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Walla Walla Basin Watershed Council
541-938-2170 or 7086 P.O.Box 68, Milton-Freewater, OR 97862

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Walla Walla Basin Aquifer Recharge
Water Quality and Water Level Monitoring
Quality Assurance Project Plan

Steven Patten
Senior Environmental Scientist
Walla Walla Basin Watershed Council

- FINAL PLAN -

May 2013 – Version 1.2

APPROVAL SIGNATURES

5-6-2013

Steven Patten, Walla Walla Basin Watershed Council
Date

5/9/2013

Mike Kuttel, Washington Department of Ecology (WQ)
Date

5/10/13

Jim Ross, Washington Department of Ecology (EAP)
Date

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Appendix C – Review of Previously Collected Source Water and Groundwater Quality data from Alluvial Aquifer Recharge Projects in the Walla Walla Basin, Washington and Oregon

REVISION HISTORY

Revision Date	Revision Number	Summary of Changes	Sections Changed	Reviser(s)
03/2013	1.0	Creation of QAPP Document	All	Steven Patten
04/2013	1.1	WDOE Comments/Changes	Sampling Process and Quality Control	Steven Patten, Mike Kuttel, Jim Ross
05/2013	1.2	WDOE Comments/Changes	Metals Lab Measurements	Mike Kuttel, Jim Ross

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Name	Affiliation	Title	Address	Phone Number	Email Address
Steven Patten	Walla Walla Basin Watershed Council	Senior Environmental Scientist	810 S. Main St. Milton-Freewater, OR 97862	541-938-2170	steven.patten@wwbwc.org
Mike Kuttel	Washington Department of Ecology	Water Quality Program	4601 N. Monroe St. Spokane, WA 99205-1295	509-329-3414	MKUT461@ECY.WA.GOV
Guy Gregory	Washington Department of Ecology	Water Resources Program - Hydrogeologist	4601 N. Monroe St. Spokane, WA 99205-1295	509-329-3529	ggre461@ecy.wa.gov
Victoria Leuba	Washington Department of Ecology	Water Resources Program	4601 N. Monroe St. Spokane, WA 99205-1295	509-329-3616	vleu461@ecy.wa.gov
Eric Hartwig	Washington Department of Ecology	Water Resources Program – Water Master		509-540-7680	ehar461@ecy.wa.gov
Bill Zachmann	Washington Department of Ecology	Water Resources Program – Grant Manager	P.O. Box 47600 Olympia, WA 98504-7600	360-407-6548	bzac461@ecy.wa.gov

BACKGROUND AND PROJECT DESCRIPTION

The Walla Walla River basin is located in northeast Oregon and southeast Washington. The Walla Walla basin has a very productive agricultural community that relies upon the watershed's water resources, both surface water and groundwater. Most of the basin's surface water systems have been developed to benefit agricultural or municipal uses. Increasing demand for water and limited surface water supply during the summer and fall has led to extensive development of groundwater resources as well. Historically, portions of the Walla Walla River and Touchet River went dry due to diversions. With the listing of steelhead and bull trout as threatened under the Endangered Species Act, local irrigation districts signed an agreement with US Fish and Wildlife Service to leave a significant portion of their water rights (25-27 cfs in Oregon and 18 cfs in Washington) instream to benefit the ESA-listed species. This agreement led to further development of the alluvial and basalt aquifers to supplement reduced surface water diversions. Also, to increase efficiency, many of the canals and ditches across the Walla Walla Valley have been piped to reduce delivery system seepage loss. The combination of increased groundwater usage (over many decades), an expanding number of canals and ditches being piped and a reduction in floodplain function precipitated by development along surface water bodies and flood control systems has resulted in declining groundwater levels throughout much of the alluvial aquifer. The alluvial aquifer is in direct hydraulic connection with many of the basin's rivers, streams and creeks (Marti, 2005 and WWBWC, 2012a).

The Walla Walla Basin Aquifer Recharge Program is addressing the need to stabilize and restore the alluvial aquifer and thus improve low-flow conditions in hydraulically connected streams. Unlike many other aquifer recharge projects being implemented nationally and internationally, Walla Walla alluvial aquifer recharge projects are not currently being implemented for aquifer storage and recovery (commonly referred to as ASR). Although some use of the improved aquifer is likely occurring at wells down gradient of the current aquifer recharge (AR) sites, the primary purpose is for public and regional benefit to restore the aquifer and enhance or support groundwater contributions to instream flow thereby maximizing the resource's potential with multiple benefits for aquatic life, recreational water use, domestic use, and irrigation use (WWBWC, 2013).

PROJECT AREA

The Walla Walla Watershed covers approximately 1,758 square miles in northeast Oregon and southeast Washington (Figure 1). The primary water body is the Walla Walla River. The Walla Walla River's main tributaries include the Touchet River, Mill Creek, Pine Creek, Dry Creek (OR), Dry Creek (WA), and Couse Creek. Individual projects in the Walla Walla Basin Aquifer Recharge Program are located on the valley floor generally north and west of Milton-Freewater, OR, south and west of Walla Walla, WA and south and east of Touchet, WA (Figure 2).

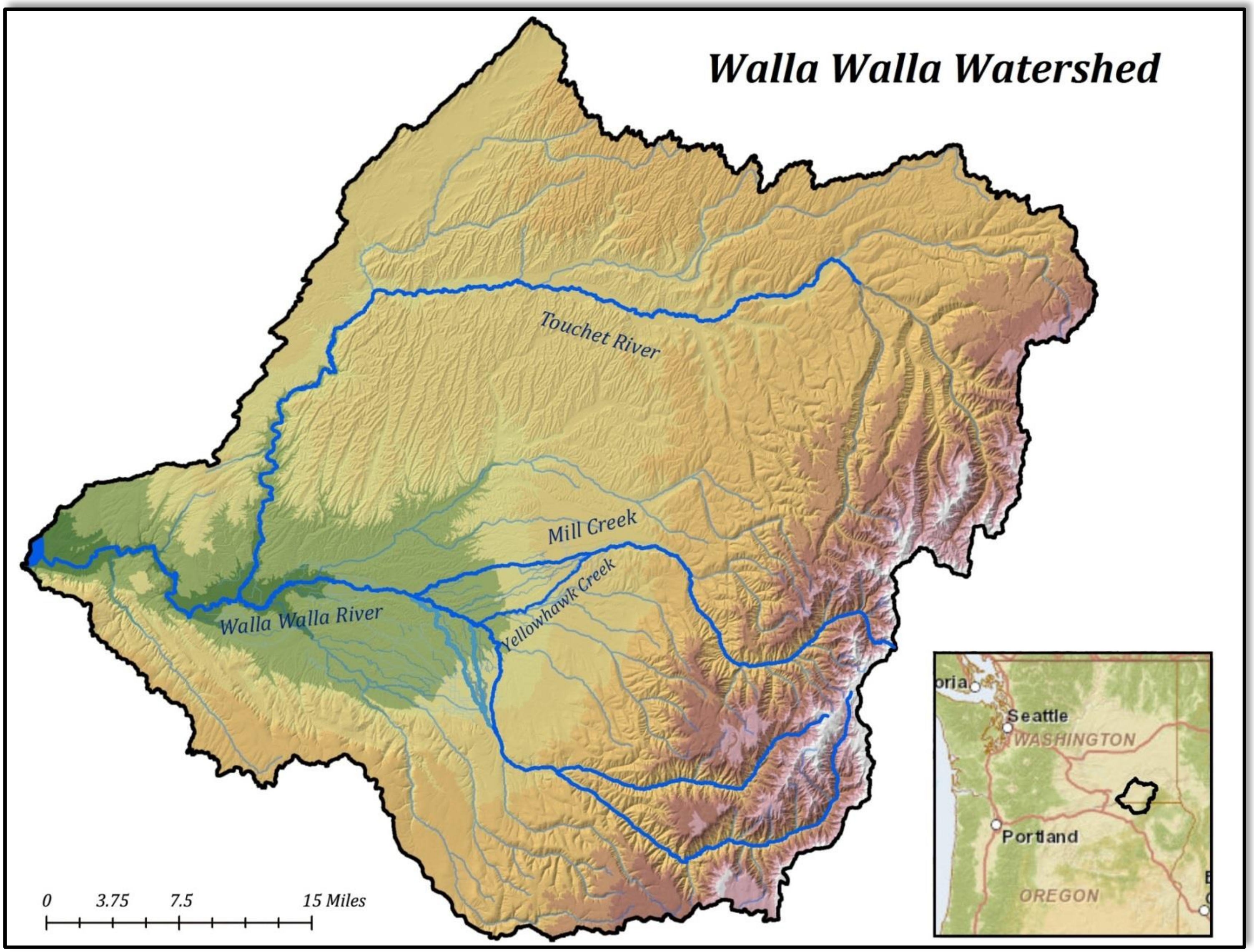


Figure 1 - Map of the Walla Walla Watershed.

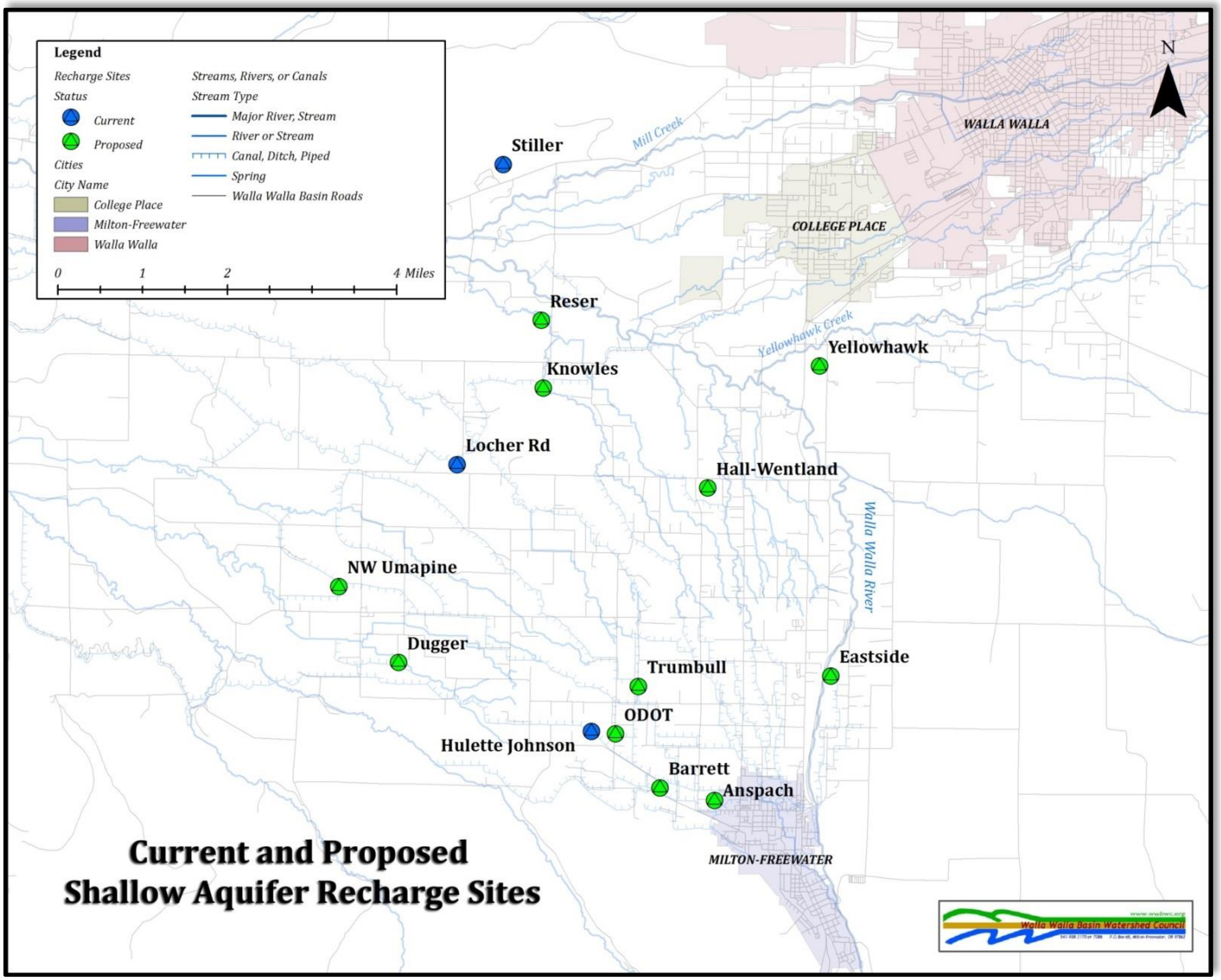


Figure 2- Individual aquifer recharge projects within the Walla Walla Basin Aquifer Recharge Program.

KNOWN CONTAMINANTS AND TMDLS

Some surface waters in the Walla Walla basin have Total Maximum Daily Loads (TMDL) Water Cleanup Plans developed for the following parameters:

- Chlorinated pesticides and Polychlorinated Biphenyls (PCBs)
- Fecal Coliform Bacteria
- Temperature
- Dissolved oxygen and pH

For this Quality Assurance Project Plan (QAPP) the first three TMDLs apply. The first TMDL, chlorinated pesticides and PCBs, requires additional monitoring to ensure groundwater quality is not degraded pursuant to WAC 173-200. The fecal coliform bacteria TMDL will also require water quality monitoring to ensure groundwater quality is not degraded. Aquifer recharge may help address this TMDL because of the natural attenuation of bacteria as recharge water migrates through the alluvial sediments before reemerging as surface water down gradient. The temperature TMDL does not require additional monitoring, but similar to the fecal coliform bacteria TMDL, aquifer recharge may help address high surface water temperatures. Recharge water, sourced during the winter and spring, typically has low water temperatures which can help reduce surface water temperatures through cool groundwater inputs down gradient of recharge sites.

PREVIOUS AQUIFER RECHARGE ACTIVITIES

Four aquifer recharge projects have operated in the Walla Walla basin. For an overview of pilot project activities and results please see WWBWC, 2010 and WWBWC, 2013.

PROJECT GOALS

The overall goal of the Walla Walla Basin Aquifer Recharge Program is to utilize aquifer recharge to stabilize and recover the Walla Walla basin's alluvial aquifer to build aquifer storage, decrease stream seepage loss, mimic floodplain processes and increase spring flows and baseflows. In conjunction with the overall goal, the program also focuses on water quality issues. The water quality goals for the program are two-fold. First to ensure that aquifer recharge does not degrade groundwater resources and second to use aquifer recharge to help improve water quality by reducing fecal coliform contamination, cooling stream temperatures and others.

PROJECT OBJECTIVES

The Walla Walla Basin Aquifer Recharge Program has three main goals (see above). Below are objectives for achieving those goals.

- Monitor groundwater levels and temperature at each recharge site as well as up and down gradient of the site.
- Monitor surface water levels and temperature at each recharge site as well as up and down gradient of the site.
- Collect water quality data during recharge operations.
- Analyze data for status/trend changes and for water quality improvements (or degradation).
- Develop reports that contain the data and Analyses for the previous objectives

To meet these goals and objectives, the following data are needed:

- Groundwater levels and temperature, monitored with pressure transducers
- Surface water stage and temperature, monitored with water level sensors
- Water quality samples (see below for details)
- Volume and timing of recharge water delivered to each site

STUDY BOUNDARY

The study boundary for this project is the extent of the alluvial aquifer in the Walla Walla basin, specifically on the Washington side of the border (Figure 3).

PROJECT TASKS

The main project tasks include:

- Surface water quantity monitoring for effectiveness monitoring, instream flow minimums and to ensure recharge activities are not impeding other water rights.
- Source water (surface water) quality monitoring to account for potential contaminants in the recharge water.
- Surface water delivery, both volume and timing, to each recharge site.
- Regional groundwater level monitoring.
- Site specific groundwater level monitoring
- Groundwater quality testing to detect existing conditions (up gradient) and influences from recharge operations (down gradient).
- Site operations – managing diversion into each project as canal/ditch levels change.

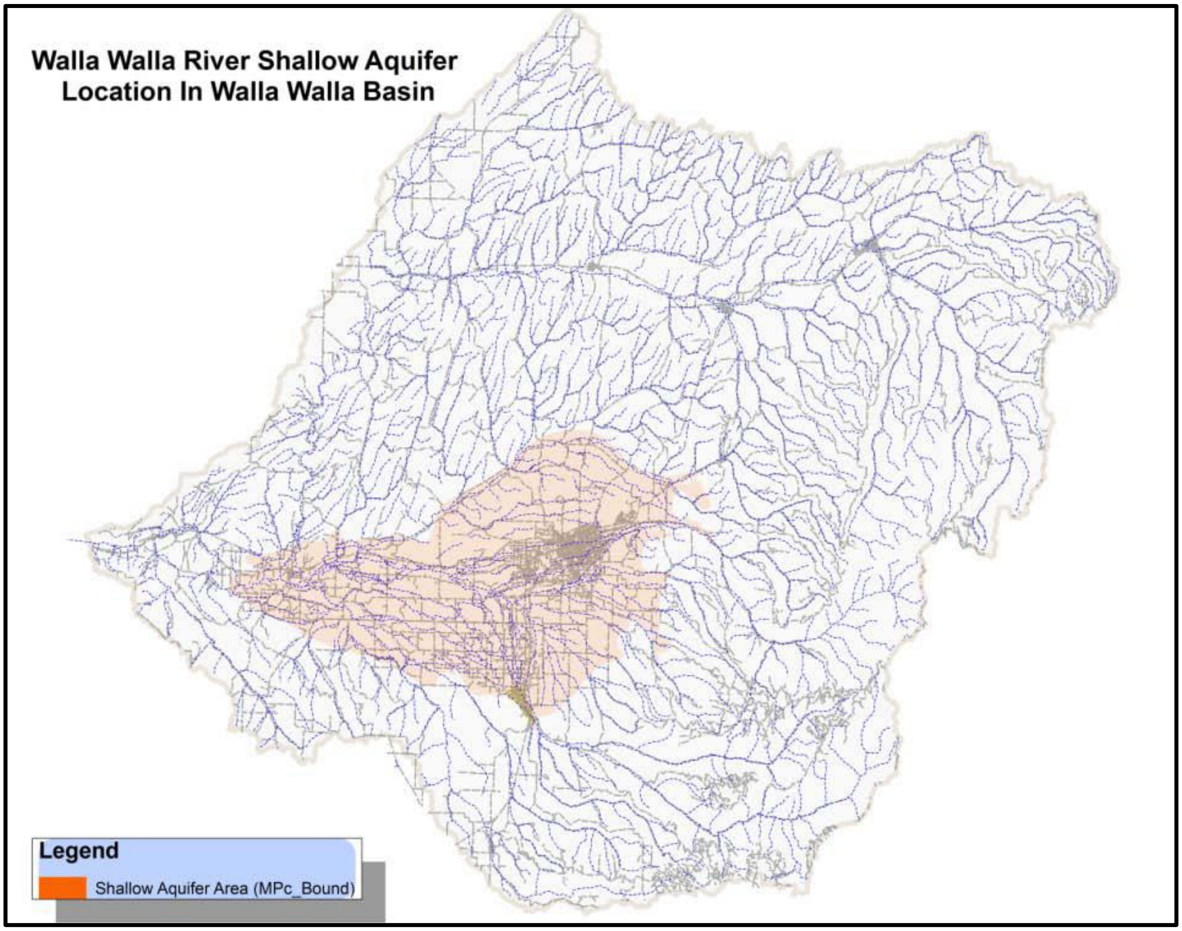


Figure 3 - The study boundary for the Walla Walla Basin Aquifer Recharge Program is the alluvial aquifer, shown in orange.

WALLA WALLA BASIN RECHARGE SITES

LOCHER ROAD

SITE DESCRIPTION

The description of the geologic and hydrogeologic setting of the project is based upon Kennedy/Jenks Consultants (2003), Initial Reconnaissance of Several Possible SAR Sites in the Walla Walla Basin.

The Locher Road Aquifer Recharge Project is located west of Walla Walla, WA and is just north of the Oregon-Washington stateline (Figure 4). The project is located at the intersection of Stateline and Locher Roads (NE ¼, NE ¼, Section 18, Township 6 North, Range 35 East). The project utilizes an excavated and shaped basin within a historic gravel quarry (Figure 5).

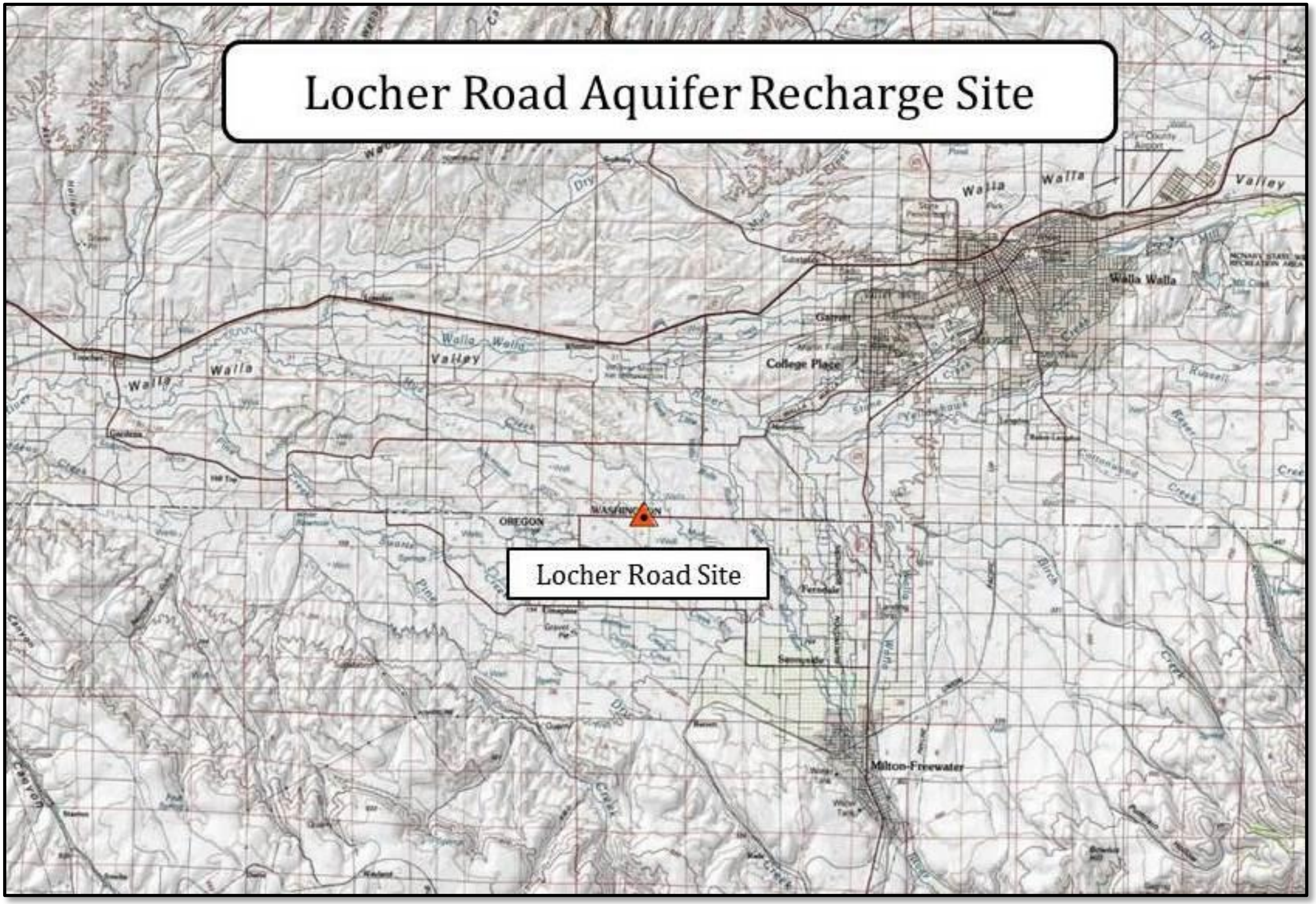


Figure 4- Location map for the Locher Road Aquifer Recharge Project in the Walla Walla Valley, Washington

Figure 5- The Locher Road Aquifer Recharge Project during expansion activities in late 2011. The project was expanded from ~1/3 acre basin to a ~2 acre basin. The project basin is located within a historic gravel quarry.

The gravel quarry is approximately 800 feet long (north to south) and approximately 500 feet wide (east to west). The quarry has a depth of approximately 15-20 feet. The north end of the gravel quarry is less than 200 feet from the Gardena Farms Canal. The project is surrounded by agricultural farming land and low density rural residential plots (including small scale farming or pastures).

GEOLOGY AND HYDROGEOLOGY

The gravel quarry is excavated into a thin (less than 5 feet thick) layer of uncemented gravel overlying red-brown (iron?) stained, partially cemented and indurated gravel assigned to the Mio-Pliocene conglomerate unit. Except for a thin (< 3 feet thick) layer of topsoil, Touchet Beds, loess and other fine-grained deposits are not found in the immediate area, the Quaternary alluvial gravel unit which normally overlies Mio-Pliocene conglomerate is interpreted to be relatively thin (< 10-15 feet-thick) in the gravel quarry area. Within the confines of the quarry, the alluvial gravel unit (Quaternary unit) has been removed and the Mio-Pliocene conglomerate unit extends from the quarry floor to an estimated depth of approximately 260 feet. A more comprehensive description of the geology of this project can be found in Kennedy/Jenks (2003), GSI (2007), GSI (2008) and GSI (2009).

The uppermost aquifer beneath the project is hosted by the Mio-Pliocene conglomerate. This aquifer is unconfined and is referred to as the suprabasalt aquifer (also known as the alluvial aquifer or the shallow gravel aquifer). The Washington Department of Ecology (Ecology) has been monitoring water levels in the suprabasalt aquifer in a well (commonly refered to as the "Ecology well" and is GW_57 in the WWBWC monitoring network) found immediately adjacent to the project. The well is located just north of the gravel quarry and south of the Gardena Farms Canal. The data from this well indicates the suprabasalt aquifer water table lies between approximately 20-45 feet below the ground surface and its depth varies with the use of the nearby Gardena Farms Canal. Based upon the results of multiple years of aquifer recharge operations, the site has demonstrated it has good infiltration rates (WWBWC, 2013a).

For additional information regarding the geology and hydrogeology please see Newcomb (1965). Also see WWBWC, 2012b for regional information on the alluvial aquifer water levels.

WATER AND SOIL QUALITY SAMPLING

The schedule for the Locher Road site is listed below. Each of the samples includes all of the water parameters listed below in the Measurement Methods. Soil samples will be collected only during the Pre-operations event. Soil samples will include 5 locations within the gravel quarry. Each location will have two samples taken: 1 – from the ground surface and 2 – from 1 foot or more below the ground surface. Parameters for soil sampling are also included in the Measurement Methods section. See Figure 6 for well and source water sampling locations.

Location	Sample	Date
Location #1 – Ground Surface	Soil Sample	~ Dec 1st - March 1st
Location #1 – 1+ Foot Below Surface	Soil Sample	~ Dec 1st - March 1st
Location #2 – Ground Surface	Soil Sample	~ Dec 1st - March 1st
Location #2 – 1+ Foot Below Surface	Soil Sample	~ Dec 1st - March 1st
Location #3 – Ground Surface	Soil Sample	~ Dec 1st - March 1st
Location #3 – 1+ Foot Below Surface	Soil Sample	~ Dec 1st - March 1st
Location #4 – Ground Surface	Soil Sample	~ Dec 1st - March 1st
Location #4 – 1+ Foot Below Surface	Soil Sample	~ Dec 1st - March 1st
Location #5 – Ground Surface	Soil Sample	~ Dec 1st - March 1st
Location #5 – 1+ Foot Below Surface	Soil Sample	~ Dec 1st - March 1st
Up Gradient Well – GW_70	Pre-operations Sample	~ Dec 1st - March 1st
Down Gradient Well (close) – GW_72	Pre-operations Sample	~ Dec 1st - March 1st
Down Gradient Well (distal) – GW_71	Pre-operations Sample	~ Dec 1st - March 1st
Source Water – S308	Pre-operations Sample	~ Dec 1st - March 1st
Up Gradient Well – GW_70	Mid-operations Sample	~April 15th
Down Gradient Well (close) – GW_72	Mid-operations Sample	~April 15th
Down Gradient Well (distal) – GW_71	Mid-operations Sample	~April 15th
Source Water – S308	Mid-operations Sample	~April 15th
Up Gradient Well – GW_70	Post-operations Sample	~ May 31st
Down Gradient Well (close) – GW_72	Post-operations Sample	~ May 31st
Down Gradient Well (distal) – GW_71	Post-operations Sample	~ May 31st
Source Water – S308	Post-operations Sample	~ May 31st

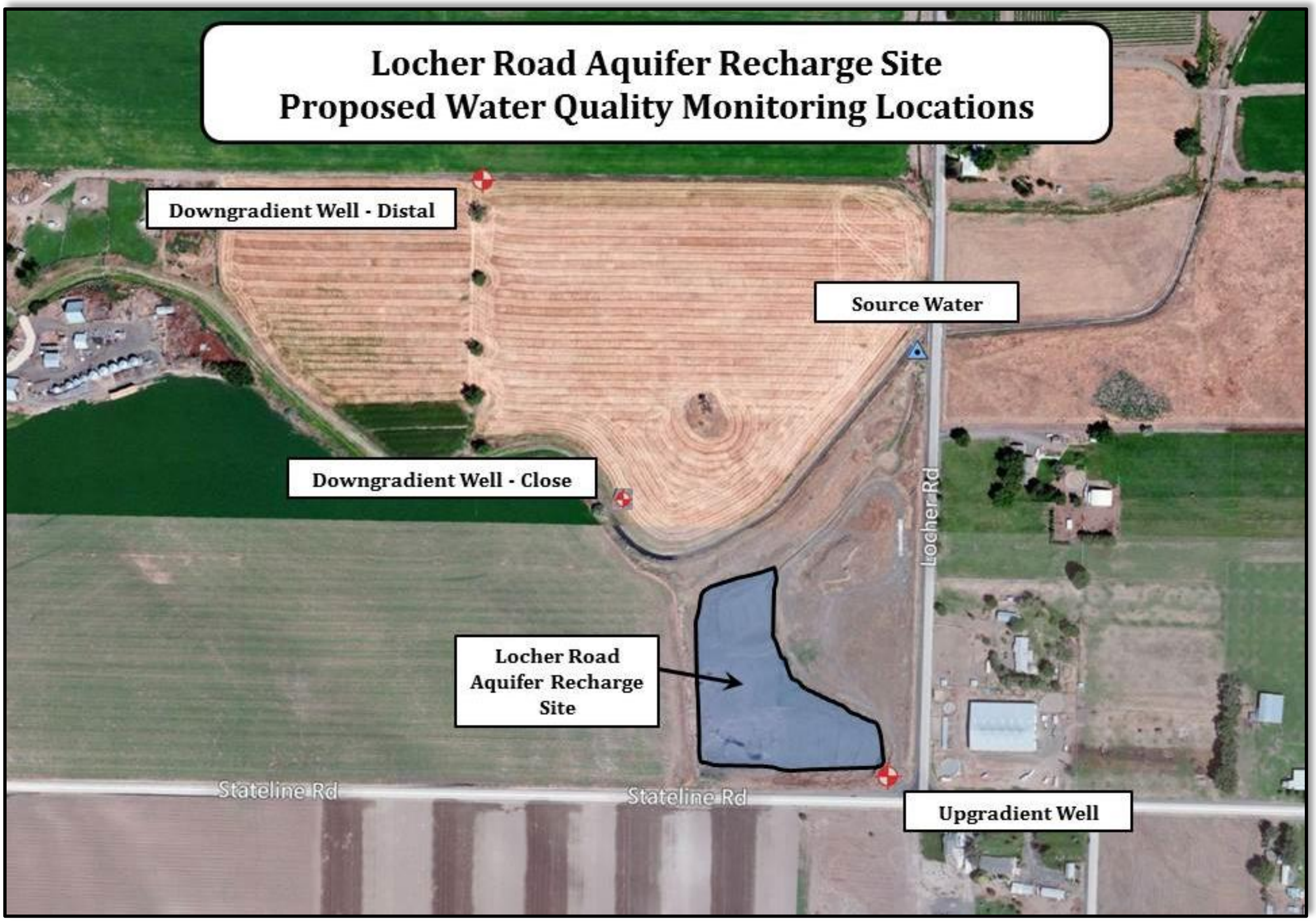


Figure 6- Locher Road aquifer recharge site water quality monitoring locations. Three groundwater wells will be sampled, one up gradient and two down gradient. Source water samples will be collected at the intake for the recharge project where water is diverted from the Gardena Farms Canal.

STILLER POND

SITE DESCRIPTION

The Stiller Pond project area (Figures 7 and 8) generally lies in and immediately east of an intermittent pond locally referred to as Stiller Pond in Walla Walla County, Washington, located in Township 7 North, Range 35 East, SW ¼ SW ¼ of Section 29. Land use around Stiller Pond currently is devoted primarily to organic irrigated agriculture and stock grazing. Historically, surface water reached Stiller Pond via a ditch connected to Mill Creek. This ditch was converted to a piped system in approximately 2004/2005. Historical evidence, based on landowner interviews, suggests Stiller Pond quickly would go dry when surface water delivery was shut off, suggesting water seeped out of the pond and into the underlying alluvial aquifer in a few days, to less than a week.

Currently, water use in the Project area focuses on winter and spring (October through May) irrigation and stock watering using surface water diverted from Mill Creek; and summer (June through September) irrigation and stock watering using groundwater. Groundwater is used from three alluvial aquifer wells (west well, middle well, east well; Figure 2) at the Project site. Winter/spring irrigation using Mill Creek water is sub-optimal because crop growing conditions are not at their best in the winter and in wet springs there is only a limited need for irrigation. In addition, the diversion point on Mill Creek is an in-stream structure that has the potential to inadvertently influence fish passage.

The basic goal of the Project is to provide surface recharge water to the alluvial aquifer to increase groundwater storage to support higher base flow to the nearby Walla Walla River and Mill Creek.

The Site lies in a shallow swale north of Mill Creek and the Walla Walla River, approximately 5.5 miles east of Lowden, Washington. This swale is located between the right-of-ways of old Highway 12 and new Highway 12. The western end of the swale is crossed by a low dike that serves to hold water in Stiller Pond when it is filled. Mill Creek flows past the Project area from the northeast and empties into the Walla Walla River southwest of the Site.

The eastern half of the Site consists of cropland that is currently undergoing the transition to organic farming practices. Stiller Pond, covering much of the western portion of the Site, has a surface area of approximately 8 acres, and an approximate average maximum depth of 4 to 5 feet when full.

The Site lies on the northern margin of the modern Walla Walla River and Mill Creek floodplain, and associated terraces, at the base of the low hills bordering the northern edge of this floodplain and terrace system. As such, the ground surface at the Site is approximately 10 to 30 feet above the Walla Walla River and Mill Creek channels at their nearest approach to the Site.

Mill Creek is the surface water body closest to the Site. The creek is an east-west flowing perennial stream located ½ to ¾ miles south of the Site. Mill Creek is a tributary of the Walla Walla River, which in the immediate vicinity of the Site lies south of Mill Creek.

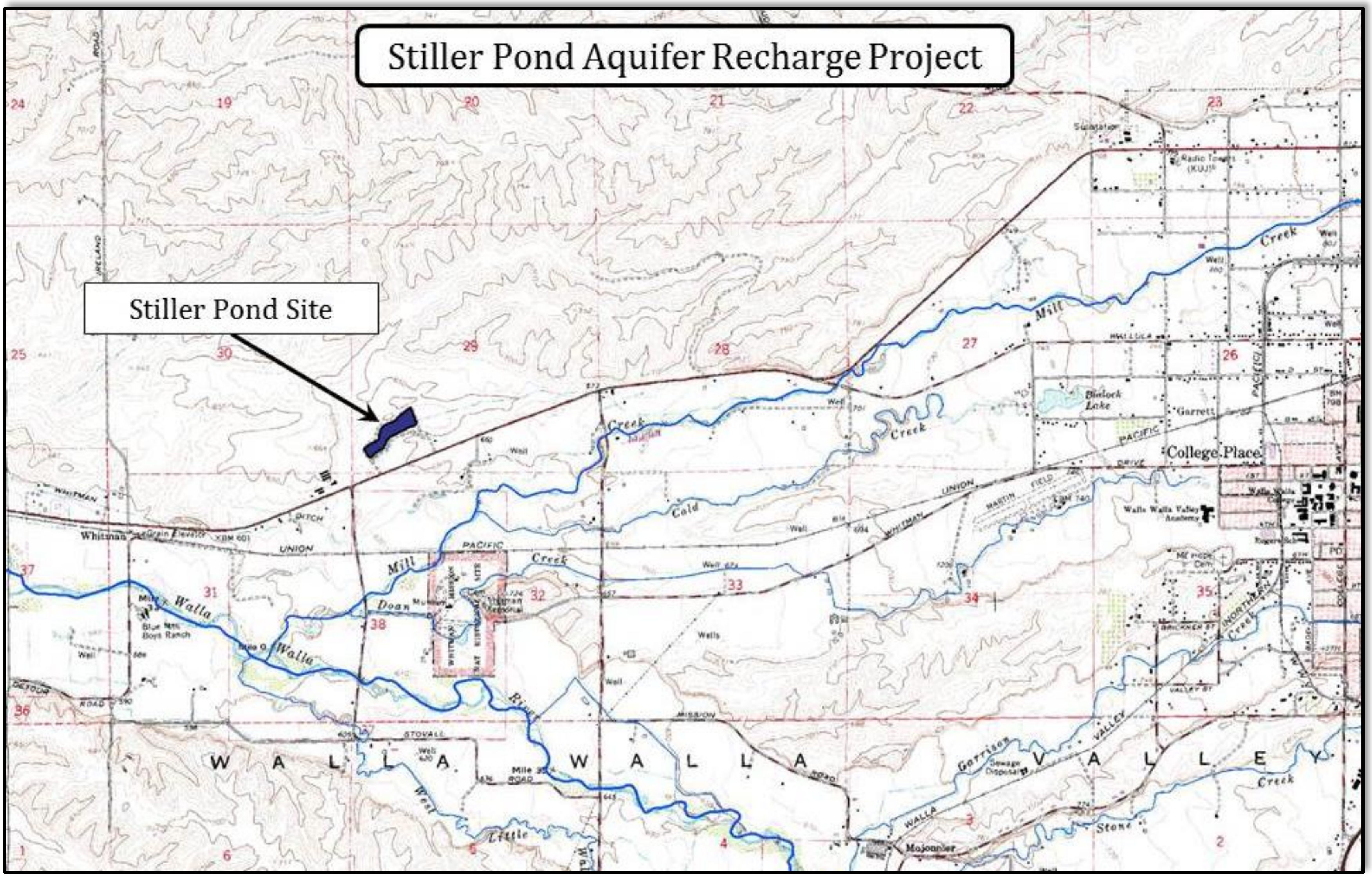


Figure 7- Location Map for the Stiller Pond Aquifer Recharge Site in the Walla Walla Valley, Washington.

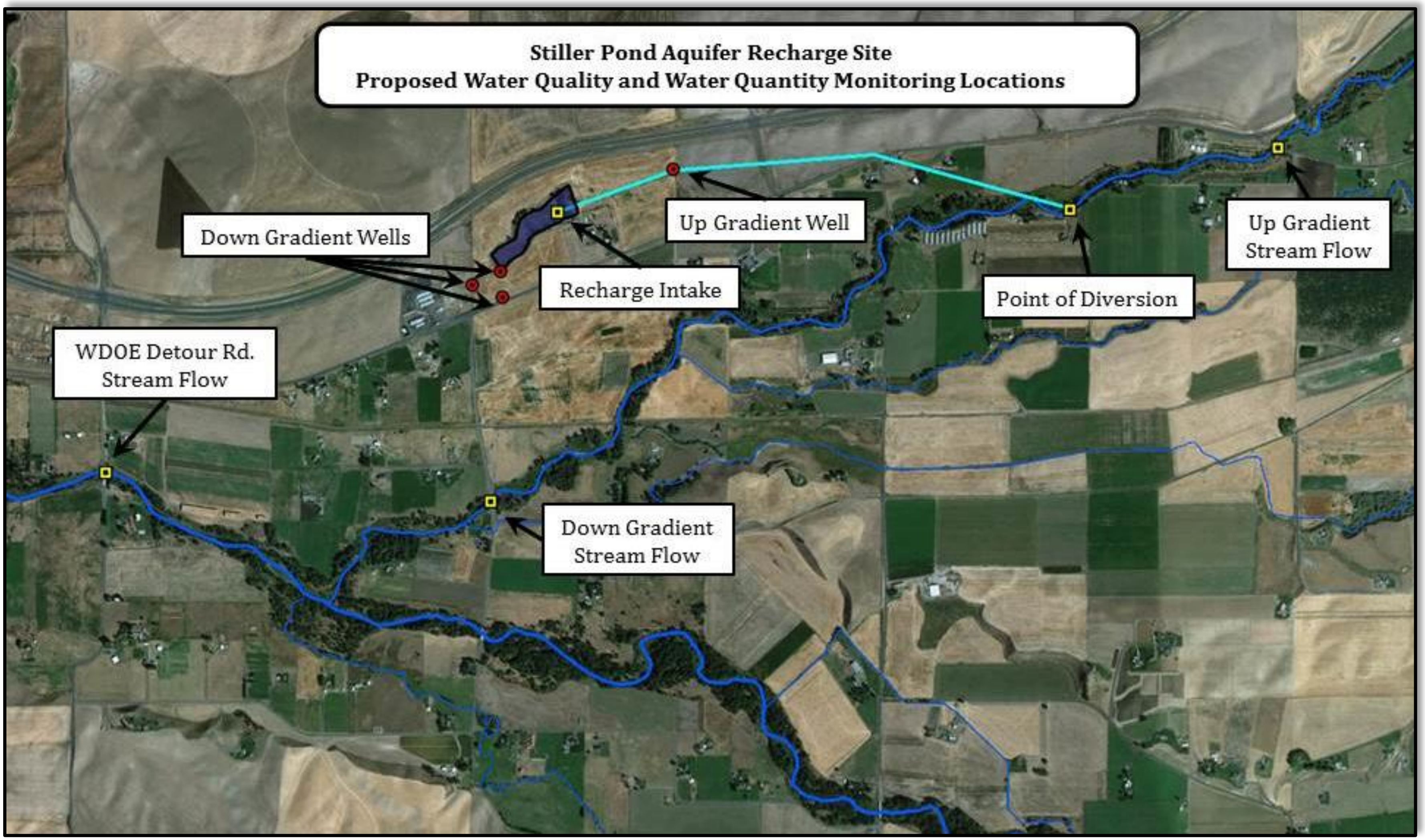


Figure 8– Stiller Pond Aquifer Recharge site water quality monitoring locations. Three groundwater wells will be sampled, one up gradient and two down gradient. Source water samples will be collected at the intake for the recharge project or at the point of di

GEOLOGY AND HYDROGEOLOGY

The shallowest aquifer underlying the Project area generally is unconfined to locally semi-confined aquifer hosted by alluvial sediments overlying the Columbia River basalts (GSI, 2010). These alluvial strata include fine- to coarse-grained continental clastic sediments referred to as the Quaternary fine unit, the Mio-Pliocene upper coarse unit, and the Mio-Pliocene fine unit (GSI, 2010). Basic observations about these units in the Project area are summarized below.

- *Quaternary fine unit* – The uppermost unit in the Project area, The Quaternary fine unit consists of fine-grained (clay, silt, and sand) deposits which were water lain and wind deposited materials derived from the Touchet Beds that comprise of the hills immediately to the North of the Project area.

- *Mio-Pliocene upper coarse unit* – In the vicinity of the Site the Quaternary fine unit is underlain by gravel and conglomerate assigned to the Mio-Pliocene coarse unit. This unit consists predominantly of indurated, slightly muddy to muddy, basaltic sand and gravel (conglomerate) and interbedded mud and it is the primary host unit for the suprabasalt (or alluvial) aquifer system. Hydrologic properties inherent in this unit are variable because of the wide range of lithologies and variable induration found within it. Crude data from step-rate pumping tests in two on-site wells yielded estimated:

    - Specific capacities of between approximately 2.8 gpm/ft, and 4.6 gpm/ft.
    - Transmissivities of between approximately 8700 ft^2/day and 24,700 ft^2/day.
    - Hydraulic conductivities of between approximately 70 ft/day and 180 ft/day.
    - The Mio-Pliocene coarse unit ranges from approximately 120 to 160 feet-thick, and well logs suggest it contains several thick muddy interbeds.

- *Mio-Pliocene fine unit* – The Mio-Pliocene upper coarse unit in the Project area is underlain by a sequence consisting predominantly of weakly indurated claystone and siltstone assigned to the Mio-Pliocene fine unit (also referred to as the old clay, or blue clay). Although not impermeable, these strata likely have significantly lower permeability than overlying strata, and functionally form the base of the alluvial aquifer system. In the Project area, these strata lie at depths of approximately 140 to 150 feet below ground surface.

The depth to groundwater, groundwater flow direction, and groundwater gradient in the alluvial aquifer system underlying the Site is difficult to deduce because of a scarcity of up-to-date data. However, based on the small amount of recent data currently available from drillers' well logs, on-site water supply wells, a single purpose built monitoring well, and recent reports related to the site Local Water Plan (GSI, 2010 and GSI, 2012) the following basic observations are reached.

- Depth to water – Historically, depth to water in the Project area may have been as little as 10 to 15 feet below ground surface. Recent well videos (from 2008 and 2009) indicate water levels are slightly deeper (15 to 25 feet below ground surface) than when the wells were first drilled. Depth to water in the on-site purpose-built monitoring well was approximately 23 feet in mid-March 2012.

- Groundwater flow direction – The general direction of groundwater flow through the greater Project area is from the east-northeast to the west-southwest, following the general orientation of the Walla Walla River valley (GSI, 2010).

- Groundwater gradient – With the data currently in-hand, estimating a gradient for the alluvial aquifer system is problematic. From what has been compiled, it appears the gradient in the general project area ranges from 5 to 25 feet/mile, possibly averaging in the range of 10 to 15 feet/mile (GSI, 2010).

Infiltration rates at the Stiller Pond site were estimated based on observations made during Local Water Plan work in the spring of 2012 (GSI, 2012). This work indicated approximate infiltration volumes per unit area of approximately 1.5 gallons/square-foot/day. It is important to note that this estimate is based on very general observations of the wetted area of the Pond, and measurements of how fast the Pond drained during this spring 2012 work. Given this, one should keep in mind that this rate is averaged across the full wetted surface of the Pond and that it likely differs across it.

GROUNDWATER QUALITY

Groundwater quality data was collected at the site during the 2012 Local Water Plan work (GSI, 2012). These data show the following:

- Pre-test groundwater, source and post-test groundwater pH values remained relatively consistent.

- Electrical conductivity (EC) in pre-test and post-test groundwater samples were 403.9 µS/cm and 334.0 µS/cm respectively. Source water EC was 59.8 µS/cm. The decrease in EC between pre and post-test EC suggests reduced EC in the groundwater resulting from recharge.

- Dissolved oxygen was higher in the post-test sample than the pre-test sample. This suggests that recent recharge water was moving in the direction of well MWSP-1.

- Oxidation-reduction potential (ORP) was higher in the post-test sample than the pre-test sample. This is likely the result of general groundwater dilution with respect to anions such as chloride. This suggests that recent recharge water was moving in the direction of well MWSP-1.

- Dissolved solids (including chloride, calcium hardness and magnesium) were all lower in the post-test sample than the pre-test sample. Source water dissolved solids were significantly lower than either groundwater sample. This observation also suggests evidence of changes in groundwater quality at MWSP-1 due to recharge.

- Total dissolved solids (TDS) were higher in pre-test groundwater than post-test groundwater and significantly lower in source water than either groundwater sample. This also is interpreted to be an indication that groundwater quality was positively influenced by the 2012 AR season.

- Nutrient concentrations (including nitrate (NO_3), phosphate (PO_4) and total Kjeldahl nitrogen (TKN)) generally suggest that AR events did not degrade groundwater quality. TKN was elevated slightly in the post-recharge sample, but this was expected due to the introduction of additional organic nitrogen, ammonia and ammonium to the groundwater via recharge through biomass on the surface of the Pond in the form of decaying plant matter. This slight rise in TKN is not interpreted to reflect groundwater degradation because the slight increase in TKN did not correspond to a matching increase in NO_3. In fact, NO_3 decreased in groundwater following the AR event.

- No fecal coliform or total coliform bacteria were detected in any sample.

Basic water quality parameters summarized above are interpreted to show that these activities did not degrade groundwater quality. This data, especially the fact that pre-test groundwater concentrations in most parameters are higher than post-test groundwater concentrations and source water, suggests operation of the Site may lead to reductions in parameter concentrations as recharge water is added to the alluvial aquifer underlying the Site. No groundwater data have been collected regarding PCBs, chlorinated pesticides or metals at the Stiller Pond site. See Appendix C for additional information on water quality collected to date.

WATER AND SOIL QUALITY SAMPLING

The water quality schedule for the Stiller Pond Recharge site is listed below. Each of the samples includes all of the water parameters listed below in the Measurement Methods. Soil samples will be collected only during the Pre-operations event. Soil samples will include 5 locations within the pond. Each location will have two samples taken: 1 – from the ground surface and 2 – from 1 foot or more below the ground surface. Parameters for soil sampling are also included in the Measurement Methods section. See Figure 8 for well and source water sampling locations.

Location	Sample	Date
Location #1 – Ground Surface	Soil Sample	~ December 1st
Location #1 – 1+ Foot Below Surface	Soil Sample	~ December 1st
Location #2 – Ground Surface	Soil Sample	~ December 1st
Location #2 – 1+ Foot Below Surface	Soil Sample	~ December 1st
Location #3 – Ground Surface	Soil Sample	~ December 1st
Location #3 – 1+ Foot Below Surface	Soil Sample	~ December 1st
Location #4 – Ground Surface	Soil Sample	~ December 1st
Location #4 – 1+ Foot Below Surface	Soil Sample	~ December 1st
Location #5 – Ground Surface	Soil Sample	~ December 1st
Location #5 – 1+ Foot Below Surface	Soil Sample	~ December 1st
Up Gradient Well	Pre-operations Sample	~ December 1st
Down Gradient Well (close)	Pre-operations Sample	~ December 1st
Down Gradient Well (distal)	Pre-operations Sample	~ December 1st
Source Water (Diversion or Intake)	Pre-operations Sample	~ December 1st
Up Gradient Well	Mid-operations Sample	~ February 15th
Down Gradient Well (close)	Mid-operations Sample	~ February 15th
Down Gradient Well (distal)	Mid-operations Sample	~ February 15th
Source Water (Diversion or Intake)	Mid-operations Sample	~ February 15th
Up Gradient Well	Post-operations Sample	~ April 30th
Down Gradient Well (close)	Post-operations Sample	~ April 30th
Down Gradient Well (distal)	Post-operations Sample	~ April 30th
Source Water (Diversion or Intake)	Post-operations Sample	~ April 30th

ORGANIZATION AND SCHEDULE

PERSONNEL

Name	Affiliation	Position	Tasks	Email Address
Steven Patten	WWBWC	Sr. Environmental Scientist	Project Manager, Data collection, Data analysis, Water Quality Coordinator, site design, and reporting	steven.patten@wwbwc.org
Troy Baker	WWBWC	GIS & Database Analyst	Data Collection, Data and database management, GIS, Water quality	troy.baker@wwbwc.org
Will Lewis	WWBWC	Environmental Scientist	Data and water quality collection	will.lewis@wwbwc.org
Lyndsi Hersey	WWBWC	Environmental Scientist	Data and water quality collection	lyndsi.hersey@wwbwc.org
Kevin Lindsey	GSI Water Solutions	Senior Hydrogeologist	Data analysis, site design, and oversight/review	klindsey@gsiws.com
Stuart Durfee	Gardena Farms Irrigation District #13	District Manager	Site operations and maintenance	gfid13@360comm.net
Mike Kuttel	WA Dept. of Ecology	Water Quality Program	Water Quality oversight	mkut461@ecy.wa.gov
Guy Gregory	WA Dept. of Ecology	Water Resources Program - Hydrogeologist	Water Level oversight	ggre461@ecy.wa.gov
Victoria Lueba	WA Dept. of Ecology	Water Resources Program	Permit oversight	vleu461@ecy.wa.gov
Eric Hartwig	WA Dept. of Ecology	Water Resources Program – Water Master	Water right oversight	ehar461@ecy.wa.gov
Bill Zachmann	WA Dept. of Ecology	Water Resources Program – Grant Manager	Grant oversight	bzac461@ecy.wa.gov

PROJECT SCHEDULE

Activity	Schedule	General Description
Surface Level Monitoring	Year-round	Mainstem sites are visited every other week to collect staff gauge measurements and perform general site maintenance. Manual discharge measurements and other data are collected during ~4-6 visits each year. A few river sites are only monitored seasonally during summer and fall base flows.
Groundwater Level Monitoring	Year-round	Sites are visited ~4 times a year to download data, conduct manual groundwater level measurements, perform site maintenance and collect other data.
Recharge Operations	Seasonal (Winter/Spring)	Aquifer recharge sites are operated in the winter and spring when adequate water volumes are in the river. Sites can turn on as early as December and turn off near the end of May.
Water Quality Monitoring – pre-operations sample	Seasonal (Winter/Spring)	Water quality samples are collected either just before or as the site is turned on.
Water Quality Monitoring – mid-operations sample	Seasonal (Winter/Spring)	Water quality samples are collected at approximately the mid-point of recharge operations.
Water Quality Monitoring – post-operations sample	Seasonal (Winter/Spring)	Water quality samples are collected either on the last day of operations or just after shut down.
Reporting	Seasonal (Fall)	Annual report for recharge operations will be completed the following fall.

Exact dates cannot be described in the project schedule because start up and shut down dates are dependent upon instream flows, environmental conditions (freezing, etc.) and other water use conditions.

QUALITY OBJECTIVES

MEASUREMENT QUALITY OBJECTIVES

Parameter	Field or Lab	Check Standard	Duplicate Samples
Water Temperature	Field	± 0.5 °C (NIST Thermometer)	± 0.2 °C
pH	Field	± 0.1 pH units	± 0.05 pH units
Specific Conductance	Field	± 5% of standard	± 5% of reading
Dissolved Oxygen	Field	± 0.2 mg/L	± 0.1 mg/L
Groundwater Level Measurement	Field	N/A	± 0.01 feet
Manual Discharge Measurement	Field	N/A	± 10%
Tape Down Stage Measurement	Field	N/A	±0.02 feet
Vertical Staff Gage Measurement	Field	N/A	±0.02 feet
Organic Pesticides (including PCBs, Organochlorines, etc.)	Lab	N/A	50% Relative Difference
Water Quality Parameters (Metals, TDS, nutrients, etc.)	Lab	N/A	50% Relative Difference

SAMPLING PROCESS

SAMPLE CONTAINERS, PRESERVATION AND HOLDING TIMES

Sample / Parameter	Matrix	Minimum quantity required	Container	Preservative	Holding Time
Water Temperature	Water	N/A	N/A	None	N/A
Specific Conductance	Water	N/A	N/A	None	N/A
pH	Water	N/A	N/A	None	N/A
Dissolved Oxygen	Water	N/A	N/A	None	N/A
Barium	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Cadmium	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Chromium	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Lead	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Mercury	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Selenium	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Silver	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Fluoride	Water	N/A	N/A	N/A	N/A
Endrin	Water	1.0 L	Amber glass bottle w/ Teflon lid liner	Refrigerate @ 4° C	N/A
Methoxychlor	Water	1.0 L	Amber glass bottle w/ Teflon lid liner	Refrigerate @ 4° C	N/A
1,1,1-Trichloroethane	Water	1.0 L	Amber glass bottle w/ Teflon lid liner	Refrigerate @ 4° C	N/A
2-4 D	Water	1.0 L	Amber glass bottle w/ Teflon lid liner	Refrigerate @ 4° C	N/A

Sample / Parameter	Matrix	Minimum quantity required	Container	Preservative	Holding Time
2,4,5-TP Silvex	Water	1.0 L	Amber glass bottle w/ Teflon lid liner	Refrigerate @ 4° C	N/A
Total Coliform Bacteria	Water	250 or 500 mL	Polypropylene or glass bottle, autoclaved	Refrigerate @ 4° C	24 hours
Copper	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Iron	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Manganese	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Zinc	Water	500 mL	Teflon FEP bottle	5 mL 1:1 Nitric Acid & Refrigerate @ 4° C	6 months
Chloride	Water	500 mL	Polypropylene bottle	Refrigerate @ 4° C	28 days
Sulfate	Water	N/A	N/A	N/A	N/A
Total Dissolved Solids	Water	N/A	Resistant Glass or Plastic	Refrigerate @ 4 °C	< 24 hours – 7 days
Foaming Agents	Water	N/A	N/A	N/A	N/A
Corrosivity	Water	N/A	N/A	N/A	N/A
Color	Water	N/A	N/A	N/A	N/A
Odor	Water	500 mL	Glass or TFE-lined	Refrigerate	<24 hours
Chlorinated Pesticides	Water	1.0 gal.	Glass bottle w/ Teflon lid liner	Refrigerate @ 4 °C	7 days
Chlorinated Pesticides	Soil	N/A	N/A	N/A	N/A
PCBs	Water	1.0 L	Amber glass bottle w/ Teflon lid liner	Refrigerate @ 4 °C	7 days
PCBs	Soil	N/A	N/A	N/A	N/A
Nitrate as N	Water	125 mL	Polypropylene bottle	H_2SO_4 to pH<2; Cool to 4° C	28 days
Nitrate as N	Soil	N/A	N/A	N/A	N/A
Total Phosphorus	Water	60 mL	Clear polypropylene bottle	Refrigerate @ 4° C; Fill bottle completely; don't agitate sample	14 days
Total Phosphorus	Soil	N/A	N/A	N/A	N/A

Sample / Parameter	Matrix	Minimum quantity required	Container	Preservative	Holding Time
Carbonate & Bicarbonate	Water	500 mL; No headspace	Polypropylene bottle	Refrigerate @ 4 °C	14 days
Turbidity	Water	500 mL	Polypropylene bottle	Refrigerate @ 4 °C	48 hours

MEASUREMENT METHODS

Analyte	Sample Matrix	Samples [number & arrival date]	Expected range of results	Reporting Limit	Sample Preparation Method	Analytical Method
Water Temperature	Surface Water	3 – Pre, Mid & Post Operations	0-10 °C	0.1 °C	N/A	NIST Thermometer
Water Temperature	Groundwater	9 – Pre, Mid & Post Operations	5-10 °C	0.1 °C	N/A	NIST Thermometer
Specific Conductance	Surface Water	3 – Pre, Mid & Post Operations	35-150 µs/cm	1 µs/cm	N/A	YSI 30/Orion 5-Star
Specific Conductance	Groundwater	9 – Pre, Mid & Post Operations	35-500 µs/cm	1 µs/cm	N/A	YSI 30/Orion 5-Star
pH	Surface Water	3 – Pre, Mid & Post Operations	6.5-8.0	0.1 pH units	N/A	Orion 5-Star meter
pH	Groundwater	9 – Pre, Mid & Post Operations	6.5-8.0	0.1 pH units	N/A	Orion 5-Star meter
Dissolved Oxygen	Surface Water	3 – Pre, Mid & Post Operations	5-12 mg/L	0.2 mg/L	N/A	Orion 5-Star meter
Dissolved Oxygen	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.2 mg/L	N/A	Orion 5-Star meter
Barium	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Barium	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Cadmium	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Cadmium	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Chromium	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.5 µg/L	N/A	Standard Method 3125
Chromium	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.5 µg/L	N/A	Standard Method 3125

Analyte	Sample Matrix	Samples [number & arrival date]	Expected range of results	Reporting Limit	Sample Preparation Method	Analytical Method
Lead	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Lead	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Mercury	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.05 µg/L	N/A	Standard Method 3112 B
Mercury	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.05 µg/L	N/A	Standard Method 3112 B
Selenium	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.5 µg/L	N/A	Standard Method 3125 B
Selenium	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.5 µg/L	N/A	Standard Method 3125 B
Silver	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3150 B
Silver	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3150 B
Fluoride	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 mg/L	N/A	Standard Method 4110
Fluoride	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 mg/L	N/A	Standard Method 4110
Endrin	Surface Water	3 – Pre, Mid & Post Operations	<0.1 µg/L	0.1 µg/L	N/A	EPA Method 8081
Endrin	Groundwater	9 – Pre, Mid & Post Operations	<0.1 µg/L	0.1 µg/L	N/A	EPA Method 8081
Methoxychlor	Surface Water	3 – Pre, Mid & Post Operations	<0.1 µg/L	0.1 µg/L	N/A	EPA Method 8081
Methoxychlor	Groundwater	9 – Pre, Mid & Post Operations	<0.1 µg/L	0.1 µg/L	N/A	EPA Method 8081
1,1,1-Trichloroethane	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	EPA Method 8260
1,1,1-Trichloroethane	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	EPA Method 8260

Analyte	Sample Matrix	Samples [number & arrival date]	Expected range of results	Reporting Limit	Sample Preparation Method	Analytical Method
2-4 D	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	EPA Method 8151
2-4 D	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	EPA Method 8151
2,4,5-TP Silvex	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	EPA Method 8151
2,4,5-TP Silvex	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	EPA Method 8151
Total Coliform Bacteria	Surface Water	3 – Pre, Mid & Post Operations	<2 MPN/100 ml	1/100 ml	N/A	Standard Method 9221 D and 9222 B
Total Coliform Bacteria	Groundwater	9 – Pre, Mid & Post Operations	<2 MPN/100 ml	1/100 ml	N/A	Standard Method 9221 D and 9222 B
Copper	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Copper	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.1 µg/L	N/A	Standard Method 3125
Iron	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.03 mg/L	N/A	Standard Method 3120 B
Iron	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.03 mg/L	N/A	Standard Method 3120 B
Manganese	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.005 mg/L	N/A	Standard Method 3120 B
Manganese	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.005 mg/L	N/A	Standard Method 3120 B
Zinc	Surface Water	3 – Pre, Mid & Post Operations	N/A	5 µg/L	N/A	Standard Method 3150 B
Zinc	Groundwater	9 – Pre, Mid & Post Operations	N/A	5 µg/L	N/A	Standard Method 3150 B
Chloride	Surface Water	3 – Pre, Mid & Post Operations	2-10 mg/L	0.1 mg/L	N/A	Standard Method 4110
Chloride	Groundwater	9 – Pre, Mid & Post Operations	2-50 mg/L	0.1 mg/L	N/A	Standard Method 4110

Analyte	Sample Matrix	Samples [number & arrival date]	Expected range of results	Reporting Limit	Sample Preparation Method	Analytical Method
Sulfate	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.5 mg/L	N/A	Standard Method 4110
Sulfate	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.5 mg/L	N/A	Standard Method 4110
Total Dissolved Solids	Surface Water	3 – Pre, Mid & Post Operations	100-500 mg/L	2 mg/L	N/A	Standard Method 2540 C
Total Dissolved Solids	Groundwater	9 – Pre, Mid & Post Operations	100-500 mg/L	2 mg/L	N/A	Standard Method 2540 C
Foaming Agents	Surface Water	3 – Pre, Mid & Post Operations	N/A	0.05 mg/L	N/A	N/A
Foaming Agents	Groundwater	9 – Pre, Mid & Post Operations	N/A	0.05 mg/L	N/A	N/A
Corrosivity	Surface Water	3 – Pre, Mid & Post Operations	N/A	Noncorrosive	N/A	N/A
Corrosivity	Groundwater	9 – Pre, Mid & Post Operations	N/A	Noncorrosive	N/A	N/A
Color	Surface Water	3 – Pre, Mid & Post Operations	N/A	15 Color Units	N/A	N/A
Color	Groundwater	9 – Pre, Mid & Post Operations	N/A	15 Color Units	N/A	N/A
Odor	Surface Water	3 – Pre, Mid & Post Operations	N/A	3 Threshold Odor Units	N/A	Standard Method 2150
Odor	Groundwater	9 – Pre, Mid & Post Operations	N/A	3 Threshold Odor Units	N/A	Standard Method 2150
Chlorinated Pesticides	Surface Water	3 – Pre, Mid & Post Operations	<0.0001-0.01 µg/L	0.1 µg/L	SW3510 / 3620 / 3665	EPA Method 8081
Chlorinated Pesticides	Groundwater	9 – Pre, Mid & Post Operations	<0.0001-0.01 µg/L	0.1 µg/L	SW3510 / 3620 / 3665	EPA Method 8081
Chlorinated Pesticides	Soil	3 – Pre, Mid & Post Operations	<0.0001-0.01 µg/Kg	0.1 µg/Kg	SW3510 / 3620 / 3665	EPA Method 8081

Analyte	Sample Matrix	Samples [number & arrival date]	Expected range of results	Reporting Limit	Sample Preparation Method	Analytical Method
PCBs	Surface Water	9 – Pre, Mid & Post Operations	0.001-0.005 µg/L	1 pg/L	EPA Method 1668C	EPA Method 1668C
PCBs	Groundwater	3 – Pre, Mid & Post Operations	0.001-0.005 µg/L	1 pg/L	EPA Method 1668C	EPA Method 1668C
PCBs	Soil	9 – Pre, Mid & Post Operations	0.001-0.005 µg/L	10 pg/Kg	EPA Method 1668C	EPA Method 1668C
Nitrate (as N)	Surface Water	3 – Pre, Mid & Post Operations	0-1 mg/L	0.01 mg/L	N/A	Standard Method 4500-NO_3^-
Nitrate (as N)	Groundwater	9 – Pre, Mid & Post Operations	0-10 mg/L	0.01 mg/L	N/A	Standard Method 4500-NO_3^-
Nitrate (as N)	Soil	3 – Pre, Mid & Post Operations	N/A	0.1 mg/Kg	N/A	Standard Method 4500-NO_3^-
Total Phosphorus (Dissolved & Particulate)	Surface Water	9 – Pre, Mid & Post Operations	N/A	0.005 mg/L	N/A	Standard Method 4500-P
Total Phosphorus (Dissolved & Particulate)	Groundwater	3 – Pre, Mid & Post Operations	N/A	0.005 mg/L	N/A	Standard Method 4500-P
Total Phosphorus	Soil	9 – Pre, Mid & Post Operations	N/A	0.05 mg/Kg	N/A	Standard Method 4500-P
Carbonate & Bicarbonate	Surface Water	3 – Pre, Mid & Post Operations	N/A	10 mg/L	N/A	Standard Method 2320B
Carbonate & Bicarbonate	Groundwater	9 – Pre, Mid & Post Operations	N/A	10 mg/L	N/A	Standard Method 2320B
Turbidity	Surface Water	3 – Pre, Mid & Post Operations	1-150 NTU	1 NTU	N/A	Standard Method 2130
Turbidity	Groundwater	9 – Pre, Mid & Post Operations	1-20 NTU	1 NTU	N/A	Standard Method 2130

SAMPLING LOCATIONS AND SCHEDULE

Unless otherwise stated in the Site Description (see Walla Walla Basin Recharge Sites section), the following locations and schedule will be followed at each recharge site.

LOCATIONS

Groundwater samples will be collected at three locations: an up gradient well and two down gradient wells. Samples will be collected from purpose built monitoring wells (according to WAC 173-160 monitoring well standards) that will generally be open to the upper 30-50 feet of the alluvial aquifer.

Source water samples will be collected at the diversion point or at the intake for the recharge site.

See site description (in Walla Walla Basin Recharge Site section) for details regarding sampling locations, schedules and maps.

SCHEDULE

Three samples will be taken at each site during a recharge season. The first sample will be taken just prior to the site starting recharge operations. The source water sample may be taken as the site is started if no other option is available. The second sample will be taken in the middle of the recharge season. The third sample will be taken near the end of the recharge season, ideally just before shutdown. See the table below for a generalized schedule.

Location	Sample	Date
Up Gradient Well	Pre-operations Sample	~ Dec 1st - March 1st
Down Gradient Well (close)	Pre-operations Sample	~ Dec 1st - March 1st
Down Gradient Well (distal)	Pre-operations Sample	~ Dec 1st - March 1st
Source Water	Pre-operations Sample	~ Dec 1st - March 1st
Up Gradient Well	Mid-operations Sample	~April 15th
Down Gradient Well (close)	Mid-operations Sample	~April 15th
Down Gradient Well (distal)	Mid-operations Sample	~April 15th
Source Water	Mid-operations Sample	~April 15th
Up Gradient Well	Post-operations Sample	~ May 31st
Down Gradient Well (close)	Post-operations Sample	~ May 31st
Down Gradient Well (distal)	Post-operations Sample	~ May 31st
Source Water	Post-operations Sample	~ May 31st

SAMPLING ORDER

Samples should be collected in order from least to most contaminated (if known) to prevent potential cross-contamination.

SAMPLE COMPARABILITY

Samples collected under this QAPP use the sample analytical methods used to collect data for the Walla Walla River Chlorinated Pesticides and PCBs Total Maximum Daily Load (Water Cleanup Plan) (Ecology Publication No. 05-10-079).

SAMPLING PROCEDURES

PROCEDURES

Sampling procedures for this QAPP are described in the Walla Walla Basin Watershed Council's Watershed Monitoring Program Standard Operation Procedures (Version 1.2). This SOP document is attached as Appendix A. The sampling procedures described in the WWBWC's SOP document are taken from Washington Department of Ecology's Standard Operation Procedures for Sampling of Pesticides in Surface Waters (EAP 003 SOP) – see Appendix B.

DECONTAMINATION

All non-disposable field equipment that may potentially come in contact with any soil or water sample shall be decontaminated in order to minimize the potential for cross-contamination between sampling locations. Thorough decontamination of all sampling equipment shall be conducted prior to each sampling event. In addition, the sampling technician shall decontaminate all equipment in the field as required to prevent cross-contamination of samples collected in the field. The procedures described in this section are specifically for field decontamination of sampling equipment.

At a minimum, field-sampling equipment should be decontaminated following these procedures:

- Wash the equipment in a solution of non-phosphate detergent (Liquinox® or equivalent) and distilled or deionized water. All surfaces that may come in direct contact with the samples shall be washed. Use a clean Nalgene and/or plastic tub to contain the wash solution and a scrub brush to mechanically remove loose particles. Wear clean latex, plastic, or equivalent gloves during all washing and rinsing operations.
- Rinse twice with distilled or deionized water.
- Dry the equipment before use, to the extent practicable.

SAMPLE IDENTIFICATION

Each sample will be labeled with the following information:

- Sampler's Name
- Sample Date
- Sample Time
- Sample Location (Groundwater = GW #, Source water = S #)
- Recharge Site
- Parameters & preservatives

SAMPLE TRANSPORTATION

Samples typically need to be shipped overnight to ensure delivery before holding times expire. Samples should be prepped and delivered to the UPS store before their deadline for overnight delivery. Call the UPS store beforehand to check when the samples need to arrive to ensure delivery to the lab.

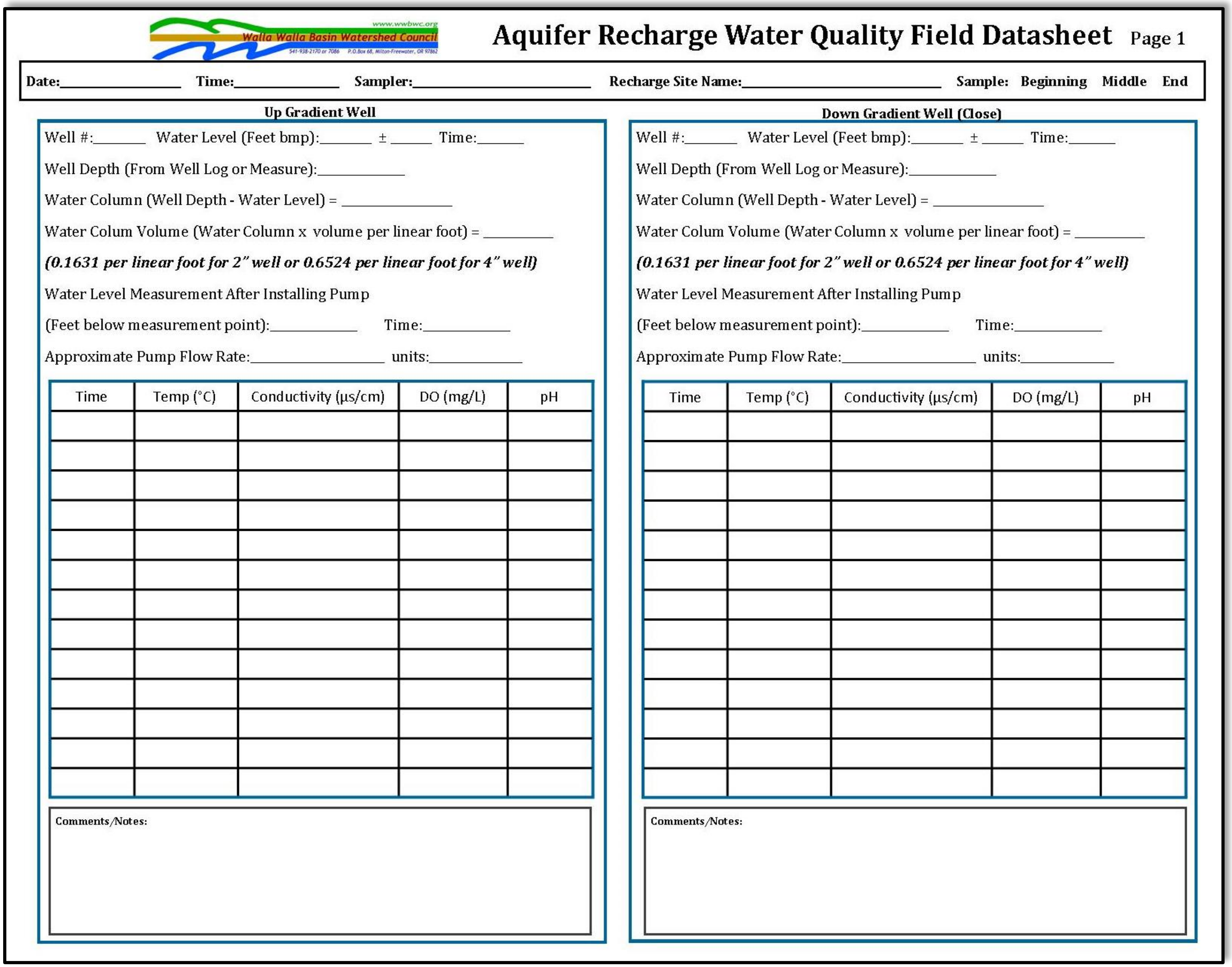
Coolers should be sealed and shipped or driven to the lab as soon as possible. The method of shipping is usually determined by the parameter having the shortest holding time. Shipping times of more than 24 hours should be avoided as the cooler(s) may warm and compromise sample quality.

CHAIN-OF-CUSTODY

A chain-of-custody form should be completed and signed by the sampler on the day samples are collected. The chain-of-custody form must be signed by laboratory personnel upon receipt and any other individuals that maintain custody of the samples in the interim (except the shipping company).

FIELD NOTES

Field notes associated with sample collection will be kept in the WWBWC's Aquifer Recharge Water Quality Field book (see below for datasheets).



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Aquifer Recharge Water Quality Field Datasheet

Page 1

Date:_______________ **Time:**_____________ **Sampler:**______________________ **Recharge Site Name:**________________________ **Sample:** **Beginning** **Middle** **End**

Up Gradient Well

Well #:______ Water Level (Feet bmp):______ ± _____ Time:______

Well Depth (From Well Log or Measure):__________

Water Column (Well Depth - Water Level) = _____________

Water Colum Volume (Water Column x volume per linear foot) = ________

(0.1631 per linear foot for 2" well or 0.6524 per linear foot for 4" well)

Water Level Measurement After Installing Pump

(Feet below measurement point):__________ Time:__________

Approximate Pump Flow Rate:_______________ units:__________

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Comments/Notes:

Down Gradient Well (Close)

Well #:______ Water Level (Feet bmp):______ ± _____ Time:______

Well Depth (From Well Log or Measure):__________

Water Column (Well Depth - Water Level) = _____________

Water Colum Volume (Water Column x volume per linear foot) = ________

(0.1631 per linear foot for 2" well or 0.6524 per linear foot for 4" well)

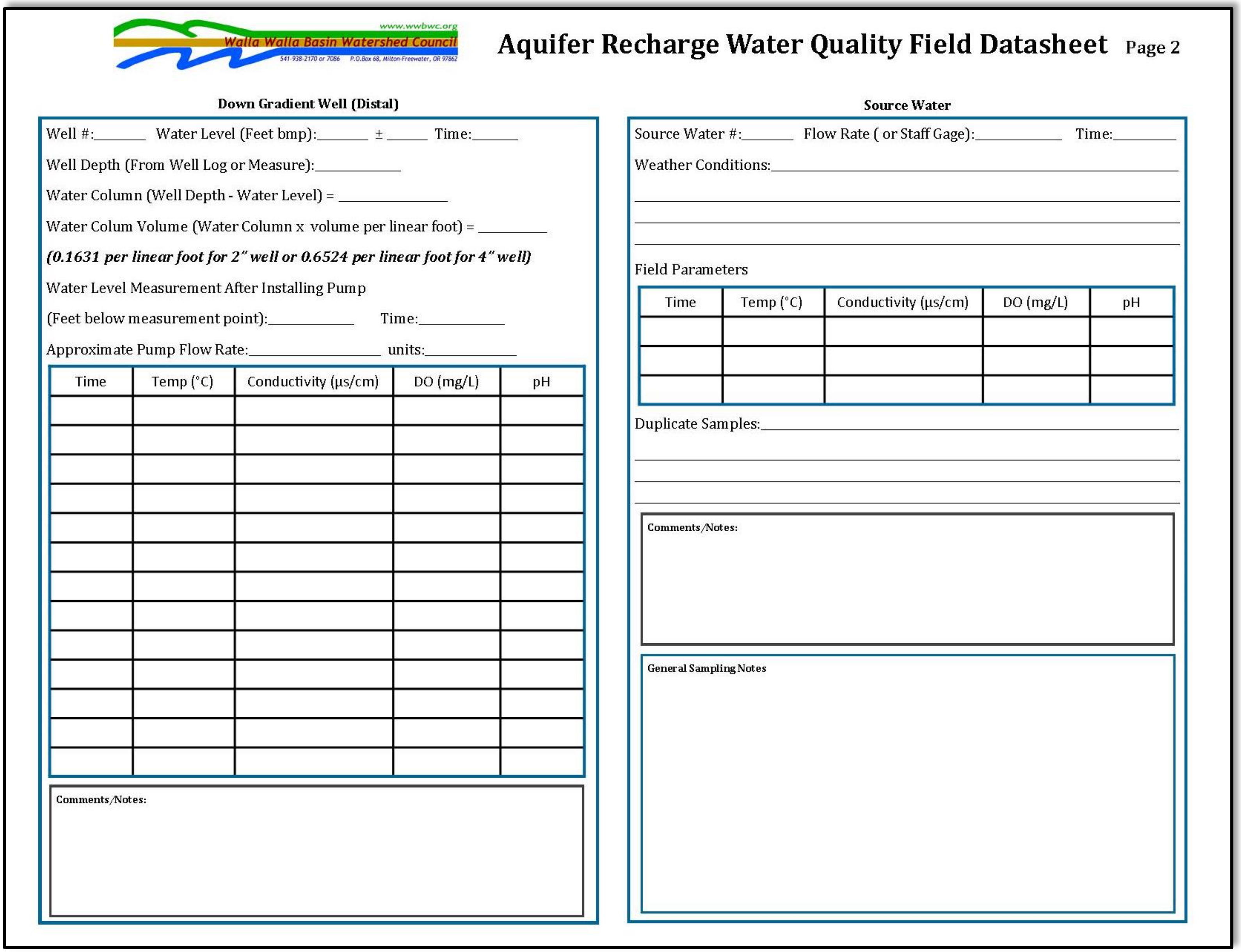
Water Level Measurement After Installing Pump

(Feet below measurement point):__________ Time:__________

Approximate Pump Flow Rate:_______________ units:__________

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Comments/Notes:



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Aquifer Recharge Water Quality Field Datasheet Page 2

Down Gradient Well (Distal)

Well #:_______ Water Level (Feet bmp):_______ ± _____ Time:______

Well Depth (From Well Log or Measure):____________

Water Column (Well Depth - Water Level) = _______________

Water Colum Volume (Water Column x volume per linear foot) = _________

(0.1631 per linear foot for 2" well or 0.6524 per linear foot for 4" well)

Water Level Measurement After Installing Pump

(Feet below measurement point):____________ Time:____________

Approximate Pump Flow Rate:__________________ units:_____________

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Comments/Notes:

Source Water

Source Water #:_______ Flow Rate (or Staff Gage):____________ Time:_________

Weather Conditions:____

Field Parameters

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Duplicate Samples:____

Comments/Notes:

General Sampling Notes

MEASUREMENT PROCEDURES

PROCEDURES

Sampling procedures for this QAPP are described in the Walla Walla Basin Watershed Council's Watershed Monitoring Program Standard Operation Procedures (Version 1.2). The SOP document is attached as Appendix A.

MEASUREMENT METHODS

FIELD MEASUREMENTS

Analyte	Sample Matrix	# of Samples	Expected Range of Results	Reporting Limit or Criterion	Analytical Method
Water Temperature	Groundwater	Depends upon purging values	5-10 °C	0.1 °C	YSI-30/Orion 5-Star
Specific Conductance	Groundwater	Depends upon purging values	50-500 µs/cm	1 µs/cm	YSI 30/Orion 5-Star
pH	Groundwater	Depends upon purging values	7.0 – 8.0	0.1 pH units	Orion 5-Star meter
Dissolved Oxygen	Groundwater	Depends upon purging values	0 – 10 mg/L	0.1 mg/L	Orion 5-Star meter

LABORATORY MEASUREMENTS

See table listed in Measurement Methods above.

QUALITY CONTROL

QUALITY CONTROL SAMPLING

FIELD MEASUREMENTS

Parameter	Field		Office/Laboratory	
	Blanks	Replicates	Check Standards	Calibration
Water Temperature	N/A	1/site	1/day	Yearly
Specific Conductance	1/day	1/site	1/day	Yearly
pH	N/A	1/site	1/day	Yearly
Dissolved Oxygen	N/A	1/site	N/A	Yearly

LABORATORY MEASUREMENTS

Parameter	Field		Laboratory		
	Blanks	Replicates	Method Blanks	Analytical Duplicates	Matrix Spikes
Barium	1/season	1/season	1/season	1/season	1/season
Cadmium	1/season	1/season	1/season	1/season	1/season
Chromium	1/season	1/season	1/season	1/season	1/season
Lead	1/season	1/season	1/season	1/season	1/season
Mercury	1/season	1/season	1/season	1/season	1/season
Selenium	1/season	1/season	1/season	1/season	1/season
Silver	1/season	1/season	1/season	1/season	1/season
Fluoride	1/season	1/season	1/season	1/season	1/season
Nitrate (as N)	1/season	1/season	1/season	1/season	1/season
Endrin	1/season	1/season	1/season	1/season	1/season
Methoxychlor	1/season	1/season	1/season	1/season	1/season
1,1,1-Trichloroethane	1/season	1/season	1/season	1/season	1/season
2-4 D	1/season	1/season	1/season	1/season	1/season
2,4,5-TP Silvex	1/season	1/season	1/season	1/season	1/season
Total Coliform Bacteria	1/season	1/season	1/season	1/season	1/season
Copper	1/season	1/season	1/season	1/season	1/season
Iron	1/season	1/season	1/season	1/season	1/season
Manganese	1/season	1/season	1/season	1/season	1/season
Zinc	1/season	1/season	1/season	1/season	1/season
Chloride	1/season	1/season	1/season	1/season	1/season
Sulfate	1/season	1/season	1/season	1/season	1/season
Total Dissolved Solids	1/season	1/season	1/season	1/season	1/season
Foaming Agents	1/season	1/season	1/season	1/season	1/season
pH	1/season	1/season	1/season	1/season	1/season
Corrosivity	1/season	1/season	1/season	1/season	1/season
Color	1/season	1/season	1/season	1/season	1/season
Odor	1/season	1/season	1/season	1/season	1/season
Chlorinated Pesticides (soil and water)	1/season	1/season	1/season	1/season	1/season
PCBs (soil and water)	1/season	1/season	1/season	1/season	1/season
Total Phosphorus	1/season	1/season	1/season	1/season	1/season
Carbonate & Bicarbonate	1/season	1/season	1/season	1/season	1/season
Temperature	1/season	1/season	1/season	1/season	1/season
Turbidity	1/season	1/season	1/season	1/season	1/season

- Field blanks will be transfer blanks created using deionized water with sample bottles filled at the recharge site.
- Field Duplicates are two samples collected at the same time and location and analyzed in the same batch.
- Laboratory Method Blanks are blanks prepared to represent the sample matrix and analyzed in a batch of samples.
- Laboratory Analytical Duplicates are where the laboratory analyzes duplicate aliquots of a sample within each batch.

DATA MANAGEMENT PROCEDURES

FIELD NOTES

All data collected in the field should be recorded on datasheets printed on waterproof paper (e.g. Rite-in-the-Rain). Notes should be clearly and legibly written so data and remarks are easily read and interpreted. If a mistake is made, draw a single line through the bad data and record the correct data next to it. Do not erase or completely mark out mistakes. All datasheets should be completed as fully as possible during data collection.

All datasheets will be scanned and stored on the WWBWC server. Data will also be entered into the WWBWC's AQUARIUS database. Once data have been entered into the database, visual checks will be done to detect and correct any errors.

LABORATORY DATA PACKAGE

Data package from the laboratory will include the following:

- Data
- Analytical Method used
- Quality Control results
- Field Blanks results
- Field Duplicate results
- Laboratory Method Blank results
- Laboratory Analytical Duplicate results
- Discussion of any problems

DATA STORAGE AND AVAILABILITY

All field notes, analytical results and other pertinent data associated with this QAPP will be maintained in a secure location and be archived for at least a 5 year period. Data will be made available in annual reports or by request from the WWBWC.

REPORTING

REPORTING SCHEDULE

Annual reports will be created either for each recharge site or for the program as a whole. Annual reports will be completed and submitted to Ecology by September 30th of each year.

REPORT COMPONENTS

The annual report will include the following information and data for each site:

- Annual recharge volume (acre-feet)
- Hydrograph of daily average and 15-minute inflow data
- Groundwater hydrographs for up and down gradient wells
- Water quality results for all three sampling events
- Issues, concerns or problems during the recharge season

Reports will be written by Steven Patten, WWBWC Senior Environmental Scientist, and Troy Baker, WWBWC GIS/Database Analyst.

DATA VERIFICATION, VALIDATION AND QUALITY ASSESSMENT

DATA VERIFICATION & VALIDATION PROCEDURES

After data have been entered into the AQUARIUS database, field data and laboratory data will be plotted to verify data are consistent, correct and complete. Data analysis will be conducted to ensure data collected met the requirements set forward for quality control (see above). Data will be graded and/or qualified as necessary.

Results from the QC sample analyses will be used to directly compare results to the measurement quality objectives laid out earlier in this document. Data

See Appendix A for additional information regarding data checks.

The WWBWC will work with Ecology staff to analyze collected data to determine the recharge site's impact on groundwater quality and groundwater and surface water levels (quantity). This analysis will be used in determining if the project qualifies for a permanent Environmental Enhancement Project permit.

REFERENCES

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WWBWC, 2013b. WWBWC Watershed Monitoring Program Standard Operating Procedures. Version 1.1, February 2013. 46 p.

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WWBWC, 2012b. Shallow Aquifer Monitoring in the Walla Walla Basin 2010-2011. 101 p.

WWBWC, 2010. Aquifer recharge as a water management tool – Hudson Bay recharge testing site report (2004-2009). Report for Hudson Bay District Improvement Company and Oregon Water Resources Department.

APPENDIX A – WWBWC STANDARD OPERATING PROCEDURES

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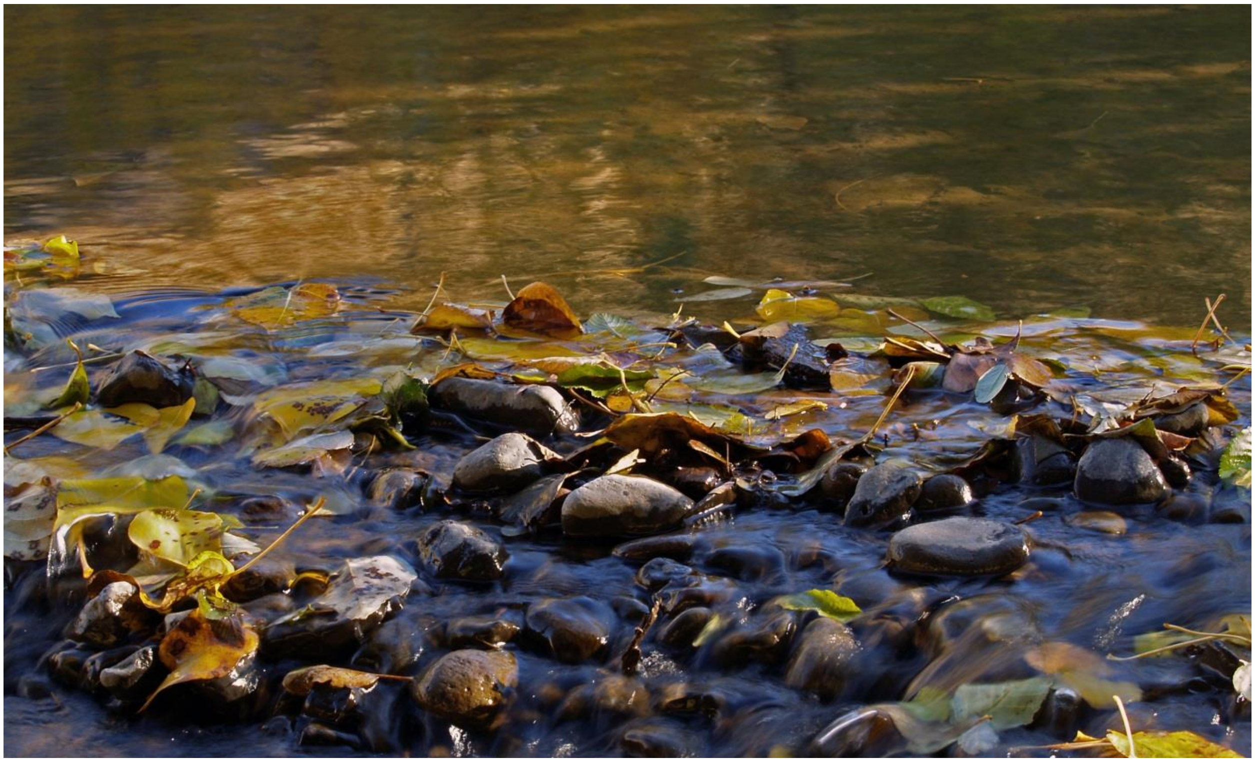
Walla Walla Basin Watershed Council
541-938-2170 or 7086 P.O.Box 68, Milton-Freewater, OR 97862

WWBWC Watershed Monitoring Program

Standard Operating Procedures



Steven Patten
Senior Environmental Scientist - WWBWC

Standard Operating Procedures

Version 1.2

April 2013

CONTENTS

SOP REVISION HISTORY

Revision Date	Revision Number	Summary of Changes	Sections Changed	Reviser(s)
11/2012	1.0	Creation of SOP document	All	Steven Patten
2/8/2013	1.1	Incorporated Review Comments	Study Design, Data Management, Surface Water monitoring and grammatical corrections	Steven Patten
4/1/2013	1.2	Photo Point Monitoring, Sampling Procedures and Grammatical changes	Photo Point Monitoring, Sampling Procedures and others	Steven Patten

DISTRIBUTION LIST

This document will be made available to the public, agencies and grant funders through the Walla Walla Basin Watershed Council's website (www.wwbwc.org). Internal distribution of the document will occur through the WWBWC's internal server. All field and technical personnel will be given an electronic copy of this document. A printed version will be available in the WWBWC office. This document will be redistributed to personnel and uploaded to the WWBWC server and website upon revision.

BACKGROUND AND PROJECT DESCRIPTION

The Walla Walla Basin Watershed Council's Watershed Monitoring Program includes more than 60 surface water sites, more than 100 groundwater sites, 10 water temperature sites, and more than a dozen water quality sites. The monitoring program covers almost the entire watershed starting in the upper reaches of the rivers and extending to the valley floor near where the Walla Walla River drains to the Columbia River. This document describes the WWBWC's Watershed Monitoring Program and includes the standard operating procedures used to collect environmental and hydrologic data.

PROGRAM AREA

The area of study for the Walla Walla Basin Watershed Council's Quality Assurance Program Plan includes the entire Walla Walla Watershed (Figure 1).

Monitoring locations for this program are spread throughout the valley (Figure 2), however the majority of the work conducted under this plan will take place on the valley floor Northwest of Milton-Freewater, OR, Southwest of Walla Walla, WA, and East of Touchet, WA. Aspects of the program (i.e. seepage runs) encompass other portions of the basin including almost the entire lengths of the Walla Walla River, the Touchet River and Mill Creek.

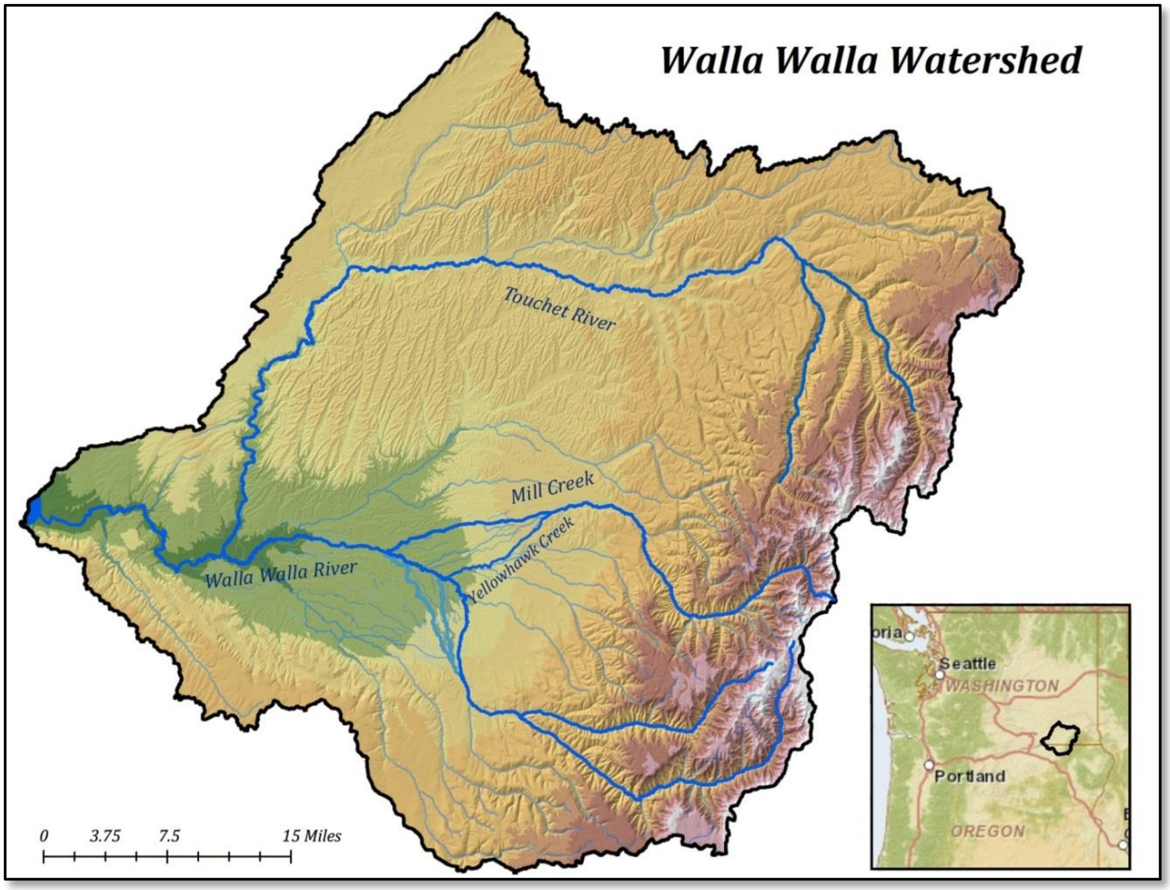


Figure 1. Map of the Walla Walla Watershed.

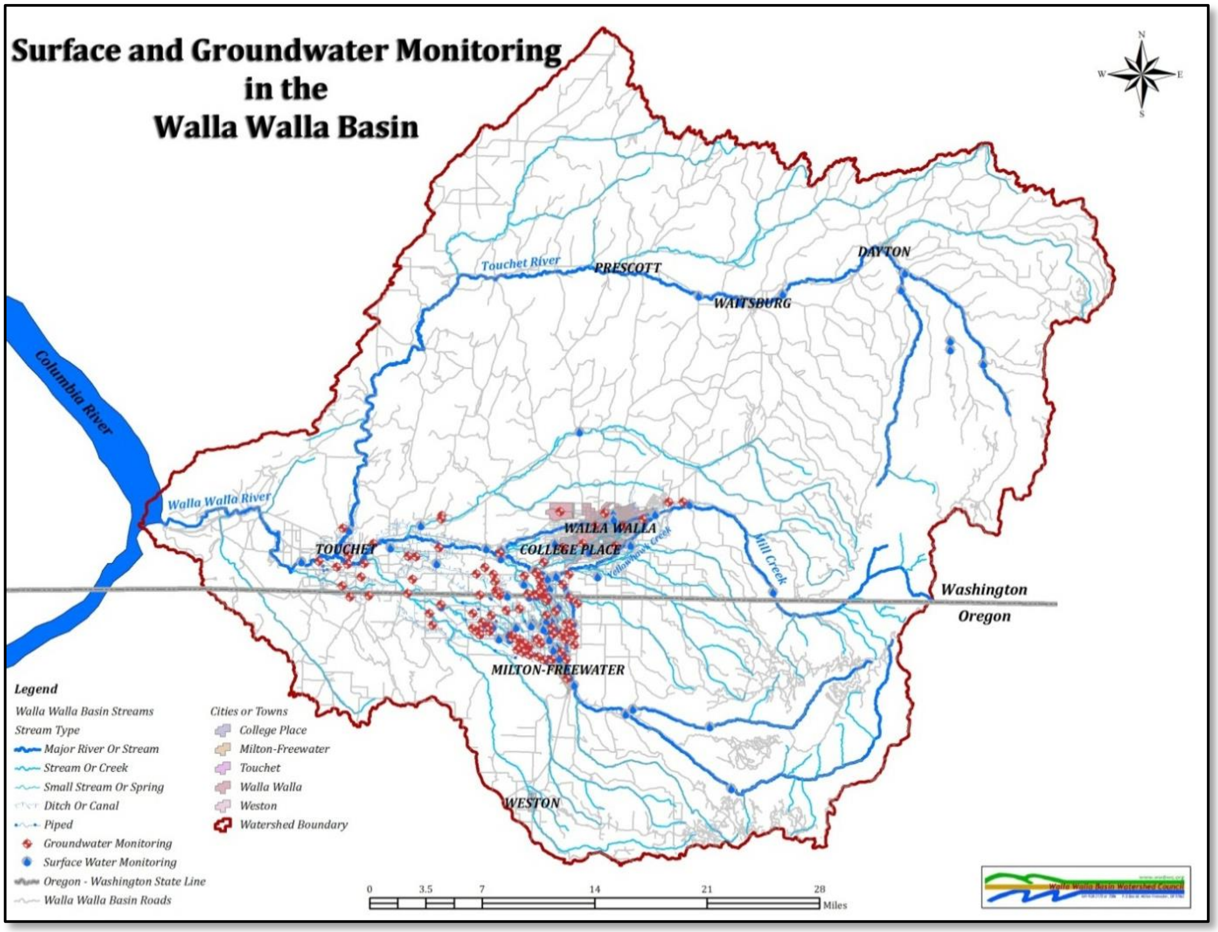


Figure 2. WWBWC Watershed Monitoring Program surface and groundwater monitoring locations.

PROJECT GOALS & OBJECTIVES

This monitoring program's goal is collect, organize, analyze and distribute hydrology related data for use by the WWBWC and other partners as projects are located, designed, installed and monitored so restoration in the Walla Walla Basin moves forward with knowledge of current and historic trends. The following objectives will achieve the program's goal.

- Collection of quality data utilizing well-established scientific protocols for monitoring activities.
- Organization of data into a functional system to allow use and analysis of data. Data must be organized and accessible for it to be useful.
- Analyzing data allows for trends and patterns to be determined. From these analyses we can determine how the basin is responding to changes (both environmental and project based).
- Distribution of data is critical. All of the above objectives can be completed, but without distribution of the data to other partners there cannot be a cohesive direction for restoration in the basin.

ORGANIZATION AND SCHEDULE

WALLA WALLA BASIN WATERSHED COUNCIL PERSONNEL

Name	Position	Main Tasks	Email
Brian Wolcott	Executive Director	Program Management	brian.wolcott@wwbwc.org
Steven Patten	Senior Environmental Scientist	Program Management & data collection and analysis	steven.patten@wwbwc.org
Troy Baker	GIS/Geodatabase Analyst	Geodatabase management & data collection and analysis	troy.baker@wwbwc.org
Wendy Harris	Operations Manager	Program/Operations Management and Oversight	wendy.harris@wwbwc.org
Will Lewis	Environmental Scientist	Data collection and analysis	will.lewis@wwbwc.org
Lyndsi Hersey	Environmental Scientist	Data collection and analysis	lyndsi.hersey@wwbwc.org
Chris Sheets	Fiscal Technician	Fiscal Oversight and management	chris.sheets@wwbwc.org
Graham Banks	Science Educator	Outreach and Education	graham.banks@wwbwc.org

The Walla Walla Basin Watershed Council's phone number is: 541-938-2170

PROGRAM PARTNERS

The Walla Walla Basin Watershed Council works with many partners throughout the basin to collect the monitoring data in the program. Program partners include: Hudson Bay District Improvement Company (HBDIC), Walla Walla River Irrigation District (WWRID), Gardena Farms Irrigation District #13 (GFID), Oregon Water Resources Department (OWRD), Washington Department of Ecology (WDOE), Confederated Tribes of the Umatilla Indian Reservation (CTUIR), City of Walla Walla, City of Milton-Freewater, City of College Place, Walla Walla Watershed Management Partnership (WWWMP), Tri-State Steelheaders (TSS), Oregon Department of Fish and Wildlife (ODFW), Washington Department of Fish and Wildlife (WDFW), Washington Water Trust, The Freshwater Trust, Walla Walla University, Whitman College, Oregon Department of Environmental Quality (ODEQ), and many businesses and individual landowners in the basin.

PROGRAM SCHEDULE

The WWBWC's monitoring program is an on-going process. A general schedule of activities is described in the table below:

Monitoring Activity	Year-round or Seasonal	General Schedule
Surface Flow (River)	Year-round and Seasonal	Sites are visited every other week to collect staff gauge measurements and perform general site maintenance. Manual discharge measurements and other data are collected during ~6 visits each year. A few river sites are only monitored seasonally during summer and fall base flows.
Surface Flow (Streams, Springs & Ditches)	Year-round	Sites are visited 4-5 times a year to download data, conduct manual flow measurements, perform site maintenance and collect other data.
Groundwater Level Monitoring	Year-round	Sites are visited ~4 times a year to download data, conduct manual groundwater level measurements, perform site maintenance and collect other data.
Water Temperature (River)	Seasonal	Data loggers are deployed in late spring or early summer and retrieved late fall or early winter dependent upon river flows.
Evaporation-Transpiration (ET) Stations	Year-round	Sites are visited ~3-4 times a year to download data and perform site maintenance.
Scour Chains and Bed Stability	Seasonal	Sites are visited ~2-3 times a year to collect data, conduct channel survey and perform any maintenance.
Seepage Analysis	Seasonal	Seepage runs occur twice a year on each river system. Typically runs are conducted late spring or early summer and late summer or early fall.
Water Quality Sampling (SAR)	Seasonal	Water quality sampling is done during the shallow aquifer recharge season which typically starts in November and continues through May.
Water Quality Sampling (PSP)	Seasonal	Water quality sampling is done from March till June during the typical pesticide application time period.
Data Analysis and Distribution	Year-round	As data are collected, analyzed and incorporated into the WWBWC's database as provisional. Data are reviewed at the end of each water year.

QUALITY OBJECTIVES

Parameter	Check Standard	Duplicate Samples
Water Temperature	± 0.5 °C (NIST Thermometer)	± 0.2 °C
pH	± 0.1 pH units	± 0.1 pH units
Specific Conductance	± 5% of standard	± 5% of reading
Dissolved Oxygen	± 0.2 mg/L	± 0.1 mg/L
Groundwater Level Measurement	N/A	± 0.01 feet
Manual Discharge Measurement	N/A	± 10%
Tape Down Measurement	N/A	± 0.02 feet
Vertical Staff Gauge Measurement	N/A	± 0.02 feet

STUDY DESIGN

Monitoring locations were determined by availability to measure parameter of interest (e.g. groundwater can only be measured at wells or bore holes or high discharge measurements can only be taken at bridges). Professional judgment was also utilized in the placement of monitoring locations if multiple sites were available. Many monitoring locations were determined based upon anthropogenic changes to the system (e.g. irrigation diversions, flood control structures or restoration projects).

Sampling locations and frequency cover temporal and spatial variability within the valley. For example, monitoring surface flow sites 4-6 times per year allows for data collection to include high and low flow periods based upon environmental changes. The schedule provided for each sampling parameter tries to accommodate temporal variability throughout the year.

The current study design is structured for two main functions. The first function is to provide baseline and/or trend monitoring for the hydrologic system within the Walla Walla Basin - are conditions improving, remaining the same or getting worse? The second function is to provide effectiveness monitoring for projects (habitat restoration, irrigation efficiency, aquifer recharge and others) occurring in the Walla Walla Basin.

The data collected under these standard operating procedures will help answer hydrologic and restoration questions such as (but not limited to):

- Are surface flows increasing in the Walla Walla River? If present, can the increases be attributed to conservation effects?
- Are groundwater levels declining in the alluvial aquifer? If so, is aquifer recharge helping to restore aquifer storage? Can declines be attributed to piping projects or other irrigation efficiency projects?
- Are water temperatures in the Walla Walla River improving over time? Where are the hottest locations? Are habitat projects improving water temperature?

FIELD MEASUREMENTS

The majority of sampling for this program will occur in the field. Refer to the table below for which samples will be collected in the field and a sampling schedule for each.

Measurement Parameter	Monitoring Program	Schedule
River/Stream Discharge	Surface Flow Monitoring	4-6 times per year
Water Temperature	Surface Flow Monitoring	4-6 times per year
Specific Conductance	Surface Flow Monitoring	4-6 times per year
Staff Gage Reading	Surface Flow Monitoring	4-6 times per year (20+ for mainstem gage locations)
Elevation Reference Checks	Surface Flow Monitoring	4-6 times per year
Channel Survey	Surface Flow Monitoring	1 every 2-3 years
Groundwater Level Measurement	Groundwater Monitoring	4 times per year
Groundwater Temperature	Groundwater Monitoring	4 times per year
Specific Conductance	Groundwater Monitoring	4 times per year
Surface/Groundwater Temperature	Recharge Water Quality Monitoring	2-3 times per year
Surface/Groundwater Specific Conductance	Recharge Water Quality Monitoring	2-3 times per year
Surface/Groundwater Dissolved Oxygen	Recharge Water Quality Monitoring	2-3 times per year
Surface/Groundwater pH	Recharge Water Quality Monitoring	2-3 times per year
Channel Survey	Scour Chains & Bed Stability	2-3 times per year
Scour Chain Measurement	Scour Chains & Bed Stability	2-3 times per year
Pebble Counts	Scour Chains & Bed Stability	1-2 times per year
Longitudinal Survey	Scour Chains & Bed Stability	1 time per year
Water Temperature	River Temperature Monitoring	2-3 time per year
River/Stream Discharge	Seepage Runs	2 times per year per river
Water Temperature	Seepage Runs	2 times per year per river
Specific Conductance	Seepage Runs	2 times per year per river

LABORATORY MEASUREMENTS

Some of the water quality sampling that is conducted under this plan requires laboratory level analysis. Some of the sampling parameters and schedules are listed in the table below.

Sampling Parameter	Monitoring Program	Schedule
pH	Recharge Water Quality Monitoring	2-3 times per year
Electrical Conductivity	Recharge Water Quality Monitoring	2-3 times per year
Dissolved Oxygen	Recharge Water Quality Monitoring	2-3 times per year
Nitrate-N	Recharge Water Quality Monitoring	2-3 times per year
Total Organic Carbon	Recharge Water Quality Monitoring	2-3 times per year
Total Kjehldahl Nitrogen (TKN)	Recharge Water Quality Monitoring	2-3 times per year
Sulfate	Recharge Water Quality Monitoring	2-3 times per year
Chloride	Recharge Water Quality Monitoring	2-3 times per year

Sampling Parameter	Monitoring Program	Schedule
Calcium	Recharge Water Quality Monitoring	2-3 times per year
Alkalinity	Recharge Water Quality Monitoring	2-3 times per year
Ortho-Phosphate	Recharge Water Quality Monitoring	2-3 times per year
Sodium	Recharge Water Quality Monitoring	2-3 times per year
Potassium	Recharge Water Quality Monitoring	2-3 times per year
Magnesium	Recharge Water Quality Monitoring	2-3 times per year
Aluminum	Recharge Water Quality Monitoring	2-3 times per year
Iron (dissolved)	Recharge Water Quality Monitoring	2-3 times per year
Manganese (dissolved)	Recharge Water Quality Monitoring	2-3 times per year
PCBs	Recharge Water Quality Monitoring	2-3 times per year
Chlorinated Pesticides	Recharge Water Quality Monitoring	2-3 times per year
Herbicides	Recharge Water Quality Monitoring	2-3 times per year
Primary and Secondary contaminants listed in WAC 173-200, Table 1	Recharge Water Quality Monitoring	2-3 times per year

SAMPLING PROCEDURES

WATER QUALITY SAMPLING (GROUNDWATER)

Groundwater sampling is conducted utilizing the following procedures. The general overview of groundwater sampling includes gathering equipment, measuring the initial water level, installing a submersible pump in the well, purging the well at a low flow rate, collecting and labeling all required samples and delivering them to the lab or shipping company. Details on parameters sampled for each site can be found in its monitoring and reporting plan.

Note: this procedure is modified from:

Marti, 2011. Standard Operating Procedure for Purging and Sampling Monitoring Wells. Washington State Department of Ecology – Environmental Assessment Program. EAP078.

EQUIPMENT

- Sampling field data sheets (see below) or field notebook
- Chain of Custody form
- Water level measuring equipment (e-tape)
- Water quality meters and probes (Temperature, Specific Conductance, pH & Dissolved Oxygen)
- Submersible pump
- Pump controller
- Tubing and connectors
- Sample bottles/containers
- Cooler
- Ice
- Deionized water
- Diluted Bleach solution
- Non-phosphate soap
- Nitrile or latex gloves

- First aid kit
- Well keys
- Camera
- Paper towels or clean rags
- Plastic sheet for keeping equipment clean
- Buckets (5-gallon or similar for purge volumes)
- 1 liter container (for purge volumes)
- Socket set
- Screwdriver(s)

PURGING AND SAMPLING

1. Check well for any changes or potential hazards.
2. Make sure equipment has been cleaned and decontaminated (see below for details). Spread plastic or other material if needed to keep equipment clean.
3. Wear clean disposable gloves (latex or Nitrile) while performing purging and sampling. If gloves become contaminated or dirty replace with new gloves.
4. Make sure field water quality meters are calibrated according to the manufacturer's instructions.
5. If well is equipped with a pressure transducer, note how it is installed and its position to replace it after sampling. Remove the pressure transducer from the well. Note the time the pressure transducer was removed from the well on the data sheet or in the field notebook.
6. Measure the static water level in the well (see Groundwater Level and Temperature protocol below for details).
7. Measure the depth of the well or refer to the well log to determine the depth of the well.
8. Calculate the length of the water column. Calculate the volume of water in the well using the following values: 2" well = 0.1631 gallons per linear foot, 4" = 0.6524 gallons per linear foot (Equation used for water volume calculation – Volume (gal/ft) = $\pi r^2(7.48 \text{ gal/ft}^3)$ where r is the radius of the well and 7.48 is the conversion factor).
9. Install the submersible pump into the well. Be sure to slowly lower the pump into the well and through the water to avoid stirring up particulates. Place the pump in the middle of the screen section of the well (refer to well log to determine the open interval for pump placement).
10. Once the pump is installed correctly re-measure the static water level to monitor during purging.
11. Start purging. Set the pump controller to the desired pumping rate (~1 liter/minute). See notes from previous sampling for pumping rate.
12. Ideally, wells should be purged and sampled at flow rates at or less than the natural flow conditions of the aquifer in the screen interval to avoid drawing down the water level in the well. Use water level measurements to help adjust pumping rates to prevent well drawdown. Purging should not cause significant drawdown (considered to be 5% of the total height of the water column). If drawdown is significant, reduce pumping rate until water levels stabilize at an appropriate level.
13. Record pumping rate on the data sheet or field notebook.
14. Discharge evacuated water as far as possible from the wellhead and work area.
15. During purging and sampling water flow should be smooth and consistent without bubbles in the tubing.
16. Once pumping rate has been determined and flow has stabilized, start collecting field parameters (water temperature, specific conductance, pH and dissolved oxygen) at regular

intervals. The measurement interval will depend upon the pumping rate (typically 2-5 minutes between measurements).

17. Record field parameters, water level measurement, and estimated amount of water purged. Note any changes in purged water's appearance (clear, turbid, odor, etc.).
18. Continue purging well until field parameters stabilize. Parameters should be considered to be stabilized when 3 consecutive measurements fall within the following ranges:

Field Parameter	Stabilized Range
Temperature	± 0.1 ° Celsius
Specific Conductance <1000 µs/cm	± 10 µs/cm
Specific Conductance >1000 µs/cm	± 20 µs/cm
Dissolved Oxygen < 1 mg/L	± 0.05 mg/L
Dissolved Oxygen > 1 mg/L	± 0.2 mg/L
pH	± 0.1 pH units

19. Collect samples once field parameters have stabilized. Do not stop or change pumping rate during the final phase of purging and sampling.
20. Collect most sensitive analytes first (i.e. organics) followed by less sensitive analytes (i.e. nutrients). This order can be modified if using sulfuric or nitric acid preservatives to prevent contamination of sulfate and/or nitrogen samples.
    Collect any duplicate or quality control samples (see below for details).
21. Place samples in an ice-cooled cooler for delivery to the lab or shipping company. Make sure samples do not freeze during transport.
22. Complete chain of custody form. Record sample date and time, final water level and estimated total purge volume on the data sheet or in the field notebook. Also record any comments or observations regarding the purging and sampling process.
23. Replace pressure transducer if the well was equipped with one. Note re-install time on the data sheet or in the field notebook.
24. Clean and disinfect sampling equipment for next sampling event.

DECONTAMINATION

All non-disposable field equipment that may potentially come in contact with any soil or water sample shall be decontaminated in order to minimize the potential for cross-contamination between sampling locations. Thorough decontamination of all sampling equipment shall be conducted prior to each sampling event. In addition, the sampling technician shall decontaminate all equipment in the field as required to prevent cross-contamination of samples collected in the field. The procedures described in this section are specifically for field decontamination of sampling equipment.

At a minimum, field-sampling equipment should be decontaminated following these procedures:

- Wash the equipment in a solution of non-phosphate detergent (Liquinox® or equivalent) and distilled or deionized water. All surfaces that may come in direct contact with the samples shall be washed. Use a clean Nalgene and/or plastic tub to contain the wash solution and a scrub brush to mechanically remove loose particles. Wear clean latex, plastic, or equivalent gloves during all washing and rinsing operations.

- Rinse twice with distilled or deionized water.
- Dry the equipment before use, to the extent practicable.

WATER QUALITY SAMPLING (SURFACE WATER)

Surface water sampling is conducted utilizing the following procedures.

Note: this procedure is a modified from:

Anderson, 2011. Standard Operating Procedure for Sampling of Pesticides in Surface Waters. Washington State Department of Ecology – Environmental Assessment Program. EAP003.

EQUIPMENT

- Sampling field data sheets (see below) or field notebook
- Chain of Custody form
- Water quality meters and probes (Temperature, Specific Conductance, pH & Dissolved Oxygen)
- Sample bottles/containers
- Cooler
- Ice
- Deionized water
- Diluted Bleach solution
- Non-phosphate soap (Liquinox or similar)
- Nitrile gloves
- First aid kit
- Camera
- Paper towels or clean rags
- Plastic sheet for keeping equipment clean
- Screwdriver(s)

SAMPLING

1. Check for any changes or potential hazards.
2. Make sure equipment has been cleaned and decontaminated (see below for details). Spread plastic or other material if needed to keep equipment clean.
3. Wear clean disposable gloves (Nitrile) while performing purging and sampling. If gloves become contaminated or dirty replace with new gloves.
4. Make sure field water quality meters are calibrated according to the manufacturer's instructions.
5. Collect required field water quality parameters and record on data sheet. Also note weather conditions
6. Fill out labels on each sample bottle with all necessary information.
7. Samples will be collected using the "Grab Sample" method described in EAP 003.
8. Take sample bottles and sampling equipment to the sample site and put on nitrile gloves.
9. Carefully collect samples by filling each container with water from the site. Note marked fill lines or preservatives to prevent over or under filling of the sample bottle.
10. Collect any duplicate or quality control samples (see below for details).

11. Place samples in an ice-cooled cooler for delivery to the lab or shipping company. Make sure samples do not freeze during transport.
12. Complete chain of custody form. Record sample date and time on the data sheet or in the field notebook. Also record any comments or observations regarding the sampling process.
13. Clean and disinfect sampling equipment for next sampling event.

DECONTAMINATION

All non-disposable field equipment that may potentially come in contact with any soil or water sample shall be decontaminated in order to minimize the potential for cross-contamination between sampling locations. Thorough decontamination of all sampling equipment shall be conducted prior to each sampling event. In addition, the sampling technician shall decontaminate all equipment in the field as required to prevent cross-contamination of samples collected in the field. The procedures described in this section are specifically for field decontamination of sampling equipment.

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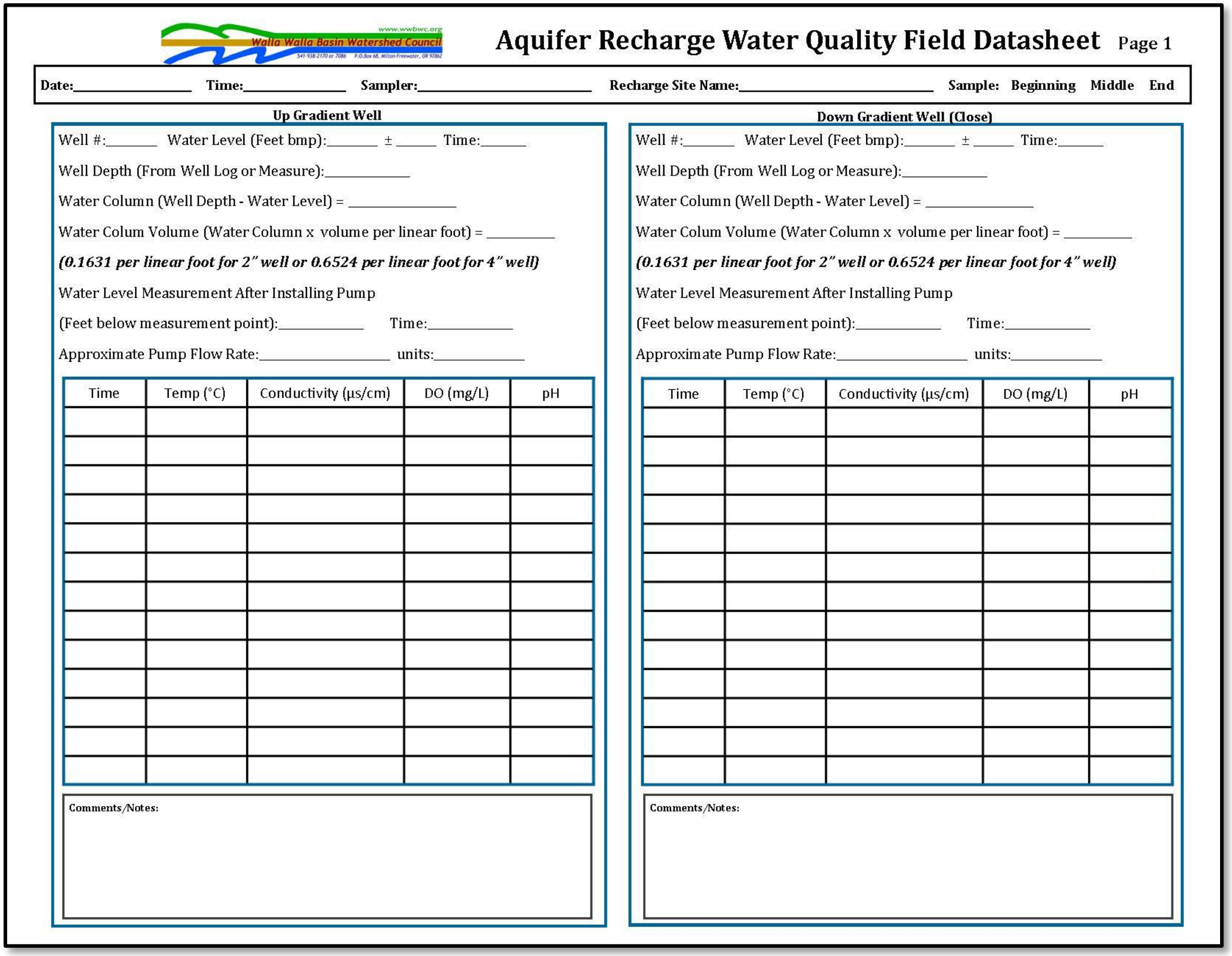
- Wash the equipment in a solution of non-phosphate detergent (Liquinox® or equivalent) and distilled or deionized water. All surfaces that may come in direct contact with the samples shall be washed. Use a clean Nalgene and/or plastic tub to contain the wash solution and a scrub brush to mechanically remove loose particles. Wear clean latex, plastic, or equivalent gloves during all washing and rinsing operations.
- Rinse twice with distilled or deionized water.
- Dry the equipment before use, to the extent practicable.

WATER QUALITY SAMPLING DATASHEET



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Aquifer Recharge Water Quality Field Datasheet Page 1

Date:_______________ **Time:**_____________ **Sampler:**______________________ **Recharge Site Name:**_________________________ **Sample: Beginning Middle End**

Up Gradient Well

Well #:_______ Water Level (Feet bmp):_______ ± _____ Time:_______

Well Depth (From Well Log or Measure):___________

Water Column (Well Depth - Water Level) = ______________

Water Colum Volume (Water Column x volume per linear foot) = _________

(0.1631 per linear foot for 2" well or 0.6524 per linear foot for 4" well)

Water Level Measurement After Installing Pump

(Feet below measurement point):___________ Time:___________

Approximate Pump Flow Rate:_________________ units:____________

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Comments/Notes:

Down Gradient Well (Close)

Well #:_______ Water Level (Feet bmp):_______ ± _____ Time:_______

Well Depth (From Well Log or Measure):___________

Water Column (Well Depth - Water Level) = ______________

Water Colum Volume (Water Column x volume per linear foot) = _________

(0.1631 per linear foot for 2" well or 0.6524 per linear foot for 4" well)

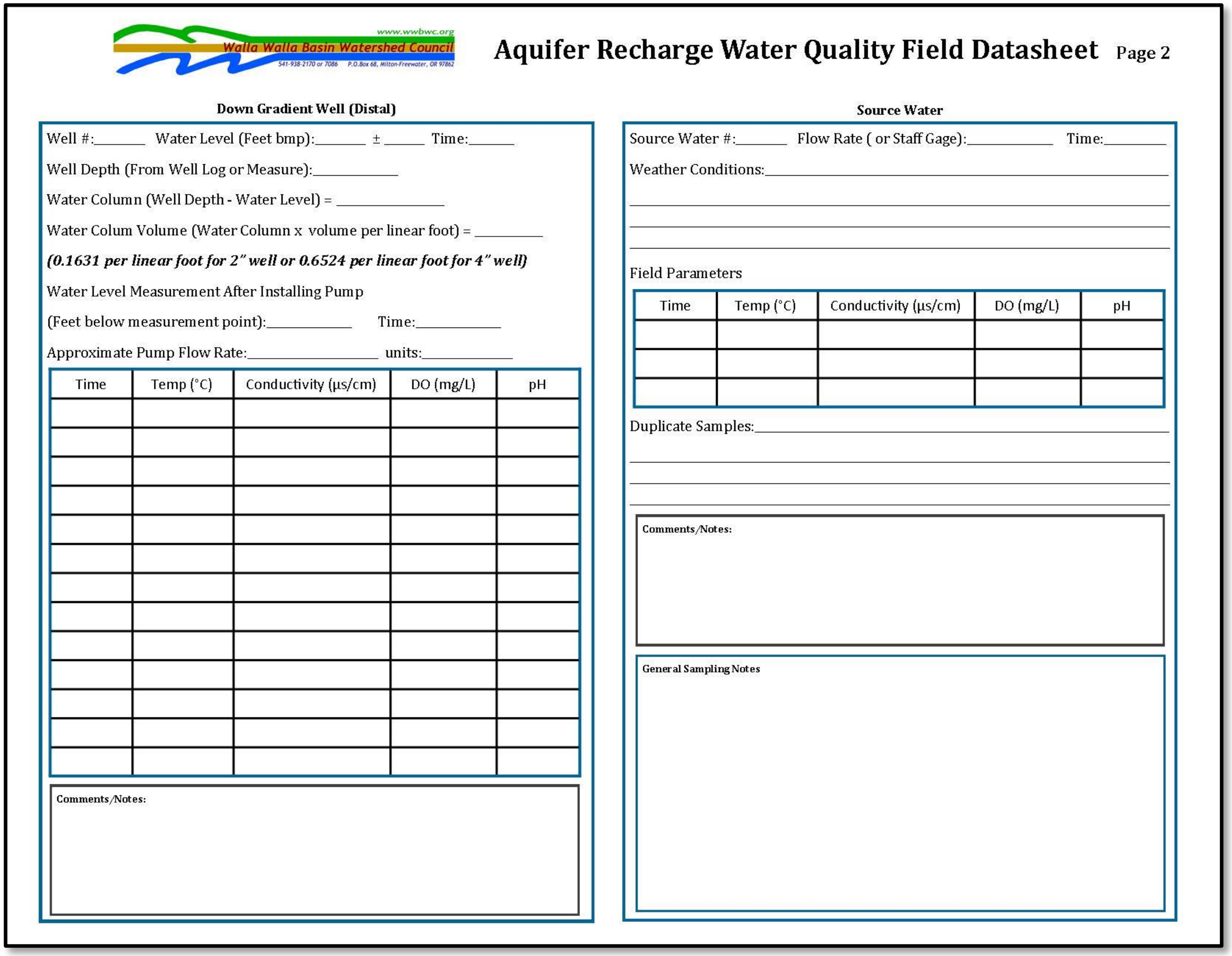
Water Level Measurement After Installing Pump

(Feet below measurement point):___________ Time:___________

Approximate Pump Flow Rate:_________________ units:____________

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Comments/Notes:



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Aquifer Recharge Water Quality Field Datasheet Page 2

Down Gradient Well (Distal)

Well #:_______ Water Level (Feet bmp):_______ ± _____ Time:______

Well Depth (From Well Log or Measure):___________

Water Column (Well Depth - Water Level) = _____________

Water Colum Volume (Water Column x volume per linear foot) = _________

(0.1631 per linear foot for 2" well or 0.6524 per linear foot for 4" well)

Water Level Measurement After Installing Pump

(Feet below measurement point):___________ Time:___________

Approximate Pump Flow Rate:_________________ units:____________

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Comments/Notes:

Source Water

Source Water #:_______ Flow Rate (or Staff Gage):___________ Time:________

Weather Conditions:____

Field Parameters

Time	Temp (°C)	Conductivity (µs/cm)	DO (mg/L)	pH

Duplicate Samples:____

Comments/Notes:

General Sampling Notes

MEASUREMENT PROCEDURES

PHOTO POINT MONITORING

Note: these procedures are based upon and modified from:
Hall, F.C., 2002. Photo Print Handgook: Part A – Field Procedures and Part B – Concepts and Analysis.

Photo point monitoring will be used to document changes at measurement points over time. For surface sites this will include change in channel shape, vegetation, and land use changes. For groundwater sites this can include casing changes, pump changes or land use changes.

EQUIPMENT

- Camera
- GPS (to find photo point)
- Clipboard
- Pencil or pen
- Datasheet (for appropriate monitoring site)
- Previous picture or description of photo point

ESTABLISHING A PHOTO POINT

1. Reconnoiter the area to determine the best location for the photo point. Take note of sun direction, potential vegetation growth and main objectives (i.e. channel shape, well casing, pump, etc.).
2. Record GPS coordinates for the photo point and record in the comments section of the data sheet. Also note the direction the photo should be taken and include a description of the main objectives of the photo (i.e. channel shape, vegetation, etc.)
3. Take photo point picture and review. Determine if all of the main objectives are visible in the picture.

VISITING A PHOTO POINT

Photo point monitoring should be conducted during every site visit.

1. Look at previous pictures taken at the photo point to orient. Look at site data sheets to determine GPS coordinates, photo direction and main objectives.
2. Take picture of site. Determine if all of the main objectives are visible in the picture.

SURFACE WATER MONITORING

Note: These procedures are based on and modified from:

Myers, J. 2009. Standard Operation Procedure for Conducting Stream Hydrology Site Visits. Version 1.0. Washington Department of Ecology – Environmental Assessment Program. EAP057.

ODEQ, 2009. Water Monitoring and Assessment Mode of Operations Manual. Watersheds Quality Monitoring Field Sampling Standard Operating Procedure – Laboratory and Environmental Assessment Division. Version 3.2

Rantz, S. E., and others. 1982 Measurement and Computation of Streamflow: Volume I. Measurment of Stage and Dischage. U.S. Geological Survey Water-Supply Paper 2175.

Rantz, S. E., and others. 1982 Measurement and Computation of Streamflow: Volume II. Computation of Discharge. U.S. Geological Survey Water-Supply Paper 2175.

Shedd, J. R. 2011. Standard Operating Procedure for Measuring and Calculating Stream Discharge. Version 1.1. Washington Department of Ecology – Environmental Assessment Program. EAP056.

Shedd, J.R. 2008. Standard Operating Procedure for Measuring Gage Height of Streams. Version 1.0. Washington Department of Ecology – Environmental Assessment Program. EAP042.

EQUIPMENT

- Four foot top set wading rod
- Mechanical Current Meter (Price AA or pygmy), Swoffer, or Marsh-McBirney Velocity Meter
- AquaCalc computer
- Bridge Board
- Sounding Reel
- Columbus sounding weight
- Tape Down Measuring Tape (with weight attached)
- Laser Level
- Stadia Rod
- NIST Thermometer
- YSI-30 Temperature and Conductivity Meter
- Measuring tape (100’ or 200’)
- Chest or Hip Waders
- Laptop Computer
- Cables for connecting to Data logger
  - LT-300 Cable
  - LT-500 Cable
  - WaterLog Cable or Memory Card
  - Campbell Scientific Cable or Card
- Pen or Pencil
- Data sheets

VERTICAL STAGE MEASUREMENT

Vertical stage measurements are obtained from mounted staff gauges. Most staff gauges used by the WWBWC are graduated in 0.01 feet increments. Measurements should be recorded to 0.01 feet resolution. Below is a photo of a typical WWBWC staff gauge.

1. Read the water level on the staff gauge to the nearest 0.01. If the water level is fluctuating during the reading take the average water level and note the range of fluctuation (1.25 ±0.04 where 1.25 is the average water level and 0.04 is the range above or below the average).
2. If water level fluctuations are excessive you can create a temporary stilling well around the staff gauge to get a more accurate reading. You can use a 5-gallon bucket with the bottom cut out for the temporary stilling well.
3. Take the necessary time to obtain an accurate staff gauge reading – both the water level and uncertainty.
4. Record the date, time and measurement data on the data sheet.

TAPE-DOWN STAGE MEASUREMENT

Measuring tape-down stage involves lowering a measuring tape with a weight attached to the end to the water surface from a reference point. Often the reference point is a metal washer attached to a bridge railing.

1. Locate the reference point
2. Lower the weighted tape down to the water surface. The weight should only just touch the water surface creating a small "V" shape on the water surface.
3. Read the tape at the edge of the reference point and record to the nearest 0.01. Include uncertainty caused by wave action or wind.
4. Because the weight is attached to the end of the measuring tape, record the correction factor that needs to be applied to the reference point reading.

LASER LEVEL STAGE MEASUREMENT

Laser levels are used to measure stage height from a known elevation and allow a check on the vertical staff gauge elevation.

1. Place the laser level on the platform of known elevation.
2. Confirm that the platform's elevation has not changed by measuring the elevation of reference marks/points with the stadia rod. Record data on the Stream Gage Logger Notes datasheet. Reference marks or points are placed near the laser level platform and are typically bolts in large boulders or other stable objects. Compare reference point elevations to ensure platform has not moved.
3. Place the stadia rod as close as possible to the primary staff gauge (typically the vertical staff gauge).
4. Read the laser level using the laser sensor on the stadia rod. Record level.
5. Observe and record the water level (including level of uncertainty) on the stadia rod.
6. Complete the calculations on the Stream Gage Logger Notes datasheet to compute the laser level stage. For the calculations you take the laser rod reading minus the depth of water and that equals the differential laser to water surface. Take the elevation of the laser beam minus the differential to get the laser level stage.

DISCHARGE MEASUREMENT (WADING)

1. Select an appropriate location to perform a discharge measurement (refer to Rantz, 1982 for full details). A good cross section will typically have the following characteristics: relatively straight channel with parallel edges, defined edges, uniform shape, free of vegetative growth and large cobbles or boulders, free of eddies, slack water and turbulence, depths greater than 0.5 feet, velocities greater than 0.5 feet per second that are evenly distributed, close to the gauging station. Often some or many of the above criteria cannot be met. The best available cross section location should be chosen.
2. Stretch a measuring tape across the channel where the measurement will be taken. The tape should be perpendicular to as much of the flow as possible to reduce oblique flow angles.
3. Determine the width of the wetted channel and divide the width into 25-30 segments. Cells should be divided such that each cell has approximately 5% of the total flow and no more than 10%. Segments should be shorter where flow is more concentrated or the bottom is irregular. The width of any segment should not be less than three tenths of a foot (0.3 feet).
4. Start at either the right or left edge of water (REW or LEW). Record tape distance for edge of water.
5. Set wading rod at location for the first measurement. Determine the depth of water.
6. If depth is less than 1.5 feet use the one point method of measuring velocity at 0.6 of the depth.
7. If depth is equal to or greater than 1.5 feet use the two point method of measuring at both 0.2 and 0.8 of the depth and average the velocities.
8. In cases where there is no logarithmic relationship to the velocities in the water column (this is when the 0.2 velocity is less than the 0.8 velocity or the 0.2 velocity is more than twice the 0.8 velocity) the three point method should be used. The three point method measures at 0.2, 0.6 and 0.8. The 0.2 and 0.8 velocities should be averaged and then that result should be averaged with the 0.6 velocity. This weights the 0.6 velocity at 50% and the 0.2 and 0.8 each at 25%.
9. Each velocity measurement should average velocity data for 40 seconds to address variations in water velocity over time at a single measurement point.
10. If water flow direction is not perpendicular to the measuring tape the meter should be pointed directly into the direction of flow. Use the data sheet to measure the angle coefficient (and apply a correction to the velocity) for velocity measurements not perpendicular to the measuring tape (see figure below). Align the point of origin on the measuring tape. Rotate the data sheet until the opposite long edge is parallel to the direction of flow (the same direction the meter is pointed). The angle coefficient is read where the measuring tape intersects the data sheet. Multiply the velocity measurement by the angle coefficient to calculate the perpendicular velocity.

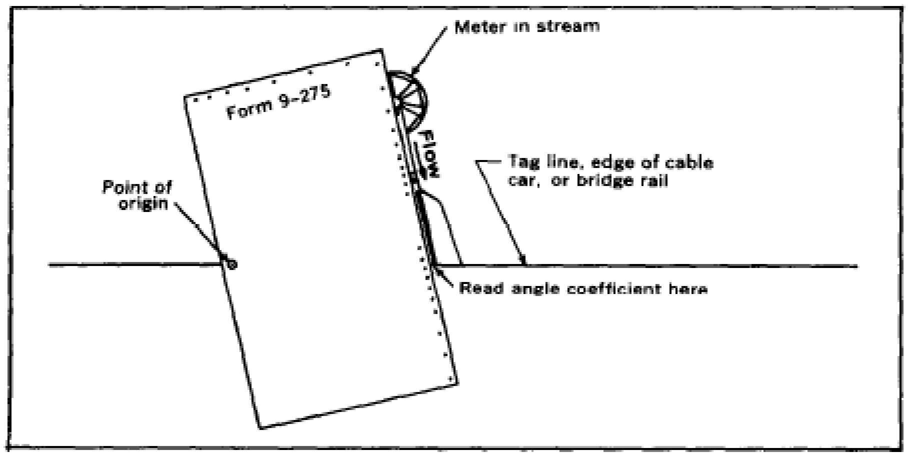


Figure taken from Rantz, 1982.

11. Repeat steps 5-10 for each of the subsequent measurement locations across the cross section until you reach the opposite edge of water.
12. Rate the measurement on a scale from excellent to poor. Rating can be based upon observed conditions as well as information from the AquaCalc file. Observations that can influence the rating of a measurement include (but are not limited to): channel characteristics, proximity to bridges or other structures, number and degree of oblique current angles, condition of equipment, weather, water level bounce and velocity pile up on wading rod and others. Use observations and professional judgment in rating a measurement. Measurements are rated excellent if the discharge value is with 2% of the actual flow value, good if within 5%, fair if within 8% and poor if within 13%.

DISCHARGE MEASUREMENT (BRIDGE)

This section will describe differences between wading and bridge discharge measurements. Follow the procedure for wading discharge measurements above with the following changes:

1. The choice of cross section locations is obviously limited when measuring from a bridge.
2. Use a bridge board, sounding reel, and Columbus weight instead of a wading rod
3. Increase velocities measurements near bridge piers
4. Use the one point method on depths less than 2.5 feet and the two point method on depths equal to or greater than 2.5 feet.
5. Sometimes, water flow direction is all oblique to the bridge. In these cases multiply the raw average velocity of the measurement by the cosine of the angle between current direction and the cross section.

DISCHARGE CALCULATION

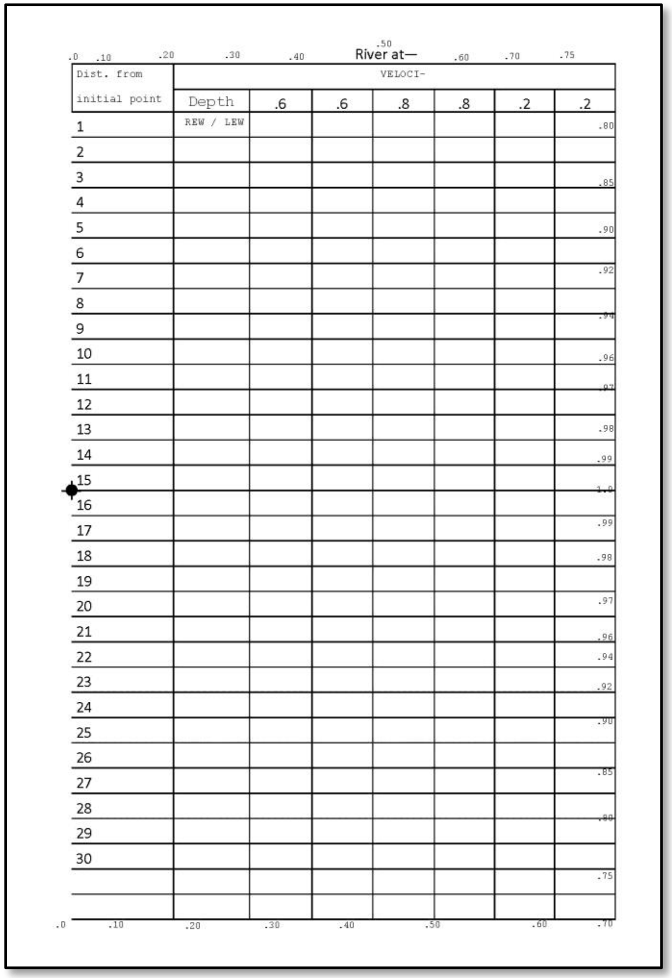
Discharge is calculated using the mid-section method in which each section extends halfway between measurement locations. The flow through each section is calculated by multiplying the average velocity with the cross-sectional area of the section. See references for a complete description of discharge calculations.

STATION VISIT (WITHOUT DISCHARGE MEASUREMENT)

River gauging stations and real-time stations are visited twice a month to collect staff gauge readings, perform any site maintenance and download data. These visits do not include a discharge measurement.

1. Open gauge station and retrieve data sheet.
2. Record primary gauge reading in the PGI row (see above for procedure). This is often a vertical staff gauge.
3. Record secondary gauge reading in the SGI row (see above for procedure). Often this is a tape-down measurement.
4. Record auxiliary gauge reading if present in the AUX row. Used for alternate staff gauge readings.
5. Record water temperature from the gauge station.
6. Record water temperature with the NIST thermometer or the YSI-30.
7. Record air temperature from the gauge station.
8. Record air temperature from the NIST thermometer or the YSI-30.
9. Record battery volts.
10. Download data from the data logger and record on the data sheet.
11. Purge the pressure sensor (if equipped).
12. Record battery minimum and maximum.
13. Reset Stats screen.
14. Note any problems, maintenance issues or other information at the bottom of the data sheet.
15. Close and secure the gauge station.

DISCHARGE NOTES DATA SHEET

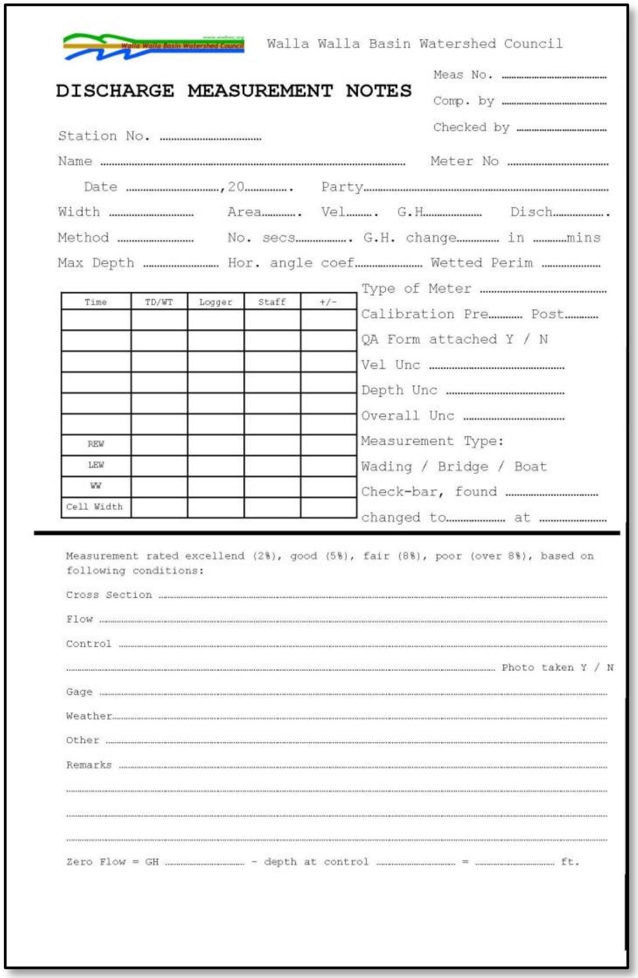


.0 .10 .20 .30 .40 .50 .60 .70 .75

River at—

Dist. from initial point	Depth	.6	.6	.8	.8	.2	.2
		VELOCI-					
1	REW / LEW						.80
2							
3							.85
4							
5							.90
6							
7							.92
8							
9							.94
10							.96
11							.97
12							
13							.98
14							.99
15							1.0
16							
17							.99
18							.98
19							
20							.97
21							.96
22							.94
23							.92
24							
25							.90
26							
27							.85
28							.80
29							
30							
							.75

.0 .10 .20 .30 .40 .50 .60 .70



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DISCHARGE MEASUREMENT NOTES

Meas No. ....

Comp. by ....

Checked by ....

Station No. ....

Name .... Meter No ....

Date ...., 20........... Party..................................

Width .... Area.......... Vel........ G.H............... Disch..............

Method .... No. secs............. G.H. change........... in ....mins

Max Depth .... Hor. angle coef.................. Wetted Perim ....

Time	TD/WT	Logger	Staff	+/-
REW				
LEW				
WW				
Cell Width				

Type of Meter ....

Calibration Pre.......... Post..........

QA Form attached Y / N

Vel Unc ....

Depth Unc ....

Overall Unc ....

Measurement Type:

Wading / Bridge / Boat

Check-bar, found ....

changed to.............. at ....

Measurement rated excellend (2%), good (5%), fair (8%), poor (over 8%), based on following conditions:

Cross Section ....

Flow ....

Control ....

.... Photo taken Y / N

Gage ....

Weather..................

Other ....

Remarks ....

....

....

....

Zero Flow = GH .... - depth at control .... = ... ft.

GAGING STATION LOG DATA SHEET

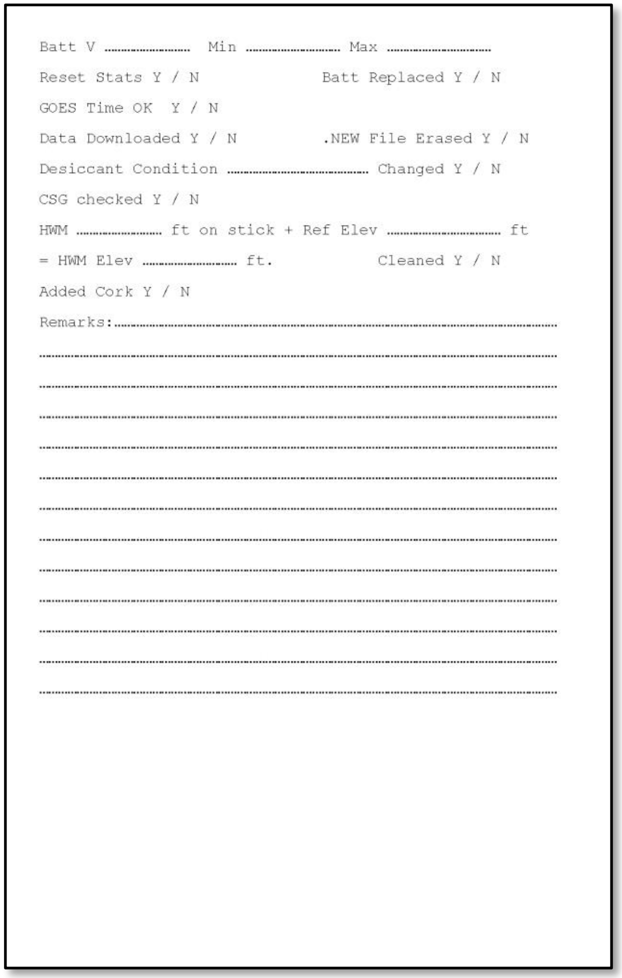
Walla Walla Basin Watershed Council

Gaging Station Log

Station Name: ______________________________ Station Number ________________ Water Year __________

Party												
Date												
Time												
PGI												
SGI												
AUX												
LOGGER												
H20 TEMP.												
THERMISTOR												
AIR TEMP.												
THERMISTOR												
BATT. V												
REPLACED (Y / N)												
DOWNLOADED (Y / N)												
PURGE (Y / N)												
SYNCED (Y / N)												
SYSTEM RESETS												
BATT. V (MIN/MAX)												
RESET STAT SCREENS (Y / N)												
MEASUREMENT (Y / N)												
MGH												
MEASURED Q												
PROFESSIONAL RATING												
METHOD												
LOCATION												
MAX DEPTH												
MAX VELOCITY												
PZF												
CONTROL (LOCATION, CONDITION, ETC.)												

STREAM GAGE NOTES DATA SHEET



Batt V .... Min .... Max ....

Reset Stats Y / N Batt Replaced Y / N

GOES Time OK Y / N

Data Downloaded Y / N .NEW File Erased Y / N

Desiccant Condition .... Changed Y / N

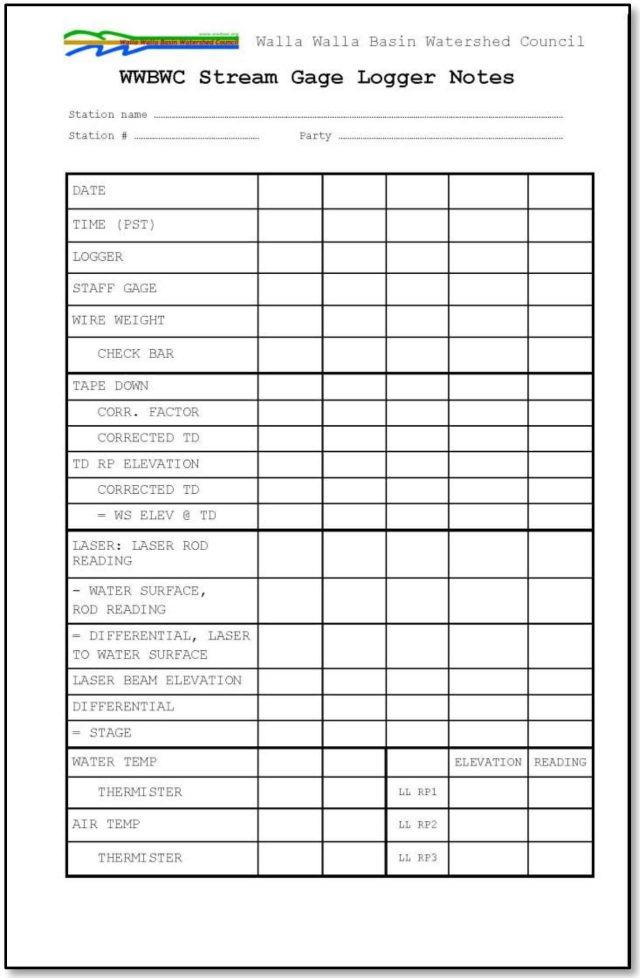
CSG checked Y / N

HWM .... ft on stick + Ref Elev .... ft

= HWM Elev .... ft. Cleaned Y / N

Added Cork Y / N

Remarks:..................



Walla Walla Basin Watershed Council

WWBWC Stream Gage Logger Notes

Station name ....

Station # .... Party ....

DATE					
TIME (PST)					
LOGGER					
STAFF GAGE					
WIRE WEIGHT					
CHECK BAR					
TAPE DOWN					
CORR. FACTOR					
CORRECTED TD					
TD RP ELEVATION					
CORRECTED TD					
= WS ELEV @ TD					
LASER: LASER ROD READING					
- WATER SURFACE, ROD READING					
= DIFFERENTIAL, LASER TO WATER SURFACE					
LASER BEAM ELEVATION					
DIFFERENTIAL					
= STAGE					
WATER TEMP				ELEVATION	READING
THERMISTER			LL RP1		
AIR TEMP			LL RP2		
THERMISTER			LL RP3		

GROUNDWATER MONITORING

These procedures are for monitoring groundwater levels and groundwater temperature and specific conductivity. The procedure covers equipment needed, establishing a measuring point, manual water level measurements, pressure transducer deployment, download and maintenance, groundwater grab samples for temperature and specific conductivity and site maintenance.

Note: These procedures are modified from Drost, B.W., 2005, Quality-assurance plan for ground-water activities, U.S. Geological Survey, Washington Water Science Center: U.S. Geological Survey Open-File Report 2005-1126, 27 p.

EQUIPMENT

- E-tape (Solinst model 102 Water Level Meter)
- Laptop
- Extra pressure transducers (if available)
- Cables for downloading pressure transducers
  - LT-300
  - MicroDiver/Solinst
  - MicroDiver (direct connect cable)
  - Solinst (direct connect cable)
  - MiniTroll
- Bailer
- Graduated Cylinder
- Temperature and Conductivity meter (YSI 30)
- Sounding Tape
- Measurement tape (measured in tenths of a foot)
- Data sheet (waterproof paper)
- Pen (waterproof) or pencil
- Well keys
- Battery removal tool for MiniTroll pressure transducers
- GPS
- Extra Batteries (AA lithium for pressure transducers & 9v for E-tape)
- Flashlight
- Screwdrivers
- Hammer
- Pipe wrench
- Socket set
- Crescent wrench
- Cable snips
- Pliers (preferably needle-nose)
- Camera
- Well Field Instructions and Procedures binder
- WellNet binder for site references and maps
- Business cards
- U-bolts and cable crimps
- Inverter (for charging laptop from vehicle)
- Cable (speaker wire or 1/16” aviation cable)
- Extra sacrificial weights for E-tape
- Work gloves

- Disposable gloves (nitrile)
- Disinfectant (Lysol or diluted bleach)
- Sharpie or other marking device (for measuring point)
- WD-40

ESTABLISHING A MEASURING POINT

This procedure is for establishing a measuring point on wells from which all water levels are measured.

1. Measuring point (MP) must be permanent as possible, clearly defined and easily located. Typical locations include the top of the well casing or access ports.
2. MP should be located so that the measuring tape can hang freely during water level measurements.
3. Mark MP with Sharpie or other marker (paintstick, etc).
4. Measure distance from the MP to the land surface and record on the data sheet. This measurement is called the top of grade (TOG) for the well. MP's located below the land surface are positive and MP's located above the land surface are negative. If the well has been GPS surveyed, measure TOG from the MP to the surveyed elevation.
5. Take a photograph of the MP to document location Well Network Database or in case the marker wears off.

MANUAL GROUNDWATER LEVEL MEASUREMENT (E-TAPE)

1. Before measuring the water level in a well utilized for drinking-water supply, disinfect the first 5-10 feet of the E-tape with diluted bleach water and dry with single-use towels (e.g. Kimwipes). Use latex or nitrile gloves for drinking-water supply wells and disinfection.
2. Review well info page in the Well Network binder for the MP.
3. Record if the Pump is On (1) or Off (0) in the "Pump" field.
4. Test the E-tape by turning it to "test" or by pressing the "test" button. If the E-tape does not buzz, check the battery. Start with sensitivity set to the mid-range and adjust as necessary.
5. Carefully lower the tape (and weight) into the well. The tape should be lowered slowly to prevent splashing or excess wear on the E-tape.
6. When the E-tape buzzes, pull the tape up and down a few inches to determine the exact level. Hold the tape at the MP and record the value to the nearest 0.01 feet in the "Static" field.
7. Repeat water level measurement. If measurements differ by more than 0.02 feet determine why (well pumping, well recovering, etc) and document reason on data sheet.
8. Periodically check the E-tape to make sure it is in good working condition.

PRESSURE TRANSDUCER DEPLOYMENT

1. Sound well and record measurement or, if available, consult the well log to determine well depth and pump location.
2. Take a manual water level measurement (see above) and record measurement on data sheet.
3. Program and start the pressure transducer. Pressure transducers should collect data every 15 minutes. Pressure transducer should be started so that data will be recorded on the hour (i.e. 12:00, 12:15, 12:30, 12:45, 13:00…). Program transducer with the well's GW

number. Follow the manufacturer's instructions on how to program and start the transducer.

4. Attached pressure transducer to one end of the cable using two wire crimps and a stainless steel U-bolt. Do not use crimps and do not over tighten the U-bolt if using a communication cable.
5. Measure and cut aviation cable or speaker wire to suspend the pressure transducer approximately 5-10 feet above the bottom of the well. This value can change depending upon the depth of the well and the pressure range of the pressure transducer. Make sure to not deploy the pressure transducer below its rated pressure range (typically marked on the side of the device). If the well is deeper than the pressure range, place the pressure transducer at a depth so there is 10-15 feet of pressure range still available (to account for potential water level increases). Pressure transducers should not rest on the bottom of the well or be surrounded by silts/fines that have accumulated in the well. Remember to account for the length of the logger when measuring the length of the cable.
6. If using a communication cable for the manufacturer, following the steps above to determine cable length.
7. Record length of cable, pressure transducer serial number and communication cable serial number if used.
8. Slowly lower pressure transducer and cable into the well making sure the transducer is not free falling. Take extra care as the transducer passes through the water-air interface to prevent damage to the transducer or entrainment of air bubbles.
9. Attach cable to the well at the surface using wire crimps and a stainless steel U-bolt.
10. Mark the cable so that cable slippage, if it occurs, can be accounted for during future site visits.
11. Make sure that all of the cable is deployed and the transducer is hanging on the cable rather than caught on a pump or some other obstruction.
12. Photograph the well to document the pressure transducer deployment and well. Try to capture the area around the well, any well apparatus and the measuring point. Multiple photos may be required.

PRESSURE TRANSDUCER DOWNLOAD AND MAINTENANCE

1. Record manual water level measurement, date, time and whether the well is being pumped.
2. Retrieve pressure transducer to the surface (if not attached to a communication cable).
3. Connect the pressure transducer, using the appropriate cable, to the field laptop.
4. Record the following information on the data sheet: Download start time (DL), Logger Time (LT – difference between pressure transducer time and computer time), Restart Time (RT – if the pressure transducer was stopped and restarted), Serial number (S#), Battery level (Batt - % of battery left or if batteries were replaced) and U-bolt and crimp conditions (Ubolts).
5. Follow manufacturer's protocol for downloading, saving and exporting data from the pressure transducer. Data should be saved in the proprietary format and in comma separated value format (.csv). File names should be in the following format: GW_xx_Data start date_Data end date_data collector's initials (For example: GW_129_3-3-11_7-6-11_sp – This file is for well GW_129 and the data in the file is from March 3rd through July 6th and was collected by Steven Patten).
6. Visually check the graphed data to ensure there are not any major issues that should be addressed. Raw data visual checks may be able to determine if the transducer came out of the water, the cable slipped/shifted or other issues that can be resolved through site

maintenance. Potential fixes could include readjusting/lengthening cable length or tighten U-bolts.

7. Note when the pressure transducer will run out of memory so a future visit will occur before that time.
8. Examine the pressure transducer for indications of damage or wear. Make sure access ports for the pressure diaphragm are clear of obstructions so the pressure transducer performs correctly.
9. Slowly lower transducer back into the well taking extra care as it transitions between air and water.

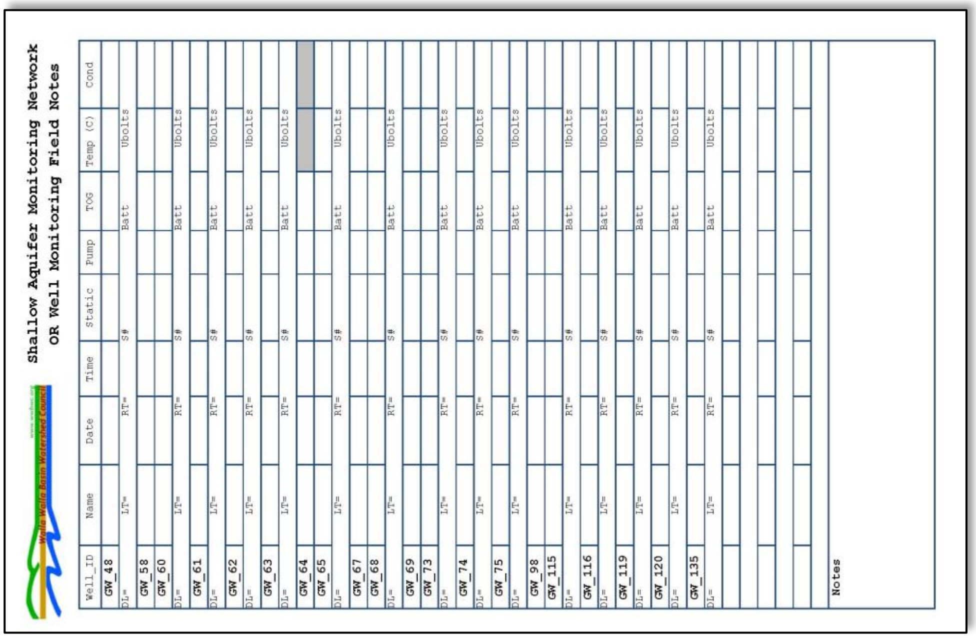
GRAB SAMPLES FOR GROUNDWATER TEMPERATURE AND SPECIFIC CONDUCTIVITY

1. Check the bailer to determine if the string/cable is attached properly and that it is not frayed or damaged and that the bailer is in proper working order.
2. Slowly lower the bailer into well until is below the water level and fills with water. NOTE: Do not put the bailer down access or vent holes. If unsure do not put the bailer down the well. The data sheet indicates which wells should have water grab samples taken – if the temperature and conductivity fields are grayed out do not take a sample. The Well Network database also indicates whether a water grab sample should be collected.
3. Slowly reel the bailer back to the surface taking care to limit it banging/hitting the well casing.
4. Empty the water in the bailer into the graduated cylinder.
5. Put the temperature/EC probe into the water in the graduated cylinder.
6. Turn on the YSI-30 (temperature/EC meter). Ensure that the meter is correctly set to measure temperature in degrees Celsius and specific conductivity in µs/cm.
7. Wait for the reading to stabilize and then record temperature and conductivity values in their appropriate fields on the data sheet. In the summer or winter water temperature may increase or decrease depending upon the ambient air temperature. If the reading does not stabilize in 15-20 seconds, record the mean value over the 15-20 second period.
8. Turn off the YSI-30.
9. Discard water from the graduated cylinder.

SITE MAINTENANCE

1. Check the well casing and surrounding area for any changes that have occurred since the last field visit. If needed document the changes on the data sheet and with photographs.
2. Check TOG measurement approximately once a year to determine if there are any changes.
3. If well has not been surveyed in, survey well using Magellan ProMark 3 GPS system at earliest opportunity.
4. Check cable integrity and other well monitoring components for wear or damage. Replace as needed.
5. Photograph the site during every field visit to visually track changes to the site.

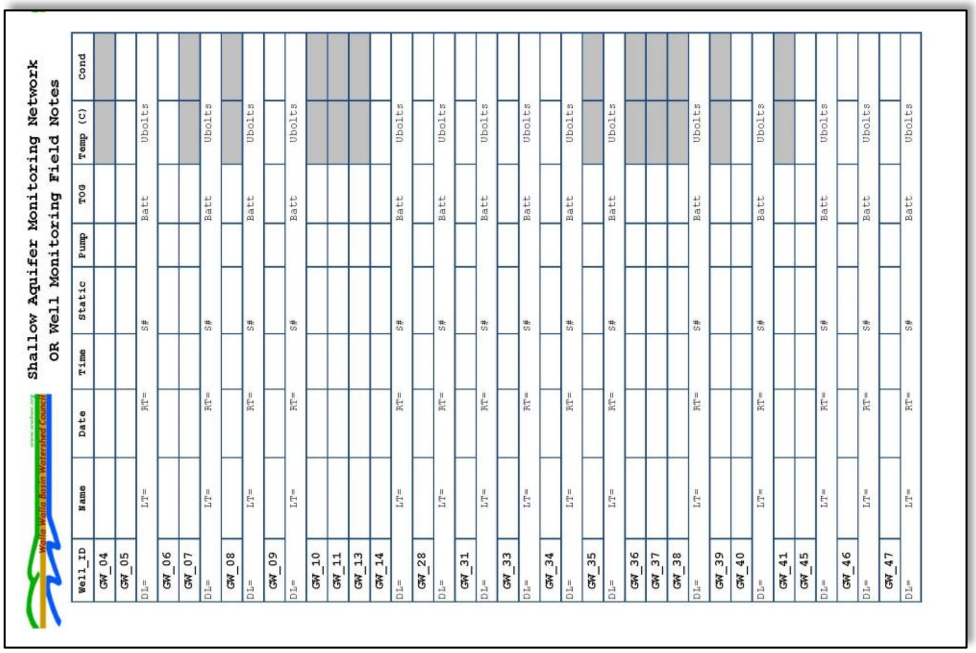
GROUNDWATER MONITORING DATA SHEETS



Shallow Aquifer Monitoring Network
OR Well Monitoring Field Notes

Well_ID	Name	Date	Time	Static	Pump	TOG	Temp (C)	Cond
GW_48								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_58								
GW_60								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_61								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_62								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_63								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_64							▨	▨
GW_65								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_67								
GW_68								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_69								
GW_73								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_74								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_75								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_98								
GW_115								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_116								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_119								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_120								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_135								
DL=	LT=	RT=		S#		Batt	Ubolts	

Notes



Shallow Aquifer Monitoring Network
OR Well Monitoring Field Notes

Well_ID	Name	Date	Time	Static	Pump	TOG	Temp (C)	Cond
GW_04							▨	▨
GW_05								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_06								
GW_07							▨	▨
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_08							▨	▨
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_09								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_10							▨	▨
GW_11							▨	▨
GW_13							▨	▨
GW_14								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_28								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_31								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_33								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_34								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_35							▨	▨
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_36							▨	▨
GW_37							▨	▨
GW_38							▨	▨
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_39							▨	▨
GW_40								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_41							▨	▨
GW_45								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_46								
DL=	LT=	RT=		S#		Batt	Ubolts	
GW_47								
DL=	LT=	RT=		S#		Batt	Ubolts	

WATER TEMPERATURE MONITORING

This procedure is for monitoring water temperature in rivers and streams using data loggers. The procedure covers equipment needed, pre & post deployment accuracy check, field accuracy check (site visits), deployment, and recovery.

Note: this procedure is modified from the following references:

Water Quality Monitoring – Technical Guide Book, 2001. Oregon Watershed Enhancement Board.

ODEQ, 2009. Water Monitoring and Assessment Mode of Operations Manual. Watersheds Quality Monitoring Field Sampling Standard Operating Procedure – Laboratory and Environmental Assessment Division. Version 3.2

EQUIPMENT

- Data Logger (Vemco, Tidbit, etc)
- Laptop/Computer
- Computer interface cable for Data Logger
- NIST-traceable thermometer
- 1 medium sized cooler
- Ice
- Temperature Accuracy Check form (see below)
- 1 ½" PVC Pipe (to reduce temperature variations due to solar radiation)
- 1/16" aviation cable
- Wire cutters
- Cable crimps
- Pliers or other device to secure crimps and cut the cable
- Forestry Flagging/Surveyors Tape
- GPS unit
- Camera
- Waders
- Field Notebook
- First Aid Kit

PRE & POST DEPLOYMENT ACCURACY CHECK

1. For 20°C calibration test, pour room temperature water into the cooler. Adjust temperature in the cooler with ice, cold water or hot water to the desired 20°C. If ice is used make sure it is completely melted. Close lid.
2. Insert the NIST thermometer probe into the cooler. Pull it through enough so that when the lid is closed, the probe will be suspended midway (or slightly lower) in the water bath.
3. Use the computer and manufacturer's software to start the temperature data loggers and set them to record data every 1-minute.
4. Place temperature data loggers directly into the water bath.
5. Allow water bath to stabilize (for 15-30 minutes) before recording NIST thermometer temperatures. After stabilization, record temperatures from the NIST thermometer every minute for ten minutes. More readings may be necessary if there is suspicion the water bath temperature changed or was not stabilized.

6. Download data from the temperature data loggers and audit thermometer results with time of record on an audit form. Water temperatures should not vary more than ± 0.5°C between the NIST thermometer and the data logger's temperature. Units not passing this accuracy test should not be used.
7. Repeat accuracy test for cold water bath at 5°C.

FIELD ACCURACY CHECKS (SITE VISITS)

During a typical season of water temperature monitoring (June-November), two field accuracy checks will be conducted using the following procedure:

1. Determine if the data logger is still adequately placed in the river (see deployment procedure for details) to record water temperatures.
2. Place field thermometer (NIST thermometer) in the water directly next to the temperature data logger. (Note: if a NIST thermometer is not available use a thermometer with an accuracy of ± 0.5°C and a resolution of ± 0.2°C)
3. Allow field thermometer to stabilize and then record the temperature reading.
4. After the temperature data loggers have been retrieved and data download, compare the field thermometer's reading to that from the temperature data logger. Data accuracy should be ± 0.5°C.

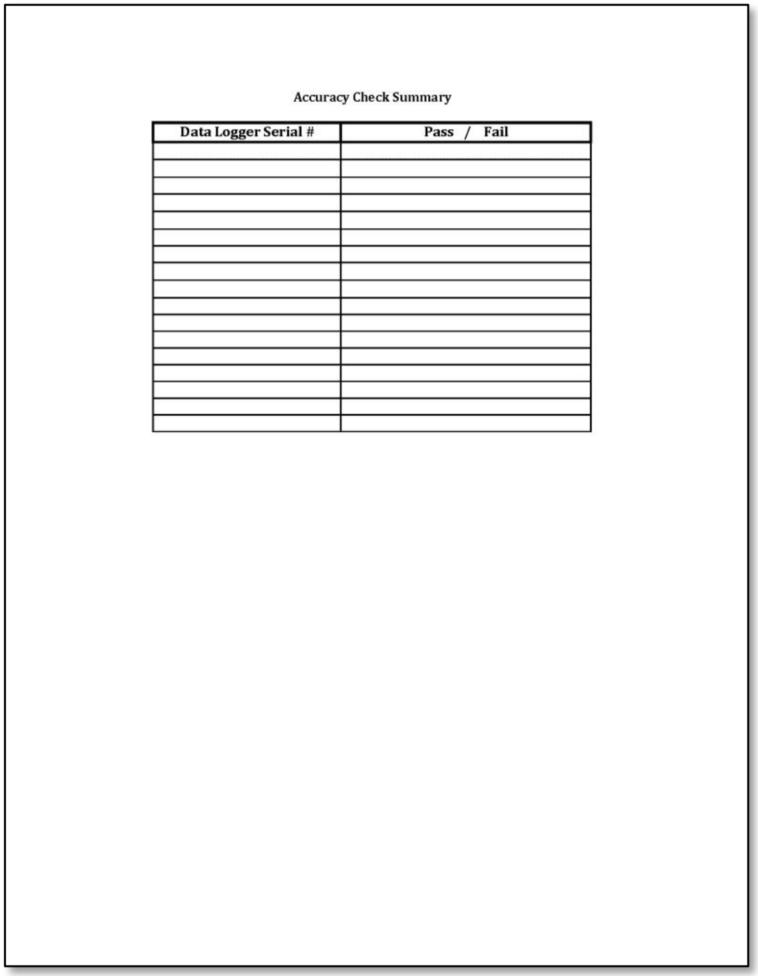
DEPLOYMENT

1. Start temperature data logger either prior to going to the field or in the field with a laptop. Data loggers should be set to record data every thirty minutes. Data loggers should be set to start collecting data either at the hour or half hour (e.g. 12:00 or 12:30).
2. Secure data logger inside of the 1 ½" PVC pipe using the aviation cable ensuring that the entire length of the logger is covered by the PVC.
3. Secure data logger at the site using the aviation cable. Often the cable can be secured to trees, logs, large rocks or other stable structures. Make sure that the logger is in a well-mixed portion of the river to ensure accurate readings. Also, place the data logger to ensure that it will stay submerged in the water as river flows drop.
4. Record in the fieldbook the time of deployment and when the data logger will run out of memory for logging data. Record site name and data logger serial number. Check stream temperature as an additional accuracy check.
5. Record site GPS coordinates using a GPS unit.
6. Take pictures of site for future reference and recovery.
7. Write a short description and create a sketch of the site including approximate distances from structures (bridges, log jams, etc.).

RECOVERY

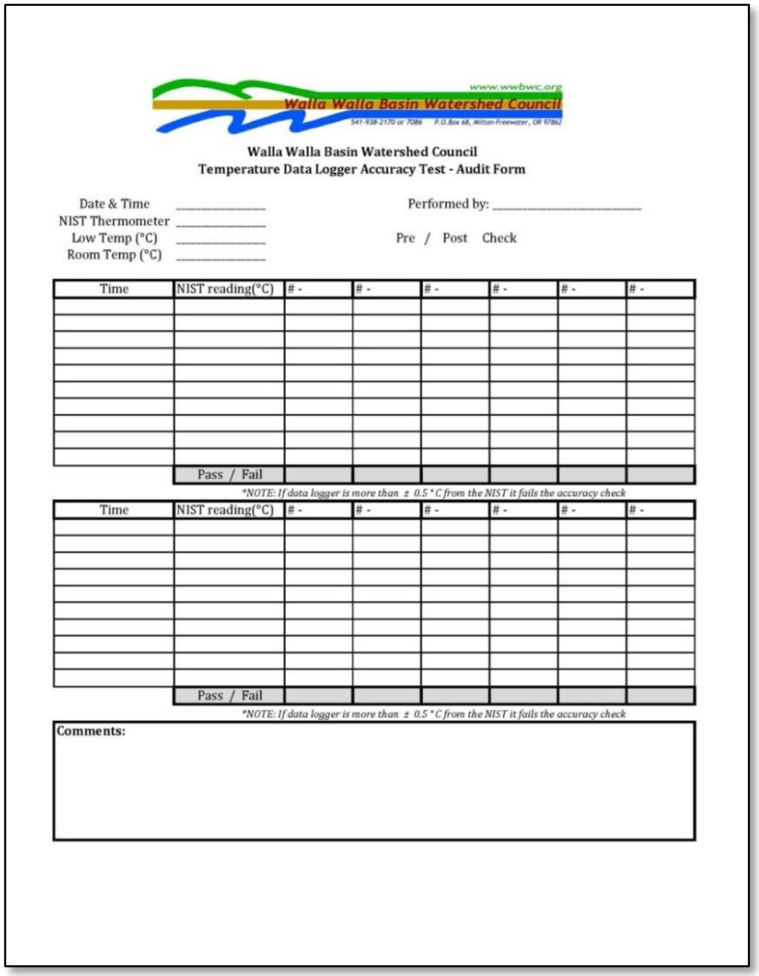
1. Locate Temperature data logger and check stream temperature with a field thermometer.
2. Record time of data logger recovery and note any site conditions that may have affected data accuracy or reliability. Cut the cable to free the data logger and return to the office and download the data. Data loggers should be stopped after data download to prevent unnecessary battery use.

PRE & POST DEPLOYMENT ACCURACY CHECK DATA SHEET



Accuracy Check Summary

Data Logger Serial #	Pass / Fail



www.wwbwc.org

Walla Walla Basin Watershed Council

541-938-2170 or 7086 P.O.Box 68, Milton-Freewater, OR 97862

Walla Walla Basin Watershed Council

Temperature Data Logger Accuracy Test - Audit Form

Date & Time ______________

NIST Thermometer ______________

Low Temp (°C) ______________

Room Temp (°C) ______________

Performed by: ______________________

Pre / Post Check

Time	NIST reading(°C)	# -	# -	# -	# -	# -	# -
	Pass / Fail						

**NOTE: If data logger is more than ± 0.5 ° C from the NIST it fails the accuracy check*

Time	NIST reading(°C)	# -	# -	# -	# -	# -	# -
	Pass / Fail						

**NOTE: If data logger is more than ± 0.5 ° C from the NIST it fails the accuracy check*

Comments:

SCOUR CHAINS AND BED STABILITY

This procedure is for monitoring bed scour and fill to look at river bed stability and river bed conditions. The procedure covers the construction, installation and monitoring of scour chains (including cross-sectional surveys) and pebble counts.

Note: Scour chain procedures were based upon the following sources:

Lisle and Eads. 1991 Methods to measure sedimentation of spawning gravels. Res. Note PSW-411. Berkley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 7 p.

Nawa and Frissell. 1993. Measuring Scour and Fill of Gravel Streambeds with Scour Chains and Sliding-Bead Monitors. North American Journal of Fisheries Management. 13: 634-639.;

Leopold, Wolman and Miller. 1964. Fluvial Process in Geomorphology. Freeman, San Francisco.

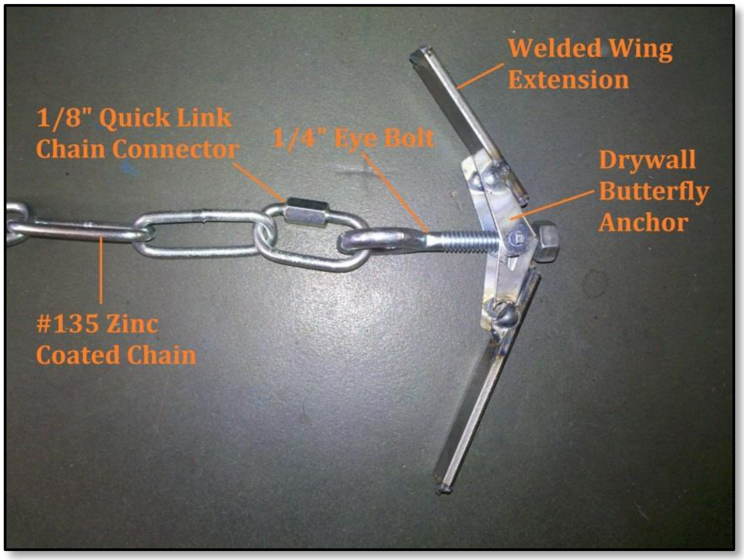
Pebble count procedures where based upon Wolman, M.G. 1954. A Method of Sampling Coarse River-Bed Material. Transactions of the American Geophysical Union. 35(6):951-956.

EQUIPMENT

- Scour Chains
  - 2.5-3.0 feet of #135 Zinc Coated Chain (links are ~1.5")
  - Chain Quick-Link Connector (1/8")
  - Anchor (Modified Drywall Butterfly Anchor)
  - Eye bolts
- 100' or 200' tape
- Waders (hip or chest)
- Laser Level with Stadia rod
- Flow meter
- Shovel
- Hand Trowel
- Fence Post Driver
- 1 ½" galvanized steel pipe
- 1" metal rod
- Rubber bands
- Fishing line
- Forestry Flagging Tape
- Pipe Wrenches
- Data Sheets or Field Notebooks
- Pen or Pencil
- First Aid Kit

SCOUR CHAIN CONSTRUCTION

Scour chains are constructed by WWBWC staff to help reduce costs. Scour chain anchors are created by modifying drywall butterfly anchors (1/4" bolt/screw). Extensions (1/2" flat metal) are welded to each wing of the anchor creating ~2-3 inch wing on each side. Eye bolts are then welded on to the anchor to prevent them from detaching. A ~2.5-3.0 foot section of #135 chain is attached to the eye bolt with a quick link chain connector. See figures below.

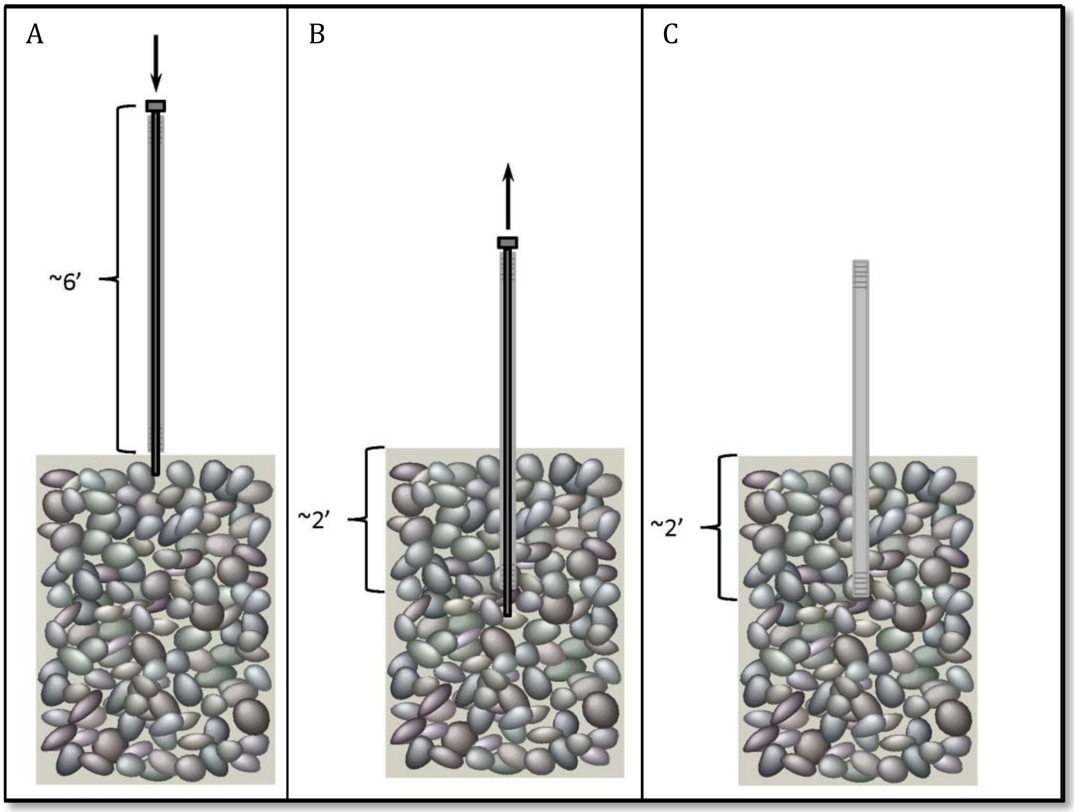


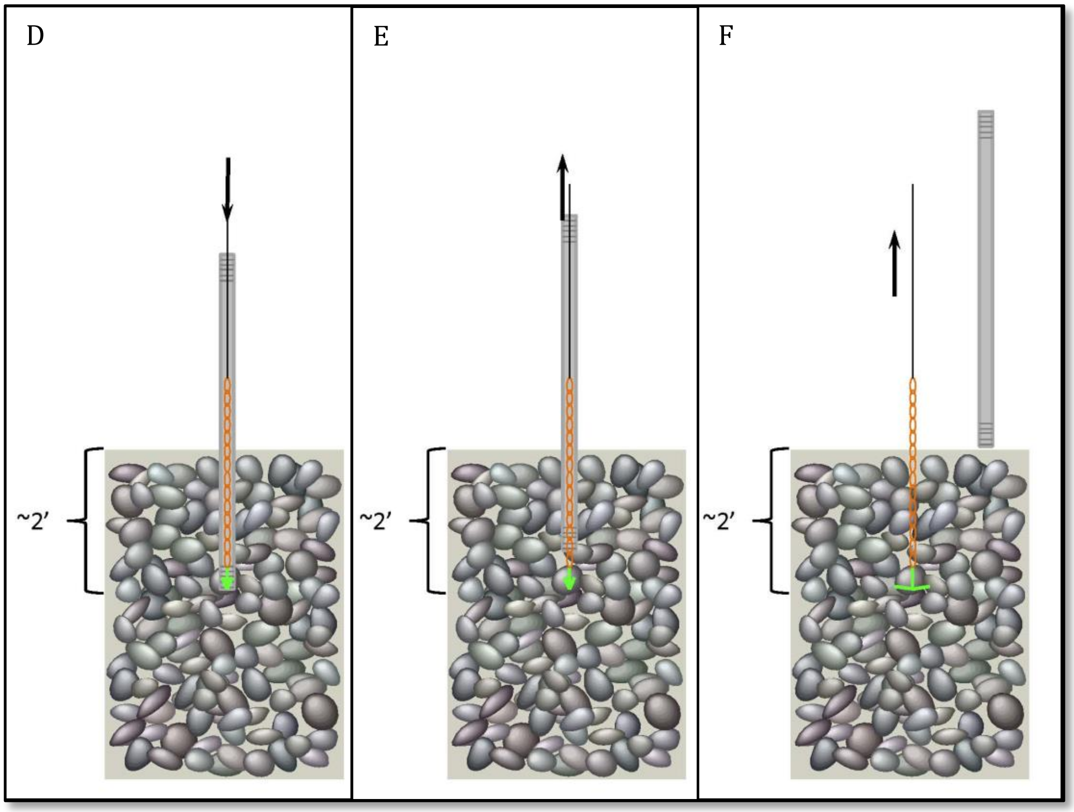
SCOUR CHAIN INSTALLATION

Scour chains are installed perpendicular to the direction of flow in the river (similar to a discharge measurement). 4-5 chains are typically installed across the width of the river, but this will increase or decrease depending upon the width of the river. Chains are installed approximately 10-12 feet apart across the channel.

1. Determine location for scour chain installation.
2. Establish a control point on both banks. Make sure the location of each control point is as stable as possible and will not be damaged by higher flows. Preferably the control points should be located above the bank full width to avoid frequent flood damage. Drive a piece of ½" rebar into the ground as far as possible. Place a blue WWBWC control point marker on the end of the rebar and flag it with forestry flagging.
3. Run a tape across the width of the channel between the control points on either bank. You can tie off the tape to the control points or to rocks/trees on the shore. If not tying off to the control points make sure the tape goes directly over each of the control points.
4. Determine the width of the river – typically this will be the bank full width as to capture river scour/fill influences during frequent high flow events.
5. Decide how many scour chains to install based upon width. Chains are installed ~10 feet apart. So if the river is 40 feet across plan on installing 4 chains.
6. Divide the river into approximately even sections and make note where each scour chain should be installed. The exact location of each chain will vary side to side by a small amount based upon sediments present at each location (see 7 below).
7. Drive pipe and metal rod into the river bed substrate using the fence post driver to a depth of ~2 feet. Because river bed sediments in the Walla Walla Basin are often gravels and cobbles (and sometime boulders) you may have to try multiple locations to find a successful spot where the pipe can be driven in ~2 feet (Figure A).
8. Remove metal rod from inside the pipe. Be sure to not remove the pipe. You may have to turn the metal rod using pipe wrenches to loosen it before it can be removed. (Figure B & C)

9. Prepare a scour chain anchor with ~2.5-3.0 feet of chain attached to it with the 1/8” quick link connector. Attach fishing line to the end of the chain to allow it to be lowered into the pipe. Count the number of links and record on the datasheet or in the field notebook.
10. Use a small rubber band to hold the two wings of the anchor device together so it will slide down into the pipe. When the anchor wings are held together the anchor is considered “closed” and when the rubber band is removed to allow the wings to spring apart the anchor is considered “open.” Tie fishing line on to the rubber band so it can be pulled off and allow the wings to spread and anchor the device.
11. Slowly slide the “closed” anchor down the inside of the pipe (Figure D).
12. Once the anchor is at the bottom of the pipe (make sure by slowly pulling up and dropping the anchor) gently lift the pipe 6-8” upwards. This should allow the “closed” anchor to be exposed to the sediments (Figure E).
13. Pull on the fishing line attached to the rubber band to release the wings and “open” the anchor.
14. Remove the pipe completely making sure to keep holding the fishing line attached to the chain to prevent the chain from falling into the hole.
15. Gently pull up on the chain/fishing line to set the anchor in the sediments. Once the anchor is set you can pull harder to verify it is solidly anchored (Figure F).
16. Count the number of links that are exposed above the river bed and lay chain downstream. Record number of links on the data sheet or in the field notebook (Figure G).
17. Take note of the distance from both the left and right bank control points to the scour chain.
18. Repeat process for the other scour chains to be installed in the set.
19. After all scour chains have been installed conduct a perpendicular channel survey (see below for procedure). Scour chain location accuracy is extremely important for finding each scour chain in the future especially since some chains will be covered by sediments.
20. Also conduct a river discharge measurement at or near the site (see above for procedure).

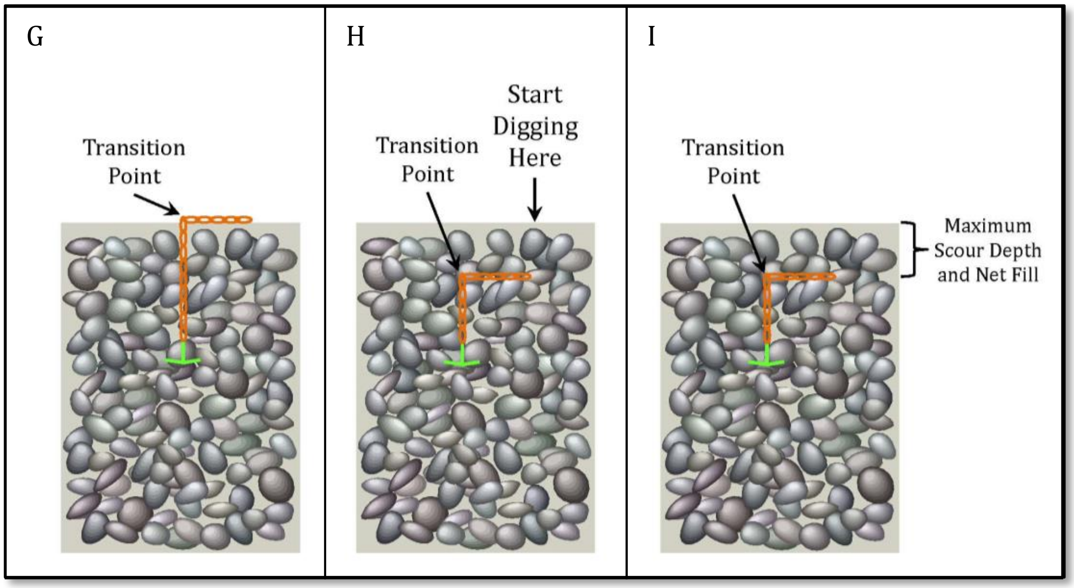

A
~6′
B
~2′
C
~2′


D
~2′
E
~2′
F
~2′

SCOUR CHAINS SCOUR/FILL MONITORING

This procedure will provide information on how to locate and measure scour chain data. Data collected at each chain will provide information on maximum scour since the last monitoring and net fill since last monitoring.

1. Locate both left and right bank control points.
2. Using a 100' or 200' tape, measure from the control points to the find the scour chain closest to the right bank (you can also start near the left bank if that is more convenient). Note – refer back to installation notes on datasheet or the field notebook to determine the location for each scour chain.
3. Once you have determined the location for the first scour chain, look to see if the chain is exposed. If the chain is not exposed on the river bed it may be buried under the sediments. Carefully and slowly dig just downstream of where the chain was installed. Dig until you find the chain and then slowly work upstream until the chain changes from lying horizontally to vertical. This transition point is the maximum scour depth. (Figure G & H)
4. Measure the vertical distance between the transition point and the river bed surface (see figures below). (Figure I)
5. Count the number of links from the transition point to the end of the chain. This can be used to verify the vertical measurement taken in step 4.
6. Hold scour chain vertically while excavated sediments are replaced.
7. Count the number of links that are exposed above the transition point (on the river bed surface).
8. Place the exposed chain on the river bed surface facing downstream.
9. Repeat process for other scour chains in the set.



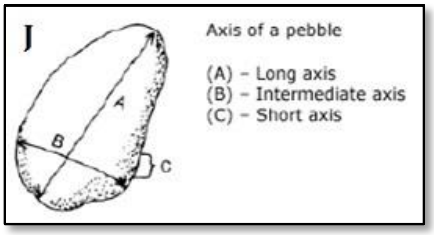
CHANNEL SURVEY

This procedure provides information for preforming a channel survey for scour/fill within a scour chain set. All changes are relative to the control point(s) established for the scour chain set (see above).

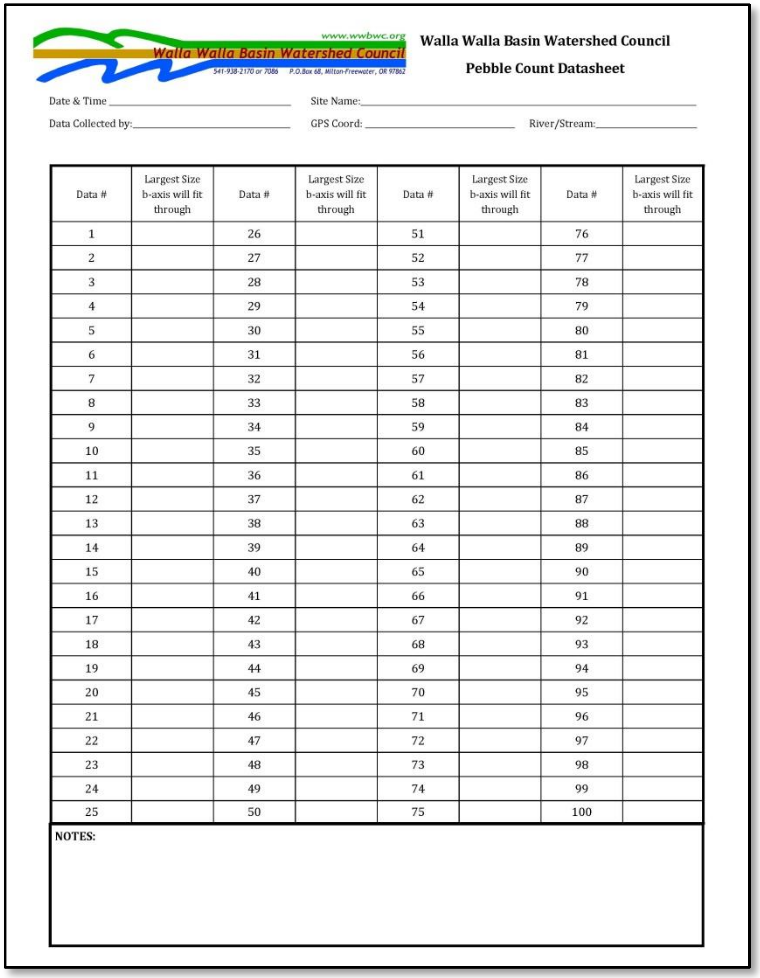
1. Place the laser level in a location where it will be visible when measuring at each scour chain in the set and visible at each control point.
2. Adjust laser as close to level as possible.
3. Turn on laser and allow it to auto level. Once the laser has leveled it should start spinning. If it does not the laser may be tilted too much and cannot level itself – turn the laser off, readjust it and turn it back on to auto level.
4. Stretch a 100’ or 200’ tape across the channel. Make sure the tape goes directly over each of the control points.
5. Take the stadia rod with the laser sensor attached to the control point on the right bank (you can start on the left bank if that is more convenient). Place the stadia rod on the control point and read the height with the laser sensor. Record laser height value, depth of water and the tape distance on the datasheet or field notebook.
6. Continue measuring height and tape distance values as you move across the channel until you reach the opposite control point. Make sure to capture changes in the river bed as well as important locations such as edge of water, gravel bars, thalweg and each scour chain.
7. Return to the first control point and measure the height and tape distance a second time to verify that the tape or the laser has not moved.

PEBBLE COUNTS

1. Select reach of the river for sediment particle size distribution (typically between two closely spaced scour chains sets).
2. Start transect randomly between the scour chain sets by throwing a rock along the stream edge. Take a step into the river, perpendicular to the flow, from that point and pick up the first pebble you touch with your index finger next to your big toe. Avert your eyes to prevent as much bias as possible when pick up pebbles.
3. Measure the intermediate axis (see Figure J below) by determining the smallest hole the pebble will fit through using the gravelometer. For embedded pebbles or those too large to pick up, use the side of the gravelometer to measure the shortest visible axis
4. Record info on the datasheet.
5. Take another step across the river and repeat the steps of picking and measuring pebbles until you reach the opposite bank. Once you reach the opposite bank, throw another rock and start back towards the first bank repeating the steps above.
6. Continue collecting pebble data until you have recorded 100 measurements.



PEBBLE COUNT DATA SHEETS



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Walla Walla Basin Watershed Council
541-938-2170 or 7086 P.O.Box 68, Milton-Freewater, OR 97862

Walla Walla Basin Watershed Council

Pebble Count Datasheet

Date & Time ____________________ Site Name: ____________________

Data Collected by: ____________________ GPS Coord: ____________________ River/Stream: ____________________

Data #	Largest Size b-axis will fit through	Data #	Largest Size b-axis will fit through	Data #	Largest Size b-axis will fit through	Data #	Largest Size b-axis will fit through
1		26		51		76	
2		27		52		77	
3		28		53		78	
4		29		54		79	
5		30		55		80	
6		31		56		81	
7		32		57		82	
8		33		58		83	
9		34		59		84	
10		35		60		85	
11		36		61		86	
12		37		62		87	
13		38		63		88	
14		39		64		89	
15		40		65		90	
16		41		66		91	
17		42		67		92	
18		43		68		93	
19		44		69		94	
20		45		70		95	
21		46		71		96	
22		47		72		97	
23		48		73		98	
24		49		74		99	
25		50		75		100	

NOTES:

Data Computation

Inches	PARTICLE	Millimeters		Particle Count	Total #	Item %	% Cum
< 0.08	Sand	< 2	**Silt/Clay/Sand**				
0.08—0.16	Very Fine	2—4	Gravels				
0.16—0.22	Fine	4—5.7					
0.22—0.31	Fine	5.7—8					
0.31—0.44	Medium	8—11.3					
0.44—0.63	Medium	11.3—16					
0.63—0.89	Coarse	16—22.6					
0.89—1.26	Coarse	22.6—32					
1.26—1.77	Very Coarse	32—45					
1.77—2.5	Very Coarse	45—64					
2.5—3.5	Small	64—90	Cobbles				
3.5—5.0	Small	90—128					
5.0—7.1	Large	128—180					
7.1—10.1	Large	180—256					
10.1—14.3	Small	256—362	Boulders				
14.3—20	Small	362—512					
20—40	Medium	512—1024					
40—80	Large	1024—2048					
80—160	Very Large	2048—4096					
	Bedrock		Bedrock				
			TOTALS				

SEEPAGE ANALYSIS

Seepage analysis protocols are discussed in the Seepage Report (found on the WWBWC website – www.wwbwc.org). The WWBWC performs seepage analyzes on multiple stream systems within the Walla Walla Basin to determine the water budget for each system and to determine gain/loss reaches. The primary measurement procedure used during a seepage analysis is a stream discharge measurement. The procedure described above for stream discharge measurements is used during seepage measurements.

WATER QUALITY MONITORING (FIELD MEASUREMENTS)

ODEQ, 2009. Water Monitoring and Assessment Mode of Operations Manual. Watersheds Quality Monitoring Field Sampling Standard Operating Procedure – Laboratory and Environmental Assessment Division. Version 3.2

WATER TEMPERATURE AND CONDUCTIVITY (YSI-30)

1. Check sensor calibration to NIST thermometer and standard conductivity solution (typically done in the office before field visit). Recalibrate if necessary.
2. Turn the YSI-30 unit on.
3. Make sure units are set to °C for temperature and to µs for conductivity. The °C should blink indicating the YSI-30 is in temperature compensating mode.
4. Gently place the sensor in the water. Make sure that the sensors are completely covered by water. Gently agitate the probe to ensure air bubbles are dislodged.
5. Allow the values to stabilize and then record on the data sheet or field notebook.
6. Replace the sensor in the holder and turn the unit off.

DISSOLVED OXYGEN

1. Connect the dissolved oxygen sensor to the meter.
2. Turn on the Thermo Scientific Orion 5-Star meter.
3. Check sensor calibration (typically done in the office before field visit). Recalibrate if necessary.
4. Make sure units are set correctly for dissolved oxygen (mg/L).
5. Gently place the sensor in the water. Make sure that the sensor is completely covered by the water.
6. Allow the value to stabilize and then record on the data sheet or field notebook.
7. Replace the sensor in the holder and turn the unit off.

PH

1. Connect the pH sensor to the meter.
2. Turn on the Thermo Scientific Orion 5-Star meter.
3. Check sensor calibration using a standard pH solution (typically done in the office before field visit). Recalibrate if necessary.
4. Gently place the sensor in the water. Make sure that the sensor is completely covered by the water.
5. Allow the value to stabilize and then record on the data sheet or field notebook.
6. Replace the sensor in the holder and turn the unit off.

CONDUCTIVITY

1. Connect the conductivity sensor to the meter.
2. Turn on the Thermo Scientific Orion 5-Star meter.
3. Check sensor calibration using a standard conductivity solution (typically done in the office before field visit). Recalibrate if necessary.
4. Gently place the sensor in the water. Make sure that the sensor is completely covered by the water.
5. Allow the value to stabilize and then record on the data sheet or field notebook.
6. Replace the sensor in the holder and turn the unit off.

TURBIDITY

1. Turn on the Hach 2100P Turbidimeter.
2. Check sensor calibration using a standard turbidity solution (typically done in the office before field visit). Recalibrate if necessary.
3. Collect water sample in glass vial and wipe clean. Insert the vial into the turbidimeter, cover and read the sample.
4. Record the value on the data sheet or field notebook.
5. Empty the vial and turn on the meter.

QUALITY CONTROL

QUALITY CONTROL FOR LABORATORY MEASUREMENTS

Field duplicates and blanks will be used to ensure quality control for lab samples.

- Field blanks: Once per sampling even a blank sample with known concentrations of the monitored constituent will be included in the samples sent to the analytical laboratory. The field blank will be purchased from a scientific supply vender.
- Field duplicates: Once per sampling event one additional sample will be collected from one of the sites.
- Analytical laboratory will also have internal QA/QC procedures to ensure data validation.

QUALITY CONTROL FOR FIELD MEASUREMENTS

FIELD RECORDS

Field notes and other pertinent data associated with the monitoring program will be maintained at the WWBWC office and archived for reference. Completeness of data sheets and chain of custody forms and verifying holding times for samples will also be used for data validation.

SURFACE WATER MONITORING

Surface water monitoring will use the following quality control measures:

- Measure a duplicate discharge measurement on approximately 5% of field visits.
- Field equipment will be maintained and calibrated to ensure proper operation and accuracy.
- Comparison of equipment to other equipment or rated structures (such as flumes, etc).
- Primary and secondary stage height values are referenced to benchmarks to ensure no elevation changes.
- Comparison of primary, secondary and laser level stage height values.

GROUNDWATER MONITORING

Groundwater monitoring will use the following quality control measures:

- Yearly comparison of E-tape measurements against other tapes.
- Duplicate groundwater level measurements during every field visit.
- If available, comparison of manual measurements to other agencies' data.
- Duplicate water sample for groundwater temperature and conductivity at approximately 5% of the sites.

WATER TEMPERATURE MONITORING

Water temperature monitoring will use the following quality control measures:

- Pre and Post data logger accuracy testing.
- Manual field checks during deployment.

WATER QUALITY MONITORING

Water quality monitoring will use the following quality control measures:

- Field equipment will be maintained and calibrated to ensure proper operation and accuracy.
- Duplicate samples will be taken at approximately 5% of the sites.
- Comparison of field and laboratory values.

DATA MANAGEMENT PROCEDURES

FIELD NOTES

IN THE FIELD

Data should be recorded on WWBWC datasheets (if available) printed on waterproof paper (Rite-in-the-Rain). Notes should be clearly and legibly written so data and remarks are easily read and interpreted. If a mistake is made, draw a single line through the bad data and record the data next to it. Do not erase or completely mark out mistakes. All datasheets should be completed as fully as possible during data collection.

AT THE OFFICE

Upon returning to the office scan all datasheets and place a scanned copy on the WWBWC server in the appropriate location and incorporated into the AQUARIUS database. After scanning the datasheets, use them to input the data into the appropriate software (AQUARIUS, Excel, etc.). After all data from the datasheet has been incorporated into the software, place the datasheet in the project's 3-ring binder.

DATA LOGGERS

IN THE FIELD

Data loggers should be downloaded during every site visit if practical. Data from the data logger should be downloaded and saved to the field laptop before the data logger file(s) is deleted or restarted to ensure data are not lost. After restarting a data logger take note of when the logger's memory will be full so a site visit can be scheduled before that date. Files should be saved in the following format: type of file (gh = gauge height, mmt = measurement and temp = temperature)_site number_data start date_data end date_downloader's initials. For a surface water example the file format for site S105 with stage data from March 1st, 2012 through July 15th, 2012 and downloaded by Steven Patten would look like: gh_S105_3-1-12_7-15-12_sp. For a groundwater example the file format for site GW_115 with water level (stage) data from May 1st, 2012 through September 29th, 2012 and downloaded by Steven Patten would look like: gh_GW115_5-1-12_9-29-12_sp.

AT THE OFFICE

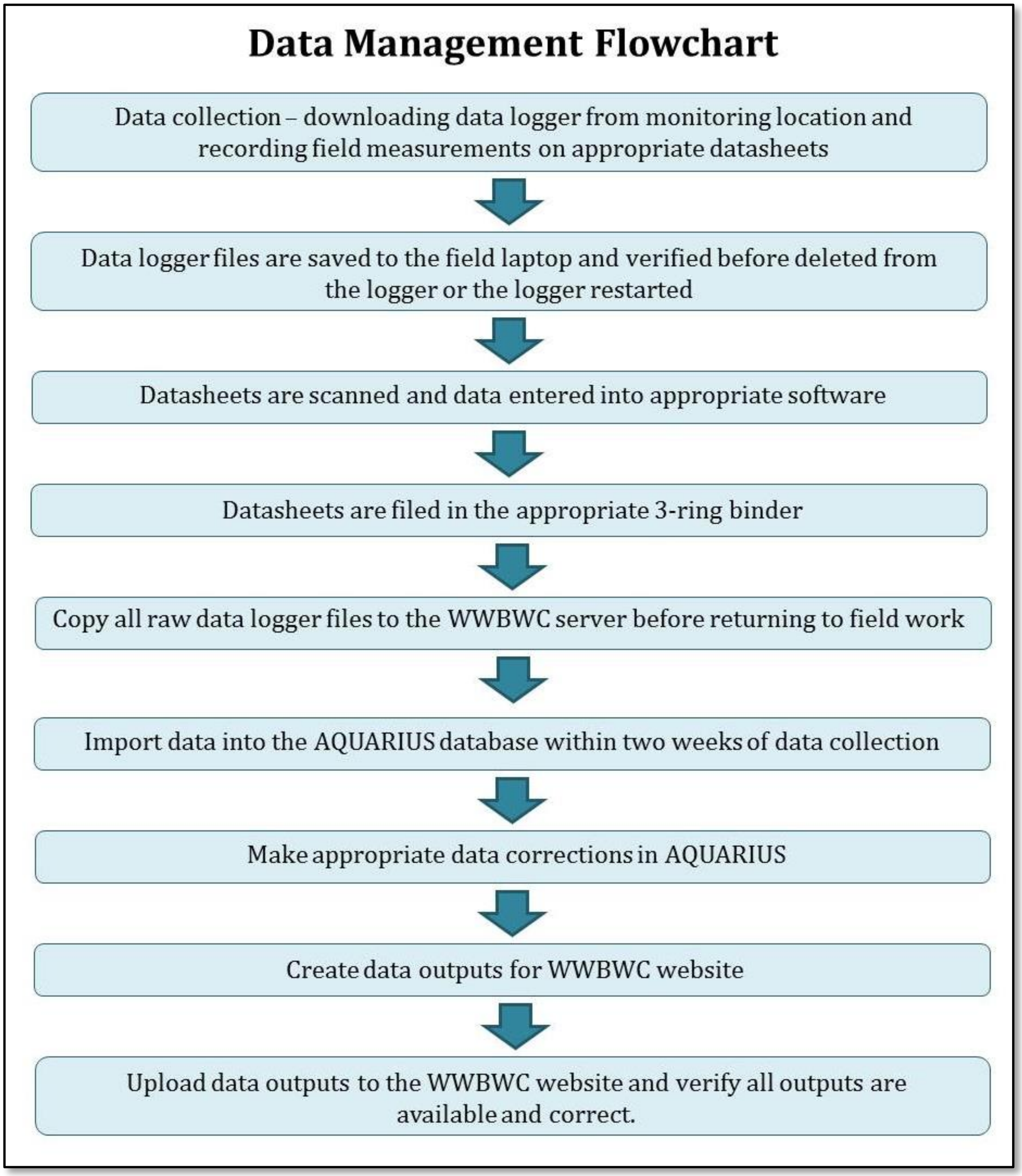
All raw data logger files collected during a day of field work should be transferred to the WWBWC server before going back out in the field to ensure data are not lost due to laptop failure or damage.

DATA INPUT (AQUARIUS)

Data should be incorporated into the AQUARIUS database within two weeks of data collection. Both manually collected data and data logger files should be imported into the AQUARIUS database. After data have been imported, data should be adjusted to account for stage shifts or cable length corrections. For surface monitoring locations, the rating curve should be checked to ensure the new discharge measurement does not indicate a change in the stream channel. If needed, adjust the rating curve with the new discharge measurement. After data are imported and corrected, outputs should be created including a hydrograph (or similar data graph), hourly data set for the entire range of data, and daily average data set for the entire range of data. All data in AQUARIUS should be rated as "unverified" until the end of the water year (Sept 30th) and a review of the entire water year's data can be completed.

DATA ACCESS (WWBWC WEBSITE)

AQUARIUS data outputs should be uploaded to the WWBWC's website (typically accomplished through Fling software). Verify that all data outputs have been successfully uploaded to the website for public and agency access. Data and information for each surface monitoring location includes: current hydrograph, hourly data set, daily average data set, rating curve, metadata and site photograph. Data and information for each groundwater monitoring location includes: current hydrograph, hourly data set, daily average data set, metadata and manual water level measurements.



Data Management Flowchart

Data collection – downloading data logger from monitoring location and recording field measurements on appropriate datasheets

Data logger files are saved to the field laptop and verified before deleted from the logger or the logger restarted

Datasheets are scanned and data entered into appropriate software

Datasheets are filed in the appropriate 3-ring binder

Copy all raw data logger files to the WWBWC server before returning to field work

Import data into the AQUARIUS database within two weeks of data collection

Make appropriate data corrections in AQUARIUS

Create data outputs for WWBWC website

Upload data outputs to the WWBWC website and verify all outputs are available and correct.

DATA SECURITY AND BACKUPS

All data incorporated into the AQUARIUS database or located on the WWBWC server has redundancy backup (i.e. stored on multiple hard drives through the use of RAID). The WWBWC server and AQUARIUS database are backed-up monthly and stored at the WWBWC office and off-site for additional security.

DATA QUALITY ASSESSMENT

INITIAL POSTING OF DATA/NEAR-REAL TIME DATA

All data posted to the WWBWC website should be considered provisional unless otherwise stated. Near-real time data from surface gauges and other sites goes through an automated process without constant human oversight. Data discrepancies will be fixed as soon as possible. Until data are reviewed and published (see below) data quality will remain "unverified" or "provisional" and are subject to change. Data may be given an initial estimated data quality (estimated excellent, good, fair or poor) however this quality rating should be considered provisional and subject to change during review.

DATA QUALITY REVIEW

After each water year (typically in October), "unverified" or "provisional" data will be reviewed by WWBWC staff and any necessary changes will be made. After any revisions, data quality will be changed to "published" and a quality grade will be assigned. The published data will be available at the WWBWC's website

DATA QUALITY RATING

SURFACE WATER

Surface water data will be given a quality rating based upon the following factors:

- Rating curve distribution and number of discharge measurements for rating curve development.
- Accuracy of discharge measurements to calculated discharge flow from stage data.
- Site maintenance issues including sediment build-up, vegetation growth, channel migration and other localized influences.
- Accuracy of individual discharge measurements including variation in duplicate discharge measurements.
- Gauge location (e.g. concrete structure, silty channel, or stable stream bed).
- Site manipulation (especially in irrigation canals or ditches).
- Data set completeness.

All stage height measurements will include a margin of error.

GROUNDWATER

Groundwater data will be given a quality rating based upon the following factors:

- Number of manual water level measurements.
- Accuracy of manual water level measurements to cable-length adjusted transducer data.
- Accuracy of manual water level measurements (e.g. cascading well, pumping well, etc.).
- Data set completeness

All manual water level measurements will include a margin of error.

TEMPERATURE

Temperature data will be given a quality rating based upon the following factors:

- Accuracy of data logger's Pre and Post deployment accuracy checks.
- Accuracy of field accuracy checks with thermometer (NIST or YSI-30).
- Data set completeness.

APPENDIX B – STANDARD OPERATING PROCEDURES FOR SAMPLING OF PESTICIDES IN SURFACE WATERS – EAP 003. ENVIRONMENTAL ASSESSMENT PROGRAM, WASHINGTON STATE DEPARTMENT OF ECOLOGY.

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Sampling of Pesticides in Surface Waters

Version 2.1

Revised: Paul D. Anderson
Date: December 19, 2011

Reviewer : Debby Sargeant
Date: December 21, 2011

Author - Paul Anderson
Date - August 18, 2006

QA Approval William R. Kammin, Ecology Quality Assurance Officer
Date - February 8, 2012

EAP003

APPROVED: February 8, 2012

Signatures on File

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
4/21/2010		Updated staff requirements, Updated cleaning procedures for US DH 79 and 81 nozzles and caps Updated bottle size/type Updated (added to) replicate MS/MSD sample collect method.	4.1, 4.11.1, 6.3.5 5.2; 6.5.2; 6.5.5 8.1.1	Debby Sargeant
12/19/2011	2.1	Updated definitions Updated carbamate bottle and preserv. Updated use of DH-81 Changed DH-76 sampler to DH-95 Changed procedure for DH-76 to DH-95 Changed reference for DH-76 to DH-95	3.9 5.3; 6.5.2; 6.5.5 5.9; 6.4.2 5.10-5.10.7; 6.4.3 6.7-6.7.9 10.5	Paul D. Anderson

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for collecting samples to monitor pesticides in surface waters.

1.2 Monitoring pesticides in surface waters can and often does cover a wide range of objectives. Some studies are designed to look for a few specific chemicals and others are designed to look for a wide range of compounds. The term pesticide is used as a general term to group together many different use classes (herbicides, insecticides, and fungicides) of chemicals. For hydrophobic compounds a relationship between Total Suspended Solids (TSS) and pesticides may exist. This leads many monitoring projects to collect TSS samples alongside pesticide samples.

2.0 Applicability

2.1 This procedure is being used in the Washington State Department of Ecology Surface Water Pesticide Sampling Project. It is recommended that this procedure be followed by the Environmental Assessment Program when sampling surface waters to determine the presence and concentration of pesticides.

3.0 Definitions

3.1 Certificate of Analysis: Certificate provided by manufacturer ensuring bottles have been cleaned to EPA specifications.
3.2 EPA – Environmental Protection Agency
3.3 FISP – Federal Interagency Sedimentation Project
3.4 MSDS – Material Safety Data Sheet: These data sheets provide important information about a chemical’s properties along with health and safety data. Other information about the chemical manufacturer, fire-fighting procedures, protective equipment requirements, and spill clean up procedures are also provided.
3.5 MS/MSD – Matrix Spike/Matrix Spike Duplicate
3.6 MEL – Manchester Environmental Laboratory: Ecology laboratory that analyzes all pesticide samples.
3.7 TSS – Total Suspended Solids: A measure of the total amount of suspended material found in the water column.
3.8 US DH-81: depth integrating sampler designed by the USGS for use in wadeable rivers and streams between 1 and 4 feet.
3.9 US DH-95: depth integrating hand line sampler designed by the USGS for use in waters that are unsafe to wade but are not deeper than 15 feet and velocities not greater than 7.4 ft/sec.
3.10 US D-77: Teflon nozzle and cap for the US DH-81

3.11 USGS – United States Geological Survey

4.0 Personnel Qualifications/Responsibilities

4.1 Personnel collecting pesticide samples in surface waters should have prior experience conducting water sampling and should have a job classification equivalent to an Environmental Specialist 1 or higher.

5.0 Equipment, Reagents, and Supplies

5.1 1-liter manufacturer cleaned clear glass jars that are organic free with Teflon lid liners and a Certificate of Analysis

5.2 1000 milliliter manufacture cleaned amber glass jars that are organic free with Teflon lid liners and a Certificate of Analysis

5.3 20-milliliter manufacturer cleaned clear amber volatile organic analysis bottles that are organic free with Teflon lid liners and a Certificate of Analysis (preserved by MEL with 0.05 milliliter of acetic acid)

5.4 Coolers and wet ice

5.5 Talc-free Nitrile gloves

5.6 Sample tags

5.7 Chain of custody seals

5.8 TSS bottle (only necessary for studies collecting TSS samples)

5.9 US DH-81 (used in waters between 1 and 4 feet but still wadeable and that are not well mixed and have upstream water inputs) (Figure 1)

5.9.1 Wading Rod Handle and extension

5.9.2 Teflon US D-77 Caps pre-cleaned[1] to EPA specifications (EPA 1990) and wrapped in aluminum foil with dull side in

5.9.3 Teflon US D-77 Nozzles pre-cleaned to EPA specifications (EPA 1990) and wrapped in aluminum foil with dull side in

5.9.4 US DH-81A adapter

5.9.5 1-liter glass bottles that will fit US D-77 nozzle pre-cleaned to EPA specifications (EPA 1990) with opening covered by dull side of aluminum foil

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[1] The cleaning procedure for the sampling equipment that needs to be pre-cleaned is provided in Section 6.0.

5.10 US DH-95 (used in waters to deep or swift to safely wade but not deeper than 15 feet and velocities not greater than 7.4 ft/sec.) (Figure 2)

5.10.1 US DH-95

5.10.2 Hanger bar and pin used to attach sampler to rope or cable

5.10.3 A length of rope appropriate for the distance to be lowered to and into the water or a bridge crane with the appropriate length of cable

5.10.4 1-liter Teflon bottles with lids pre-cleaned to EPA specifications (EPA 1990)

5.10.5 Teflon nozzle holder cap pre-cleaned to EPA specifications (EPA 1990) and wrapped in aluminum foil with dull side in

5.10.6 Teflon nozzles (1/4” or 5/16”) pre-cleaned to EPA specifications (EPA 1990) and wrapped in aluminum foil with dull side in

5.10.7 O-Ring retainer or rubber bands to secure the bottle in the sampler

5.11 Supplies Needed for Cleaning Sampling Equipment

5.11.1 Pesticide grade acetone and hexane – Acetone and hexane are not known to be carcinogenic or teratogenic. The MSDS for acetone can be found at http://www.vwrsp.com/msds/10/BJ0/BJ010-4.pdf and for hexane at http://www.sciencelab.com/msds.php?msdsId=9927187

5.11.2 Aluminum foil

5.11.3 Liquinox soap

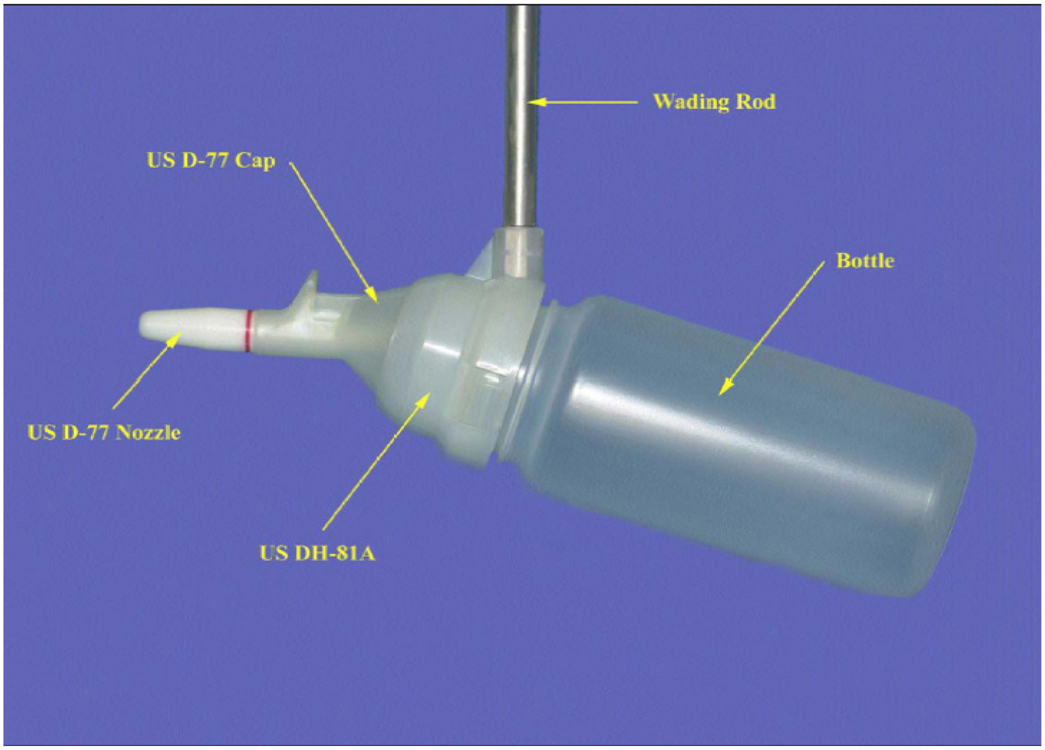

Figure 1. US DH-81 complete assembly.

Figure 2. US DH-95 complete assembly.

6.0 Summary of Procedure

6.1 General Sample Collection Techniques

6.1.1 Samples will be collected at quarter point transects unless the width of the river or stream makes doing so impractical or useless. A quarter point transect consists of collecting water at 3 points on a line perpendicular to the stream. The points are generally near the right and left bank and near the center of the river or stream.

6.1.2 Always collect the sample facing upstream to avoid collecting what is re-suspended by wading. In slow moving waters movement upstream after each transect may be necessary to avoid the plume of re-suspended material.

6.1.3 Always were Nitrile gloves when sampling. The use of the Nitrile gloves protects the sample from contamination from the hands of the sampler.

6.1.4 Take care not to bias the sample at any one depth of water. Pesticides may be distributed throughout the water column and by taking a sample at one depth the sampler may miss what is present elsewhere. Particular care should be taken to avoid collecting a disproportionate quantity of water or suspended sediment at the surface of the river or stream. Some pesticides may partition to the surface layer or sorb to bedload constituents. Collecting water in a single region may bias the concentration in the sample.

6.1.5 When possible keep the lid on the sample containers between transect points. This will avoid contamination from atmosphere and rain. This is not always possible and should be assessed on a case by case basis.

6.1.6 When possible keep the sample containers out of the sun during sample collection. In addition, use amber bottles for those pesticides susceptible to photolysis.

6.1.7 Fill sample containers to the shoulder. If testing for highly volatile products, sample containers should be filled to the top of container (no headspace). In this instance, volatile products are compounds with a Henry's Law constant greater than or equal to 10^{-3} atm*m^3/mole.

6.1.8 Take care not to disturb the substrate with the transfer bottle or collect anything from the substrate.

6.2 Handling of Sampling Equipment and Bottles

6.2.1 No part of any piece of sampling equipment that will come into contact with the sample during collection should be touched without wearing Nitrile gloves.

6.2.2 Never touch the inside of a sample container or Teflon lid liner even if wearing Nitrile gloves.

6.3 Pre-Cleaning Procedure for US DH-81 and DH-76 parts and bottles, or other pieces of equipment that will come into contact with the sample water

6.3.1 When cleaning sampling equipment follow all safety procedures and wear all necessary safety equipment as detailed in the Ecology Chemical Hygiene Plan.

6.3.2 Wash with hot tap water and brush with Liquinox detergent.

6.3.3 Rinse with tap water 3 times.

6.3.4 Rinse with deionized water 3 times and let drain.

6.3.5 Rinse with pesticide grade acetone and let dry in fume hood.

6.3.6 Rinse with pesticide grade hexane and let dry in fume hood.

6.3.7 Wrap in aluminum foil with dull side towards sampling equipment.

6.4 Types of Sampling

6.4.1 Grab Sampling – Water collection method using a handheld 1 liter jar in waters less than or equal to 1 foot.

6.4.2 US DH-81 Depth Integrated Sampling – Water collection method using a 1 liter jar attached to a nozzle that is raised and lowered in the water column by a metal handle. This method is used in waters greater than 1 foot but less than 4 feet in depth, not well mixed, and have upstream water input.

6.4.3 US DH-95 Depth Integrated Hand Line Sampling – Water collection method using a 1 liter jar placed in the housing of a weighted sampling devices lowered by a rope or cable. The US DH-95 method is used in waters greater than or equal to 4 feet but not greater than 15 feet in depth and with maximum velocities of 7.4 ft/sec.

6.4.4 Automatic Sampling – water collection method where an automated mechanical sampling device is used to collect water over a period of time or a time specified by the user. This is a specialized type of sampling and will not be covered in this procedures manual.

6.5 Grab Sampling

6.5.1 The sampler fills out a field sheet with the date, time, samplers, station name, method of collection, sample number, and weather observations. At this time the sampler will also fill out the sample label with all necessary information. This part of the procedure may be done in the office prior to sampling with the exception of the noting sample time and collection method.

6.5.2 The sampler will need 2 1000-milliliter amber bottles, 1 20-milliliter amber bottle, 1 1-liter transfer jar and 1 1-liter polypropylene bottle (optional). One of the 1000-milliliter bottles will be used for the herbicide analysis and the other will be used for the remainder of the pesticide analysis except for carbamates. The 20-milliliter bottle will be used for carbamate analysis. The 1-liter polypropylene bottle will be used for TSS.

6.5.3 The sampler will then take all of the containers and sample equipment to the sample site and put on Nitrile gloves.

6.5.4 The sampler removes the lid from the transfer jar.

6.5.5 The sampler then uses the 1 liter transfer jar to collect water at each point of the transect. The 1000 milliliter amber bottles will be filled by compositing 1/3 of the transfer bottle from each point of the transect. This equates to filling the 1000-milliliter jar 1/3 full at each point on the transect. In most cases a small amount more from each point will be needed to fill the jar to the shoulder. The 20-milliliter bottle and the 1-liter polypropylene bottle will be filled 1/3 full from each transect point.

6.5.6 After each sample container has been filled the sampler will place a sample tag with the date, time, study name, station name, laboratory sample number, and type of analysis filled out. Take care to make sure the proper tags are placed on the correct sample containers.

6.5.7 Once the sample containers are labeled the samples must be put in ice in a cooler. Placing the samples in a cooler in ice will bring down the temperature and preserve the samples before they are extracted and analyzed.

6.5.8 Upon return to the point of departure the sampler will need to fill out a laboratory analysis required sheet and place chain of custody seals on the cooler(s). Laboratory analysis sheets and chain of custody seals may be found at the Operations Center or may be obtained from MEL.

6.6 Sampling Using the US DH-81 Depth-Integrating Sampler

6.6.1 The sampler will follow most of the directions listed above in the grab sampling section. What is described here pertains mainly to the set-up and use of the US DH-81 depth integrating sampler.

6.6.2 Before leaving the van screw the DH-81A adaptor to the wading rod. All other parts of the US DH-81 should be left wrapped in foil until reaching the sample location.

6.6.3 Follow procedures 6.4.2-6.4.4. Sampling equipment for the US DH-81 are the US D-77 cap and nozzle, US DH-81A, and wading rod.

6.6.4 Remove the foil from the US D-77 nozzle and D-77 cap and put them together. Place the single piece into the US DH-81A and turn the piece to lock it in place.

6.6.5 Remove the foil from the opening of the 1-liter pre-cleaned sample jar that fits the DH-81 and screw it into the UD D-77 cap. The US DH-81 is now fully assembled.

6.6.6 Fill the bottle at each transect point by moving the assembly up and down in the water column. The rate of movement up and down depends on the velocity of the water. If the water moves fast then the rate will be fast. If the water is slow then the rate will be slow. The rate of upward and downward movement determines how much water from each part of the water column enters the bottle. Rate of movement should be consistent in the vertical profile and between transect points at individual sample sites.

6.6.7 Once the bottle is full unscrew it and put the water into one of the sample containers. Repeat this process following procedure 6.5.5.

6.6.8 Complete sampling following procedures 6.5.6-6.5.8.

6.6.9 When sampling at the station is complete, remove the US D-77 cap and nozzle out of the US DH-81A and place it in a bag for cleaning. These pieces are expensive and should be re-used.

6.6.10 Further information on the use of the US DH-81 may be found in the Operator's Manual for the US-DH-81 Depth Integrating Suspended-Sediment Sampler, produced by the Federal Interagency Sedimentation Project (FISP).

6.7 Sampling Using the US DH-95

6.7.1 The sampler will use most of the procedures described in the grab sampling section. What is described here mainly pertains to the set-up and use of the US DH-95 sampler.

6.7.2 Follow procedures described in the Grab Sampling section (6.5.1-6.5.3. Sampling equipment for the US DH-95 is the sampler, cap and nozzle, 1-liter Teflon bottle, O-Ring or rubber band, hanger and pin, and rope or bridge crane with cable.

6.7.3 Once at the sample site remove the sampler from the box and attach the hanger using the pin. Tie the rope to the hanger using a secure knot or attach the cable from the bridge crane. If possible tie the bitter end of the rope or secure the bridge crane to a solid object to prevent loss of the sampler.

6.7.4 Remove the nozzle and cap from the foil and screw the nozzle into the cap. Make sure that the nozzle is only finger tight. Remove the cap from the bottle and screw the bottle onto the cap and nozzle. Place the entire set-up into the sampler and secure it with an O-Ring or rubber band.

6.7.5 Lower the sampler to the water at the first transect point. Lower the sampler into the water until the tail of the sampler just touches the bottom. Move the sampler up and down until the sampler is filled to 80% or 800 milliliters. Movement should be at a constant rate and the same at each transect point.

6.7.6 Raise the sampler set it up on ground making sure not to let the nozzle come into contact with any surface. If using a bridge crane keep the sampler suspended. Remove the bottle and fill each sample container 1/3 full. Repeat this process following procedure 6.5.5.

6.7.7 Complete sampling following procedures 6.5.6-6.5.8.

6.7.8 When sampling is complete, remove the cap and nozzle put them in a bag for cleaning and re-use. Parts are cleaned and re-used because they are expensive. Remove the hanger and rope from the sampler and put the sampler back in it box.

6.7.9 Further information on the use of the US DH-95 may be found in the Sampling with the US D-95TM Depth-Integrating Suspended-Sediment Sampler, produced by FISP.

7.0 Records Management

7.1 For each site where pesticides samples are collected, the following must be recorded in a field book:
7.1.1 Station name
7.1.2 Date and time of collection
7.1.3 Person or persons collecting samples
7.1.4 Weather observations
7.1.5 Method used for collection
7.1.6 Any field notes that may be pertinent to the investigation (e.g., dead fish)
7.2 All incoming MEL data should be stored in an organized manner for easy retrieval and review at a later date (e.g., File folders with the week number and date).

8.0 Quality Control and Quality Assurance Section

8.1 Field Quality Control Samples

8.1.1 Replicate Samples: Replicate samples consisting of two samples collected at the same time or in series should be included at the discretion of the project lead. Water for the replicate sample shall be collected at the same time as the regular sample at each point on the transect. These samples will estimate the total random variability (precision) of individual results.

8.1.2 Matrix Spike/Matrix Spike Duplicate (MS/MSD) samples: MS/MSD samples consisting of 2 extra volumes of water collected at one station should be included at the discretion of the project lead. These samples are used to evaluate the potential for significant bias in the results due to the interference of the water matrix.

8.1.3 Field Blanks (transfer blanks): A transfer blank is prepared by filling a sample container with pure water during routine sample collection to check for possible contamination from the surroundings. The transfer blank will also detect contamination from the containers or from cross-contamination during transportation and storage of the samples. Transfer blank samples should be included at the discretion of the project lead.

8.2 Results Quality Control

8.2.1 After MEL performs the sample analysis and obtains numerical results the analyst and the lab QA/QC officer will review data and write up a case narrative. The results and narrative will be compiled into a report.

8.2.2 After laboratory review the report will be given to the project lead or other designated project personnel. The person receiving the report will review the results and case narrative and look for any errors, omissions, or inconsistencies. It is the responsibility of the reviewer to investigate any issues and notify the project lead.

9.0 Safety

9.1 Field work done in connection with collecting pesticide samples in surface waters should follow the protocols described in the Environmental Assessment Program Safety Manual, paying special attention to those parts devoted to working in rivers and streams and working near traffic and from bridges.

10.0 References

10.1 Ecology. 2006. Environmental Assessment Program Safety Manual. Washington State Department of Ecology. Olympia, WA.

10.2 Ecology. 2006. Chemical Hygiene Plan & Hazardous Materials Management Plan. Washington State Department of Ecology. Olympia, WA.

10.3 EPA. 1990. Specifications and Guidance for Obtaining Contaminant-Free Sample Containers. OSWER Directive #93240.0-05.

10.4 FISP. 2001. Operator’s Manual for the US DH-81 Depth-Integrating Suspended-Sediment Sampler. http://fisp.wes.army.mil/Instructions%20US_DH-81_010612.pdf

10.5 FISP. 2000. Sampling with the US D-95TM Depth-Integrating Suspended-Sediment Sampler. http://water.usgs.gov/fisp/docs/Instructions_US_D-95_000608.pdf

APPENDIX C – REVIEW OF PREVIOUSLY COLLECTED SOURCE WATER AND GROUNDWATER QUALITY DATA FROM ALLUVIAL AQUIFER RECHARGE PROJECTS IN THE WALLA WALLA BASIN, WASHINGTON AND OREGON

Contents

Introduction

Present and future alluvial aquifer recharge (AR) projects in the Walla Walla Basin (the Basin) must proceed with the assurance that these projects not only provide recharge to the alluvial aquifer but also that the additional recharge does not degrade native, or background, groundwater quality. Traditionally water quality monitoring focuses on project-by-project and/or site specific up-gradient and down-gradient sampling. For Walla Walla Basin AR projects this has resulted in each individual AR site having a water quality monitoring program specific to that site, and independent of other AR sites.

In reviewing water quality data collected at multiple AR sites in the Basin, Walla Walla Basin Watershed Council (WWBWC) staff and consultants have made a preliminary observation that AR in the Walla Walla Basin has not resulted in detectable degradation of native groundwater quality. Given this preliminary observation and the desire to streamline water quality monitoring associated with multiple, but inter-related AR sites, the WWBWC decided to do a more comprehensive review of the historical water quality monitoring data collected at the four AR sites it has worked on since AR began in the Walla Walla Basin in 2004. Two of these sites, Hall-Wentland and Hulette Johnson (formerly referred to as the Hudson Bay site) are located in Oregon. The other two, Locher Road and Stiller Pond, are located in Washington (Figure 1). Based on that effort the WWBWC, would like to eliminate synthetic organic compounds (SOC's) from the analyte list for the proposed multi-site AR monitoring program.

This report presents the results of this review of available AR water quality monitoring data, and WWBWC's recommendations for a single, multi-site water quality monitoring program to be used in lieu of a series of independent site-specific monitoring efforts, including the elimination of SOC sampling from normal AR monitoring for the proposed multi-site AR project.

To that end, the purpose of the analysis is twofold:

1. Evaluate water quality data collected before, during, and following various AR events at the four AR sites in an effort to identify analyte trends that may indicate any possible negative or positive effects with respect to water quality on the alluvial aquifer from AR operations.
2. Using that evaluation, propose removing synthetic organic compounds (SOC's) from the list of sampled parameters is plausible.

The remainder of this report focuses on a review of water quality data collected to-date at each of the four AR sites, the evaluation of the impacts of AR on groundwater quality, and recommendations for the scope of a potential future multi-site AR monitoring effort that eliminates expensive and time consuming SOC sampling. Details of AR operations at the four sites are found in Kennedy/Jenks (2006), GSI (2007a, 2007b, 2008a, 2008b, 2009, 2012), and WBWC and GSI (2010). Alluvial aquifer geology and hydrogeology are discussed in detail in Newcomb (1965), Barker and McNish (1976), and GSI (2007c).

Alluvial Aquifer Water Quality

Alluvial aquifer water quality data collected from the various AR sites and evaluated for this effort varies from site-to-site. However, they generally included field parameters, major ions, nutrients (nitrate-N, total Kjeldahl nitrogen (TKN) and ortho-phosphate), PCB's, bisphenol-A (BPA), and agricultural synthetic organic compounds (SOC's).

AR Site Water Quality Findings

Hulette Johnson

The Hulette Johnson site (Figures 1 and 2) is a fully developed AR site that has been in operations since 2004. Both recharge basins and infiltration galleries are used at this site. It is the most up-gradient of all the sites evaluated herein (WWBWC, 2012) and is located about 2 miles northwest of Milton-Freewater, Oregon. Water quality data used in this evaluation come from two monitoring wells (HJ-1 and HJ-2) and from the source water intake at the site. The source water is Walla Walla River water delivered to the site via the White Ditch operated by HBDIC. This site has been operated under a Limited License issued to the HBDIC.

The samples evaluated herein were collected periodically between 2006 and 2012. Water quality parameters evaluated from the Hulette Johnson site include nitrate-N, total Kjeldahl nitrogen (TKN), ortho-phosphate, chloride, total organic carbon (TOC), total suspended solids (TSS), total dissolved solids (TDS), hardness, and a suite of synthetic organic compounds (SOC's). Field parameter data, consisting of pH and electrical conductance (EC), where only collected at this site during its early years of operation. Plots for many of the parameters collected at this site are provided in Appendix A.

A range of source water and groundwater quality relationships are found in the Hulette Johnson site data. Some parameters display higher values in groundwater, while others display higher values in the source water. In other data sets groundwater quality parameter values are similar to those from source water samples. Specific observations are as follows.

Ortho-phosphate, nitrate-N (nutrient type parameters) and TDS generally are lower in source water during the same sampling events as compared to local groundwater. Slightly negative correlations (Table 1) between both source and alluvial groundwater ortho-phosphate data with sampling dates over time suggest that with respect to this parameter groundwater quality is not degraded but improved during AR operations. Groundwater nitrate-N concentrations have a slightly positive (0.02) correlation to sampling date but source water nitrate-N has a negative correlation (-0.45). The slightly increasing nitrate correlation in groundwater with sampling date over time, as compared to decreasing correlation in surface water, is interpreted to show that surface water introduced via AR is not degrading groundwater quality.

Chemical oxygen demand (COD) data exhibit no trends in groundwater and surface water, but do show generally values with the range of concentrations measured to-date in both systems overlapping (Appendix A Figure A-12). A slightly negative correlation between the data from each sampling location at this site and the sampling date suggests that groundwater quality at this site is not degraded but improved with respect to organic constituents.

TKN and TOC in groundwater and surface water generally show similar values with the range of concentrations measured to-date in both systems overlapping (Appendix A Figures A-17 and A-19). A slightly negative correlation (TKN = -0.31, TOC = -0.52) between the data from each sampling location at this site and the sampling date suggests that groundwater quality at this site is not degraded but improved with respect to TKN and TOC.

Chloride and TSS in source water generally is the same as, or higher than is seen in local groundwater (Appendix A Figures A-15 and A-13). The parameter concentrations measured to-date are low in general and suggest no contamination issues related to TSS and chloride. A positive correlation of chloride data to sampling date (0.54) suggests that chloride in groundwater may be increasing slightly over time. TSS source water data also has a positive correlation to sampling date (0.11), also suggesting that it could be slightly increasing over time. For both parameters though negative correlation in groundwater of -0.03 for chloride and -0.54 for TSS is interpreted to show that AR is not degrading local groundwater quality with respect to these two parameters.

Bisphenol-A (BPA) is the only ***SOC*** at this site with repeat detections, being detected intermittently in site groundwater between 2008 and 2012. BPA has not been detected at this site in source water. To-date, these measured BPA concentrations are two orders of magnitude lower than EPA toxic levels for aquatic organisms. EPA toxic levels for aquatics are between 1100 and 10,200 µg/L for aquatic organisms (EPA, 1988). Insufficient data is available for statistical and long term trend evaluation of BPA at this site.

In summary, these data are interpreted to show that to-date, AR operations at the Hulette Johnson site generally have not lead to degradation of local groundwater. Nutrients in source water are lower than seen in groundwater; therefore if they have any influence on groundwater, they decrease down gradient concentrations. Although Chloride and TSS are higher in source water, the relatively low concentrations seen in local groundwater are interpreted to reflect a minimal impact on local groundwater quality by AR operations. With respect to other parameters TDS, TKN, and TOC in both groundwater and surface water overlap to such a degree that they are interpreted to reflect a similar origin and AR operations has a minimal influence on them. SOC data collected to-date do not show any impact to groundwater by AR activities. BPA when found in groundwater is not detected in source water, suggesting its introduction to groundwater via other means than AR activity at this location.

Hall-Wentland

The Hall-Wentland site (Figures 1 and 3) hosted AR activity between 2006 and 2009. This site is located 4 miles southwest of Walla Walla, WA and about 6 miles northeast of the Hulette Johnson site. The Hall-Wentland site is on irrigated pasture and adjacent cropped ground which was flooded for AR operations. Water was delivered to the Hall-Wentland site via a small canal, the Wells ditch. Wells ditch is sourced from a weir structure on the East Branch of the Little Walla Walla River less than one mile south-southeast of the site. When operated, this AR project was operated under a Limited License issued to the WWRID, but operated by a local land owner.

WQ samples were collected in 2006, 2007, 2008, and 2009 from one up-gradient monitoring well (HW-2), two down-gradient monitoring wells (HW-1 and HW-3), and from source water before, during, and after AR operations. Parameters used in this evaluation of AR influences on groundwater at the Hall-Wentland site include pH, EC, turbidity, nitrate-N, hardness, TDS, chloride, and SOC's. Plots for these data are provided in Appendix B. As with the Hulette Johnson site, water quality data from the Hall-Wentland site shows that for some constituents source water and groundwater geochemistry are similar, while for others they differ, but without a significant change, or degradation, in groundwater conditions resulting from AR operations.

With respect to the ***field parameters (pH and EC)*** source water pH generally is higher than groundwater pH, and while there is a slight increase in down-gradient pH the differences between the two are small (Appendix B Figures B-13 and B-14), and up-gradient to down-gradient changes are not consistent. Source water EC generally is lower than groundwater EC, and groundwater EC does not show any clear up-gradient to down-gradient changes that are interpreted as indicative of AR influences on groundwater quality (Appendix B Figure B-14). These trends are exemplified with a positive correlation (0.23) between pH and sampling date over time in source water and slightly negative correlations between groundwater data sets (-0.05, -0.23 and -0.23 for HW-1, HW-2 and HW-3 respectively).

Turbidity also appears to be generally higher in source water when compared to groundwater. With that though, there is no readily apparent increase in groundwater turbidity from up-gradient to down-gradient at the Hall-Wentland site (Appendix B Figure B-15). This likely reflects the filtration of fines from the source water as it migrates through the vadose zone to the water table.

Source water generally displays lower values for ***hardness, TDS, and nitrate-N*** than groundwater (Appendix B Figures B-16 and B-19). Given that, if there were significant changes in groundwater quality caused by AR operations at the Hall-Wentland site one should expect to see up-gradient to down-gradient decreases in these parameters. Such trends are not readily apparent in the data collected to-date. Negative correlations (see Table 1) between source and groundwater samples at this site for all but one sampling location (HW-3, which is the furthest down-gradient) indicate that groundwater quality with respect to TDS could have improved due to AR at this site. All sampling locations at this site exhibited positive correlations between nitrate values and sampling dates over time (See Table 1). Being that groundwater values are higher than source water values (Appendix B Figure B-19), it is most likely that nitrate-N levels in groundwater are influenced by other activities than AR.

Ortho-phosphate in groundwater and surface water generally show similar values with the range of concentrations measured to-date in both systems overlapping (Appendix B Figure B-20). Positive correlations between ortho-phosphate values and sampling times (See Table 1) showed that values increased over the time of sampling at this site.

The ***chloride*** data collected during Hall-Wentland operations contains some anomalously high values which may mask a trend indicative of AR influences on groundwater quality (Appendix B Figure B-18). Although chloride concentrations generally are low in both groundwater and source water (<5 mg/L) high and low source water values do seem to generally be reflected in down-gradient increases and decreases. Given that though, negative correlations between chloride data and sampling dates over time for all sampling locations at this this site suggest that chloride over time could be decreasing.

Three ***SOC's, di(ethylhexyl)-phthalate, diethyl phthalate, and Malathion***, were detected in 4 different sampling events. However, in only one sampling event were SOC's (di(ethylhexyl)-phthalate and diethyl phthalate) detected in the source water. In all cases, the detected concentrations were below EPA drinking water standards, as follows:

- Di(ethylhexyl)-phthalate values ranged from 1.6 to 4.1 µg/L. The EPA drinking water standard is 6.0 µg/L.
- Diethyl phthalate values ranged from 0.5 to 2.2 µg/L. The EPA drinking water standard for diethyl phthalate is 5000 µg/L.
- Malathion was detected only for the 04/11/07 sampling event in the three wells and not in the source water. Malathion levels ranged 0.3 to 0.4 µg/L. This is far below the EPA drinking water standard of 500 µg/L.

Insufficient data is available for statistical and long term trend evaluation of SOC's at this site.

In summary data from the Hall-Wentland site are interpreted to show that AR operations generally had little or no significant influence on local groundwater quality. There are likely several reasons for this, including:

- The general similarity of the source water and the groundwater at the Hall-Wentland site may be related to the location and leaky nature of the Wells ditch with respect to the monitoring wells and the AR site. Wells ditch was shown during work on the AR project to be a leaking ditch, supplying recharge to local groundwater. The ditch is in-turn located up gradient of the up gradient well, HW-2. Given this relationship, water leaking from the canal to the aquifer has already influenced local groundwater up gradient of the AR site, masking any potential AR site influence on local groundwater. This relationship is one we have come to expect across much of the Basin, the surface water system contributes significant recharge to the alluvial aquifer, and as such, exerts a strong influence on local groundwater quality quite independently of any AR activity.
- For some constituents the soil column (vadose zone) acts as a filter and these constituents are held up, or filtered, by the soil column as water infiltrates from the surface to the underlying alluvial aquifer.
- In other cases, where constituents are present in groundwater but not in source water, such as is usually the case with SOC's, we infer that these entered the groundwater system at a location(s) other than the AR site.

Based on what was seen at the Hall-Wentland site when it was operated, AR activity may have influenced down-gradient water quality, but the changes from up to down-gradient are relatively small, with the total potential change caused by AR less than variation occurring independent of AR resulting from natural (or normal) canal and ditch operations. With that though, even normal operation generally appears to not cause degradation of the underlying alluvial aquifer.

Locher Road

The Locher Road site is an excavated basin specifically designed for AR located within a larger, inactive gravel pit. It is cross gradient of the Hall-Wentland site and down gradient from the Hulette Johnson site. It is located about 5 miles southwest of College Place, WA (Figures 1 and 4). AR operations occurred seasonally at the site in 2006, 2007, 2008, 2009, 2011, and 2012. The Locher Road site is operated by GFID#13 under an agreement with the owner of the site.

Water quality samples have been collected from one up gradient monitoring well (L-1), two down gradient monitoring wells (L-2 and L-3), and from the source water diversion on GFID's Burlingame Canal. Parameters used in this evaluation of potential AR influences on the alluvial aquifer include the field parameters pH and EC, turbidity, nitrate-N, hardness, TDS, chloride, and SOC's. Plots for these data are provided in Appendix C.

Locher Road groundwater monitoring data is interpreted to show that AR at this site does influence groundwater quality. In addition, some of the data may show the influence of local land uses.

TDS, hardness, and EC data are interpreted to show up gradient to down gradient decreases directly related to AR. Generally source water values are lower than down gradient groundwater, and down gradient groundwater values are lower than up gradient (Appendix C Figures C-15, C-16 and C-12). Scatter plot trends and positive correlations between TDS data and sampling dates over time for all site source and all groundwater datasets indicates a slight increasing trend over time. However, this trend appears to be slight enough as to not be indicative of any groundwater degradation by AR operations at the site (Appendix C Figures C-5, C-15 and Table 1). EC at this site exhibits slightly increasing trends on scatter plots and positive correlations between EC values and sampling dates over time in source water and all monitoring wells except the up-gradient well LR-1 which exhibits a slightly negative trend and negative correlation (Appendix C Figures C-2, C-12 and Table 1). However actual values of EC from LR-1 average higher than all other locations and source water at this site which is typical for up-gradient conditions. LR-1 is very close to the recharge basin and the decreasing trend and negative correlation with sampling date over time could be due to some groundwater dilution caused by possible groundwater mounding from AR.

Chemical oxygen demand (COD) show concentration ranges where both source water and groundwater overlap (Appendix C Figure C-14 and Table 1). These data are interpreted to show that there are no trends in groundwater and surface water.

Locher Road site ***nitrate- N*** data is interpreted to in part reflect groundwater impacts unrelated to AR operations. Source water nitrate-N is very low and prior to 2009 there was an up gradient to down gradient decrease in constituent concentration that is interpreted to result from source water dilution of groundwater nitrate -N. In the 2009, 2011, and 2012 there is elevated nitrate-N in the most down gradient well, L-2, while source nitrate-N is extremely low, less than 1 mg/L. Elevated nitrate-N in well L-2 is interpreted to be because the well is down gradient of an actively farmed field and results from fertilizer application on that field, and not AR operations. Box-plot analysis and positive correlation coefficient comparisons between sampling location datasets at this site indicate dilution of groundwater with respect to nitrate-N in a down gradient direction (Appendix C Figure C-18 and Table 1). This is interpreted to show no alluvial groundwater quality degradation, but possibly improvement, because of AR operations with respect nitrate-N.

Source water generally displays lower values for ***ortho-phosphate*** than groundwater. These values do trend together and are relatively close suggesting a common source of ortho-phosphate for both systems. These observations can be seen in box-plots comparing sampling location datasets for this site (Appendix C Figure C-19). Source water ortho-phosphate correlation with sampling date over time is slightly positive but moderately negative for all monitoring wells. This suggests that AR operation at Locher Road does not degrade alluvial groundwater quality with respect to ortho-phosphate.

Chloride, pH, and turbidity data are less clear, and at this time are interpreted to show that source water and local groundwater have many similarities. With that general interpretation groundwater chloride generally is higher than source water, groundwater pH generally is lower, and turbidity does not seem to show a clear trend because of intermittent elevated levels in L-1. On box-plots, source and groundwater chloride ranges overlap, further illustrating the similarity between them (Appendix C Figure C-17). Turbidity does exhibit slightly negative correlations with sampling dates over time suggesting some possible flushing of fine materials from the alluvial aquifer in the vicinity of Locher Road due to AR (Table 1).

With respect to ***SOC's***, the Locher Road SOC data collected in 2007 and 2008 is similar to the other SOC data sets, showing intermittent low concentration detections of just a few parameters ***(Bromacil, Malathion, Di-N-Butyl-Phthalate)***, although these parameters differ somewhat from the other sites. Bromacil is detected in some of the up gradient groundwater samples, but not in the down gradient samples, suggesting potential down gradient dilution from AR activities. The other low concentration SOC detections for Malathion (detected once in all three wells) and Di-N-Butyl-Phthalate (detected in 2 sampling events in 2007) are sporadic, low concentration in nature, and show down gradient reduction in concentrations when seen. These are interpreted to show that Locher Road AR activities are not causing degradation of local groundwater by introducing SOC's to the alluvial aquifer system. Insufficient data is available for statistical and long term trend evaluation of SOC's at this site.

Stiller Pond

The Stiller Pond AR site is an artificial pond that has been used historically as an irrigation water storage impoundment. Unlike the other three sites it is located north of the Walla Walla River and several miles west of Walla Walla (Figure 1 and 5). The source of water for the Stiller Pond site is Mill Creek, and water is delivered via a pipeline that extends from the creek to the site. The Stiller Pond site was operated by the WWCCD, under an agreement with the land owner.

AR operations first began at Stiller Pond in the spring of 2012 and lasted approximately 3 weeks. During this AR event water quality samples were collected at one down gradient well and from the source water. Parameters used in this evaluation of potential AR influences on the alluvial aquifer include the field parameters pH, EC, dissolved oxygen (DO), and oxidation-reduction potential (ORP) and hardness, chloride, magnesium, TDS, nitrate-N, phosphate, and TKN.

SOC's were not collected at the Stiller Pond site. Comparative histograms for the data collected are provided in Appendix D.

Like the other AR sites described herein, at Stiller Pond, the influence of AR operations on local groundwater is apparent but impacts are not major and do not appear to lead to degradation of local groundwater quality. Specifically:

- Pre- and post-test groundwater and source water ***pH*** remained relatively consistent.
- ***EC and ORP*** appear to have decreased as a result of AR activities, with the down gradient well dropping soon after the start of AR operations and infiltration of low EC and anion source water.
- ***Chloride, hardness, magnesium, and TDS*** were all lower following the AR event. This is again inferred to result from dilution of groundwater constituents as low concentration source water infiltrated to and recharge the local alluvial aquifer.
- Nutrient concentrations, which include ***nitrate-N, phosphate, and TKN*** are interpreted to show that AR at this site did not degrade groundwater quality. TKN was elevated slightly in the post-recharge sample, but this was expected due to the introduction of additional organic nitrogen, ammonia and ammonium to the groundwater via recharge through the biomass on the surface of the Pond in the form of decaying plant matter. This slight rise in TKN is not interpreted to reflect groundwater degradation because the slight increase in TKN did not correspond to a matching increase in nitrate-N. In fact, nitrate-N decreased in groundwater following the AR event.

Basic water quality parameters summarized above are interpreted to show that AR activities at the Site did not degrade groundwater quality during the 2012 AR season. This data, especially the fact that pre-test groundwater concentrations in most parameters are higher than post-test groundwater concentrations and source water, suggests AR operations at the Site may lead to reductions in parameter concentrations as recharge water is added to the alluvial aquifer underlying the Site.

Summary

Review of the groundwater quality monitoring data collected to-date at the three active AR sites, Hulette Johnson, Locher Road, and Stiller Pond and at the inactive Hall-Wentland site we conclude that while AR operations conducted in the Walla Walla Basin does influence local groundwater quality, this influence should not be construed as degradation. Based on the data reviewed here the basic changes seen include the following:

- With respect to nutrient type constituents, including nitrate-N, TKN, phosphate, and ortho-phosphate the groundwater changes we see generally show down gradient declines in constituent concentrations, which we interpret to reflect dilution of groundwater concentrations by AR water.
- Other parameters, such as TDS, chloride, and EC also commonly show evidence of down gradient reductions through AR sites that we again interpret as evidence of dilution of these parameters in groundwater by AR water.
- The SOC data available for these sites is interpreted to show that AR operations have essentially no influence on SOC's present in groundwater. Based on what we reviewed

SOC detections are sporadic, not systematic, and at very low concentrations. With that observation, we interpret the few detections to result from background conditions reflective of activities other than AR operations.

- In addition to these observations, the Hall-Wentland data is instructive as it shows the importance of natural leakage from surface waters (which typically are the same waters these AR sites use for source water) influencing local groundwater chemistry.

The water quality data collected over several AR seasons from four different sites are interpreted to have not resulted in alluvial aquifer water quality degradation. Field parameters and major ion hydrochemical trends seen in monitoring well data commonly show reduced concentrations, indicating dilution of groundwater concentrations by AR operations. A few anomalies did occur in these trends, but low source water concentrations versus high monitoring well concentrations strongly suggest that AR operations were not the cause of these anomalies. There were no significant SOC detections from any site. Of the SOC detections seen in the data sets, SOC concentrations are low enough to be considered background levels and/or these detections were instances of localized transient introduction to the water table from an unaltered ground surface AR site (specifically HW).

Recommendations

Based on our interpretation that AR has led to little to no degradation of groundwater quality in the Walla Walla Basin, we recommend that future monitoring of AR projects exclude extensive sampling and testing for SOC’s. The data collected to-date is interpreted to show very low, and sporadic background SOC concentrations not related to AR activities. Rather SOC detections are likely related to transient events originating at sites other than the AR sites. Thus it is unlikely that SOC’s have been or would be introduced to the alluvial groundwater by AR source water.

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Table 1. Correlation Coefficients between Water Quality Parameters and Sampling Dates over Time. EC =electrical conductivity, COD = chemical oxygen demand, TDS = total dissolved solids, TSS = total suspended solids, TKN = total Kjeldahl nitrogen and TOC = total organic carbon.

Site/ Well	**Correlation Coefficient**											
	pH	**EC**	**Turb.**	**COD**	**TDS**	**TSS**	**HCO3**	**Cl-**	**NO3-**	**TKN**	**Ortho-phos.**	**TOC**
Hall-Wentland												
Source	0.23	0.34	0.16	-0.33	-0.23	N/A	-0.15	-0.44	0.07	N/A	0.42	N/A
HW-1	-0.05	0.66	0.61	-0.28	-0.06	N/A	-0.08	-0.36	0.52	N/A	0.61	N/A
HW-2	-0.23	0.57	0.18	-0.28	-0.02	N/A	-0.36	-0.27	0.32	N/A	0.59	N/A
HW-3	-0.23	0.86	0.12	-0.25	0.21	N/A	0.05	-0.37	0.64	N/A	0.71	N/A
Hulette-Johnson												
Source	N/A	N/A	N/A	-0.89	0.33	0.11	N/A	-0.03	-0.45	-0.31	-0.15	-0.52
HJ-1	N/A	N/A	N/A	-0.57	0.30	-0.54	N/A	0.54	0.02	-0.25	-0.20	-0.35
Locher Road												
Source	-0.50	0.01	0.76	0.31	0.14	N/A	0.00	-0.57	-0.25	N/A	0.14	N/A
LR-1	-0.43	-0.16	-0.11	0.03	0.44	N/A	-0.37	0.40	0.28	N/A	-0.40	N/A
LR-2	-0.69	0.54	-0.03	-0.05	0.68	N/A	0.42	0.55	0.63	N/A	-0.42	N/A
LR-3	-0.65	0.12	-0.22	-0.09	0.33	N/A	0.07	-0.27	0.43	N/A	-0.39	N/A

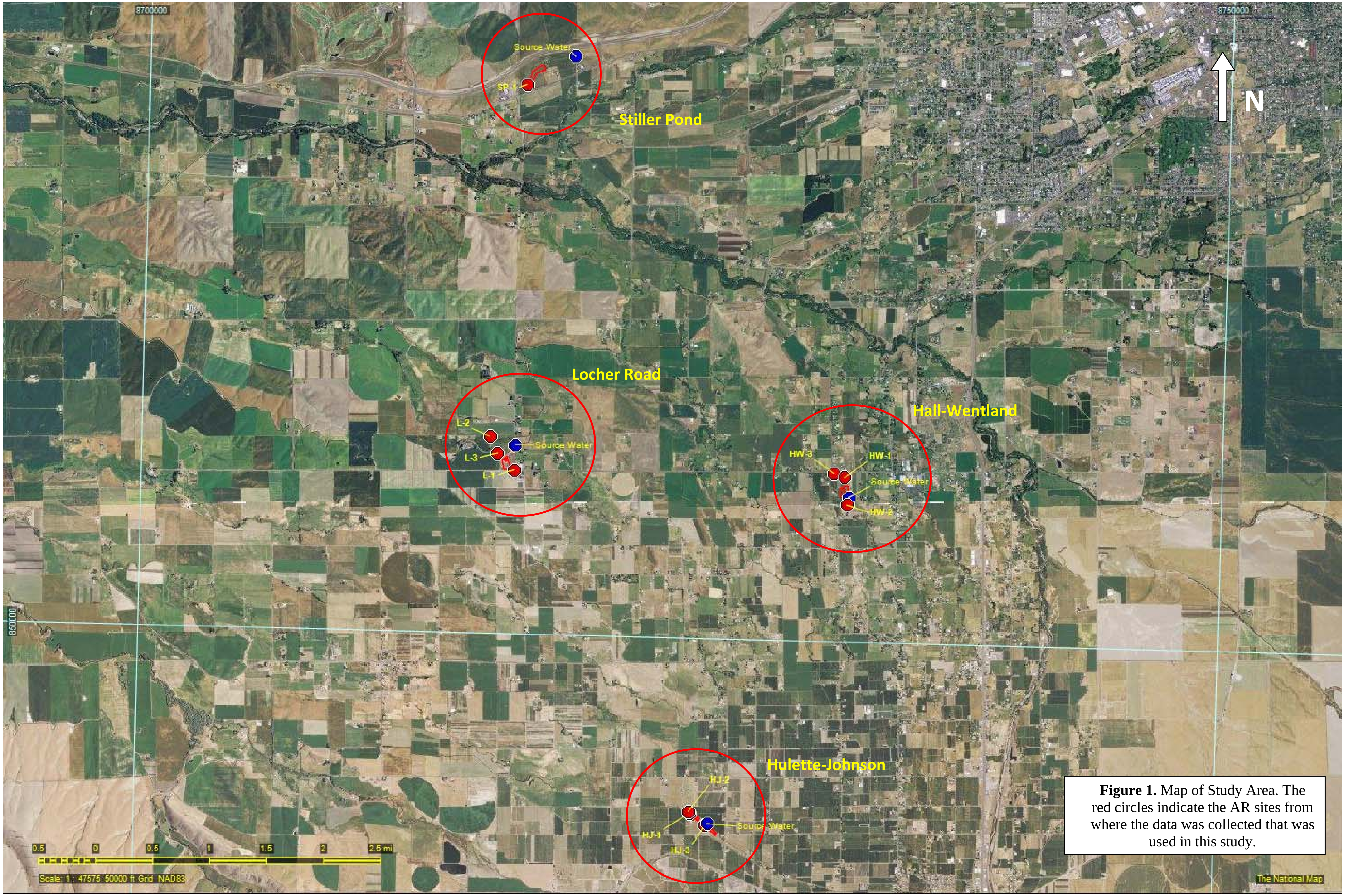

Figure 1. Map of Study Area. The red circles indicate the AR sites from where the data was collected that was used in this study.

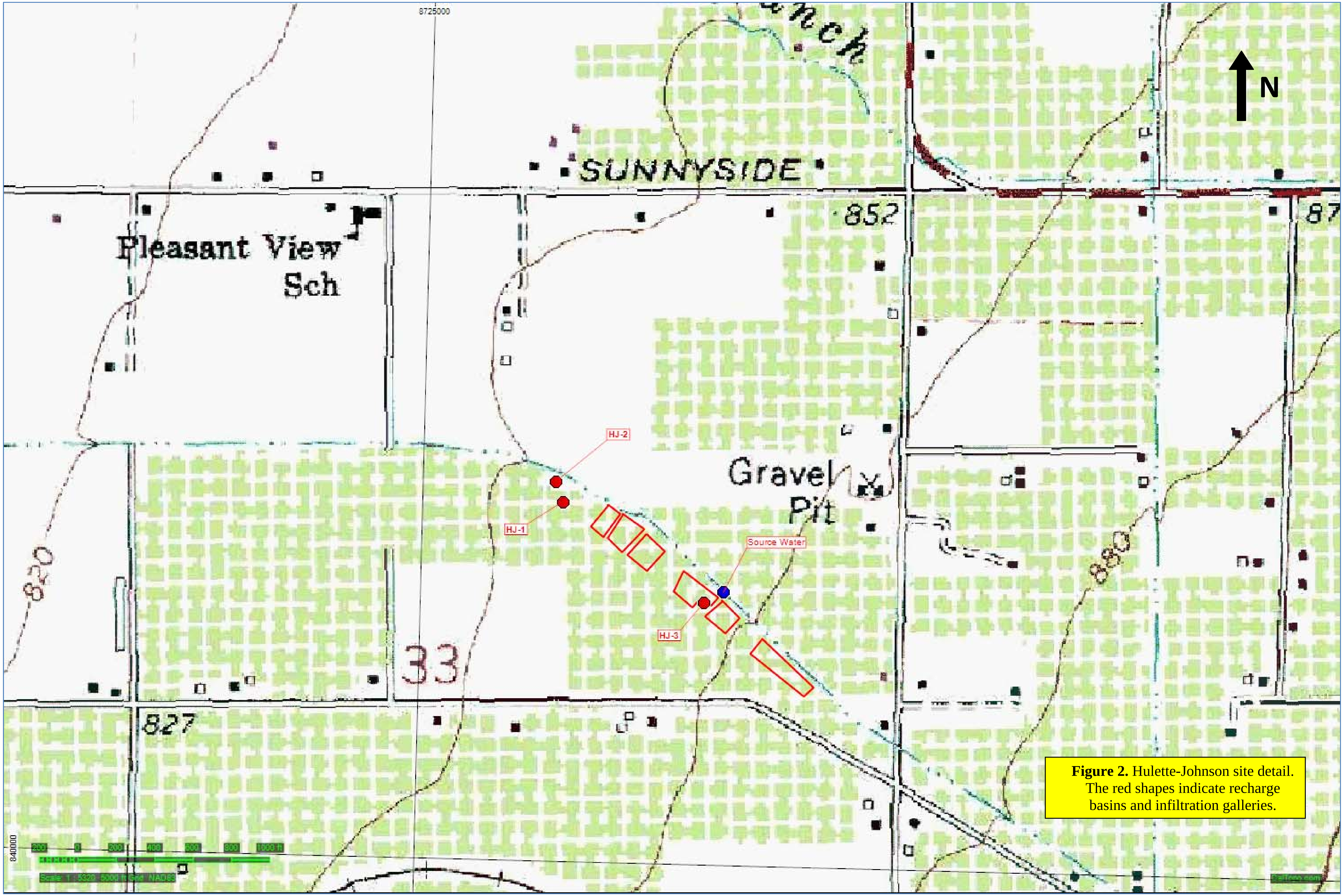

Figure 2. Hulette-Johnson site detail. The red shapes indicate recharge basins and infiltration galleries.

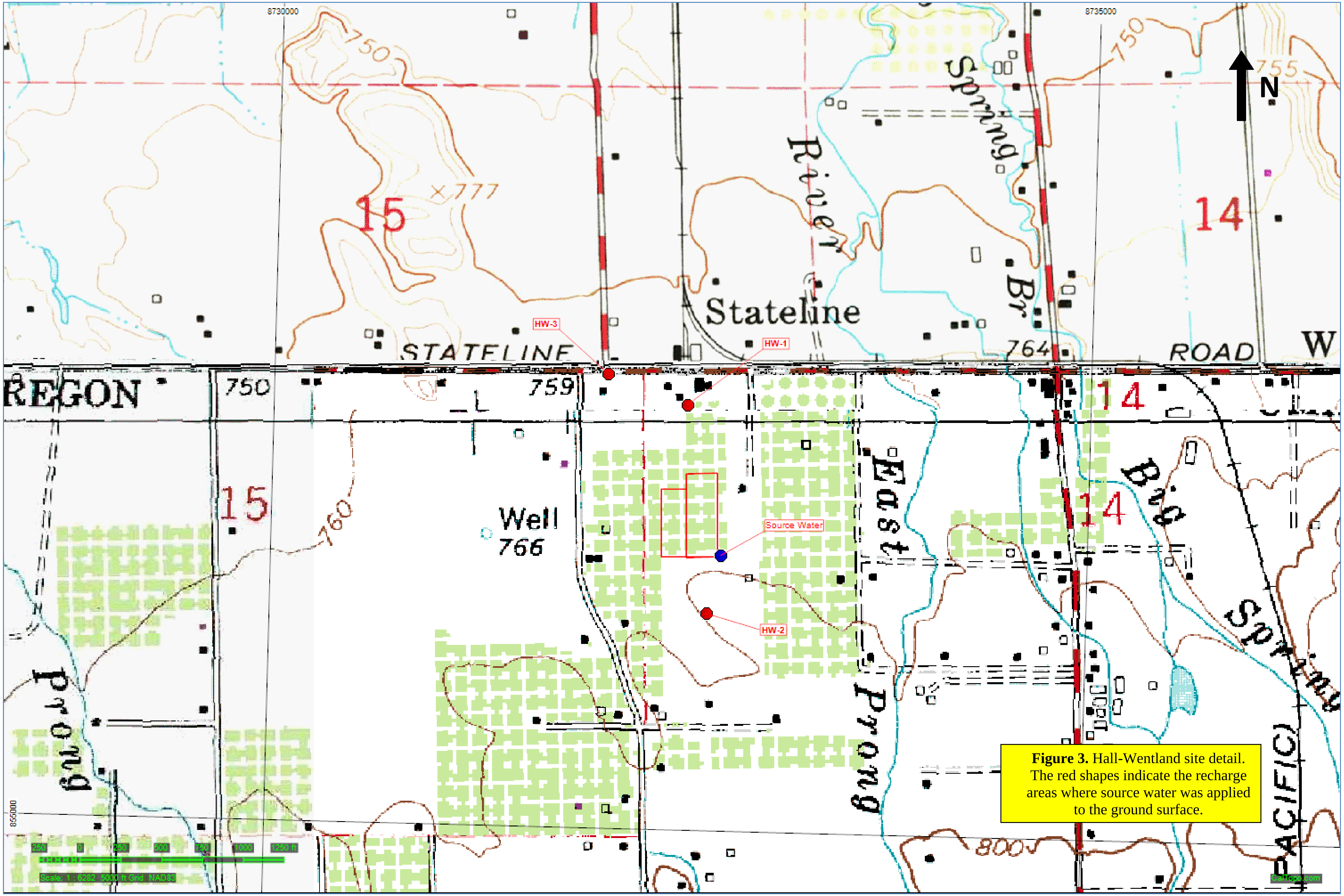

Figure 3. Hall-Wentland site detail. The red shapes indicate the recharge areas where source water was applied to the ground surface.

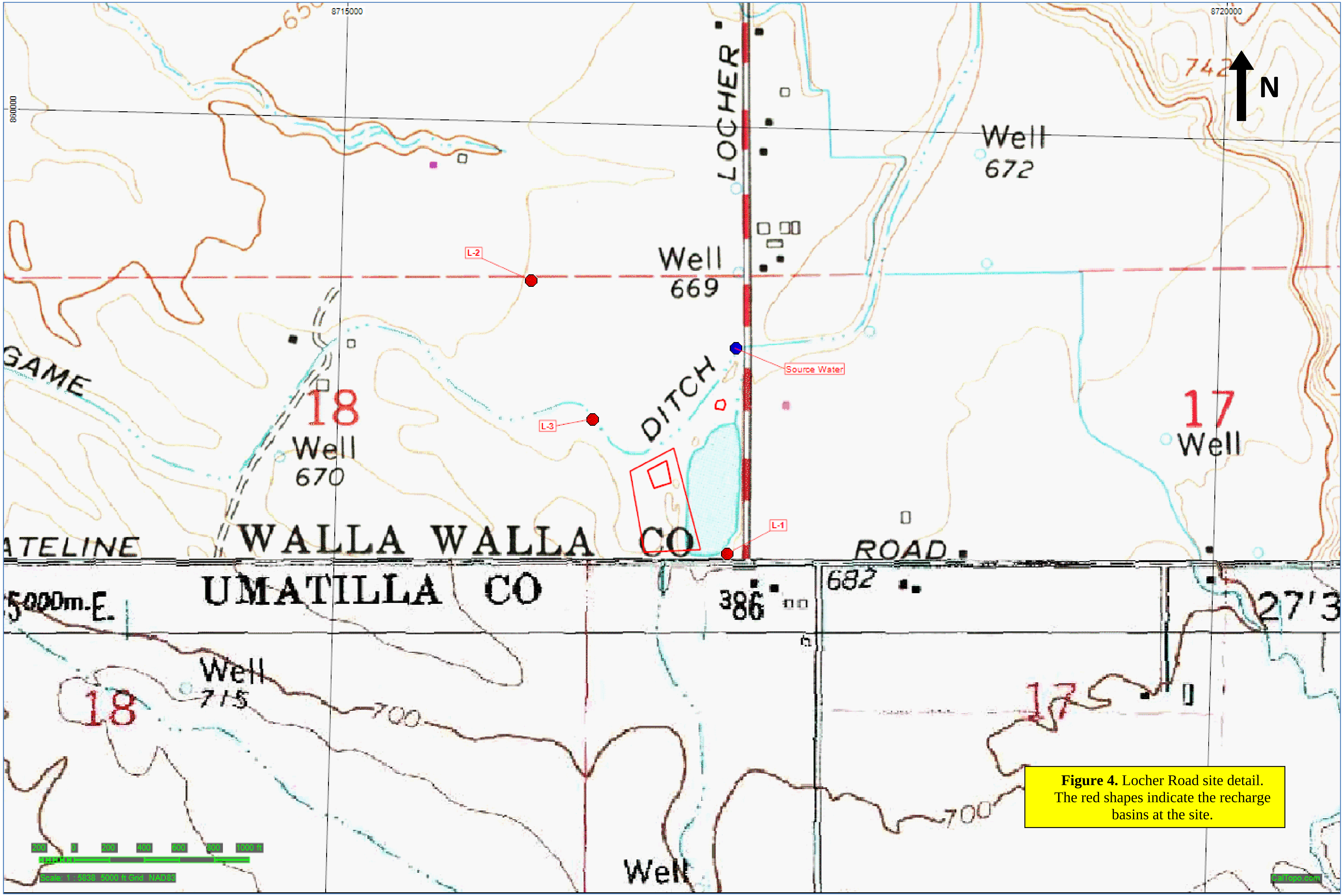

Figure 4. Locher Road site detail. The red shapes indicate the recharge basins at the site.

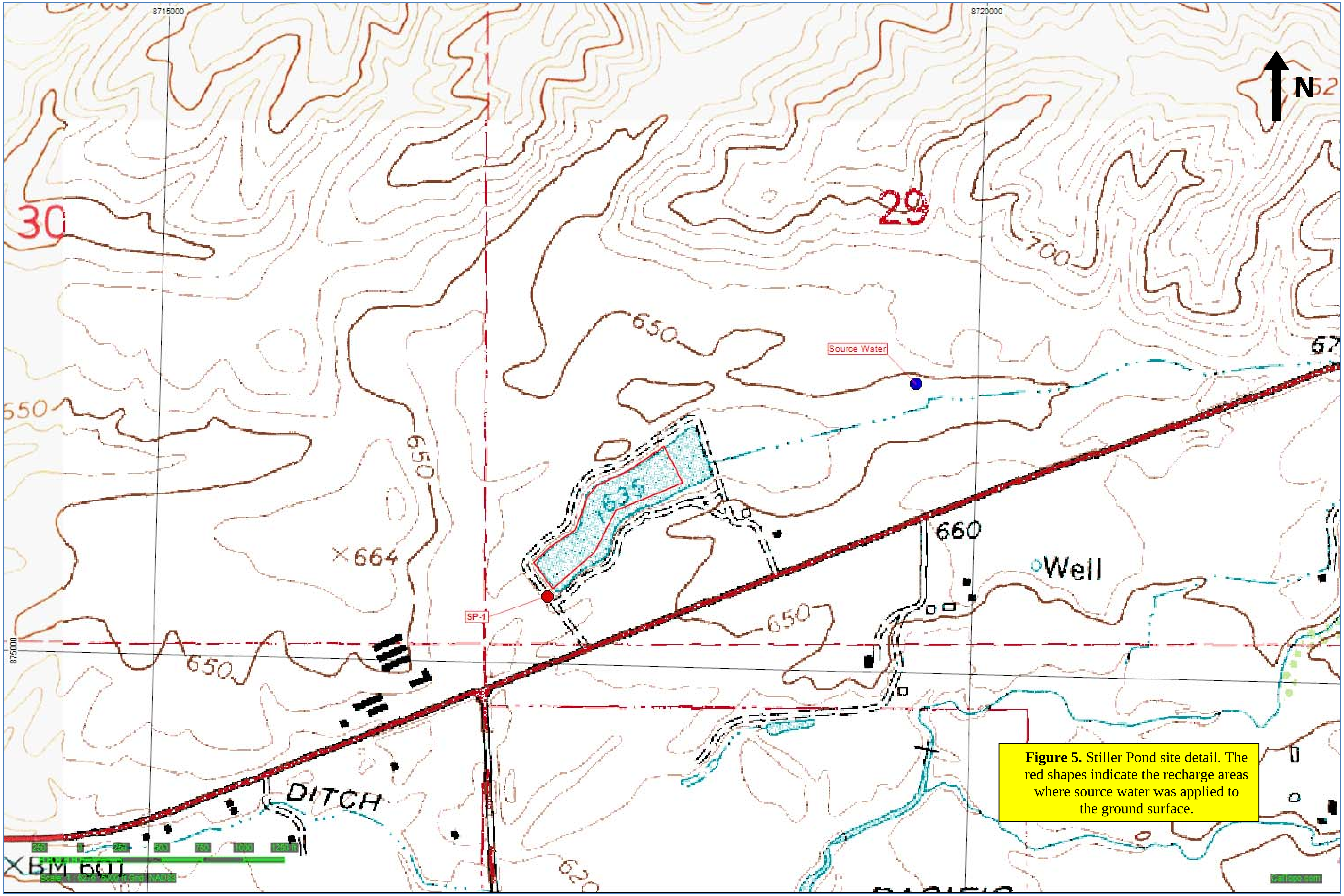

Figure 5. Stiller Pond site detail. The red shapes indicate the recharge areas where source water was applied to the ground surface.

Appendix A

Hewlett-Johnson Data Plots

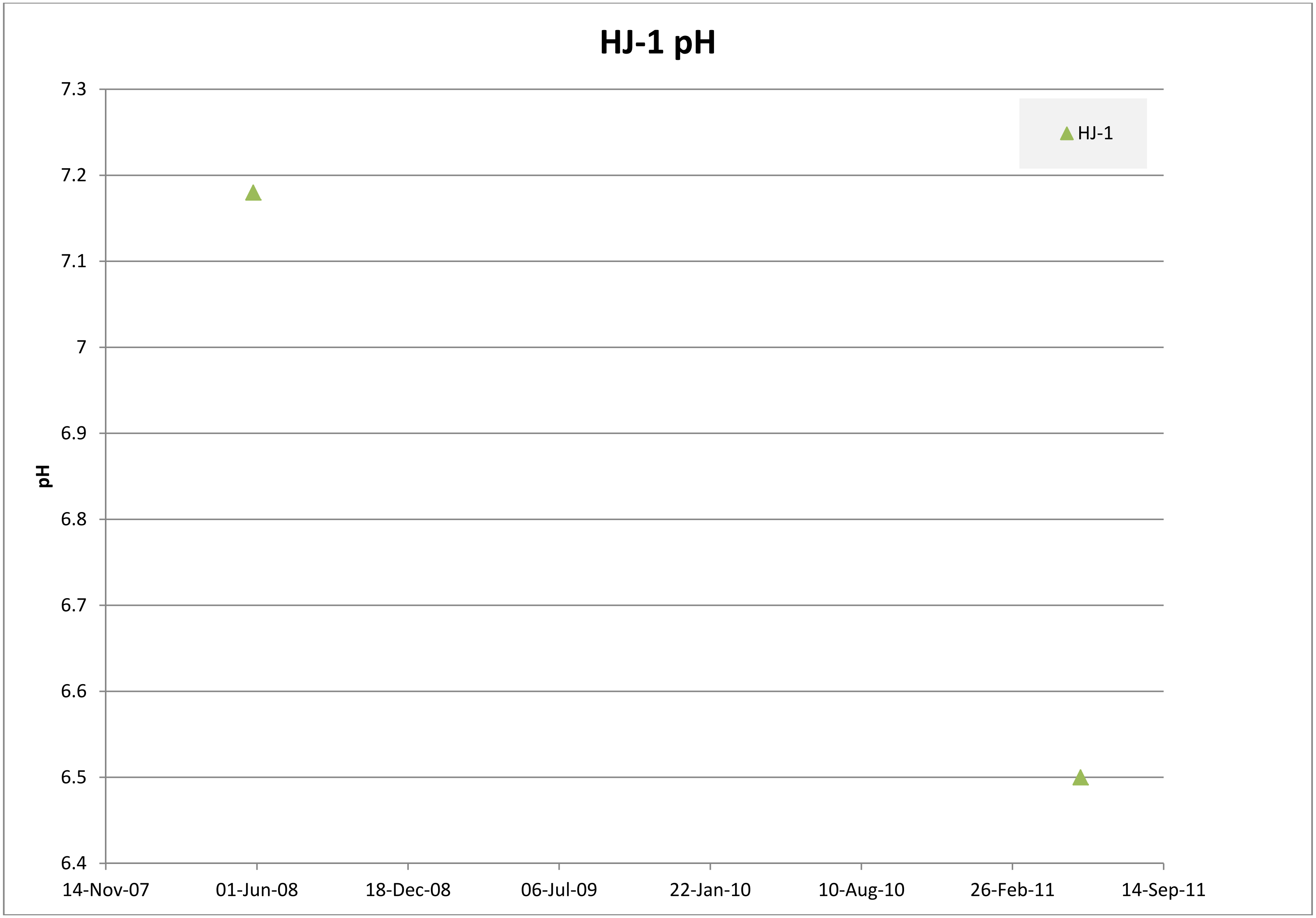

Figure A-1. Hewlett-Johnson pH. HJ-1 = Hewlett-Johnson monitoring well 1.

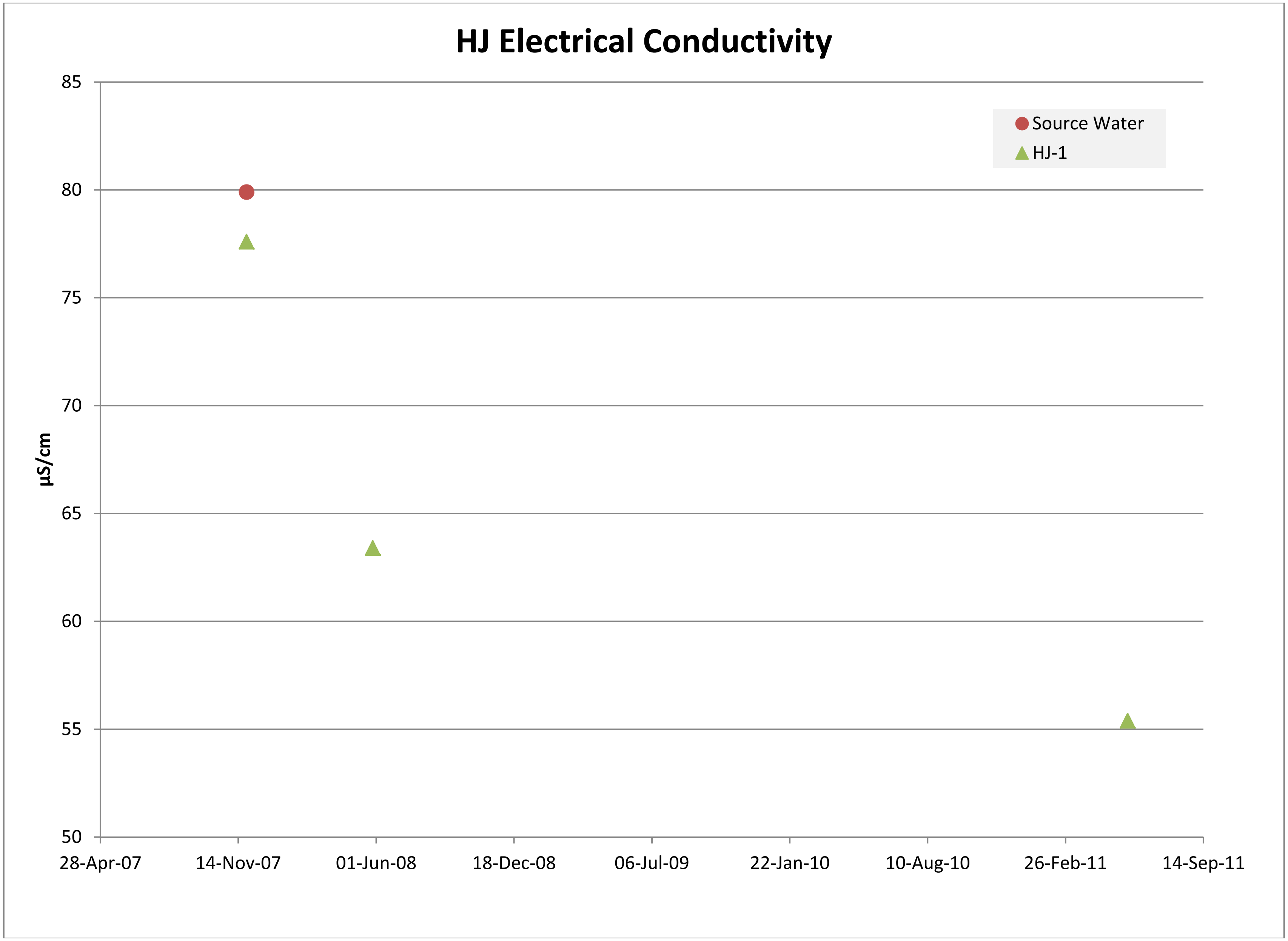

Figure A-2.Hewlett-Johnson electrical conductivity (EC). HJ-1 = Hewlett-Johnson monitoring well 1.

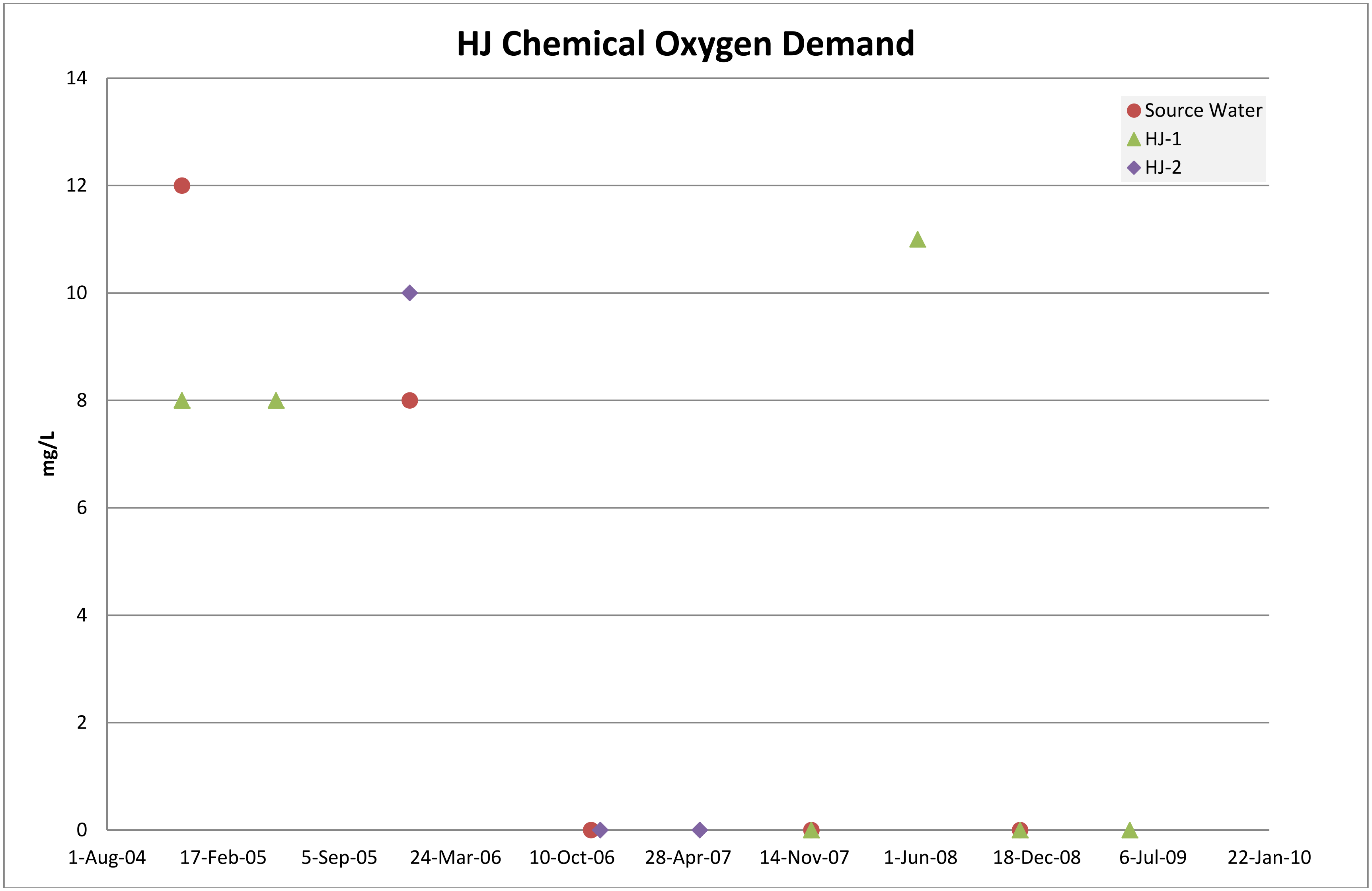

Figure A-3. Hewlett-Johnson chemical oxygen demand (COD). HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

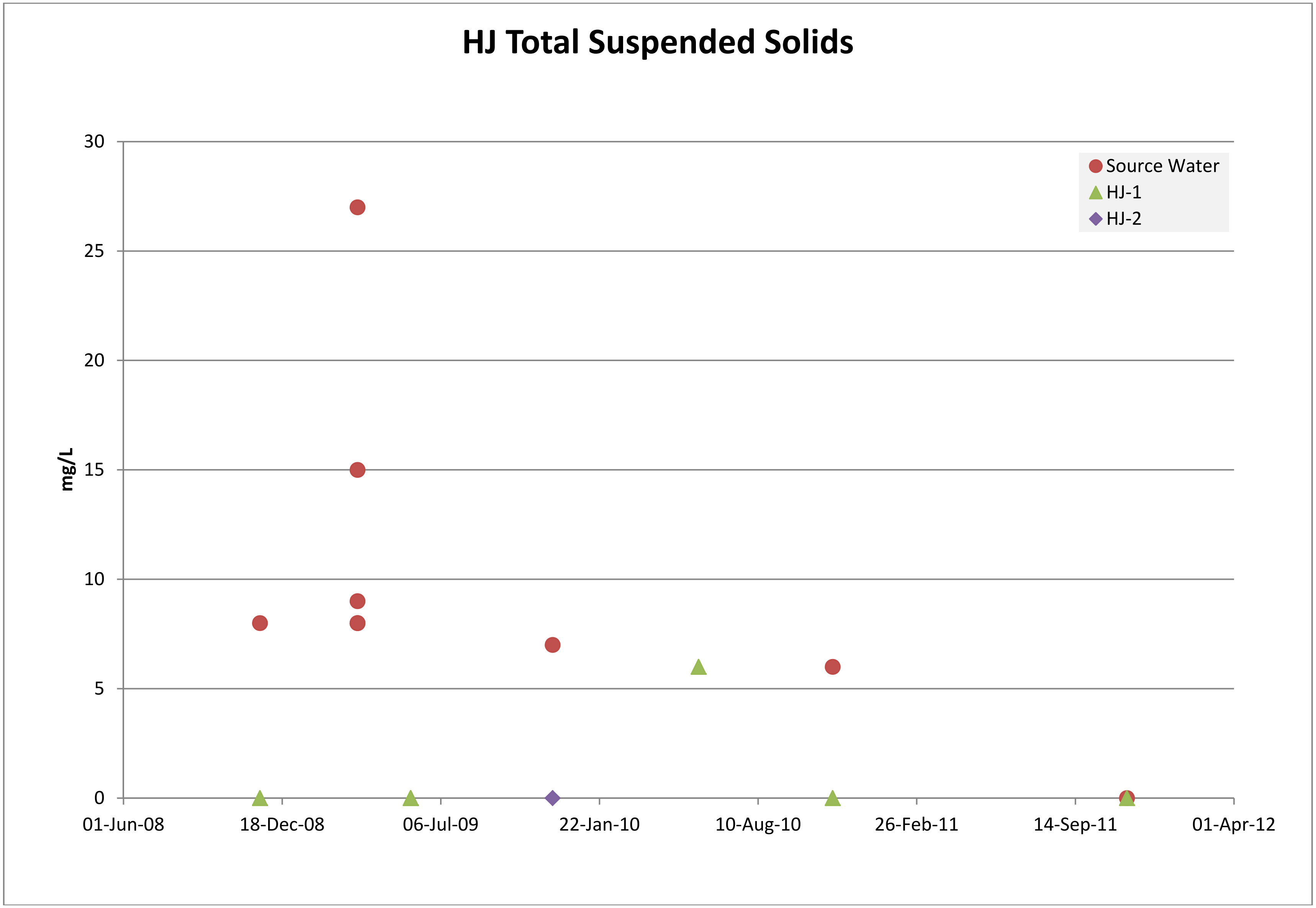

Figure A-4.Hewlett-Johnson total suspended solids (TSS). HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

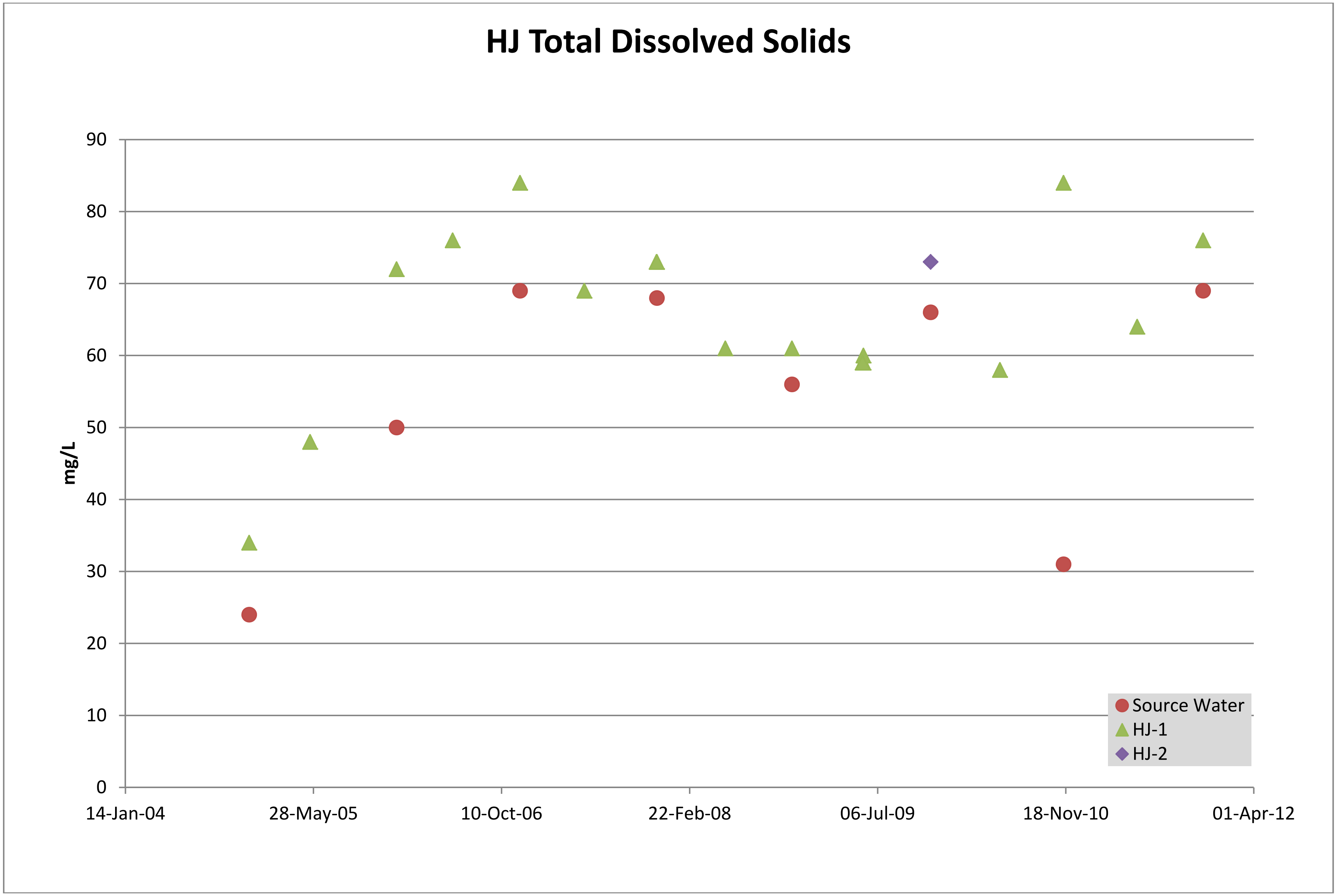

Figure A-5. Hewlett-Johnson total dissolved solids (TDS). HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

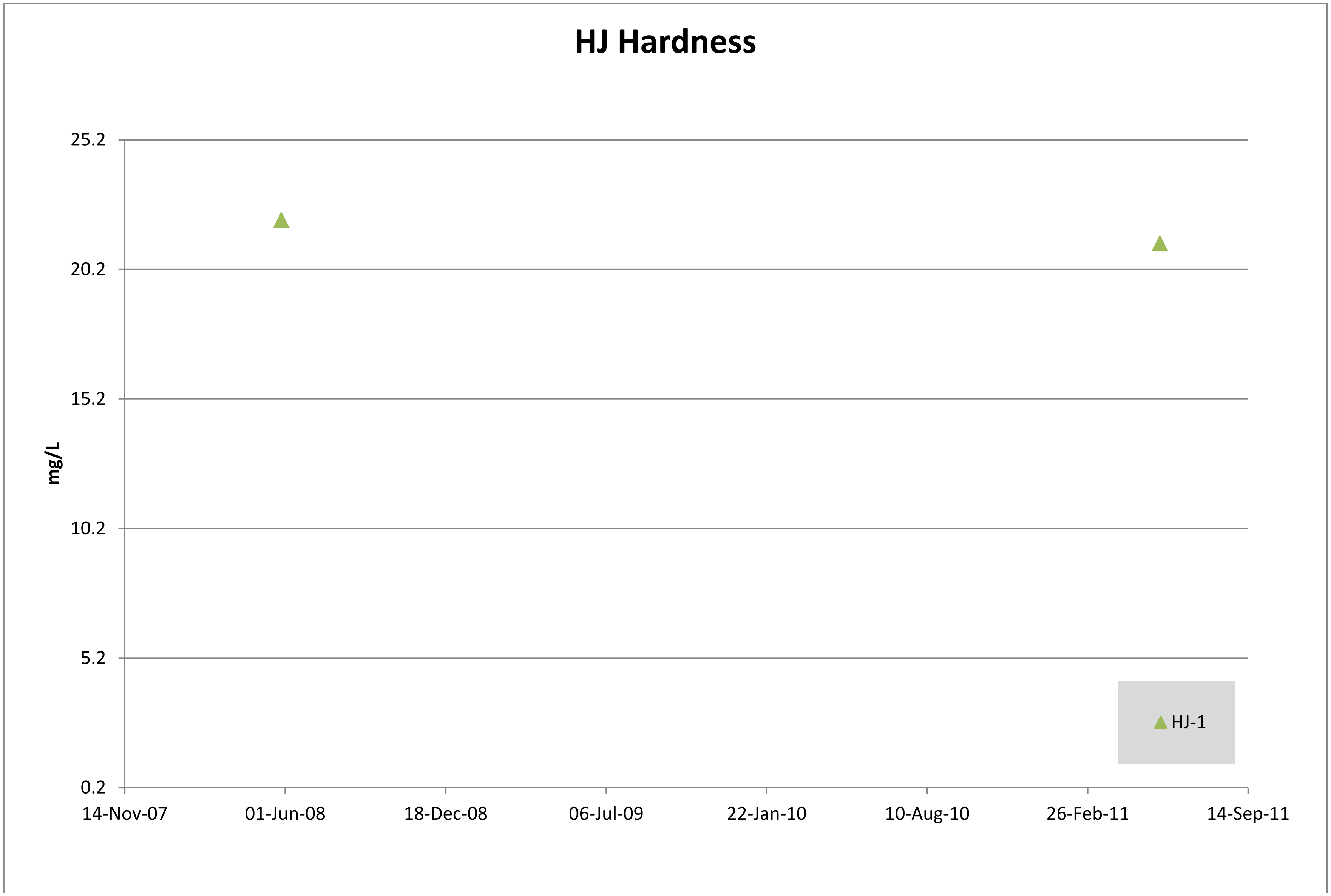

Figure A-6. Hewlett-Johnson hardness. HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

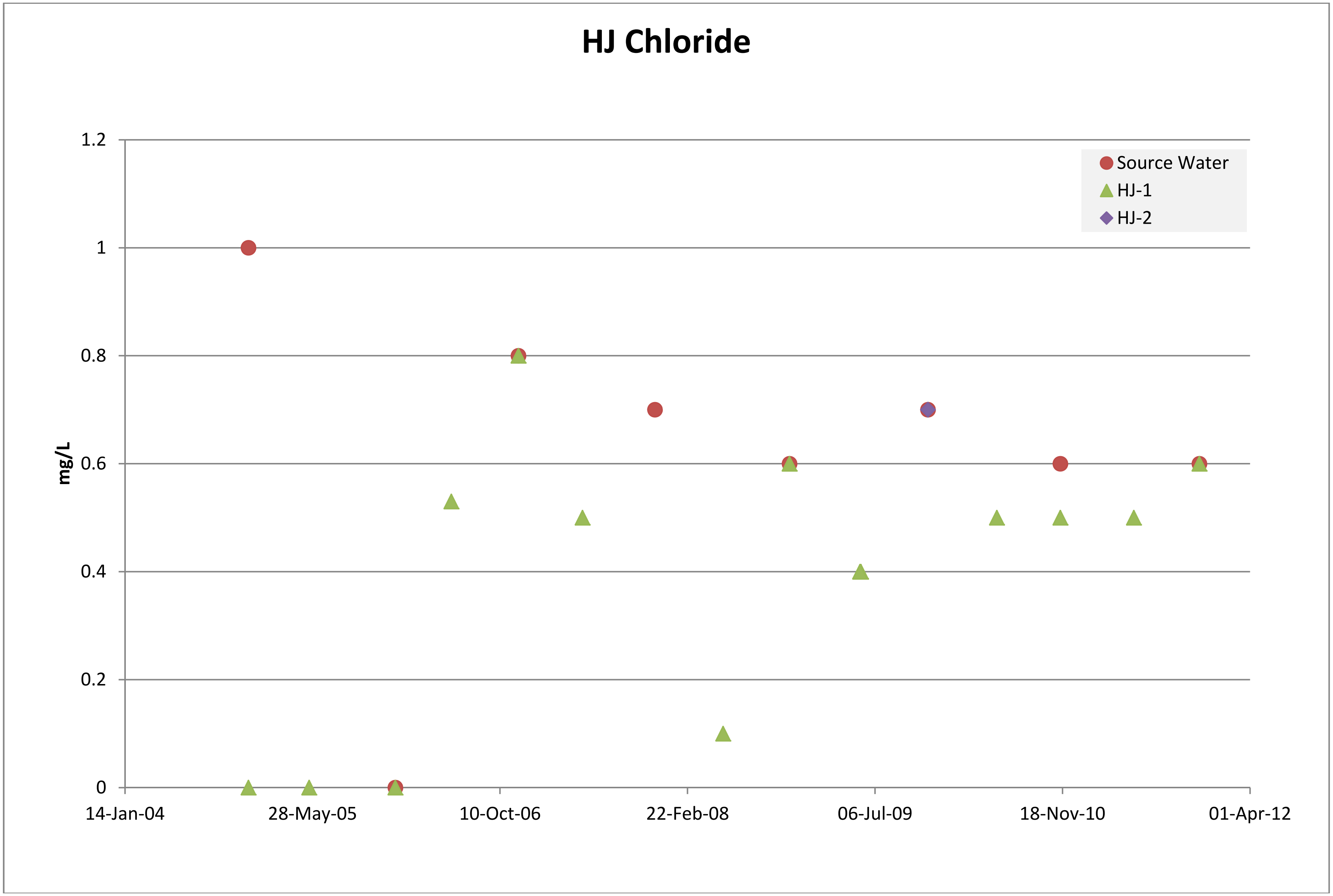

Figure A-7. Hewlett-Johnson chloride. HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

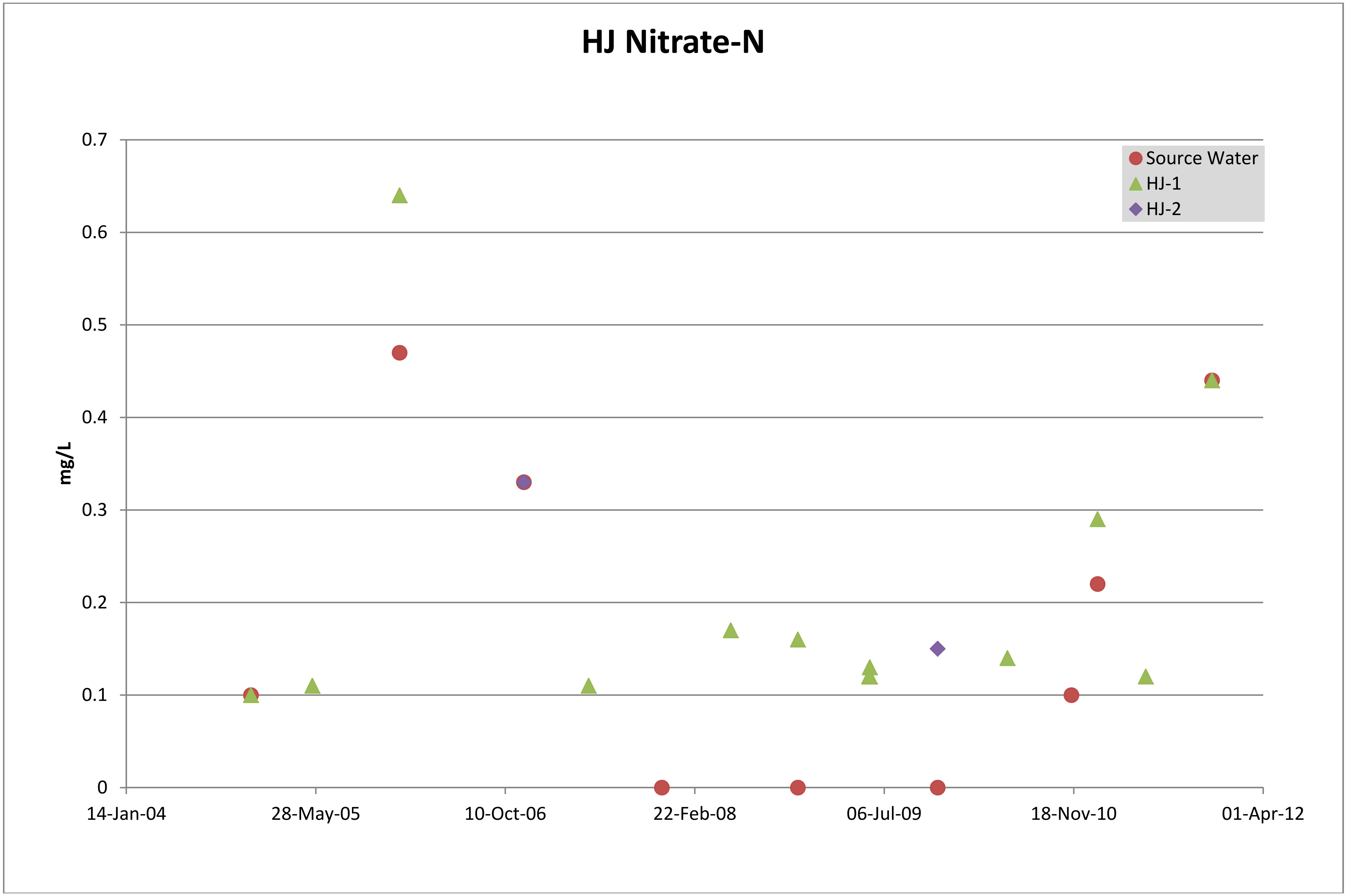

Figure A-8. Hewlett-Johnson nitrate. HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

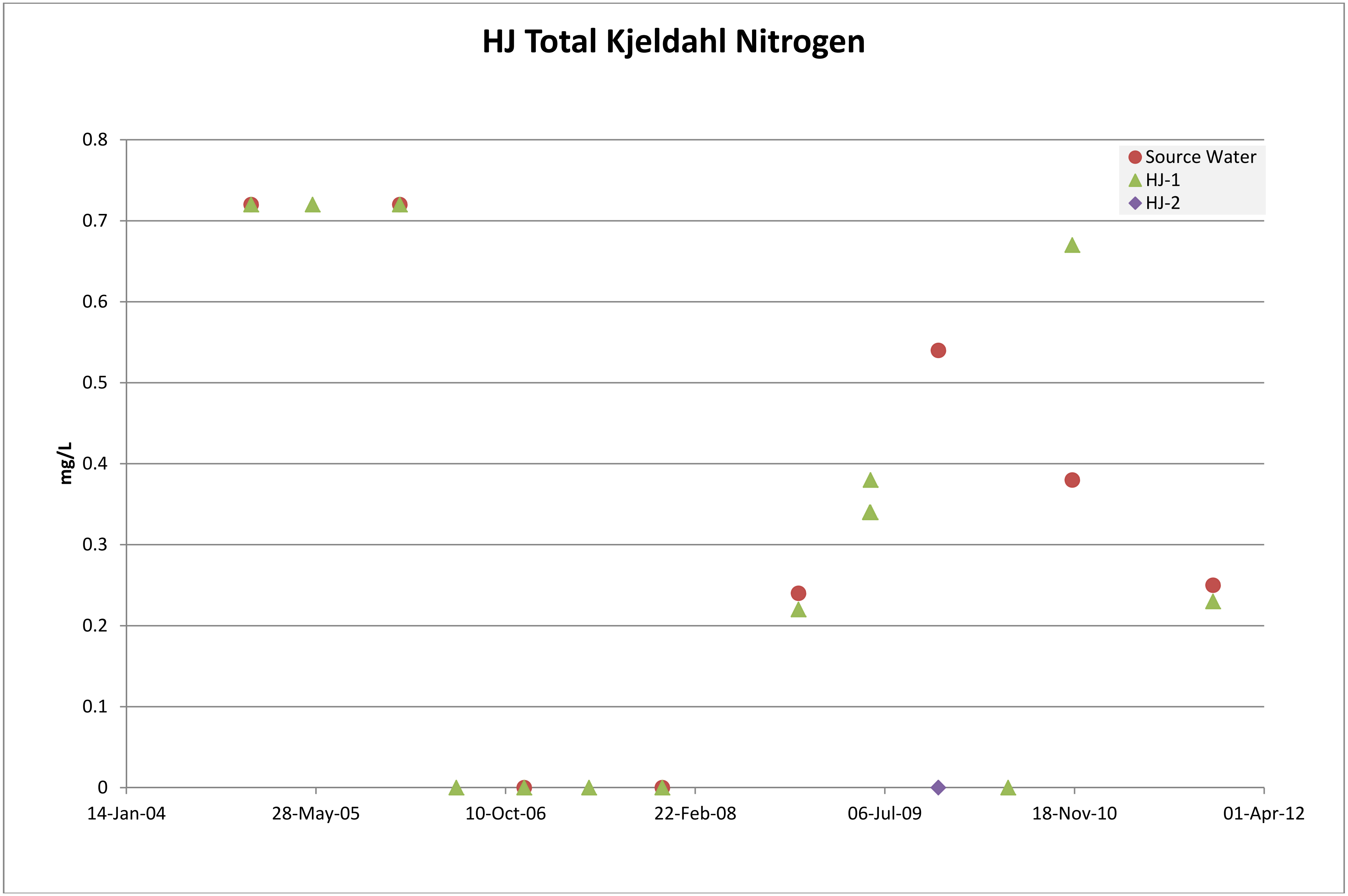

Figure A-9. Hewlett-Johnson total Kjeldahl nitrogen (TKN). HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

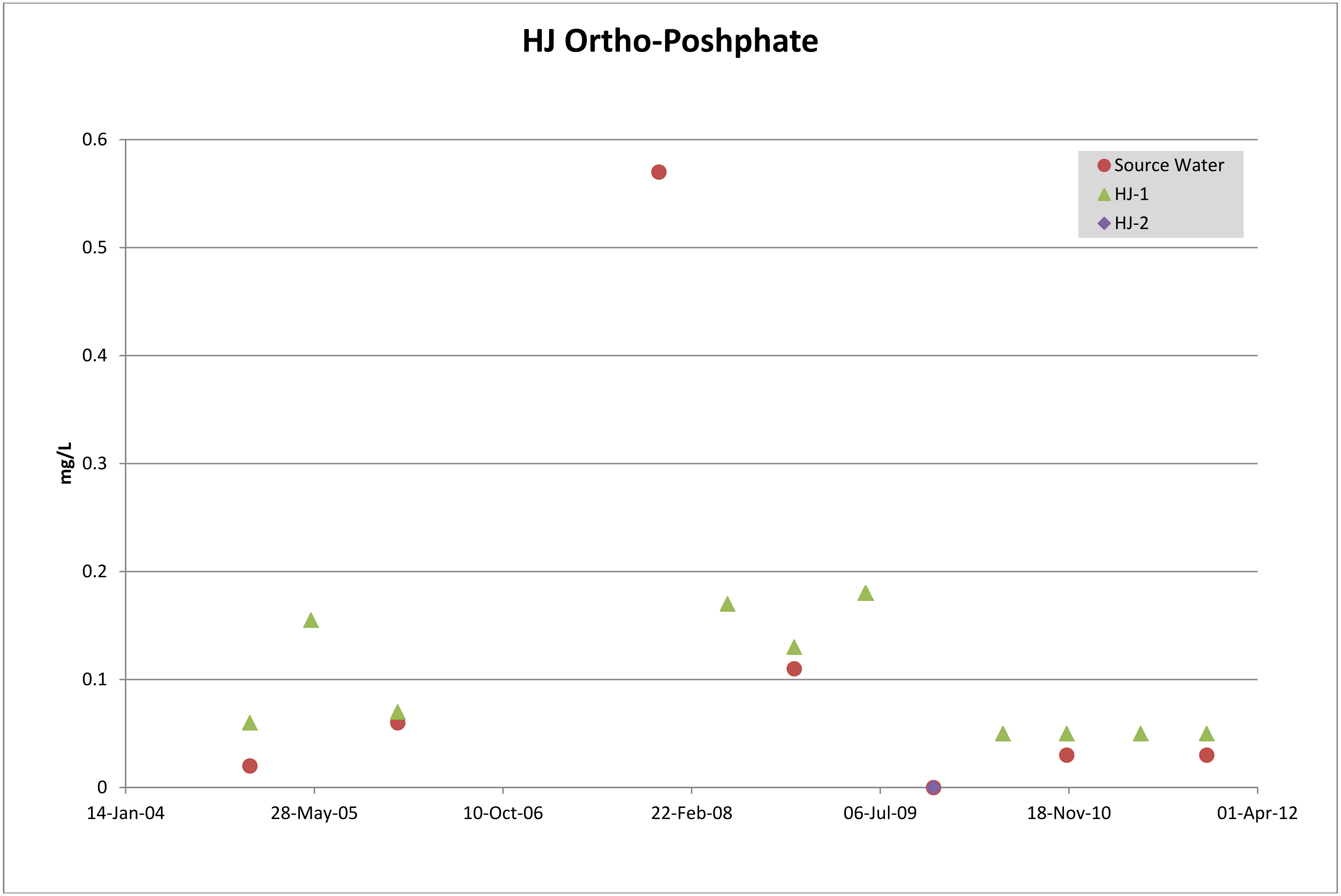

Figure A-10. Hewlett-Johnson ortho-phosphate. HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

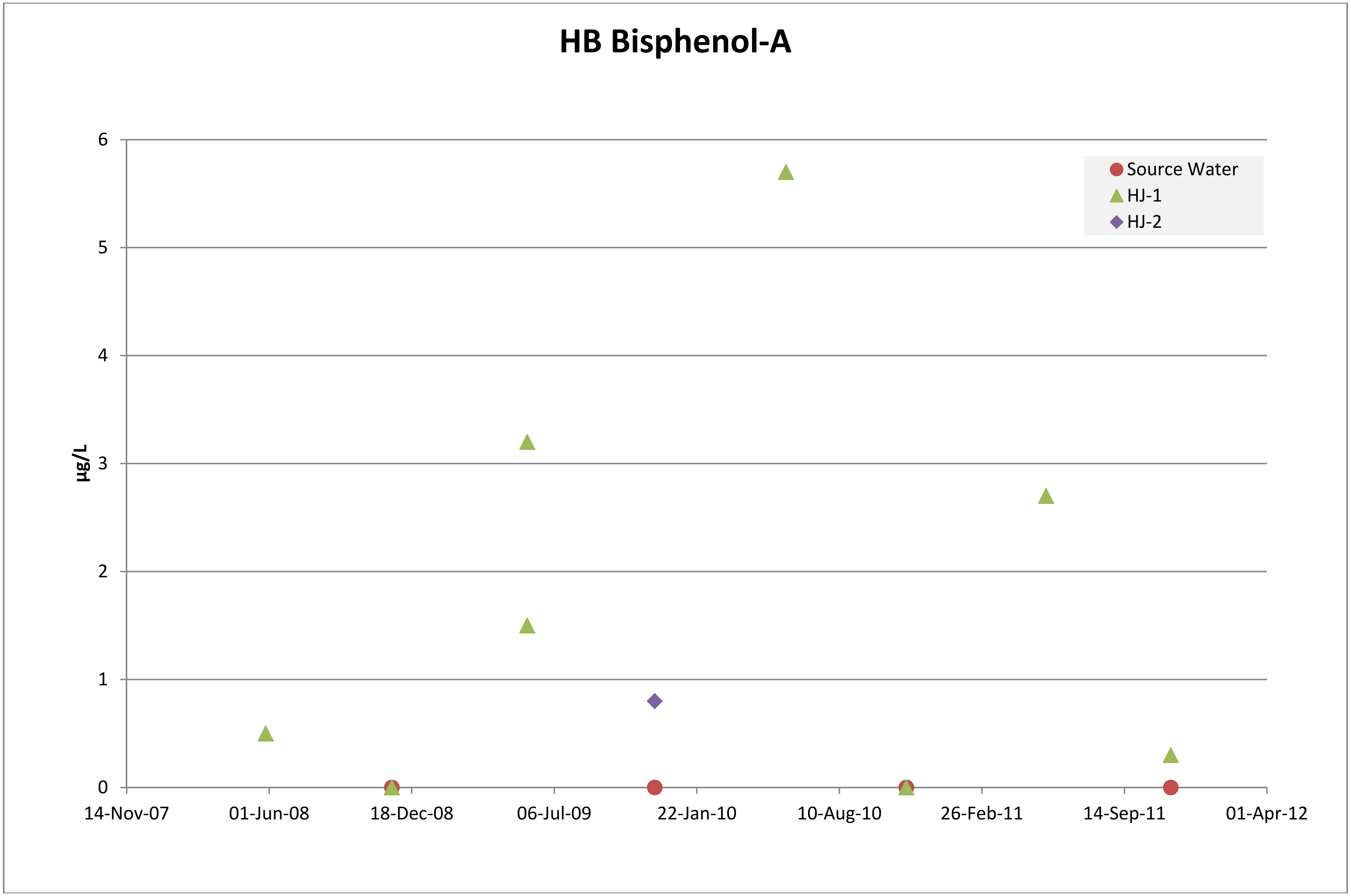

Figure A-11. Hewlett-Johnson bisphenol-A. HJ-1 = Hewlett-Johnson monitoring well 1. HJ-2 = Hewlett-Johnson monitoring well 2.

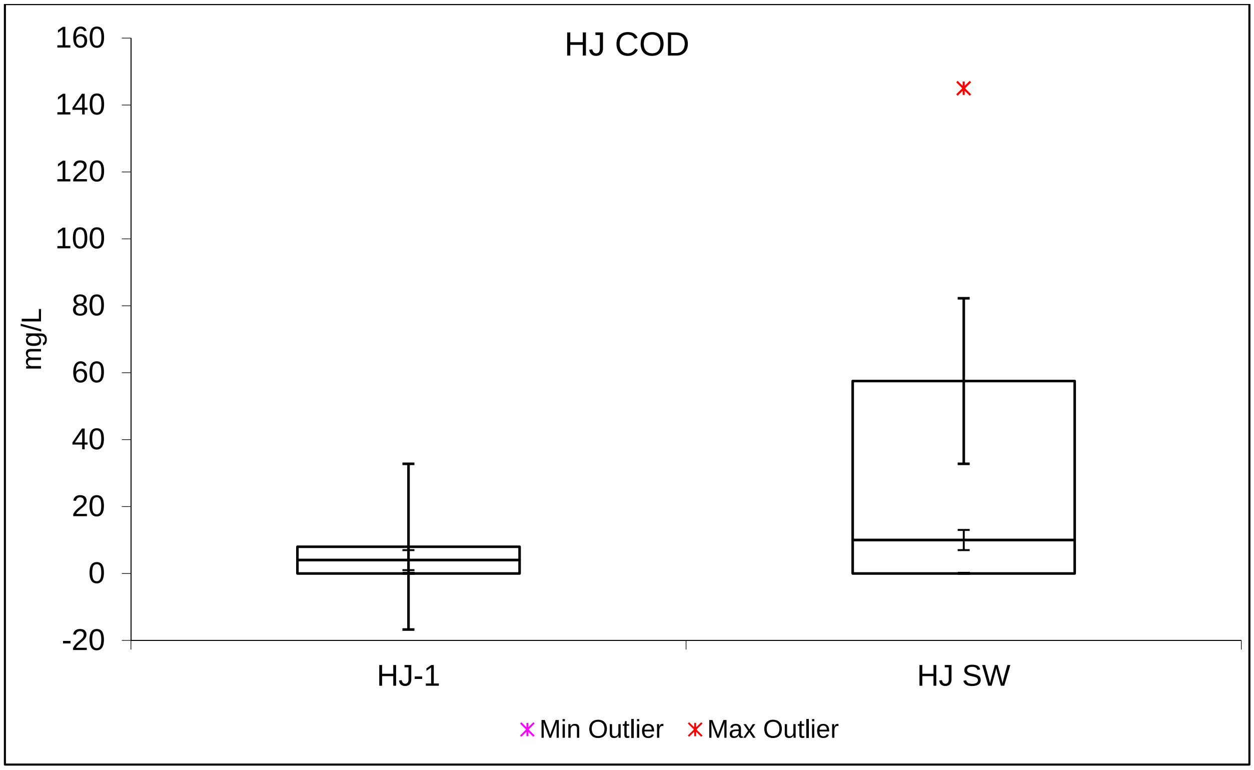

Figure A-12. Hewlett-Johnson pH box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

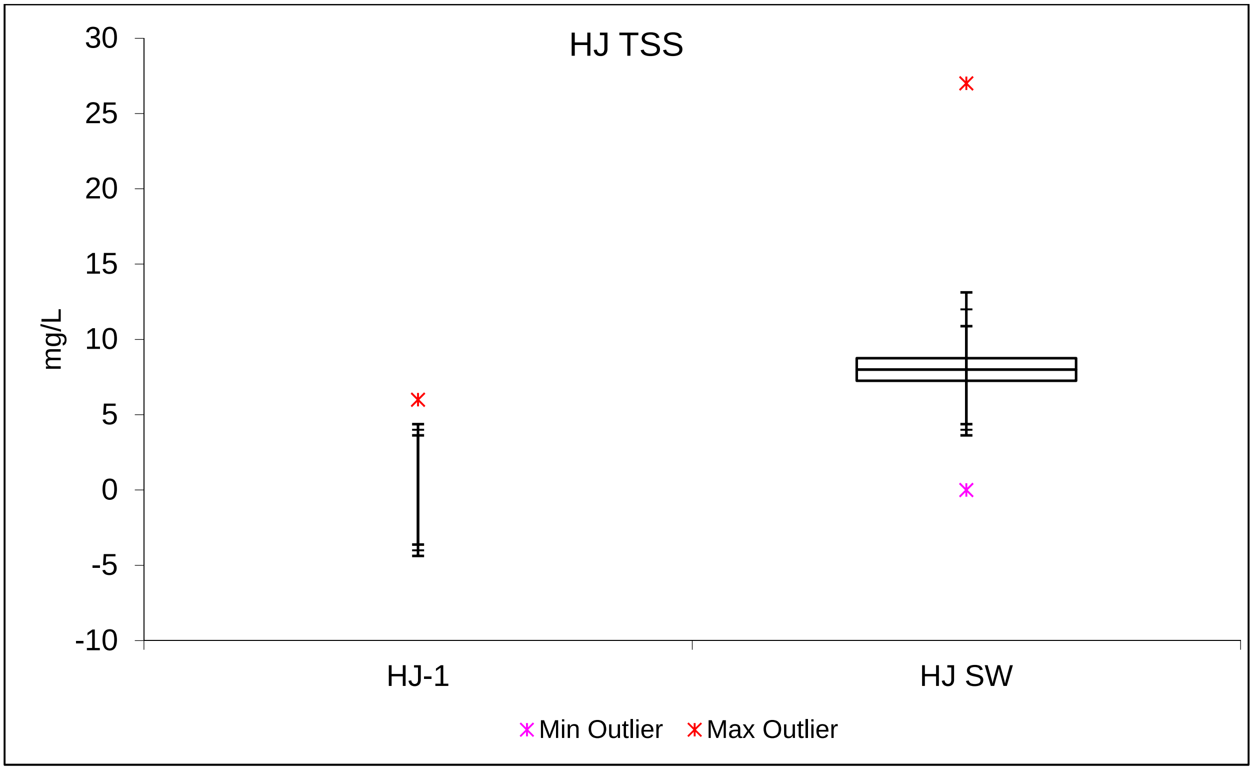

Figure A-13. Hewlett-Johnson TSS box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

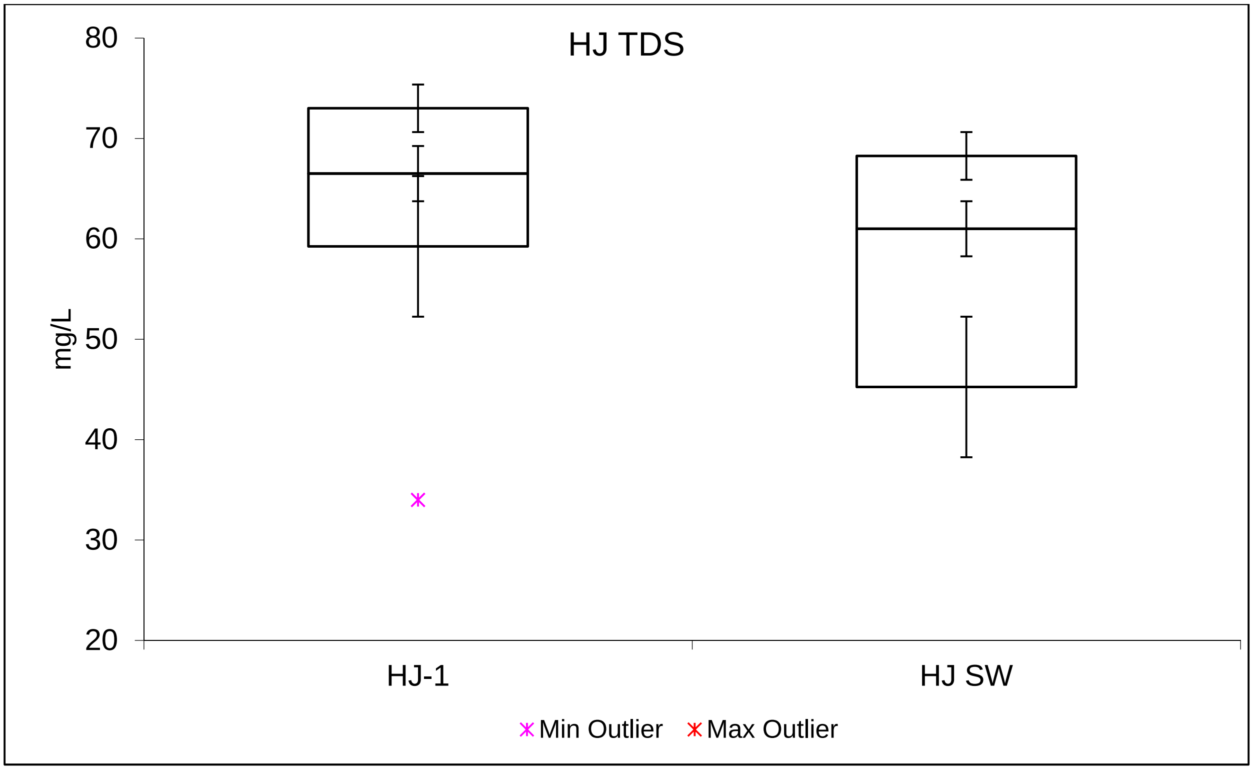

Figure A-14. Hewlett-Johnson TDS box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

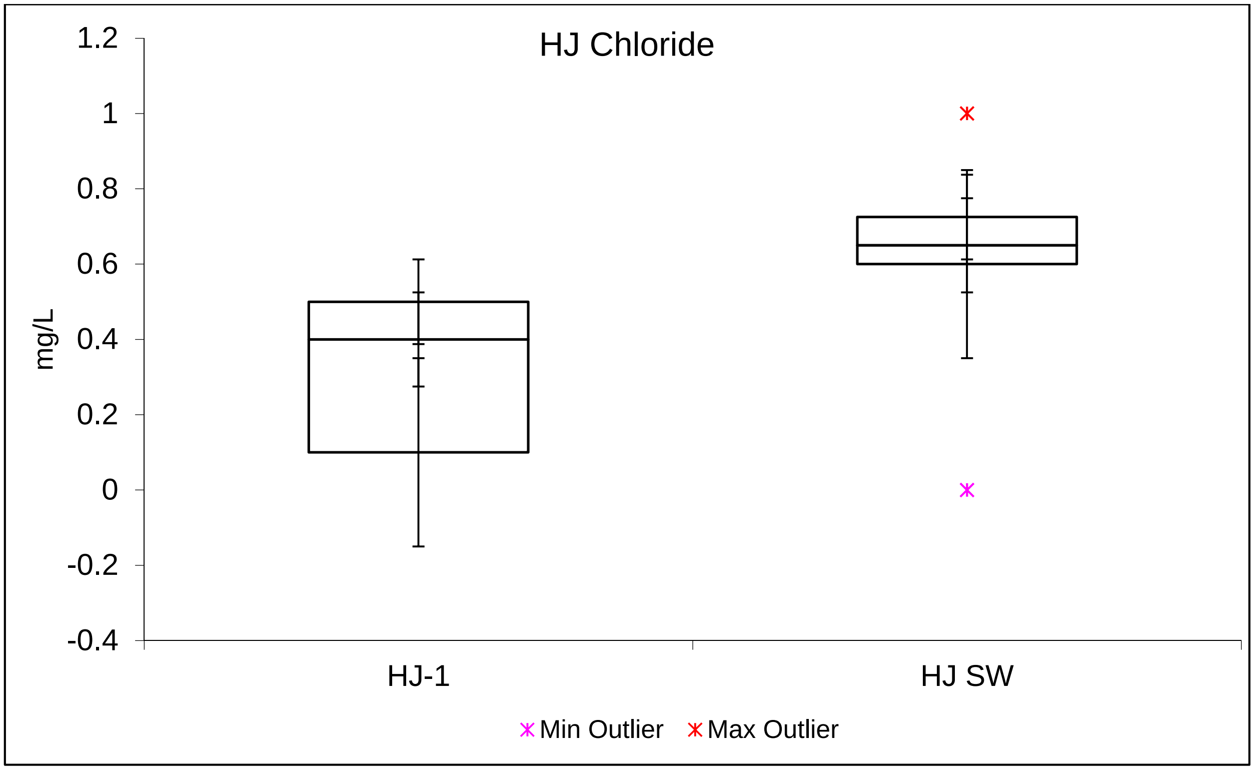

Figure A-15. Hewlett-Johnson chloride box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

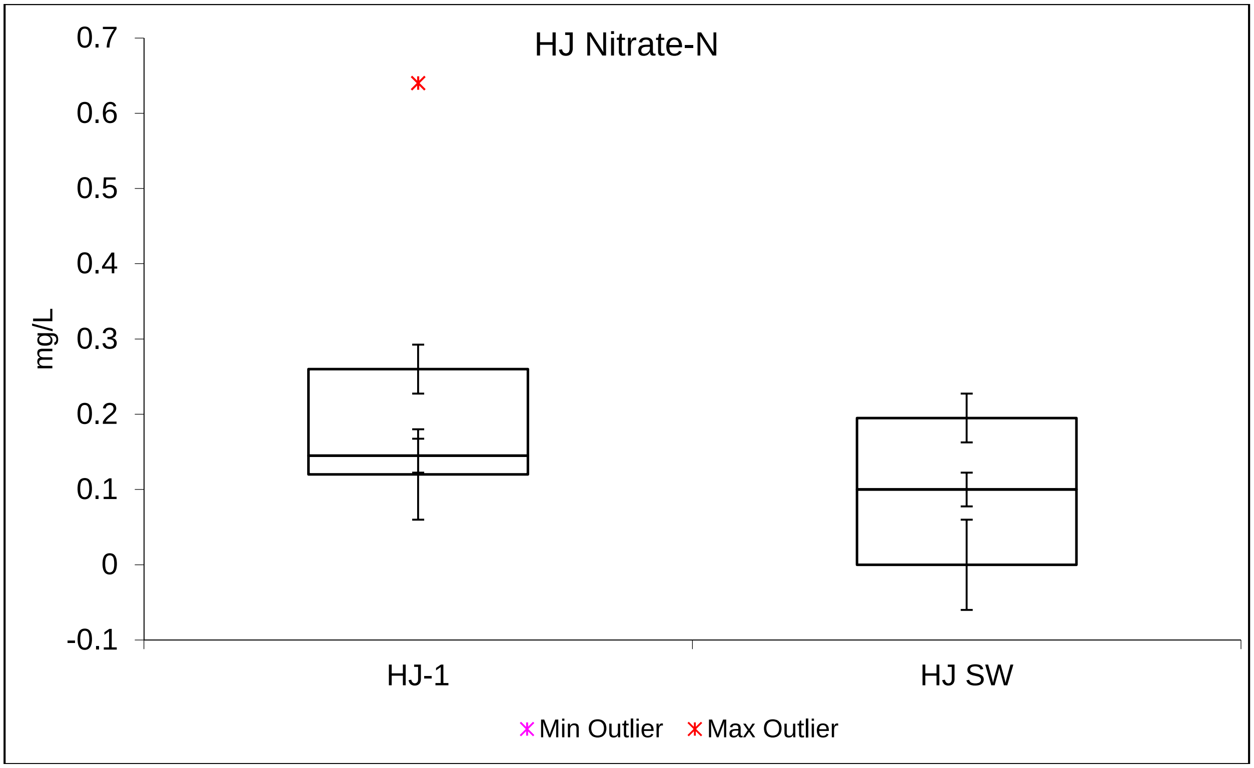

Figure A-16. Hewlett-Johnson nitrate-N box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

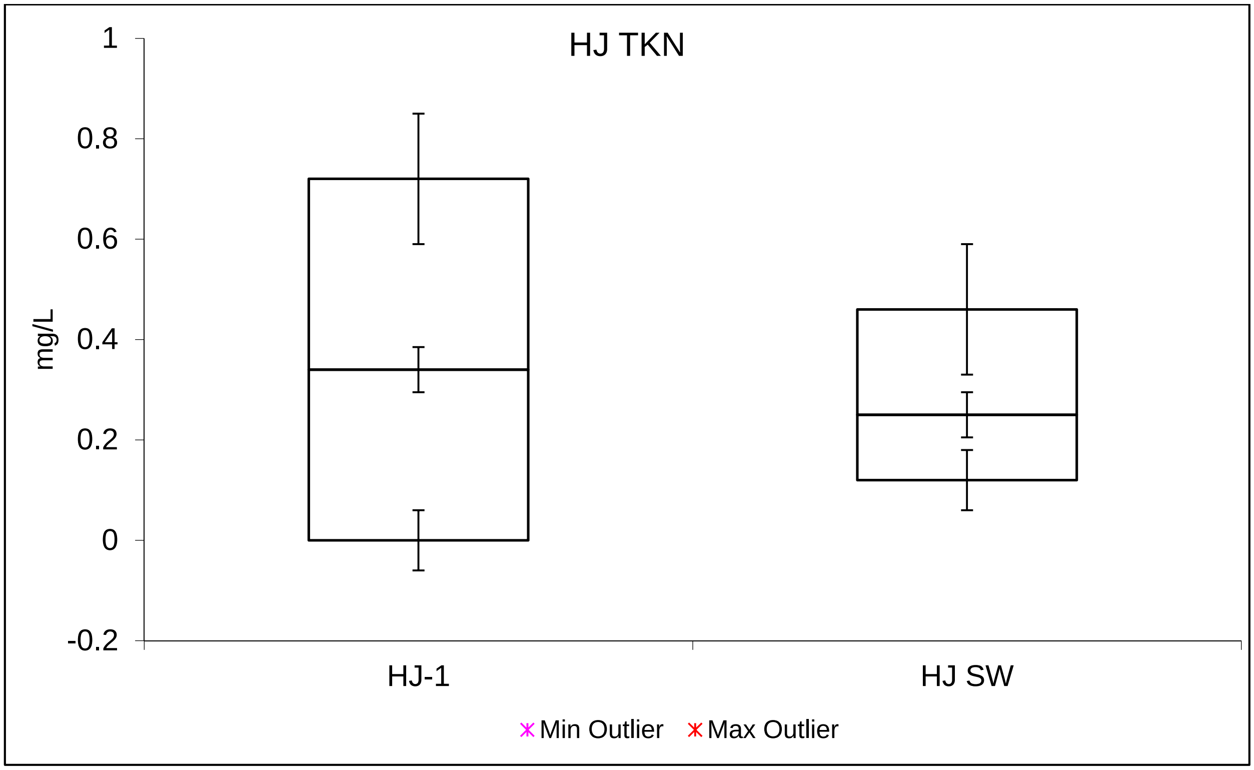

Figure A-17. Hewlett-Johnson TKN box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

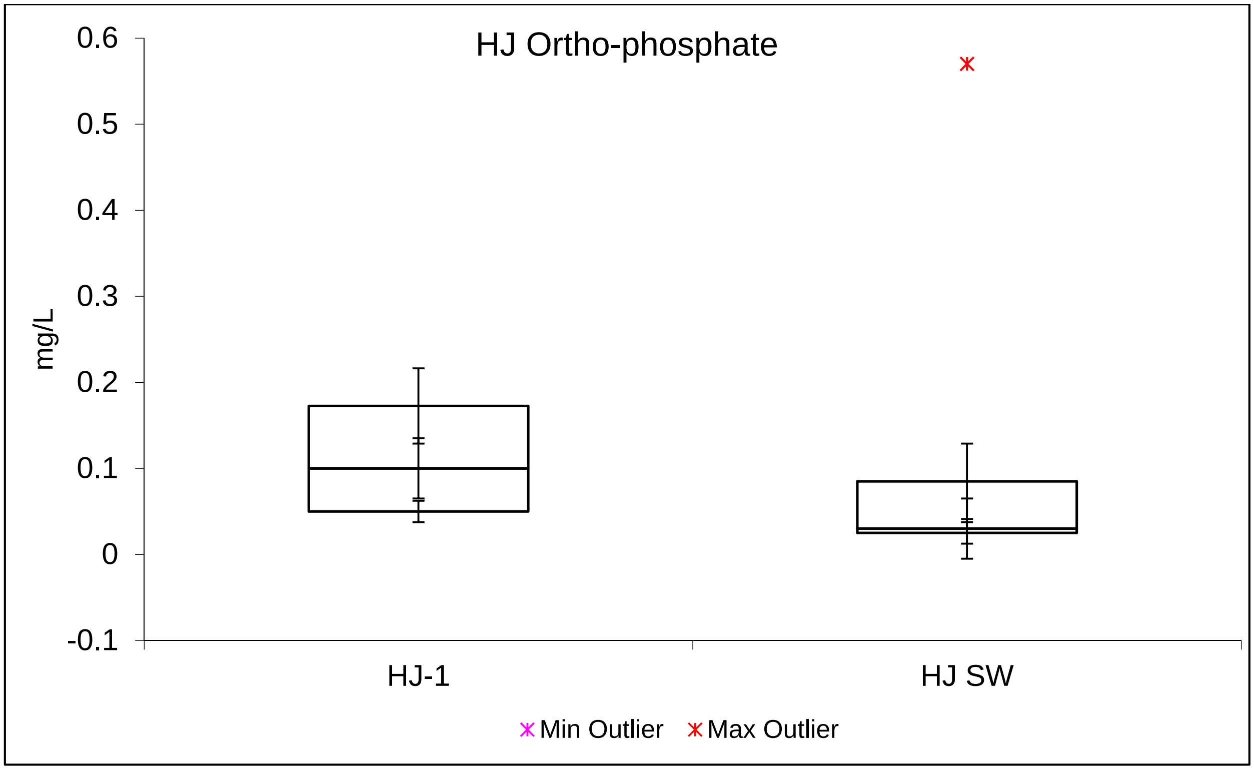

Figure A-18. Hewlett-Johnson ortho-phosphate box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

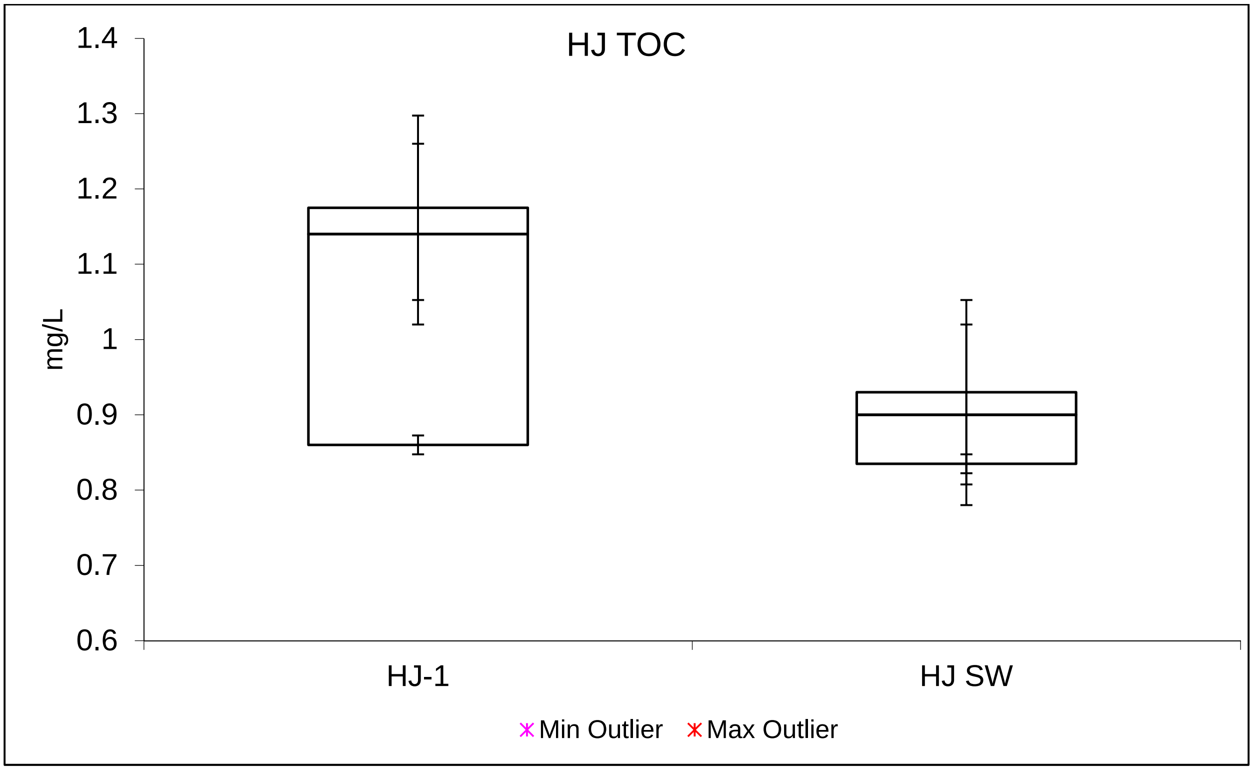

Figure A-19. Hewlett-Johnson TOC box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

Appendix B

Hall-Wentland Data Plots

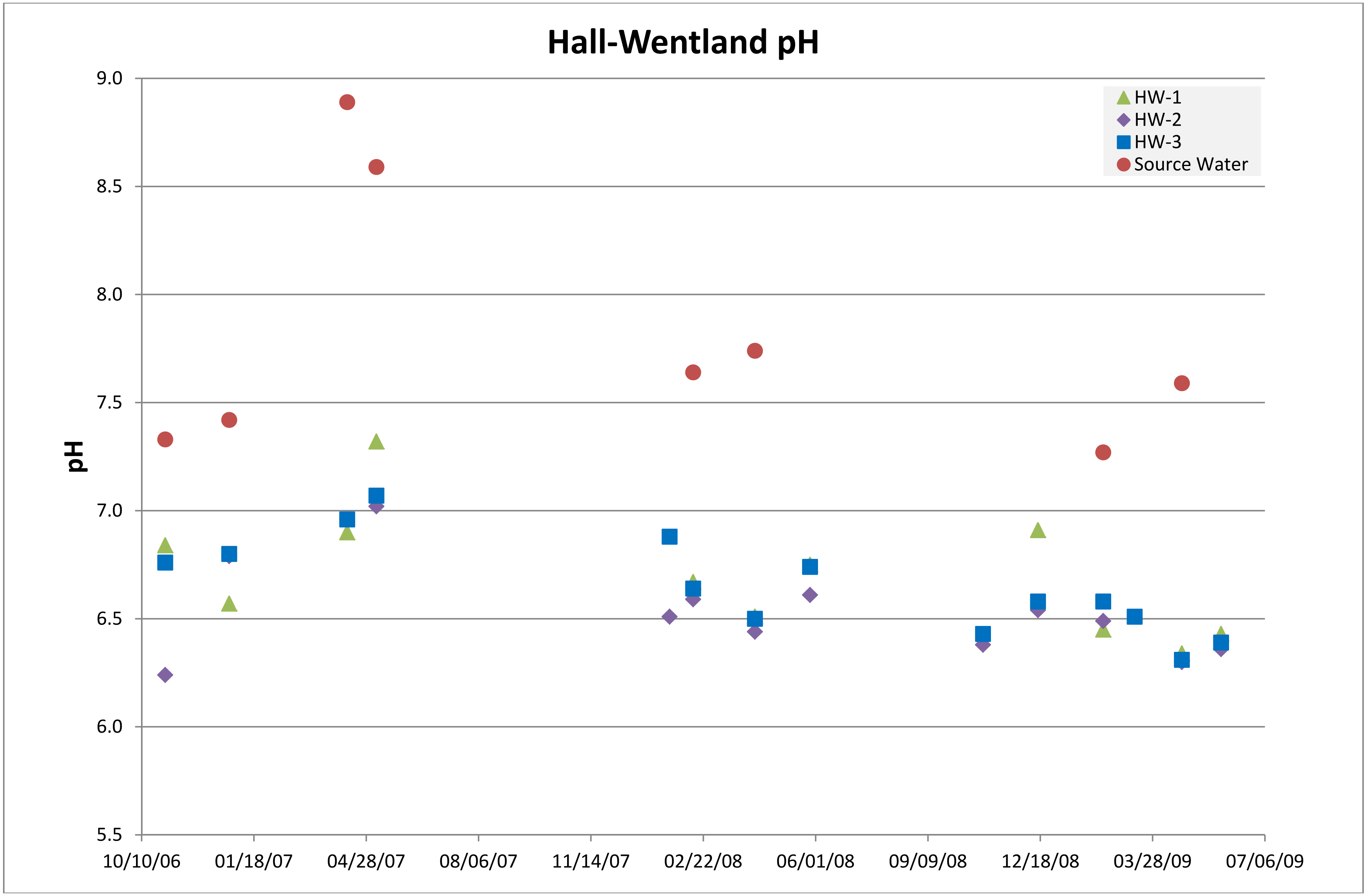

Figure B-1. Hall-Wentland pH. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

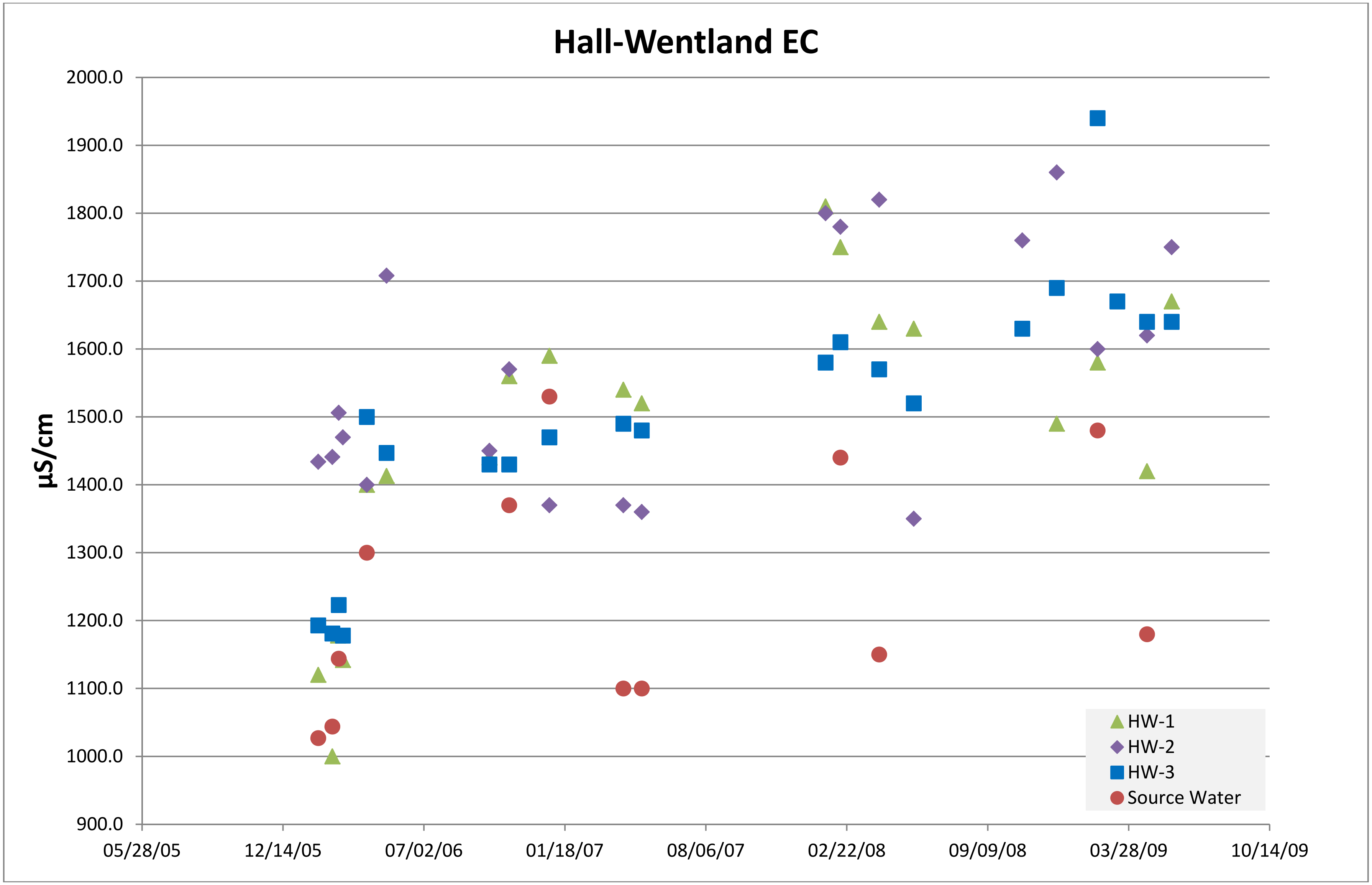

Figure B-2. Hall-Wentland electrical conductivity. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

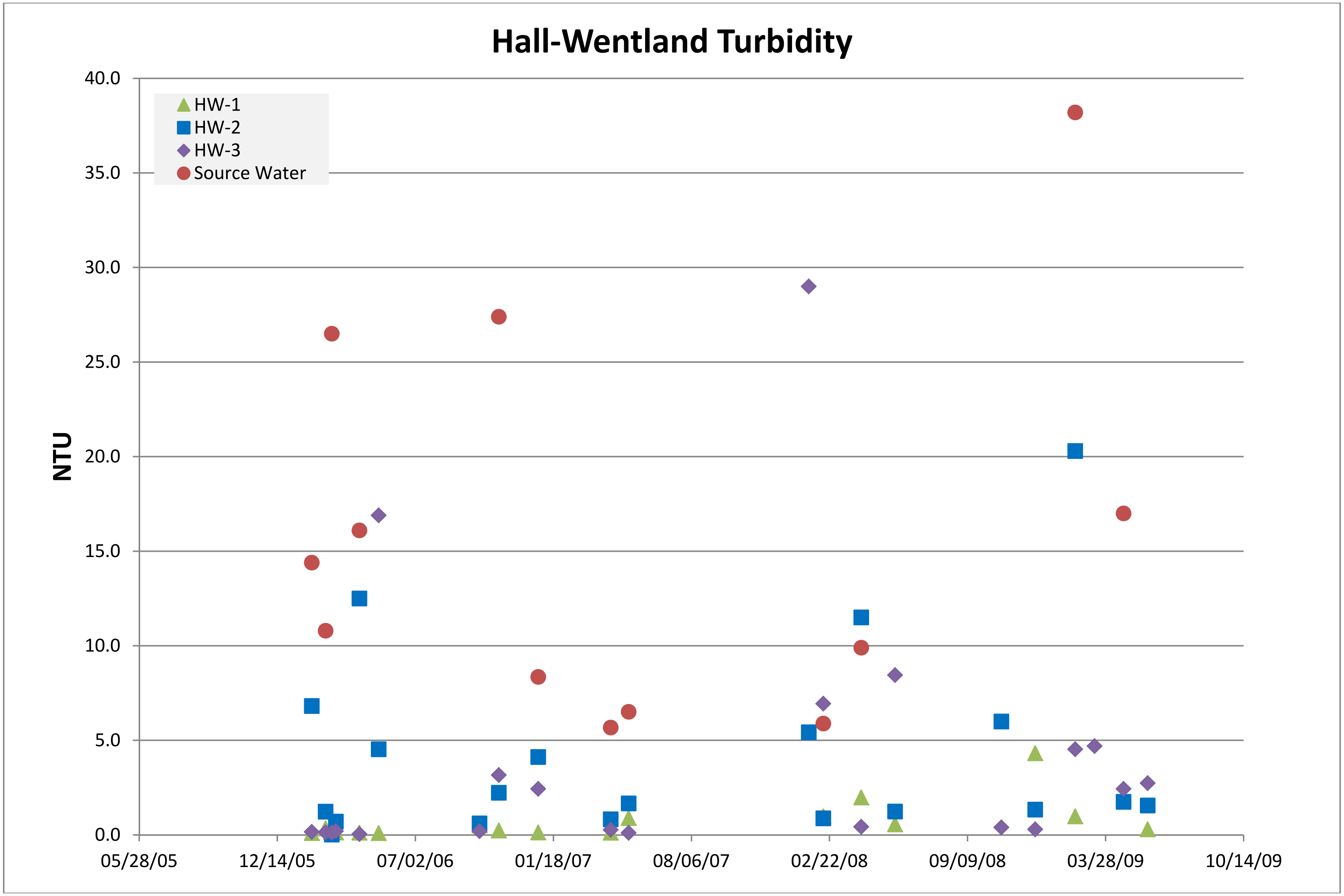

Figure B-3. Hall-Wentland turbidity. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

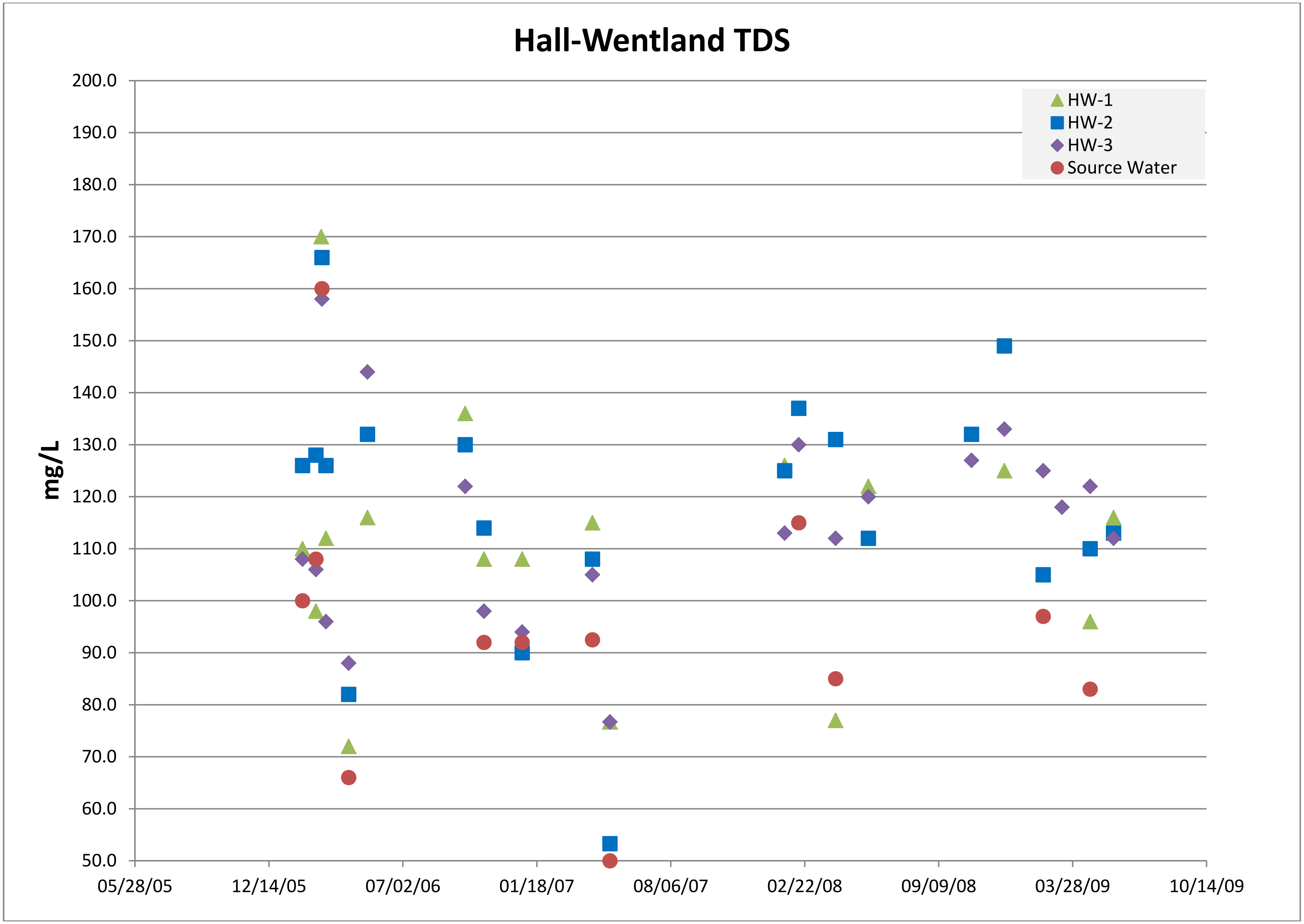

Figure B-4. Hall-Wentland total dissolved solids (TDS). HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

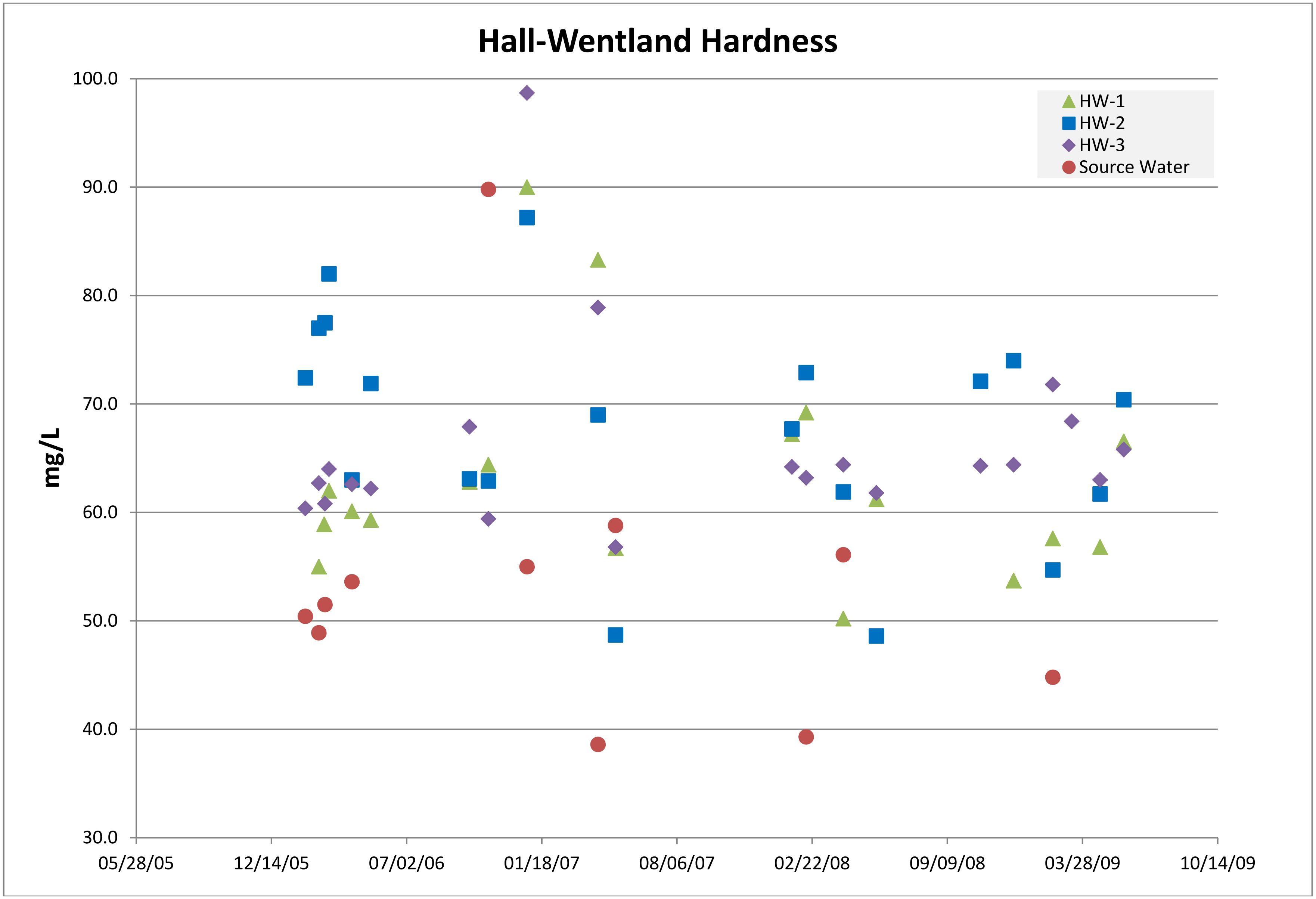

Figure B-5. Hall-Wentland Hardness. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

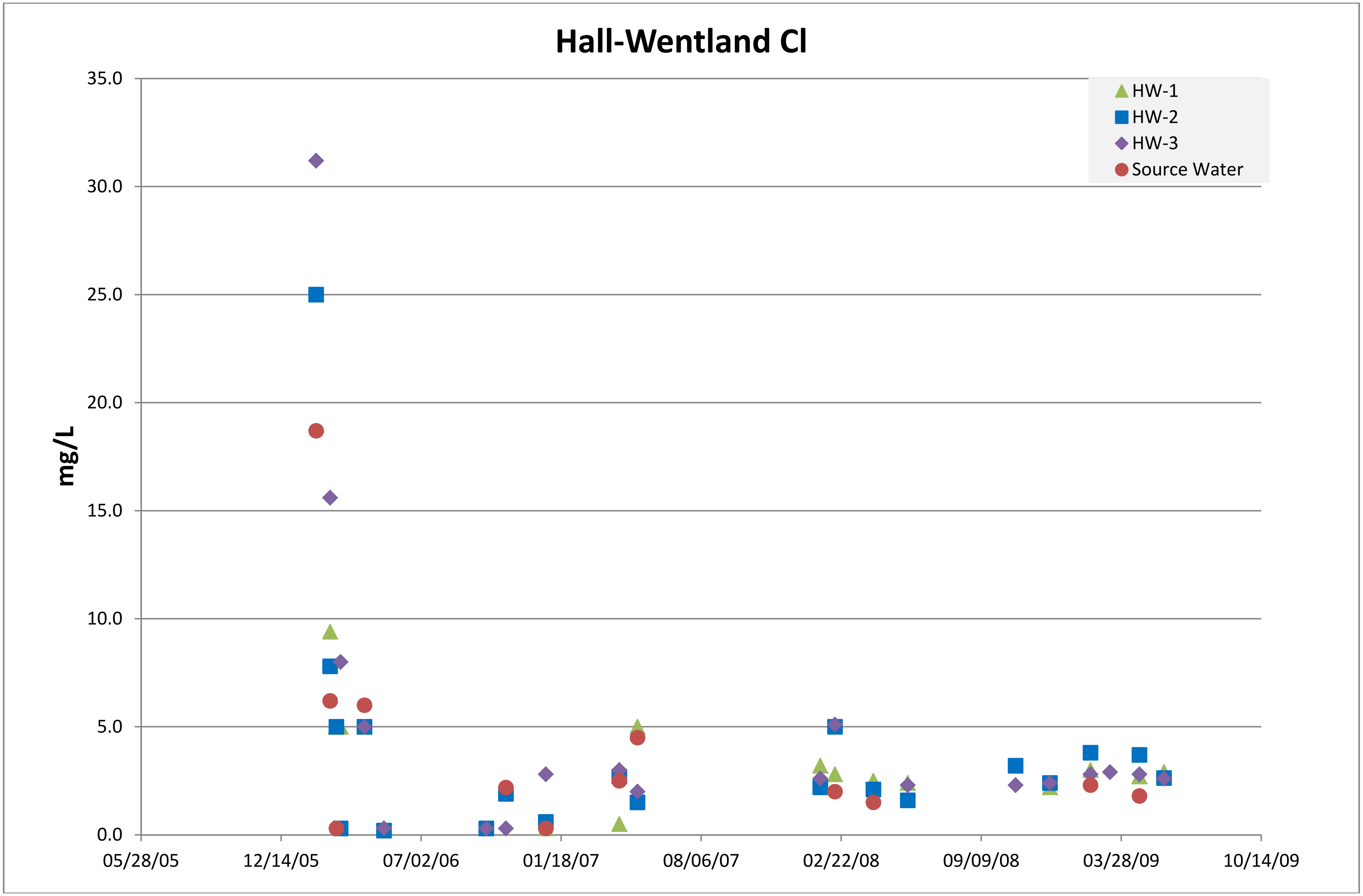

Figure B-6. Hall-Wentland chloride. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

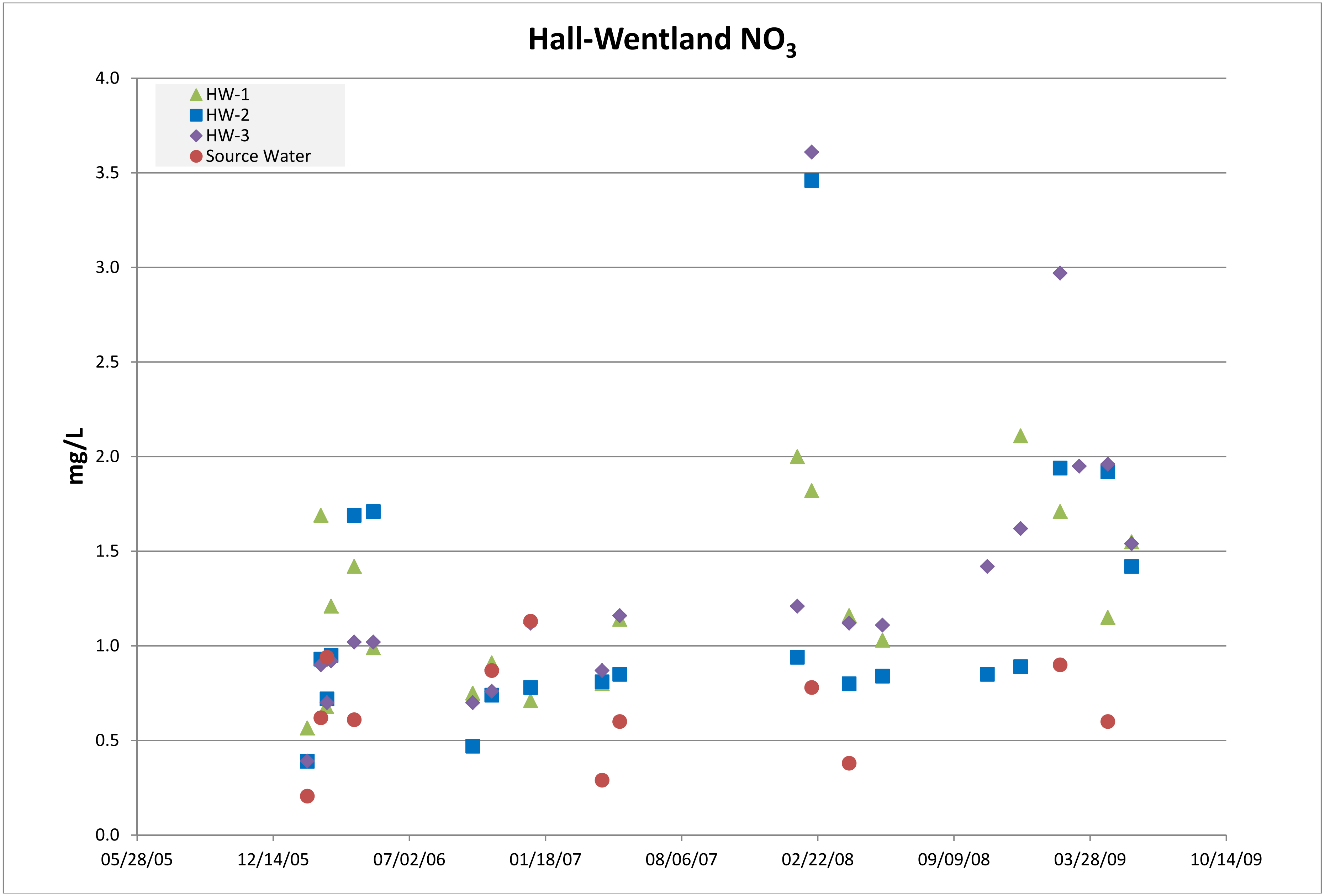

Figure B-7. Hall-Wentland nitrate-N. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

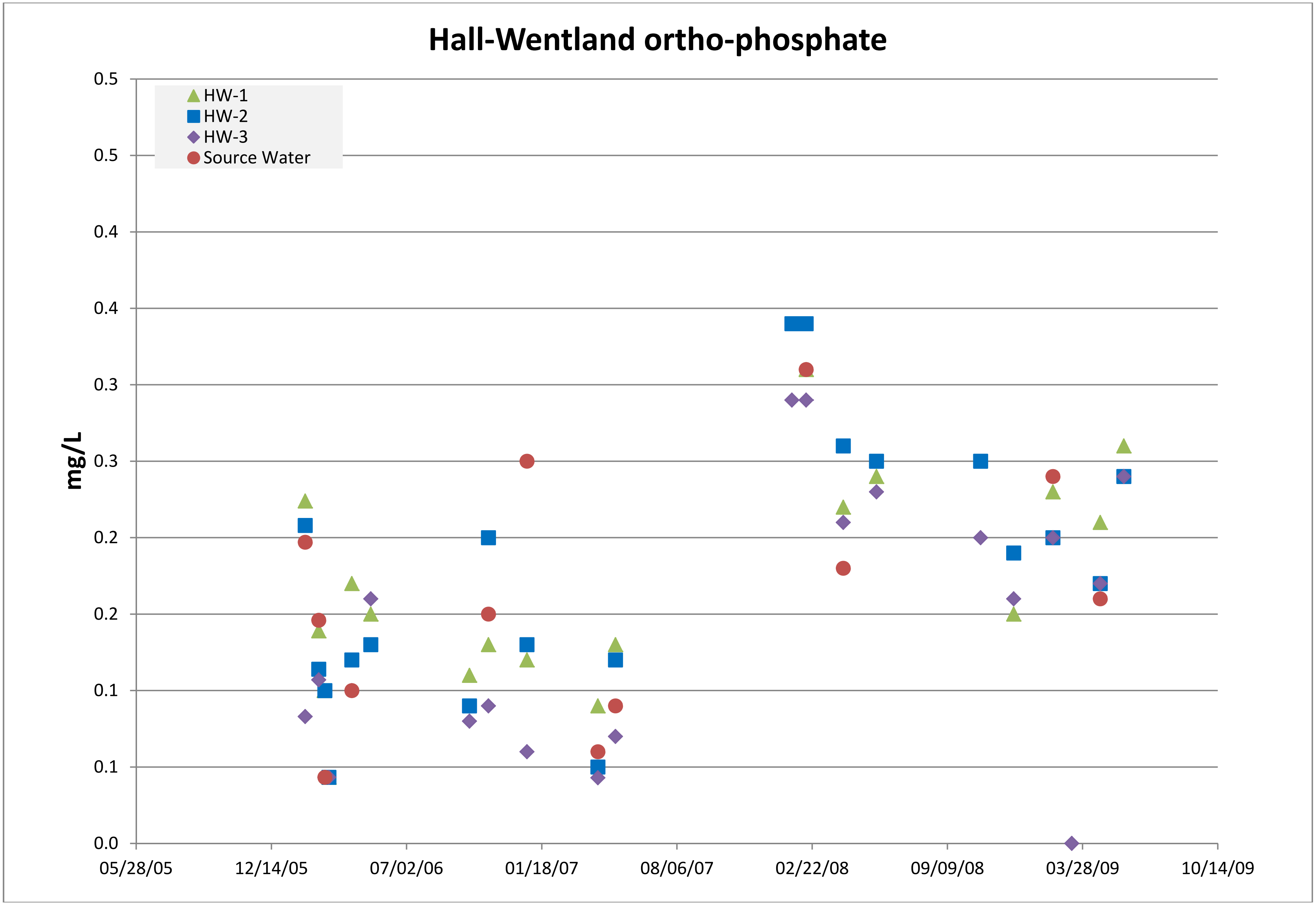

Figure B-8. Hall-Wentland ortho-phosphate. HW-1 = Hall-Wentland monitoring well 1. HW-2 = Hall-Wentland monitoring well 2. HW-3 = Hall-Wentland monitoring well 3.

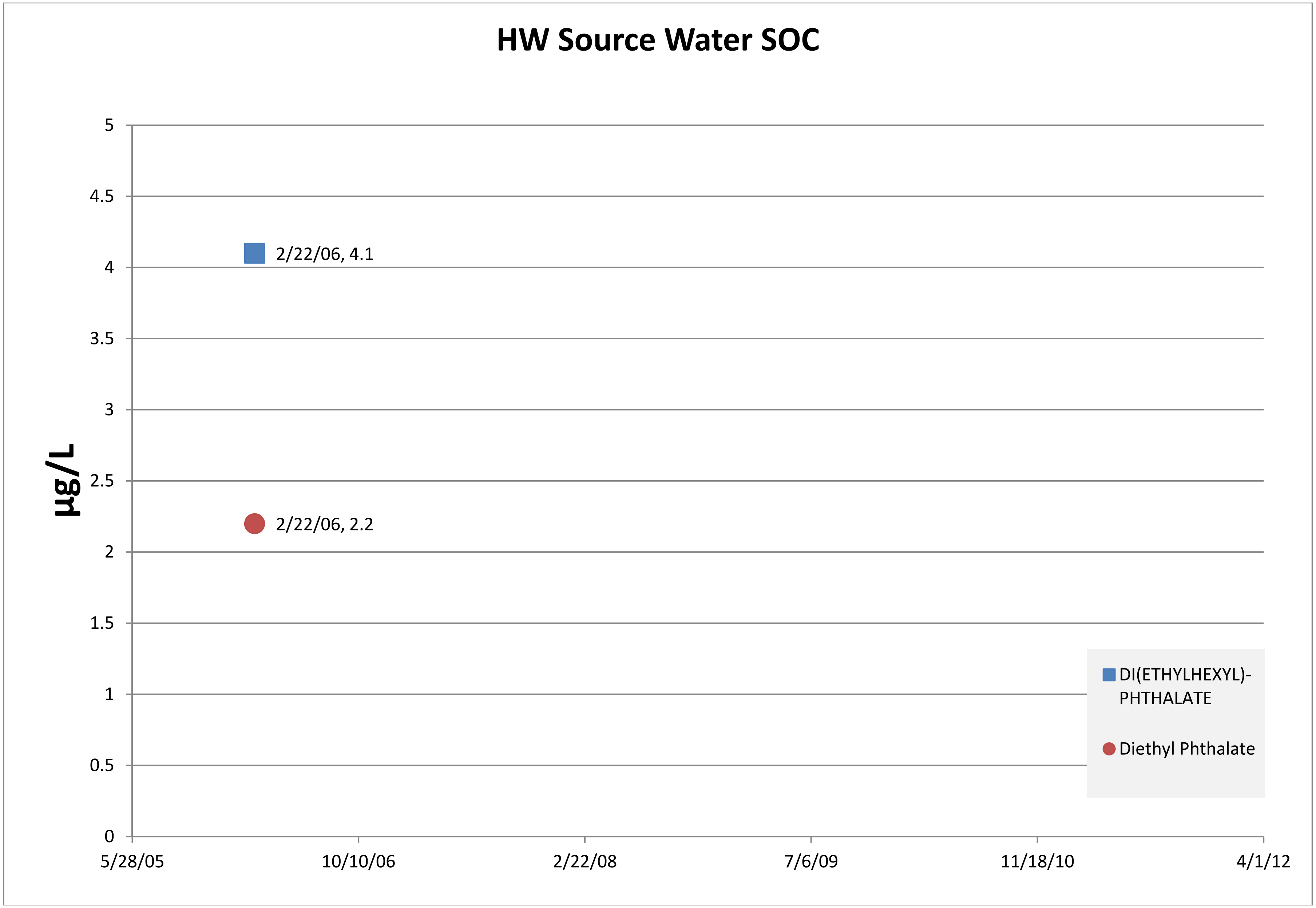

Figure B-9. Hall-Wentland source water SOC's.

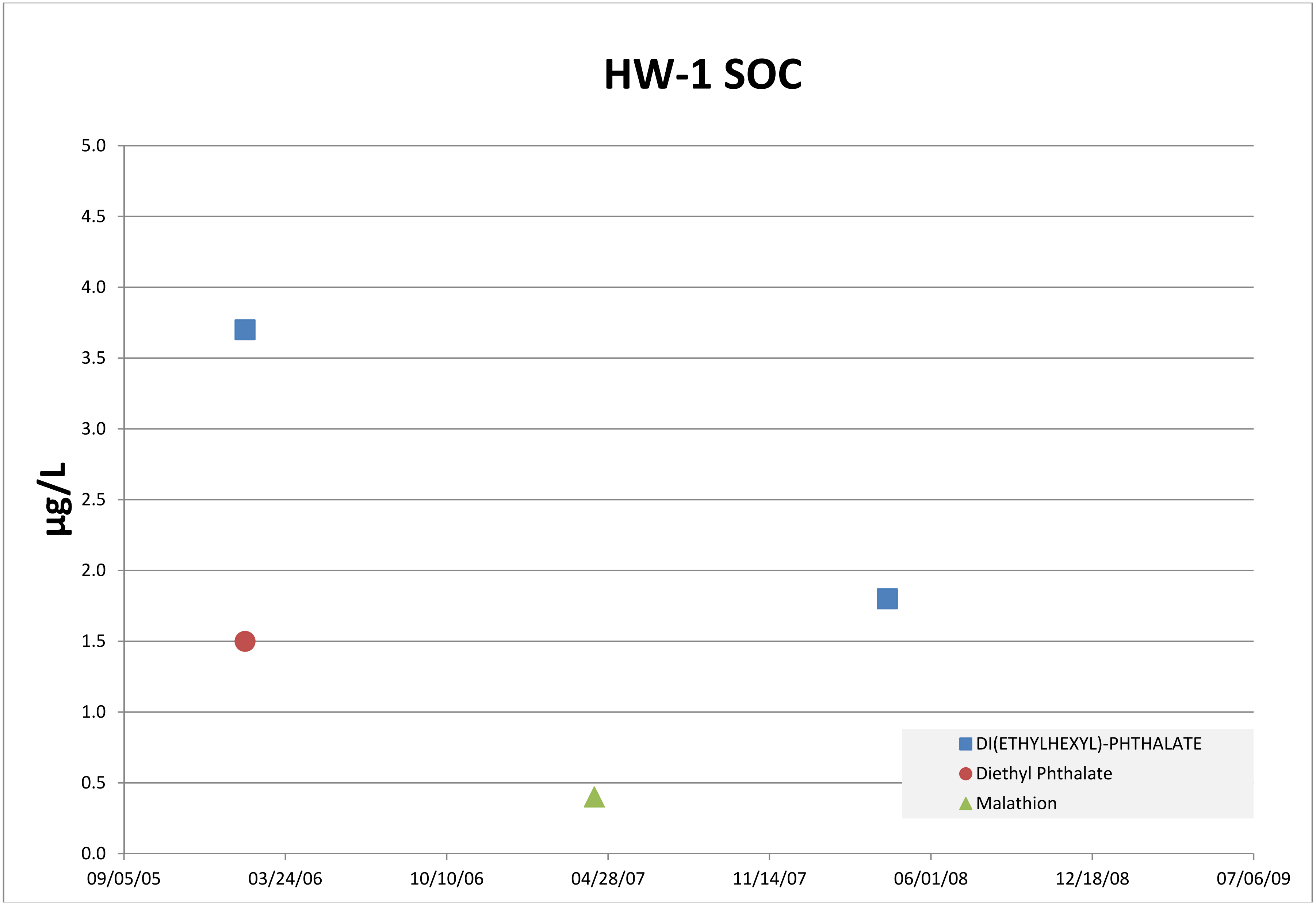

Figure B-10. Hall-Wentland monitoring well HW-1 water SOC’s.

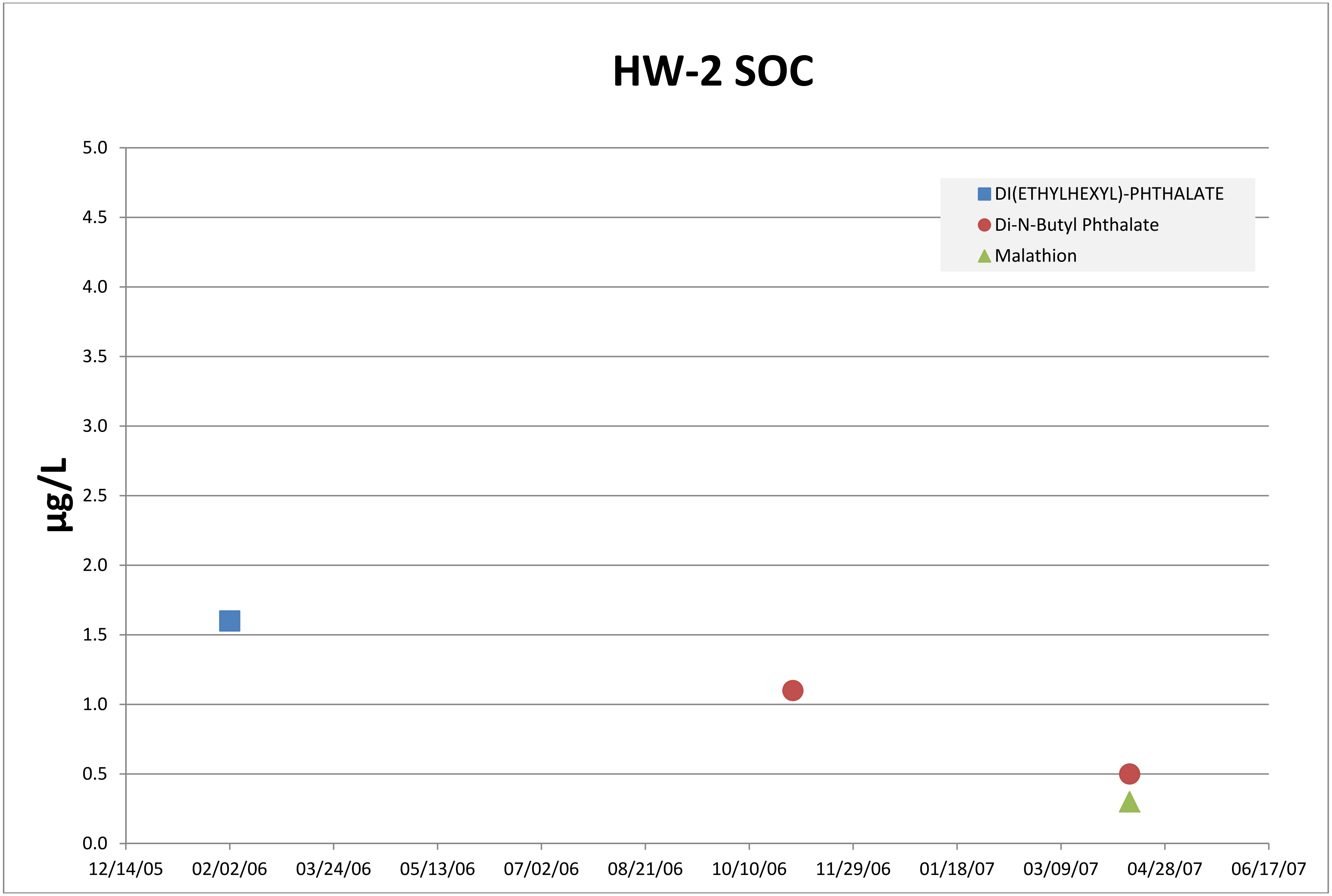

Figure B-11. Hall-Wentland monitoring well HW-2 water SOC’s.

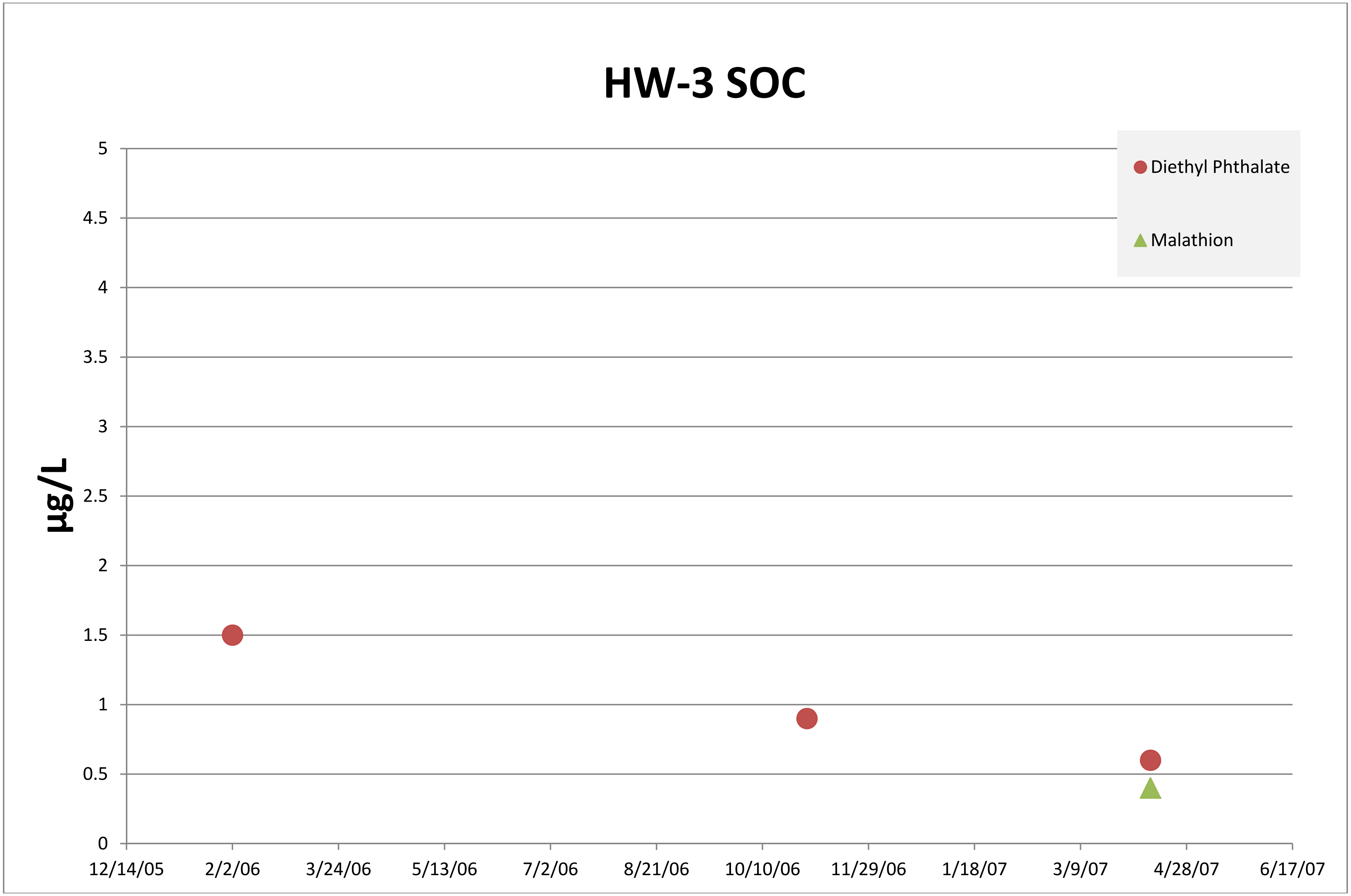

Figure B-12. Hall-Wentland monitoring well HW-3 water SOC's.

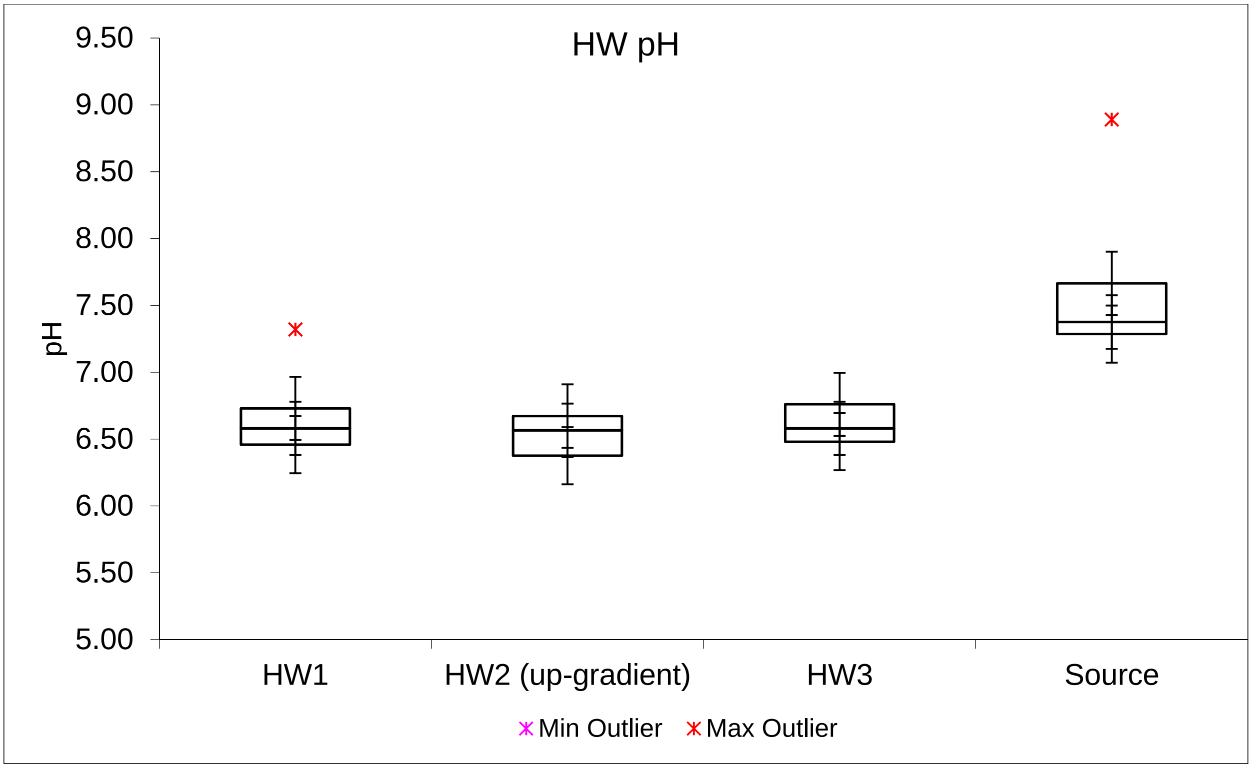

Figure B-13. Hall-Wentland pH box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

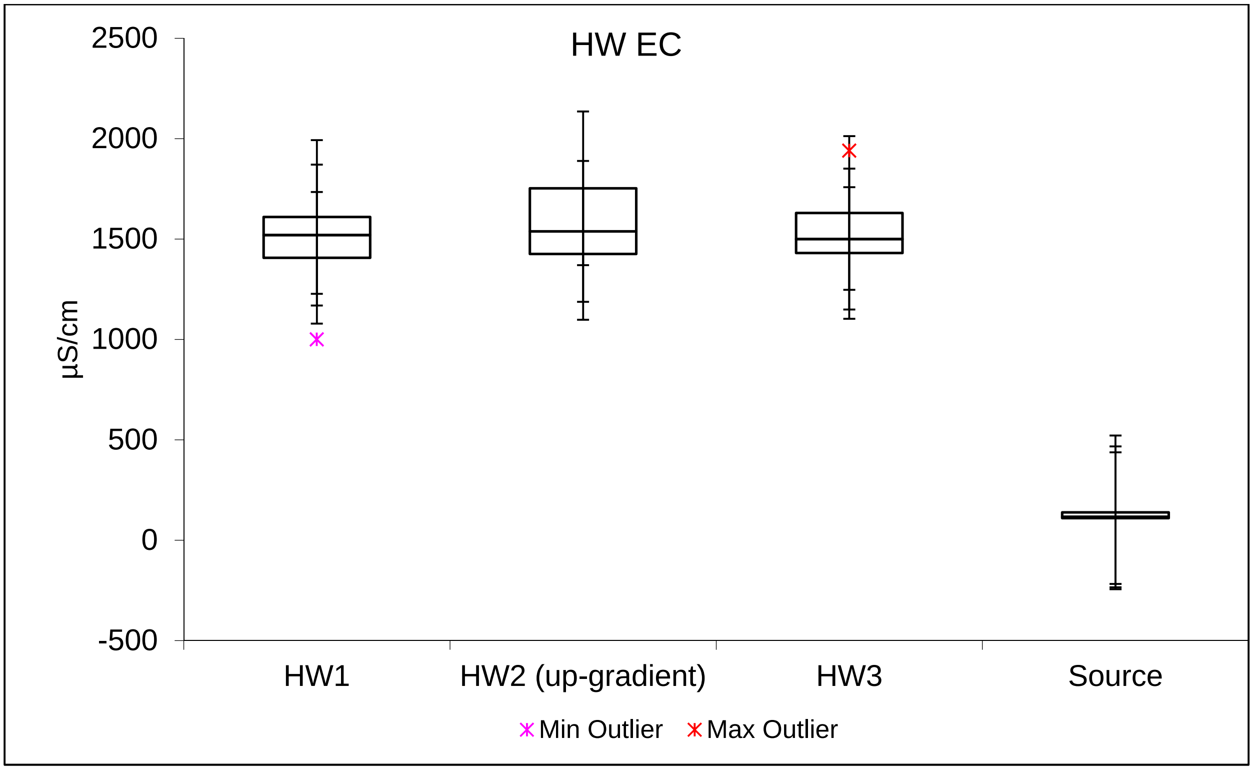

Figure B-14. Hall-Wentland EC box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

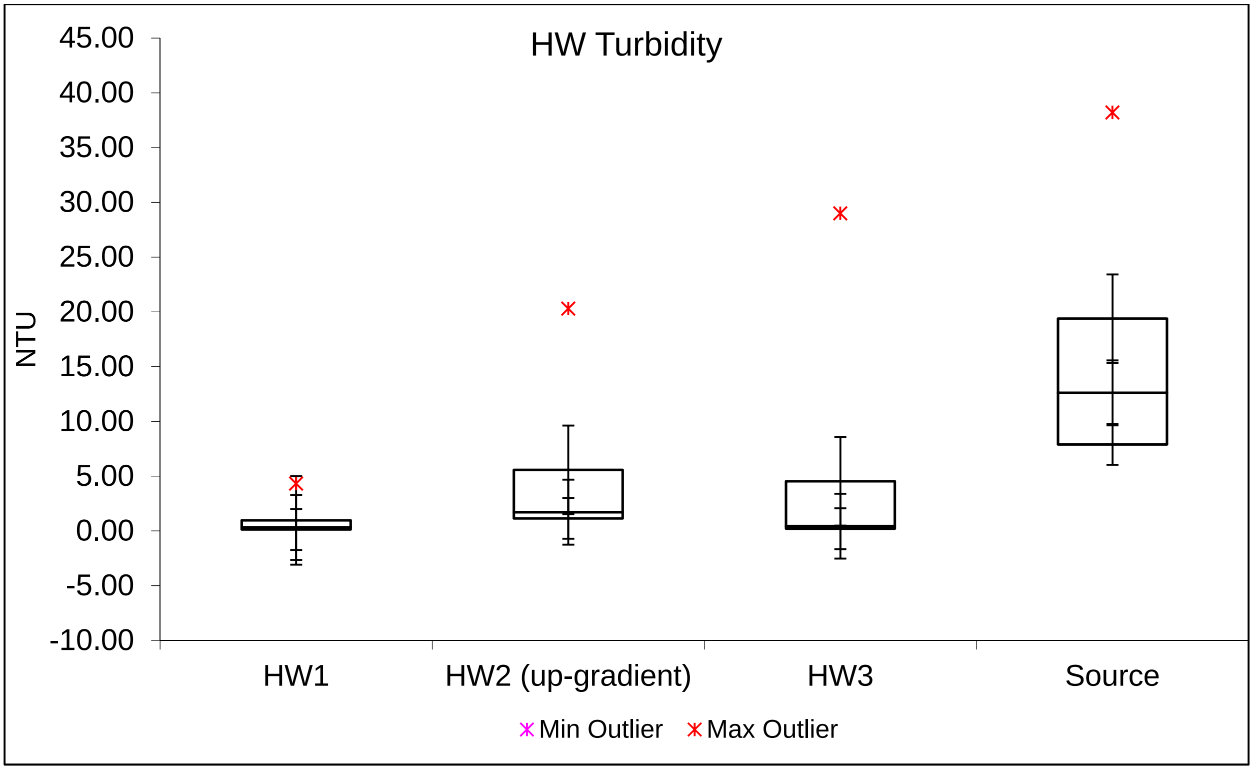

Figure B-15. Hall-Wentland turbidity box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

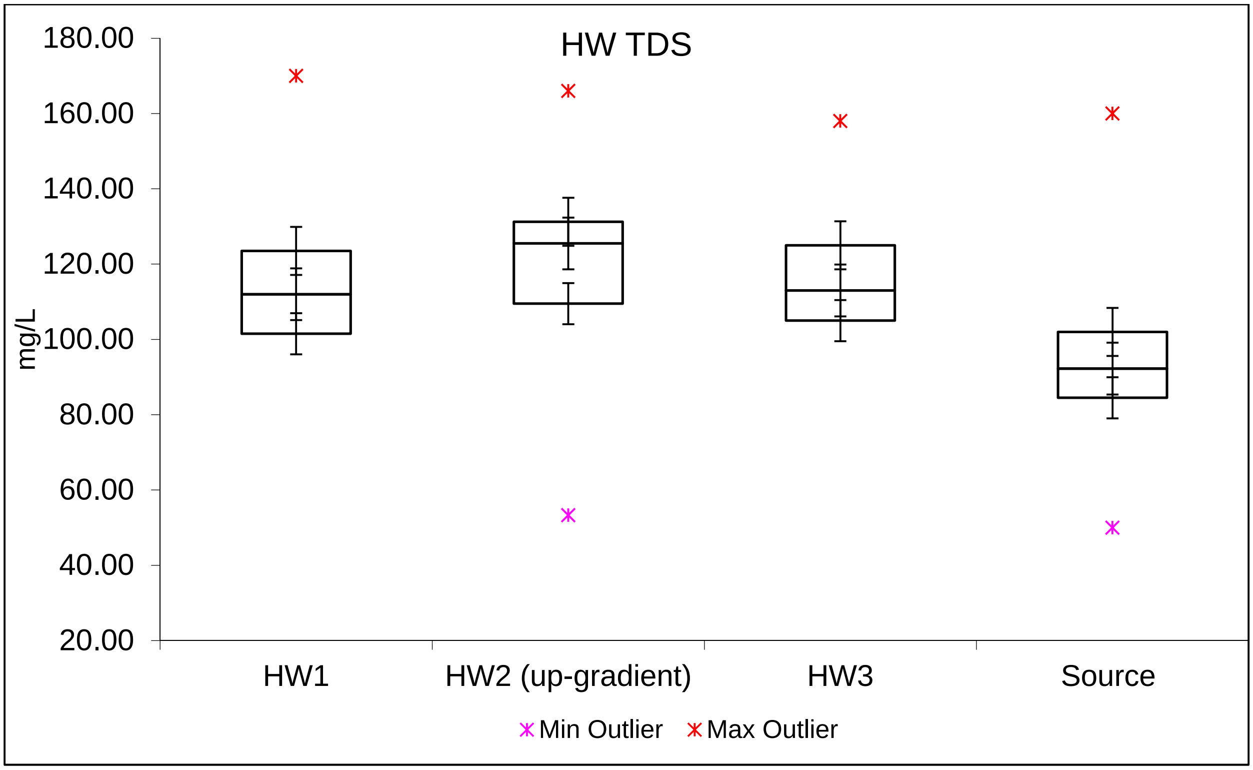

Figure B-16. Hall-Wentland TDS box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

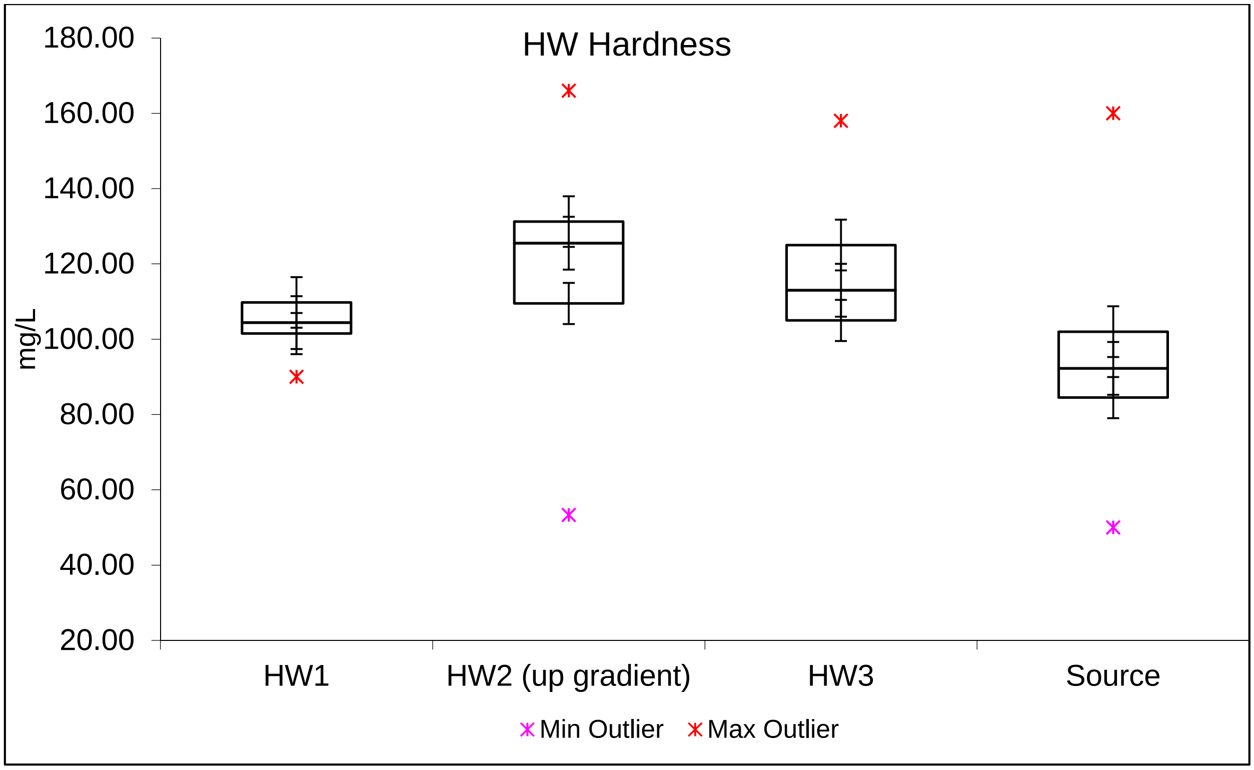

Figure B-17. Hall-Wentland hardness box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

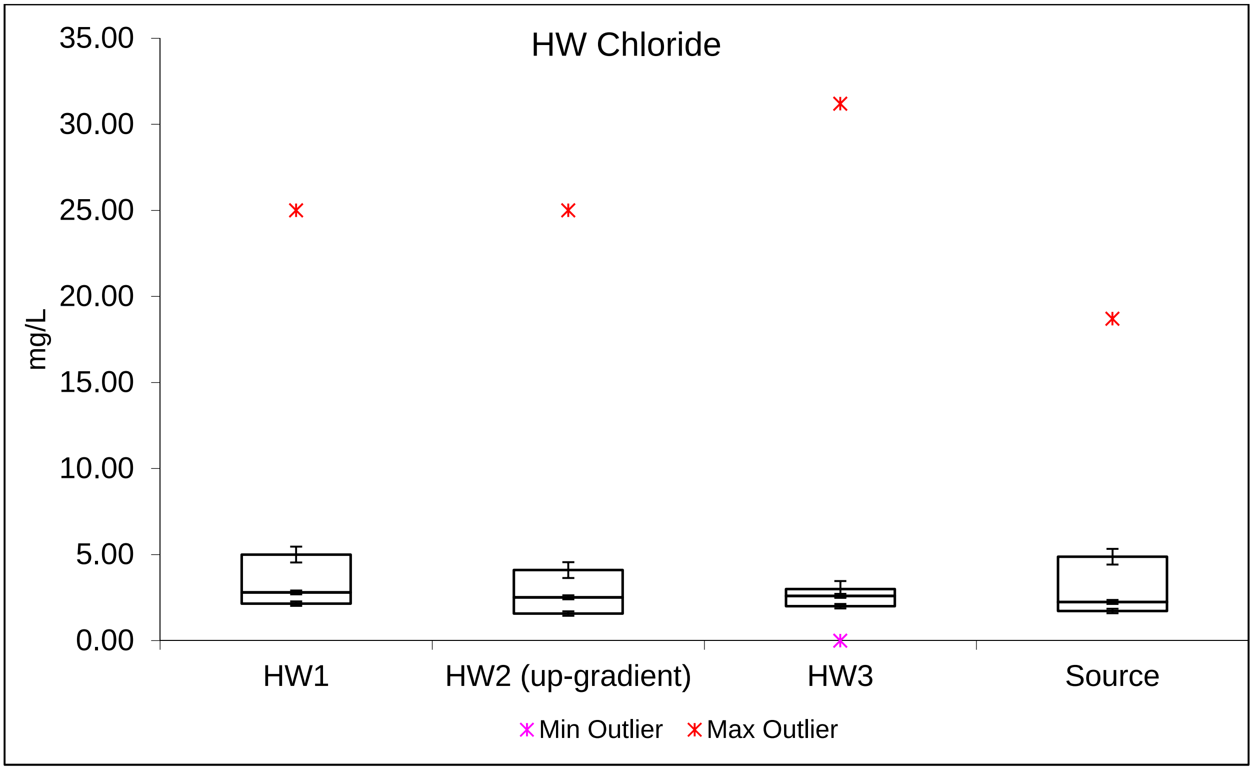

Figure B-18. Hall-Wentland chloride box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

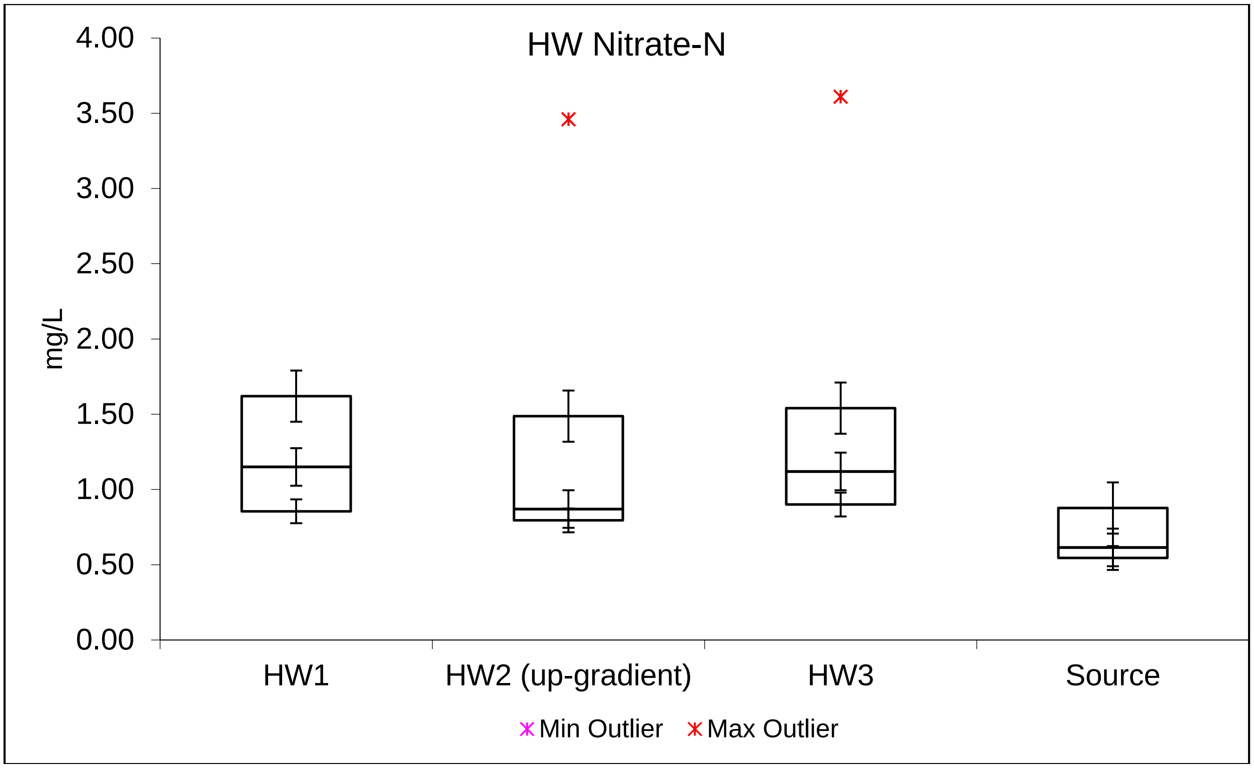

Figure B-19. Hall-Wentland nitrate-N box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

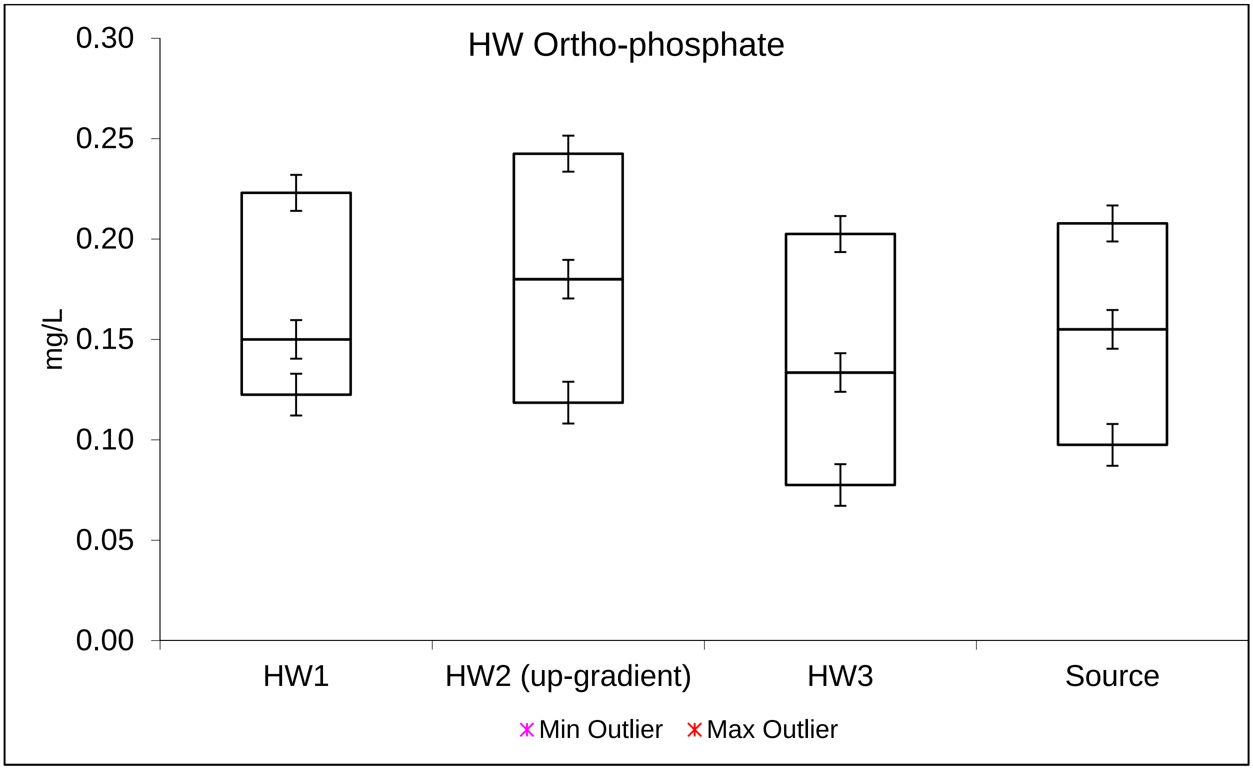

Figure B-20. Hall-Wentland ortho-phosphate box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

Appendix C

Locher Road Data Plots

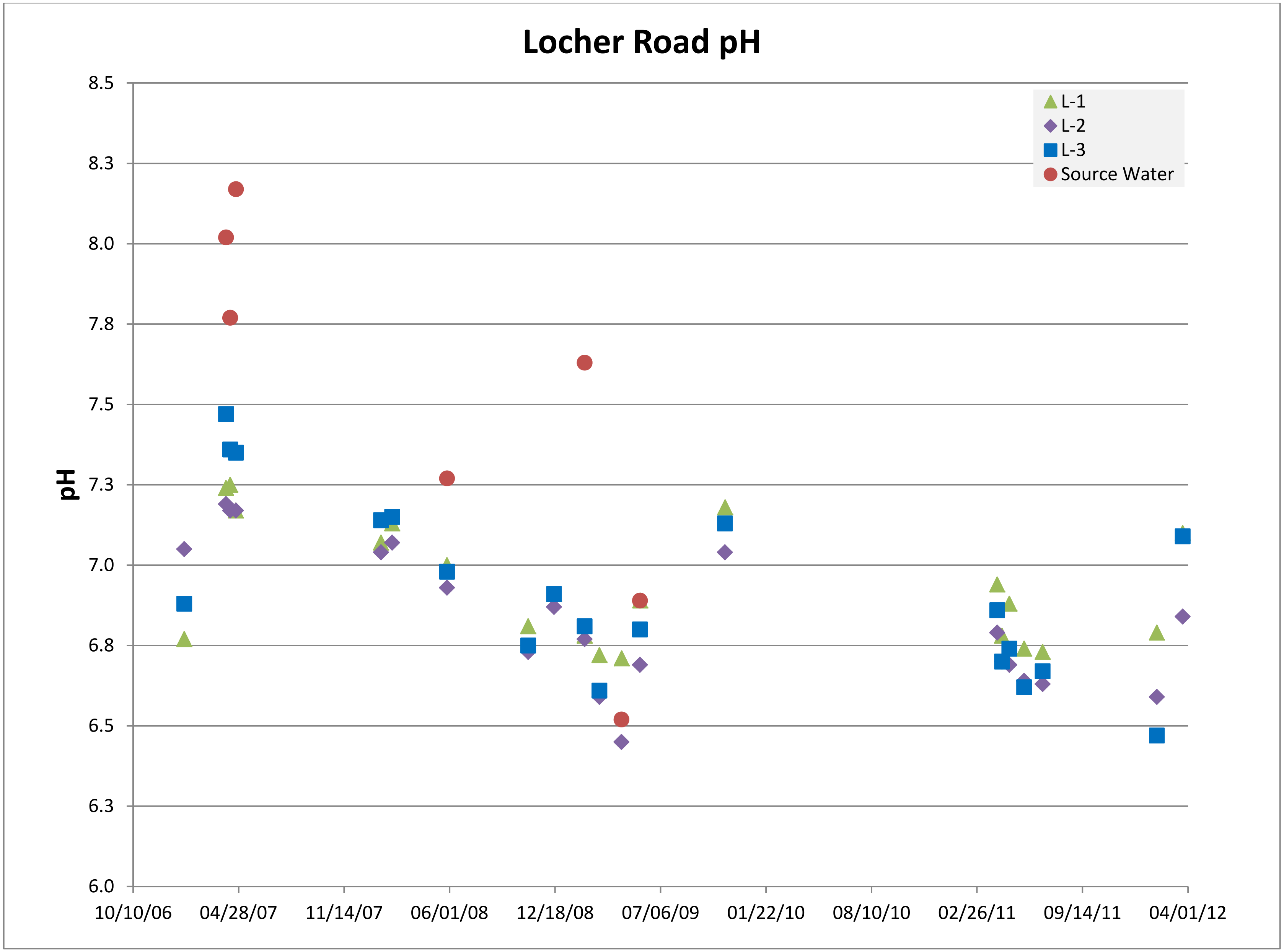

Figure C-1. Locher Road pH. L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

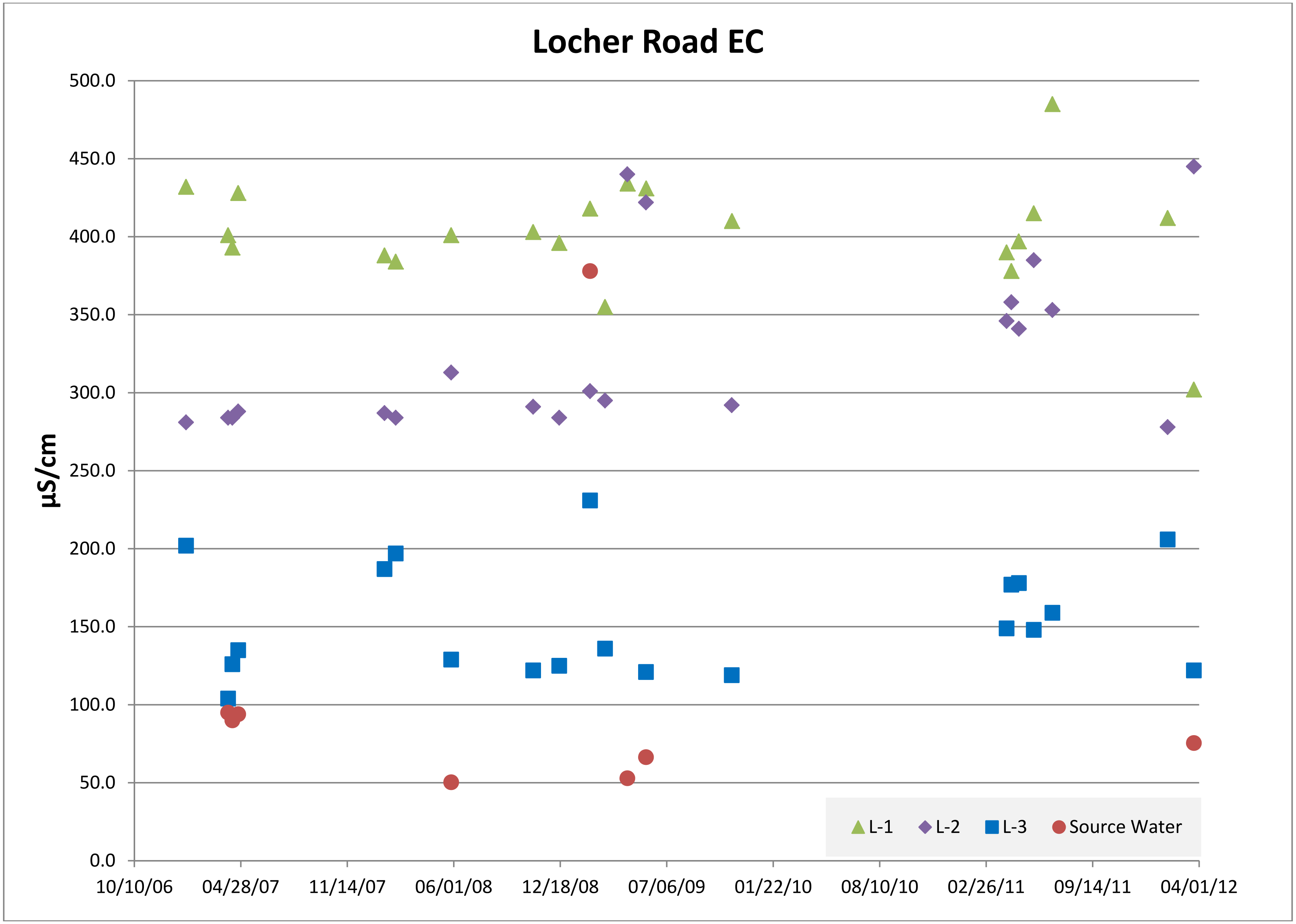

Figure C-2. Locher Road electrical conductivity (EC). L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

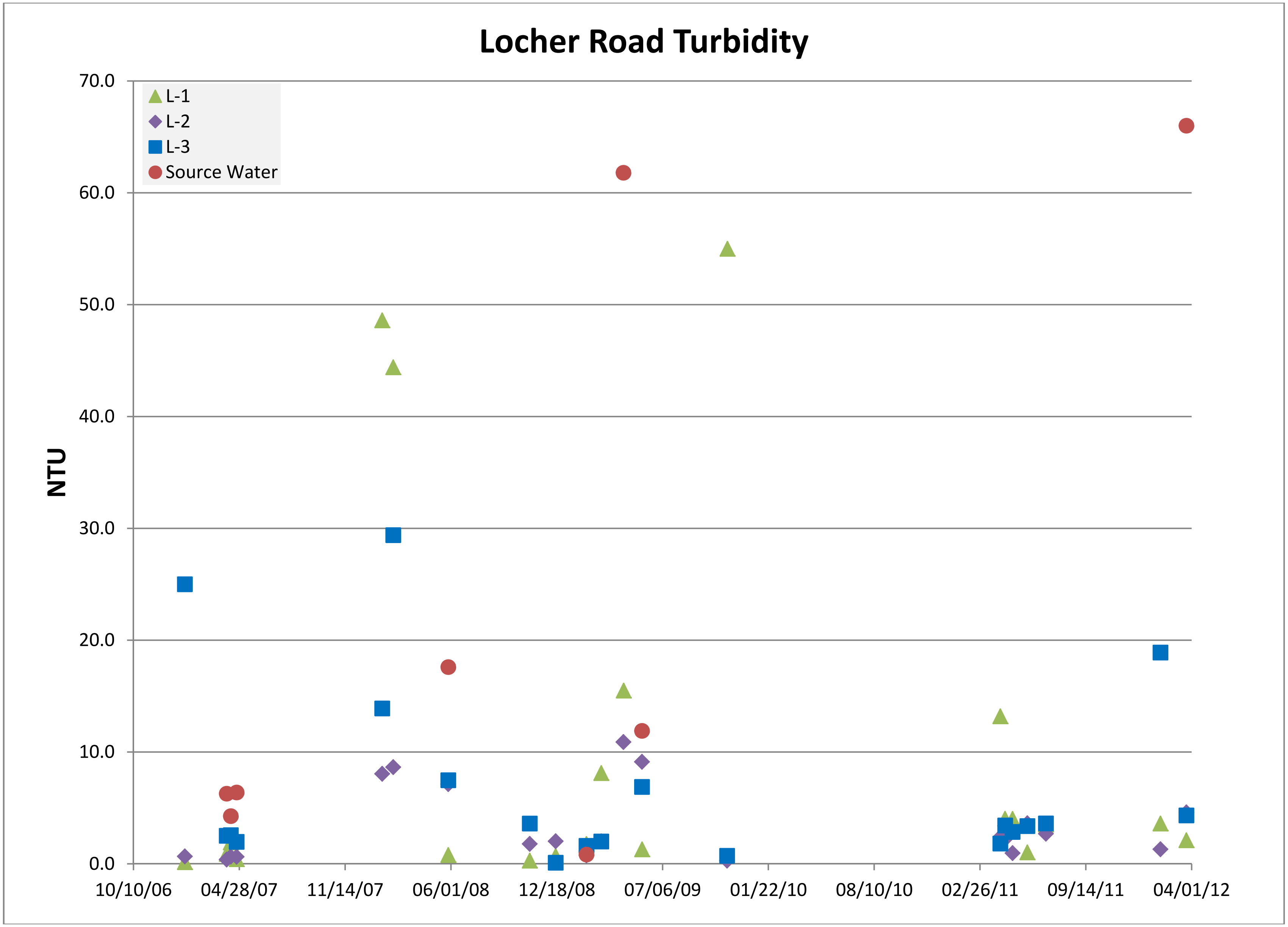

Figure C-3. Locher Road turbidity. L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

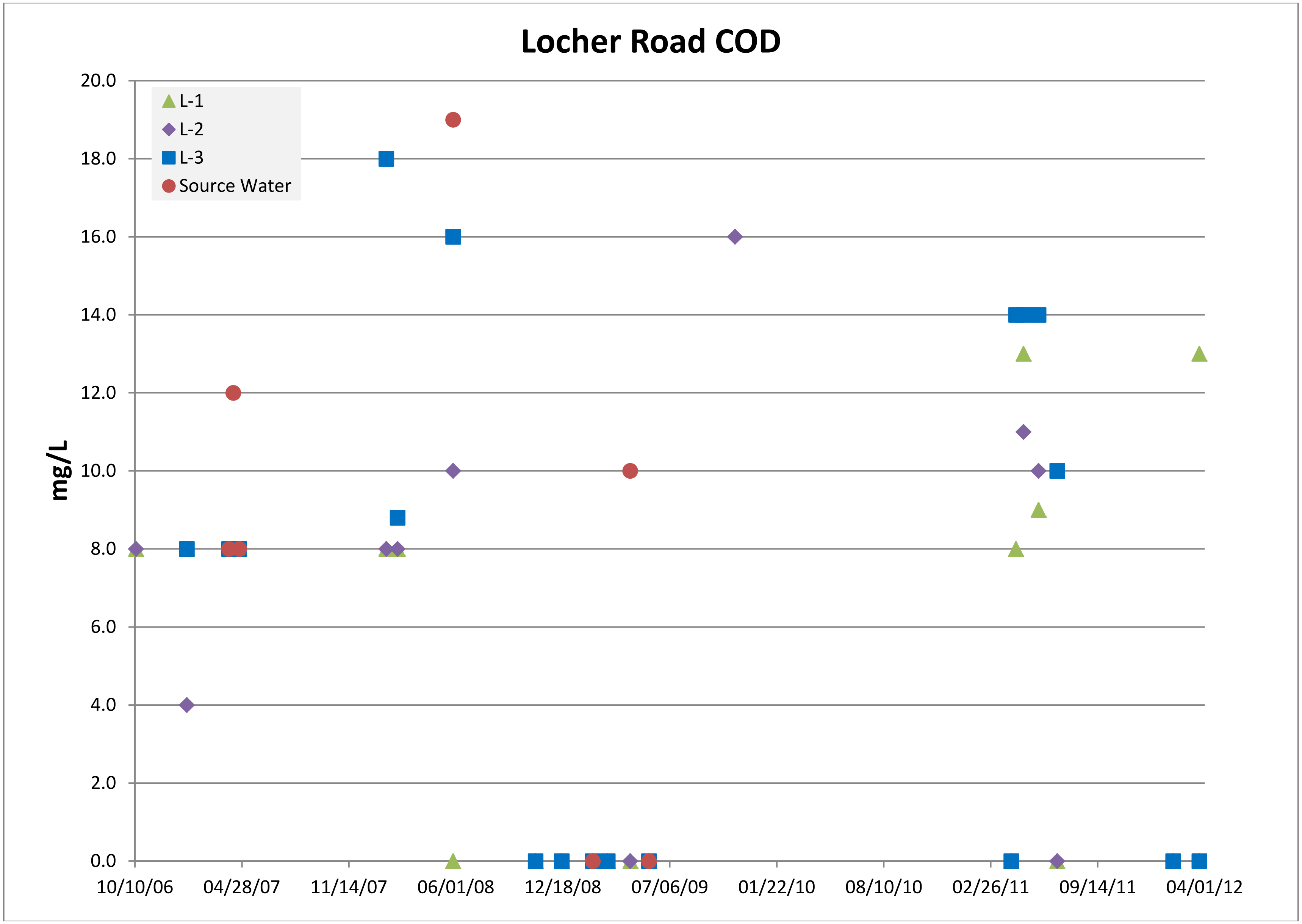

Figure C-4. Locher Road chemical oxygen demand (COD). L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

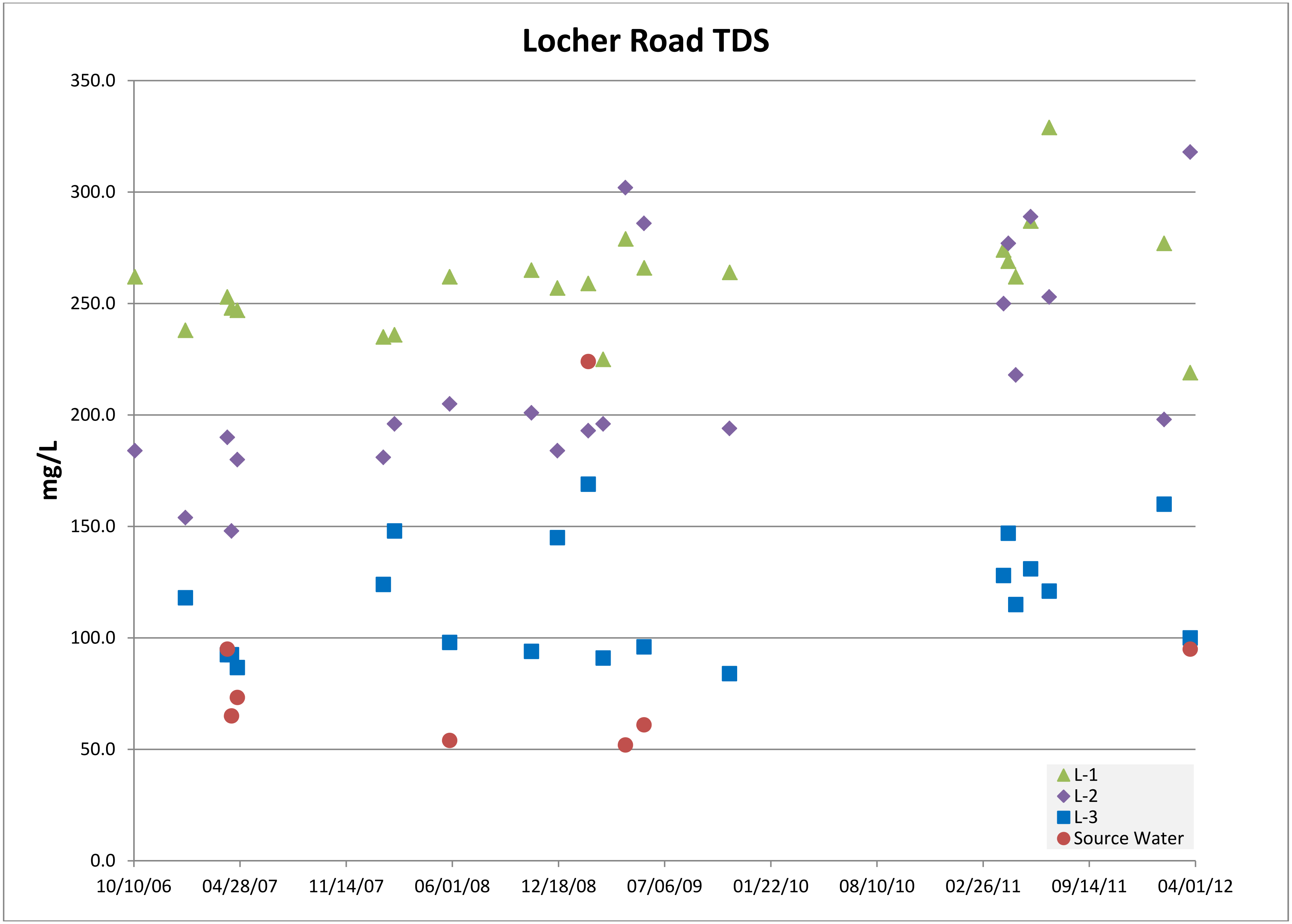

Figure C-5. Locher Road total dissolved solids (TDS). L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

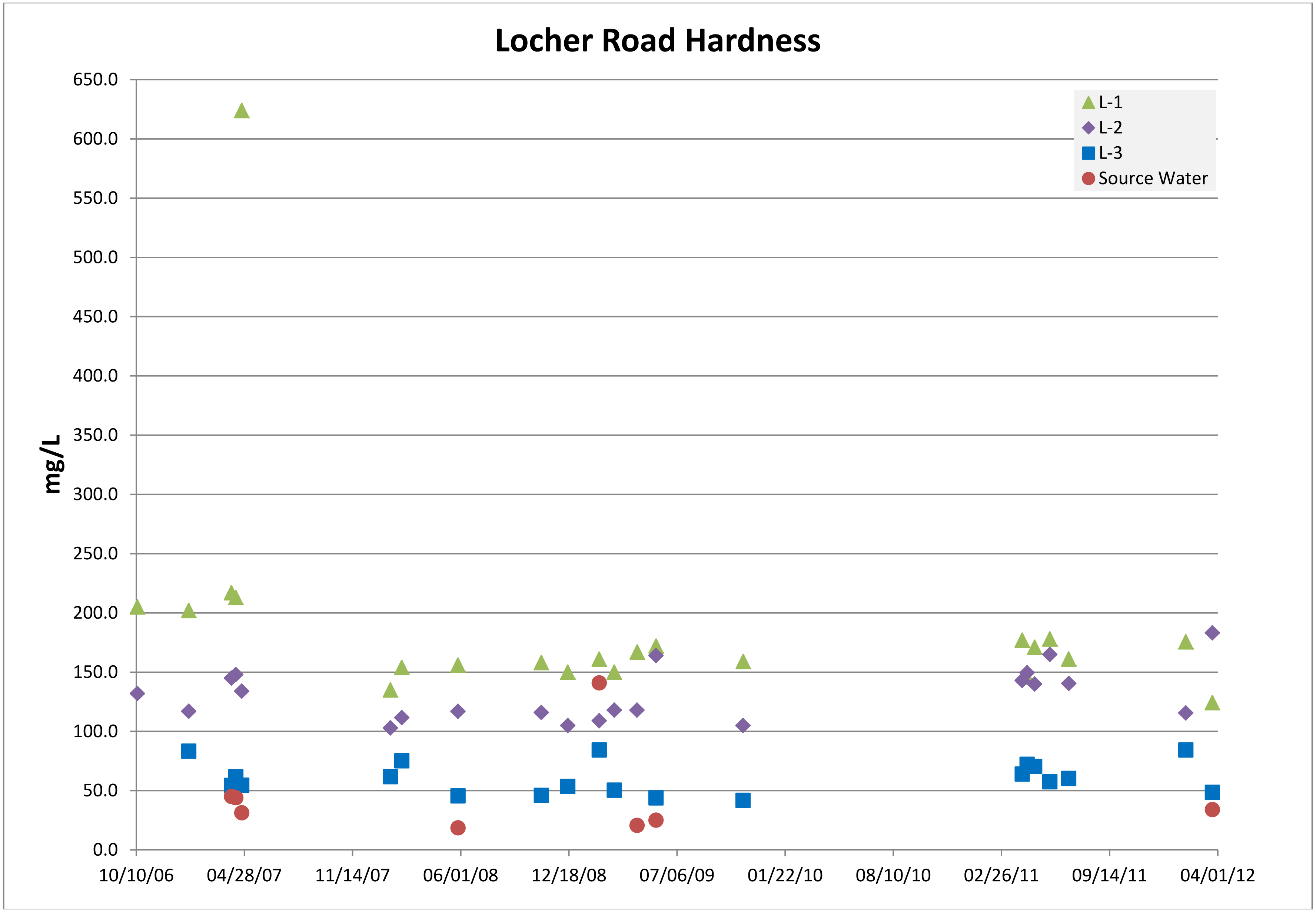

Figure C-6. Locher Road hardness. L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

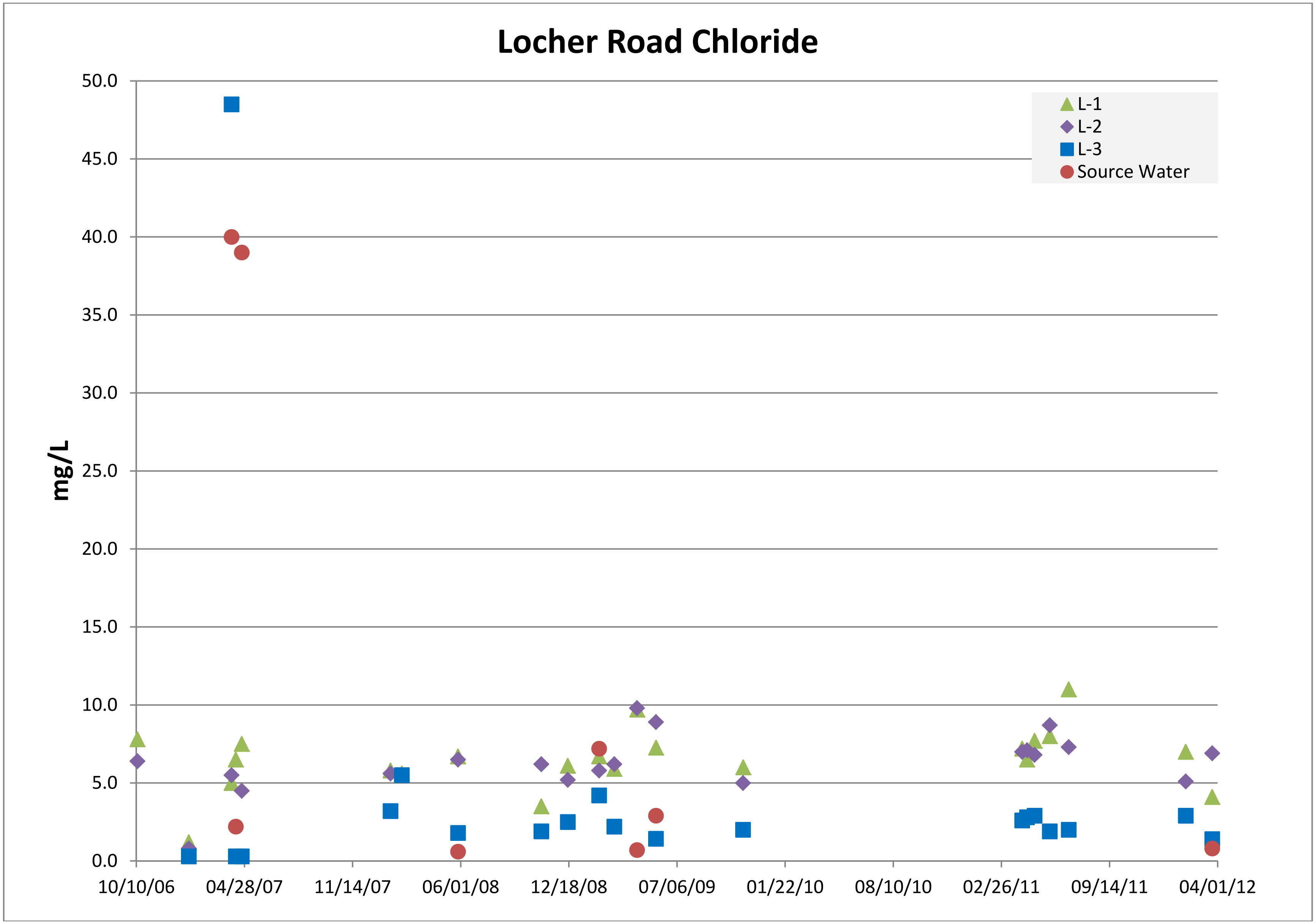

Figure C-7. Locher Road chloride. L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

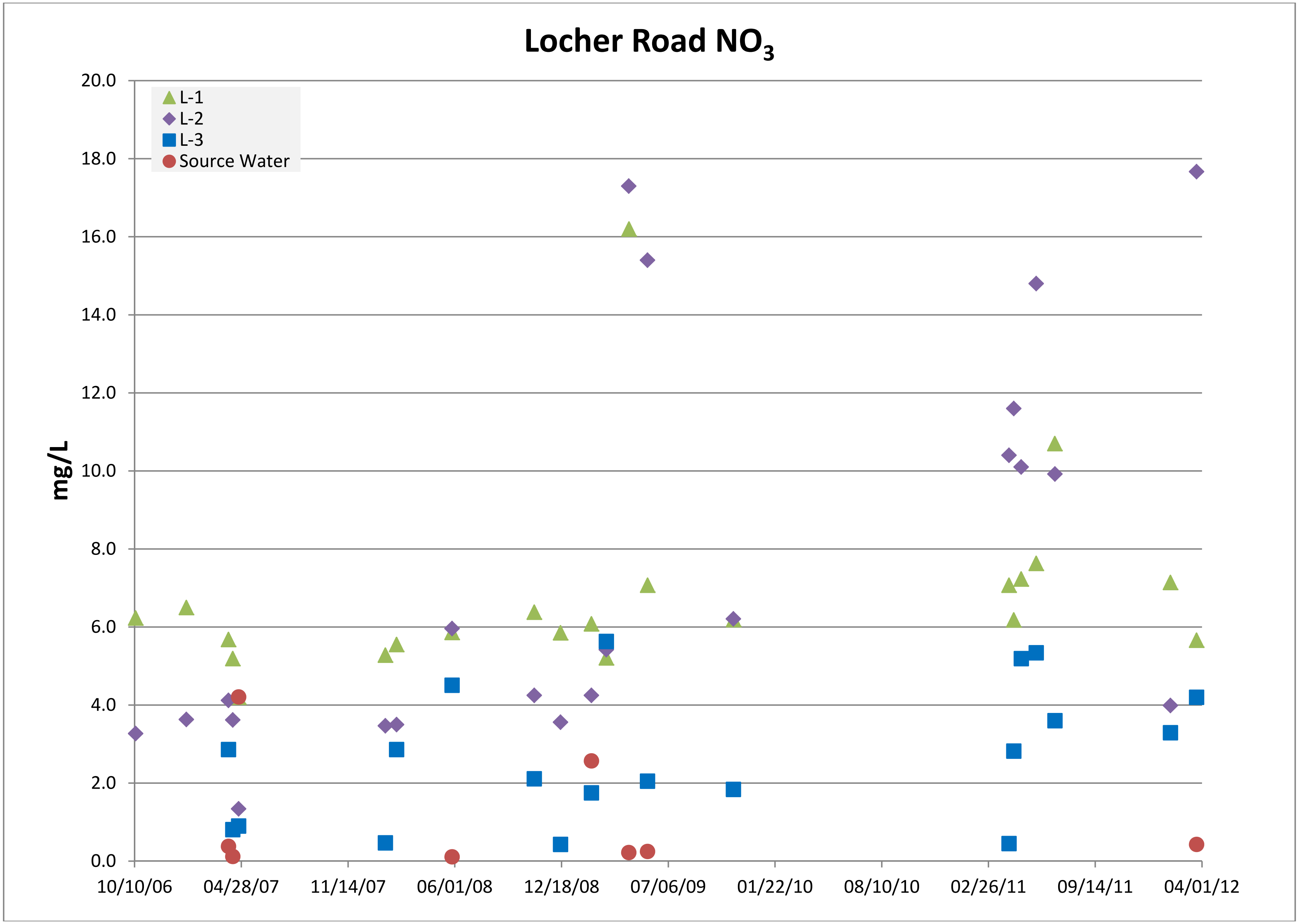

Figure C-8. Locher Road nitrate-N. L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

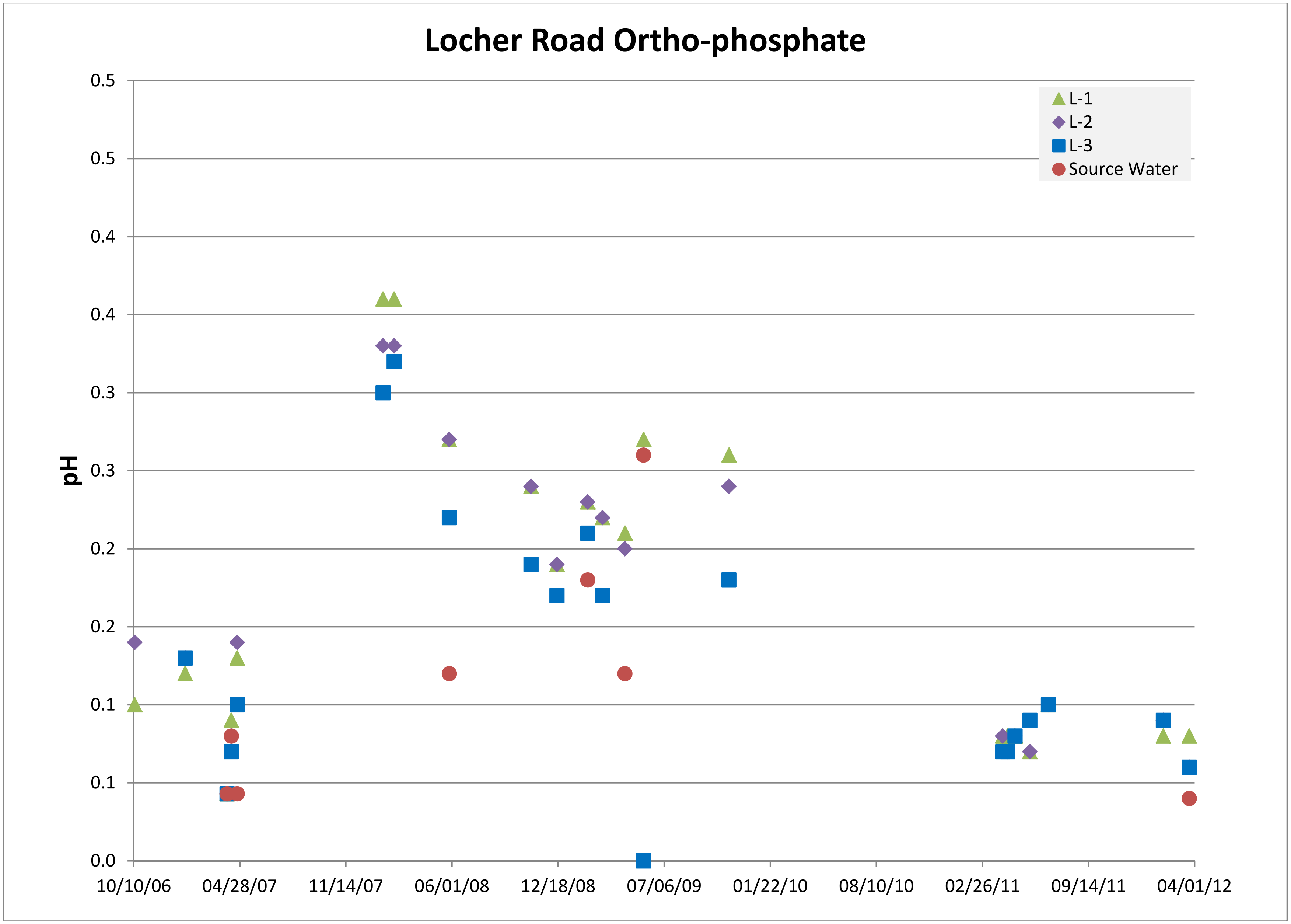

Figure C-9. Locher Road ortho-phosphate. L-1 = Locher Road monitoring well L-1. L-2 = Locher Road monitoring well L-2. L-3 = Locher Road monitoring well L-3.

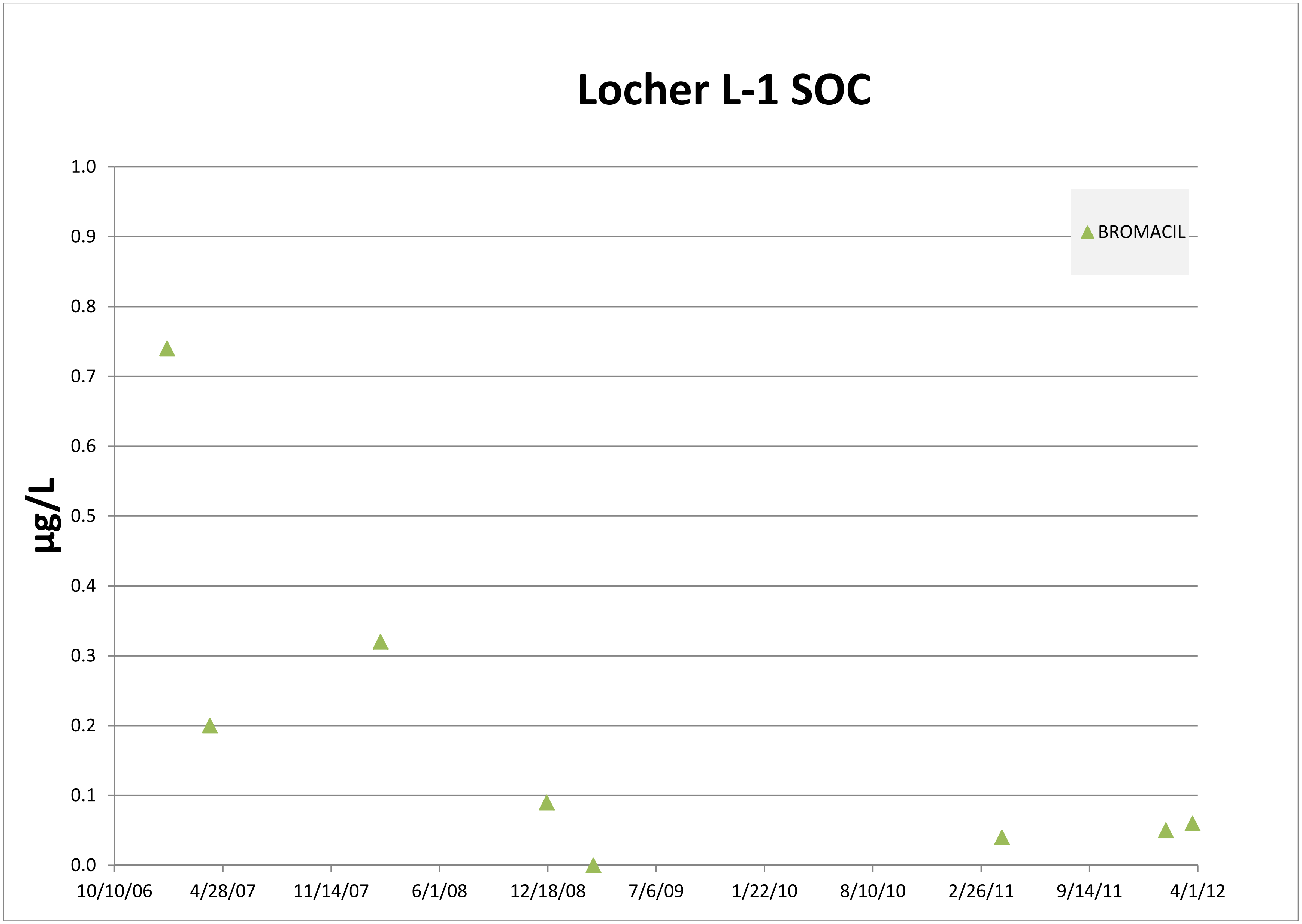

Figure C-10. Locher Road monitoring well L-1 SOC's.

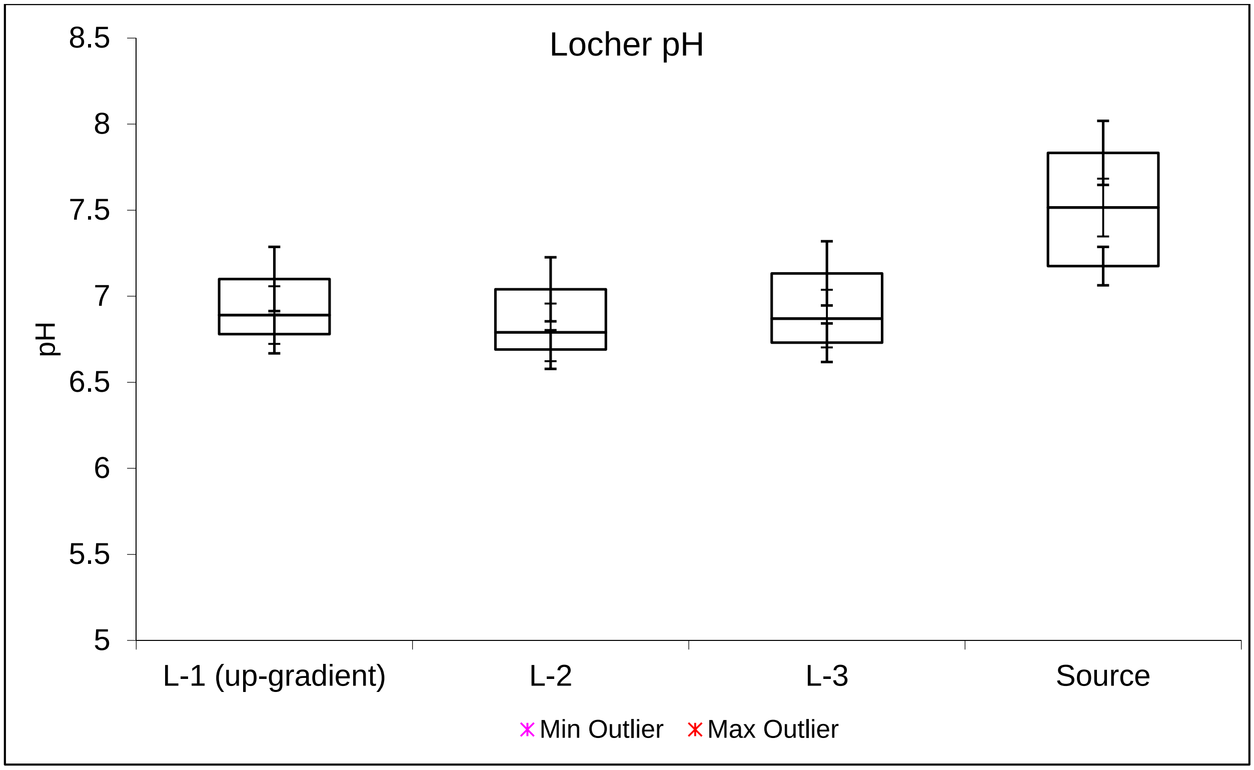

Figure C-11. Locher Road pH box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

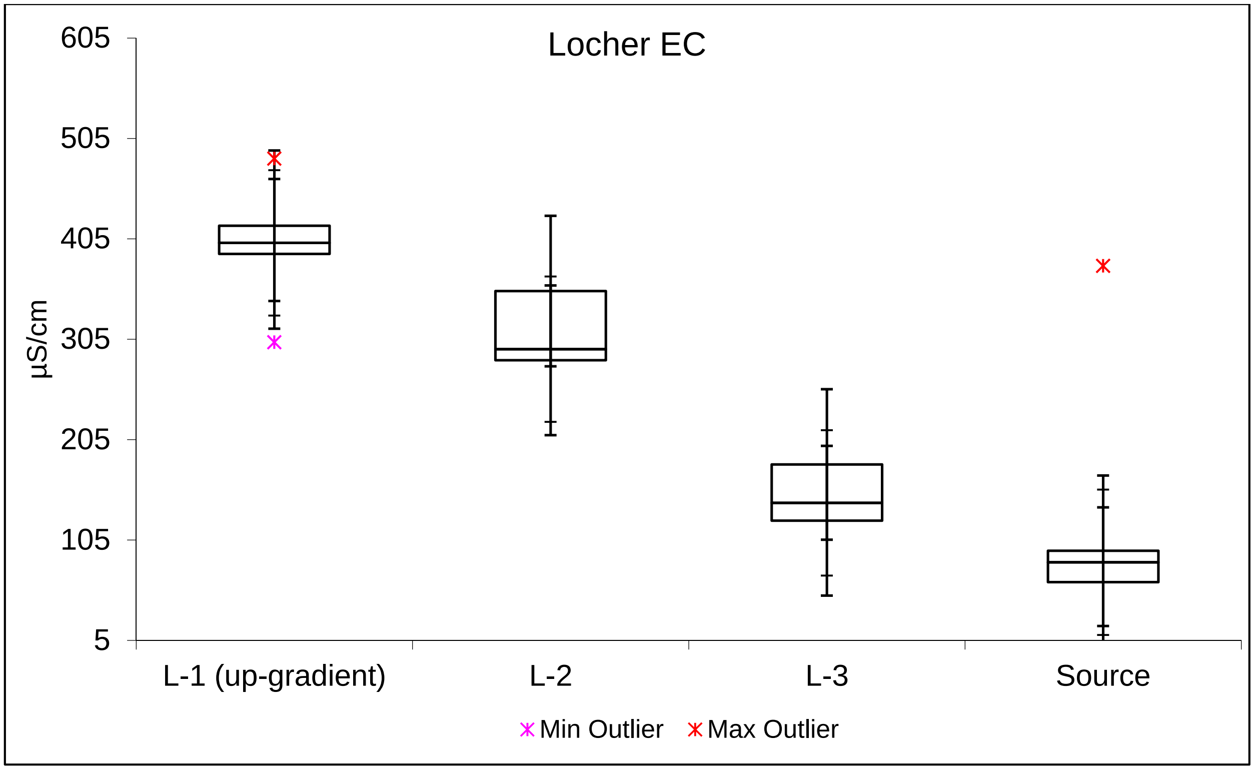

Figure C-12. Locher Road EC box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

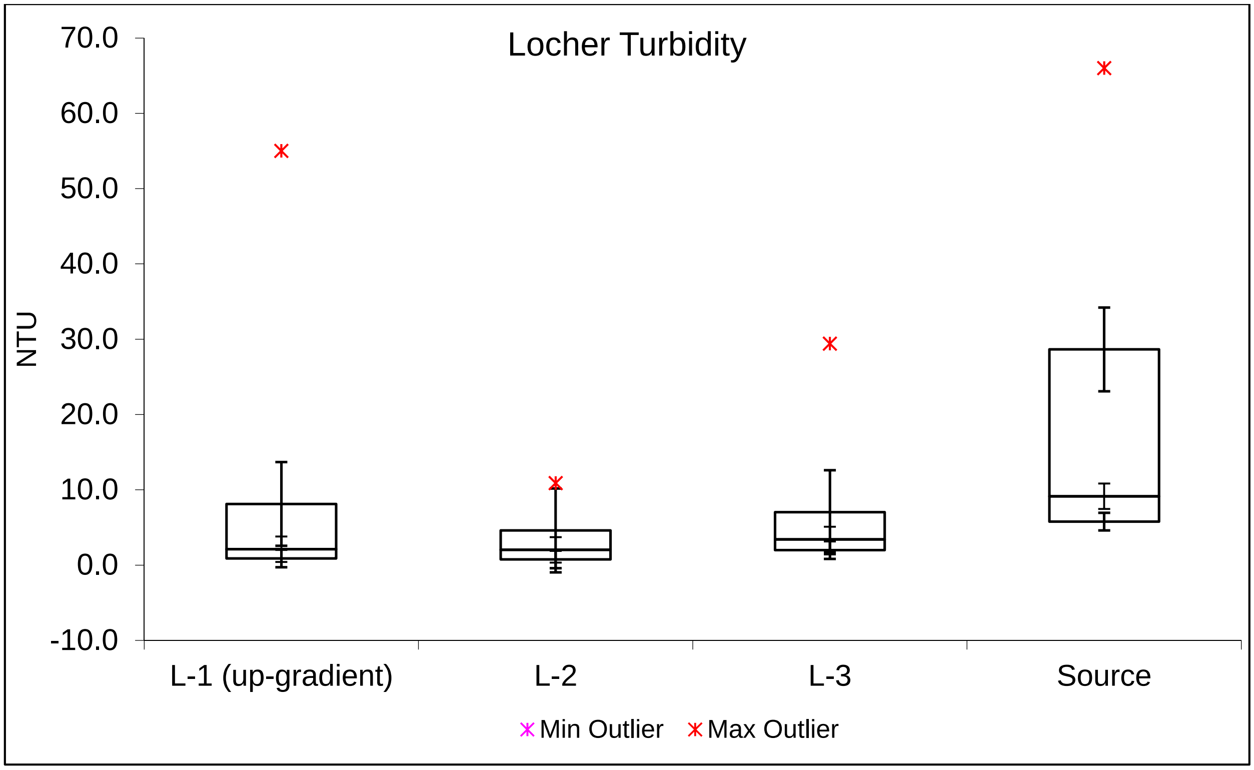

Figure C-13. Locher Road turbidity box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

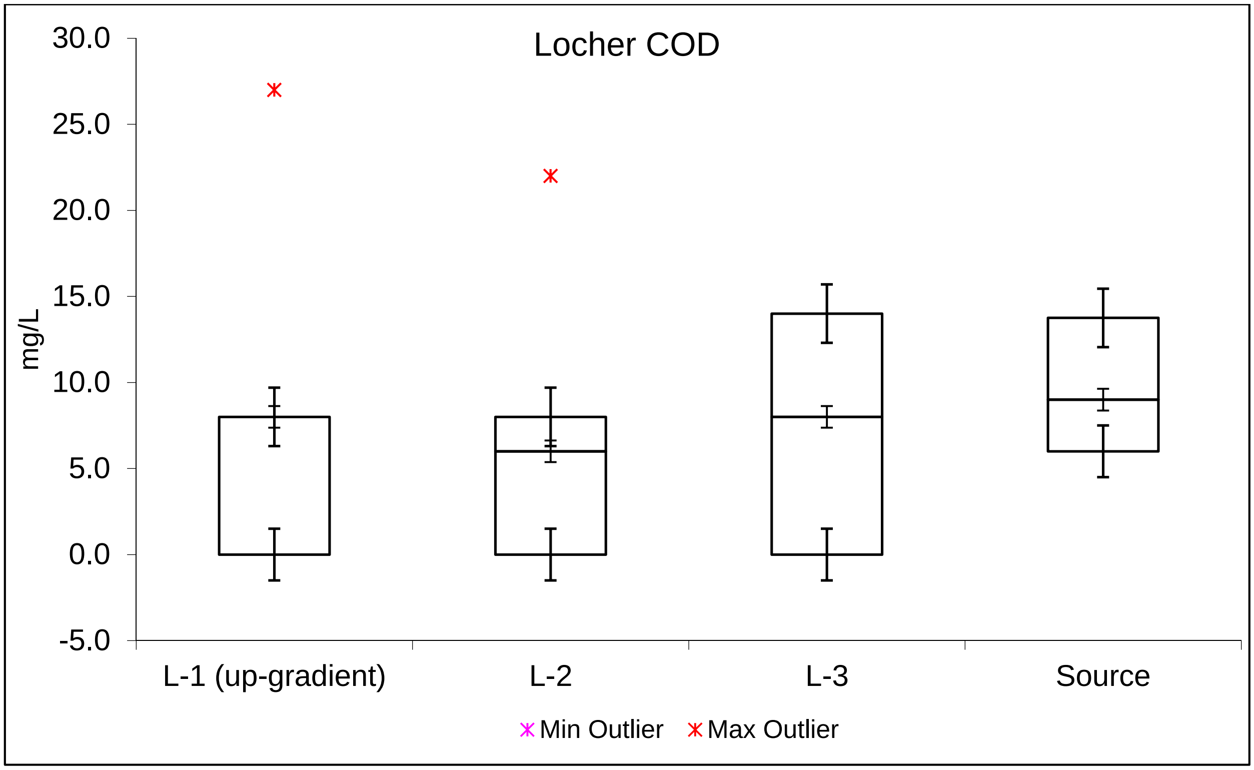

Figure C-14. Locher Road COD box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

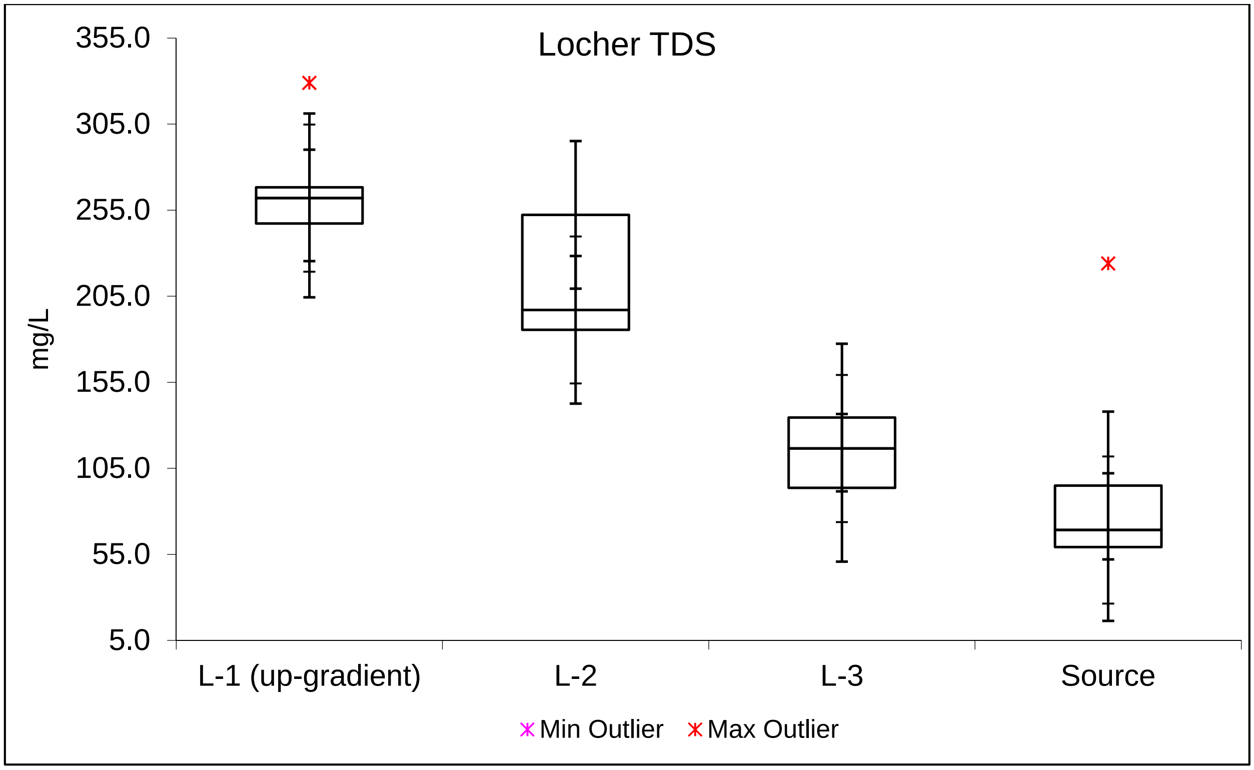

Figure C-15. Locher Road TDS box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

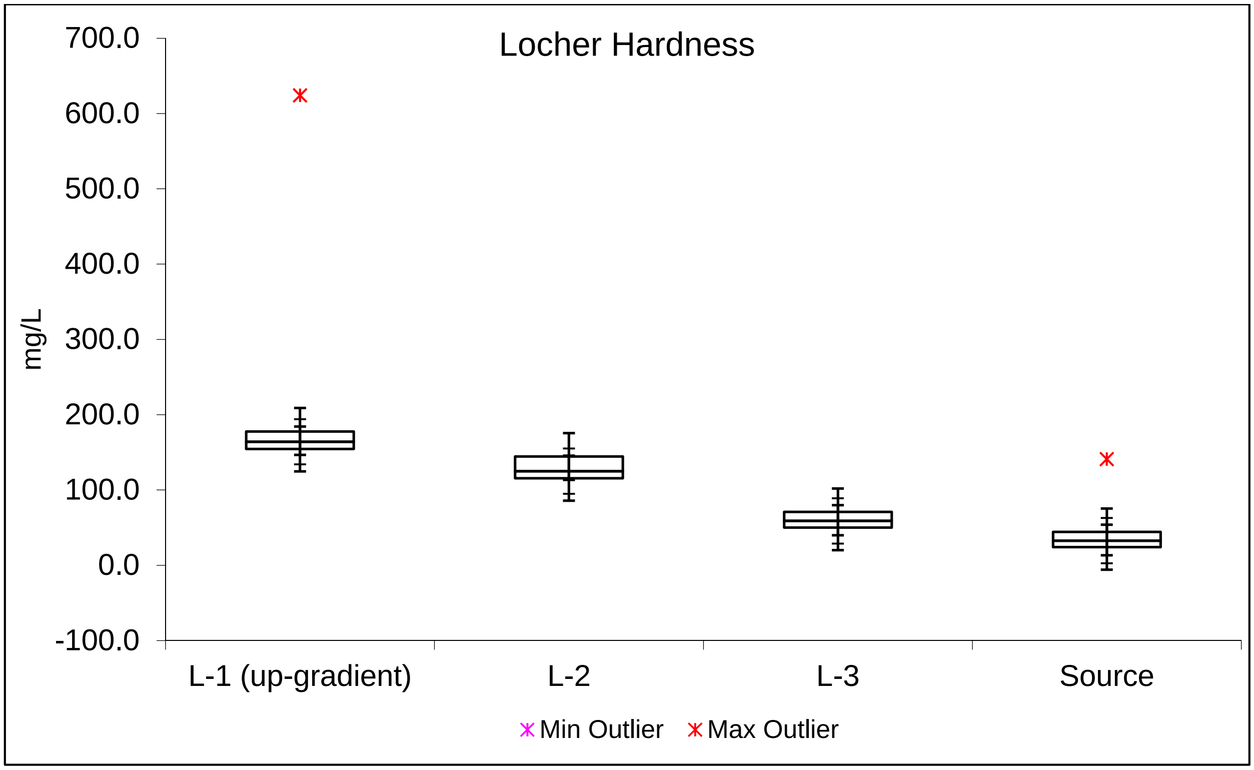

Figure C-16. Locher Road TDS box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

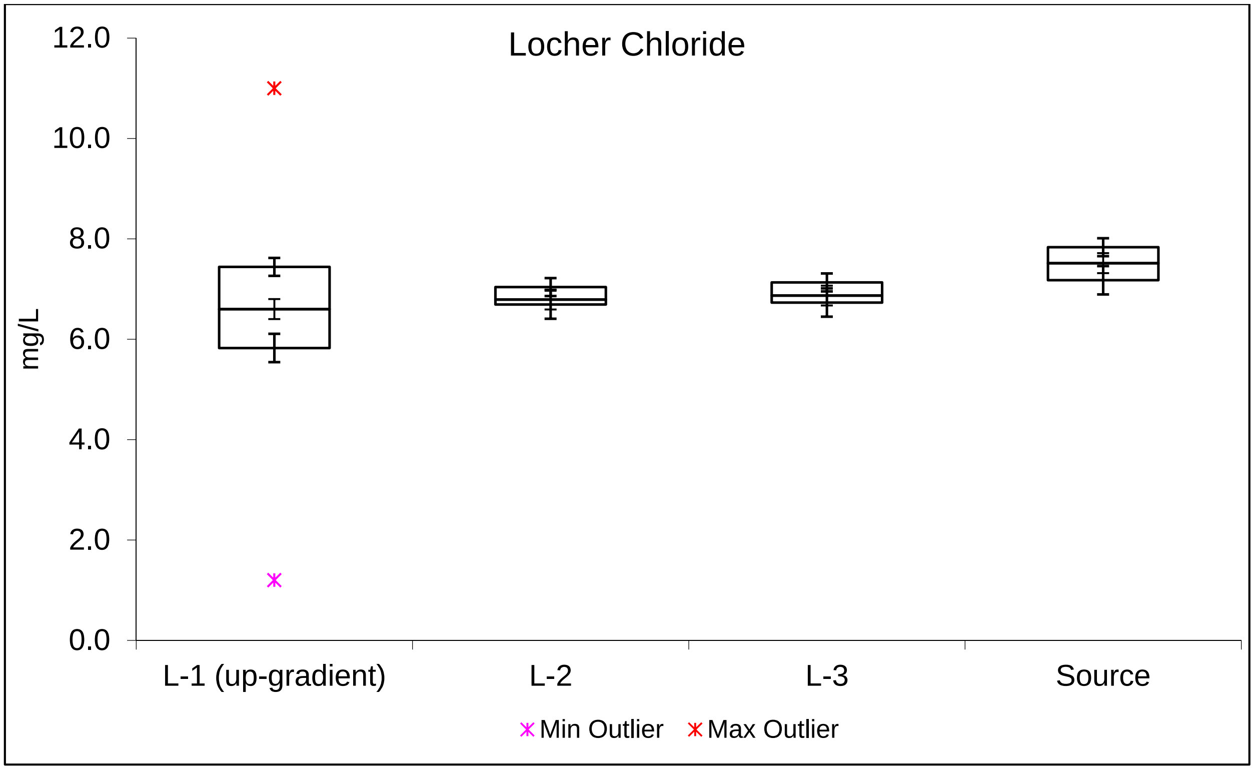

Figure C-17. Locher Road chloride box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

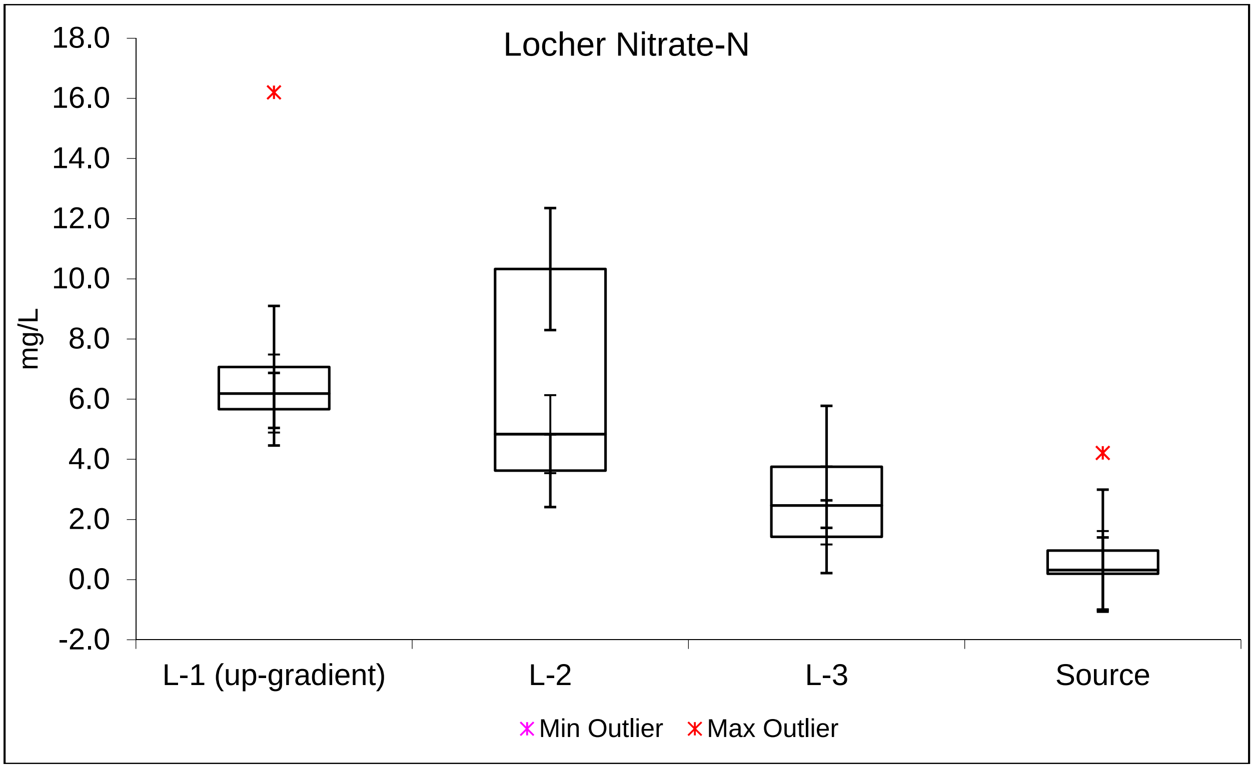

Figure C-18. Locher Road nitrate-N box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

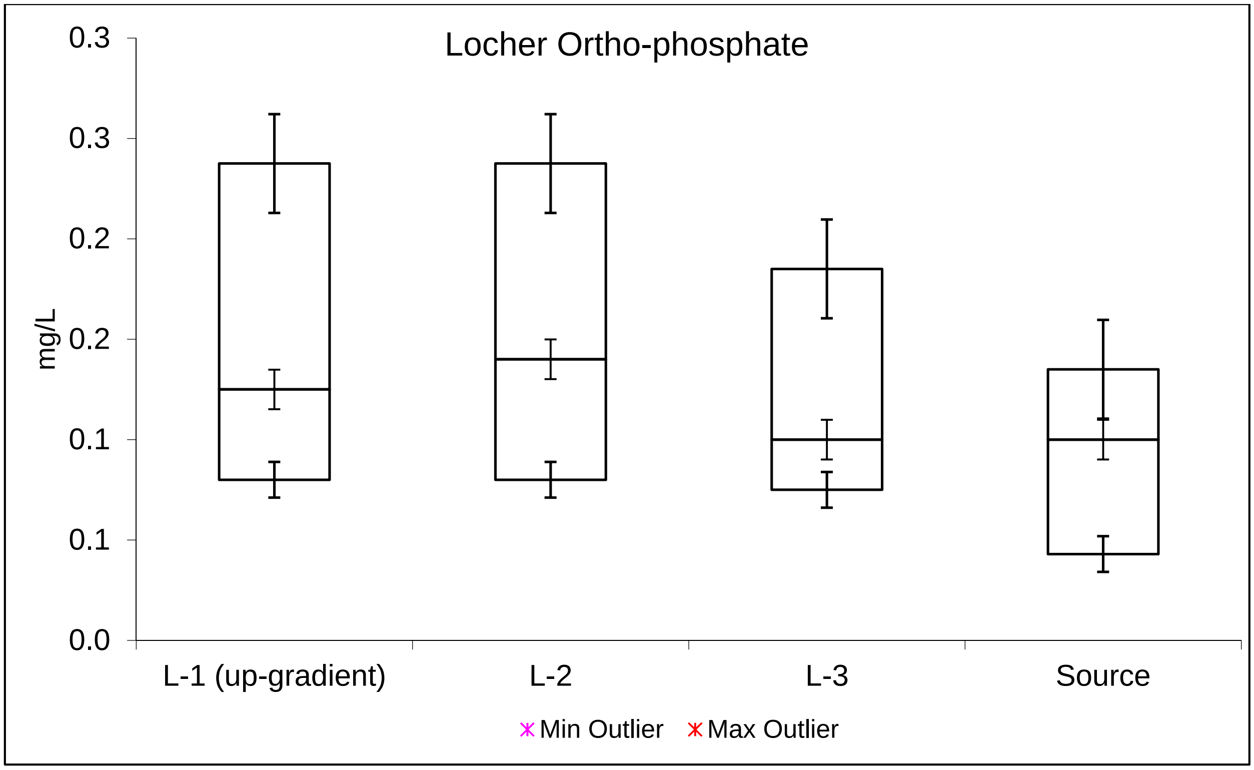

Figure C-19. Locher Road ortho-phosphate box-plot comparison displaying standard error bars for the median, upper and lower interquartile ranges.

Appendix D

Stiller Pond Data Comparison Histograms

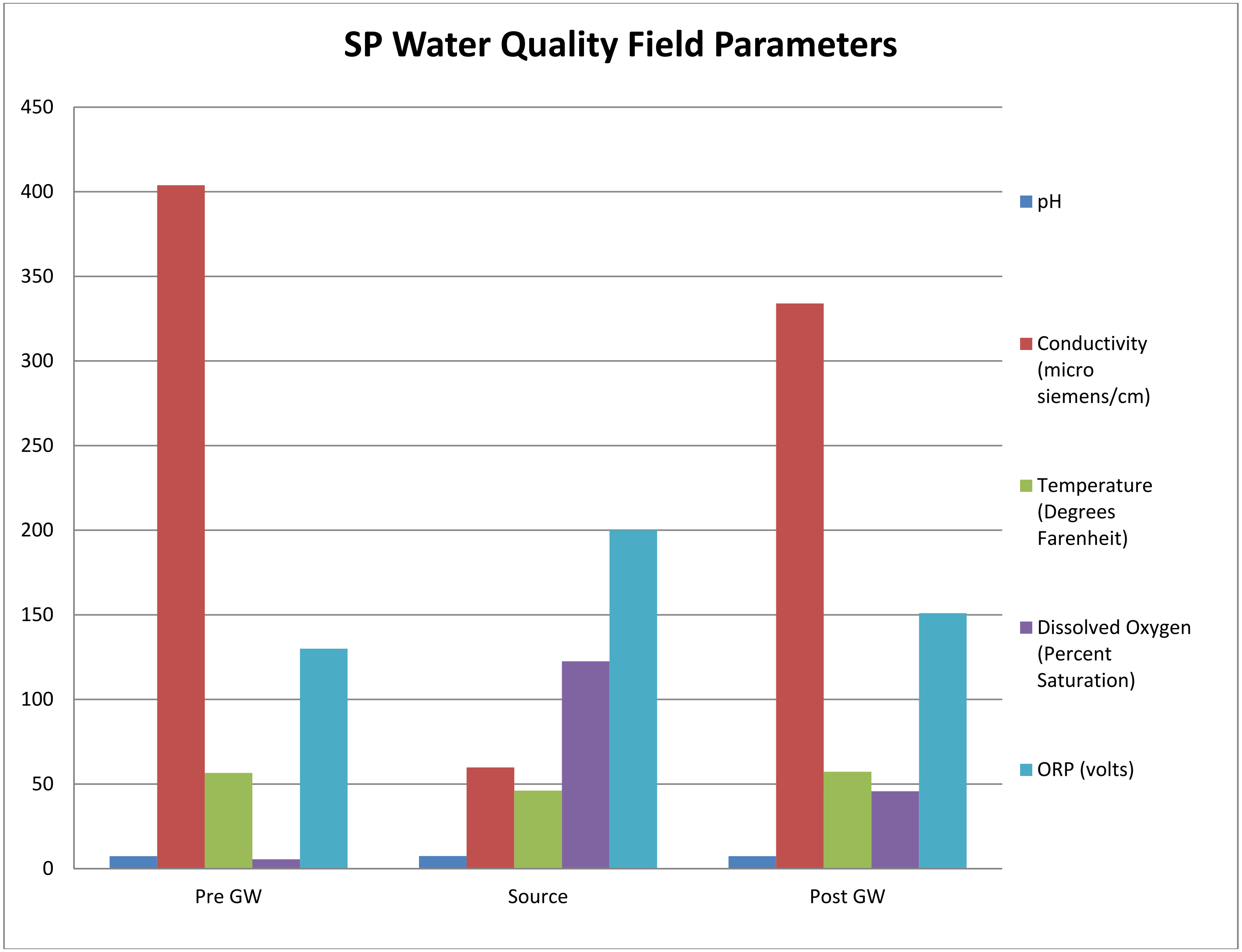

Figure D-1. Stiller Pond field parameters. Pre GW = pre-recharge groundwater sample; Source = recharge source water sample; Post GW = post-recharge groundwater sample. All groundwater samples were collected from monitoring well MWSP-1.

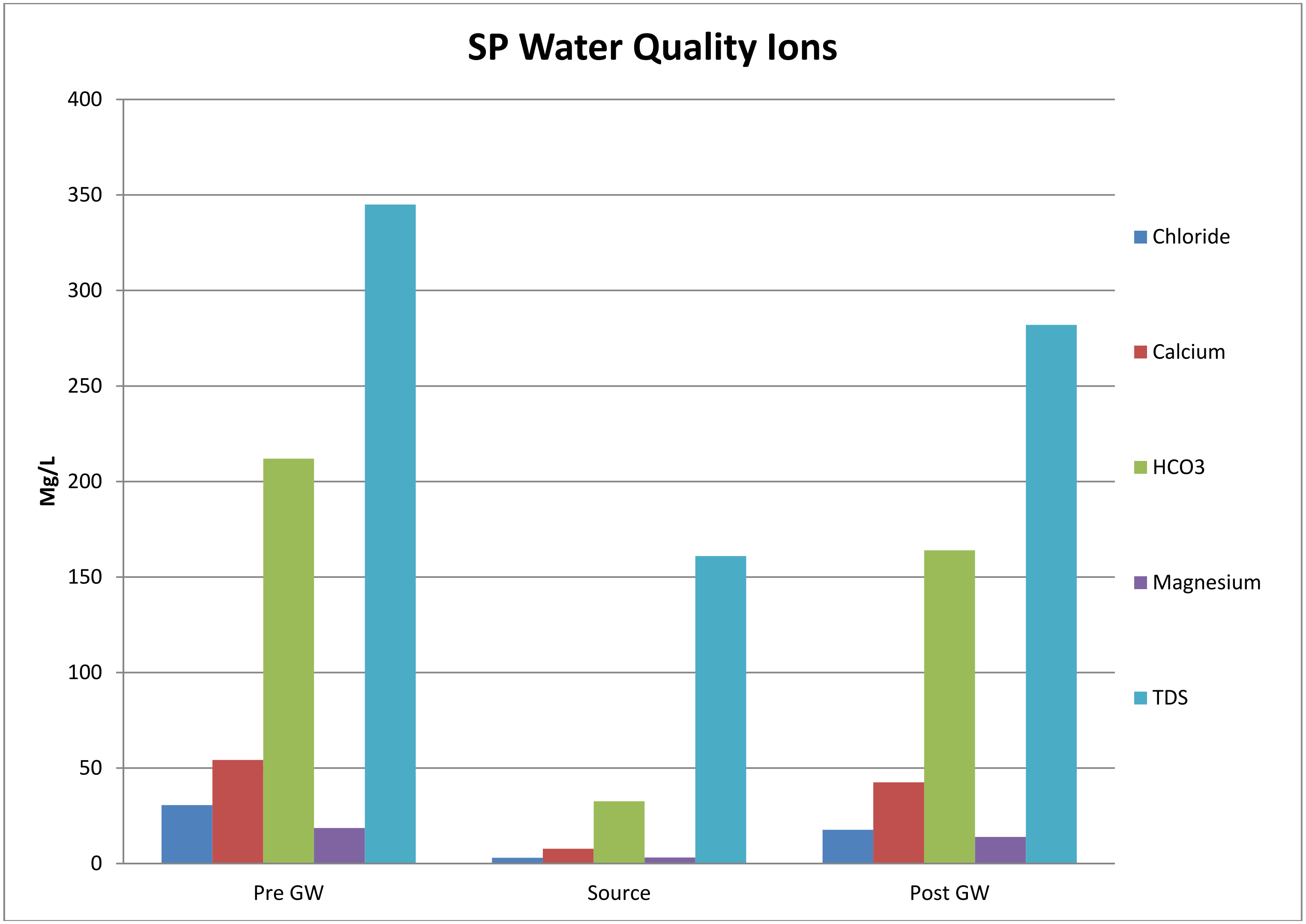

Figure D-2. Stiller Pond water quality ions. Pre GW = pre-recharge groundwater sample; Source = recharge source water sample; Post GW = post-recharge groundwater sample. All groundwater samples were collected from monitoring well MWSP-1. TDS = total dissolved solids.

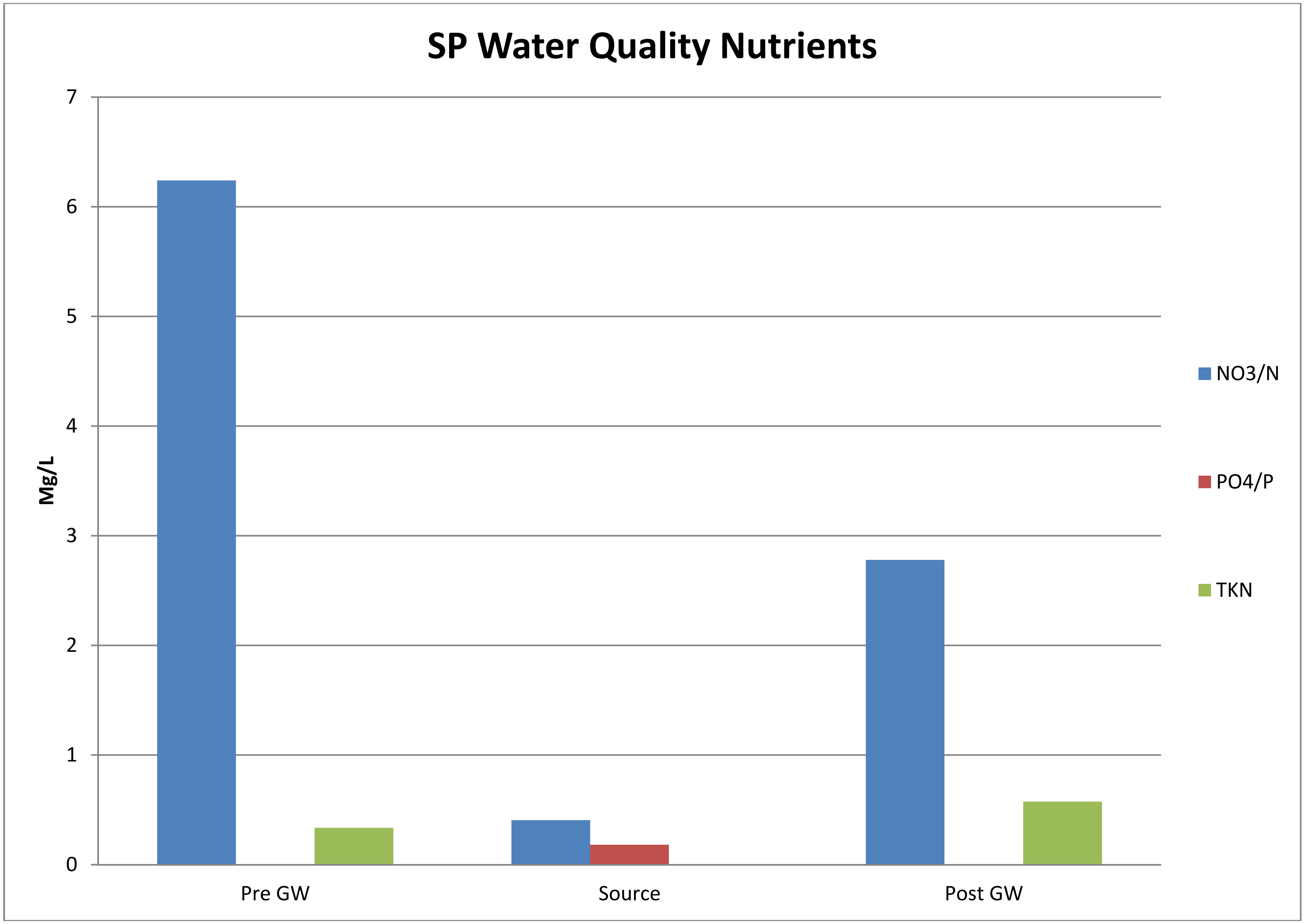

Figure D-3. Stiller Pond water nutrients. Pre GW = pre-recharge groundwater sample; Source = recharge source water sample; Post GW = post-recharge groundwater sample. All groundwater samples were collected from monitoring well MWSP-1. TKN = total Kjeldahl nitrogen.