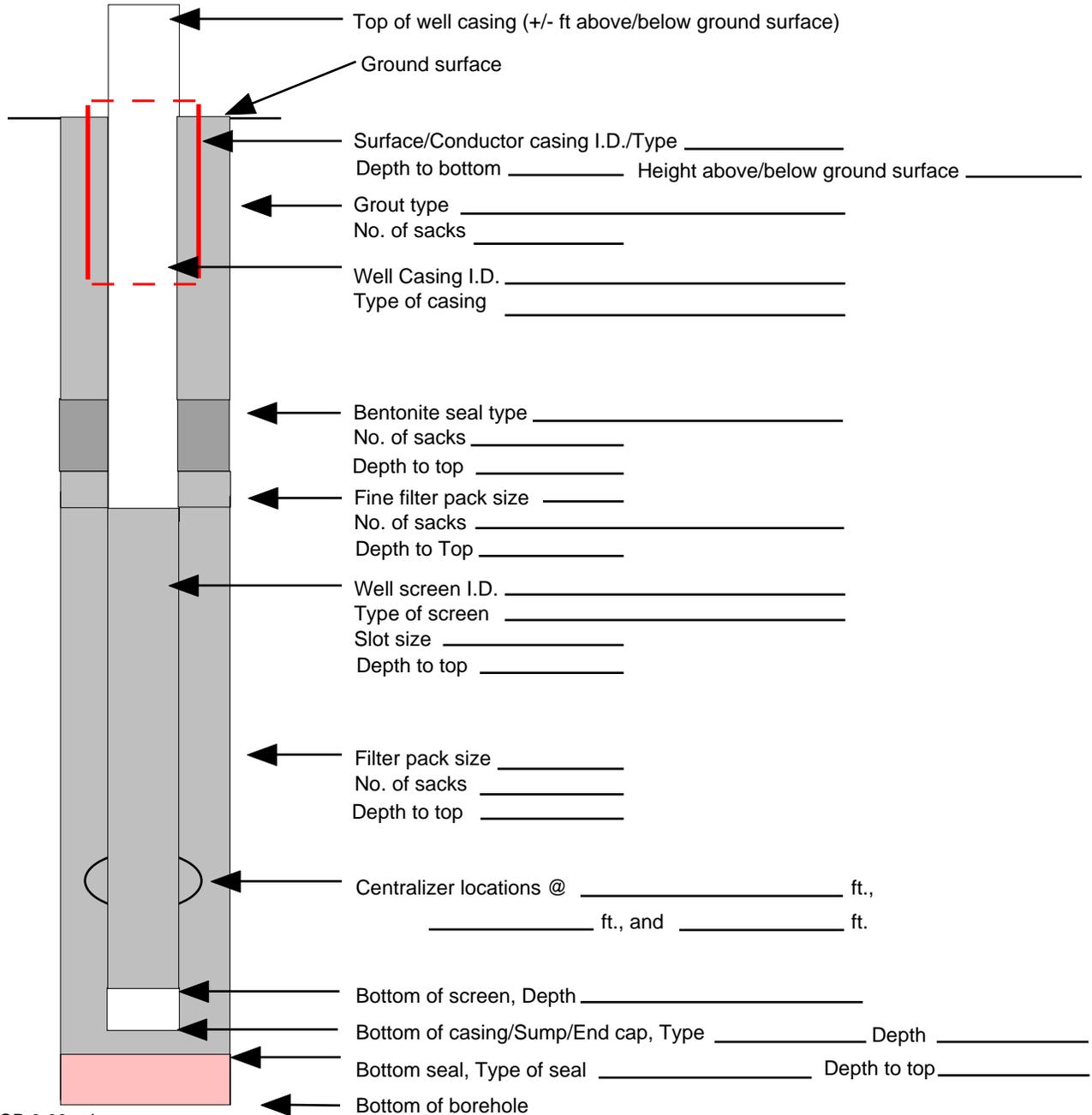
Attachment B

Monitoring Well As-Built Report

Location _____
Observed By _____
Driller/Installer _____

Project _____
Job No. _____
Boring/Well No. _____
Date _____

NOTE: final wellhead completion details not included



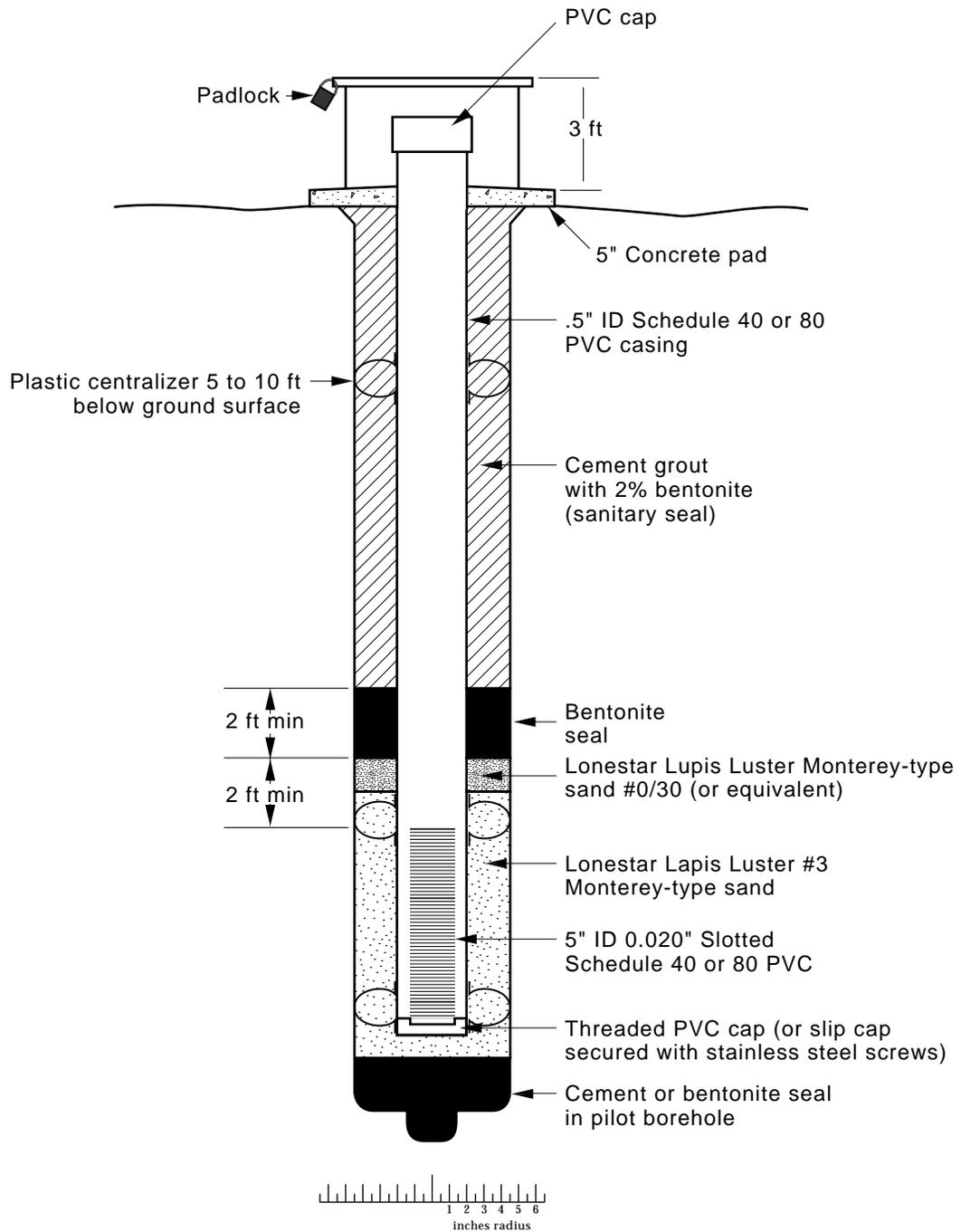
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Remarks _____

ERD Approval By _____

Attachment C

Typical Monitor Well



ERD-LSR-00-0136

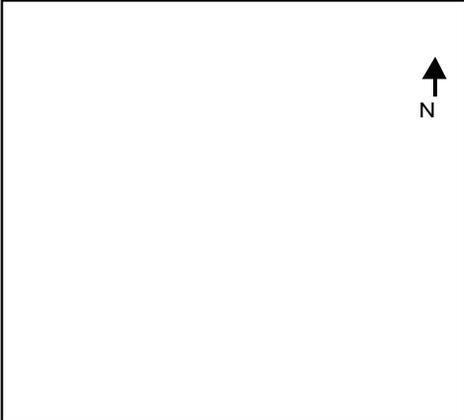
Attachment C. Typical monitor well.

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Attachment D

Well Specifications Form

WELL SPECIFICATIONS Form

<p>FOR WELL INSTALLATION USE</p> <hr/> <p style="text-align: center;">SAMPLE LOCATION IDENTIFICATION</p> <hr/> <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Total boring depth - ground (ft)</td> <td style="width: 50%; border: none;">Static depth</td> </tr> <tr> <td style="border: none;">Casing diameter</td> <td style="border: none;">Sustainable Q</td> </tr> <tr> <td style="border: none;">Casing depth - ground (ft)</td> <td style="border: none;">Hydro unit (Water bearing zone)</td> </tr> <tr> <td style="border: none;">Screened interval from ground</td> <td style="border: none;">Sand Pack</td> </tr> </table> <hr/> <p>Date: _____ Signature: _____ <i>DRILLING GEOLOGIST</i> Print name <i>Drilling Geologist</i></p>	Total boring depth - ground (ft)	Static depth	Casing diameter	Sustainable Q	Casing depth - ground (ft)	Hydro unit (Water bearing zone)	Screened interval from ground	Sand Pack	<p>Approximate Location of Well:</p> <div style="border: 1px solid black; padding: 10px; text-align: center;">  <p style="margin: 0;">Location of well & surrounding area</p> </div>
Total boring depth - ground (ft)	Static depth								
Casing diameter	Sustainable Q								
Casing depth - ground (ft)	Hydro unit (Water bearing zone)								
Screened interval from ground	Sand Pack								

<p>FOR WELL DEVELOPMENT USE</p> <hr/> <p>Date: measured _____ Flow rate (Q) _____</p> <hr/> <p style="text-align: center;">Recommended Pump Type / H P</p> <hr/> <p>Estimated Contaminant Level (ppb)/other. <i>(include all voc's, metals, rad., other)</i></p> <hr/> <hr/> <p>Date: _____ Signature: _____ <i>HYDROGEOLOGIST</i> Print name <i>Hydrogeologist</i></p>	<p>DESCRIPTION OF INTENDED USE AND WELL LOCATION:</p> <hr/>
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Original Form to: EPD/ERD/DMT (Data Management Team) T4383 L-528

Copies to: _____ *Circle one* _____ *Specify Name*

FOR WELL COMPLETION SPECS, PLEASE COMPLETE THE FOLLOWING INFORMATION:

Stove pipe or Christy box <i>Circle one</i>	Stove pipe height	Total depth <i>(Tagged from TOP of POM to bottom of casing)</i>	P.O.M. <i>(Shiner elevation plus Stovepipe height = POM)</i>	
Date installed	Pump type/Vol/HP	Pump intake depth from P.O.M.	Pump start date	Date well completed and ready for sampling
Survey data:	Northing	Easting	Shiner elevation	

Date: _____ **Signature:** _____ *TECHNOLOGIST* **Print name** *Technologist*

Legend: Pump Types: GF = Grundfos Elect. Sub.; RF = RediFlo 115v/230v.; WW- Well Wizard,Bladder Pump; NP= No Pump; NA = Not Applicable; Well Types: BC= Barcad; LY = Lysimeter; MW = Monitor Well; NP = Newtron Probe; PR = Production Well/Water Supply Well

DMT/RTD/ERD 09-08-00