DEPARTMENT OF ECOLOGY
State of Washington

Standard Operating Procedure
EAP061, Version 2.1

Installing, Monitoring, and Decommissioning Hand-driven In-water Piezometers

May 2018

Publication No. 18-03-216

Purpose of this document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication information

This SOP is available on the Department of Ecology's website at https://fortress.wa.gov/ecy/publications/SummaryPages/1803216.html

Ecology's Activity Tracker Code for this SOP is 10-134.

Contact information

For more information contact:

Communications Consultant
Environmental Assessment Program
P.O. Box 47600, Olympia, WA 98504-7600
Phone: 360-407-7680

Washington State Department of Ecology – https://ecology.wa.gov

Location of Ecology Office	Phone
Headquarters, Lacey	360-407-6000
Northwest Regional Office, Bellevue	425-649-7000
Southwest Regional Office, Lacey	360-407-6300
Central Regional Office, Union Gap	509-575-2490
Eastern Regional Office, Spokane	509-329-3400

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Installing, Monitoring, and Decommissioning Hand-Driven In-Water Piezometers

Version 2.1

Authors – Kirk Sinclair and Charles Pitz
Date-

Reviewer - Martha Maggi, Groundwater/Forests & Fish Unit Supervisor
Date -

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date -

EAP061

APPROVED: 07/26/2010
Recertified: 06/20/2013
Recertified: 06/22/2016

Signatures on file

The Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturers, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the authors or by the Department of Ecology.

Although Ecology follows this SOP in most cases, there may be situations where an alternative methodology, procedure, or process is employed to meet specific project objectives. In such cases the project manager is responsible for documenting significant deviations from these procedures in the formal study report.

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.	Appendix B	Sinclair
06/20/2013	2.0	Added water quality sampling procedures and updated well notification and reporting requirements	Added sections 5.5, 6.8, and 6.17- 6.22; revised Appendix B	Sinclair and Pitz
04/06/2016	2.1	Updated HPA requirement discussion and references to other EAP SOPs	Appendix B	Sinclair
6/22/2016	2.1	Recertified	All	Kammin

TABLE OF CONTENTS

Page

LIST OF FIGURES

Environmental Assessment Program

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, sample, and remove hand-driven piezometers along streams, rivers, or other water bodies. This is one of several documents developed to record 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 (EAP044 - Bilhimer and Stohr, 2009), performing manual depth to groundwater measurements (EAP052 - Marti, 2009), purging and sampling monitoring wells (EAP078 – Marti, 2011) and piezometer-based hydraulic test procedures (Pitz, 2006).

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:

- Estimating hydraulic conductivity values for streambed, lakebed, or other sediments,
- Measuring the vertical hydraulic gradient between a surface water body and near-surface groundwater,
- Monitoring sediment thermal profiles, and
- Sampling groundwater quality near its point of discharge to surface water.

2.2 Detailed knowledge of these factors is important for total maximum daily load (TMDL) investigations or other studies where an understanding of surface water/groundwater (SW/GW) interactions is important. In-water piezometers are typically installed in the near-surface transition zone where groundwater and surface water intermix. Thus, the interstitial porewater they are intended to evaluate may consist of a mixture of surface water and groundwater. The terms porewater and groundwater are used interchangeably in this document to describe such waters.

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 Annulus; annular space – Open void space that is sometimes present between the casing of an in-water piezometer and the adjacent sediments. An unsealed annular space can serve as a preferential pathway for fluid flow.

3.2 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).

3.3 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.

3.4 Dissolved Oxygen (DO) – The amount (concentration) of oxygen that is dissolved in water.

3.5 DNR – Washington Department of Natural Resources

3.6 EAP – Environmental Assessment Program

3.7 Ecology – The Washington State Department of Ecology

3.8 EIM – Environmental Information Management System. Ecology’s database of environmental monitoring information.

3.9 E-tape – electric water level tape; an electronic field instrument that allows measurements of depth to water inside an open casing.

3.10 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.

3.11 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.

3.12 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 NGVD88) is given in the well description.

3.13 "Leaky" In-Water Piezometer – An in-water piezometer whose open interval is not effectively isolated from the overlying surface water. Piezometer leakage most often arises when sediments do not collapse around and effectively seal the annular space around the casing during piezometer installation and development.

3.14 Manometer board – a field instrument used to measure and compare fluid pressures. A manometer board can be used to determine differences in hydraulic head between surface water and underlying sediment porewater.

3.15 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).

3.16 ORP – Oxidation-Reduction Potential. The electric potential required to transfer electrons from one compound or element (the oxidant) to another compound (the reductant). ORP serves as a qualitative measure of the oxidation state of water.

3.17 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.

3.18 pH – A measure of the acidity or alkalinity of water. pH values less than 7 indicate acidic conditions, while pH values greater than 7 indicate basic or alkaline conditions. A pH of 7 is considered neutral. The pH scale is logarithmic and spans a range from 0 to 14. Thus, water with a pH of 8 is 10 times more basic than water of pH 7.

3.19 Pressure transducer – An instrument that can be programmed and deployed to measure and record air or fluid pressures at a defined time interval.

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

3.21 Sediment – A generic term used to describe the unconsolidated 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.

3.22 Specific Conductance (SC) – A measure of water's ability to conduct electricity. Specific conductance is related to the concentration and charge of dissolved ions in water.

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

3.24 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.

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

3.26 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 7).

3.27 Thermistor (recording) – A programmable instrument that measures and records the temperature of water, air, or other media at a user-defined time interval.

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

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

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

4.0 Personnel Qualifications and 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, 2017).

4.2 For piezometers greater than 10 feet deep, 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 by boat, at least one crew member must be a qualified boat operator. All crew members are responsible for reading and following the general boating guidance in the EAP Safety Manual (Chapter 3).

4.4 The field lead is expected to have detailed working knowledge of the project Quality Assurance Project Plan (QAPP). They are responsible for briefing field staff on the study goals and objectives and for ensuring workers adhere to prescribed sampling methods.

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 work gloves
5.1.8 Sun hat
5.1.9 warm non-cotton clothing
5.1.10 personal flotation device

5.1.11 sunscreen
5.1.12 drinking water and food
5.1.13 calculator
5.1.14 Photo ID

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
5.2.18 magnet
5.2.19 12V battery charger

5.3 Piezometer Installation and Development

5.3.1 Appropriate piezometer materials (such as pre-fabricated galvanized steel or PVC piezometer casings; pipe couplers, extensions, caps/plugs, screen points (shielded or unshielded); or rigid-wall ¼" ID HDPE 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 with tie-off rope or anchor (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, 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)
5.3.16 300-foot tape measure
5.3.17 Long-shaft temperature probe and meter

5.4 Water Level Monitoring and Thermistor Deployment

5.4.1 Peristaltic pump, charged portable 12-volt battery, and flexible-wall pump tubing (as appropriate)
5.4.2 Manometer board, hanger with clamps, and tubing (as appropriate)
5.4.3 Calibrated low displacement e-tape (as appropriate)
5.4.4 Stilling tube
5.4.5 12-foot engineer's tape
5.4.6 Pre-calibrated and launched thermistors (four thermistors per piezometer for initial deployment)
5.4.7 Extra piezometer cap(s), coupler(s), and extension pipe(s) (as appropriate)
5.4.8 Pre-launched thermistor shuttle(s) (to download thermistors)
5.4.9 Extra pre-launched thermistors (replacements for failed thermistors)
5.4.10 Thermistor shade devices (see Bilhimer and Stohr, 2009)

5.5 Water quality sampling

5.5.1 Cooler(s), strapping tape, ice or blue ice, plastic grocery bags, Ziploc bags
5.5.2 Peristaltic pump, charged portable 12-volt battery, flexible-wall pump tubing (Silastic® or other as necessary) ¼-inch ID,
5.5.3 Floating sampling platform with tie-off rope or anchor
5.5.4 Water quality field meter(s), flow chamber, and calibration standards (pH, conductivity, etc.)
5.5.5 Printout of project station table with well tag ID, station names, laboratory numbers, parameter list, sample containers, preservation and holding time requirements
5.5.6 Field WQ data sheets, sample tags, laboratory analysis and sampling form(s), sample shipping manifests (if applicable), pens and pencils
5.5.7 Sample containers/bottles, nitrile gloves,
5.5.8 ¼-inch ID rigid-wall high density polyethylene (HDPE) sample tubing
5.5.9 0.45 micron in-line cartridge filters (standard and high capacity) and filter tubing connectors,
5.5.10 5-gallon equipment cleaning bucket with Liquinox™ solution
5.5.11 5-gallon equipment rinse bucket and DI water
5.5.12 laboratory grade DI water (used to prepare field filter blanks)
5.5.13 DI water from OC, DI squeeze bottle, Kimwipes
5.5.14 Test kits and spectrophotometer for field analysis (DO, Alkalinity, etc), sharps bottle
5.5.15 Copy of study QAPP, permits, and waivers

5.5.16 Personal field equipment, water, and food (waders, PFDs, rain gear, hat, etc.)
5.5.17 Phone list/contact numbers for the Manchester lab, field helpers, etc.
5.5.18 Paper towels

5.6 *Decommissioning Piezometers*

5.6.1 Two high-lift jacks with extension handles and attached chains
5.6.2 Star clamp, appropriately sized for pipe (as necessary)
5.6.3 Five feet of heavy gage chain with end hook
5.6.4 16-pound sledge hammer (as necessary)
5.6.5 2-pound hand sledge
5.6.6 2 14-inch lengths of 2 by 8 inch board or heavy plywood (as necessary to support jack base)
5.6.7 Pipe wrenches

6.0 Summary of Procedures

6.1 *Project Planning*

6.1.1 The successful deployment and monitoring of in-water piezometers requires 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 and waivers may need to 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 Quality Assurance Project Plan (QAPP) must be completed and approved before beginning the field work for a project. The QAPP details project goals, data quality objectives, quality assurance procedures, sample collection and handling requirements, and laboratory procedures. The document *Guidelines for Preparing Quality Assurance Project Plans for Environmental Studies* (Lombard, 2004) provides detailed guidance for developing EAP project plans. The QAPP can reference SOPs for standard field monitoring or measurement procedures; however, non-standard procedures or deviations should be described in the project QAPP.

6.1.7 A brief discussion of these topics is presented below, as a primer for readers new to 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), Rosenberry and LaBaugh (2008), and EPA (1991) prior to preparing project plans or installing piezometers. Geist et al., (1998) suggest procedures for piezometer installation in very coarse-grained settings. 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 When selecting potential piezometer sites, the goal for most EAP studies 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. Unless your project goals and objectives dictate otherwise, river reaches or lake shore areas that are known to consistently lose water to the underlying aquifer should not be targeted for water quality sampling.

6.2.4 When conducting site reconnaissance surveys a long-line hardened temperature probe can generally be used to measure the near surface sediment/porewater temperature at several points along the shoreline. Large thermal contrasts between the sediment porewater and overlying surface water can often be used to tentatively identify the presence of groundwater discharge conditions (Rosenberry and LaBaugh, 2008). Thermal reconnaissance surveys can be conducted on foot or by boat.

6.2.5 When selecting potential piezometer locations in the field, target 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.

6.2.6 On streams and rivers, avoid locations near point bars, riffles, pools, or steep drops that might locally induce surface-water flow through the streambed (hyporheic exchange).

6.2.7 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.

6.2.8 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.

6.2.9 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 site access permits or arranging access with property owners.

6.3 *Regulatory Permits and Waivers*

6.3.1 The project manager or hydrogeologist is typically responsible for securing the regulatory permits and waivers to install in-water piezometers. These currently include 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 that are completed at depths greater than 10 feet below ground surface are regulated under Washington's minimum well construction statutes and regulations (Chapter 18.104 RCW, Chapter 173-160WAC, and Chapter 173-162WAC). For these "regulated" installations, a licensed well driller (or engineer) must be present to oversee piezometer installation and removal. The well driller or engineer is responsible for signing and filing well completion and abandonment reports for these wells.

6.3.3 Piezometers less than 10 feet deep are currently exempt from Washington's well construction and reporting requirements. Although it's not required, EAP hydrogeologists are encouraged to submit well construction logs to Ecology's well log reporting system for any exempt piezometers they deploy.

6.3.4 The steps required to secure environmental permits, variances, and regulatory waivers for in-water piezometers are outlined in Appendix B[1].

6.4 *Piezometer Material and Design Considerations*

[1] In 2008, EAP obtained a "state wide" DNR aquatic lands access agreement for the 2009-2013 field seasons. The information in Appendix B is provided as a general guide, in the event this agreement is 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.

6.4.1 In-water piezometers can be constructed from a variety of commonly available materials including steel (black, galvanized, or stainless), thick-walled PVC, or high-density rigid-wall 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
Rigid wall polyethylene tubing	$$	P-E	G-E	P	E	P	E
Rigid PVC pipe	$	P-G	G-E	G-E	E	E	E
Galvanized or black steel pipe	$$$	G-E	G-E	G-E	E	E	P-E

P-poor, G-good, E-excellent

6.4.2 When selecting piezometer material(s) and design(s) choose those that best complement the study goals and data quality objectives. Piezometers that will be sampled to characterize groundwater quality should be constructed of material(s) that are compatible with the chemicals of concern; to minimize the potential for sampling-introduced chemical bias. 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. The open-interval design should favor materials and construction that minimize the entry of suspended sediments during sampling. Particularly if the chemical parameters of interest have the potential to sorb to particulate matter.

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.

6.5.7 Steel piezometers can also be fitted with a commercially-fabricated, stainless steel screened drive point to help minimize the entry of suspended sediments during sampling and to reduce the potential for chemical bias when sampling for metals. Shielded screen points that remain closed during deployment (and are later exposed by partially withdrawing the drive casing) are also available, and can help reduce the need for piezometer development.

6.6 *Rigid-Wall Tubing Piezometers*

6.6.1 Small-diameter tubing piezometers (e.g., 0.25-inch ID high-density rigid-wall polyethylene) are relatively inexpensive to construct and may be easier to install in coarse grained substrates than larger-diameter steel piezometers (Figure 1). Tubing piezometers are particularly well-suited for lake deployments since they can be installed and monitored at greater water depths than rigid pipe designs can reasonably accommodate (Lee and Harvey, 1996).

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

6.6.3 Tubing piezometers may be 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 sediment into the well.

6.6.4 In gaining settings, water levels in tubing piezometers can be observed and measured directly through the translucent tubing, allowing rapid direct comparisons to surface water stage. A manometer board can also be attached directly to a tubing piezometer for precise measurement and comparison of porewater and surface water hydraulic heads. Use of a manometer board is required in cases where the water level inside the tubing equilibrates at a level below the surface water stage (i.e. a losing condition).

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.

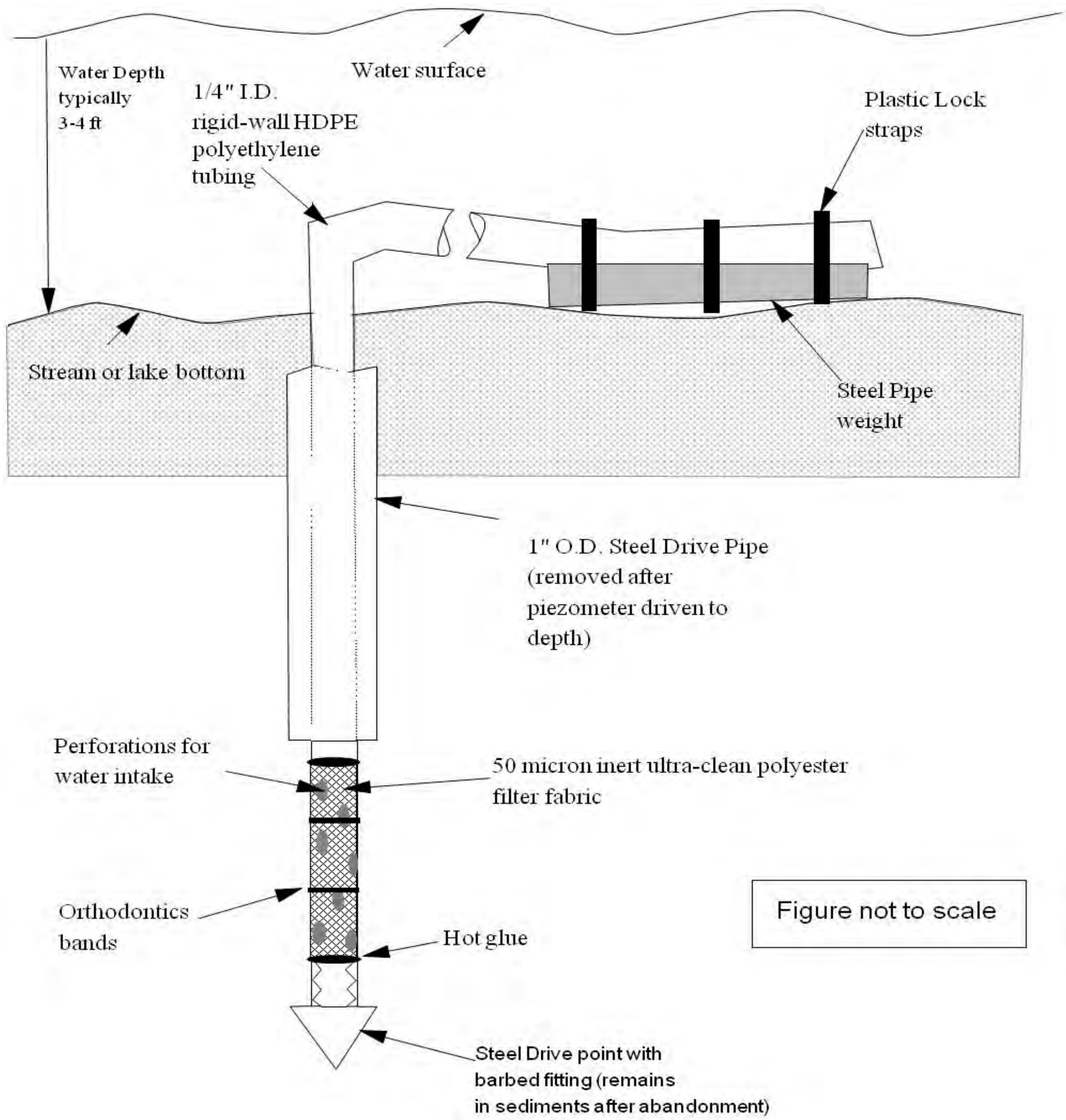


Figure 1 – Example schematic of a rigid-wall tubing piezometer

6.7 *PVC and Stainless Steel Piezometers*

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

6.8 *Piezometer Deployment – General Considerations and Method Limitations*

6.8.1 Most in-water piezometers installed by EAP are hand-driven into the subsurface with a fence post driver or comparable tools. They are not constructed with the bentonite or neat-cement surface seal commonly installed on most upland monitoring wells. The absence of a traditional surface seal coupled with shallow installation depths (typically <10 ft) makes in-water piezometers susceptible to the upward or downward movement of water along the outside of the piezometer casing (also called casing annular leakage).

6.8.2 When it occurs, annular leakage can bias the hydraulic measurements and water quality samples collected from piezometers (see section 6.17 for additional information). Accordingly, the water quality and hydraulic gradient data collected from in-water piezometers should be interpreted in light of the possibility that some leakage may have occurred during sampling. This is particularly important in situations where water quality samples are collected for comparison against regulatory standards (due to the potential for surface water leakage to dilute in situ groundwater concentrations to levels below those of concern).

6.8.3 Field staff should always be mindful of the potential for leakage when monitoring or sampling piezometers. The following guidance is intended to help staff identify and minimize the potential impacts of casing leakage:

6.8.4 Use Teflon plumber's tape to seal all coupled casing joints (don't use joint compound or plumber's putty if you plan to collect water quality samples).

6.8.5 After piezometer installation and development, fill and pack any obvious open annular space that is present with native fine-grained sediment.

6.8.6 Whenever possible, allow a piezometer to equilibrate after installation (preferably for a few weeks or more) before making hydraulic measurements or collecting water quality samples. This will provide time for adjacent/mobile bed sediments to naturally repack around the casing.

6.8.7 Restrict purge and sample rates to ≤ 0.5L per minute, to minimize pumping induced drawdown during sampling.

6.8.8 Minimize the total volume of water pumped from the piezometer during a monitoring event by having all bottles, filters, and other necessary supplies accessible and ready for use prior to the start of purging.

6.8.9 When working with low-yield wells that experience significant pumping induced drawdown, coordinate with the lab to see if they can manage an analysis with less than the ideal recommended sample volume(s).

6.8.10 Be cognizant of the equilibrated hydraulic head differences between groundwater inside the piezometer and surface water stage outside the piezometer. Little or no difference between these water levels may indicate a compromised casing seal.

6.8.11 Compare the field parameter chemistry for surface water and groundwater while purging the piezometer. Similarities in dissolved oxygen, specific conductance, and other parameter concentrations may be an indication of leakage.

6.8.12 Whenever possible use a preponderance of evidence approach, which includes hydraulic gradient measurements, streambed/surface water thermal differences, and field water quality information, to establish the adequacy of the casing seal.

6.8.13 When the adequacy of the casing seal can't be confirmed via the above methods, it may be necessary to conduct more extensive evaluations (such as tracer testing) to confirm/assess seal integrity.

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 2). 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, porewater quality, and other variables.

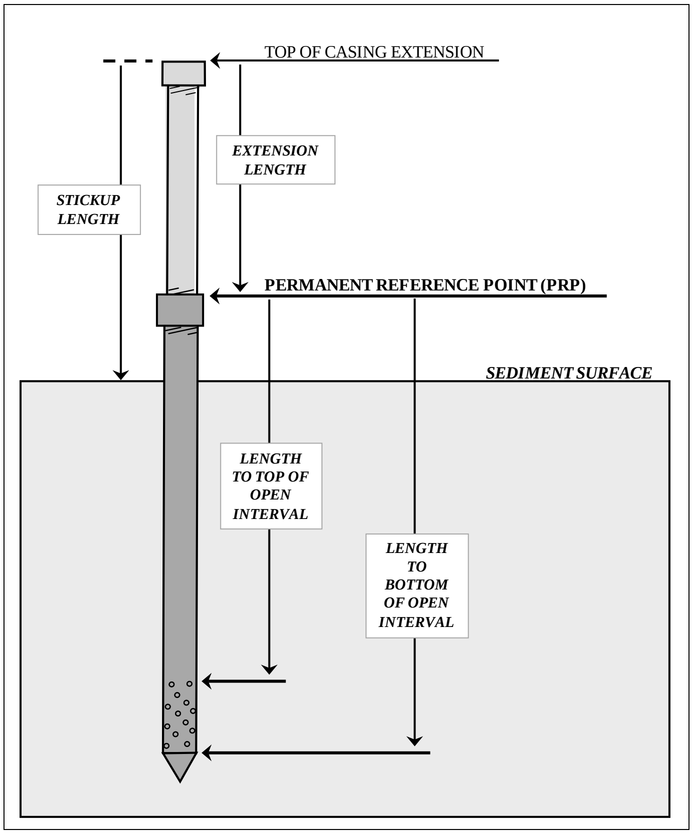


Figure 2 – Schematic of a typical rigid-pipe, in-water piezometer

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 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 **Rigid-wall tubing piezometers**: the PRP for rigid-wall 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, an air powered jack-hammer, or similar means (Figure 3). Choose the most appropriate installation method based on local site and permit conditions.

Tripod and drop hammer

Fence post driver

Figure 3 – 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 water-tight and secure. (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 in your field notes (as a potential aid to later conceptual model development and data interpretation) and move to another 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 For those installations where thermistors will also be deployed (see Section 6.15), drive the casing until the PRP lies about 6 inches above the sediment surface, if possible. 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 Piezometers intended primarily for water quality sampling, should be driven until the casing open interval is positioned at the desired depth for monitoring.

6.10.2.6 In some cases it may be necessary to install more than one piezometer at a site to satisfy all monitoring objectives.

6.10.2.7 Below-water completions are less prone to vandalism or impacts from floating debris; however, a water-tight extension is required to raise the piezometer above the water surface during field visits. (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.)

6.10.2.8 If possible, backfill and pack any annular space that has been created during the installation process with fine-grained sediments to help isolate the piezometer open interval from direct communication with surface water.

6.10.3 **Tubing Piezometers**: Tubing piezometers are installed using a temporary steel drive pipe that is removed or partially retracted after the tubing is driven to final depth. Completely removing the drive pipe can leave an annular space that must be filled or 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. If a tubing piezometer is installed at an angle (i.e. is not perpendicular to the sediment surface), measure and record the casing angle (as degrees from vertical). Do this <u>before</u> extracting the drive pipe 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 can be helpful when preparing 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*

6.11.1 Piezometer installation procedures disturb the sediments in the immediate vicinity of the drive pipe or casing. Consequently, all piezometers (except perhaps those that incorporate a shielded screened drive point) should be developed after installation to remove sediment that accumulated in the casing or open interval during installation. The general goals of development are the following:

- Remove sediment that may have accumulated inside the casing.
- Establish an adequate hydraulic connection between the piezometer open interval and the adjacent sediments.
- Condition the sediments surrounding the open interval to produce enough water to allow water quality samples to be collected in a reasonable time frame.
- Reduce the amount of fine sediment produced during well purging and sampling.

6.11.2 Development should be conducted in a way that accomplishes the above goals, while also minimizing in situ sediment alterations. Avoid overly aggressive development procedures that could potentially establish a preferential flow path to/from the overlying surface water along the casing exterior (thereby introducing bias into monitoring results).

6.11.3 If a piezometer will be used to test or evaluate sediment hydraulic properties (such as CHIT tests), perform these tests *before* proceeding with significant well development, since development can potentially alter the in situ hydraulic properties of the sediments adjacent to the piezometer open interval (see Cardenas and Zlotnik, 2003; Pitz, 2006).

6.11 After completing hydraulic property test(s), it may be necessary in some cases to further develop a piezometer to enable it to produce an adequate volume of sediment-free water to satisfy subsequent sampling needs. If a piezometer produces an abundance of sediment during follow up development, consider conducting a second post-development hydraulic test. The combined test results will enable you to evaluate whether development has significantly altered the near-casing sediment hydraulic properties.

6.12 **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- to 12-foot length of ½-inch diameter polyethylene tubing (Figure 4).

Figure 4 – Bilge pump development of a steel piezometer

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

6.12.2 Insert the opposite end of the tubing into the piezometer until it rests on the piezometer bottom.

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

6.12.4 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.

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

6.12.6 Repeat this cycle until the piezometer produces a sustained supply of sediment-free water. Sediments with significant silt or clay content may require additional 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 raising and lowering the tubing a few feet while alternatively pumping water into then out of the casing.

6.12.7 Smaller diameter (< one inch) steel or PVC piezometers are developed in similar fashion using a peristaltic pump and an 8- to 10-foot length of rigid ¼-inch diameter polyethylene tubing. Periodically reversing the pumping direction may help speed the development process in this case.

6.12.8 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 clean sediment-free surface water and watching for a short time to confirm that the level moves toward its natural equilibrium position.

6.12.9 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 positive-head difference (i.e. the water level in the piezometer equilibrates at higher head than the adjacent surface water stage) suggests that the piezometer has an effective casing (annular) seal.

6.12.10 As a secondary check, confirm this by slowly purging the piezometer with a peristaltic pump (<0.5 L/min) while periodically measuring the water's 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.

6.12.11 If the water level and water quality values for the surface water and piezometer are the same or nearly so, it's possible that surface water is bypassing the sediments and preferentially entering the piezometer via a poorly sealed casing annulus. In such cases, attempt to pack fine sediments around the casing if possible before repeating the above tests.

6.12.12 If these initial attempts to seal the casing prove inadequate, try deepening the piezometer as long as doing so won't place the casing open interval beyond your target monitoring depth. After deepening, repeat the tests described above to confirm an effective casing seal.

6.12.13 Experience has shown that piezometers installed in free flowing rivers or streams, often seal naturally within a month or so of deployment as suspended sediment and movable streambed materials repack around the casing. If possible, plan for a month or so of down time, between piezometer installation and the first round of water quality sampling, to enable piezometers to equilibrate with the surrounding sediments. (It is import to keep in mind as you collect and evaluate piezometer-based data that measurable differences in head and water quality between a piezometer and the adjacent surface water are not definitive proof of an effective casing seal.)

6.12.14 For critical assessments (such as compliance monitoring) where small concentration differences can be significant, additional leakage evaluations such as tracer testing may be necessary to confirm the adequacy of the casing annular seal.

6.12.15 After the piezometer has been developed, complete the installation by measuring the maximum casing incline (as degrees away from vertical). Record the result in the installation field form.

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

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

6.12.18 Describe and/or sketch the piezometer location including its position (left bank/right bank) and distance/bearing from local landmarks. If possible, locate the piezometer position on a field copy of an orthophoto for later refinement of site coordinates in GIS.

6.12.19 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.

6.12.20 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. (If the piezometer is not vertical, remember to measure the stickup length—and associated water levels—from the lowest point of the circumference of the casing rim.)

6.12.21 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.

6.12.22 Finally, measure and record the initial hydraulic head values for the piezometer and surrounding surface water (see Section 6.16 for details).

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

6.13.1 Begin development by connecting the flexible-wall pump tubing directly to the upper end of the rigid-wall piezometer tubing. Start the pump and alternately pump water into and out of the piezometer by periodically reversing the pump direction.

6.13.2 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.

6.13.3 When development is complete, perform the casing seal evaluation outlined in Sections 6.12.8 through 6.12.12.

6.13.4 Measure and record the length of tubing projecting above the sediment surface (to the nearest 0.01 foot).

6.13.5 Subtract this length from the *total initial* tubing length (see Section 6.9.3.3) 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.

6.13.6 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 surface water stage. Permanently mark the water level MP with an indelible ink pen or a plastic zip tie secured firmly around the piezometer tubing.

6.13.7 Hold the tubing vertically 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.

6.13.8 While holding the tubing vertically, measure and record the initial hydraulic head values for the piezometer and surrounding surface water (see Section 6.16.6 for details).

6.13.9 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.

6.13.10 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.

6.13.11 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.

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

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

6.13.14 Describe and/or sketch the piezometer location on the field form and orthophoto 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.

6.14 General Development Considerations - All Piezometers

6.14.1 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.

6.14.2 Occasionally piezometers are completed with their screen or perforations in the unsaturated zone 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 poorly developed. In these situations, confirm development by verifying the piezometer 'takes' water introduced into the casing. If the piezometer simply fills as you add 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 that 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.

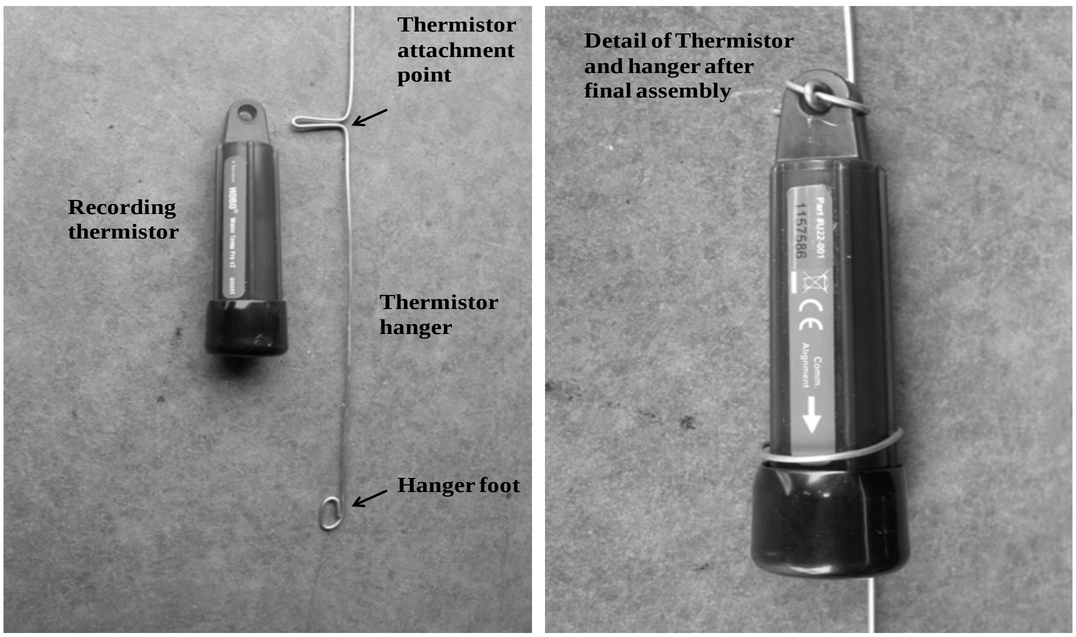
6.15 *Thermistor Installation*

6.15.1 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. Vertically distributed thermal data from a piezometer can also be used to develop numeric estimates of the sediment hydraulic properties adjacent to the casing. Instrumenting a standard 1.5-inch diameter steel or PVC piezometer requires four pre-calibrated and launched thermistors and one roll each of 12- to 14-gage and 20- to 22-gage aluminum or galvanized wire.

6.15.2 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.

6.15.3 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].

6.15.4 Form a small crimp about 8 inches above the hanger foot to anchor the lower-most thermistor (Figure 5).



(Before) (After)

Figure 5 – Details of a typical thermistor and hanger array shown before and after assembly

6.15.5 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.

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

[2] EAP typically installs thermistors using heavy gage wire or a rod that rests on the piezometer bottom. Thermistors can also be weighted and suspended on small diameter cable from an anchor point on the piezometer cap or upper casing. Suspended deployment techniques are generally used when a combination of thermistors and a transducer are deployed in a piezometer.

6.15.7 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.

6.15.8 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.

6.15.9 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 5). 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.

6.15.10 Install the middle and upper thermistors in similar fashion.

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

6.15.12 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 6).

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

Figure 6 – Deploying a thermistor array into an in-water piezometer

6.15.14 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. (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.)

6.15.15 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 0.01 foot and record them on the installation form. These values represent the initial thermistor depths relative to the PRP.

6.15.16 Measure the distance from the piezometer PRP to the sediment surface. Subtract this value from each of the thermistor depths just measured (Section 6.15.15) to define the initial thermistor depths in feet below the sediment surface.

6.15.17 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. (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.)

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

6.15.19 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.

6.15.20 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.

6.15.21 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.)

6.15.22 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.

6.15.23 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.)

6.15.24 Piezometers that are routinely sampled for water quality can also be completed (extended) above the water surface throughout the project 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.

6.16 *Routine Monitoring of Piezometers*

6.16.1 A principal use of in-water piezometers is to monitor the water level (hydraulic head) relationships between a surface water body and the near-surface groundwater at discrete points (Figure 7). Piezometer networks installed along the length of a stream (or lake) can be used to track where gains from or losses to groundwater occur over time. Such measurements are useful for confirming the reach-based water exchanges estimated from stream seepage evaluations.

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

6.16.2.1 $i_v = dh/dl$ (Equation 1)

6.16.2.2 where: i_v = the vertical hydraulic gradient (dimensionless)

6.16.2.3 *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 7).[3]

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

6.16.3 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).

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

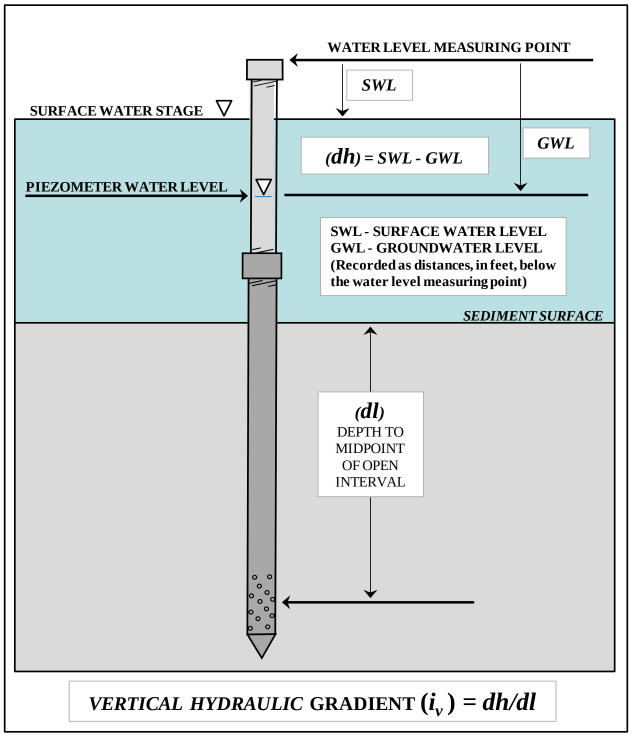


Figure 7 – Determination of surface water and groundwater head relationships using an in-water piezometer

[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.

6.16.5 Measuring Hydraulic Heads and Sediment Temperatures in Pipe Piezometers

6.16.5.1 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).

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

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

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

6.16.5.5 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, 2009 for additional guidance).

6.16.5.6 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]:

6.16.5.6.1 The distance from the casing top to the surface water level (the "*S Length*" on Figure 8). Measure *along* the casing with an engineer's hand tape (Figure 9). For inclined piezometers, the surface water level (and subsequent piezometer measurements) should be measured from the *lowermost* point of the casing circumference (see Figure 8). In fast flowing water a clear or translucent stilling tube may be used to stabilize the surface water stage during measurement.

6.16.5.6.2 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 section 6.16.7).

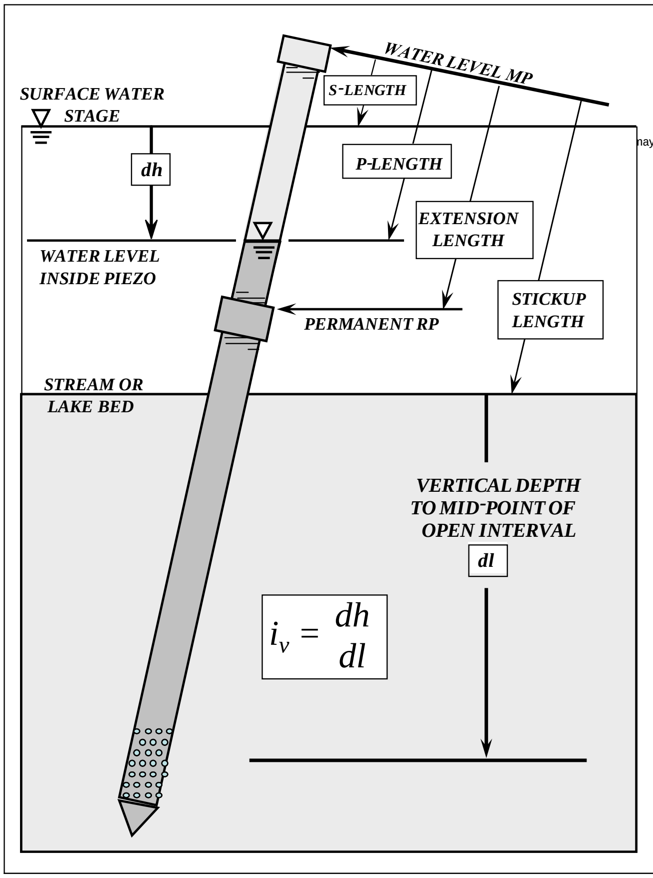
---

[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 8).

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 8 – Example Field Form for Recording Piezometer Water Level Data

6.16.5.6.3 Measure the depth to groundwater *inside* the piezometer (the *"P length" on Figure 8*) from the same point, using a properly calibrated e-tape or steel tape (Marti, 2009) (Figure 9). 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 6.16.7). (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 will not represent true static conditions, particularly if the perforations do not extend to the bottom of the piezometer.)

6.16.5.6.4 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 8). (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.)

6.16.5.6.5 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 9 – Using an e-tape and steel hand tape to measure water levels inside (left) and outside (right) of a steel piezometer

6.16.5.6.6 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. (This information is used to determine if the piezometer is filling with sediment over time and is therefore in need of re-development.)

6.16.5.6.7 After completing the above measurements, proceed with thermistor downloads (see Bilhimer and Stohr, 2009 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.

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

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

6.16.6 Measuring Hydraulic Heads in Rigid-wall Tubing Piezometers

6.16.6.1 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.

6.16.6.2 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. (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.)

6.16.6.3 Hold the tubing as vertically 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.

6.16.6.4 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 vertically as possible once in position. Allow the water in the stilling tube to drain until it equilibrates with the surface water.

6.16.6.5 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 10). This distance is the *dh* variable in Equation 1. 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.

---

[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 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.

6.16.6.6 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 6.16.7).

Figure 10 – Using a metric scale and stilling tube to measure relative heads in a tubing piezometer

6.16.7 Using a Manometer Board to Measure Hydraulic Heads in Piezometers

6.16.7.1 In some situations a manometer board may be the only practical way to measure 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.

6.16.7.2 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.

6.16.7.3 Attach one end of the flexible-wall tubing from the peristaltic pump to the top barbed tubing-fitting on the manometer board (Figure 11).

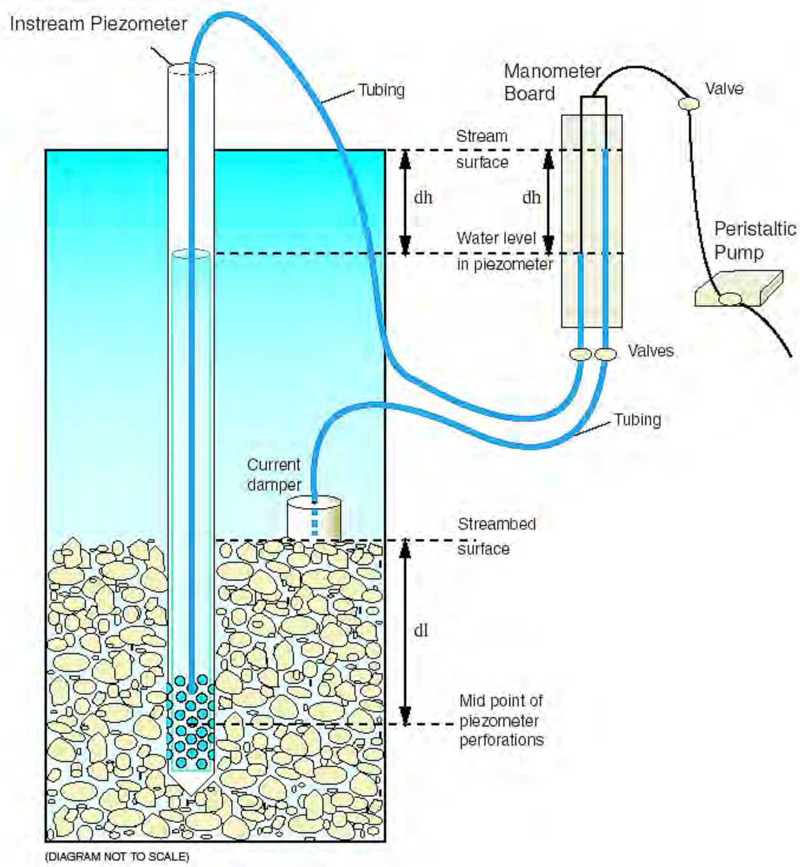


Figure 11 – Typical Manometer Board Setup (figure courtesy of F.W. Simonds, USGS)

6.16.7.4 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. (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.)

6.16.7.5 For tubing piezometers, secure the manometer tubing directly to the piezometer tube.

6.16.7.6 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).

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

6.16.7.8 If you are using a manometer board hanger (recommended) attach the hanger to the piezometer casing using spring clamps. Suspend the manometer from the hanger hook so that the scales are level (Figure 12). It may be necessary to attach a weight to the bottom of the board to ensure it hangs vertically. If you aren't using a manometer hanger, rest the bottom of the manometer on the piezometer casing or another stable surface.

6.16.7.9 Open the top valve that leads to the pump and the lower valve that leads to the surface water tubing. 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.

6.16.7.10 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.

6.16.7.11 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. (Leave the lower two valves open and the surface water and piezometer tubes submerged.)

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

6.16.7.13 Hold the manometer stable and as vertically as possible (use a manometer hanger or the bubble level on the board itself 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).

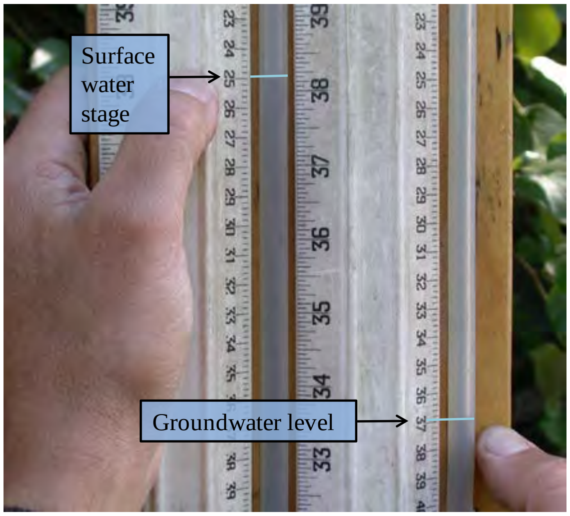
6.16.7.14 After completing the first reading, *briefly* re-open the top valve and let additional air into the manometer, dropping the respective water levels ~8-10 cm on the scale. Again, allow the water levels in each tube to stabilize while holding the manometer steady/vertically. Record the resultant readings on the field form. Repeat this procedure until 5 or more readings have been obtained[6]. (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] When measuring piezometers with large gradients, it may not be possible to complete all 5 readings without first re-charging the manometer with water.

6.16.7.15 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* in Equation 1) for that site and measurement event.

6.16.7.16 If the readings are inconsistent or gradually decrease in magnitude from reading to reading, check the manometer for vacuum leaks. If there are no leaks, it is likely the piezometer was completed in low-permeability sediments and is still recovering after being pumped to charge the manometer. If you encounter such conditions, use an alternative measurement method to define heads if possible. Manometer boards are not well-suited for such conditions since the act of charging the manometer with water can 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.

(In use)



(Detail of water levels)

Figure 12 – Manometer board in use and detail of manometer water levels

6.16.7.17 As a final check and aid during 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.

6.16.7.18 When the measurements are complete, proceed with thermistor downloads (see Bilhimer and Stohr, 2009 for details) or water quality sampling as appropriate[7].

6.16.7.19 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

[7] 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 attaching an extension. The important thing is to complete all the indicated steps.

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 above. 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.

6.17 *General Considerations When Sampling In-Water Piezometers*

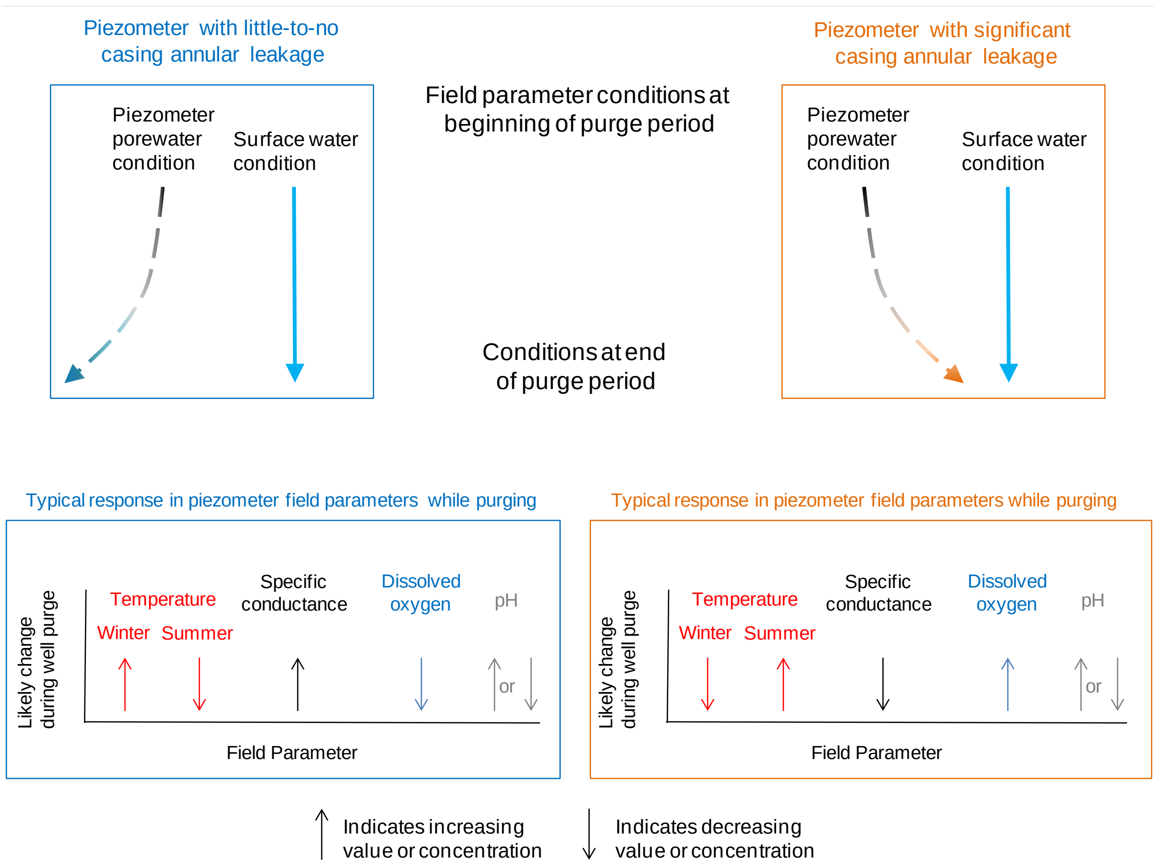
6.17.1 The usual motivation or goal for sampling in-water piezometers is to characterize groundwater quality as-near-as possible to its point of discharge into surface water. This can be especially important for regulatory- and compliance-based projects, since natural bio/geochemical transformations and dilution may significantly alter constituent concentrations in groundwater as it passes through and exits the unconsolidated sediments that typically underlie surface water bodies (e.g. Cox et al., 2005; Ford, 2005; Pitz, 2009).

6.17.2 The goal of collecting representative near-stream porewater samples must always be balanced against the competing need of ensuring adequate hydraulic isolation of the piezometer intake from direct surface water contact. For the rigid-pipe and tubing piezometer designs described in this SOP, the top of the open interval is usually positioned a minimum of 3-5 feet below the sediment surface. This helps to ensure a competent annular seal while also providing sufficient casing length to install streambed thermistors or other instrumentation, if desired.

6.17.3 If your project needs dictate porewater sampling at significantly shallower depths than this (e.g., to characterize near-stream pollutant attenuation/dilution effects), it may be difficult to achieve consistent open interval isolation with traditional piezometer designs. For these situations it's best to use an alternative sampling approach such as those described by Ford, 2005; Zimmerman and others, 2005; and Pitz, 2009.

6.17.4 Ultimately, decisions about the optimum placement depth for a piezometer's open interval and its effective isolation from direct surface water contact are often made in the field using empirical evidence gathered during well installation and development. Absent obvious leakage, the groundwater from an in-water piezometer installed along a gaining stream reach or lake shore will generally be cooler (in summer/afternoon) or warmer (in winter/morning) than the overlying surface water[8]. Additionally, interstitial porewater typically has higher conductivity and lower dissolved oxygen concentrations than overlying surface water (Figure 13). Thus, in the absence of obvious leakage, porewater temperature, specific conductance, and dissolved oxygen values will tend to diverge from those of the overlying surface water during purging.

6.17.5 When measurable leakage is present during purging, the piezometer field parameters will converge on, and in cases of extreme leakage, may equal their corresponding surface water values (Figure 13). This difference in field parameter response during purging provides one simple, semi-quantitative method for evaluating obvious surface water leakage into a piezometer. (Since the water pumped from a leaky piezometer will be a composite of surface water and groundwater, a difference in field parameters between the stream and piezometer porewater is *not* definitive proof of an annular seal. Where possible, always use multiple lines of evidence to establish the efficacy of the annular seal.)



[8] Surface water bodies commonly experience pronounced (several degree) daily and longer-term seasonal fluctuations in water temperature due to daily/seasonal variations in atmospheric and solar heating. Groundwater generally shows little, if any, diurnal temperature variability and only small seasonal differences, since it is typically insulated from the sun and atmosphere by overlying rock or sediment.

Figure 13 – Purge parameter response for a "non-leaky" (left) and "leaky" (right) piezometer installed along a gaining stream reach or lake shoreline

6.17.6 If leakage is present, the water samples collected from a piezometer will not accurately reflect true in situ porewater conditions. Instead, the samples will be biased either high or low depending on each analyte's relative concentration in surface water and groundwater (Figure 14). Always be mindful of this possibility both while sampling and later when evaluating the porewater analytical results obtained from the laboratory.

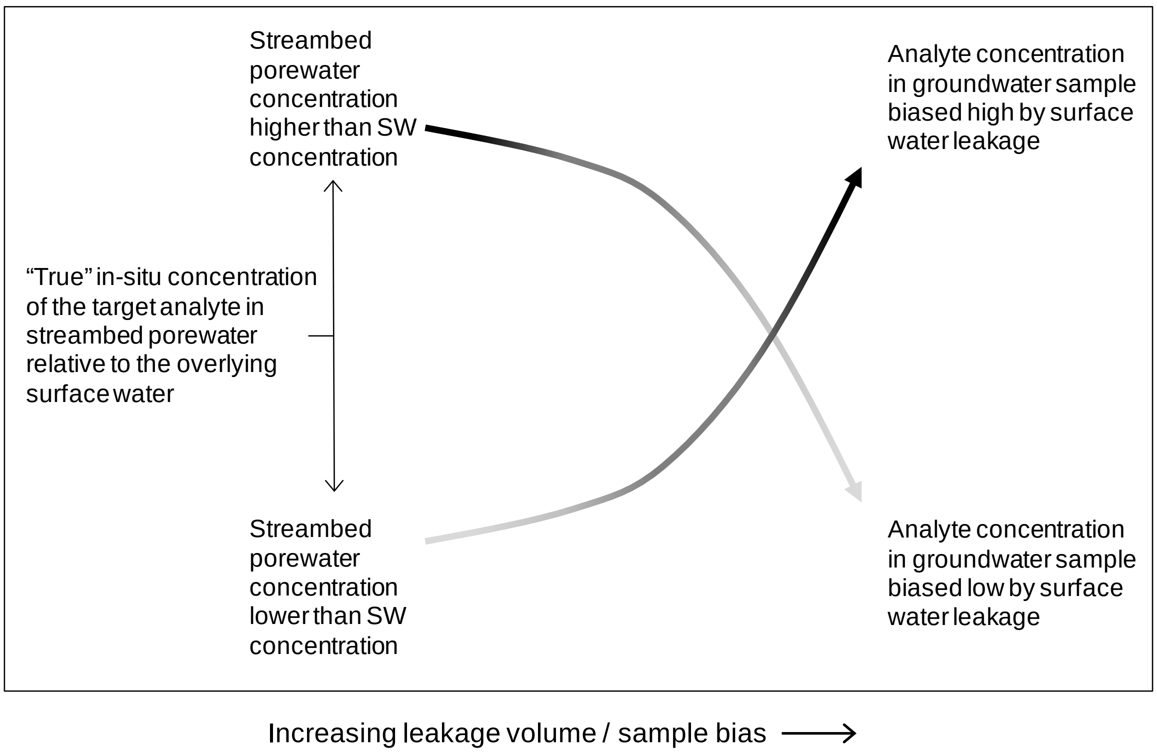


Figure 14 – Conceptual schematic of the potential biases imparted on analytical sample results by piezometer leakage

6.18 *Piezometer Sampling Procedures*

6.18.1 The procedures used to sample in-water piezometers are similar, in most respects, to those used to collect groundwater from traditional upland monitoring wells.

These include:

- Pre-sample preparation (assembling supplies, coordinating with the laboratory, preparing sample tags, calibrating field meters, etc).

- Measuring the static water level in the piezometer for comparison to surface water stage

- Setting up equipment and preparing the site for sampling

- Purging the piezometer and measuring field water quality parameters

- Conducting field based water quality confirmation tests for field sensitive chemical parameters, as appropriate

- Collecting, filtering, preserving, labeling, and preparing samples for laboratory shipment

- Securing the piezometer and sample equipment at the completion of sampling

- Delivering or shipping samples to the laboratory for analysis

- Post-sample equipment cleaning, maintenance, and storage

6.19 *Pre-sampling preparations*

6.19.1 Before the first scheduled sample date for a project, inventory consumable field supplies such as disposable gloves, meter calibration standards, sample tubing, filters, etc. (see Section 5.5 for a list of typical sample supplies and equipment.)

6.19.2 Order any non-laboratory-supplied items that will be needed to complete the project. Plan ahead and allow ample time for delivery. (Most equipment suppliers offer price breaks and reduced shipping costs for larger orders. Take advantage of these opportunities by coordinating equipment purchases with others on the groundwater team, particularly when ordering commonly used items.)

6.19.3 Inspect all field equipment that will be used while sampling, including personal field gear. Verify that field meter(s) calibrate properly per the instrument instruction manual(s) and that pumps and other monitoring equipment are in good working order. Confirm that all portable electrical instruments have fresh batteries (or are fully charged).

6.19.4 If it is cost effective to do so, return defective instruments that are not user-serviceable to the manufacturer for repair. For user-serviceable equipment, install (or order) replacement parts as necessary to restore instruments to good working order. Defective instruments or equipment that cannot be repaired should be sent to surplus.

6.19.5 Arrangements must be made with Ecology's Manchester Environmental Laboratory before each sampling event. The Manchester Environmental Laboratory (MEL) Laboratory User's Manual (Ecology, 2016) contains detailed guidance on the steps required to request, track, ship, and analyze field-collected water quality samples.

6.19.6 To inform the lab of your plans, submit a Pre-sampling Notification Form and a Sample Container Request Form at least 2 weeks before sampling (see Appendix A for example forms). Allow at least 4-6 weeks laboratory lead time for unusually large projects, or those that require the use of a contract lab, non-standard sample shipment, or unique/specialized analyses.

6.19.7 Inventory sample bottles, filters, syringes, and other supplies soon after they arrive from the laboratory. Confirm that the correct type and number of bottles, filters, and other supplies (such as DI water) were shipped to complete all planned sampling including any field QA samples that may be submitted. (It is common to order a few extra bottles and filters for a sample run to ensure an adequate supply in the event a bottle gets dropped or a filter becomes clogged or contaminated during sampling.)

6.19.8 A few days before each scheduled sampling event, confirm that non-dedicated batteries such as those used to power the peristaltic pump are fully charged and reserved for your use.

6.19.9 Prepare field data sheets and sample tags for each site. Assemble other sample-related paperwork such as the Manchester Laboratory Chain-of-Custody/Lab Analysis Required (LAR) form.

6.19.10 To help minimize field-day mistakes, complete as much of the sample paperwork as you can while in the office (e.g., fill in station IDs, analyses required, and laboratory sample IDs). (See Appendix A for examples.)

6.19.11 At the start of each sampling day, load sample cooler(s) with sufficient ice to ensure proper storage temperatures (< 4° C) can be maintained until the day's samples are safely delivered to the OC walk-in cooler or equivalent. Ice machines are located at the EAP operations center and at Ecology headquarters (near the loading dock). (If you will be shipping samples to the laboratory via commercial ground or air carrier, bring enough blue ice to maintain proper sample storage temperatures during shipment. On hot days it may be necessary to periodically drain and replenish coolers with purchased ice.)

6.19.12 If you haven't already, calibrate the water quality field meters per the manufacturer instructions. Supplemental procedures for calibrating Hydrolab® datasondes are described in EAP SOP033, V.1.0 (Swanson, 2010). (Some field meters must be calibrated at the start of each sample day and then checked at mid-day and at the end of the sample day against known standards. Other meters such as the Hydrolab® are more stable and hold their calibration for considerably longer periods. Always follow the appropriate calibration and check procedures for the meter(s) you are using.)

6.19.13 Insert a short (2-3 ft) length of new, clean, flexible wall tubing into the peristaltic pump rotor assembly[9].

6.20 *Field Procedures for Collecting Water Quality Samples from In-water Piezometers*

6.20.1 At the piezometer site, confirm the well tag ID against your pre-printed field form (Figure 15). The IDs must match. Fill in the date and sampling crew initials. In Figure 15, the time field is used to record the sample collection time, so don't complete this field until sampling is complete.

[9] Silastic or other types of soft, flexible tubing can potentially bias water quality results or cause cross contamination between sites by adsorbing chemicals and later releasing them. Strive to minimize the use of flexible tubing during sampling. When using a peristaltic pump to sample in-water piezometers, use only a short length of silastic tubing (to route water through the pump head itself) coupled with less problematic HDPE or other sample-compatible rigid-walled tubing. For most contaminants of concern a short DI rinse between field sites followed by a thorough pre-sample well purging is typically sufficient to prevent tubing-related contamination problems.

Piezometer Water Quality Sampling Field Sheet

Date: 11/ /07 Time: ______ Crew: TR/LB

Well Tag ID: XXX123 Piezo Name: PZ-04-ZZ

Lab Sample #: 07481034

Field Meter: ______

Duplicate: ☐ Equip Blank: ☐ Reference: ☐

Surface Water Parameters:

Time	pH	Temp. (°C)	Cond. (µS/cm)	DO (mg/L)

Purge Parameters:

Time	pH	Temp. (°C)	Cond. (µS/cm)	DO (mg/L)

Piezometer Water Quality Sampling Field Sheet (cont.)

Well Tag ID: XXX123 Piezo Name: PZ-04-ZZ

Purge Parameters (cont.):

Time	pH	Temp (°C)	Cond (µS/cm)	DO (mg/L)

Photometric O_2: Kit: Conc.

Photometric O_2: Kit: Conc.

Colorometric O_2:

Field Alkalinity: Kit: Conc.

Comments:

Figure 15 – Example Field Sheet for recording in-water piezometer field water quality data (front and back) (For wells with installed thermistors, use the sample form shown in Appendix A.)

6.20.2 If you are sampling a rigid steel or PVC piezometer, use a pair of pipe wrenches or equivalent to remove the well cap. To maintain the integrity of the annular seal, work carefully to prevent the piezometer casing from spinning in the sediments. Place the cap in a safe place. If necessary, install an extension pipe to extend the casing top above the water surface. (It's common to add an extension to rigid piezometers a few weeks in advance of the first water quality sampling event to enable the piezometer to be sampled without surface water entering the casing. An extension also allows the piezometer to be completed with a vented cap, which can be advantageous when measuring and sampling low yield piezometers or when deploying a pressure transducer inside the casing.)

6.20.3 Carefully note the position of any installed instrumentation (such as thermistors or transducers). Remove the instrument(s) and set them aside in a safe visible place. Note the instrument removal time on the field data sheet.

6.20.4 If you are sampling a tubing piezometer, locate and retrieve the coiled tubing from the sediment surface.

6.20.5 Allow the piezometer water level to stabilize, and then follow the procedures described in Section 6.16 to measure the piezometer static water level and surface water stage. Follow the measurement procedure most applicable to the piezometer type being evaluated. (When sampling low-yield piezometers that are completed with an above-water vented cap, attempt to measure the piezometer water level before removing any installed instrumentation, if possible. This will expedite sampling since you won't have to wait for the water level to stabilize following instrument removal.)

6.20.6 If the water level measurements indicate a negative hydraulic gradient (suggesting loss of surface water to the underlying sediments) decide whether or not to proceed with sampling based on your specific study goals and objectives. If sampling will not be conducted, reinstall any removed instruments, note the re-installation time on the field form, and secure the piezometer.

6.20.7 If the piezometer exhibits a positive hydraulic gradient (suggesting groundwater inflow to surface water), proceed with sampling by setting up the floating platform adjacent to the piezometer casing (Figure 16). Secure the platform in place so the current doesn't carry it away while working. Place the field meter(s), flow cell, peristaltic pump, and battery on the platform surface. Arrange the items to balance the platform. Orient the flow-cell discharge line so that overflow from the cell discharges to surface water and not onto the platform.

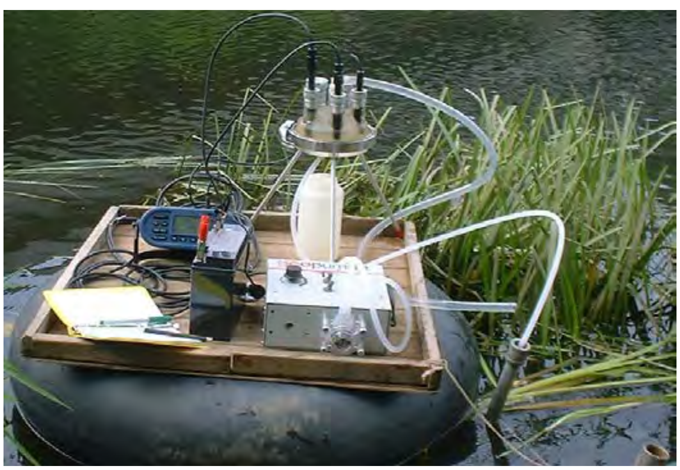


Figure 16 – Floating sample platform and instruments used to sample in-water piezometers

6.20.8 As previously discussed, it is important that one measure and document the field water quality conditions for the adjacent surface water *prior* to purging and sampling a piezometer. These surface water measurements serve two important purposes:

- They provide a useful point of reference for evaluating the piezometer purge status, and

- They also provide a simple and easy way to evaluate obvious (measurable) surface water leakage into the piezometer.

6.20.9 To measure the surface water field parameters, push one end of the pump's flexible-wall tubing over the flow cell inlet port until it seats securely. Insert the other end of the tubing into the surface water a short distance above the point where the piezometer enters the sediments. Attach the pump battery clips to the battery terminals and start the pump. Check the pump rotation and reverse the flow direction if necessary.

6.20.10 Begin pumping surface water through the flow cell. Orient the tubing inlet to avoid pumping floating debris or drawing in bottom sediment. Purge any large air bubbles that remain in the flow cell after it fills[10]. Adjust the pump speed to achieve a steady flow rate of approximately 0.25 to 0.5 L/min. Set the purge rate by timing how long it takes to fill a 0.5 L poly bottle from the the flow cell discharge line.

6.20.11 Turn on the water quality field meter (if you haven't already done so), and begin monitoring the surface water field parameters (temperature, conductivity, pH, DO, and, if applicable, ORP). If you are sampling a steel or PVC piezometer for the first time, use this opportunity to measure and cut a length of new ¼-inch ID rigid wall HDPE tubing for dedicated use when purging and sampling that piezometer.

6.20.12 To do this don a clean set of nitrile gloves and uncoil a short length of tubing from a roll of new, clean tubing. Insert the tubing end into the piezometer until it gently rests at the bottom of the pipe. Carefully cut the tubing so that at final length it extends approximately 2-3 feet above the upper end of the piezometer. (Cutting the tubing at a moderate angle rather than square to the tubing wall will make it easier to complete later sampling steps.) Store the remaining tubing coil in a clean, sealable plastic bag to keep it free of surface contamination. If the piezometer has been sampled previously during the project, simply redeploy the tubing previously prepared and dedicated to the well.

6.20.13 When the surface water readings stabilize, record the final values in the appropriate section of the field datasheet (Figure 15). The convention is to record the following:

- Time in military units, to the nearest minute
- pH, to the nearest 0.01 standard unit

[10] A few small air bubbles in the flow cell pose no problem as long as the probe sensors are completely submerged during measurement, and a constant flow rate is maintained through the measurement chamber.

- Temperature, to the nearest 0.1ºC
- Specific conductance (SC), to the nearest µS/cm (25 ºC reference temperature)
- Dissolved oxygen (DO), to the nearest 0.01 mg/L
- ORP to the nearest mV

6.20.14 After recording the surface water reference values, stop the pump and remove the pump tubing from the surface water. Leave the opposite end of the pump tubing attached to the flow cell inlet port.

6.20.15 If you are sampling a tubing piezometer, push the flexible-wall pump tubing over the upper end of the rigid-wall piezometer tubing until they overlap by about ½" to ¾".

6.20.16 For steel and PVC piezometers press the upper end of the rigid-wall HDPE sample tubing (discussed above) into the flexible-wall pump tubing until they overlap by ½" to ¾". Next, raise the sample tubing until the lower end (intake) is positioned adjacent to the mid-point of the piezometer screen or perforations. Secure the tubing in place. (Positioning the HDPE tubing as described will help minimize sediment production from the well during purging and sampling.)

6.20.17 You are now ready to begin purging the piezometer. Start the pump and adjust the speed until the purge rate settles between 0.25 and 0.5 L/min. If pumping at the above rate causes unacceptable drawdown in the piezometer or bubbles to form in the sample tubing, decrease the pump speed until the bubbles stop and the water level stabilizes. (During purging and sample collection, the pump discharge should ideally be a smooth, solid stream of water with no air or gas bubbles in the tubing or flow cell.) Record the final purge rate on the field data sheet.

6.20.18 Some piezometers installed in low-permeability sediments can be pumped "dry" even while purging at low rates. You may have to shut the pump off periodically during purging to allow the piezometer water level to recover. Repeat this purge and recover cycle 2 to 4 times if possible, measure field parameters, and then proceed with sample collection.

6.20.19 When sampling low-yield piezometers, one must often strike a balance between the time spent sampling and the sample volume retrieved. Communicate with the lab to determine the minimum volume of sample needed to analyze each parameter. If necessary, the lab can often dilute small volume samples to increase method detection limits. If it is likely there won't be sufficient sample volume to complete all of the planned analyses, prioritize sampling to collect the highest priority parameters first.

6.20.20 Once the pump rate is set, begin monitoring and recording the groundwater field parameter values at regular intervals (e.g., every 2 to 3 minutes). The measurement interval should be based on the piezometer purge rate and the estimated time it will take for the groundwater field parameters to stabilize. At a minimum, the recording interval should be long enough to completely exchange the purge water in the flow cell between measurements. Record the field parameters and time of measurement for each interval.

6.20.21 As purging progresses, compare the groundwater field parameters against the previously collected surface water reference measurements. Confirm that the groundwater values aren't converging on the surface water values. If they are, it's possible that surface water leakage into the piezometer is occurring. If leakage is suspected, note this on the field data sheet and attempt to correct the problem before proceeding with sampling.

6.20.22 Also note and document other potentially useful observations such as water clarity and odor. (During well purging, the short periods of down time between measurement intervals present good opportunities to complete any remaining sample-related paperwork. Except for the final sample time, use this opportunity to fill in the remaining fields on sample tags and other paperwork.)

6.20.23 Continue purging until the field parameters stabilize. Field parameters are considered stable when three consecutive readings fall within the following stabilization criteria:

- **pH**: ± 0.1 standard units
- **Specific Conductance**: ± 10.0 µmhos/cm for values < 1000 µmhos/cm, ± 20.0 µmhos/cm for values > 1000 µmhos/cm
- **Dissolved Oxygen**: ± 0.05 mg/L for values < 1 mg/L, ± 0.2 mg/L for values > 1 mg/L
- **Temperature**: ± 0.1° Celsius
- **ORP**: ± 10 millivolts

6.20.24 Record the final values on the field data sheet. (Water temperature is usually the least reliable indicator of stabilization due to atmospheric heating or cooling of the flow cell. Dissolved oxygen (DO) is typically the most reliable indicator of stabilization. We recommend you not begin filling sample bottles until DO concentrations stabilize, even if the remaining field parameters appear stable.)

6.20.25 Do not stop or significantly change the pumping rate between the completion of purging and initiation of sampling. The purging and sample collection steps should be a continuous, seamless process if possible.

6.20.26 After recording the porewater field parameter values, proceed with any additional field-based analyses that may be required for the project (e.g., confirmation of low dissolved oxygen concentrations and/or ferrous iron analyses).

6.20.27 If dissolved oxygen concentrations at the completion of purging was less than 1.0 mg/L (per the field meter), and an accurate reading of DO is important to the project goals, use a field photometer or colorimetric test kit to verify the result[11].

6.20.28 To perform the verification test using EAP's field photometer, detach the flexible wall tubing from the flow cell inlet port and attach the DO sampling cone (do not filter samples collected for DO analysis). Stabilize the cone in an upright position so that water from the piezometer flows up and over the rim of the cone[12]. Place an unused vacuum ampoule of the appropriate concentration range into the cone, tip end down, and allow its temperature to equilibrate with the water being pumped from the piezometer. While keeping the ampoule submerged, snap the tip by pushing the narrow lower-end into the side of the sampling cone. Water will be pulled by vacuum into the ampoule. Dry the ampoule, and place it into the "pre-zeroed" field photometer to make a reading. Record the resulting value on the field sample sheet. Detailed instructions and additional guidance for using the photometer (or colorimetric test kits) are provided in the equipment manual.

6.20.29 When all field analyses are complete, proceed with the collection of samples intended for laboratory analysis. It's good practice to employ "clean hands/dirty hands" sampling techniques among team members to minimize the potential for sample contamination. Anyone who handles bottles, filters, or other equipment that will contact the samples should put on a clean pair of nitrile gloves before sampling commences.

6.20.30 Avoid possible contamination by keeping sample containers capped until it's time to fill them.

6.20.31 Samples should be collected in the order specified in the project QAPP. The order of sample collection, processing, and preservation should be adhered to consistently throughout a project.

6.20.32 For surface water/groundwater interaction studies conducted by EAP staff, water samples intended for laboratory analysis are typically collected in the following order[13]:

- Unfiltered, unpreserved samples (e.g., BNA semi-volatiles)[14]
- Unfiltered, preserved samples (e.g.VOCs)

---

[11] Spectrophotometric test vials are also available for DO concentrations between 2.0 and 15.0 mg/L, if necessary.

[12] A bracket to hold the DO cone upright can be attached to the side of the floating platform.

[13] If additional (or alternative) parameters will be evaluated, decide in advance where in the sampling sequence they should be collected. As a general rule, unpreserved samples are most always collected prior to preserved samples. Similarly, volatile parameters are always collected prior to non-volatile parameters. When sampling low-yield wells that do not produce enough water to fill all sample bottles, collect samples for the analytes of greatest interest first to ensure a representative sample is obtained for these parameters. Also, if you will be collecting samples at multiple sites, sample the least contaminated sites first.

[14] Since in-water piezometers are constructed without a conventional screen and filter pack, unfiltered samples may contain sorbed or suspended chemicals that are not normally mobile in the fluid phase. If laboratory analysis is conducted without further treatment of the sample, this extra material could bias the concentration results. Extra caution should be used to minimize this bias if you plan to collect unfiltered samples.

- Filtered, unpreserved samples (e.g., TDS, chloride, fluoride, sulfate, orthophosphate)
- Filtered, preserved[15] samples (in the following example order):
  - Organic parameters (e.g., DOC)
  - Total phosphorus
  - Nitrogen-based parameters (e.g., nitrate+nitrite-N, ammonia-N, TPN)
  - Inorganics (e.g., iron, silica, calcium, magnesium, sodium, potassium, and heavy metals)

6.20.33 The sampling order that is ultimately selected for a project should focus on preventing cross-contamination. For example, samples that are preserved using a nitrogen-based preservative such as nitric acid should be collected only after the sampling for nitrogen-based parameters of interest has been completed.

6.20.34 Unfiltered samples are collected by filling the sample bottle(s) directly from the pump discharge tubing.

6.20.35 Depending on the analyte being evaluated, filtered samples are typically collected using either a syringe or in-line, cartridge-based filter.

6.20.36 Syringe-based filters are often analyte specific (e.g., DOC) and attach via a threaded coupler to a 60 ml syringe (Figure 17).

Figure 17 – Syringe filtering of samples

6.20.37 Prior to conducting syringe-based sample filtration, thoroughly rinse the syringe (inside and out) with DI water or with water from the piezometer being sampled.

[15] Whenever possible, obtain pre-preserved sample bottles from the laboratory for these analyses.

Attach a new, clean filter to the syringe end. Be sure to use the appropriate filter for each analyte of concern (see WA. Dept. of Ecology, 2017). Withdraw the plunger and fill the syringe with laboratory-supplied DI water. Reinsert the plunger and purge the entire syringe volume (60 ml) through the filter to remove potential residual contamination from the filter manufacturing process. Again withdraw the plunger and refill the syringe with water from the piezometer. (It is generally easier to withdraw the plunger without the filter attached.) Purge an additional 30+ ml of well water through the filter to clear the initial filtrate before you begin filling sample bottles.

6.20.38 To collect samples using an inline cartridge filter, begin by attaching a clean pressure-fitted filter connector to the discharge end of the pump tubing. Start the pump and thoroughly rinse the filter connector interior and exterior with well water. Thread a clean 0.45 µm in-line capsule filter onto the connector. Purge at least 300-500 ml of porewater through the filter before you begin filling sample bottles.

6.20.39 When filling sample containers, the discharge line (or filter tip) should be near but not touching the sample container or other items (Figure 18). Best practice is to point the filter discharge tip upward at a 45 degree angle so the sample stream arcs up into the bottle. This will prevent water from the filter exterior or your gloves from accidentally dripping into the sample.

6.20.40 Fill containers to their shoulder and cap them immediately after collection. Avoid overfilling containers, especially those that are pre-acidified. (There is an important exception to this rule: when collecting samples for laboratory analysis of total alkalinity, fill the container completely so little-to-no air space remains when the bottle is capped.) Bottles containing acid preservative should be capped and inverted a few times after filling to thoroughly mix the sample. If any acid escaped from the bottle while filling, discard the sample and start over with a fresh sample container.

Figure 18 – Filtering samples with an inline cartridge filter

6.20.41 If a filter becomes clogged while sampling, unscrew the spent filter (with the pump still running) and attach a new filter. Repeat the process of flushing and discarding the first 300-500 ml of filtrate, before you resume sampling.

6.20.42 As you fill sample bottles, remember to collect quality control (QC) samples such as a field duplicate from the well(s) specified in the project QAPP. Field duplicate samples are collected at the same time as the primary sample by alternating the sample stream between two containers of the same type. The same bottle types are often used to collect samples for different analyses (e.g., DOC and Dissolved TP). Since these analytes may require different filter types, take care to keep filled sample bottles separate until they are appropriately tagged. This is true for field duplicate samples too.

6.20.43 Record a common collection time to the nearest quarter hour on each of the sample tags for a station (and at the top of the field sheet – Figure 15). When all bottles are full and properly tagged, confirm one final time that the laboratory sample number on the tags and field sheet match correctly to the station. Put all of the samples collected for a station into a plastic bag, knot or twist tie the top and place the bag in an ice-filled cooler. Samples must remain at or below 6°C throughout handling, storage, and shipping. Do not freeze samples.

6.20.44 Field QA samples such as duplicates and equipment blanks are usually submitted to the laboratory as "blind" samples (i.e. they are not identified in any special manner for the laboratory; they are instead submitted under a false station name in a manner consistent with a normal sample.) Standard practice is to assign a station ID and laboratory number to a duplicate sample set that is distinct from the primary sample set. Indicate a time of collection 15 to 30 minutes before or after the time assigned to the primary sample set. Bag field duplicate sample sets in a separate bag from the primary set. If you are collecting QA samples that are specifically necessary for laboratory testing (e.g., matrix spike samples), label and bag the samples the same as, and along with, the primary sample set.

6.20.45 Record any final observations or comments related to sample collection on the field data sheet.

6.20.46 Analysis for alkalinity (which is required if evaluation of ionic chemistry is of interest) is ideally a field-based test, that should be conducted on a filtered sample. Samples for alkalinity testing can be collected after all laboratory-bound samples have been collected, or while sampling for filtered general chemistry. Instructions for conducting the field alkalinity analysis are contained in the test kit. If for any reason you cannot conduct alkalinity analysis in the field, *fully* fill an appropriate laboratory-supplied container (no head space), keep the sample cool, and make a special note to the laboratory analyst to titrate the *entire* sample volume.

6.20.47 When all sampling tasks for the site are complete, remove the ¼” dedicated HDPE sample tubing from the piezometer. Label the tubing and place it in a clean, sealable, plastic storage bag until the next sample round. Carefully replace any instrumentation that was removed from the piezometer during sampling. Note the reinstallation time on the field data sheet. When all work at the site is complete, properly close and secure the well. (Take care to avoid twisting the piezometer casing when reinstalling the well cap.)

6.20.48 If a tubing piezometer was sampled, loosely coil any tubing that projects above the sediment surface, seal the upper end of the tubing, and lay the coiled tubing on the stream bottom or lake bed. Where waves or current are present, the upper tubing end can be inserted into a short length of steel pipe or otherwise weighted to hold it in place between sample events.

6.21 *Sample Transport to the Lab*

6.21.1 At the end of each sampling day complete the LAR form. Carefully check the form against the sample numbers and times you recorded on the field sample sheets. Retain a copy of the LAR form for your records.

6.21.2 If samples will be shipped to the laboratory by commercial air or freight services they must first be transferred to a cooler(s) containing blue ice. Most commercial carriers won’t ship containers that contain ice due to potential leakage issues. Place the original LAR form in a zip lock bag to keep it dry during shipment and place it on top of the samples inside the cooler. Complete any sample shipment paperwork required by the shipping company. Securely tape the cooler lid closed with duct tape or packing tape before surrendering the cooler(s). Retain a copy of the shipping manifest for your project files. To minimize potential problems during sample shipment, always follow the procedures in the project QAPP or Manchester Lab Manual (MEL, 2016).

6.22 *Post sampling equipment maintenance and instrument storage*

6.22.1 At the completion of each sampling event, properly clean, store, and repair (if necessary) all equipment so that it will be ready for future use. If equipment malfunctioned or was damaged during use, don't place it back on the OC shelf until it has been repaired and is working properly. Follow the equipment manufacturer instructions for proper cleaning and storage of water quality field meters and probes. Dirty e-tapes and other measurement equipment should be cleaned prior to placing it back on the OC shelves.

6.22.2 If group supplies such as DO ampoules or meter calibration standards are running low at the end of your sample event, take the initiative to place an order for additional supplies so that they will be available in advance of future sampling events.

6.23 *Decommissioning piezometers*

6.23.1 If a piezometer was installed to a depth of greater than 10 feet below the sediment surface, 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) the piezometer (See Appendix A for additional details). The intended decommissioning procedure(s) should follow those outlined in the project well construction variance.

6.23.2 Depending on local site conditions, steel piezometers are most commonly removed with the following methods:

- Twisting and pulling the casing with opposed pipe wrenches,
- Attaching chains or a star-clamp assembly to the casing and extracting it with high-lift jacks, or
- Back hammering against a star clamp assembly with sledge hammers.

6.23.3 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.

6.23.4 If it is not possible to remove a piezometer by hand, always use two jacks to decommission a steel piezometer—each with an attached 3- to 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.

6.23.5 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 19). 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.

6.23.6 Secure the loose end of each chain to its corresponding jack with a chain hook. Tightly wrap a third length of chain around the casing and the two jack bases and secure with a chain hook.

6.23.7 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. (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 19 – Decommissioning a steel piezometer with high-lift jacks

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

6.23.9 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.

6.23.10 After the casing has been removed, fill any hole that remains with fine sediment.

6.23.11 If there was a well construction/decommissioning variance issued for the project that specifies additional abandonment steps, proceed with and document the procedure(s) on the well decommissioning form.

6.23.12 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, 2009 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 To ensure that representative, good-quality data are obtained during a project, a Quality Assurance Project Plan (QAPP) must be completed and approved before undertaking field work. The QAPP details project goals, data quality objectives, quality assurance program procedures, sample handling requirements, and field and laboratory procedures.

8.2 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, 2009), the procedures for measuring water levels and calibrating water level meters (Marti, 2009).

8.3 Repeat measurements of the piezometer 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.

8.4 The equipment and procedures used to collect and handle groundwater samples introduce some degree of unavoidable error (variability and/or bias) into analytical results. To minimize error introduction, all field staff should follow accepted QA/QC procedures when collecting samples. These include the following practices:

- Following the project QAPP and applicable standard operating procedures when collecting and handling samples.
- Using consistent sampling procedures from well to well.
- Calibrating and post checking field water quality meters according to the manufacturer instructions and project QAPP.
- Using analyte compatible equipment during well purging and sampling. Operating and maintaining equipment according to the manufacturer instructions.
- Properly collecting, handling, and storing samples per the procedures specified in the project QAPP or Manchester Lab Manual.
- Collecting appropriate quality control samples. These may include field duplicates and/or a field blanks (e.g. filter, equipment, or transport). The type and number of quality control samples should be specified in the project QAPP.
- Documenting field measurements, observations, notes, deviations from the project QAPP, etc. on the field data sheets and other project paperwork.
- Properly cleaning, maintaining, and storing field equipment after use.

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 Many of the sample bottles supplied by the Manchester Laboratory contain acid preservative. Always wear protective gloves when uncapping and filling acidified bottles. Take care to avoid inhaling acid vapors that may escape when filling sample bottles. Also avoid acid contact with clothing, skin, or eyes.

9.6 Use caution when sampling in or around water with deep cycle batteries.

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

- Float Plan Form (if using a boat to access sites)
- Field Work Plan and Contact Person Form

10.0 References

10.1 Bilhimer, D., and Stohr, A., 2009, Standard Operating Procedures for continuous temperature monitoring of freshwater rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature. Environmental Assessment Program, EAP044, Version 3.0. www.ecology.wa.gov/quality

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 EPA, 1991, A review of methods for assessing nonpoint source contaminated ground-water discharge to surface water. U.S. EPA Groundwater Protection Division, Office of Water Publication EPA 570/9-91-010, 99p.

10.4 Ford, R.G., 2005, The impact of groundwater/surface water interactions on contaminant transport with application to an arsenic contaminated site. U.S. EPA Environmental Research Brief, National Risk Management Research Laboratory, Ada, OK. EPA 600-S-05-002, 22p. www.epa.gov/ada/download/briefs/epa_600_s05_002.pdf

10.5 Geist, D.R., Joy, M.C., Lee, D.R., and Gonser, T., 1998, A method for installing piezometers in large cobble bed rivers, Ground Water Monitoring and Remediation, Vol. 18, No. 1, p. 78-82.

10.6 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. www.ecology.wa.gov/quality

10.7 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.

10.8 Konrad, C. P., 2006, Longitudinal hydraulic analysis of river-aquifer exchanges: Water Resources Research, 42, W08425, doi:10.1029/2005WR004197

10.9 Lee, D.R., and Harvey, F.E., 1996, Installing piezometers in deepwater sediments, Water Resources Research, Vol. 32, No. 4, p. 1113-1117.

10.10 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 1.1. www.ecology.wa.gov/quality

10.11 Marti, P.B., 2011, Standard operating procedure for purging and sampling monitoring wells. Washington State Department of Ecology, Environmental Assessment Program, EAP078, Version 2.0. www.ecology.wa.gov/quality

10.12 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. https://fortress.wa.gov/ecy/publications/summarypages/0603042.html

10.13 Pitz, C.F., 2009, High-resolution porewater sampling near the groundwater/surface water interface, Washington State Department of Ecology, Publication No. 09-03-017, 41 p. https://fortress.wa.gov/ecy/publications/summarypages/0903017.html

10.14 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

10.15 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

10.16 Washington State Department of Ecology, Environmental Assessment Program, 2017, Safety Manual. 192 p.

10.17 Washington State Department of Ecology, 2016. Manchester Environmental Laboratory - Lab Users Manual. 9th edition.

10.18 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

10.19 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/

10.20 Zimmerman, M.J., Massey, A.J., and Campo, K.W., 2005. Pushpoint sampling for defining spatial and temporal variations in contaminant concentrations in sediment pore water near the ground-water/surface-water interface. U.S. Geological Survey Scientific Investigations Report 2005-5036, 75 p. http://pubs.usgs.gov/sir/2005/5036/pdf/sir2005_5036.pdf

Appendix A: Example Forms

EAP has developed several spreadsheet templates to speed up 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.

Up-to-date laboratory related forms can be obtained using the Manchester Laboratory link provided on EAP's intranet home page.

Example Form – Resource Protection Well Completion Report

RESOURCE PROTECTION WELL REPORT

CURRENT
Notice of Intent No.__________________

(SUBMIT ONE WELL REPORT PER WELL INSTALLED)

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)__________________

Tax Parcel No. __________________

Driller/Engineer/Trainee Signature __________________

Cased or Uncased Diameter ______ Static Level______

Driller or Trainee License No.__________________

Work/Decommission Start Date __________________

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

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: ______________________

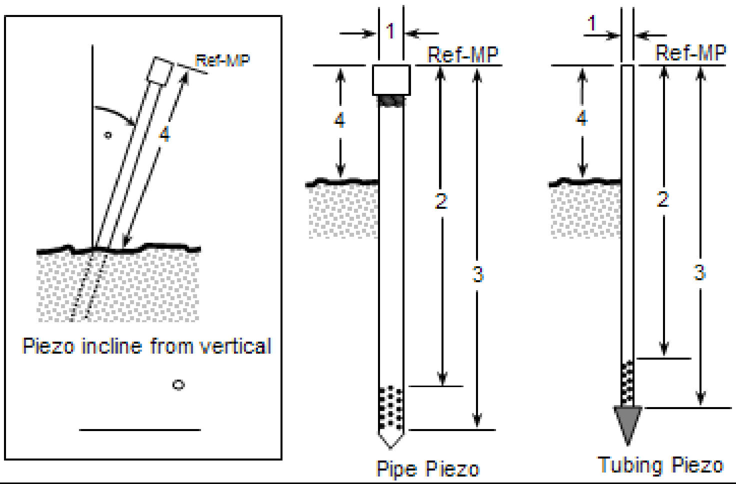
DD Long: ______________________

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

____

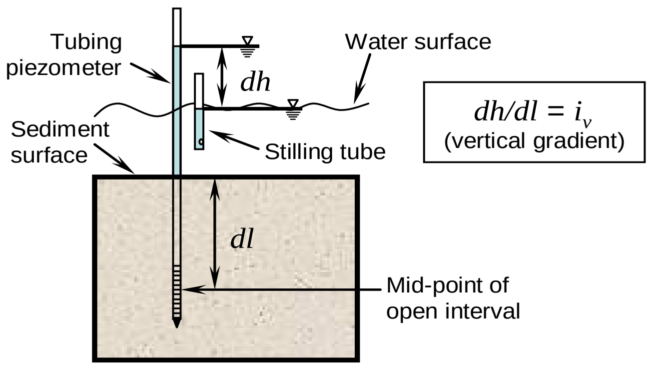
____

Example Form – Manometer Measurement

Tubing Piezometer Measurement

Stickup Length (measuring point to streambed) ____________

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



Manometer board measurements

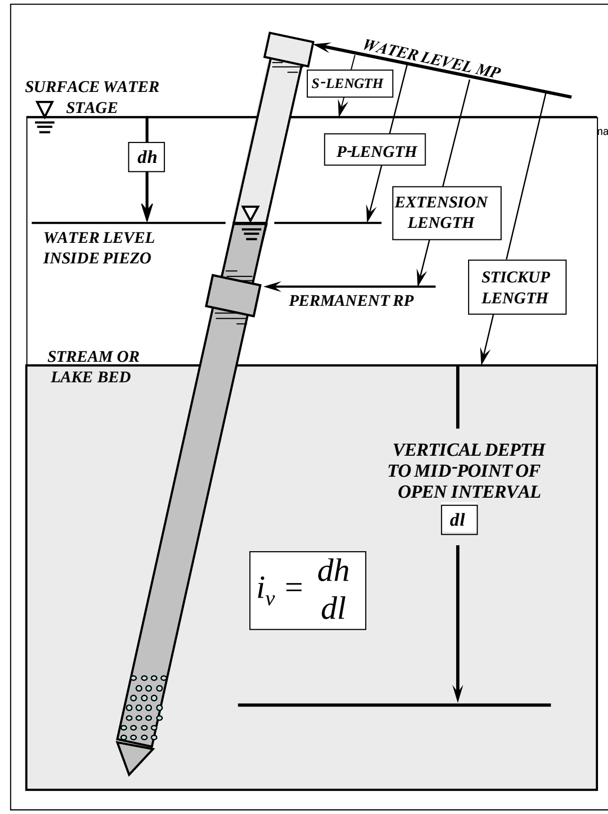
Surface Water (cm)	Piezometer (cm)	Head Difference (SW – Piezo)

Example Form – Manual Water Level Measurement

Piezometer Water Level Field Sheet (Hand)

Date: ___________ **Time:** __________ **Crew:** ________________

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

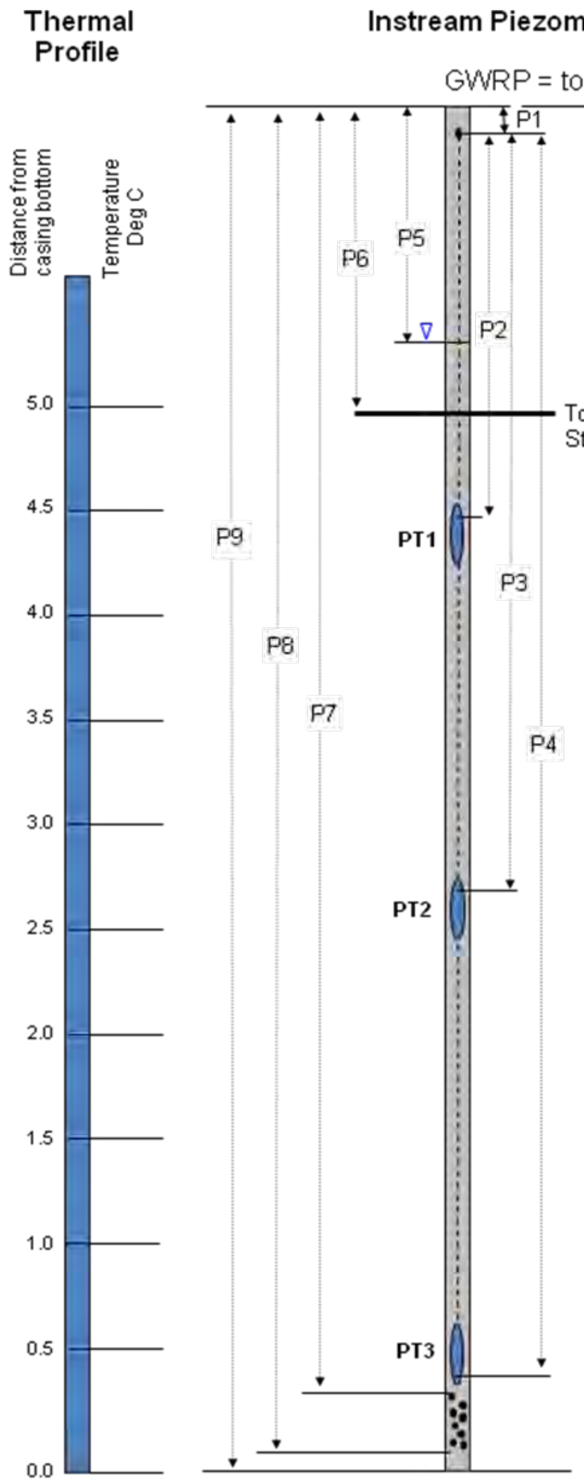


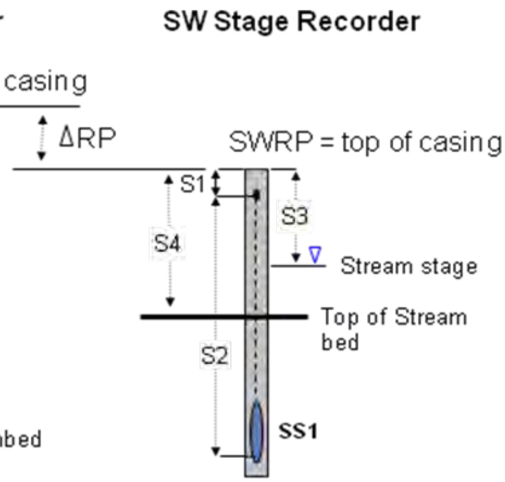
Water Level MP: TOC other: ____________________________

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





Casing Inclination angle (Degrees off vertical)

Piezometer_________

Stage Recorder________

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= ____________________

Well tag ID:______________ County: _____________________
Stream name and station location: _______________________________
____
Date__/_____/__ Time__________
Weather____________________ Party: ______________

Piezometer Physical Measurements (measure each time as appropriate)

Depth to water inside piezometer pipe (GWL)___________(ft)

Distance to water outside piezometer pipe (stream tape-down)____________(ft)

Total length (ft)________ Stickup (ft above streambed)__________ Extension length (feet)_______ Stream depth (feet)______

Water Quality Observations

Meter Type and Number: ____________________

SW Temp _________ (°C) SW conductivity___________(um/cm@25°C) (us/cm@25°C)

GW Temp_________ (°C) GW conductivity___________(um/cm@25°C) (us/cm@25°C)

Thermistor Data

	Thermistor Serial Number	Removal Time	Reinstall time	Distance Above bed	Distance below surface
Air					
Stream					
Piezo Upper					
Piezo Middle					
Piezo Lower					
Stream Transducer					
Piezo Transducer					

SAMPLING DATA (required only if piezometer is sampled)

Surface Water Reference Measurements (taken from flow cell):

Temperature ________________(C) Conductivity________________(us/cm)

pH _______________ (std units) DO ___________________(mg/L)

Piezometer Purge Data

Purge Time (minutes)	GW Temperature (Degrees C)	GW Conductivity (us/cm @ 25C)	GW pH (standard units)	GW Dissolved Oxygen (mg/L)	GW ORP (mV)

Sample time: ________________

Manchester LAB number: ______________

Duplicate sample collected (Circle one) YES NO

Duplicate time:_____________

Duplicate lab number: _________________

OTHER COMMENTS OR OBSERVATIONS:

Sample Container Request Form

Please **FAX** to: (360) 871-8850
Contact: Leon Weiks, Lab Assistant and Courier
Phone: (360) 871-8825 Email: lwei461@ecy.wa.gov
Please allow about 2 weeks for typical requests; longer for special requests

Requestor: ____________________ Project Name: ____________________

Phone: ____________________ Today's Date: ____________________

Location for Delivery: ____________________ Date Needed by: ____________________

Index #	Description	Qty.
1	1 gallon jar WM, CLR (BNA)	
2	1/2 gallon jar WM, CLR	
3	1 liter jar WM, CLR (Organics) for HCID only, no preservative	
4	1 liter jar NM, CLR w/ 1:1 HCl 15mL dropper bottle included (Oil & Grease)	
7	16 oz short jar WM, CLR	
5	8 oz short jar WM, CLR	
8	4 oz short jar WM, CLR	
34	2 oz short jar WM, CLR	
13	2 oz short jar WM, CLR, w/septum	
11	40mL vial AMB w/septum □ pre-preserved with HCl □ dropper bottle of HCl □ ascorbic acid for chlorinated VOA samples	
14	20mL vial w/acetic acid (Carbamates)	
39	1 liter glass NM, AMB (TPH-D)	
15	1 liter glass NM, AMB (All other Organics)	
16	500mL HDPE bottle w/5mL 1:1 nitric acid (Metals including **standard** level mercury)	
17	1 gallon cubitainer (BOD)	
19	125mL Nalgene WM, CLR w/1:1 sulfuric acid (Nutrients or COD)	
20	125mL Nalgene WM, AMB (filters and syringe also required for orthophosphate)	
21	125mL poly NM, CLR (Hardness) w/ 1:1 sulfuric acid *Hexachrome request w/o acid*	

Index #	Description	Qty.
22	500mL poly WM, CLR (General Chem.)	
23	1000mL poly WM, CLR (TSS)	
24	1000mL poly WM, AMB (Chlorophyll)	
25	250mL poly NM, AMB (Cyanide)	
26	125mL poly WM, CLR w/ 1:1 hydrochloric acid (TOC/DOC or TP) □ Filters and syringe for DOC	
27	250mL poly WM, CLR (Fecal Coli)	
28	500mL poly WM, CLR (Multiple Micro Tests)	
29	250mL poly WM, CLR w/thiosulfate (Fecal Coliform - Chlorinated)	
30	500mL poly WM, CLR w/thiosulfate (Multiple Micro Tests - Chlorinated)	
31	8oz plastic jar (Grain size only)	
32	1 liter jar WM, CLR w/sulfuric acid (Phenolics)	
33	4oz sterile specimen cup (Micro - sediment)	
35	Soil VOA/BTEX Airtight Sampling Capsules (3 per sample)	
36	Soil VOA/BTEX Sampling Handle (1 per sampling event)	
37	500mL Teflon NM, CLR (low level mercury ONLY) □**Total**, Recoverable - nitric acid and no filter □**Dissolved** w/filter and nitric acid	
38	Nalgene Metals Filters 0.45um	
Other Supplies		

All containers for organics are organic free with Teflon lined lids
WM = Wide Mouth **NM** = Narrow Mouth **CLR** = Clear **AMB** = Amber

Pre-Sampling Notification Form

Fax to Manchester Laboratory: (360) 871-8850
OR email to Nancy Rosenbower: nros461@ecy.wa.gov AND cc: Leon Weiks: lwei@ecy.wa.gov

Project Name: ______________________ **SIC:** ______________ ☐Enforcement

Requested by: ______________________ Sampling Date(s): ______________ ☐Monitoring

Program: ______________________ Date to Lab: ______________ ☐Emergency

Phone No.: ______________________ Sample Pickup Location: ______________ ☐Class II

Date results needed by: ______________ EIM Study ID (if available) ______________ ☐Preliminary Invest

Reference # of QAPP: ☐Special turnaround

General Chemistry	W	S	O	Microbiology	W	S	O	Organic Chemistry	W	S	O
Alkalinity				Fecal Coliforms ☐MF ☐ MPN				Base/Neutral/Acids (BNA)			
Conductivity				E. Coli MF				Polynuclear Aromatics (PAH)			
Hardness				E. Coli MPN							
pH								Volatile Organic Analysis (VOA)			
Turbidity								BTEX			
☐ Fluoride ☐Chloride ☐ Sulfate								Pest/PCBs (Organochlorine)			
Cyanide ☐Total ☐ Dissociable				**Metals**	W_T	W_D	S / O	Pesticides only (Organochlorine)			
Total Solids				Priority Pollutant Metals (13 elements)				PCBs only			
Total Nonvolatile Solids (TNVS)				TCLP metals				OP - Pests (Organophosphorous)			
Total Suspended Solids (TSS)				Hardness				Herbicides (Chlorophenoxy)			
Total Nonvolatile Suspended Solids (TNVSS)								Nitrogen Pesticides			
Total Dissolved Solids (TDS)				Mercury (Hg) ☐ Regular ☐ Low Level				Organochlorine Pesticides by GCMS 8270			
Chlorophyll ☐ Filtered in field ☐ Filtered at lab				Other: List individual elements below:				PBDEs			
% Solids								Hydrocarbon ID (match to source)			
% Volatile Solids (TVS)								TPH-ID (gas/diesel/oil)			
Total Organic Carbon								TPH-Dx			
Dissolved Organic Carbon								TPH-Gx			
Biochemical Oxygen Demand (BOD) 5 day											
BOD - Inhibited											
BOD - Ultimate											
Ammonia											
Nitrate-Nitrite											
Orthophosphate											
Total Phosphorous											
☐ TPN ☐ TKN											

Comments: Enter the number of samples in the appropriate box(es) above W = water S = soil/sediment O = other (please specify)
W_{TR} = water total W_D = water dissolved

ECY 040-2-62 (Rev. 11/15) Ecology is an Equal Opportunity Employer.

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 (https://www.epermitting.wa.gov/site/alias__resourcecenter/jarpa/9983/jarpa.aspx). 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 shorelines permit exemption and to declare your project's categorical exemption from the State Environmental Policy Act (SEPA) (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.

Many counties charge a fee to process the shorelines exemption paperwork. Use an A19 form (available internally from http://awwecology/sites/asi/forms/Shared%20Documents/A19-1A.docx) 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 (www.callbeforeyoudig.org). Allow 3-5 working days for utility locations to be marked.

Well Construction and Decommissioning Requirements for Piezometers Greater Than 10 Feet Deep

If you intend to construct an in-water piezometer (either temporary or permanent) that is greater than 10 feet deep and which 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 you will be working for details.

“Temporary” piezometers are installed just long enough to perform a single water-level measurement or to collect 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.

For in-water piezometers greater than 10 feet deep, 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 installation. Notice of intent forms are not required for wells less than 10 feet deep. 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 12-foot deep Environmental Investigation wells (temporary piezometers) and four 15-foot deep 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://awwecology/sites/asi/forms/Shared%20Documents/A19-1A.docx) 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 under the terms of a notice of intent (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	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 for in-water piezometers greater than 10 feet deep[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)