Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for installing, measuring, and decommissioning hand-driven in-water piezometers

Version 1.1

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EAP061

APPROVED: August 2, 2010

Signatures on file

Revision History

Date	Revision number	Summary of change(s)	Revised section(s)	Reviser(s)
07/26/2010	1.1	Updated well construction fees and discussion of procedures, Appendix B.	Append B	K. Sinclair

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Standard Operating Procedures for Installing, Measuring, and Decommissioning Hand-Driven In-Water Piezometers

1.0 Purpose and Scope

1.1 The Environmental Assessment Program (EAP) is responsible for measuring, assessing, and reporting information about the environmental condition and health of Washington's land and water resources. This information is used by resource managers, policymakers, and others to help protect and manage Washington's environment. As such there is a need to document and ensure that consistent and scientifically defensible practices, procedures, and techniques are used by EAP staff, and that the data and information they provide are of consistent and high quality.

1.2 This SOP summarizes the general procedures and practices EAP staff use to install, measure, and remove hand-driven piezometers along streams, rivers, or other water bodies and is one of several documents developed to memorialize the program's standard operating procedures and practices.

1.3 Staff deploying or monitoring in-water piezometers should also consult and follow EAP's companion documents and SOPs that describe the use of GPS instruments (EAP013 - Janisch, 2006), stream temperature monitoring (EAP0044 - Bilhimer and Stohr, 2007), performing manual depth to groundwater measurements (EAP052 - Marti, 2009), hydraulic test procedures (Pitz, 2006), and groundwater sampling (under development).

2.0 Applicability and Background

2.1 In-water piezometers are one of several tools used by EAP to help define the distribution, timing, volume, and quality of groundwater that discharges to streams, lakes, and other water bodies. In this context piezometers serve several important roles. They can be used to:

2.1.1 Estimate hydraulic conductivity values for streambed, lakebed, or other sediments,

2.1.2 Measure the vertical hydraulic gradient between a surface water body and near-surface groundwater,

2.1.3 Monitor sediment thermal profiles, and

2.1.4 Sample groundwater quality.

2.2 Detailed knowledge of these factors is important for total maximum daily load (TMDL) investigations or other studies where an understanding of local surface water/groundwater (SW/GW) interactions is important.

2.3 For ease of presentation the discussion that follows centers around piezometer deployments in streams or lakes. However, these techniques and tools can easily be adapted to assess SW/GW interactions within wetland, estuarine, or marine environments.

2.4 This document supplements but does not replace the need for on-the-job training. When in doubt seek additional guidance.

3.0 Definitions

3.1 Constant Head Injection Test (CHIT) – A procedure whereby the bulk hydraulic conductivity of streambed or other "in-water" sediments are evaluated by injecting water into a piezometer at a rate sufficient to maintain a constant pre-determined water level (or head) in the piezometer (see Cardenas and Zlotnik, 2003; and Pitz, 2006 for additional details regarding the theoretical basis for these tests and the standard field procedures EAP uses to conduct them).

3.2 Development (of piezometers) – The process of removing fine sediment that accumulates within the casing or open interval of a piezometer during installation. Development is typically accomplished using a combination of jetting, surging, and pumping.

3.3 DNR – Washington Department of Natural Resources

3.4 EAP – Environmental Assessment Program

3.5 Ecology – The Washington State Department of Ecology

3.6 EIM – Environmental Information Management System. Ecology's database of environmental information.

3.7 Global Positioning System (GPS) receiver – An instrument capable of receiving signals from the U.S. Department of Defense Global Navigation Satellite System. GPS receivers use these signals to determine their current geographic location, the time, and their velocity.

3.8 In-Water Piezometer – A small-diameter observation well installed directly into a surface water body to monitor depth to groundwater, sediment water temperatures, sediment hydraulic properties, and/or to periodically collect groundwater quality samples.

3.9 Land Surface Datum (LSD) – a datum plane that is approximately at land surface at each well. If known, the elevation of the land-surface datum relative to a standard geodetic datum (such as NGVD 1929 or NGVD88) is given in the well description.

3.10 Water Level Measuring Point (MP) – The point on an in-water piezometer (typically the top of casing) from which depth-to-water and surface water stage measurements are made. Unlike the piezometer reference point which is fixed (see below), the position of the water level measuring point can vary over time as extensions are added to or removed from a piezometer to accommodate project needs or changing surface water conditions.

3.11 Open Interval – The portion of a piezometer pipe that is perforated or screened to allow water entry into the casing. The open interval is typically described based on its overall length and position relative to the piezometer reference point (see below).

3.12 Pressure transducer - An instrument that can be programmed and deployed to measure and record water pressures at a defined time interval.

3.13 Quality Assurance Project Plan (QAPP) – A written plan that describes how a study will be conducted and its results assessed.

3.14 Permanent Reference Point (PRP) – A permanent (fixed) reference point on a piezometer casing that is used to measure a piezometer's physical characteristics (such as the total installation depth or position of the open interval) with respect to the sediment surface.

3.15 Sediment – A generic term used to describe the surficial materials (especially sand, gravel, silt, and clay) that typically mantle the bed of streams, rivers, lakes, or other water bodies – and into which in-water piezometers are driven.

3.16 Static Water Level (SWL) – The level to which water in a well casing naturally rises in the absence of external stresses (such as the withdrawal or injection of water locally or in nearby wells).

3.17 Stilling tube – A short length of perforated-translucent tube used to measure the position of the water surface in rivers, lakes, or other water bodies. Stilling tubes help to stabilize the water surface by minimizing short-term instabilities arising from turbulence, pressure waves, or other factors.

3.18 Stream seepage evaluation – A study conducted to define the relative stream-flow gain from or loss to groundwater along a stream reach.

3.19 Surface water stage (as measured using an in-water piezometer) - The position (level) of the water surface in a stream, lake, or other water body with respect to the piezometer water level measuring point (see Figure 6).

3.20 Thermistor (recording) – A programmable instrument that can be deployed to measure and record the temperature of water, air, or other media at a user-defined time interval.

3.21 Total Maximum Daily Load (TMDL) (study) – A study conducted to define the maximum potential contaminant load (for specific parameters of concern) that a water body can assimilate without violating water quality standards.

3.22 Vertical Hydraulic Gradient (as measured using an in-water piezometer) – The difference in total head between a surface water body and groundwater divided by the distance between the sediment surface and the midpoint of the piezometer perforations.

4.0 Personnel Qualifications/Responsibilities

4.1 All staff who deploy or monitor in-water piezometers are responsible for complying with this SOP and the requirements of the EAP safety manual - particularly Chapter 1 'General Field Work' and the following sections of Chapter 2: 'Measuring Flows in Rivers and Streams', 'Groundwater Sampling and Water-Level Measurements', 'Using Hand or Power Tools', and 'Using Brush Cutters and Trimmers' (Ecology EAP, 2009).

4.2 The Water Well Construction Act of 1971 (Chapter 18.104 RCW) requires that a licensed well driller or engineer be present at all times to oversee piezometer installation or decommissioning activities. The driller/engineer must also sign and submit well drilling notice of intents, well completion reports, and other associated paperwork to Ecology's Water Resources Program within the timelines specified in Chapter 173-170 WAC (Minimum Standards for Construction and Maintenance of Wells) (see Appendix B for details).

4.3 When conducting field work via a boat, at least one crew member must be a qualified boat operator (per interim Ecology Policy 11-60). All crew members are responsible for reading and following the general boating guidance in the EA Safety Manual (Chapter 3).

4.4 The field lead is expected to have a detailed working knowledge of the project Quality Assurance Project Plan (QAPP) and is responsible for ensuring that other field staff are briefed on the study goals and objectives and that they adhere to prescribed sampling methods while conducting field work.

5.0 Equipment and Supplies

5.1 Personal Field Gear

5.1.1 a small backpack
5.1.2 rain gear top and bottom
5.1.3 hearing protection
5.1.4 eye protection
5.1.5 hardhat
5.1.6 hip/chest waders with wading boots
5.1.7 leather gloves

5.1.8 Sun hat
5.1.9 Extra warm non-cotton clothing
5.1.10 personal flotation device
5.1.11 sunscreen
5.1.12 filled water bottle and extra food

5.2 Portable Field Toolbox

5.2.1 two pipe wrenches
5.2.2 hammer and assorted nails
5.2.3 knife
5.2.4 screwdriver set with commonly used head types and sizes
5.2.5 assorted stainless steel screws, nuts, and bolts
5.2.6 duct tape
5.2.7 assorted pliers
5.2.8 100 - foot coil of 12 to 14 gage aluminum or galvanized wire
5.2.9 100 - foot coil of 18 to 20 gage aluminum or galvanized wire
5.2.10 ¼ - inch standard and metric socket set plus assorted stainless nuts and bolts
5.2.11 crescent wrenches
5.2.12 plumber's tape
5.2.13 wire clippers
5.2.14 12-foot engineer's hand tape
5.2.15 wire-reinforced zip ties, various lengths
5.2.16 extra piezometer caps, plugs, and couplers
5.2.17 indelible ink pen

5.3 Piezometer Installation and Development

5.3.1 Appropriate piezometer materials (such as pre-fabricated galvanized steel or PVC piezometer pipes, pipe couplers, extensions, and caps/plugs; or flexible-poly tubing with drive rod assembly and drive point).
5.3.2 Global Positioning System (GPS) receiver
5.3.3 Field compass with inclinometer
5.3.4 Well tagging equipment
5.3.5 Clip board, piezometer installation form(s), and pencils
5.3.6 Digital camera
5.3.7 Small step ladder (as necessary)
5.3.8 Floating work platform and inner tube (as necessary)
5.3.9 Calibrated low-displacement e-tape (as necessary)
5.3.10 Stilling tube (as necessary)
5.3.11 Fence post driver, sledge hammer, PVC drive rod, gas jackhammer, drop hammer and tripod assembly (as appropriate)
5.3.12 Manual bilge pump with fittings and a 10 to 12-foot length of ½ -inch diameter polyethylene tubing (to develop rigid piezometers)
5.3.13 Peristaltic pump, charged portable 12-volt battery, and silastic tubing (as necessary)

5.3.14 Plugs or caps (tubing piezometers)
5.3.15 Pipe weights (tubing piezometers)

5.4 Water Level Monitoring and Thermistor Deployment

5.4.1 Peristaltic pump, charged portable 12-volt battery, and silastic tubing (as appropriate)
5.4.2 Manometer board and tubing (as appropriate)
5.4.3 Calibrated low displacement e-tape (as appropriate)
5.4.4 Stilling tube
5.4.5 Pre-calibrated and launched thermistors (four thermistors per piezometer for initial deployment)
5.4.6 Extra piezometer cap(s), coupler(s), and extension pipe(s) (as appropriate)
5.4.7 Pre-launched thermistor shuttle(s) (to download thermistors)
5.4.8 Extra pre-launched thermistors (replacements for failed thermistors)
5.4.9 Thermistor shade devices (see Bilhimer and Stohr, 2007)

5.5 Decommissioning Piezometers

5.5.1 Two high-lift jacks with extension handles and attached chains
5.5.2 Star clamp, appropriately sized for pipe (as necessary)
5.5.3 Five feet of heavy gage chain with end hook
5.5.4 16-pound sledge hammer (as necessary)
5.5.5 2-pound hand sledge
5.5.6 2-14 inch lengths of 2 inch by 8 inch board or heavy plywood (as necessary to support jack base)

6.0 Summary of Procedures

6.1 <u>Project Planning</u>

6.1.1 Successful deployment of in-water piezometers involves considerable up-front planning.

6.1.2 Previous studies and data must be assembled and evaluated (where available) to develop a preliminary conceptual model of SW/GW interactions for the study area.

6.1.3 Potential piezometer sites must be field scouted and selected.

6.1.4 Regulatory permits, variances, and waivers must be obtained from County and State agencies to install piezometers and perform in-water work.

6.1.5 Appropriate piezometer material(s) must be selected and piezometers designed and fabricated.

6.1.6 A brief discussion of these topics is presented below, as a primer for readers newto SW/GW interaction studies. New readers and others seeking a refresher should consult the excellent reference publications by Winter and others (1998), Stonestrom and Constantz (2003), and Rosenberry and LaBaugh (2008), prior to preparing project plans or installing piezometers. These documents present numerous SW/GW interaction case studies and contain a wealth of information about potential piezometer designs and deployment strategies.

6.2 Preliminary Site Selection and Field Reconnaissance

6.2.1 Before heading to the field, review previous seepage evaluations and other published information about the hydrogeologic setting and groundwater flow patterns for the study area. Note the location of geologic contacts, mapped springs, or other geomorphic features that might suggest where groundwater potentially discharges to the stream or water body of interest (see Konrad, 2006, and Rosenberry and LaBaugh, 2008 for additional guidance).

6.2.2 Use surficial geology maps and aerial photographs to tentatively identify locations where surficial bedrock exposures may prevent piezometer installation. From this assembled information, target stream reaches or shoreline areas to visit during site reconnaissance efforts.

6.2.3 The goal when selecting potential piezometer sites is to characterize the quality and quantity of groundwater that discharges to the water body of interest (such as areas of known contamination) while also providing estimates of the overall range in groundwater chemical concentrations and flux volumes/rates.

6.2.4 When selecting potential piezometer locations in the field target calm-water sites within wading distance of shore that can be safely accessed during all but flood periods and which will not be left dry when flows drop during baseflow periods.

6.2.5 Avoid locations near point bars, riffles, or steep drops that might locally induce surface-water flow through the streambed (hyporheic exchanges).

6.2.6 To minimize potential equipment vandalism, target locations where overhanging trees or bushes provide natural cover. Also, try to locate piezometers where they are least likely to be impacted by floating debris or boats.

6.2.7 Depending on the study objectives and local site conditions it may be necessary to install more than one piezometer per location to adequately characterize the subtleties of local SW/GW interactions.

6.2.8 Record the information collected during preliminary site visits on a piezometer reconnaissance field form or equivalent (see example in Appendix A). This information will be required when applying for well construction variances and site access permits.

6.3 Regulatory Permits, Variances, and Waivers

6.3.1 The project hydrogeologist is typically responsible for securing the regulatory permits and waivers to install in-water piezometers. These currently include a hydraulic project approval (HPA), a shorelines permit exemption, a DNR aquatic lands right of entry agreement (when working in navigable waters), and information about the location of nearby underground utilities. These approvals must be obtained *before* piezometer installation begins.

6.3.2 In-water piezometers are also subject to Washington's minimum well construction and licensure requirements (Chapter 18.104 RCW, Chapter 173-160WAC, and Chapter 173-162WAC). Accordingly, a licensed well driller (or engineer) must be present to oversee piezometer installation and removal. They are also responsible for signing and filing the well completion and abandonment reports for the project.

6.3.3 The steps required to secure environmental permits, variances, and regulatory waivers for in-water piezometers are outlined in Appendix B (also see footnote below) [1].

6.4 Piezometer Material and Design Considerations

6.4.1 In-water piezometers can be constructed from a variety of commonly available materials including steel (black, galvanized, or stainless), thick-walled PVC, or polyethylene tubing, among others (Table 1).

Table 1 – Suitability of piezometer materials for different applications

Material Type	Material and fabrication costs	Security	Design flexibility	Streambed hydraulic tests	Periodic water level monitoring	Continuous temperature or water level monitoring	Water quality monitoring
Flexible polyethylene tubing	$$	P-G	G-E	P	E	P	E
Rigid PVC pipe	$	P-G	G-E	G	E	E	E
Galvanized or black steel pipe	$$$	G-E	G-E	E	E	E	G-E

P-poor, G-good, E-excellent

6.4.2 When selecting piezometer material(s) and design(s) chose those that best complement the study goals and objectives. In some situations a variety of materials or designs may be the best approach.

6.4.3 Selecting an appropriate open-interval type (e.g. perforated pipe, filter fabric wrapped tubing, commercial stainless steel well point, etc.) is also an important design consideration. Again, select the open-interval type that best meets the study needs, budget, and site conditions.

[1] NOTE: in 2008 EAP negotiated "state wide" HPA and DNR aquatic lands access agreements for the 2008-9 field season. The information in Appendix B is provided as a general guide, in the event these permits are not renewed during subsequent field seasons. In either case, the project manager is responsible for ensuring that the regulatory permits and wavers described in Appendix B are in place for their project **before** beginning field work.

6.5 Steel Pipe Piezometers

6.5.1 Piezometers constructed from galvanized or black steel pipe are relatively expensive but are robust and often reusable. They are well suited for longer-term deployments where equipment vandalism or frequent contact with floating debris is likely.

6.5.2 Steel offers significant flexibility during the initial design and subsequent maintenance of piezometers, due to the wide variety of fittings, couplers, and end-caps that are available at most hardware stores.

6.5.3 One-inch diameter or smaller steel piezometers are relatively easy to install and are well suited for manual water level and water quality monitoring.

6.5.4 Larger 1.5- inch piezometers are more difficult to install but have the added benefit of accommodating recording thermistors or pressure transducers. They can also be fabricated with a larger effective open interval and are therefore better suited for sediment hydraulic tests than smaller diameter steel or tubing piezometers.

6.5.5 If vandalism or encounters with floating debris are likely, steel piezometers can be fabricated with removable extensions that enable them to be capped and completed below the water surface between field visits.

6.5.6 Steel piezometers can also be combined with a flexible polyethylene tube that extends along the sediment surface to a safe access point on the shoreline. This arrangement enables piezometers to be safely measured or sampled during high-water periods.

6.6 Flexible Polyethylene Tubing Piezometers

6.6.1 Smaller-diameter tubing piezometers (e.g. 0.25 - inch ID polyethylene tubing) are relatively inexpensive to construct and may be easier to install than larger-diameter steel piezometers.

6.6.2 They are particularly well suited for lake deployments since they are easily hidden from boaters and swimmers.

6.6.3 Where floating debris is present or vandalism likely, tubing piezometers can be coiled and weighted to lie on the streambed or lake bottom between site visits.

6.6.4 Tubing piezometers may also the best choice when low-concentration sampling of metals is planned. They can also be fabricated with a fine mesh screen to help minimize the entry of fine sediment into the well.

6.6.5 Due to their small diameter however, tubing piezometers can’t accommodate recording thermistors or water level probes (e-tapes) and are not well suited for hydraulic tests.

6.7 PVC and Stainless Steel Piezometers

6.7.1 Piezometers can also be constructed using heavy walled PVC or stainless steel casing. Traditional steel piezometers can also be designed to accept pre-fabricated stainless steel well points. EAP has used these materials and designs only sparingly, however, due to cost (stainless) or difficulty of installation (PVC).

6.8 Piezometer Deployment

6.9 Establishing a Permanent Reference Point on the Piezometer Casing

6.9.1 The first step, when installing a piezometer, is to establish and document a *Permanent Reference Point (PRP)* on the piezometer casing (Figure 1). The PRP is used to track a piezometer's geometry (installed depth, open interval, etc.) with respect to the sediment surface. This is important since the *effective* piezometer depth, open interval position, and installed instrumentation depths can change as surface sediments shift around the casing over time. These changes must be tracked to properly interpret SW/GW head relationships, bed-sediment thermal profiles, and other variables.

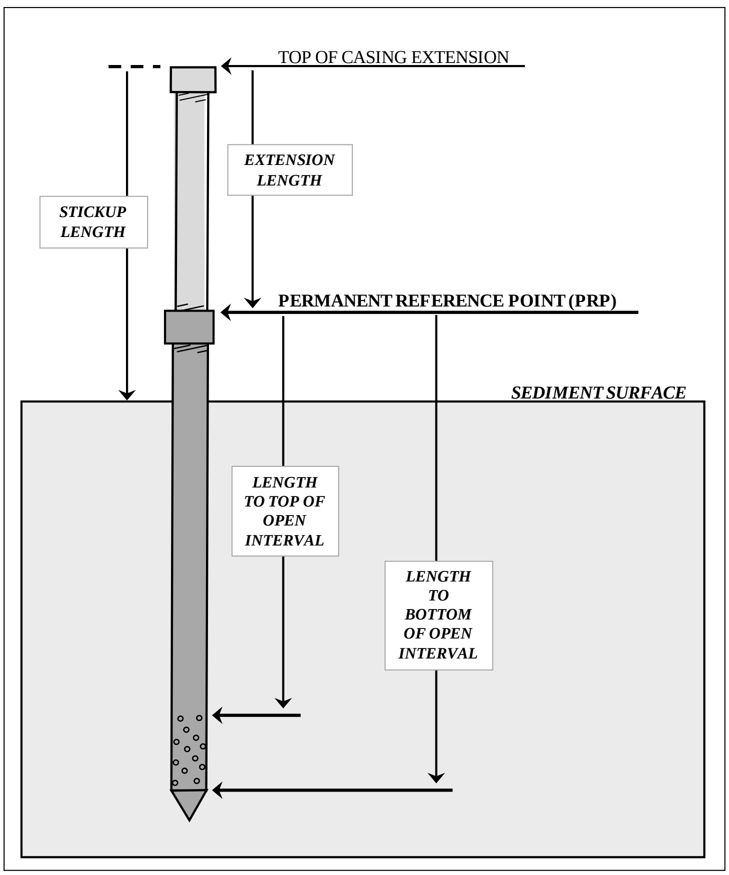


Figure 1– Schematic of a typical in-water piezometer

6.9.2 **Steel (or PVC) piezometers**: For steel, PVC, or other rigid piezometers select a PRP that will project above the sediment after the piezometer is driven to final depth. For single piece piezometers the PRP is usually defined as the top of casing with a pipe coupler attached. For multi-section piezometers the PRP is usually defined as the top of the pipe coupler attached to the lower-most 5-foot long perforated-casing segment. After establishing the PRP, lay the pipe assembly on a flat surface and use an engineer's hand tape to carefully measure:

6.9.2.1 The distance from the PRP to the top and bottom of the open interval. Be sure to include the *entire length* of pipe where water can enter the casing.

6.9.2.2 Also measure the extension length (if any) and the total inside casing length. Measure all lengths to the nearest 0.01 foot.

6.9.2.3 Record the above measurements and other pertinent information (such as the pipe type, diameter, and the screen or perforation type) on a piezometer installation field form or equivalent (see example form in appendix A).

6.9.3 **Flexible tubing piezometers**: the PRP for flexible tubing piezometers is generally defined as the upper end of the tubing opposite the drive point.

6.9.3.1 When installing a standard 5-foot deep tubing piezometer start with at least 10 feet of tubing.

6.9.3.2 Lay the tubing section on a flat surface and carefully measure its overall length (including the drive point) with an engineer's hand tape.

6.9.3.3 Measure the distance from the PRP to the top and bottom of the open interval. Record all values on the piezometer installation field form. (Note: The initial depth of a tubing piezometer is determined after installation by subtracting the tubing length that projects above the sediment surface, after installation, from the total beginning length measured above.)

6.10 Piezometer Installation

6.10.1 Piezometers can be installed with a fence post driver, a tripod and drop-hammer, a gas-powered jack-hammer, or similar means (Figure 2). Choose the most appropriate installation method based on local site and permit conditions.

Tripod and drop hammer

Fence post driver

Gas powered jack hammer

Figure 2 – Common Tools for Piezometer Installation

6.10.2 **Steel piezometers**: Before driving the casing attach a temporary drive cap or coupler to the casing top to protect the pipe threads. Use a pair of pipe wrenches to confirm that all couplers and caps are tight and secure. (Note: Teflon plumbers tape should be used to seal any joints that might potentially leak due to worn or loose threads. Do not use plumbers putty or other sealants that might potentially bias future water-quality results).

6.10.2.1 Begin driving the piezometer - keeping the casing as vertical as possible. If the casing strays significantly from vertical, while still at a shallow depth, remove it and try driving again a few feet away. Strive for a vertical installation where possible.

6.10.2.2 If near-surface bedrock or consolidated sediments prevent piezometer installation note the location on the field form and move to a nearby site. Try to avoid too much casing "bounce" while driving as this can damage pipe threads or loosen couplings.

6.10.2.3 Periodically stop and retighten any loose couplers or caps as the casing is advanced.

6.10.2.4 If conditions allow, drive the casing until the PRP lies about 6 inches above the sediment surface. This will enable the piezometer to be capped below the water surface, if desired (assuming the PRP was established at the top of the casing coupler attached to the lowermost casing segment as described above).

6.10.2.5 Below-water completions are less prone to vandalism or impacts from floating debris. However, an extension is required to raise the piezometer above the water surface during field visits. (Note: when sampling for water quality an extension can be left in place, between visits, to prevent surface water from entering the casing when the cap is removed).

6.10.3 **Flexible Tubing Piezometers**: Tubing piezometers are installed using a rigid-temporary-drive pipe that must be removed after the tubing is driven to final depth. Extracting the drive pipe can leave an annular space that must be collapsed around the tubing to isolate the piezometer from the overlying surface water. To minimize the potential for water leakage along the casing, use a drive pipe/drive point only slightly larger in diameter than the piezometer tubing. Also, pack fine surface sediments tightly around the tubing as (and after) the drive pipe is removed. (Note: If a tubing piezometer is installed at an angle, measure and record the angle if the drive pipe (as degrees from vertical) <u>before</u> extracting it so that geometric corrections can be made to define the installation depth of the piezometer and open interval).

6.10.4 Observations to Note and Record – All Sites

6.10.4.1 As the piezometer casing (or temporary drive pipe) is driven make note of the general nature of the surficial sediments that are encountered; such as the general clast size and degree of sorting. Also note the relative effort required to advance the casing or drive pipe with depth.

6.10.4.2 The goal is to develop a qualitative sense of the type(s) and relative compactness of the sediments encountered at each piezometer site. This information will be used to prepare the piezometer well report. It also provides a context for evaluating subsequent hydraulic tests or water quality sampling that may be undertaken.

6.11 Piezometer Development and Completion

6.12 Piezometer installation disturbs the sediments in the immediate vicinity of the drive pipe or casing. Consequently, all piezometers must be developed after installation to remove sediment that accumulates in the casing or open interval; thereby ensuring the piezometer has an unobstructed hydraulic connection with the surrounding sediments. (Note: If a piezometer will be used to test or evaluate sediment hydraulic properties (such as CHIT tests) perform these tests *before* proceeding with *rigorous* well development (see Cardenas and Zlotnik, 2003; Pitz, 2006).

6.13 **Steel (or PVC) piezometers:** Steel (or PVC) piezometers of one-inch or larger diameter are developed using a manual-bladder-type bilge pump and a 10-12 foot length of ½ inch diameter polyethylene tubing (Figure 3).

Figure 3 – Bilge pump development of a steel piezometer

6.13.1 Begin development for these larger diameter piezometers by attaching one end of the polyethylene tube to the inlet (suction) port of the bilge pump (Note: the direction of water flow is indicated on the pump ports).

6.13.2 Insert the second end of the tubing into the piezometer until it rests on the piezometer bottom.

6.13.3 Pump any accumulated sediments from the casing. (Note: The pump body may need to be submerged in the surface water during the first few strokes to prime it with water).

6.13.4 Transfer the tubing to the pump outlet (pressure) port and slowly raise and lower the tubing across the length of the piezometer open interval while pumping water from the stream (or lake) into the casing.

6.13.5 Reset the tubing to the pump inlet port and again remove accumulated sediments from the casing.

6.13.6 Repeat this cycle until the piezometer produces a sustained supply of sediment free water. (Note: Sediments with significant silt or clay content may require more vigorous development to loosen and remove “smeared” fines from the well screen or perforations. In such cases it may help to simulate a “surge-block” effect by vigorously raising and lowering the tubing a few feet while alternatively pumping water into then out of the casing).

6.13.7 Smaller diameter (< one inch) steel or PVC piezometers are developed in similar fashion using a peristaltic pump and an 8-10 foot length of rigid ¼ inch diameter polyethylene tubing.

6.13.8 When development appears complete, confirm that the piezometer freely exchanges water with the surrounding sediments (subject to sediment limitations). Do this by filling the casing with surface water and watching for a short time to confirm that the level moves toward its natural equilibrium position.

6.13.9 Check that the piezometer is hydraulically isolated from the overlying surface water by visually comparing (or measuring) the hydraulic heads (water levels) inside and outside of the piezometer casing. A distinct head difference suggests that the piezometer has an effective casing (annular) seal.

6.13.10 As a secondary check, purge the piezometer with a peristaltic pump and periodically measure the waters dissolved oxygen (DO) and specific conductance (SC) concentrations. Purge until equilibrium is achieved. Compare the piezometer values to those for surface water. Groundwater often has lower DO concentrations and higher SC values than surface water.

6.13.11 If the water level and water quality values of the surface water and piezometer are the same, it’s possible that surface water is entering the piezometer via a poorly sealed casing annulus. In such cases repack sediments around the casing and repeat the above tests. (Note: If these initial attempts do not adequately seal the casing, try deepening the piezometer (if practical) or allowing surface sediments to naturally repack around the casing for a few weeks before repeating the above tests. (Note: Additional leakage evaluations, such as dye testing, may be necessary to confirm the adequacy of the casing annular seal).

6.13.12 Complete the installation by measuring the maximum casing incline (as degrees away from vertical). Record the result in the installation field form.

6.13.13 Attach an Ecology well tag to the casing using heavy gage aluminum wire. Record the tag number and piezometer description on the installation field form.

6.13.14 Collect and record final GPS coordinates for the piezometer per EAP SOP-013 (Janisch, 2006).

6.13.15 Describe and/or sketch the piezometer location including its position (left bank/right bank) and distance/bearing from local landmarks.

6.13.16 Take a few wide-angle photographs of the piezometer showing its location relative to the described landmarks. Note the photo sequence number on the installation form.

6.13.17 Determine the casing stickup by extending a steel hand tape *along* the length of the casing and measuring the distance from the sediment surface to the top of the piezometer casing – including the length of any attached extension(s). Record the value on the installation form to the nearest 0.01 foot. (Note: If the piezometer is not vertical remember to measure the stickup (and associated water levels) from the lowest point along the casing rim).

6.13.18 Next measure the attached length of any extensions or couplers that were added to the piezometer upon arrival. Record the value on the field form.

6.13.19 Finally, measure and record the initial hydraulic head values for the piezometer and surrounding surface water (see section 6.17 - routine monitoring - for details).

6.14 **Tubing Piezometers:** Tubing piezometers (like smaller diameter rigid piezometers) are best developed using a peristaltic pump.

6.14.1 Begin development by connecting the silastic tubing from the pump directly to the upper end of the piezometer tubing. Start the pump and alternately pump water into and out of the piezometer by periodically reversing the pump direction.

6.14.2 Repeat this process until the piezometer produces a sustained discharge of sediment free water (subject to formation limitations). A floating platform can be used to hold the pump and battery if necessary.

6.14.3 When development is complete perform the casing-seal evaluation outlined in sections 6.13.8 through 6.13.10.

6.14.4 Measure and record the length of tubing that projects above the sediment surface (to the nearest 0.01 foot).

6.14.5 Subtract this length from the *total initial* tubing length (see Section 6.9.3.2) to determine the installation depth. Note these values on the piezometer installation form. The previously measured drive casing angle (if any) can be used to correct this value to a vertical depth.

6.14.6 Establish a permanent water level measuring point (MP) at a convenient point on the tubing. Select a point that will always be above the water surface when the tubing is held vertically – regardless of river stage. Permanently mark the water level MP with an indelible ink pen or a plastic zip tie secured firmly around the piezometer tubing.

6.14.7 Hold the tubing vertical and use a steel hand tape to measure the distance between the water level MP and the sediment surface, to the nearest 0.01 foot. Record this value as the initial piezometer stickup length on the piezometer installation form. This initial stickup value will be used to track changes in effective piezometer depth due to sediment deposition or scour.

6.14.8 While holding the tubing vertical measure and record the initial hydraulic head values for the piezometer and surrounding surface water (see Section 6.17 for details).

6.14.9 Submerge the exposed end of the tubing to remove all air then plug or cap the end with a rubber stopper or equivalent to keep sediment or debris from entering the piezometer.

6.14.10 Arrange the tubing into a loose coil (leaving enough free tubing to allow it to be lifted above the water surface during the next field visit) and attach a pipe or other suitable weight to the coil with plastic zip ties.

6.14.11 Attach an Ecology well tag around the weight with a zip tie or heavy gage wire. Record the tag number and piezometer description in the field notes.

6.14.12 Lay the tubing assembly on the sediment surface and cover it with sediment or rocks (as necessary) to hold it in place.

6.14.13 Collect and record final GPS coordinates for the piezometer per EAP SOP-013 (Janisch, 2006).

6.14.14 Describe and/or sketch the piezometer location on the field form including its position (left bank/right bank) and distance/bearing from local landmarks. To supplement the field notes take a few wide-angle photographs of the piezometer showing its location relative to described landmarks.

6.15 General Development Considerations - All Piezometers

6.15.1 Regardless of piezometer type, track pertinent information about the development process on the installation form. For example, does the piezometer develop quickly with only minimal silt and sand production or does it develop slowly producing considerable silt and sand that clears only after a period of extended development? Does the piezometer easily take and produce water or does it exchange little water even after extended development? Except in the finest of sediments the piezometer water level should perceptibly raise or fall as it moves toward its natural equilibrium condition. This information will prove useful when preparing the formal well report and will provide a qualitative check of the results from any hydraulic tests that are run.

6.15.2 Occasionally piezometers are completed with their screen or perforations above the water table (e.g. along a 'losing' stream reach). In such cases the piezometer may quickly pump dry and appear to be clogged or undeveloped. In these situations confirm development by verifying that the piezometer 'takes' water introduced into the casing. If the piezometer won't accept water the open interval may be clogged and need further development. Alternatively, the sediments may simply be too fine to transmit much water. If continued development doesn't improve well yield, and/or the water that is produced remains highly turbid, it's likely the piezometer is installed in low permeability sediments. With experience, you will gain a feel for the relative grain size and compactness of the sediments encountered while installing a piezometer.

6.16 Thermistor Installation

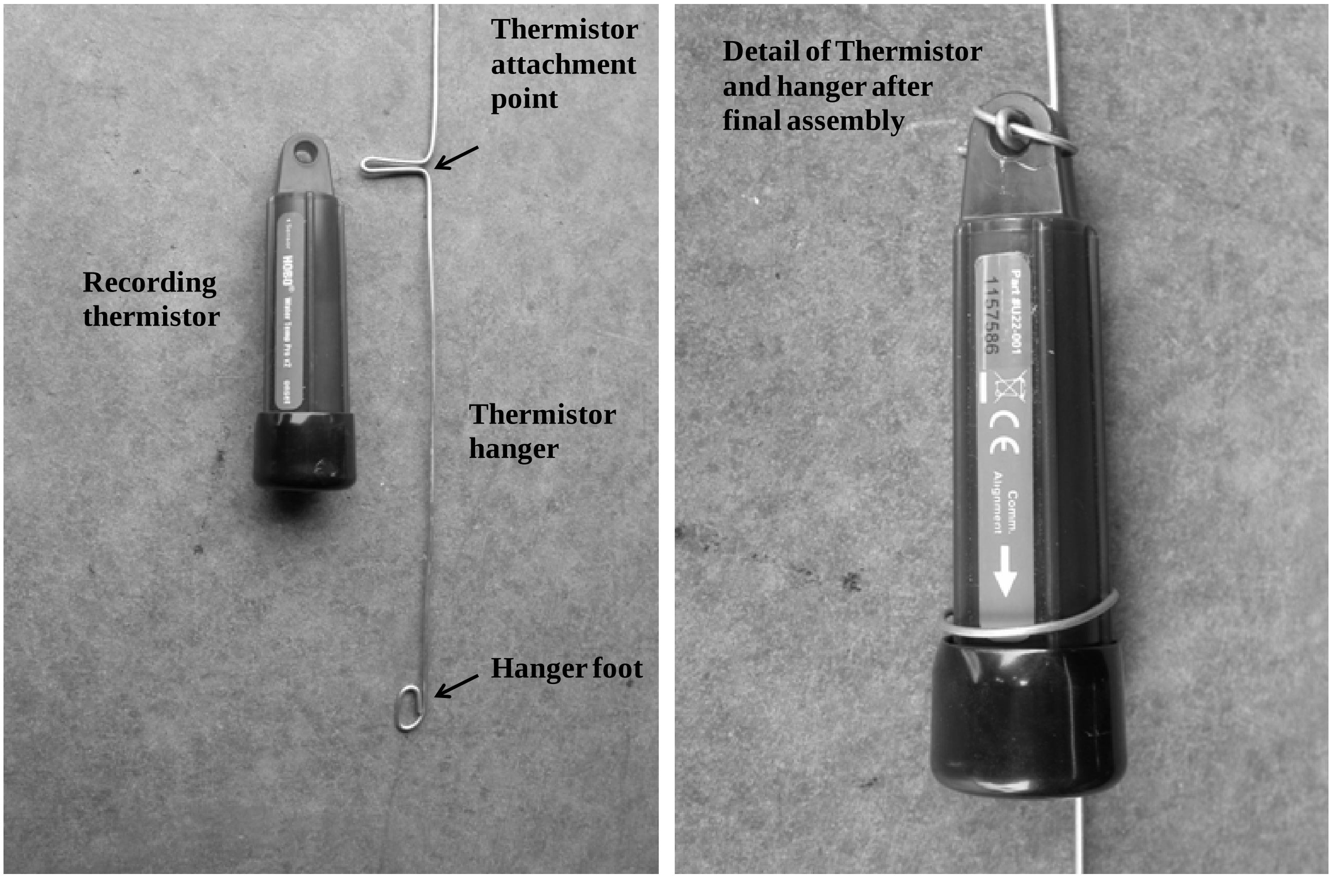
6.16.1 Rigid pipe piezometers are often instrumented with recording thermistors to help estimate the thermal load (or buffering potential) that discharging groundwater imparts to surface water. Instrumenting a standard 1.5 inch diameter steel or PVC piezometer requires four pre-calibrated and launched thermistors and one roll each of 12-14 gage and 20-22 gage aluminum or galvanized wire.

6.16.2 To prepare the thermistor hanger begin by cutting a piece of the heavy-gage wire from the roll that is approximately 2-3 feet longer than the total depth (length) of the piezometer being instrumented.

6.16.3 Form a small closed loop at one end of the wire with a pair of needle nose pliers. This loop serves as the base (or foot) that the thermistor hanger wire sits on when it is installed in the piezometer[2].

6.16.4 Form a small crimp about 8 inches above the hanger foot to anchor the lower-most thermistor (Figure 4).

[2] EAP typically installs thermistors using a heavy gage support wire that rests on the piezometer bottom. However, thermistors can also be weighted and suspended on small diameter cable from an anchor point on the piezometer cap or upper casing. Suspended thermistor deployments are generally used when a combination of thermistors and transducers are deployed in a single piezometer.



(Before) (After)

Figure 4 - Details of a typical thermistor and hanger array shown before and after final assembly

6.16.5 For piezometers installed along a *losing* reach form a second crimp about 0.75-1.0 foot below the sediment surface to anchor the uppermost thermistor.

6.16.6 Add a third crimp approximately mid-way between the upper and lower thermistor anchors to attach the middle thermistor. (Note: For piezometers extending less than 2 feet into the sediments the middle thermistor is often omitted).

6.16.7 For piezometers installed along a *gaining* reach the upper thermistor should be placed higher on the hanger (about 0.5 – 0.6 feet below the sediment surface) so that it records the muted diurnal temperature signal the surface water imparts on the upwelling groundwater (see Stonestrom and Constantz, 2003). Similarly, the middle thermistor should be placed somewhat above the midpoint location between the upper and lower thermistors to ensure that the middle thermistor records temperatures that are distinguishable from those of the lower thermistor.

6.16.8 To determine where best to place the middle thermistor along the hanger, check sediment thermal conditions by lowering a long line thermistor to the bottom of the piezometer. Wait for the temperature to stabilize and record the value and depth on the piezometer installation form. Then slowly raise the thermistor by approximately 0.5 foot increments while recording the corresponding (stable) temperature for each interval. Use this initial thermal profile to help place the middle thermistor approximately midway between the temperature extremes recorded at the piezometer top and bottom.

6.16.9 When the hanger is complete, attach a thermistor to the lowermost anchor point and secure it in place at the top and bottom with light gage wire or small zip-ties (Figure 4). Make the lower wire (or zip tie) snug enough to hold the thermistor securely against the hanger but not so tight that the thermistor cap can't be removed during downloads.

6.16.10 Install the middle and upper thermistors in similar fashion.

6.16.11 Write the thermistor IDs and their positions (upper, middle, lower) on the field form.

6.16.12 Slip the lower end of the thermistor string into the piezometer and press it down until the hanger foot rests firmly on the casing bottom (Figure 5).

6.16.13 Gently rotate the hanger to confirm that it's seated at the lowest point in the casing.

Figure 5 - Deploying a thermistor array into an in-water piezometer

6.16.14 Now bend the remaining wire over the casing top so that the resulting bend marks the position of the piezometer reference point (PRP) established prior to installation. (Note: When using heavy-gage wire it may be easier to mark the position of the casing top on the hanger wire with a piece of tape or an indelible ink pen – rather than bending the wire over the casing top).

6.16.15 Remove the hanger. With a steel engineers tape measure the distance from the top of the bend (or mark) to the sensor position near the upper end of each thermistor. Measure distances to the nearest 0.01foot and record them on the installation form. These values represent the initial thermistor depths relative to the PRP.

6.16.16 Measure the distance from the piezometer PRP to the sediment surface. Subtract this value from each of the thermistor depths just measured (section 6.16.15) to define the initial thermistor depths in feet below the sediment surface.

6.16.17 Reinstall the thermistor hanger, keeping the extra wire folded over so that it can be inserted into the piezometer and serve as a retrieval handle during subsequent measurements. (Note: Do not remove the extra wire – particularly if an extension may be added to the piezometer at some later point to enable it to be sampled. The extra wire will enable the thermistors to be retrieved without having to remove the extension).

6.16.18 Attach a 2 foot length of heavy gage wire to the remaining thermistor. Note the thermistor ID on the piezometer installation form.

6.16.19 Thread the wire through one of the holes on a standard PCV shade device and pull the wire tight until the thermistor is seated snug inside the PVC.

6.16.20 Securely attach the surface water thermistor to the outside of the piezometer casing by wrapping the remaining wire around the casing a few times and then several times around the wire itself.

6.16.21 Position the thermistor so that it lies about midway between the water surface and the bed sediments. (Note: If you expect the surface water stage (level) to drop significantly before the next field visit, position the thermistor lower in the water column to prevent it from being exposed to the air. However, do not rest the thermistor directly on the sediment surface).

6.16.22 Measure the distances from the thermistor to the water surface and from the thermistor to the bed sediments. Record the values on the installation form.

6.16.23 After thermistor installation is complete securely cap the upper end of the piezometer to prevent debris or surface water from entering the casing. (Note: Low yield piezometers or those that are instrumented with transducers, should be completed with an above-water extension and vented cap (or equivalent) so that the water level accurately reflects true static conditions when the cap is in place).

6.16.24 Piezometers that are routinely sampled for water quality can also be completed (extended) above the water surface during the sampling period to prevent surface water from entering the well when the cap is removed. The extension(s) can be removed during non-sampling periods to protect the piezometer from impact damage or vandalism.

6.17 Routine Monitoring of Piezometers

6.17.1 A principal use of in-water piezometers is to monitor the water level (head) relationships between a surface water body and the near-surface groundwater at discrete points (Figure 6). Piezometer networks installed along the length of a stream (or lake) can be used to quickly and easily track where gains from or loses to groundwater occur over time. Such measurements are useful for confirming the reach-based water exchanges estimated from stream seepage evaluations.

6.17.2 To normalize for differences in piezometer depth between sites, field-measured water levels are typically converted to vertical hydraulic gradients using the relation:

6.17.2.1 $i_v = dh/dl$ (Equation 1)

6.17.2.2 **where:** **i_v = the vertical hydraulic gradient (dimensionless)**

6.17.2.3 ***dh* = the vertical distance from the piezometer water level measuring point to the surface water stage *minus* the vertical distance from the water level measuring point to the piezometer water level (see Figure 6)** [3]

6.17.2.4 ***dl* = the vertical distance from the sediment surface to the midpoint of the piezometer's screened or perforated interval**

6.17.3 Negative values of $\mathbf{i_v}$ indicate the potential for downward movement of water from surface water to groundwater (loss), while positive values indicate upward movement of groundwater into the surface water body (gain).

6.17.4 Hydraulic gradient measurements can be made by periodic manual means such as a low displacement E-tape, chalked steel tape, or manometer board; or they can be measured and recorded more frequently using an automated pressure transducer. (Note: transducer calibration, installation, and use is covered under a separate SOP).

[3] By convention, if the stream stage is higher in elevation than the piezometer water level, the ***dh*** value is a *negative* number. If the piezometer water level is higher than the stream stage, the ***dh*** value is *positive*. Note that Equation 1 provides an estimate of vertical hydraulic gradient *averaged* over the length of the piezometer screen or perforations.

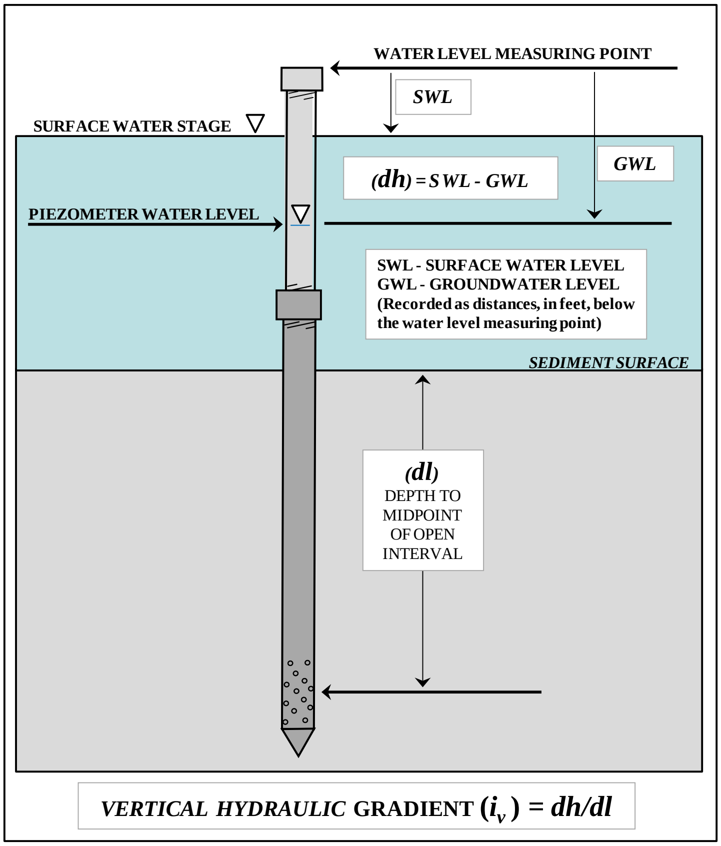


Figure 6 – Determination of Surface water and groundwater head relationships using an in-water piezometer

6.17.5 Measuring Hydraulic Heads and Sediment Temperatures in Pipe Piezometers

6.17.5.1 After arriving at the piezometer fill out the header fields on the field form including - the well tag ID, site location, crew members, weather conditions, date and time. (See example Water Level Measurement Form, Appendix A).

6.17.5.2 Use two pipe wrenches to remove the piezometer cap. (Note: Always use two wrenches when installing or removing caps or extensions to prevent the piezometer from rotating and potentially compromising the casing seal).

6.17.5.3 Attach an extension pipe (if necessary) to extend the casing rim above the water surface.

6.17.5.4 If the piezometer recovers slowly and contains thermistors or other instrumentation, attempt to measure the water level before removing the instruments.

6.17.5.5 If instrument removal is required, note the 'reference' position of the instrument hanger so it can be returned to the same position when your work is complete. Record the thermistor removal time on the field form so that temperatures or water levels that are logged while the instruments are out of the piezometer can be identified and removed from the data record (see Bilhimer and Stohr, 2007 for additional guidance).

6.17.5.6 Collect and record the following measurements as positive values, to the nearest 0.01 ft, using the piezometer casing top (with extension attached if appropriate) as the water level reference point[4].

6.17.5.6.1 The distance from the casing top to the surface water level (the *"S Length" on* Figure 7). Measure *along* the casing with an engineer's hand-tape. For inclined piezometers the surface water level (and subsequent piezometer measurements) should be measured from the *lowermost* point of the casing circumference (see Figure 7). In fast flowing water a clear or translucent stilling tube may be used to stabilize the surface water stage during measurement.

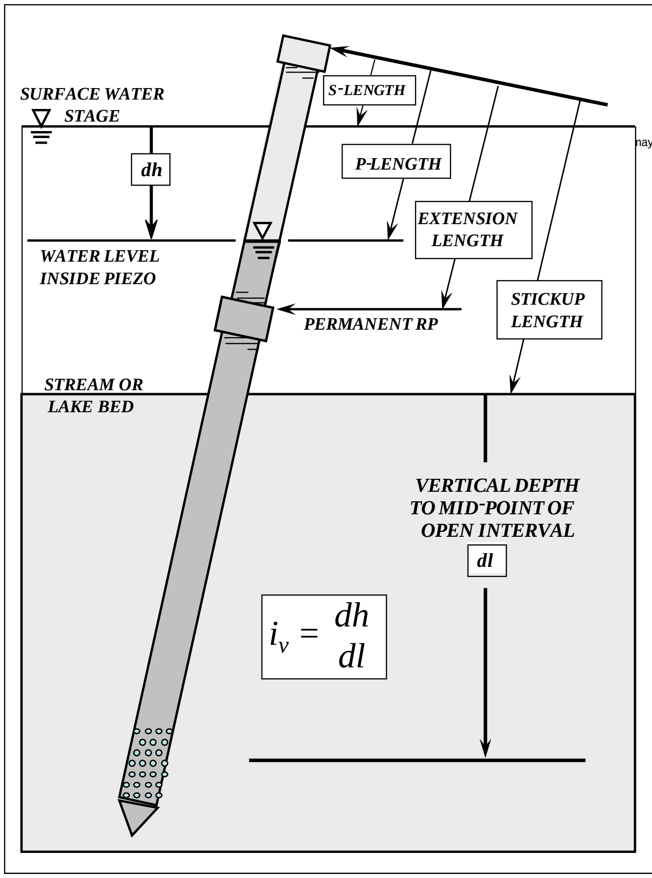
6.17.5.6.2 If the surface water level drops to the point that the piezometer is no longer contained within the active (wetted) area of the stream or lake, note this on the data form. A manometer board must be used to measure the piezometer in such cases (see the manometer measurement section).

[4] For vertical (non-inclined) casings the convention is to measure water levels from the north-side of the casing rim. Whatever measuring point (MP) scheme you choose, apply it consistently to all piezometers in the study and describe the location for each piezometer in your field notes. All subsequent stickup, water levels, and other measurements should be made from this same location. For inclined (off-vertical) piezometers, the water level MP should be located at the lowest point of the arc defined by the top rim of the piezometer casing (Figure 7).

Piezometer Water Level Field Sheet (Hand)

Date: ___________ **Time:** ___________ **Crew:** _________________

Tag ID: _______________ **Piezo Name:** ______________________



Water Level MP: TOC other: ______________________________

E-tape #:	Hold	Cut
S-Length	ft	ft
P-Length	ft	ft
Extension Length	ft	ft
Stickup Length	ft	ft
Total Interior Length	ft	ft

Measure inclined lengths, not corrected vertical heights

Figure 7 – Example Field Form for Recording Piezometer Water Level Data

6.17.5.6.3 Measure the depth to groundwater *inside* the piezometer (the *"P length" on Figure 7*) from the same point, using a properly calibrated e-tape or chalked steel tape (Marti, 2009) (Figure 8). Record the tape 'cut' value (if any) and the ID of the e-tape on the field form. Measure the piezometer water level at least twice (preferably separated by a few minutes) to confirm the level represents static conditions. If the water levels inside and outside the piezometer casing are very close, hand measurement may not be sufficiently accurate to estimate the hydraulic gradient. In such cases, use a manometer board (see Section 6.17.7.0). (Note:

When large negative gradients are encountered always check the piezometer construction log and associated reference measurements to confirm that the groundwater level hasn't dropped below the piezometers perforated interval. If it has, the water level may not represent true static conditions - particularly if the perforations do not extend to the bottom of the piezometer).

6.17.5.6.4 Use an engineer's hand tape to measure the *effective* length of any extension(s) that were added to the piezometer. This is the distance from the top of the uppermost extension (if more than one is used) to the piezometer PRP. Record the value on the field form (Figure 7). (Note: The PRP is *usually* the top of the pipe coupler attached to the lowermost piezometer segment. Always consult the piezometer well completion report (well log) when the position of the PRP is in doubt).

6.17.5.6.5 Use an engineer's hand tape to measure the casing "*stick-up length*". This is the distance from the piezometer measuring point at the top of the casing (TOC) to the sediment surface as measured *along the casing*. Record the result on the field form.

Figure 8 - Using an E-tape to measure the water level in an inclined steel piezometer

6.17.5.6.6 Use an engineer's hand tape to measure the total interior length of the piezometer (including any attached extensions or couplers) and record the result on the field form. (Note: This information is used to determine if the piezometer is filling with sediment over time and therefore in need of re-development).

6.17.5.6.7 After completing the above measurements, proceed with thermistor downloads (see Bilhimer and Stohr, 2007 for details) or water quality sampling as appropriate[5]. When done, return any continuous data instrumentation to its correct position in the piezometer and note the reinstall time on the field form.

[5] The order of these steps can be rearranged to accommodate the needs of individual piezometers. For example thermistors can be downloaded while waiting for the piezometer water level to stabilize after removing the cap or

6.17.5.6.8 Visually scan the field form to confirm that all measurements were completed and that the corresponding values were recorded in their appropriate location.

6.17.5.6.9 Remove any extensions that were added to the piezometer on arrival and re-cap the casing. (Note: Always use two pipe wrenches to prevent the casing from spinning and potentially compromising the annular seal).

6.17.6 Measuring Hydraulic Heads in Flexible Tubing Piezometers

6.17.6.1 After locating the piezometer bring the tubing coil to the surface. Record the date and time, well tag ID, piezometer name, and other site data on the field form.

6.17.6.2 Remove the upper end cap or plug from the tubing. While holding the open tubing end above the water surface, wait for the groundwater level to equilibrate with the atmosphere. In low permeability sediments it can take several minutes or more for the groundwater level to reach equilibrium. (Note: Check to make sure there aren't water pockets in the tubing above the water surface since they can block free-air exchange with the atmosphere. Flick or tap the tubing to dislodge any droplets).

6.17.6.3 Hold the tubing as vertical as possible and with an engineer's hand-tape measure the casing stickup to the nearest 0.01 foot. This is the distance from the sediment surface to the permanent measuring point (MP) established on the tubing during installation. Record the measured value on your field form.

6.17.6.4 When the piezometer water level is stable fill a stilling tube (the same diameter as the piezometer) with water, and hold it against the casing so that the stilling tube mid-point lies at approximately the same level as the surface water stage. Hold both tubes still and as vertical as possible once in position. Allow the water in the stilling tube to drain until it equilibrates with the surface water.

6.17.6.5 Use a metric scale to measure the difference (distance) between the water level inside the piezometer (groundwater head) and the water level in the stilling tube (surface water head) (Figure 9). Repeat the measurement a few times to confirm the piezometer is fully equilibrated. Record the final stable reading on the field form to the nearest centimeter and millimeter.

6.17.6.6 If the hydraulic head in the piezometer is below the surface water stage, a manometer board will be needed to measure the head difference (see Section 6.17.7.0).

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attaching an extension. The important thing is to confirm that the piezometer water levels have stabilized prior to final measurement and to remember to complete all the indicated steps - regardless of the order they are performed in.

Figure 9 – Using a metric scale and stilling tube to measure relative heads in a tubing piezometer

6.17.7.0 Using a Manometer Board to Measure Hydraulic Heads in Piezometers

6.17.7.1 In some situations a manometer board may be the only practical way to measure water level relationships (hydraulic head differences) between surface water and groundwater (Winter, et al, 1988). Manometer boards are particularly useful for measuring small head differences or when ripples or water surges make it difficult to accurately measure surface-water stage with a steel tape. A manometer board may also be required to measure tubing piezometers installed along losing reaches or where a piezometer no longer lies in direct contact with surface water.

6.17.7.2 (Note: Manometer boards should be tested and calibrated at the beginning of each field season (and periodically during use) to ensure they don't have air leaks and are otherwise working properly. The simplest way to perform this test is to position two "identical" 5-gallon buckets of clean water side-by-side on a level surface. One bucket should have more water than the other so that their water surfaces settle at different heights when stable. Set up the manometer board so that the lower "surface water" and "piezometer" tubes rest well below the water surface in their respective buckets. Charge the manometer board per the instructions below, turn off the pump, and disconnect the pump tubing from the upper manometer valve. Measure and record the distance from the top of each bucket to its corresponding water surface using a metric ruler. Proceed with the replicate manometer board measurements (5 sets) using the techniques described below, and then compare the average of these values to the initial water level difference measured for the buckets. If all is working correctly, the average head difference from the manometer should match the initial water level difference measured using the metric scale).

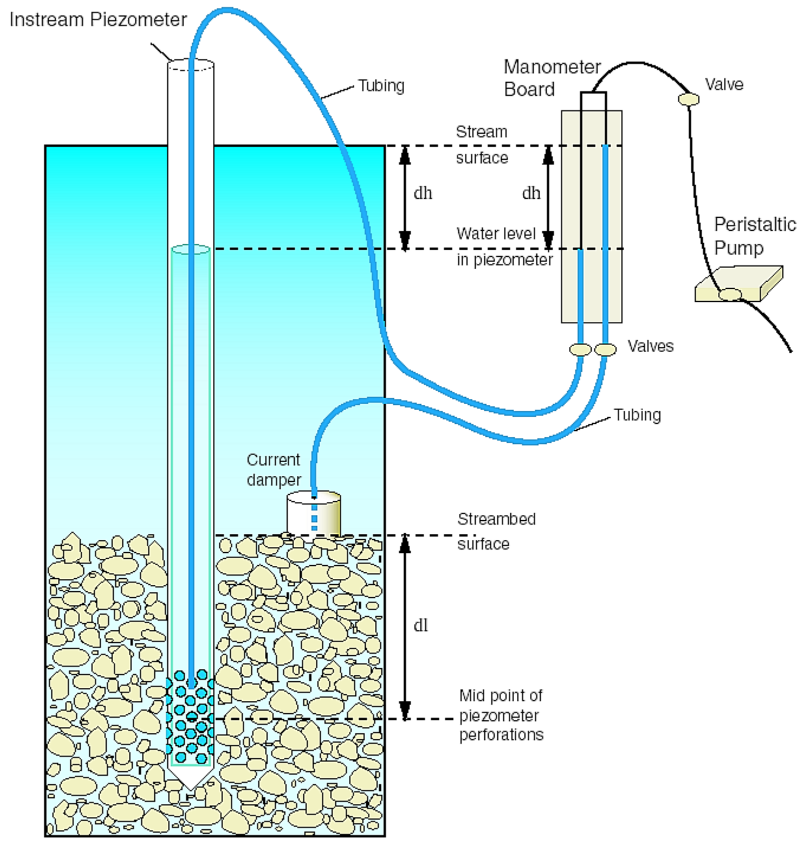


Figure 10 - Typical Manometer Board Setup (figure courtesy of F.W. Simonds, USGS, Tacoma, WA)

6.17.7.3 Manometer board use typically requires a battery, peristaltic pump, and a floating platform to hold the assembled equipment. Set up the floating platform, peristaltic pump, and battery adjacent to the piezometer casing and secure in place.

6.17.7.4 Attach one end of the silastic tubing from the peristaltic pump to the top barbed tubing-fitting on the manometer board (Figure 10).

6.17.7.5 For pipe piezometers place one of the lower manometer tubes (typically the right-hand tube) into the piezometer, so that it extends well below the piezometer water level. (Note: if the piezometer contains thermistors they will likely need to be removed before inserting the manometer tubing. If so, record the thermistor removal time on the field form).

6.17.7.6 For tubing piezometers secure the manometer tubing directly to the piezometer tube.

6.17.7.7 Insert the second manometer tube into a current damper and place the damper into the surface water so that the manometer tube remains under water but does not rest directly on the sediment surface (where it might clog with fine sediment).

6.17.7.8 Make sure all three manometer valves (one upper and two lower) are in their closed position.

6.17.7.9 Rest (or clamp) the manometer board on the piezometer casing or other stable surface. Open the top valve that leads to the pump and the lower valve that leads to the surface water tubing.

6.17.7.10 Start the pump and completely fill the surface-water side of the manometer with water from the stream or lake. The surface tubing should be *completely* full of water with no visible bubbles or sediment.

6.17.7.11 When the surface tubing is fully charged, slowly open the third valve and fill the remaining tube with water from the piezometer. As the piezometer tube fills, tap the board firmly with the flat of your hand to ensure both sides of the manometer are filled with water and to remove any air bubbles or sediment that may be trapped in the tube.

6.17.7.12 When both sides of the manometer are full with water, close the top valve that leads to the pump and shut the pump off. Disconnect the pump tubing from the top valve. (Note: leave the lower two valves open).

6.17.7.13 *Briefly* open the top valve and let just enough air into the manometer so that the water level drops to the point that you can see the location of the air/water interface for both tubes on the manometer scale.

6.17.7.14 Hold the manometer stable and as vertical as possible (use the levels on the board to confirm this) and allow the water levels to stabilize. Read the level at the bottom-most point of the meniscus in each tube and record the values to the nearest centimeter and millimeter in the appropriate columns (surface stage or groundwater level) of the field form (Appendix A).

6.17.7.15 After completing the first reading, *briefly* re-open the top valve and let additional air into the manometer. Again, allow the water levels in each tube to stabilize while holding the manometer steady/vertical. Record the resultant readings on the field form. Repeat this procedure until 5 or more readings have been obtained[6]. (Note: It may be necessary to give the manometer a good rap between measurements to release air bubbles or water droplets stuck to the manometer tubing).

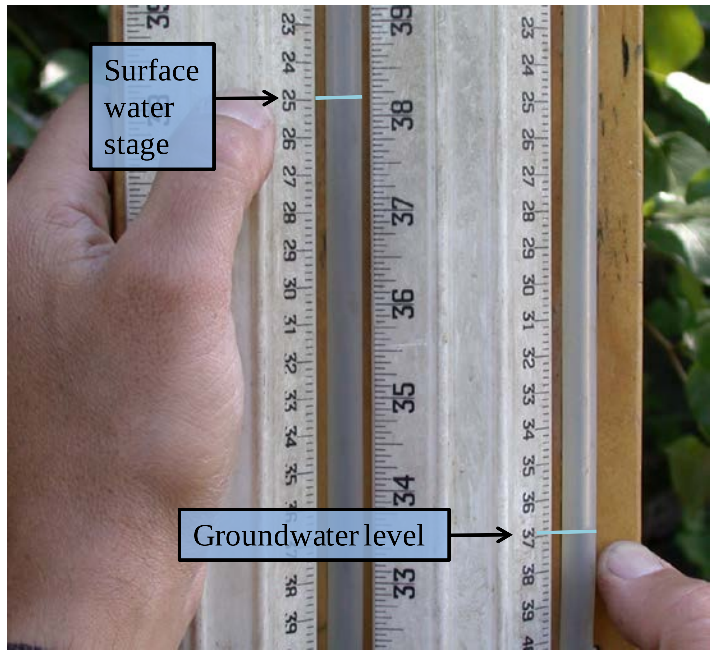
6.17.7.16 If all is working well, the resultant readings should show approximately the same head difference and can be combined to define the average difference (dh) for that

[6] When measuring piezometers with large gradients, it may not be possible to complete all 5 readings without first recharging the manometer with water.

site and measurement event. (Note: If the readings are inconsistent or gradually decrease in magnitude from reading to reading, check the manometer for vacuum leaks).

6.17.7.17 If there are no leaks, then it's likely the piezometer is completed in low-permeability sediments and is still recovering after being pumped to charge the manometer. Manometer boards are not well suited for such conditions since the act of charging the manometer may cause the piezometer to run dry or drawdown to non-static head conditions that do not recover to equilibrium conditions within a reasonable time period. A manometer board should not be used to measure heads in these situations.

(In use)



(Detail of water levels)

Figure 11 - Manometer board in use and detail of manometer water levels

6.17.7.18 As a final check and memory jog for later data analysis, determine the direction of water movement indicated by the manometer (into or out of the stream or lake) and record this observation on the field form.

6.17.7.19 When the measurements are complete, proceed with thermistor downloads (see Bilhimer and Stohr, 2007 for details) or water quality sampling as appropriate[7]. When done return any continuous data instrumentation to its correct position in the piezometer, note the reinstall time on the field form, and re-cap the casing.

[7] The order of these steps can be rearranged to accommodate the needs of individual piezometers. For example thermistors can be download while waiting for the piezometer water level to stabilize after removing the cap or attaching an extension. The important thing is to complete all the indicated steps.

6.18 <u>Decommissioning Piezometers</u>

6.19 The project engineer or hydrogeologist must file a "Notice of Intent to Decommission a Well" form with the regional Water Resources Program office, at least 72 hours before removing (decommissioning) a piezometer (See Appendix A for additional details). The intended decommissioning procedure(s) should follow those outlined in the project well construction variance.

6.20 Depending on local site conditions steel piezometers are most commonly removed by:

6.20.1 Twisting and pulling the casing with opposed pipe wrenches,

6.20.2 Attaching chains or a star-clamp assembly to the casing and extracting it with high-lift jacks, or

6.20.3 Back hammering against a star clamp assembly with sledge hammers.

6.21 <u>High-lift jacks and sledge hammers exert considerable force on piezometer pipes, couplers, and related equipment. Avoid injuring yourself or others by always working safely (wear proper eye, head, and hand protection) and communicating your intentions with fellow workers.</u>

6.22 Always use two jacks to decommission a steel piezometer - each with an attached 3-4 foot length of heavy gage chain. This arrangement spreads the load between jacks and minimizes the potential for bent casing, or jack slippage during extraction.

6.23 Start by placing the jacks on opposite sides of the casing. In soft sediment support the foot of each jack with a piece of heavy plywood or a short length of 2 by 8 lumber. Wrap each of the jack chains around the casing several times and then pull them tight to hold the jacks and casing in close contact (Figure 12). If possible wrap the chain around the lowermost casing rather than a casing extension(s) to avoid placing too much strain on pipe threads or couplers.

6.23.1 Secure the loose end of each chain to its corresponding jack with a chain hook.

6.23.2 Tightly wrap a third length of chain around the casing and the two jack bases and secure with a chain hook.

6.23.3 Set the jack direction lever to the lift position. With a person operating each jack slowly raise the jack heads until the chains snug tightly around the casing. Continue working the jacks in unison, applying just enough pressure to extract the casing. (Note: For stuck or difficult to remove casings, try tapping the piezometer cap with a 2-pound hand sledge while applying upward force with the jacks. This often helps to get the casing moving).

Figure 12 - Decommissioning a steel piezometer with high-lift jacks

6.23.4 PVC cased piezometers can generally be removed by hand or by carefully twisting and pulling with pipe wrenches.

6.23.5 Likewise, tubing piezometers can often be pulled by hand. When they can't, cut the tubing off 6-12 inches below the sediment surface, plug the exposed end, and refill the excavation with sediment.

6.23.6 After the casing has been removed, fill any hole that remains with fine sediment. If the project well construction/decommissioning variance specifies additional abandonment steps, proceed with and document the procedure(s) on the well decommissioning form.

6.23.7 Remove the well tag from the piezometer casing and submit it to Ecology's Water Resources program along with the completed well decommissioning form.

7.0 Record Management

7.1 The In-water piezometers that EAP installs or monitors must be documented to enable information about their location, construction, and subsequent monitoring to be archived in Ecology's Environmental Information Management (EIM) system and well log imaging databases. Consult the EIM help documents and EAP SOP-052 subsection 7.0 (Marti, 2009) for a list of the well specific metadata required by EIM.

7.2 Station information and monitoring notes should be documented, during each site visit, using EAP's standard piezometer field forms (or equivalent) (Appendix A). All field entries should be neat and concise. The field lead is responsible for reviewing the form(s) for completeness before leaving a field site.

7.3 Data Processing

7.3.1 EAP staff have developed a number of data analysis spreadsheets, field forms, and other tools to standardize data collection and processing for projects involving in-water piezometers. See the EAP GW TCT website for the most up-to-date version of these tools.

7.3.2 See Bilhimer and Stohr, 2007 for additional guidance about managing and processing the continuous temperature data collected at in-water piezometer sites.

7.4 Field Form Archives

7.4.1 All original field forms (including piezometer installation forms, well reports, routine monitoring, and decommissioning forms) should be compiled in a project notebook and retained in the permanent project archive.

8.0 Quality Control and Quality Assurance

8.1 The following general quality assurance/quality control (QA/QC) procedures apply:

8.1.1 All personnel installing and monitoring in-water piezometers must adhere to EAP's standard operating procedures (SOP) for data collection involving piezometers (this document) as well as the SOP's for monitoring surface water temperatures (Bilhimer and Stohr, 2007) and the procedures for measuring water levels and calibrating water level meters (Marti, 2009).

8.1.2 All instrumentation must be operated in accordance with the operating instructions supplied by the manufacturer, unless otherwise specified in the project's Quality Assurance Project Plan (QAPP).

8.1.3 Repeat measurements of the well depth or depth-to-water at each location must be made to ensure reproducibility and accuracy. Repeat measurements should be within the method's specified accuracy standards. If repeated check measurements are not reproducible, then a reason must be established and documented.

8.1.4 All data and other measurements must be documented and permanently archived on project field data forms.

9.0 Safety

9.1 Installing and monitoring in-water piezometers can pose significant risks to field personnel. Take these hazards seriously. When appropriate, use work gloves, safety glasses, hard hats, hearing protection, and steel-toed boots. Personal flotation devices are required for persons working in or near surface water.

9.2 Do not enter water that is too deep or swift for safe entry and exit.

9.3 Use common sense, work in teams, and read and follow the procedures outlined in the EAP Safety Manual for in-water work.

9.4 Always consider the safety and traffic situations when accessing a stream or lake from highway bridges. Consult the EAP Safety Manual for further guidance regarding bridge safety.

9.5 The following forms must be completed to document field personnel, sampling locations, overnight lodging, planned itinerary, contact person(s), and emergency contacts:

9.5.1 Float plan Form (if using a boat to access sites)

9.5.2 Field Work Plan and Contact Person Form

10.0 References

10.1 Bilhimer, D., and Stohr, A., 2007, Standard Operating Procedures for continuous temperature monitoring of fresh water rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature. Environmental Assessment Program, EAP044, Version 2.2. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_044Cont_Temp_Monit_TMDL.pdf

10.2 Cardenas, M.B., and Zlotnik, V.A., 2003, A simple constant-head injection test for streambed hydraulic conductivity estimation, Ground Water, Vol. 41, No. 6, p. 867-871.

10.3 Janisch, J., 2006, Standard operating procedure for determining coordinates via hand-held GPS receivers. Washington State Department of Ecology, Environmental Assessment Program, EAP013, Version 1.0.

10.4 Konrad, C. P., 2006, Location and timing of river-aquifer exchanges in six tributaries to the Columbia River in the Pacific Northwest of the United States, Journal of Hydrology 329, p. 444– 470.

10.5 Marti, P.B., 2009, Standard operating procedure for manual well-depth and depth-to-water measurements. Washington State Department of Ecology, Environmental Assessment Program, EAP052, Version 1.0. http://www.ecy.wa.gov/programs/eap/qa/docs/ECY_EAP_SOP_052ManualWellDepth&DepthtoWaterMeasures_v_1_0.pdf

10.6 Pitz, C.F., 2006, An evaluation of a piezometer-based constant head injection test (CHIT) for use in groundwater/surface water interaction studies, Washington State Department of Ecology, Publication No. 06-03-042, 31 p. http://www.ecy.wa.gov/biblio/0603042.html

10.7 Rosenberry, D.O., and LaBaugh, J.W., 2008, Field techniques for estimating water fluxes between surface water and ground water: U.S. Geological Survey Techniques and Methods 4–D2, 128 p. http://pubs.usgs.gov/tm/04d02/pdf/TM4-D2ALL.pdf

10.8 Stonestrom, D.A., and Constantz, J.E., eds., 2003, Heat as a tool for studying the movement of ground water near streams: U.S. Geological Survey Circular 1260, 96 p. http://pubs.usgs.gov/circ/2003/circ1260/pdf/Circ1260.pdf

10.9 Washington State Department of Ecology, Environmental Assessment Program, 2009, Safety Manual. 192 p. http://aww.ecology/programs/eap/Safety/Safety1.html

10.10 Winter, T.C., Harvey, J.W., Franke, O.L., and W.M. Alley, 1998. Ground water and surface water – a single resource, U.S. Geological Survey Circular 1139, 79 pp. http://pubs.usgs.gov/circ/circ1139/

10.11 Winter, T.C, Labaugh, J.W., and Rosenberry, D.O., 1988, The design and use of a hydraulic potentiomanometer for direct measurement of differences in hydraulic head between groundwater and surface water, Limnol. Oceanogr., Vol. 33, No. 5, p. 1209-1214. http://new.aslo.org/lo/toc/vol_33/issue_5/1209.pdf

Appendix A: Example Forms

EAP has developed several spreadsheet templates to speed and where possible automate the repetative tasks required to install and monitor in-water piezometers. Examples of commonly used forms are included here. See EAP's GW TCT (Technical Coordination Team) Sharepoint site for up-to-date versions of field forms, data analysis spreadsheets, and other helpful tools.

Example Form – Notice of Intent to Construct a Resource Protection Well

WASHINGTON STATE DEPARTMENT OF ECOLOGY

NOTICE OF INTENT TO CONSTRUCT A MONITORING/RESOURCE PROTECTION WELL

Notification Number [redacted]

This form and required fees MUST BE RECEIVED by the Department of Ecology 72 HOURS BEFORE you construct a well.

Submit one form and required fee (check or money order ONLY) for each job site. Instructions for filling out this form are printed on the back. **Mail this form to the Department of Ecology, P.O. Box 5128, Lacey, WA 98509-5128.**

NOTE: PLEASE PRINT ALL ANSWERS. PROCESSING YOUR NOTICE OF INTENT MAY BE DELAYED IF ALL FIELDS OUTLINED IN THE BOXES ARE NOT FILLED IN COMPLETELY.

1. Property Owner ________________ Phone No. ________________

Address (include city, state and zip) ________________

2. Consulting Firm (if different from #1) ________________ Phone No. ________________

Address (include city, state and zip) ________________

01-Adams, 02-Asotin, 03-Benton, 04-Chelan, 05-Clallam, 06-Clark, 07-Columbia, 08-Cowlitz, 09-Douglas, 10-Ferry, 11-Franklin, 12-Garfield, 13-Grant, 14-Grays Harbor, 15-Island, 16-Jefferson, 17-King, 18-Kitsap, 19-Kittitas, 20-Klickitat, 21-Lewis, 22-Lincoln, 23-Mason, 24-Okanogan, 25-Pacific, 26-Pend Oreille, 27-Pierce, 28-San Juan, 29-Skagit, 30-Skamania, 31-Snohomish, 32-Spokane, 33-Stevens, 34-Thurston, 35-Wahkiakum, 36-Walla Walla, 37-Whatcom, 38-Whitman, 39-Yakima

3. Print CODE NUMBER and COUNTY NAME (e.g. 01-Adams) of well location from list above **(DO NOT ABBREVIATE)** ________________

4. Well Location: ______ 1/4 of the ______ 1/4 Section ______ Township ______ Range ______ EWM or WWM *(circle one)*

5. Approx construction start date ________________

Latitude and Longitude (if available) NOTE: 1/4, 1/4, section, township and range are REQUIRED.

Lat Degrees ________ Lat Time ________

Long Degrees ________ Long Time ________

Horizontal collection method ________________

6. Well Site Street Address ________________

7. Tax parcel number ________________

8. Contractor L & I Registration No. ________________

9. Well Drilling Company Name ________________ Phone No. ________________

10. Well Driller Name ________________ License No. ________________

11. SEND THE ENTIRE FORM. The bottom portion of this notice will be validated in our office and sent back to the name and address contained on the address label. This is the proof of notification. Please fill out the portion below CAREFULLY.
NOTE: Please copy the Notification Number (located in the upper and lower right corner) and keep in a safe place. Please reference this number when communicating with the Department of Ecology.

- -

Amt of payment: $40 per well

This notification number must be provided to your well driller: [redacted]

x ________ ***Number of wells to be constructed on this job site***

$ ________ ***Total Due and Amt Enclosed***

RETURN NAME AND MAILING ADDRESS

Name ________________

Address ________________

City ________________ State ______ Zip ______

Client Name ________________

Agency Validation

CJ No. ________________

Date ________________

REV CODE 027-WEL1**-0287-000101

ECY 040-22 (Rev. 5/01)

Example Form – Notice of Intent to Decommission a Well

WASHINGTON STATE DEPARTMENT OF ECOLOGY

NOTICE OF INTENT TO DECOMMISSION A WELL

Notification Number

A 136404

This form *MUST BE RECEIVED by the Department of Ecology 72 HOURS BEFORE you decommission a well.*

Submit one form and required fee (check or money order ONLY) for each job site. Mail this form to the Department of Ecology, Water Resources Program, Well Drilling Unit, P.O. Box 47611, Olympia, WA 98504-7611. Instructions for filling out this form are printed on the back.

NOTE: PLEASE PRINT ALL ANSWERS. PROCESSING YOUR NOTICE OF INTENT MAY BE DELAYED IF ALL FIELDS OUTLINED IN THE *BOXES* ARE NOT FILLED IN COMPLETELY.

1. Property Owner ______ Phone No.______
   Mailing Address ______ City______ State___ Zip______

2. Agent (if different from #1): ______ Phone No. ______
   Mailing Address ______ City______ State___ Zip______

3. Well Location: ____ 1/4-1/4 of the _____ 1/4 Section _____ Township _____ Range _____ *Circle one* EWM or WWM
4. Print COUNTY NAME of well location (DO NOT ABBREVIATE) ______
5. Type of well to decommission *(please "x" appropriate circle below)*

O Water Well ($50.00)		Rev. Code: 027-WEL8-02-87-000108
O Resource Protection ($20.00 ea)	How many? ______	Rev. Code: 027-WEL9-02-87-000109
O Ground Source Heat pump ($20.00 ea)	How many? ______	Rev. Code: 027-WL10-02-87-000110
O Grounding Well ($20.00 ea)	How many? ______	Rev. Code: 027-WL10-02-87-000110
O Geotech Soil Boring (No Fee)	How many? ______	
O Soil Sampling (No Fee)	How Many? ______	
O Environmental Investigation Well (No Fee)	How Many? ______	
O Dewatering Well (No Fee)	How Many? ______	

Latitude and longitude (if available) NOTE: 1/4, 1/4, section, township and range are REQUIRED.
Lat Degrees ______ Lat Time ______
Long Degrees ______ Long Time ______ Horizontal Collection Method ______

6. Well Site Street Address ______
7. Original construction notice of intent number if applicable, and Unique Well ID Tag # (if applicable)______
8. Tax parcel number ______ 9. Approx. decommissioning start date ______

10. Contractor L & I Registration No.______
11. Well Drilling Company Name ______ Phone No. ______
12. Well Driller Name ______ License No. ______

SEND THE ENTIRE FORM. The bottom portion of this notice will be validated in our office and sent back to the name and address contained on the address label. This is the proof of notification. Please fill out the portion below CAREFULLY.

NOTE: Please copy the Notification Number (located in the upper and lower right corner) and keep in a safe place. Please reference this number when communicating with the Department of Ecology.

Total Enclosed

______**Water Well $50.00**

______**Resource Protection Well =$20.00 per Well**

This notification number must be provided to your well driller:

A 136404

RETURN NAME AND MAILING ADDRESS

Name ______

Mailing Address ______

City ______ State ______ Zip ______

Client Name______

Agency Validation

Date:______

ECY 040-24 (Rev. 3/08)

Example Form –Resource Protection Well Completion Report

RESOURCE PROTECTION WELL REPORT

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

CURRENT
Notice of Intent No.__________________

Construction/Decommission *("x" in circle)*

O Construction
O Decommission *ORIGINAL INSTALLATION Notice of Intent Number*________________

Type of Well *("x" in circle)*

O Resource Protection
O Geotech Soil Boring

Property Owner ____________________

Consulting Firm ____________________

Site Address ____________________

Unique Ecology Well ID
Tag No: ____________________

City __________ County: __________

Location ___1/4 ___1/4 Sec___ Twn___ R___ EWM or WWM *circle one*

WELL CONSTRUCTION CERTIFICATION: I constructed and/or accept responsibility for construction of this well, and its compliance with all Washington well construction standards. Materials used and the information reported above are true to my best knowledge and belief.

Lat/Long (s, t, r still REQUIRED) Lat Deg_____ Lat Min/Sec _____
Long Deg _____ Long Min/Sec _____

☐ Driller ☐ Engineer ☐ Trainee Name (Print)____________________

Driller/Engineer/Trainee Signature ____________________

Driller or Trainee License No.____________________

Tax Parcel No. ____________________

Cased or Uncased Diameter _______ Static Level_______

If trainee, licensed driller's Signature and License no. ____________________

Work/Decommission Start Date ____________________

Work/Decommission Completed Date ____________________

Construction/Design	Well Data	Formation Description

Scale 1"=______________ Page________ of ________

ECY 050-12 (Rev 2/01)

Example Form – Piezometer Site Reconnaissance

Piezometer Reconnaissance Field Sheet

Date: ________________ **Time:** ____________________

Field Crew: ____________________

Stream/River Name: ______________________________

Location/Access Description: ______________________

____

____

____

____

Preliminary GPS Coordinates

Recording Datum: **NAD83HARN** ☐ **NAD83** ☐ **NAD27** ☐

DDLAT: ________________ **DDLONG:** ________________

Adjacent Property Ownership Info:

Name: ______________________________________

Address: ____________________________________

Phone: ______________________________

Permission Granted? ☐

Property Access Notes: ____________________________

____

____

Name: ______________________________________

Address: ____________________________________

Phone: ______________________________

Permission Granted? ☐

Property Access Notes: ____________________________

____

____

Recon Photo #: __________________________

Add sketch map of recon location on back
Piezometer Reconnaissance Field Sheet

Example Form - Piezometer Installation, No Thermistors

GPS Location - NAD 27 / NAD 83 **DD Lat:** ____________________

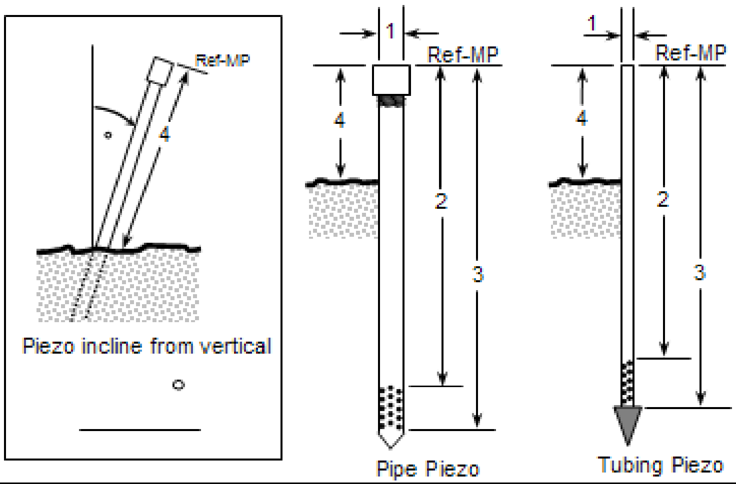
DD Long: ____________________

Site Description/Bearing Info: ____________________

____

____

Substrate: ____________________



1 – Casing or Tubing Diameter *	ft
2 – Length from Ref-MP to top of open interval *	ft
3 – Length from Ref-MP to bottom of open interval *	ft
4 – Stickup length – from Ref-MP to streambed (after installation; along pipe)	ft

**Measure these lengths BEFORE piezometer installation*

Reference Measuring Point (Ref-MP) Notes

____

Piezometer Open Interval Notes

Piezometer/Open Interval Type:

- ☐ Metal pipe/drilled or perforated
- ☐ Well point/manufactured screen
- ☐ Poly tubing/filter fabric

Open Interval Description

____

____

____

____

Piezometer Development Notes

____

____

____

____

Site Photo Notes

____

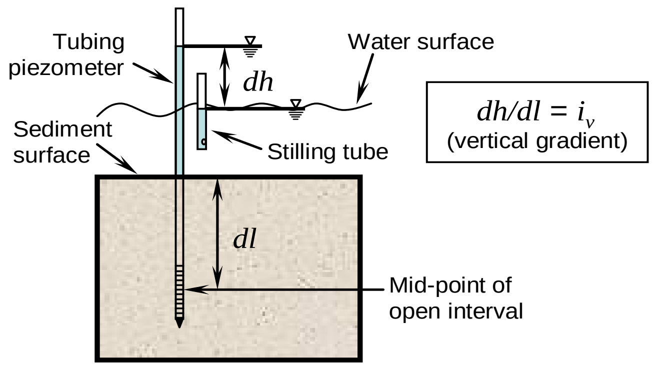
____

Example Form – Manometer Measurement

Tubing Piezometer Measurement

Stickup Length (measuring point to streambed) ___________

GW/SW Head Difference __________ **(*dh*)**



Manometer board measurements

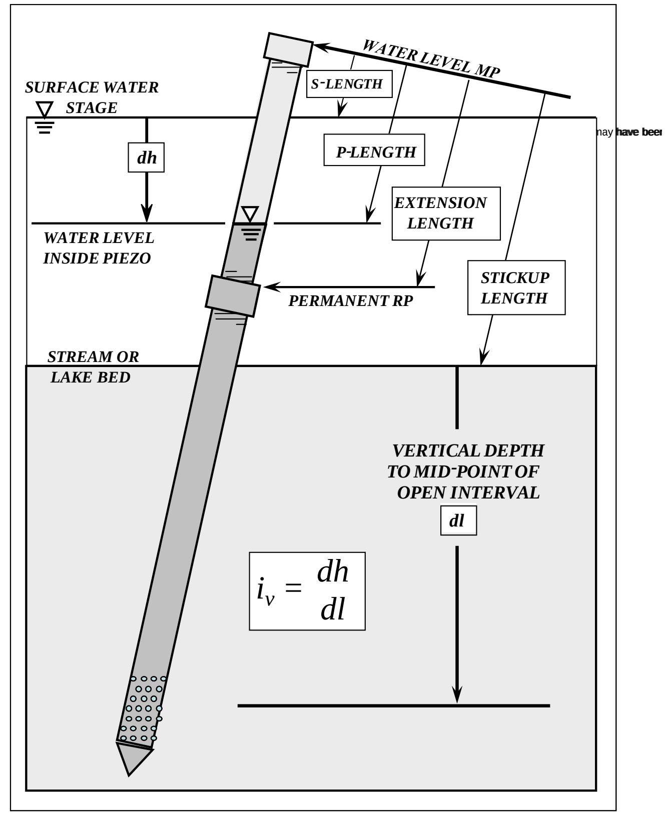
Surface Water (cm)	Piezometer (cm)	Head Difference (SW – Piezo)

Example Form – Manual Water Level Measurement

Piezometer Water Level Field Sheet (Hand)

Date: __________ **Time:** __________ **Crew:** ______________

Tag ID: ______________ **Piezo Name:** ____________________

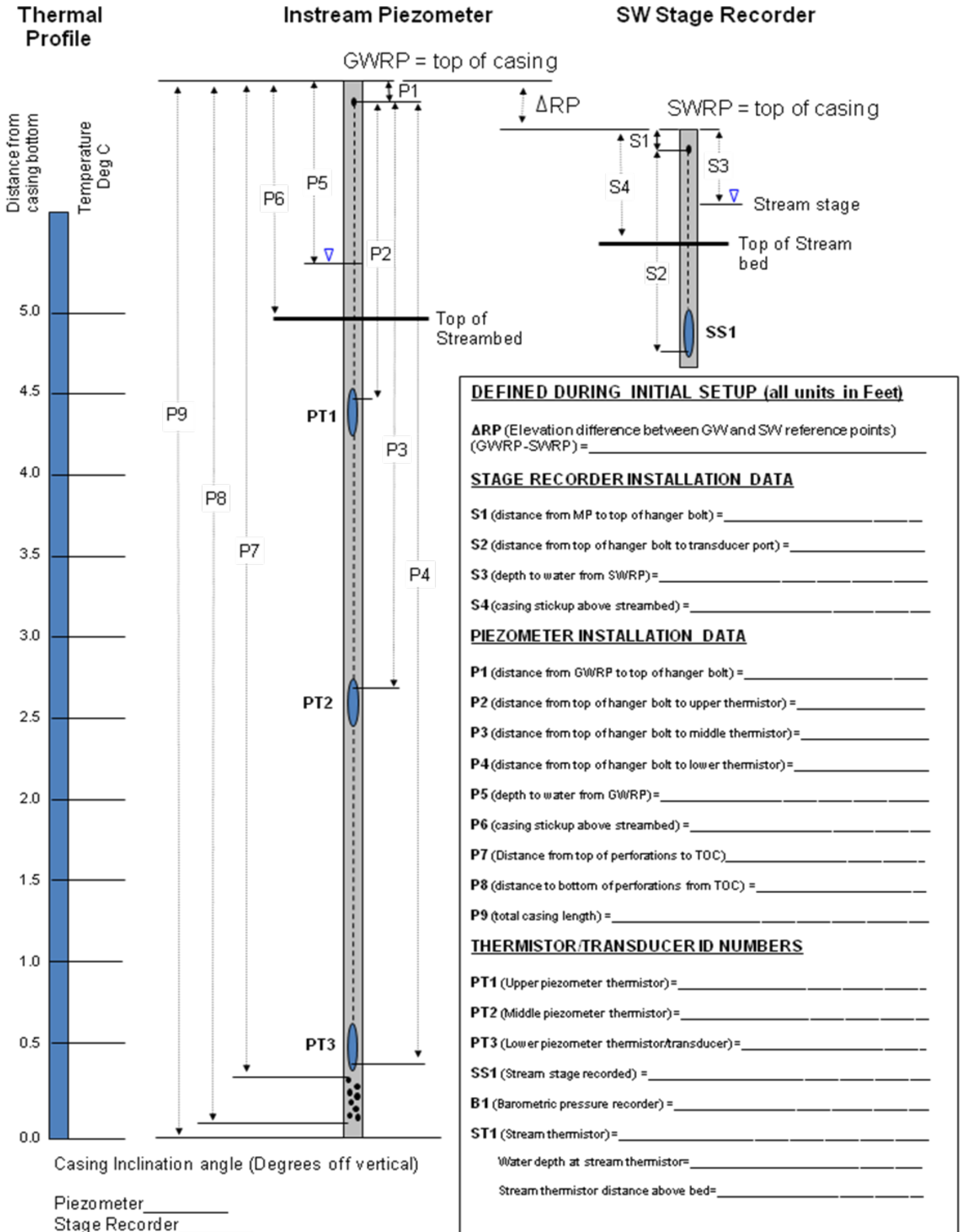


Water Level MP: TOC other: ____________________________

E-tape #:	Hold	Cut
S-Length	ft	ft
P-Length	ft	ft
Extension Length	ft	ft
Stickup Length	ft	ft
Total Interior Length	ft	ft

Measure inclined lengths, not corrected vertical heights

Example Form – Piezometer Installation Including Thermistors and/or Water Level Transducers



DEFINED DURING INITIAL SETUP (all units in Feet)

ΔRP (Elevation difference between GW and SW reference points) (GWRP-SWRP) =________________________

STAGE RECORDER INSTALLATION DATA

S1 (distance from MP to top of hanger bolt) =________________________

S2 (distance from top of hanger bolt to transducer port) =________________________

S3 (depth to water from SWRP) =________________________

S4 (casing stickup above streambed) =________________________

PIEZOMETER INSTALLATION DATA

P1 (distance from GWRP to top of hanger bolt) =________________________

P2 (distance from top of hanger bolt to upper thermistor) =________________________

P3 (distance from top of hanger bolt to middle thermistor) =________________________

P4 (distance from top of hanger bolt to lower thermistor) =________________________

P5 (depth to water from GWRP) =________________________

P6 (casing stickup above streambed) =________________________

P7 (Distance from top of perforations to TOC)________________________

P8 (distance to bottom of perforations from TOC) =________________________

P9 (total casing length) =________________________

THERMISTOR/TRANSDUCER ID NUMBERS

PT1 (Upper piezometer thermistor) =________________________

PT2 (Middle piezometer thermistor) =________________________

PT3 (Lower piezometer thermistor/transducer) =________________________

SS1 (Stream stage recorded) =________________________

B1 (Barometric pressure recorder) =________________________

ST1 (Stream thermistor) =________________________

Water depth at stream thermistor=________________________

Stream thermistor distance above bed=________________________

Appendix B: Permit Requirements and Procedural Checklist for Installing and Decommissioning In-water Piezometers

This checklist was prepared to help workers complete the required forms and environmental permit applications for projects where piezometers or other hydraulic monitoring devices are deployed within a lake, stream, or other waterbody. Be advised that some projects may require additional local, state, and/or federal permits/exemptions beyond those discussed here.

Piezometer Installation

JARPA application

If you intend to install or anchor monitoring equipment in a stream or lake you must file a JARPA (Joint Aquatic Resource Permit Application) application for your project (http://www.ecy.wa.gov/programs/sea/pac/index.html). The JARPA application is intended to streamline the permitting process by enabling workers to apply for most common environmental permits using a single application form. See the GWTCT website for an example JARPA application. At a minimum use the JARPA application to secure a hydraulics project approval (HPA), shorelines permit exemption, and to declare your project's categorical exemption from SEPA if appropriate (hydraulic monitoring devices are exempt from SEPA oversight). If you will be working in "navigable waters of the state" you must also complete an Aquatic Lands Right of Entry Agreement with WADNR as part of the JARPA process.

Per the JARPA instructions forward signed copies of the completed application to the county shorelines administrator (usually the planning department) for each county you will be working in. Forward another copy to the WDFW district/regional office that has jurisdiction over your project area (see map below).

Many counties charge a fee to process the shorelines exemption paperwork. Use an A19 form (http://aww.ecology/forms/forms_toc.htm#financial) to pay this fee.

Underground Utility Location Services

To ensure that you will not damage buried power lines, gas lines, fiber optic cables, or other utilities, call the underground utility location service to identify utility locations in the vicinity of your proposed piezometer sites (http://www.callbeforeyoudig.org/). Allow 3-5 working days for utility locations to be marked.

Well construction/decommissioning paperwork requirements

If you intend to construct an in-water piezometer (either temporary or permanent) that does not fully comply with Chapter 173-160 WAC and Chapter 173-162 WAC (well construction and licensing requirements) a written variance from those rules must be obtained in advance of any work. Contact the appropriate Well Construction Coordinator for the Ecology Region(s) where work is contemplated for details.

“Temporary” piezometers are installed just long enough to perform a single water-level measurement or to collect a water quality samples. These devices are removed immediately after the measurement and decommissioned per the written project variance. Such wells fit the definition of an “environmental investigation well” which is a sub-category of “resource protection well” (see Chapter 173-160-410(2) and (13) WAC for additional guidance). “Permanent” piezometers are those where a casing is left in place to enable multiple measurements or samples to be collected over time at the same location.

A “notice of intent to construct a resource protection well” form must be filed with Ecology’s Water Resources Program at least 72 hours before installing piezometers. There is a $40 fee for the first 4 temporary piezometers and a $10 fee for each additional temporary piezometer reported on the same Notice of Intent. The filing fee for permanent piezometers is $40 per well.

A separate notice form is required for each type of piezometer and quarter/quarter section (40 acre area). For example: to construct four Environmental Investigation wells (temporary piezometers) and four Resource Protection wells (permanent piezometers) in the same quarter/quarter section would initially require submission of three notices: one with $40 attached for construction, and a second with no fees attached for decommissioning the temporary piezometers, and a third with $160 attached for construction of the permanent piezometers. A final notice and $80 should be submitted at least 72 hours before decommissioning the permanent piezometers.

Use an A19 form (http://aww.ecology/forms/forms_toc.htm#financial) to pay the notice of intent fees. Piezometer installation must be done by a licensed well driller or under the direct oversight of a licensed engineer.

Each permanent piezometer must be physically tagged with a unique well ID tag. Obtain well tags from Ecology’s regional well drilling coordinators. Temporary piezometers should also be assigned a tag ID to facilitate data entry into Ecology’s well log and EIM databases. Be sure to destroy and recycle the tag for any temporary piezometers that are installed to prevent them from accidently being reused on another piezometer.

A well log must be completed for each piezometer that is constructed or decommissioned (either permanent or temporary) and submitted to the appropriate Ecology regional office within 30 days of completing work. Blank well log forms are available from Ecology’s regional well drilling coordinators. Be sure to include the unique well ID tag number on each well log.

When permanent piezometers are no longer needed, file a “notice of intent to decommission a well” form for each piezometer (or group of piezometers in the same quarter/quarter section) that will be removed. Use a single A-19 form to pay the total decommissioning cost for the project (see Table 2). Complete and file a well decommissioning report form with Ecology’s Water Resources Program for each piezometer you remove (see example form in Appendix A).

Table B1 - Summary of permits and approval requirements for in-water piezometers

Application/action	Permit/document Type	Lead Agency/ Authority	Estimated Fee/Cost	Approximate timeline for issuance/action
Non-Ecology permits/approvals that must be obtained prior to installing piezometers[1]				
JARPA	HPA	WADFW-regional office	None	15-30 days after shorelines permit issues
JARPA	Shorelines Exemption	County planning department	None-$200+	30-60 days after completed app. received.
JARPA	SEPA - categorical exemption	County planning department	None	NA - part of JARPA application
JARPA	Aquatic lands right of entry agreement	WADNR - regional office	Notary public fees may apply in some cases.	20-30 days
Utilities Underground Location Center (UULC)	None- field location of underground utilities	UULC 1-800-424-5555 See UULC web site for details.	None	Allow 3-5 business days for response.
Ecology well construction/abandonment notices, variances, and related paperwork[2]				
Memo requesting a well construction variance	Well construction variance letter	Ecology regional office - Water Resources Program	None	Submit variance request at least 3 months before project start date.
Submit notice of intent to construct a monitoring / resource protection well	A separate notice is required for each section and quarter/quarter	Ecology - Water Resources via purchasing unit	$10-$40 per piezometer (see next item)	Submit notice at least 72 hours before installing first piezometer
File a completed A-19 form with your notice of intents (submit both to Ecology's purchasing unit in fiscal)	A-19 (one per project)	Project manager	$10 / non-cased $40 / cased piezometer	Submit one A-19 form per project with notice of intent(s)
Submit well completion report(s)	One completion report (well log) per piezometer	Ecology Water Resources	None	Submit well log(s) within 30 days of well installation
Submit notice of intent to decommission a well	A separate notice is required for each section and quarter/quarter	Ecology - Water Resources	$0-$20 per piezometer (see next item)	Submit notice at least 72 hours before decommissioning first piezometer
File an A-19 form with the notices of intent to decommission a well - submit both to Ecology's purchasing unit	A-19 (one per project)	Project manager	$0 / non-cased $20 /cased piezometer	Submit one A-19 form per project with notice of intent(s)
Submit decommissioning report(s)	One report per piezometer	Ecology Water Resources	None	Submit report within 30 days of well decommissioning

[1] EAP currently has a procedure in place to streamline permit acquisition, see the groundwater TCT website for details.

[2] (see Chapter 173-160 WAC for the most up to date guidance on these and other well related requirements)