



Guide for Fabricating and Installing Shallow Ground Water Observation Wells

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Abstract—The fabrication and use of three tools to assist in the manual installation of shallow ground water observation wells are described. These tools are easily fabricated at a local machine shop. A method for calibrating pressure transducers is also described.

Keywords: instrumentation, pressure transducers, observation wells, piezometers

Ground water elevations are typically determined from observation wells or piezometric wells. In stream-side areas, the subsurface free water elevation is often monitored in studies of riparian plant communities, nutrient transport, and seasonal waterflow direction. While professional well drilling is limited by accessibility and cost, it is possible to manually install shallow wells along riparian and floodplain corridors. In the past, we have attempted to dig shallow wells with a soil auger. However, soil augers are easily stopped by rocks or gravel, and the walls of the hole tend to collapse before the casing can be installed. Digging pits and backfilling around the casing is another method, but it causes a large amount of soil disturbance. The simple tools described here dig holes up to 10 feet deep with minimal soil disturbance, eliminate the problem of collapsing walls, and can often break through or work around cobbles and gravel. These tools are easily fabricated at a local machine shop. In addition, a tool for calibrating pressure transducers for shallow wells and piezometers is described.

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Description of Tools

Well-Drilling Tools

The tool used to initially make the hole in the ground for the well casing has three components: an outer sleeve, an inner core, and a pounder. The core is a solid iron rod that fits inside the iron pipe called the sleeve and is pointed on the bottom. When the core is in place, the point extends beyond the end of the sleeve. The lower end of the sleeve is beveled to match the angle of the core's pointed end so that the end of the core-sleeve assembly forms one continuous point. The opposite end of the core is equipped with a pounding cap that prevents the core from falling through the sleeve. The cap provides a solid surface by which the core and sleeve assembly may be simultaneously driven into the ground. With the core inside the sleeve, the pointed end of the assembly is positioned at the site of the well. The core-sleeve assembly is driven into the ground with a modified hand-held fencepost pounder. Typically, commercial fencepost pounders are not strong enough to withstand pounding the heavy core-sleeve assembly through gravel and cobbles, so instructions for fabricating a heavily reinforced pounder are provided. For maximum depth, use the pounder until it touches the ground. Then drive the assembly further with a sledge hammer or turn the pounder upside down and pound with the closed end of the pounder. Once the assembly has been driven its full length (approximately 5 feet deep), the core can be lifted out and replaced with PVC pipe for well casing. After the casing is placed, the sleeve can be removed by slipping a rebar handle through two holes in the outer sleeve and pulling or jacking the sleeve out of the ground. The casing remains in place at the full depth of the hole. Ideally, the holes are backfilled with sand around the casings, although native material is also acceptable. The casing/ground-surface interface should be sealed with bentonite

(available from well-drilling suppliers). It is easiest to pound the assembly into wet soils, when the resistance is minimal. In saturated soils, installation time may be as little as 15 minutes per well.

The length of the core-sleeve assembly limits the depth of the hole to approximately 5 feet. Another tool can be fabricated to drive down an additional 5 feet. This tool consists of an 8 to 10 foot length of iron pipe that has a machined metal point attached to one end, along with holes and screen at the same end, which allow the iron pipe to act as well casing. Unlike the sleeve and core that are removed and reused, the black pipe and steel point are driven into the ground and left in place as well casing. To install this iron well casing, the core-sleeve assembly that was first described is driven into the ground to its full length. The core is then removed and replaced with the iron pipe, metal point first. The same pounder can be used to pound the iron pipe the rest of its length. Then the pounder and sleeve are removed, and the pipe is left in place as well casing. Using the core-sleeve assembly to create the first 5 feet of the hole allows use of a 10 foot pipe without pounding from a ladder, and the sleeve reduces the frictional drag on the pipe while it is being pounded down the last 5 feet. Any space around the pipe should be backfilled with sand or native material, and the casing/ground interface should be sealed with bentonite.

Some problems have been encountered with this tool. Soil may plug the drilled holes in the pipe while it is driven into the ground, which can slow water transfer and, therefore, the response of the water level inside the pipe. Also, the iron pipe has rusted in some locations.

Pressure Transducer Calibration Device

Although most pressure transducers come with product information that can be used to convert the millivolt readings to depth of water, accurate conversions require site-specific calibration through the full length of wire, wire splices, and data logger that will handle the signal. More importantly, transducers may drift over time, particularly if vapor or moisture condenses in the vent tubes. Therefore, it is good practice to calibrate pressure transducers before installation, and periodically during use if signs of drift are detected or if changes in the hardware setup are made. This device simply provides a tube to house a transducer temporarily above ground for calibration, and in which the water level may be varied.

Fabrication of the Well-Drilling Tools

Materials for the sleeve, core, and pounder

- 5 feet of black iron pipe (2 inch od)
- 5 feet of black iron rod (1.5 inch diameter)

- 3 inch diameter disk ($\frac{3}{4}$ inch iron)
- 2 feet of $\frac{3}{4}$ inch diameter rebar, or similar metal rod
- 7 feet 8 inches of black iron pipe (4 inch od, $\frac{1}{8}$ inch walls)
- 3- $\frac{3}{4}$ inch diameter disk (1 inch iron)
- Two 2-foot iron rods ($\frac{3}{4}$ inch diameter)

The sleeve and core (fig. 1) will accommodate a 1 inch PVC pipe ($1\text{-}\frac{5}{16}$ inch od) and a 1 inch diameter sensor. Adjust the dimensions accordingly for larger sensors.

The prototype inner core was made by machining one end of the 1.5 inch iron rod to a point using a 45 degree angle. Although it was not tested, a 30 degree angle could also be used, and might be easier to pound in. The 3 inch diameter disk was then securely welded to the other end for the pounding cap. This rod is the inner core.

Bevel one end of the 2 inch black pipe to match the slope of the point of the core. Beginning the bevel about 0.5 inch above the pipe end easily approximates the 45 degree slope. Drill a 1 inch hole straight through both walls of the pipe about 2 inches from the unbeveled end. Slide the rebar through these holes after installing the casing to use as a handle for pulling the pipe out

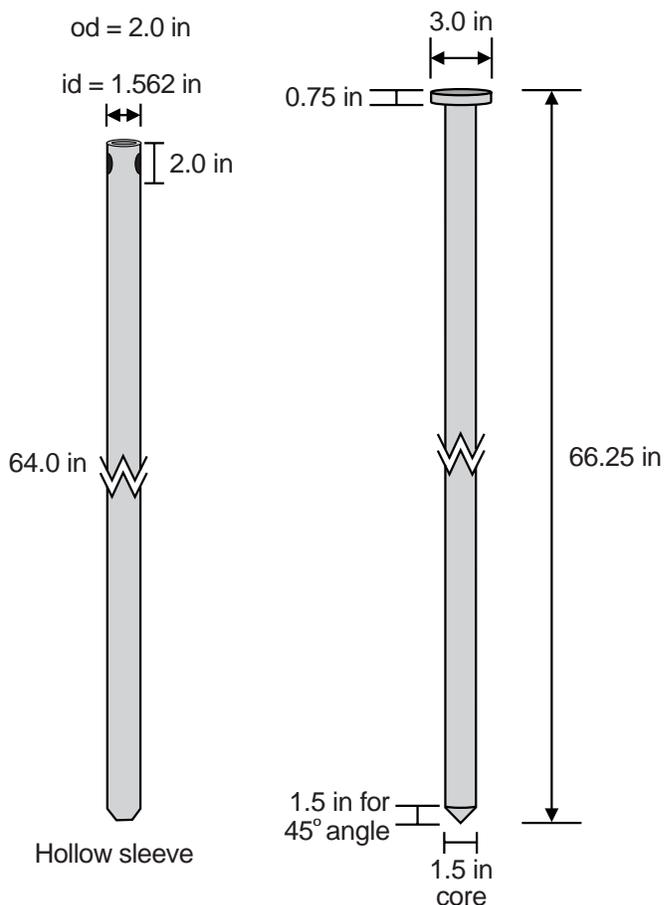


Figure 1—Sleeve and core.

of the ground. The pipe can also be jacked out of the soil by placing a handyman jack under this handle.

The 4 inch pipe will form the body of the pounder (fig. 2). The 3/4 inch rods are bent into handles that are welded to the body with 2 inch long welds, and the disk of 1 inch iron is welded inside one end of the body. Triangles of iron can be welded beneath the handles for additional support. This design evolved from less heavily reinforced prototypes that did not withstand the repeated pounding.

Materials for the PVC well casings

- 5 feet of 1 inch thin wall PVC pipe
- plastic screening
- #6 cork or rubber stopper
- PVC primer and glue

The 5 foot holes made by the core-sleeve assembly are cased with 1 inch thin wall PVC. Plug the bottom of the PVC with a #6 rubber stopper or cork prior to installation to keep soil from pushing up into the well. The lower 8 to 12 inches of the pipe are perforated for water entry, and then screened against larger soil particles. Perforate the pipe either with drilled holes (the size of the holes is not critical; 1/4 inch holes work well) or with slits cut with a hacksaw. The plastic window screening available at most hardware stores works well because it can be glued tightly to the outside of the perforated part of the pipe with PVC glue. Apply the PVC primer and glue to the pipe where the top, bottom, and seam of the screen will be, followed by tightly wrapped screen. More glue can be applied to the seam of the screen if necessary to prevent loose edges. The glue dries quickly. An alternative to homemade perforations and screening may be commercial threaded well screen

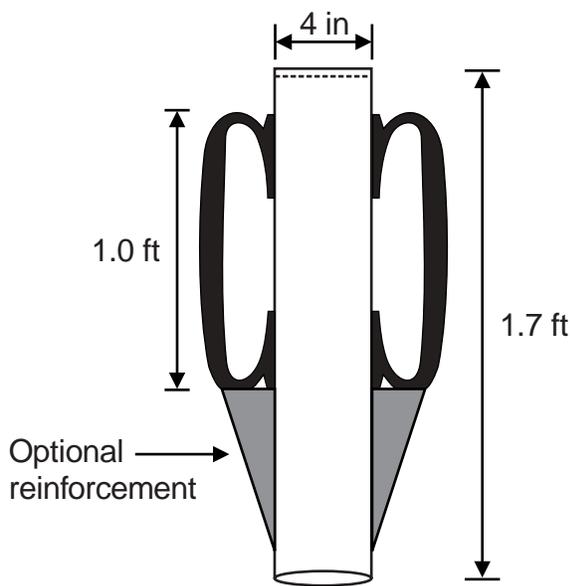


Figure 2—Pounder.

and threaded PVC (Miner and Simon 1997). The top opening may be closed with a cork or a #6 rubber stopper, or fit with a PVC threaded coupler and plug. Slip-on caps are also available, but very difficult to remove after they have been buried under snow. A small vent hole should be drilled just below the bottom of the cork or plug to prevent pressure buildup from trapped air.

Materials for the 10 foot pipe and well point

- 10 feet of 1 inch black iron pipe
- steel point, machined as in figure 3
- tension pins
- epoxy glue
- plastic screening

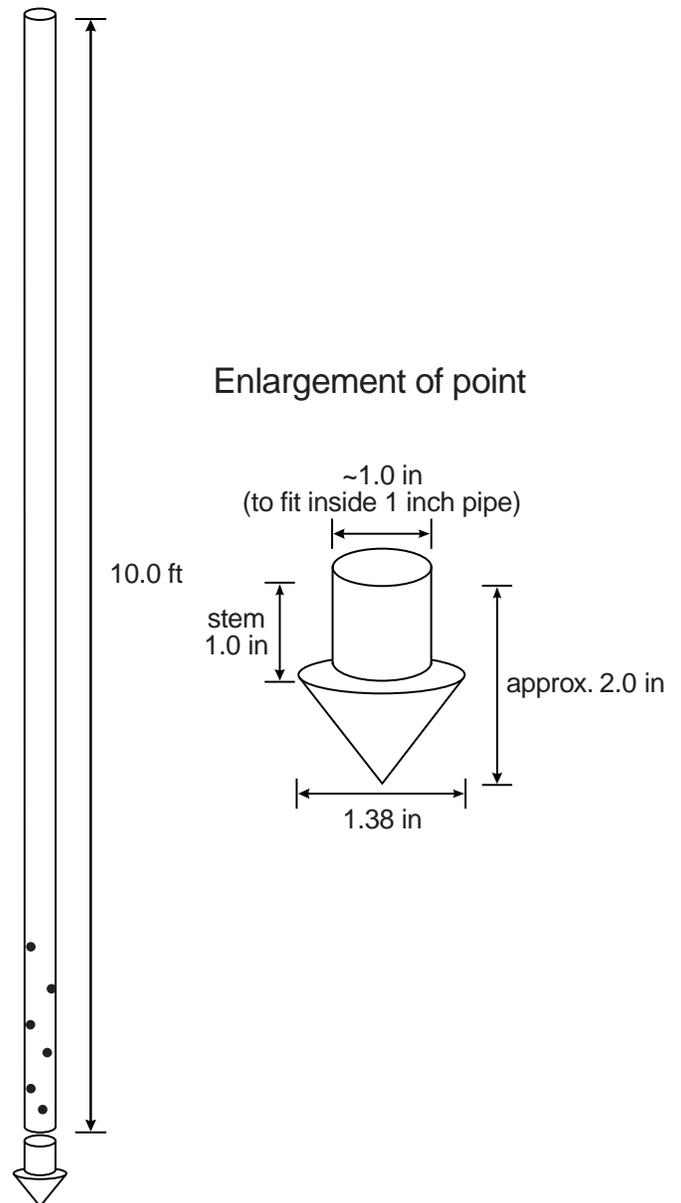


Figure 3—Point for 10 foot pipe (not drawn to scale).

The point can be fabricated at a local machine shop; the cost will probably depend on the quantity ordered. The stem of the point fits inside the 1 inch pipe and can be held in place with tension pins and/or quick setting epoxy. Alternatively, the stem of the point and the inside of the pipe can be threaded to fit each other. Before the point is installed, perforate the lower end of the pipe with drilled holes for water entry. (The length of pipe that is perforated will depend on the study objectives. Eight inches is a reasonable length for most observation wells.) The drilling will leave burrs on the inside of the pipe, which can be smoothed down with a file. The screen for the metal casing must be rolled and slipped inside the pipe before the point is installed. Close the top of the casing with a #5.5 rubber stopper after installation is complete. Drill a vent hole just below the bottom of the stopper to prevent pressure buildup from trapped air.

Sensors

Once a well casing is in place, the well can be instrumented with a number of different types of sensors to detect the free water surface in the well. The most common sensors are pressure transducers for automatic data logging, well level sensors for individual, instantaneous measurements, and ground cork with a

stick for the single highest stage. While pressure transducers are the most versatile, they are expensive and require periodic calibration and other handling for optimal results (Hvorslev 1951).

Materials for calibration tube

- 5 feet of 3 inch diameter plexiglass tube (or other clear plastic tube)
- 4 inch square or circle of plexiglass
- circle bubble level
- 6 feet of slotted angle iron, 14 gauge (or what is available at local hardware store)
- 3/4 inch pipe hanger strap
- 3/4 inch plywood triangle, approximately 26 inches across x 15 inches high
- six 1/4 x 3/4 inch bolts with 12 nuts
- eight 5/16 x 3/4 inch lag screws
- three 3/8 x 2-1/2 inch carriage bolts, with 6 washers, 3 nuts, and 3 wing bolts
- Duco Cement
- tape measure
- small spring clamp

The dimensions of the parts used for the calibration tube assembly are not critical, although it is best if the height of the tube approximates the range of operation for the pressure transducer. The prototype (fig. 4) used a 3 inch diameter tube because that was the best price

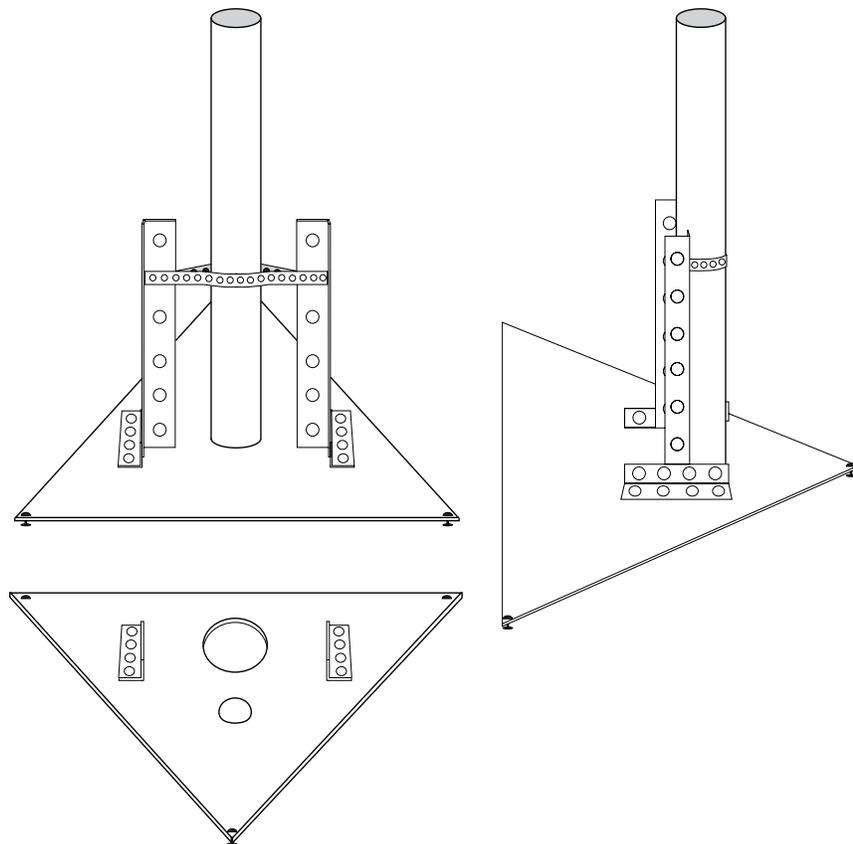


Figure 4—Calibration tube for pressure transducers (not drawn to scale).

available locally in a 5 foot length. Seal the bottom of the tube with the flat square or circle of plexiglass with a generous application of the Duco Cement. Do not trim the excess because it helps stabilize the tube. Cut the slotted angle iron into two 6 inch and two 30 inch pieces. The rough ends can be filed smooth or dipped in liquid plastic tool handle dip, if desired. Center the plexiglass tube on the base. Cut two 13 inch lengths of pipe hanger. Place them on opposite sides of the tube about 2- $\frac{1}{2}$ feet above the base and pinch them together with 2 bolts and nuts where they extend past the tubes so that they encircle the tube. Stand the longer lengths of slotted angle iron on end on the base so that one side of one piece lines up with one end of the pipe hanger, and the other piece lines up with the other end. Adjust the pipe hangers and attach the angle irons and pipe hangers with nuts and bolts. Lay the two remaining angle irons on the base, just outside of the vertical long pieces with the upright sections toward the tube, and perpendicular to the 26 inch side of the base. Line up holes in the short angle irons with holes in the vertical, longer angle irons, and attach with bolts and nuts. Mount the short angle irons to the base with lag screws. Because it is important that the assembly be level for proper calibration, the carriage bolts are used as leveling feet at each corner of the triangular base. Drill slightly oversized holes in the base for the bolts, thread the wing nuts onto the bolts *upside down*, add a washer to each bolt, and slide the bolts through the holes from the underside of the base. Fit the remaining washers and nuts onto the ends of the bolts, leaving the nuts loose. Glue the circle bubble level onto the base near the tube. Level the assembly by threading the wing nuts up or down at each corner. The tape measure and spring clamp will be used during calibration.

Calibrating Pressure Transducers

Suspend the pressure transducer inside the tube, at the bottom, by clipping its cord to the top of the tube with a small spring clamp (a battery clamp works well). The transducer must hang straight for accurate measurement. This was accomplished by taping three short pieces of $\frac{1}{2}$ inch PVC pipe to the pressure transducers with electrical tape, and worked well. Other, less clumsy setups are certainly available to the imaginative. Once the transducer is set in the tube, hook the end of the tape measure to the top edge of the tube and measure

along the outside of the tube to the exact level of the sensing point on the transducer. Then add small increments of water: fill to the sensing point on the transducer, and continue filling incrementally until the tube is filled. Carefully measure the water level height of each increment and record it along with the voltage across the transducer at the data logger for each increment. The difference between the level of the transducer and each water level is the head of water. Regress the voltages with the water heads to calculate the relationship between the two. (You can also measure from the bottom up to the transducer and water levels, but it is more difficult to keep the tape straight.)

Other Sensor Problems

Regardless of the type of sensor you chose, you will need to know the elevation of the top of the pipe to calculate the elevation of the water surface from its stage (Hvorslev 1951). You can then measure down to the water surface with a well level sensor, or other devices, to calculate the elevation of the water surface and the sensor. Pressure transducers must be vented to ambient air pressure through one or two small tubes to function properly. These tubes are usually bundled with the electrical wires, but must terminate in a dry environment so vapor does not accumulate in the tube. Desiccant holders, or "dry boxes" are available commercially, or it is also possible to fabricate a satisfactory dry box if you can change desiccant regularly. The "dry box" container must be able to hold desiccant and accept the end of the vent tube while limiting moisture transfer and allowing the air pressure to equilibrate with the ambient pressure. For example, fill a baby bottle with desiccant and push the vent tube into the desiccant through the nipple (clip the end of the nipple if necessary). Indicator desiccant is highly recommended. Even though the electrical wires may reach some distance, keep the vent tubes as short as is practical because the moisture cannot diffuse out efficiently over several yards.

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