Geoprobe® 0.5-in. x 1.4-in. OD and 0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Wells

Standard Operating Procedure

Technical Bulletin No. 962000

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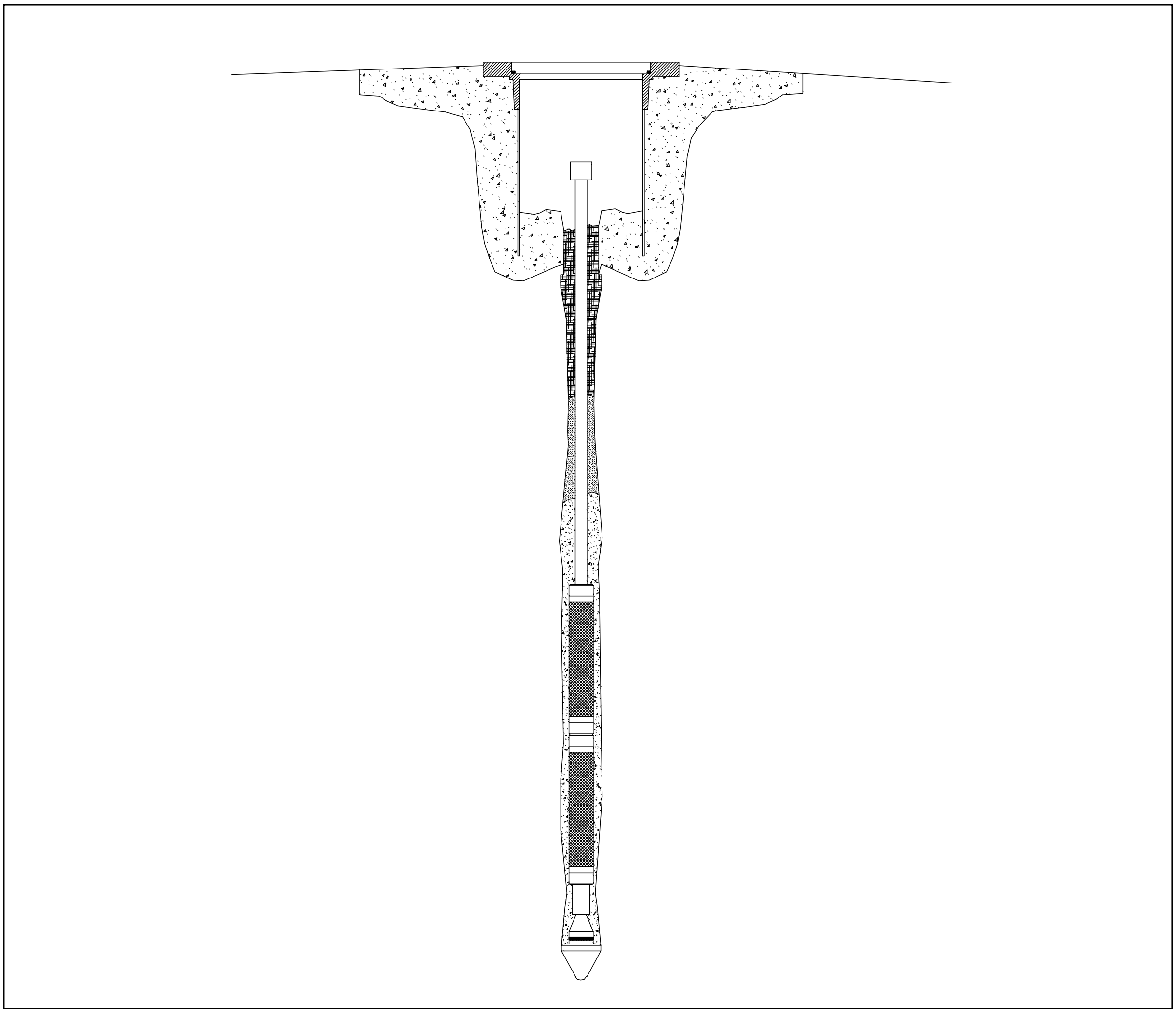

GEOPROBE® PREPACKED SCREEN MONITORING WELL

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Geoprobe® Prepacked Screens are manufactured under U.S. Patent No. 7,735,553B2.

1.0 OBJECTIVE

The objective of this procedure is to install a permanent, small-diameter groundwater monitoring well that can be used to collect water quality samples, conduct hydrologic and pressure measurements, or perform any other sampling event that does not require large amounts of water over a short period of time (e.g. flow rate > 1 liter/minute). These methods meet or exceed the specifications discussed for direct push installation of permanent monitoring wells with prepacked screens in the U.S. Environmental Protection Agency's guidance document, *Expedited Site Assessment Tools For Underground Storage Tank Sites*, (EPA, 1997) and ASTM Standards *D 6724* (ASTM, 2002) and *D 6725* (ASTM, 2002).

2.0 BACKGROUND

2.1 Definitions

Geoprobe® Direct Push Machine: A vehicle-mounted, hydraulically-powered machine that uses static force and percussion to advance small-diameter sampling tools into the subsurface for collecting soil core, soil gas, or groundwater samples. The Geoprobe® brand name refers to both machines and tools manufactured by Geoprobe Systems®, Salina, Kansas. Geoprobe® tools are used to perform soil core and soil gas sampling, groundwater sampling, soil conductivity and contaminant logging, grouting, materials injection, and to install small-diameter permanent monitoring wells or temporary piezometers.
**Geoprobe® is a registered trademark of Kejr, Inc., Salina, Kansas.*

0.5-inch x 1.4-inch OD Prepacked Well Screen (0.5-inch prepack): An assembly consisting of a slotted PVC pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.5-inch Schedule 80 PVC pipe with 0.01-inch (0.25 mm) slots. Stainless steel wire mesh with a pore size of 0.011 inches (0.28 mm) makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe® 0.5-inch x 1.4-inch prepacks are available in 3-foot and 5-foot sections and have an outside diameter of 1.4 inches (36 mm) and a nominal inside diameter of 0.5 inches (13 mm).

0.75-inch x 1.4-inch OD Prepacked Well Screen (0.75-inch prepack): An assembly consisting of a slotted PVC pipe surrounded by environmental grade sand contained within a stainless steel wire mesh cylinder. The inner component of the prepacked screen is a flush-threaded, 0.75-inch Schedule 40 PVC pipe with 0.01-inch (0.25 mm) slots. Stainless steel wire mesh with a pore size of 0.011 inches (0.28 mm) makes up the outer component of the prepack. The space between the inner slotted pipe and outer wire mesh is filled with 20/40 mesh silica sand. Geoprobe® 0.75-inch x 1.4-inch prepacks are available in 3-foot and 5-foot sections and have an outside diameter of 1.4 inches (36 mm) and a nominal inside diameter of 0.75 inches (19 mm).

2.2 Discussion

Conventional monitoring wells are typically constructed through hollow stem augers by lowering slotted PVC pipe (screen) to depth on the leading end of a string of threaded PVC riser pipe. A filter pack is then installed by pouring clean sand of known particle size through the tool string annulus until the slotted section of the PVC pipe is sufficiently covered.

Installing the entire filter pack through the tool string annulus becomes a delicate and time-consuming process when performed with small-diameter direct push tooling. Sand must be poured very slowly in order to avoid bridging between the riser pipe and probe rod. When bridging does occur, considerable time can be lost in attempting to dislodge the sand or possibly pulling the tool string and starting over.

Prepacked screens greatly decrease the volume of loose sand required for well installation as each screen assembly includes the necessary sand filter pack. Sand must still be delivered through the casing annulus to provide a minimum 2-foot grout barrier, but this volume is significantly less than for the entire screened interval.

The procedures outlined in this document describe construction of a permanent groundwater monitoring well using Geoprobe® 2.125-inch (54 mm) or 2.25-inch (57 mm) outside diameter (OD) probe rods and 1.4-inch OD prepacked screens. Geoprobe® 1.4-inch prepacks are available with either nominal 0.5-inch schedule 80 or 0.75-inch schedule 40 PVC components. Further options include running lengths of 3 and 5 feet for both 0.5- and 0.75-inch prepacks.

Installation of a prepack monitoring well begins by advancing 2.125-inch (54 mm) or 2.25-inch (57 mm) outside diameter (OD) probe rods to depth with a Geoprobe® direct push machine. Prepacked screen(s) are then assembled and installed through the 1.5-inch (38 mm) inside diameter (ID) of the probe rods using corresponding 0.5-inch schedule 80 or 0.75-inch schedule 40 PVC riser (Fig. 2.1-A).

The prepack tool string is attached to an expendable anchor point with a locking connector that is threaded to the bottom of the leading screen. Once the connector is locked onto the anchor point, the rod string is slowly retracted until the lower end of the rods is approximately 3 feet above the top prepack. Threaded bottom plug with an expendable point is another way to set the well.

Regulations generally require a minimum 2-foot grout barrier above the top prepack (Fig. 2.1-B) to avoid contaminating the well screens with bentonite or cement during installation. In some instances, natural formation collapse will provide the required barrier. If the formation is stable and does not collapse around the riser as the rod string is retracted, environmental grade 20/40 mesh sand may be installed through the probe rods to provide the minimum 2-foot grout barrier.

Granular bentonite or bentonite slurry is then installed in the annulus to form a well seal (Fig. 2.1-B). A high-pressure grout pump (Geoprobe® Model GS1000 or GS500) may be used to tremie high-solids bentonite slurry or neat cement grout to fill the well annulus as the probe rods are retracted (Fig. 2.1-B). The grout mixture must be installed with a tremie tube from the bottom up to accomplish a tight seal without voids to meet regulatory requirements.

In certain formation conditions, the prepacked screens may bind inside the probe rods as the rods are retracted. This is most common in sandy formations sometimes called flowing or heaving sands. This binding can generally be overcome by lowering extension rods down the inside of the well riser and gently, but firmly, tapping the extension rods against the base of the well as the rods are slowly retracted. If the binding persists, clean tap water or distilled water may be poured down the annulus of the rods to increase the hydraulic head inside the well. This, combined with the use of the extension rods, will free up the prepacked screen and allow for proper emplacement.

Once the well is set, conventional flush-mount or aboveground well protection can be installed to prevent tampering or damage to the well head (Fig. 2.1-B). These wells can be sampled by several available methods (bladder pump, peristaltic pump, mini-bailer, Geoprobe® tubing check valve, etc.) to obtain high integrity water quality samples. These wells also provide accurate water level measurements and can be used as observation wells during aquifer pump tests.

When installed properly, these small-diameter wells generally meet regulatory requirements for a permanent monitoring well. While a detailed installation procedure is given in this document, it is by no means totally inclusive. **Always check local regulatory requirements and modify the well installation procedure accordingly.** These methods meet or exceed the specifications discussed for direct push installation of permanent monitoring wells with prepacked screens in the U.S. Environmental Protection Agency's guidance document, *Expedited Site Assessment Tools For Underground Storage Tank Sites*, (EPA, 1997) and ASTM Standards *D 6724* (ASTM, 2002) and *D 6725* (ASTM, 2002).

** The Mechanical Bladder Pump is manufactured under U.S. Patent No. 6,877,965 issued April 12, 2005.*

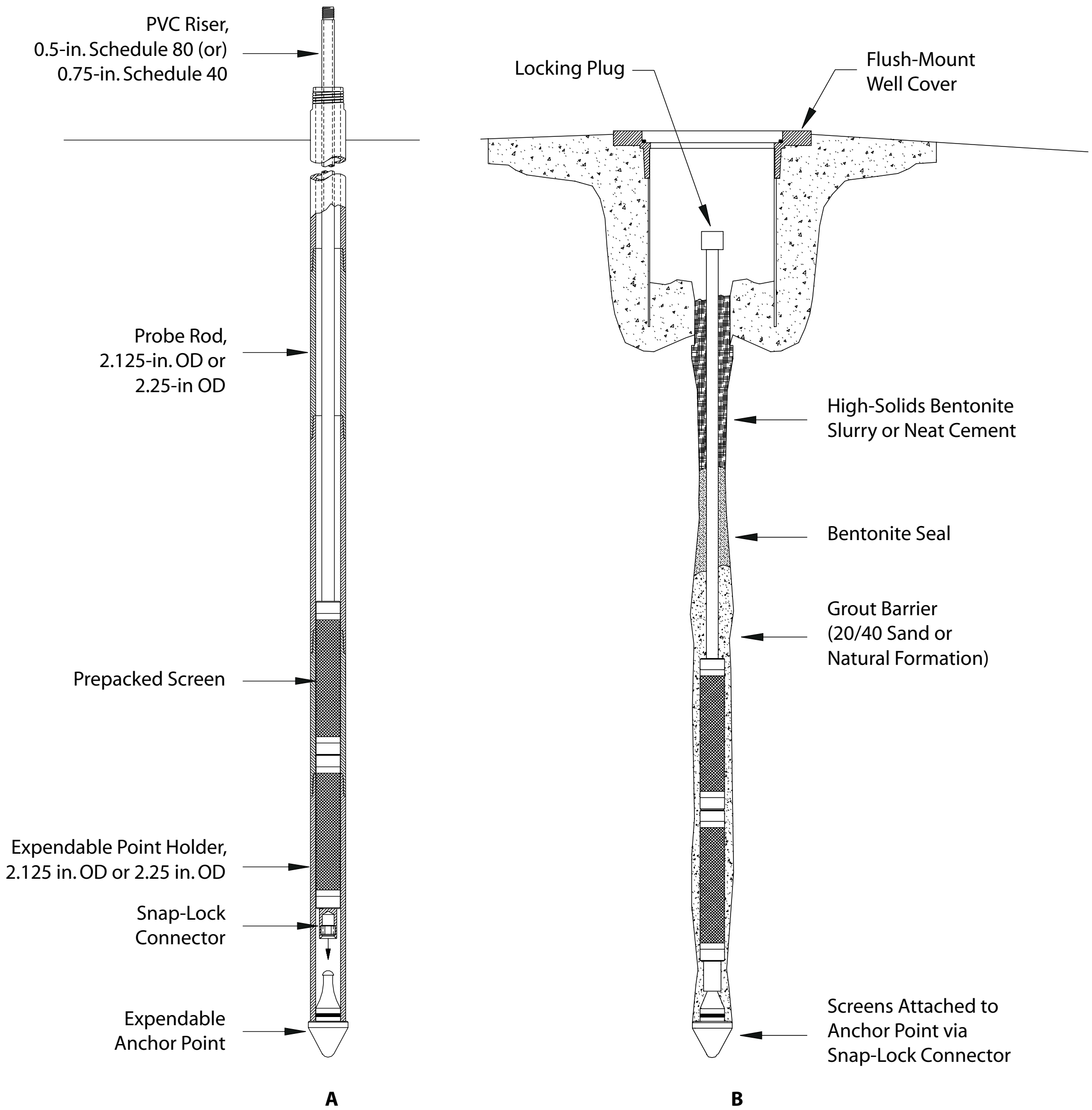

FIGURE 2.1:
Insertion of Prepacked Screens (A) and Installed Geoprobe Monitoring Well (B)

3.0 TOOLS AND EQUIPMENT

The following can be used to install a permanent monitoring well with Geoprobe® 1.4-inch OD prepacked screens. Refer to Figures 3.1-3.4 for illustrations of the specified parts.

0.5-in. X 1.4-in. OD Prepack Well Components	Part Number
0.5-in. x 1.4-in. OD Prepacked Screen, 3-ft. length	GW2010
0.5-in. x 1.4-in. OD Prepacked Screen, 5-ft. length	GW2020
Snap-Lock Connector Assembly, 0.5-in. Sch. 80	GW2030
Expendable Anchor Point, 2.5-in. OD	GW2040
PVC Riser, 0.5-in. sch. 80, 5-ft. length	GW2050
O-rings for 0.5-in. PVC Riser, Pkg. of 25	GW430R
PVC Top Cap, 0.5-in. sch. 80 Flush Thread	GW2055
Locking Well Plug, for 0.5-in. sch. 80 riser	WP1750
Non-Locking Well Plug, for 0.5-in. sch. 80 riser	WP1751
Vinyl Cap, 0.812-in. ID (optional)	AT441
PVC Bottom Plug, 0.5-in. Sch. 80 Flush Thread (optional)	GW2056
Expendable Drive Point, 2.125-in. rods / 2.5-in. OD (optional)	AT2015
Expendable Drive Point, 2.125-in. rods / 2.5-in. OD (Extended Shank)	19442

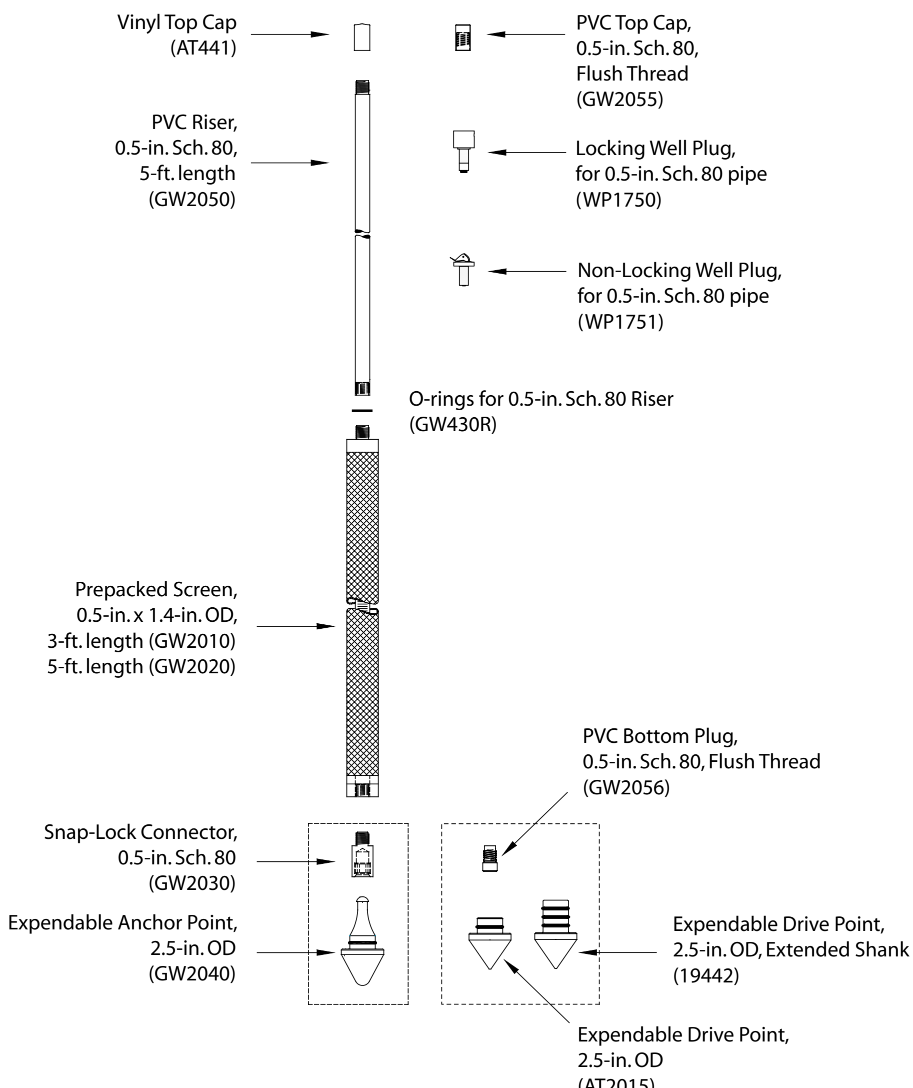

FIGURE 3.1:
0.5-in. x 1.4-in. OD Prepacked Screen Monitoring Well Parts

0.75-in. X 1.4-in. OD Prepack Well Components	Part Number
0.75-in. x 1.4-in. OD Prepacked Screen, 3-ft. length	11678
0.75-in. x 1.4-in. OD Prepacked Screen, 5-ft. length	17466
Snap-Lock Connector Assembly, 0.75-inch sch. 40	17469
Expendable Anchor Point, 2.5-in. OD	GW2040
PVC Riser, 0.75-in. sch. 40, 5-ft. length	11747
O-rings for 0.75-in. PVC Riser, Pkg. of 25	GW4401R
Vinyl Cap, 1.0-in. ID	12258
Locking Well Plug, for 0.75-in. sch. 40 riser	WP1775
Non-Locking Well Plug, for 0.75-in. sch. 40 riser	WP1776
PVC Bottom Plug, 0.75-in. Sch. 40 Flush Thread (optional)	12385
Expendable Drive Point, 2.125-in. rods / 2.5-in. OD (optional)	AT2015
Expendable Drive Point, 2.125-in. rods / Extended Shank	19442

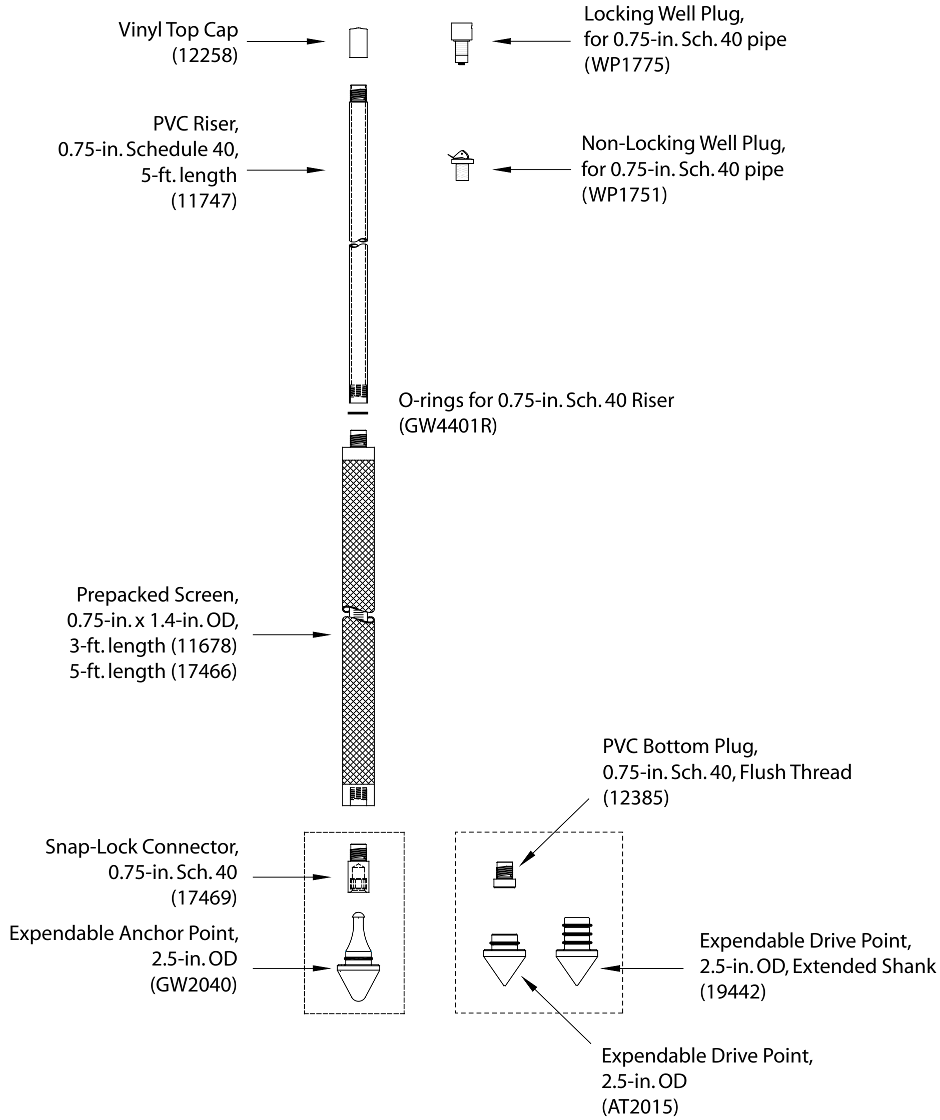

FIGURE 3.2:
0.75-in. x 1.4-in. OD Prepacked Screen Monitoring Well Parts

Monitoring Well Accessories	**Part Number**
Well Cover, flush-mount, 4-in. x 12-in., cast iron / ABS skirt (optional)	WP1741
Well Cover, flush-mount, 7-in. x 10-in., cast iron / galvanized skirt (optional)	WP1771
Sand, environmental grade (20/40 mesh, 50 lb. bag)	AT95
Bentonite, granular (8 mesh, 50 lb. bag)	AT91
Bentonite, powdered (200 mesh, 50 lb. bag)	AT92

Geoprobe® Tools and Equipment	**Part Number**
2.125-in. OD Probe Rods*	
Drive Cap, 2.125-in. Threaded (GH40 Hammer)	AT2101
Expendable Point Holder, 2.125-in. x 48-in.	AT2111
Probe Rod, 2.125-in. x 48-in.	AT2148
Probe Rod, 2.125-in. x 1 meter (optional)	AT2139
Rod Grip Puller Assembly (GH40)	GH2150K
2.25-in. OD Probe Rods*	
Drive Cap, 2.25-in. Threaded (GH40 Hammer)	25362
Expendable Point Holder, 2.25-in. x 48-in	25355
Expendable Point Holder, 2.25-in. x 1 meter (optional)	25354
Probe Rod, 2.25-in. x 48-in.	25300
Probe Rod, 2.25-in. x 1 meter (optional)	25352
Miscellaneous**	
O-rings for 2.125-in. and 2.25-in. Probe Rod, Pkg. of 25	AT2100R
Extension Rod, 48-in.	AT671
Extension Rod, 1 meter (optional)	AT675
Extension Rod Coupler	AT68
Extension Rod Quick Link Coupler, Box	AT696
Extension Rod Quick Link Coupler, Pin	AT695
Extension Rod Handle	AT69
Grout Machine	GS1000 or GS500
Grout System Accessories	GS1012 or GS1015
Water Level Meter, 0.438-in. OD Probe, 100-ft. cable*	GW1200
Screen Push Adapter	GW1535
Stainless Steel Mini-Bailer Assembly (optional)	GW41
Check Valve Assembly, 0.375-in. OD Tubing	GW4210
Polyethylene Tubing, 0.375-in. OD, 500-ft. (for purging, sampling, etc.)	TB25L
High PressureNylon Tubing, 0.375-in. OD, 100-ft. (for tremie tube grouting)	11633
MBP***	MB470

Additional Tools, Equipment, and Supplies

Locking Pliers
Pipe Wrench
Volumetric Measuring Cup
PVC Cutting Pliers
Weighted Measuring Tape (optional)
Small Funnel or Flexible Container (for pouring sand)
Duct or Electrical Tape Roll
Bucket or Tub (for dry grout material, water, and mixing)
Portland Cement, Type I
Concrete Mix (premixed cement and aggregate)
Clean Water (of suitable quality for exposure to well components)

**Tools and equipment are listed for Geoprobe® 54 Series Direct Push Machines. See Appendix A for tool options for 66 and 77 Series Direct Push Machines.*

***Refer to Appendix A for additional tool options.*

****Refer to Standard Operating Procedure (SOP) for the Mechanical Bladder Pump (Technical Bulletin No. MK3013) for additional tooling needs.*

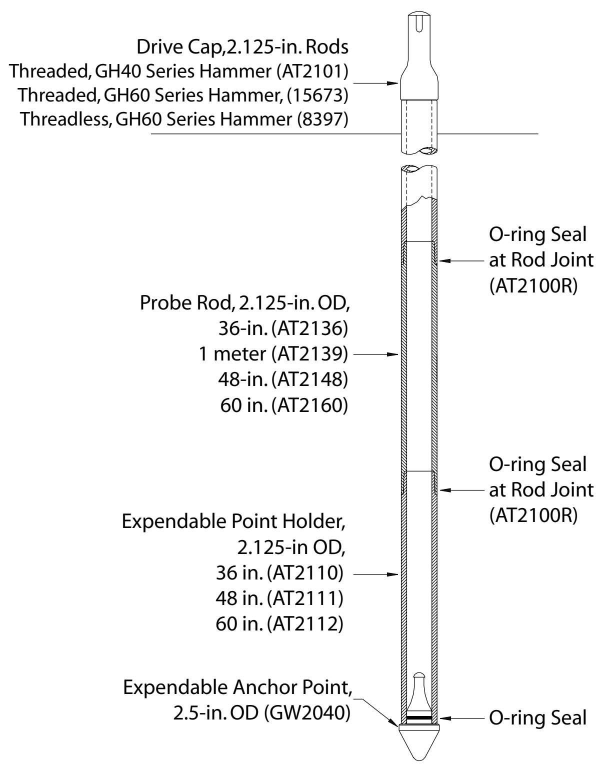

FIGURE 3.3:
2.125-inch OD Probe Rod Assembly

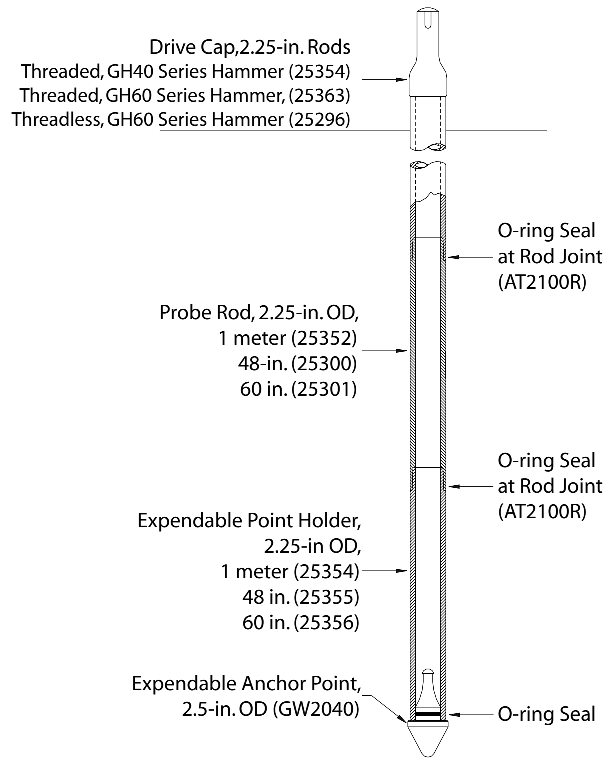

FIGURE 3.4:
2.25-inch OD Probe Rod Assembly

4.0 WELL INSTALLATION

Monitoring well installation can be broken down into five main steps:

- Anchoring the well assembly at depth
- Providing a sand pack and grout barrier
- Installing a bentonite seal above the screen
- Grouting the well annulus
- Installing well protection

4.1 Anchoring the Well Assembly

In this portion of the well installation procedure, an expendable anchor point is driven to depth on the end of a 2.125-inch (54 mm) or 2.25-inch (57 mm) OD probe rod string (Fig. 3.3 and Fig. 3.4). A prepacked screen assembly is inserted into the I.D. of the rod string with 5-foot (1.5 m) sections of PVC riser pipe (Fig. 4.1). The screens and riser pipe are attached to the anchor point via a snap-lock connector.

1. If the monitoring well is to have a flush-mount finish, it is a good practice to prepare a hole large enough to accept a standard well protector before driving the probe rods.

2. Move the Geoprobe® direct push machine into position over the proposed monitoring well location. Unfold the probe and place in the proper probing position as shown in the unit Owner's Manual. Access to the top of the probe rods will be required. It is therefore important to allow room for some derrick retraction when placing the unit in the probing position.

3. Referring to Figure 4.3, place an O-ring in the groove of an Expendable Anchor Point (GW2040) or Drive Point (AT2015 or 19442). Insert the point into the unthreaded end of a 2.125-inch or 2.25-inch Expendable Point Holder.

4. Attach a 2.125-inch or 2.25-inch Drive Cap to the threaded end of the point holder (Fig. 3.3 and Fig. 3.4).

5. Place the expendable point holder under the probe hammer in the driving position (refer to unit Owner's Manual). Drive the point holder into the ground utilizing percussion if necessary. It is important that the rod string is driven as straight as possible to provide a plumb monitoring well. If the point holder is not straight, pull the assembly and start over with Step 2.

6. Remove the drive cap from the expendable point holder. Install an O-ring (AT2100R) on the point holder in the groove located at the base of the male threads (Fig. 4.2).

   Note: The operator may choose to lubricate the O-ring with a small amount of clean water. Lubricating the O-ring makes it easier to thread the probe rods together and nearly elimate torn O-rings. A small spray bottle works well for applying the water.

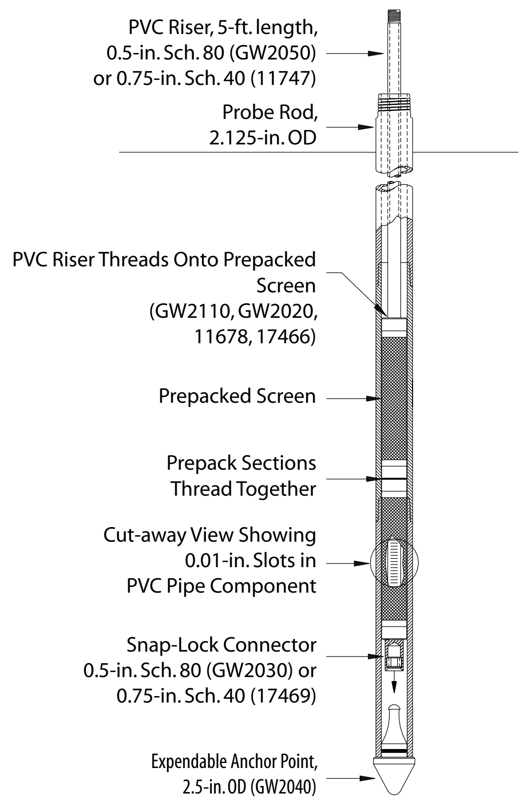

FIGURE 4.1:
Prepacked Screens Inside Probe Rod String

7. Thread a 2.125-inch or 2.25-inch probe rod onto the expendable point holder. Place the drive cap on the probe rod and advance the rod string.

8. Remove the drive cap and install an O-ring (AT2100R) at the base of the male threads of the probe rod (Fig. 4.2). Add another probe rod and replace the drive cap. Once again, advance the rod string.

9. Repeat Step 8 until the end of the rod string is approximately 4 inches (102 mm) below the bottom of the desired screen interval. The additional depth allows for the connection between the expendable anchor point and screen assembly. The top probe rod must also extend at least 1 foot (25 mm) above the ground surface to allow room for the rod grip puller later in this procedure. Move the probe foot back to provide access to the top of the rod string.

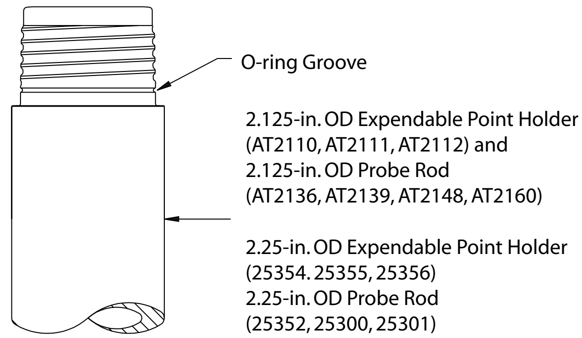

FIGURE 4.2:
O-ring Groove in 2.125-inch and 2.25-inch Expendable Point Holders and Probe Rods

10. With the probe rods and anchor point driven to the proper depth, the next step is to deploy the screen(s) and riser pipe. Thread together 1.4-inch OD prepack sections to achieve the desired screen interval. As shown in Figure 4.3, 1.4-inch OD prepacks are available with 0.5-inch Schedule 80 PVC or 0.75-inch Schedule 40 PVC components and in lengths of 3 or 5 feet (0.9 or 1.5 m). O-rings (GW430R) can be installed between the screen sections if desired.

11. Thread a Snap-lock Connector (0.5-inch GW2030 or 0.75-inch 17469) or a bottom plug (0.5-inch GW2056 or 0.75-inch 12385) into the female end of the assembled prepacks (Fig. 4.3). An O-ring can be placed on the male threads of the connector if desired.

12. Insert the screen assembly into the top of the probe rod string with the connector or bottom plug facing toward the bottom of the rods as shown in Figure 4.1.

13. With the assistance of a second person, attach 5-foot (1.5 m) sections of 0.5-inch Schedule 80 or 0.75-inch Schedule 40 PVC Riser (GW2050 or 11747) to the top of the screen assembly. O-rings are required at each riser joint to prevent groundwater from seeping into the well from above the desired monitoring interval. Continue adding riser sections until the assembly reaches the bottom of the rods (Fig. 4.1). At least 1 foot (0.3 m) of riser should extend past the top probe rod.

14. Install a PVC top cap, non-locking, or locking well plug on the top riser (Figure 4.3). If using the vinyl cap, secure the cap with two wraps of duct tape or electrical tape.

15. Raise the screen and riser assembly a few inches and then quickly lower it onto the expendable anchor point. This should force the snap-lock connector over the mushroomed tip of the anchor (Fig. 4.4). Gently pull up on the riser to ensure that the connector and anchor are firmly attached. Approximately 0.25 inches (6 mm) of play is normal. Or pop the bottom plug against the Expendable Anchor Point (AT 2015)

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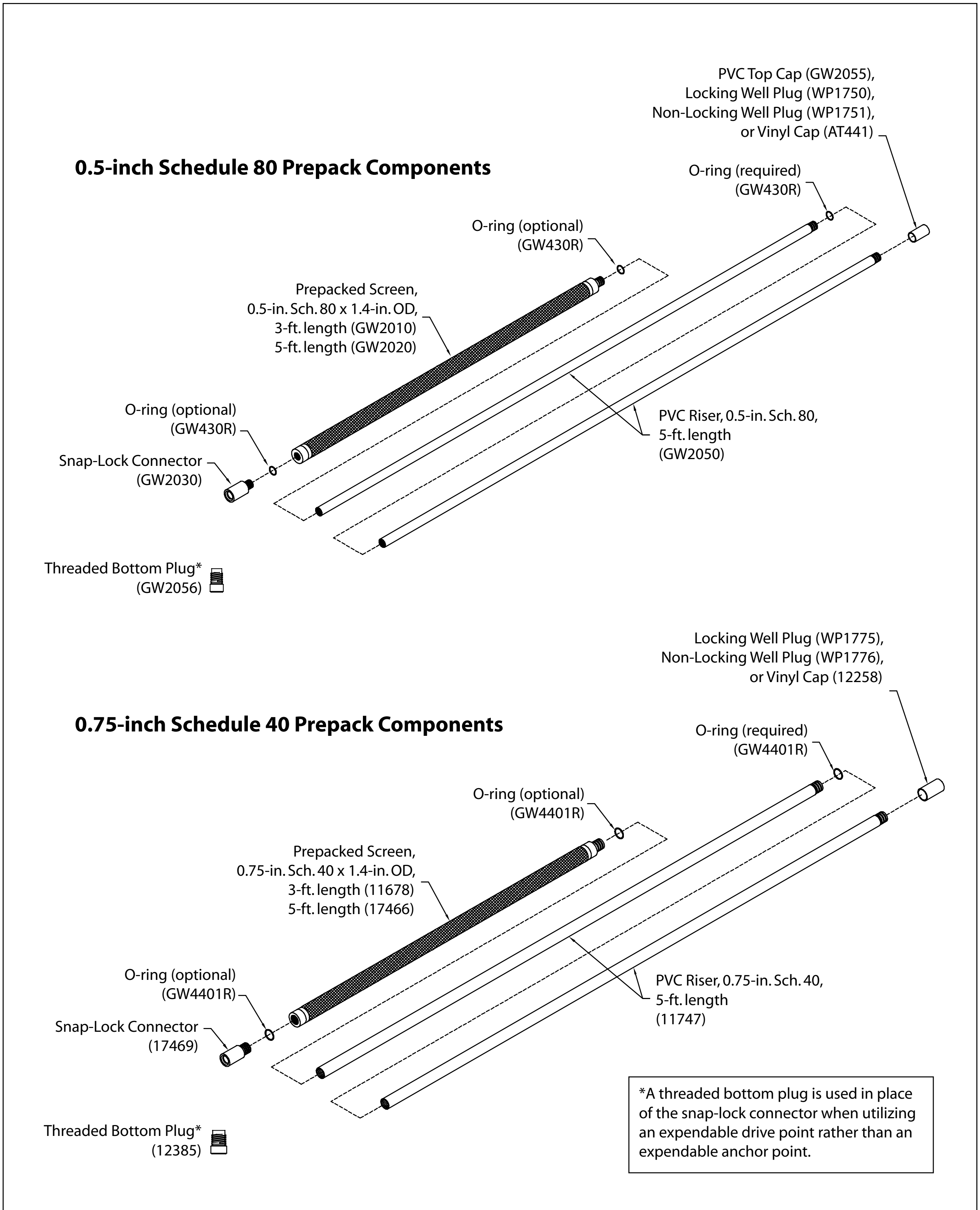

FIGURE 4.3:
0.5-inch Schedule 80 and 0.75-inch Schedule 40 Prepacked Screen Components

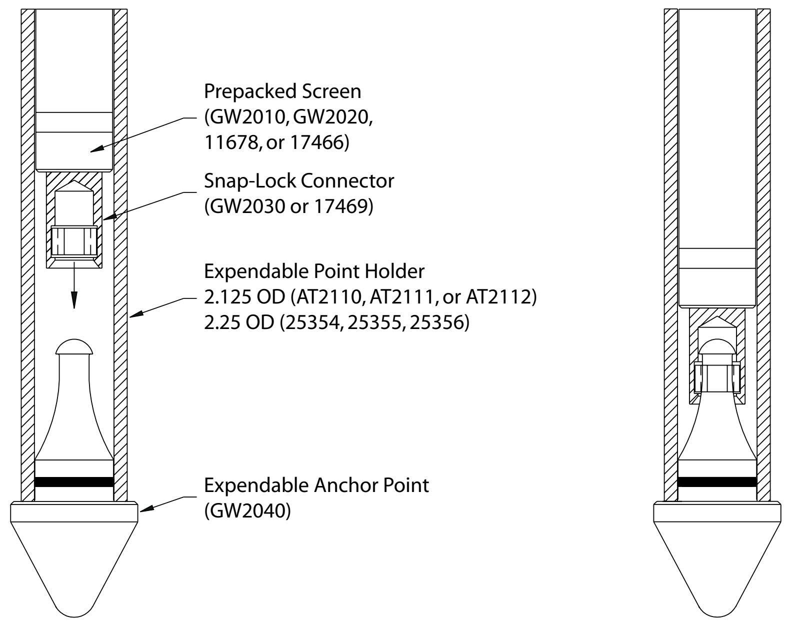

FIGURE 4.4:
Connecting Prepack(s) To Expendable Anchor Point

16. It is now time to pull up the probe rods from around the well screen and riser. Reposition the probe unit so that the Rod Grip Puller can be attached to the rod string.

17. Retract the rod string the length of the screens plus an additional 3 feet (1 m). Hold the riser as retracting rods. While pulling the rods, observe whether the PVC risers stay in place or move up with the rods.

a. If the risers stay in place, stable formation conditions are present. Continue retracting the rods to the depth specified above. Go to Section 4.2.

b. If the risers move up with the probe rods, have a second person hold it in place while pulling up the rods. An additional section of PVC riser may be helpful. Once the probe rods have cleared the anchor point and part of the screen, the screen and riser assembly should stop raising with the rods. Continue retracting to the depth specified above. Go to Section 4.2.

c. If the risers continue to move up with the probe rods and can not be held in place by hand, the anchor point is most likely located in heaving sands. Extension rods are now required. (Refer to Figure 4.4 for an illustration of extension rod accessories.)

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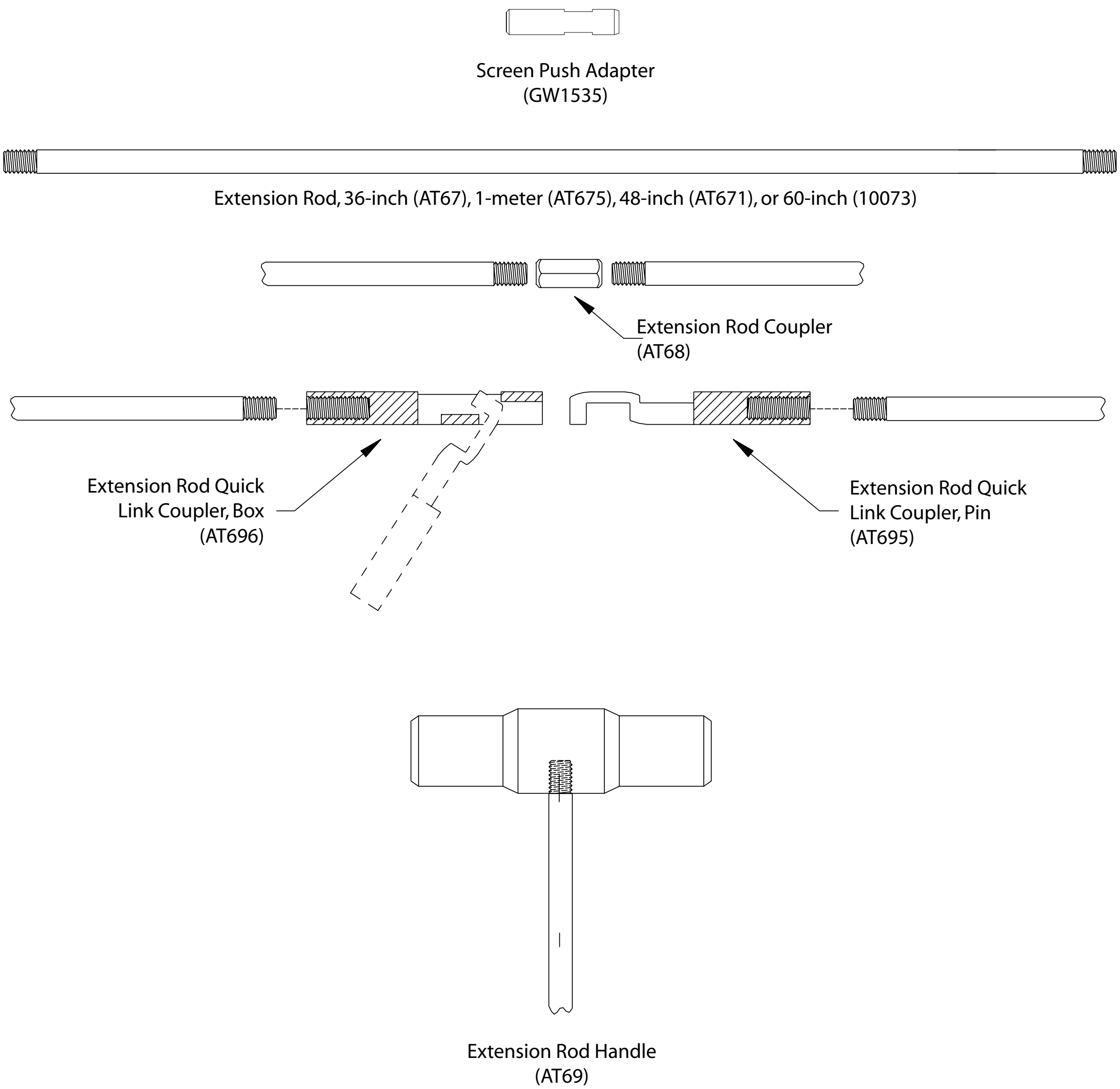

FIGURE 4.5:
Geoprobe Extension Rods and Accessories

d. Place a Screen Push Adapter (GW1535) on the end of an Extension Rod. Insert the adapter and extension rod into the PVC riser and hold by hand or with an Extension Rod Jig (AT690). Attach additional extension rods with Extension Rod Couplers (AT68) or Extension Rod Quick Links (AT695 and AT 696) until the push adapter contacts the bottom of the screens (Fig. 4.6). Place an Extension Rod Handle (AT69) on the top extension rod after leaving 3 to 4 feet (1 to 1.2 m) of extra height above the last probe rod.

e. Slowly retract the probe rods while another person pushes and taps on the screen bottom with the extension rods (Fig. 4.6). To ensure proper placement of the screen interval and prevent damage to the well, be careful not to get ahead while pulling the probe rods. The risers should stay in place once the probe rods are withdrawn past the screens. Retrieve the extension rods. Place the cap back on the top riser and secure the cap with duct tape if necessary.

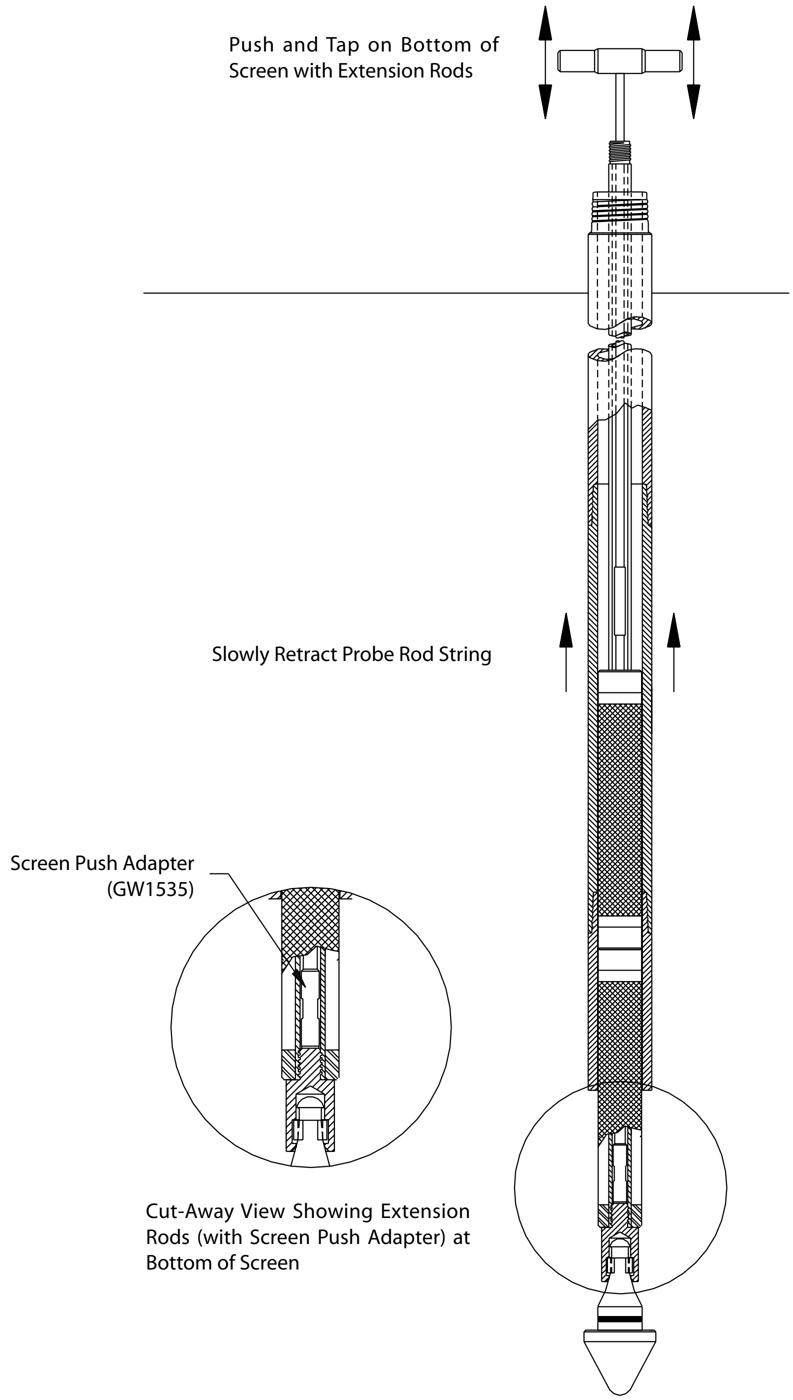

FIGURE 4.6:
Use Extension Rods To Tap Out Wedged Screens

4.2 Sand Pack and Grout Barrier

The natural formation will sometimes collapse around the well screens as the probe rod string is withdrawn. This provides an effective barrier between the screens and grout material used to seal the well annulus. If the formation does not collapse, a sand barrier must be placed from the surface. This portion of the well installation procedure is important because an inadequate barrier will allow grout to reach the well screens. Nonrepresentative samples and retarded groundwater flow into the well may result from grout intrusion.

1. Using a Water Level Meter (GW2000) or flat tape measure, determine the depth from the top of the PVC riser to the bottom of the annulus between the riser and probe rods. Two scenarios are possible:

   a. Measured depth is 2 to 3 feet (0.6 to 0.9 m) less than riser length. This indicates that unstable conditions have resulted in formation collapse. A natural grout barrier has formed as material collapsed around the PVC riser when the probe rods were retracted. This commonly occurs in heaving sands. No further action is required. Proceed to Section 4.3 and perform Step 2 (for unstable formations).

   b. Measured depth is equal to or greater than riser length. This indicates that stable conditions are present and the cohesive formation did not collapse. The probe hole has remained open and void space exists between the riser (and possibly the screen) and formation material. Clean sand must be placed downhole to provide a suitable grout barrier. Continue with Step 2.

2. Begin slowly pouring 20/40 mesh sand (AT95) down the annulus between the PVC riser and probe rod string. Reduce spillage by using a funnel or flexible container as shown in Figure 4.6. Add approximately 2.0 liters of sand for each 3-foot (1 m) screen section or 3.25 liters of sand for each 5-foot (1.5 m) screen, plus 1.75-2.0 liters for a minimum 2-foot (0.6 m) layer of sand above the top screen section.

   Note: The sand volumes specified above assume maximum annular space where no formation collapse has occurred. Actual volumes may be less in field conditions.

3. Measure the annulus depth after each 1.0-1.5 liters of sand. The sand may not fall all the way past the screens due to the tight annulus and possible water intrusion. This is acceptable, however, since the prepacked screens do not require the addition of sand. The important thing is that a sand barrier is provided above the screens.

4. Sand may also bridge within the annulus between the risers and probe rods and consequently fail to reach total depth (Fig. 4.7). This most likely occurs when the sand contacts the water inside the probe rods during well installations below the water table. Wet probe rods also contribute to sand bridging. If the annulus is open, skip to Section 4.3, Step 1. If bridging is evident, continue with Step 5.

5. In case of a sand bridge above the screens (wet rods, high water table, etc.), insert clean extension rods into the well annulus to break up the sand (Fig. 4.7). Simultaneously retracting the probe rods usually helps. Check annulus depth again. If sand is no longer bridged, proceed to Section 4.3. If bridging is still evident, continue with Step 6.

6. If the sand bridge can not be broken up with extension rods, inject a small amount of clean water into the annulus. This is accomplished with a Geoprobe® Model GS1000 or GS500 Grout Machine and 3/8-inch (9.5 mm) OD nylon tubing (11633). Simply insert the nylon tubing down the well annulus until the sand bridge is contacted. Attach the tubing to the grout machine and pump up to one gallon of clean water while moving the tubing up and down. The jetting action of the water will loosen and remove the sand bridge. Check annulus depth again. The distance should be 2 to 3 feet (0.6 to 0.9 m) less than the riser length when the sand barrier is completed. Proceed with Section 4.3.

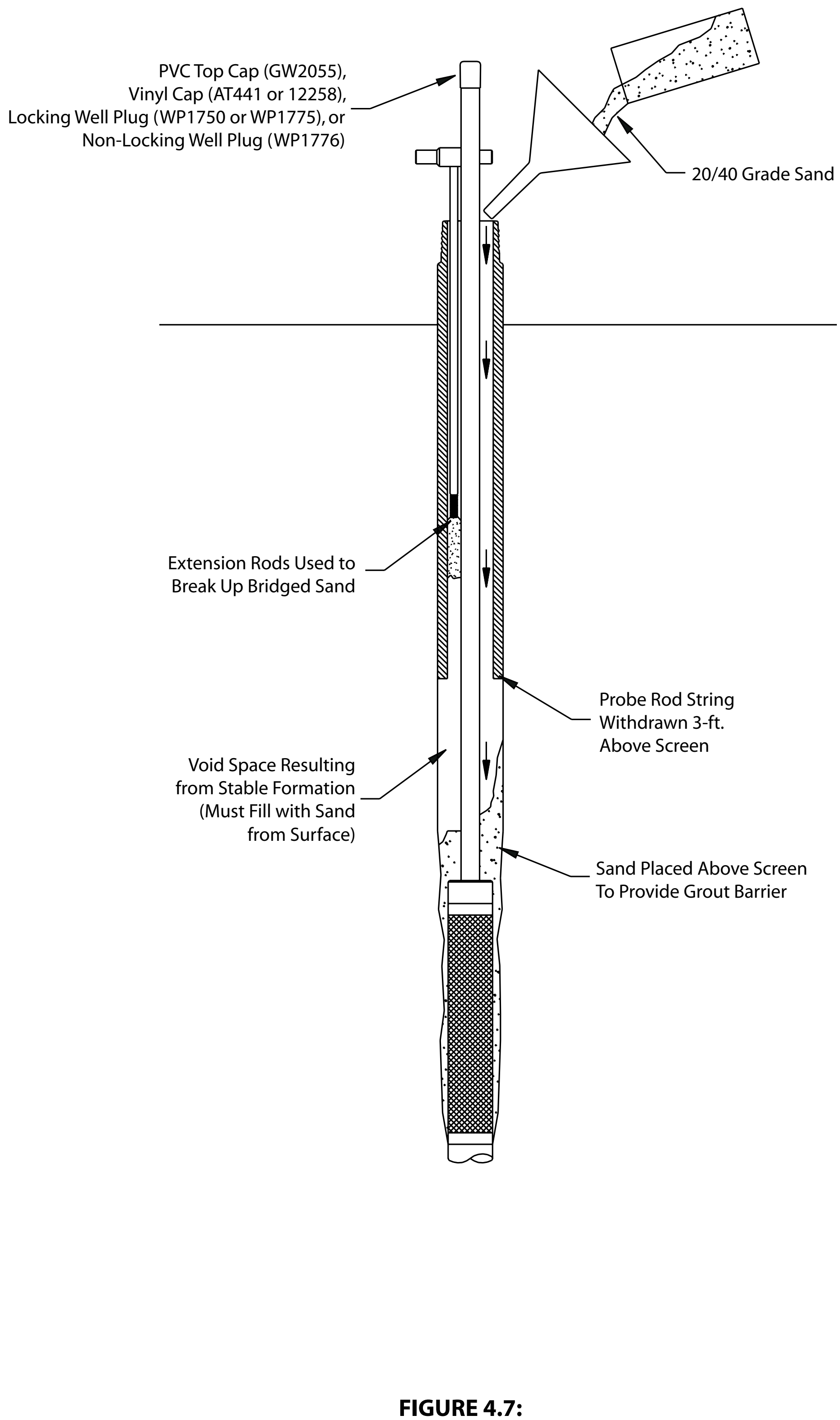

FIGURE 4.7:
Installing Grout Barrier from Ground Surface with 20/40 Mesh Sand

4.3 Bentonite Seal Above Screen

Bentonite is a clay material which exhibits very low permeability when hydrated. When properly placed, bentonite can prevent contaminants from moving into the well screens from above the desired monitoring interval. The seal is formed either by pouring granular bentonite into the annulus from the ground surface, or by injecting a high-solids bentonite slurry directly above the grout barrier. The use of bentonite chips is limited to cases in which the top of the screen ends above the water table (no water is present in the probe rods). Whichever method is used, at least 2 feet (0.6 m) of bentonite must be placed above the sand pack.

1. **(Stable Formation)** Granular bentonite (AT91) is recommended if the following conditions are met:
   1) Top of screen interval is above the water table
   2) Formation remained open when probe rods were retracted
   3) Bridging was not encountered while installing the sand pack and grout barrier in Section 4.2.

   a. Withdraw the probe rod string another 3 to 4 feet (0.9 to 1 m) and ensure that the PVC riser does not rise with rods. It is important that the bottom of the rod string is above the proposed seal interval. If positioned too low, dry bentonite will backup into the expendable point holder. Bridging then results if moisture is present inside the probe rods.

   b. Pour approximately 1.5 liters of granular bentonite between the probe rods and PVC riser as was done with the sand in Section 4.2

   c. Measure the riser depth to the bottom of the annulus. The distance should now equal the installed riser length minus the minimum 2 feet (0.6 m) of sand pack and 2 feet (0.6 m) of bentonite seal. As was stated with the sand pack, if the measured depth is significantly less than expected, the bentonite has more than likely bridged somewhere along the rod string. A procedure similar to that identified for bridged sand (Section 4.2, Steps 5 and 6) may be utilized to dislodge the granular bentonite.

   d. Once it has been determined that the bentonite seal is properly emplaced, add 1 liter of clean water to hydrate the dry bentonite according to regulations. This is not necessary if water was used to clear bridged bentonite.

2. **(Unstable Formation)** A grout machine is required to install the bentonite seal if the formation collapsed when the rods were retracted or the sand bridged when installing the grout barrier. The pump is able to supply a high-solids bentonite slurry under sufficient pressure to displace formation fluids. Void spaces often develop when poured (gravity installed) granular bentonite is used under these conditions, resulting in an inadequate annular seal. Wet rods will often lead to bridging problems as well.

   a. Mix 1 gallon (3.8 L) of high-solids bentonite (20 to 25 percent by dry weight) and place in the hopper of the grout machine.

   b. Insert 3/8-inch nylon tubing (see note below) to the bottom of the annulus between the probe rods and well riser. Leaving at least 15 feet (5 m) extending from the top of the rod string, connect the tubing to the grout machine. This extra length will allow rod extraction later in the procedure.

   NOTE: The side-port tremie method is recommended to prevent intrusion of grout into the sand barrier. To accomplish side-port discharge of grout, cut a notch approximately one inch up from the leading end of the tubing and then close the leading end with a threaded plug of suitable size.

   c. Activate the grout pump and fill the tremie tube with bentonite. Begin slowly pulling the rod string approximately 3 feet (1 m) while operating the pump (Fig. 4.8). This will place bentonite in the void

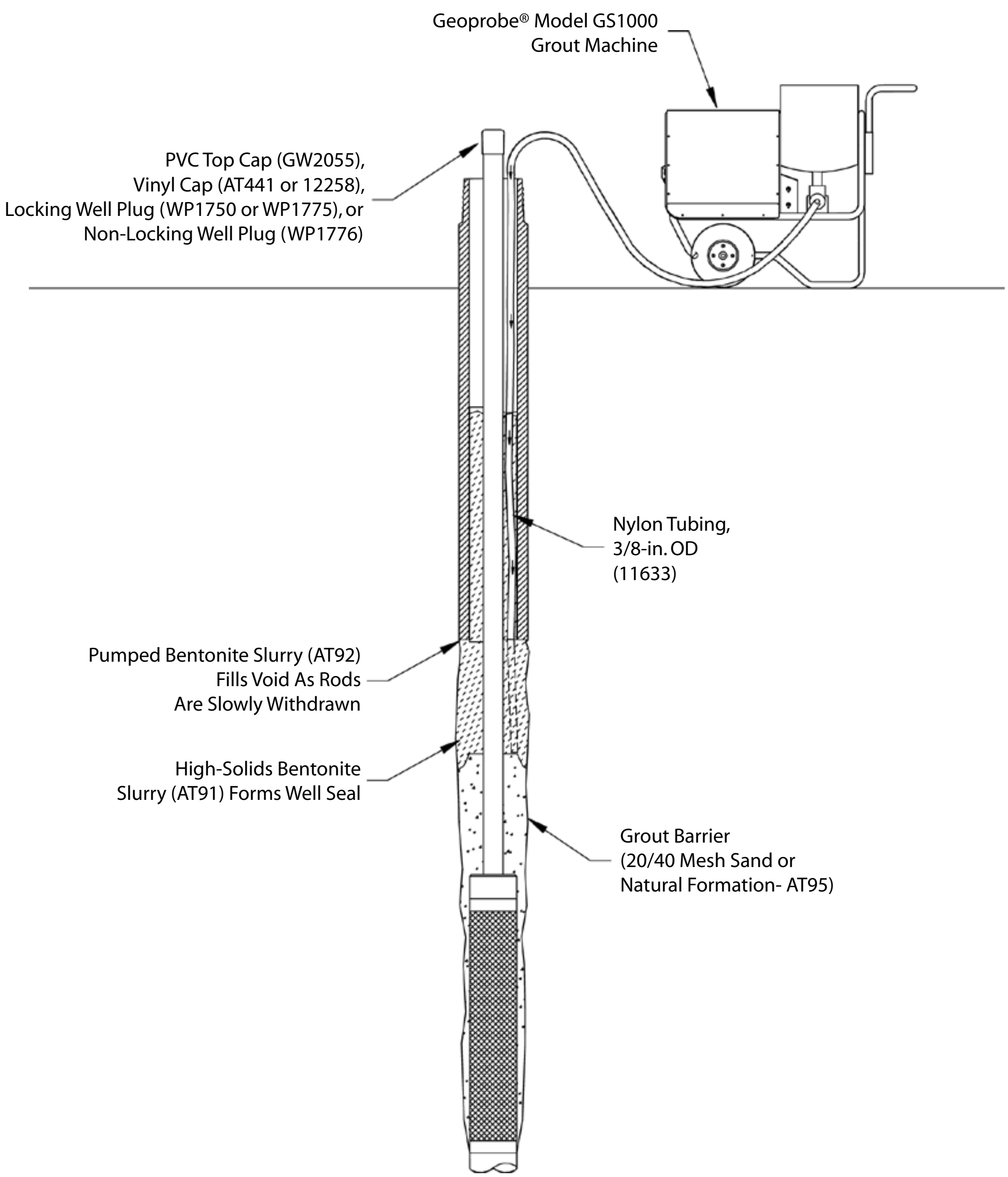

FIGURE 4.8:
Providing Bentonite Seal With Geoprobe® Model GS1000 Grout Machine

left by the retracted rods before it is filled by the collapsing formation. Continue to watch that the PVC riser does not come up with the rod string. When removing the retracted probe rod, slide the rod over the nylon tubing and place it on the ground next to the grout machine. This eliminates cutting and reattaching the tubing for each rod removed from the string. Take care not to "kink" the tubing during this process as it will create a weak spot in the tubing which may burst when pressure is applied.

d. Measure the annulus depth to ensure that at least 2 feet (0.6 m) of bentonite was delivered. Pump additional bentonite slurry if needed.

4.4 Grouting Well Annulus

The placement of grout material within the remaining well annulus provides additional protection from vertical contaminant migration. Most grout mixes are composed of neat cement, high-solids bentonite slurry, or a combination of cement and bentonite. Such mixes must be delivered with a high-pressure grout pump. When stable formations exist, the well may be sealed by pouring dry granular bentonite directly into the annulus from the ground surface. Consult the appropriate regulatory agency to determine approved grouting methods.

This section presents the procedure for grouting the well annulus with the Geoprobe® Model GS1000 or GS500 Grout Machines. Refer to Figure 4.9 as needed.

1. Mix an appropriate amount of grout material and place it in the hopper on the grout machine. (Refer to the Geoprobe® Yellow Field Book for tables on grout volume requirements.)

   NOTE: It is recommended that an additional 25 to 30 percent of the calculated annulus volume is included in the total grout volume. This allows for material that is left in the grout hose and tubing or moves into the formation during pumping. An approximate range is 0.25 to 0.30 gallons (0.9 to 1.1 L) of grout for each foot of riser below ground surface.

2. A side-port tremie tube may be made from a roll of .375-inch OD High Pressure Nylon Tubing (11633) by cutting a notch in the side of the tubing approximately 1 inch (25 mm) up from the discharge end. Thread a bolt or screw of suitable diameter into the end of the tubing so that pumped grout is forced out through the notch in a side-discharge manner.

   Insert the side-port tremie tube into the well annulus until the leading end of the tube reaches the top of the bentonite seal. At least 15 feet (5 m) of tubing should extend from the top of the rod string. This extra length allows rod extraction with the tubing attached to the pump.

3. Attach the tubing to the grout machine and begin pumping. If the bentonite seal was below the water table (deep well installation), water will be displaced and flow from the probe rods as the annulus is filled with grout. Continue operating the pump until undiluted grout flows from the top probe rod.

4. Reposition the direct push machine and prepare to pull rods.

5. Begin pulling the probe rods while continuing to pump grout. Match the pulling speed to grout flow so that the rods remain filled to the ground surface. This maintains hydraulic head within the probe rods and ensures that the space left by the withdrawn rods is completely filled with grout.

   NOTE: Slide the probe rods over the nylon tubing and place neatly on the ground next to the grout machine. **Be careful not to pinch or bind the tubing as this forms weak spots which may burst when pressure is applied.**

   NOTE: Try to avoid filling the upper 12 inches (305 mm) of well annulus with grout when pulling the expendable point holder. This will make for a cleaner well protector installation.

6. When all probe rods have been retrieved and the well is adequately grouted, unstring the tremie tube and begin cleanup. It is important to promptly clean the probe rods, grout machine, and accessories. This is especially true of cement mixes as they quickly set up and are difficult to remove once dried.

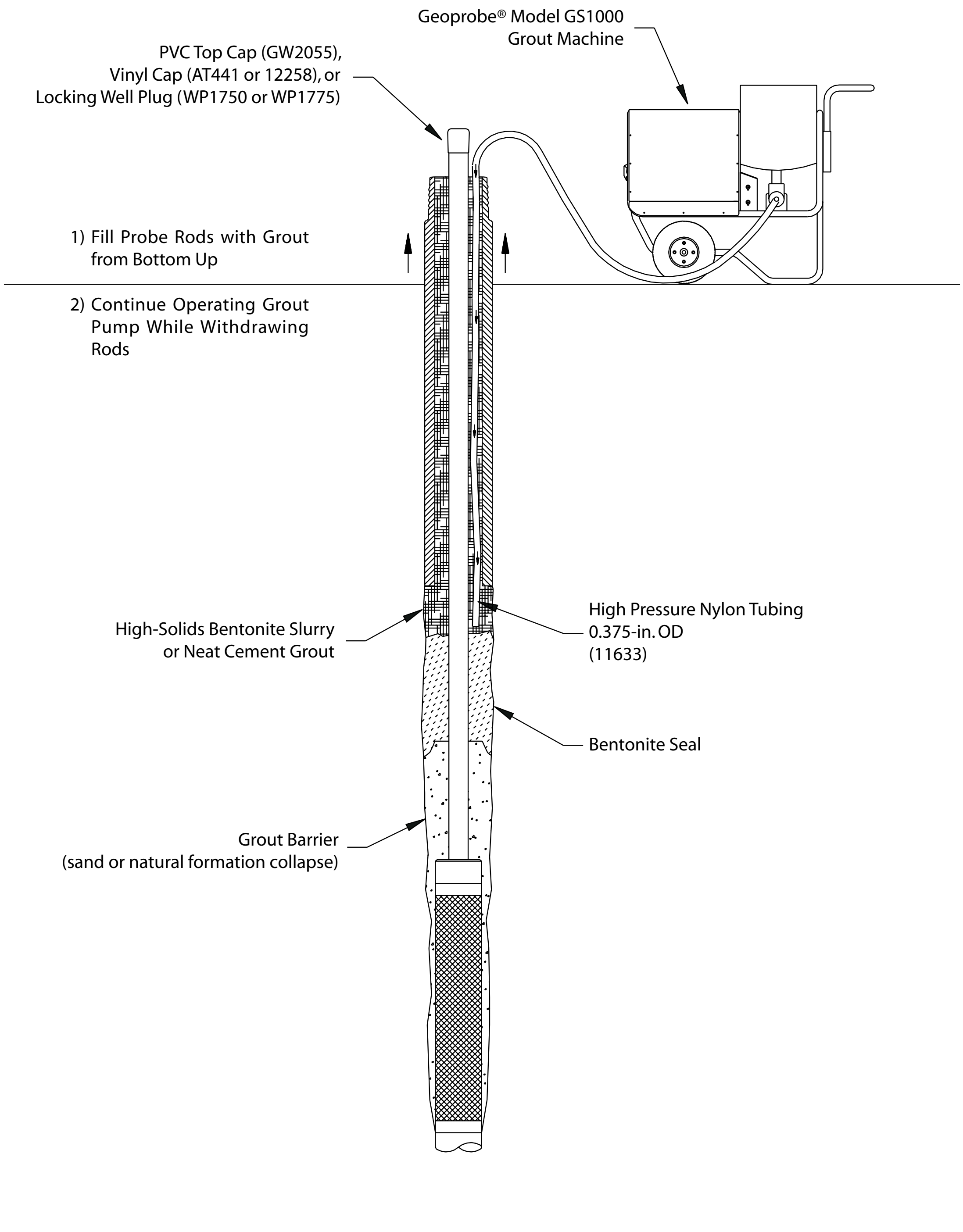

FIGURE 4.9:
Grouting Well Annulus with Geoprobe® Model GS1000 Grout Machine

4.5 Surface Cover / Well Protection

A surface cover protects the PVC well riser from damage and tampering. Although aboveground and flush-mount well covers may be used, most Geoprobe® prepack monitoring wells have been installed with flush-mount covers (Fig. 4.10). Consult the project planners and/or appropriate regulators to determine the approved well cover configuration for your specific application.

1. In order to fit under a flush-mount cover, the top of the well riser must be below the ground surface. Place the well cover over the riser to mark the cover diameter. Remove the cover and excavate the soil around the well head to install the protector.

2. The top of the riser should be located several inches above the bottom of the hole (but below the adjacent ground surface) before installation of the well cover. If a riser joint is near this level, the operator may choose to unthread the top riser and adjust the depth of the hole to fit the riser height. Most prepack installations will instead require trimming the top riser to the appropriate height with PVC cutters.

NOTE: Do not cut off the riser with a hacksaw as cuttings may fall down into the screens.

3. In most areas, regulations specify that a locking plug be installed on the top riser of permanent monitoring wells. Insert a locking well plug (Figure 4.10) into the riser and tighten the hex bolt with a 1/2-inch T-handle wrench or nut driver until the cap fits snugly.

4. Position the well cover so that it is centered over the well riser. Provide at least 0.5 inches (13 mm) of space between the top of the locking plug and bottom of the well cover lid. If flush-mount protection is used, install the cover slightly above grade to prevent ponding of runoff water at the well head.

5. Support the well cover by installing a concrete pad according to project requirements. Pads are commonly square-shaped with a thickness of 4 inches (102 mm) and sides measuring 24 inches (610 mm) or greater. Finish the pad so that the edges slope away from the center to prevent ponding of surface water on the well cover.

6. Fill the inside of the well cover with sand up to approximately 2 to 3 inches (51 to 76 mm) from the top of the riser and locking plug.

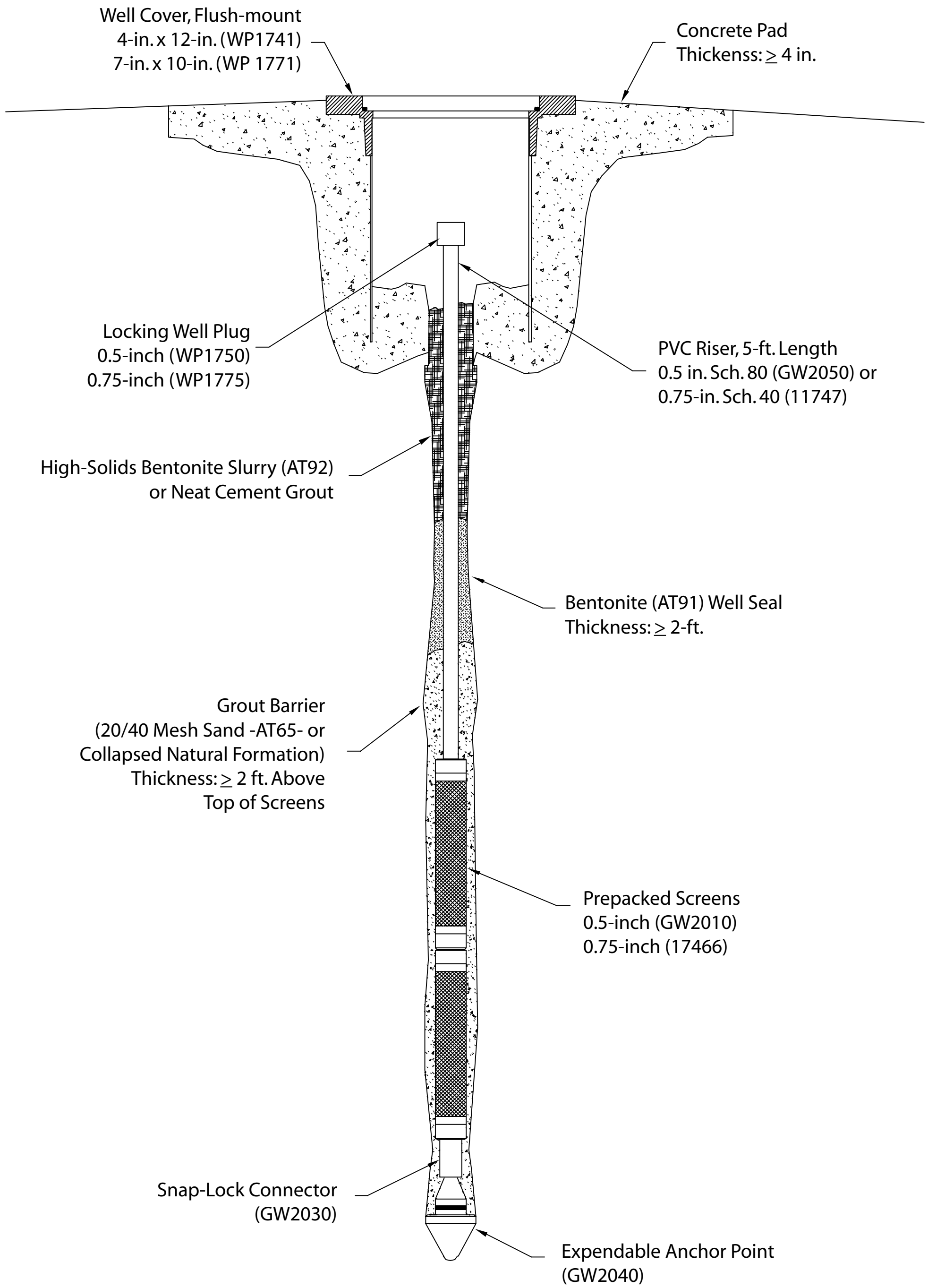

FIGURE 4.10:
A Properly Installed Geoprobe Prepacked Screen Monitoring Well

5.0 WELL DEVELOPMENT

"The development serves to remove the finer grained material from the well screen and filter pack that may otherwise interfere with water quality analyses, restore groundwater properties disturbed during the (probing) process, and to improve the hydraulic characteristics of the filter pack and hydraulic communication between the well and the hydrologic unit adjacent to the well screen," (ASTM D 5092).

The two most common methods of well development are bailing or pumping (purging) and mechanical surging.

Purging involves removing at least three well volumes of water with either a Check Valve Assembly (GW4210) or a Stainless Steel Mini-Bailer Assembly (GW41). Include the entire 2.125-inch (54 mm) diameter of disturbed soil at the screen interval when calculating the well volume.

Mechanical Surging utilizes a surge block or swab which is attached to extension rods and lowered inside the riser to the screen interval. The extension rods and surge block are moved up and down, forcing water into and out of the screen. A tubing bottom check valve or peristaltic pump is then used to remove the water and loosened sediments (Fig. 4.11).

NOTE: Mechanical surging may damage the well screen and/or reduce groundwater flow across the filter pack if performed incorrectly or under improper conditions. Refer to ASTM D 5521, "Standard Guide for Development of Groundwater Monitoring Wells in Granular Aquifers" for a detailed discussion of mechanical surging.

Fine Grained Formations: Many times field conditions or regulations require us to install monitoring wells in fine-grained formations that would not be considered a true aquifer. Development in these conditions is difficult at best. There are various development methods that may be useful depending on the specific grain size distribution of the formation. In formations with a good proportion of sand, using a rod brush slightly larger than the ID of the well as a swab may help in surging the well without clogging the filter pack. Caution is required. Adding water to slow-yielding wells may also help to loosen fines and improve recharge when swabbing. Purging wells in fine-grained formations with a peristaltic pump or bladder pump may offer the best means of development as high-energy surging can clog the screens. For more information on this topic request the Geoprobe® bulletin titled *Groundwater Quality and Turbidity vs. Low Flow*.

Development should continue until representative water is obtained and natural flow is established into the well. Previously, representative water was defined primarily on the basis of consistent pH, specific conductance, temperature measurements, and visual clarity (ASTM D 5092). To meet the more stringent requirements of the low-flow sampling protocol (EPA 1996), monitoring of additional parameters such as dissolved oxygen (DO) and oxidation/reduction potential (ORP or Eh), and quantitative measurement of turbidity may be required.

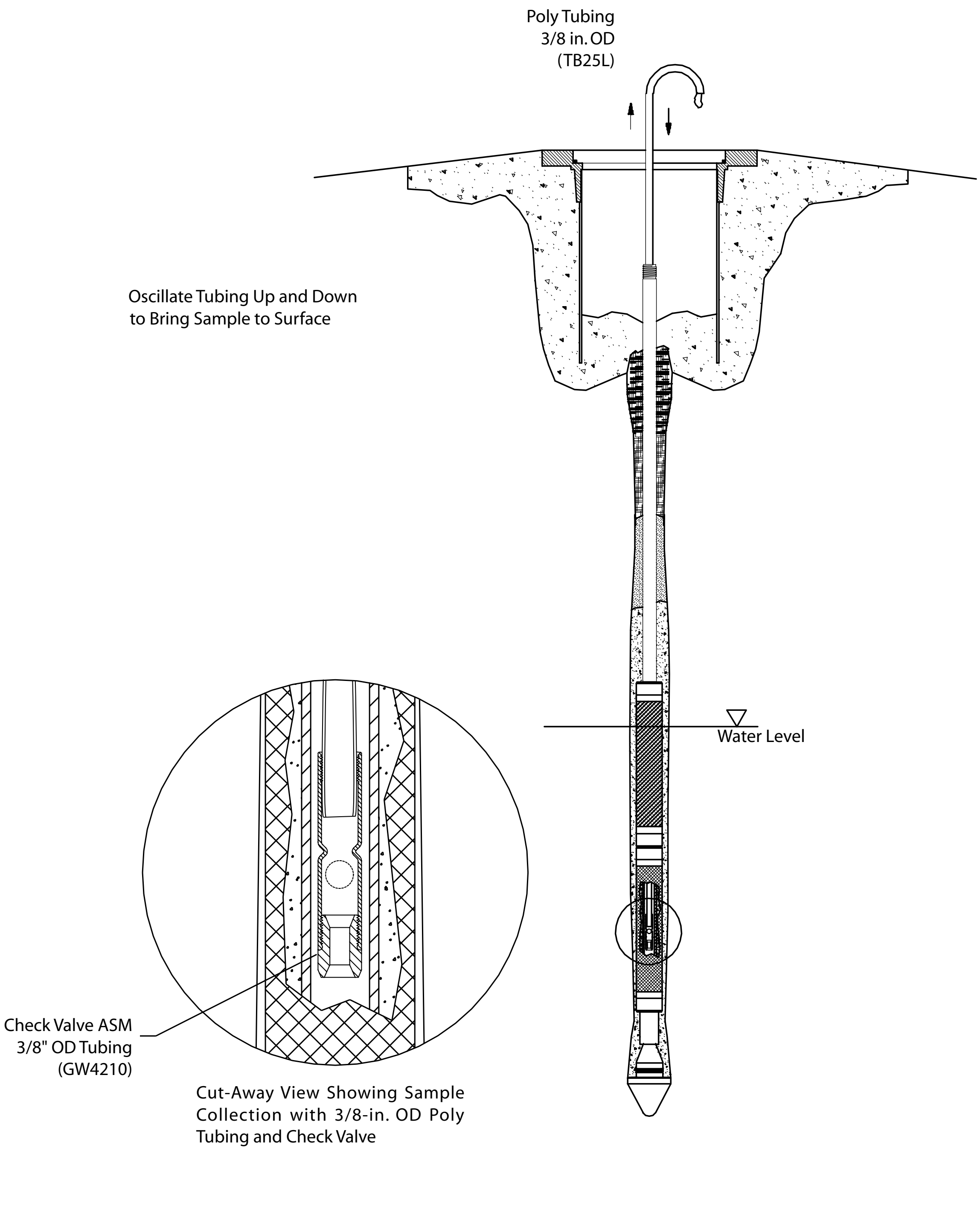

FIGURE 4.11:
Sampling With Polyethylene Tubing and a Tubing Bottom Check Valve

6.0 SAMPLE COLLECTION

As the federal EPA and more state agencies are recommending or requiring use of the "low-flow" sampling protocol (EPA 1996), the ability to sample small-diameter, direct push (DP) installed monitoring wells with bladder pumps has significantly increased. The latest option for collecting groundwater is to utilize a Geoprobe® MB470 Mechanical Bladder Pump. It may be used to meet requirements of the low-flow sampling protocol (EPA 1996). The low-flow sampling method is preferred when sampling for volatile contaminants or metal analytes. The Mechanical Bladder Pump can be used with any of the available flow-through-cells and water quality monitoring probes. Smaller volume flow-through-cells are recommended when available. Use of the Mechanical Bladder Pump and flow-through-cell allows you to meet the stringent requirements for monitoring pH, specific conductance, DO, and ORP, and obtaining low-turbidity samples for metals analysis.

Groundwater samples may be collected with a check valve assembly (with 3/8-inch OD poly tubing as shown in Fig. 4.11) or a stainless steel mini-bailer assembly when appropriate. While the check valve is the quicker and more economical sampling device, some operators still prefer the traditional mini-bailer.

Before going into the field to sample monitoring wells (or groundwater samplers), be sure to know the level of sample quality that will be required. For high-integrity samples that must meet strict data quality objectives, sampling with a mechanical bladder pump may be required. Conversely, if screening level data is required (is it there and about how much?) a check valve assembly may be sufficient and could save time and money. For further information on this topic, request the Geoprobe® bulletin titled *Groundwater Quality and Turbidity vs. Low Flow*.

7.0 REFERENCES

American Society for Testing and Materials (ASTM), 1992. ASTM D 5092 *Standard Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers.* ASTM West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1995. ASTM D 5521 *Standard Guide for Development of Ground Water Monitoring Wells in Granular Aquifers.* ASTM West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 2002. ASTM D 6724 *Standard Guide for Selection and Installation of Direct Push Ground Water Monitoring Wells.* ASTM West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 2002. ASTM D 6725 *Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers.* ASTM West Conshohocken, PA.

Geoprobe Systems®, 2003. *Tools Catalog, V. 6.*

U.S. Environmental Protection Agency (EPA), 1996. Robert W. Puhls and Michael J. Barcelona. *Ground Water Issue: Low-Flow (Minimal Drawdown) Ground-Water Sampling Procedures*. OSWER. EPA/540/S-95/504. April.

U.S. Environmental Protection Agency (EPA), 1997. *Expedited Site Assessment Tools For Underground Storage Tank Sites: A Guide for Regulators.* EPA 510-B-97-001. March, 1997.

APPENDIX A
ALTERNATIVE PARTS

Geoprobe® Tools and Equipment	**Part Number**
2.125-in. OD Probe Rods	
Drive Cap, 2.125-in. Threaded (GH60 Hammer)	15673
Drive Cap, 2.125-in. Threadless (GH60 Hammer)	8397
Expendable Point Holder, 2.125-in. x 36-in.	AT2110
Expendable Point Holder, 2.125-in. x 60-in.	AT2112
Probe Rod, 2.125-in. x 36-in.	AT2136
Probe Rod, 2.125-in. x 60-in.	AT2160
Rod Grip Handle (GH60)	9640
2.25-in. OD Probe Rods	
Drive Cap, 2.25-in. Threaded (GH60 Hammer)	25363
Drive Cap, 2.25-in. Threadless (GH60 Hammer)	25296
Expendable Point Holder, 2.25-in. x 60-in.	25356
Probe Rod, 2.25-in. x 60-in.	25301
Rod Grip Puller Assembly (GH60)	29385
Miscellaneous	
Extension Rod, 36-in.	AT67
Extension Rod, 60-in.	10073

Groundwater Purging and Sampling Accessories	**Part Number**
Polyethylene Tubing, 0.25-inch OD, 500 ft.	TB17L
Polyethylene Tubing, 0.5-inch OD, 500 ft.	TB37L
Polyethylene Tubing, 0.625-inch OD, 50 ft.	TB50L
Check Valve Assembly, 0.25-inch OD Tubing	GW4240
Check Valve Assembly, 0.5-inch OD Tubing	GW4220
Check Valve Assembly, 0.625-inch OD Tubing	GW4230
Water Level Meter, 0.375-inch OD Probe, 100-ft. cable	GW2001
Water Level Meter, 0.438-inch OD Probe, 200 ft. cable	GW2002
Water Level Meter, 0.375-inch OD Probe, 200-ft. cable	GW2003
Water Level Meter, 0.438-inch OD Probe, 30-m cable	GW2005
Water Level Meter, 0.438-inch OD Probe, 60-m cable	GW2007
Water Level Meter, 0.375-inch OD Probe, 60-m cable	GE2008

**The tools and equipment listed are for the 66 and 77 Series Direct Push Machines. See Section 3.0 for tool options of the 54 Series Direct Push Machines.*

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