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TECHNICAL MEMORANDUM

Date: May 24, 2018

To: Wes Kameda, King County Department of Natural Resources

From: Rob Zisette and Phil Coughlan, Herrera Environmental Consultants, Inc.

Subject: Horseshoe Lake Pumping Project Water Quality Analysis

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INTRODUCTION

Since 1991, King County has pumped water out of Horseshoe Lake using temporary pumping systems to reduce flooding of 15 residences on the lake because the lake does not have a surface outlet. King County proposed construction of a permanent pumping system to an infiltration area located 0.7 miles south of the lake that is intended to be used in the future for infiltration of stormwater from surrounding residential developments. In 2015, King County prepared a draft State Environmental Policy Act (SEPA) Checklist summarizing environmental impacts of the permanent pumping system.

The Muckleshoot Indian Tribe (Tribe) commented on the draft SEPA checklist because they operate a salmon hatchery near the mouth of Crisp Creek, which is a high-quality stream located downgradient of the infiltration area. The Tribe was seeking assurances that no adverse impacts to surface and groundwater resources would result from the lake pumping project and stormwater infiltration proposals. Their water quality concerns generally included:

- More than 5 years may be needed to monitor impacts on streams and groundwater due to extended travel times of the infiltrated waters through the aquifer.
- Criteria for determining significant impacts of the pumping project need to be developed cooperatively between the Tribe and King County.
- Surface water monitoring stations should be expanded to also include Crisp Creek at the Auburn-Black Diamond Road.
- Surface water quality monitoring parameters should be expanded to also include ammonia nitrogen, orthophosphate, and total phosphorus.
- Groundwater quality monitoring parameters should include temperature, pH, dissolved oxygen, conductivity, orthophosphate, nitrate+nitrite, and the following dissolved metals: arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.
- Dissolved zinc and copper concentrations may increase due to pipeline construction materials or other sources, and it was recommended to treat infiltration waters if the dissolved zinc concentration exceeds 5 µg/L or the dissolved copper concentration exceeds 2 µg/L.

In 2016 and 2017, King County monitored surface water and groundwater quality during and after separate pumping events that discharged lake water to the infiltration area using a temporary pumping system. King County requested that Herrera Environmental Consultants prepare a new draft SEPA checklist to evaluate the potential impacts from construction and operation of a portion of the proposed permanent floodwater conveyance pipeline, and to address the Tribe's concerns with updated project and monitoring information. The purpose of this technical memorandum is to evaluate effects of the pumping project on surface water and groundwater quality for the SEPA checklist.

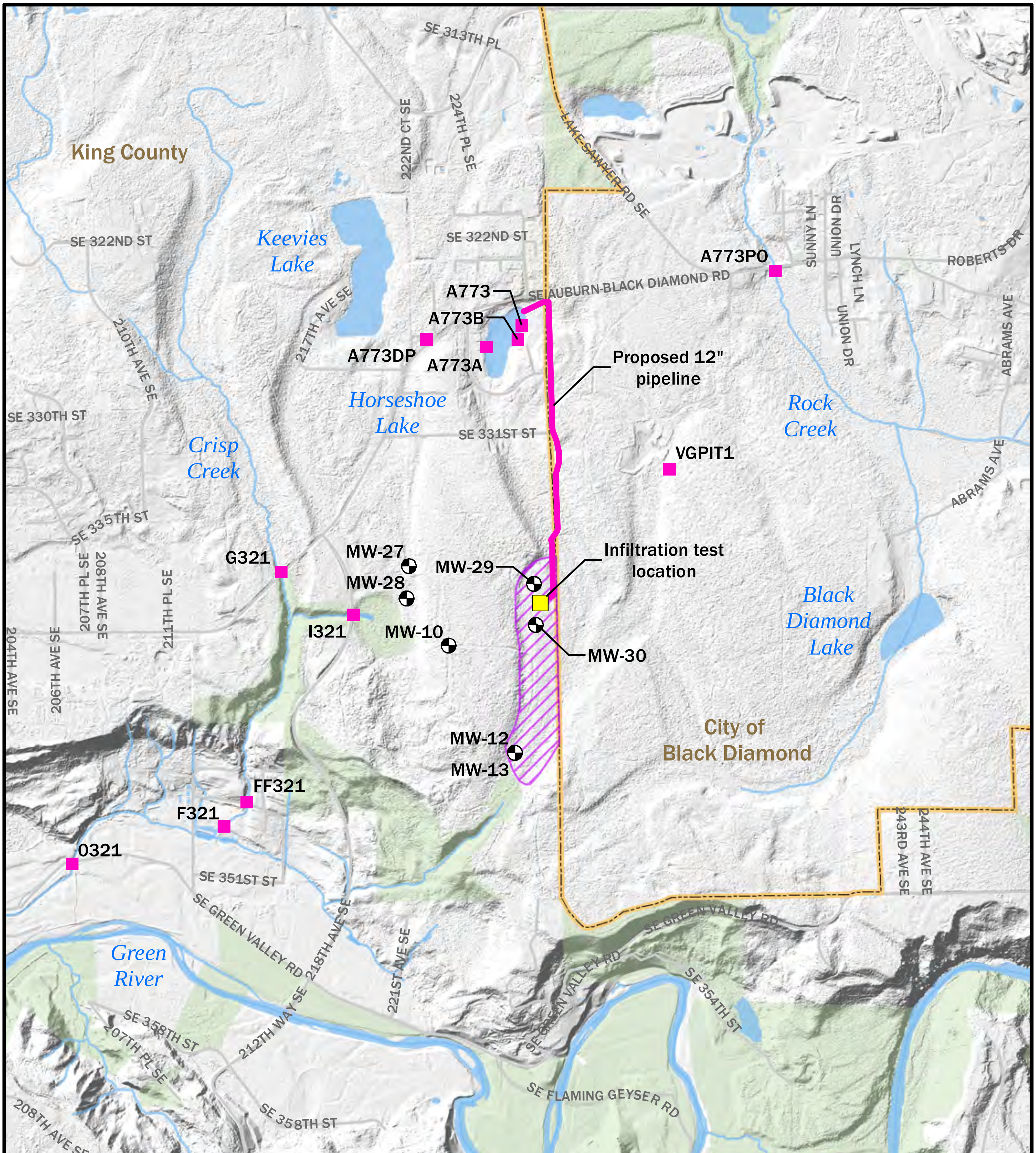
Pumping Project Background

Horseshoe Lake is a closed depression in unincorporated King County just west of the city of Black Diamond. Horseshoe Lake does not have a surface water outlet; however, it is hydraulically connected to groundwater and is subject to rapid changes in elevation. Periodically, the rising water level of Horseshoe Lake threatens infrastructure and the 15 residences along the waterfront. Emergency pumping of Horseshoe Lake is required to maintain roadway access, protect property, and protect the environment by preventing flooding of septic systems (King County 2017).

King County has performed emergency pumping nine times (1991, 1996, 1997, 2007, 2009, 2011, 2014, 2016, and 2017) (King County 2017; Wes Kameda, King County WLRD, personal communication). Prior to 2016, water was pumped to various locations located east or north of the lake. In 2016 and 2017, water was pumped south to an infiltration test pit within the proposed “Reserve at Woodlands.” However, reestablishing equipment access and clearing of an area to place a pump each time there is a threat of flooding is costly and time consuming and creates the potential for an unintended expansion of impacts adjacent to the edge of Horseshoe Lake.

King County, with the help of BD Village Partners, LP, is proposing to construct a 5,000-foot-long pipeline from Horseshoe Lake to the Reserve at Woodlands infiltration test pit (Figure 1.) The purpose of the pipeline is to convey excess lake water (floodwater) away from the lake during periods when lake levels threaten to flood homes and a county road. Periods of threatening lake levels occur nearly every year during the winter/spring wet season in response to high rainfall amounts causing stormwater runoff and a rising groundwater table in the vicinity of the lake. The infiltration test pit will allow water discharged from the pipeline to infiltrate into the ground without causing flooding of nearby areas.

King County, with the assistance of Golder Associates, monitored groundwater and streams in the vicinity of the infiltration test pit for 2 years (2016 and 2017) during use of the temporary conveyance pipeline. In accordance with the development agreement (King County 2014), they will continue monitoring through 2020, or until the pit is approved to accept stormwater from the proposed new developments. If significant adverse impacts have been or will be caused, use of the pipeline will cease; and King County will seek a different discharge location for Horseshoe Lake flood water. If that happens, any portion of the pipeline on the surface will be removed; and the rest will be abandoned. If King County finds that significant adverse impacts will not be caused, King County and BD Village Partners plan to bury the remaining surface portion of the pipe permanently and make the Reserve at Woodlands infiltration test pit the permanent discharge location for Horseshoe Lake flood water.



Legend

- Groundwater monitoring well
- Surface water sampling site
- Proposed pipeline
- Proposed regional stormwater facility
- City limits
- Waterbodies

Figure 1.
Horseshoe Lake Pumping Project Water Quality Monitoring Locations.

N

0 1,000 2,000 4,000 Feet

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When King County monitoring determines that Horseshoe Lake levels have risen to and will exceed a surface water elevation of 512.0 feet, pumping will be initiated to convey the excess water through the pipeline to the Reserve at Woodlands infiltration test pit. Pumping will be conducted at a flow rate, duration, and volume necessary to reduce the potential for flooding of homes and to bring the lake levels back down to a surface water elevation of 510.0 feet. The maximum flow rate of pumping will not exceed 6 cubic feet per second (cfs), and the maximum continuous duration and volume of pumping is expected to be no more than 2 weeks and 167 acre-feet, based on past events where pumping was required to prevent flooding of homes (King County 2014).

During periods of pumping in the 5 years following installation of the pipeline, BD Village Partners, LP, will perform groundwater monitoring as outlined in the attached Golder Associates memorandum entitled "Reserve at Woodlands Infiltration Testing and Monitoring Strategy." The strategy includes monitoring groundwater levels at identified test wells and surface water conditions along Crisp Creek and the Green River north valley wall. Results of the monitoring and related analysis will be shared with King County and the Muckleshoot Tribe, per the Development Agreement. King County will monitor surface and groundwater quality as described in a water quality monitoring plan and summarized below for 2016 and 2017.

During previous pumping events, King County staff monitored various environmental factors in the area to determine impacts, if any, from the pumping. Water quality parameters were monitored in the lake and other receiving waters, but groundwater quality was not monitored before 2016 (King County 2016).

In 2016 and 2017, the water levels of Horseshoe Lake increased to near-flood levels after one of the wettest October-through-March periods on record, raising the groundwater levels that control the lake level in the winter. King County decided to conduct emergency pumping of the lake due to a rapid steady rise in lake levels during January 2016 and March 2017. Water was pumped from the lake to the Reserve at Woodlands infiltration test pit south of the lake, (Figure 1), which is the site of the proposed regional stormwater facility on property owned by Yarrow Bay Holdings (King County 2016). Seven monitoring wells in the vicinity of the infiltration test pit were monitored for water level changes and water quality during the emergency pumping in 2016 and 2017.

Horseshoe Lake pumping events that have occurred since 2009 are summarized in Table 1. In 2009 and 2011, moderate amounts of water (24 and 43 acre-feet, respectively) were pumped to a detention pond located northwest of the lake. In 2014, a moderate amount (38 acre-feet) was pumped to a gravel pit located east of the lake. Pumping amounts increased to 79 acre-feet in 2016 and to 109 acre-feet in 2017 Reserve at Woodlands infiltration pit located south of the lake.

Table 1. Horseshoe Lake Pumping Events.

Year	Discharge Location	Pump Volume (AF)[a]	Pump Rate Maximum (cfs)	Pump Rate Average (cfs)[b]	Pump Start Date	Pump Stop Date	Pump Days
2009	W Pond D98730	24	1.5	0.3	3/23/09	4/29/09	37
2011	W Pond D98730	43	1.5	0.3	3/23/11	5/29/11	67
2014	SE Gravel Pit	38	4	0.8	4/7/14	5/1/14	24
2016	Infiltration Site	79	8.4	0.9	2/5/16	3/18/16	42
2017	Infiltration Site	109	6	1.2	3/24/17	5/9/17	46

[a] The 2009 pump volume assumes it was proportional to 2011 pump days based on same reported rate and location.

[b] Average pump rate is based on pump volume and days.

AF = acre feet; cfs = cubic feet per second

Water Quality Data Analysis Methods

Surface water and groundwater monitoring station locations are presented in Table 2 and shown in Figure 1. Surface water quality data were collected for each of the five pumping events since 2009 at different locations and for different parameters (Table 3) (Tim Clark, King County Department of Natural Resources, personal communication, August 23, 2017). Stations monitored in 2016–2017 include the lake (A773B), infiltration pit (INFILT), wetland (I321), and Crisp Creek immediately above the Muckleshoot Tribe's Keta Creek Hatchery (FF321). Parameters monitored in 2016–2017 include field parameters (temperature, pH, dissolved oxygen, and conductivity), alkalinity, hardness, total suspended solids, turbidity, nutrients (orthophosphate, total phosphorus, ammonia nitrogen, nitrate+nitrite, and total nitrogen), and dissolved metals (aluminum, antimony, arsenic, beryllium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, selenium, silver, thallium, and zinc). Total metals were added in 2017 along with fecal coliform and *E. coli*.

Table 2. Horseshoe Lake Pumping Project Monitoring Stations.

Name	Locator ID	Description
Surface Water		
Crisp Mouth	0321	Crisp Creek at bridge on SE Green Valley Road, west of 212th Place SE
Crisp Hatchery 1	F321	Crisp Creek above hatchery pond intake
Crisp Hatchery 2	FF321	Crisp Creek at SE 348th Street upstream of hatchery intake
Crisp Upper	G321	Upper Crisp Creek at Auburn/Black Diamond Road
Crisp east of Hatchery	H321	Crisp Creek east of hatchery pond (2014 only)
Wetland Outflow	I321	Wetland east of 218th Avenue SE
Outfall – Pond	A773DP	Detention pond pipe outfall, north of Horseshoe Lake (2009–2011 only)
Lake	A773	Horseshoe Lake, 0.5 miles west of Black Diamond
Lake Shore	A773A	Shoreline of Horseshoe Lake
Lake E Shore	A773B	East Shoreline of Horseshoe Lake, south of pipe intake

Table 2 (continued). Horseshoe Lake Pumping Project Monitoring Stations.

Name	Locator ID	Description
Surface Water (continued)		
Outfall – Pipe	A773PO	Rock Creek (overflow for 2009/2011 sampling only)
Village Pit	VGPIT1	VILLAGE GRAVEL PIT – PUMPING SITE (2014 only)
Infiltration Pit	INFILT	Reserve at Woodlands Infiltration Pit
Groundwater		
MW-29	SEKC_MW-29	Adjacent and North of pit; screened in Qpog1(silty) shallow
MW-30	SEKC_MW-30	Adjacent and South of pit; screened in Qpog1(silty) shallow
MW-12	SEKC_MW-12	South of pit; screened in Qpog1(silty) shallow – bottom
MW-13	SEKC_MW-13	South of pit; screened in Qpog1(silty) shallow – top
MW-10	SEKC_MW-10	West of pit; screened in Qpog1(gravel) deep – bottom
MW-28	SEKC_MW-28	West of pit; screened in Qpog1(gravel) deep – top
MW-27	SEKC_MW-27	West of pit; screened in Qpog1(gravel) deep – top

Table 3. Horseshoe Lake Pumping Project Sampling Events.

Year	Event	Sample Start Date	Sample Stop Date	No. of Sample Events	Stations Sampled	Parameters Analyzed
Surface Water						
2009	Pumping	2/28/09	5/18/09	5	A773, A779DP	Field, TSS, TP/SRP, Fecal
2011	Pumping	3/10/11	4/25/11	6	A773, A773DP, F321, G321	Field, TSS, Alk, T/D Metals
2014	Pumping	4/2/14	5/15/14	5	A773B, VGPIT1, F321, I321	Field, TSS, Alk, T/D Metals
2016	Pumping	1/7/16	4/14/16	8	A773B, INFILT, F321, I321	Field, Alk, TSS, Nutrients, D Metals
2017	Pumping	3/22/17	5/30/17	8	A773B, INFILT, F321, FF321, I321	Field, Alk, TSS, Nutrients T/D Metals
Groundwater						
2016	Pumping	2/16/16	3/10/2016	1	MW-10, 12, 13, 27, 28, 29, 30	Field, Alk, TSS, Turb, Nutrients, D Metals
	Post-Pump	9/26/2016	10/6/2016	1	MW-10, 12, 13, 27, 28, 29, 30	Field, Alk, TSS, Turb, Nutrients, D Metals
2017	Pumping	4/17/17	4/19/2017	1	MW-10, 12, 13, 27, 28, 29, 30	Field, Alk, TSS, Turb, FC/EC, Nutrients, T/D Metals
	Post-Pump	8/29/17	8/31/2017	1	MW-10, 12, 27, 28, 29, 30	Field, Alk, TSS, Turb, Nutrients, T/D Metals

TSS = total suspended solids; Turb = turbidity; TP/SRP = total and soluble reactive phosphorus; Alk = alkalinity; Nutrients = nitrogen and phosphorus analyses; D/T Metals = total and dissolved metals analyses; FC/EC = fecal coliform and *E. coli* bacteria.

Groundwater quality data were collected from each of seven wells on one occasion both during and after each of the pumping events in 2016 and 2017 as summarized in Table 3 (Wesley Kameda, King County Department of Natural Resources, personal communication, August 16, 2017; and Eric Ferguson, King County Department of Natural Resources, personal communication, October 25, 2017). The seven monitoring wells include two wells (MW-29 and MW-30) located in the shallow silt aquifer within 400 feet of the infiltration pit, two wells (MW-12 and MW-13) located next to each other in the shallow silt aquifer approximately 2,200 feet south of the infiltration pit, and three wells (MW-10, MW-27, and MW-28) located in the deep gravel aquifer at 1,230–1,730 feet west of the infiltration pit (see Figure 1 and Table 6). One exception is that samples were not collected at MW-13 during post-pumping events because the well was dry. Parameters monitored in 2016–2017 were the same as the surface water quality parameters.

As part of an ambient stream monitoring program, King County monitors the ecological health of Crisp Creek in a variety of ways including collecting and analyzing water, sediment, and benthic invertebrate samples (King County 2018). Station 0321 is located at the mouth of the creek at the bridge on Southeast Green Valley Road, west of 212th Place Southeast. Water quality samples were collected monthly at this station from 1972 to 2008 when budget cutbacks forced King County to reduce the breadth of its water quality monitoring program. Sampling at this station resumed in February 2013. In 1993, King County began collecting water quality samples at an additional station on Crisp Creek (F321) located upstream of the Keta Creek Hatchery inflow near Southeast 348th and 215th Avenue Southeast. Sampling at this station was discontinued in 2008 due to the aforementioned budget issues, but resumed in February 2013. In 2017, the Crisp Creek hatchery station was moved upstream roughly 100 feet due to construction in the area, and was renamed FF321. Additional stream stations monitored on rare occasions for special studies include upper Crisp Creek at Auburn/Black Diamond Road (five samples in 2011 at station G321) and Crisp Creek east of hatchery ponds (six samples in 2014 at station H321) (see Figure 1).

Ambient water quality monitoring data collected by King County for Crisp Creek were used to supplement pumping project data for this water quality evaluation. Monitoring data were evaluated separately for samples collected in two separate periods of time (historical in 1998–2008 and recent in 2013–2016) and two types of flow condition (base flow in dry conditions and storm flow in wet conditions), as summarized in Table 4. Data collected prior to 1998 were not used in the analysis because metals detection limits were high and some water quality conditions have since changed, and no data were available for 2009 through 2012. Ambient monitoring parameters generally include those monitored in surface waters for the pumping project, but metals were analyzed less frequently than other parameters.

Table 4. Ambient Crisp Creek Data Used for the Horseshoe Lake Pumping Project Water Quality Evaluation.					
	Number of Base Samples		Number of Storm Samples[a]		
Period	0321	F321	0321	F321	Parameters Analyzed
1998–2008	127	157	38	12	Field, TSS, Alk, Nutrients
	11	8	36	12	D/T Metals
2013–2016	48	48	0	0	Field, TSS, Alk, Nutrients
	0[b]	0[b]	0	0	D/T Metals

[a] Storm samples were collected for the Green-Duwamish River Watershed Water Quality Assessment.

[b] Metals are no longer analyzed for the ambient water quality monitoring program.

TSS = total suspended solids; Turb = turbidity; TP/SRP = total and soluble reactive phosphorus; Alk = alkalinity; Nutrients = nitrogen and phosphorus analyses; D/T Metals = total and dissolved metals analyses

Water quality data were compiled into groups to evaluate how water quality conditions vary with the following locations and conditions (Table 5):

- Ambient Surface Water – Historical (1998–2008) base and storm flow conditions, and recent (2013–2016) base flow conditions in Crisp Creek at the hatchery and stream mouth station
- Pumping Project Surface Water – Recent conditions during the 2016 and 2017 pumping events at Horseshoe Lake, infiltration pit, 212th wetland, and Crisp Creek at the hatchery stations
- Pumping Project Groundwater – Recent conditions during and after the 2016 and 2017 pumping events at the shallow nearby wells, shallow south wells, and deep west wells

Table 5. Horseshoe Lake Pumping Project Water Quality Evaluation Data Analysis Grouping.			
Data Group Name	Locator ID	Sample Start Date	Sample Stop Date
Ambient Surface Water			
Crisp Hatchery 1998–2008 Base	F321	2/10/1998	12/3/2008
Crisp Hatchery 1998–2008 Storm		11/14/2001	11/18/2003
Crisp Hatchery 2013–2016 Base		2/5/2013	12/14/2016
Crisp Mouth 1998–2008 Base	0321	2/10/1998	12/11/2008
Crisp Mouth 1998–2008 Storm		1/14/1998	8/20/2008
Crisp Mouth 2013–2016 Base		2/5/2013	12/14/2016
Pumping Project Surface Water			
Lake 2016 Pump	A773B	1/7/2016	9/29/2016
Lake 2017 Pump		3/22/2017	5/30/2017
Pit 2016 Pump	INFILT	2/10/2016	3/17/2016
Pit 2017 Pump		3/30/2017	5/2/2017

Table 5 (continued). Horseshoe Lake Pumping Project Water Quality Evaluation Data Analysis Grouping.			
Data Group Name	**Locator ID**	**Sample Start Date**	**Sample Stop Date**
Pumping Project Surface Water (continued)			
Wetland 2016 Pump	I321	1/28/2016	4/14/2016
Wetland 2017 Pump		3/22/2017	5/30/2017
Crisp Hatchery 2016 Pump	F321	1/28/2016	9/29/2016
Crisp Hatchery 2017 Pump	F321, FF321	3/22/2017	5/30/2017
Pumping Project Groundwater			
Shallow Near Wells 2016/17 Pump	MW-29, MW-30	2/16/2016	3/10/2016
		4/17/2017	4/19/2017
Shallow Near Wells 2016/17 After	MW-29, MW-30	9/26/2016	10/6/2016
		8/29/2017	8/31/2017
Shallow South Wells 2016/17 Pump	MW-12, MW-13	2/16/2016	3/10/2016
		4/17/2017	4/19/2017
Shallow South Wells 2016/17 After	MW-12	9/26/2016	10/6/2016
		8/29/2017	8/31/2017
Deep West Wells 2016/17 Pump	MW-10, MW-27, MW-28	2/16/2016	3/10/2016
		4/17/2017	4/19/2017
Deep West Wells 2016/17 After	MW-10, MW-27, MW-28	9/26/2016	10/6/2016
		8/29/2017	8/31/2017

The groundwater data were grouped to account for different travel times through aquifers to wells and surface waters. Table 6 presents estimated ranges of travel times to each well and surface water station. King County estimated a range in travel rates for one well in the shallow silt aquifer (MW-12) and one well in the deep gravel/sand aquifer (MW-10) based on a range in hydraulic gradient, average hydraulic conductivity, and average porosity (Eric Ferguson, King County Department of Natural Resources, personal communication, October 25, 2017). Hydraulic conductivity for the wells ranged from 0.002 feet/feet in the fall to 0.006 feet/feet in the winter and spring when groundwater levels are higher. Hydraulic conductivity was calculated as aquifer transmissivity divided by thickness for MW-10 (358 feet/day) and MW-12 (38.5 feet/day). Average porosity was similar for each well (0.32 for MW-10 and 0.35 for MW-12). Travel rates for MW-12 were applied to other wells located in the shallow silt aquifer (MW-13, MW-29, and MW-30). Travel rates for MW-10 were applied to other wells in the deep gravel/sand aquifer (MW-27 and MW-28). The range in travel rates from the infiltration pit to the wetland and Crisp Creek were based on the minimum rate for the shallow silt aquifer and the maximum rate for the deep gravel/sand aquifer because groundwater from both aquifers drains to these surface waters. Travel rates were multiplied by the distance to the wells and surface waters to obtain travel time.

Table 6. Horseshoe Lake Pumping Project Water Quality Evaluation Travel Time Estimates.

Location	Distance from Pit (feet)	Aquifer/ Direction from Pit	Travel Rate Minimum (feet/day)	Travel Rate Maximum (feet/day)	Travel Time Minimum (years)	Travel Time Maximum (years)
Well MW-29	290	Shallow/North	0.2	0.7	1.1	4.0
Well MW-30	340	Shallow/South	0.2	0.7	1.3	4.7
Well MW-12	2,230	Shallow/South	0.2	0.7	8.7	31
Well MW-13	2,230	Shallow/South	0.2	0.7	8.7	31
Well MW-10	1,480	Deep/West	2.2	6.7	0.6	1.8
Well MW-28	1,960	Deep/West	2.2	6.7	0.8	2.4
Well MW-27	2,000	Deep/West	2.2	6.7	0.8	2.5
Wetland E of 218th	2,400	Both/West	0.2	6.7	1.0	33
Crisp Creek (at seeps)	3,500	Both/West	0.2	6.7	1.4	48

Travel rates are based on the range in hydraulic gradient range and average transmissivity/porosity of MW-10 for deep gravel/sand aquifer and of MW-12 for shallow silty aquifer.

Travel times are shorter for the wells located west of the infiltration pit (0.6 to 2.5 years) than those located nearest the infiltration pit because of the higher travel rate through the deep gravel/sand aquifer. Travel times are greatest for the wells located south of the infiltration pit (9 to 31 years). Travel times to surface waters are estimated to range over a long period of time (1 to 48 years). Thus, it is expected to take at least a year for the majority of pumped water to drain to any monitoring well or surface water station.

The approximate amount of dilution occurring in the aquifers was calculated for the shallow and deep aquifers from the area of aquifer impacted, depth of water in the aquifer, and porosity of the aquifer. The area of aquifer impacted was estimated at 187 acres, which includes the area extending west and southwest from the infiltration pit to Crisp Creek between the monitoring station at Auburn-Black Diamond Road (station G321) and the current monitoring station at the hatchery (station FF321) (see Figure 1). Aquifer depth was estimated at 15 feet for the shallow aquifer and 50 feet for the deep aquifer based on the depth of water for MW-29 and MW-10, respectively, shown on the east-west geologic cross-section prepared by Golder Associates (Figure 3 in Golder 2013). The porosity was estimated at 0.35 for the shallow aquifer and 0.32 for the deep aquifer based on the average porosity for MW-12 and MW-10, respectively (Eric Ferguson, King County Department of Natural Resources, personal communication, October 25, 2017). The resulting aquifer volumes are 980 acre-feet for the shallow aquifer (187 acres area x 15 feet deep x 0.35 porosity) and 2,990 feet for the deep aquifer (187 acres area x 50 feet deep x 0.32 porosity), or approximately 4,000 acre-feet for both aquifers. This compares to a pumping volume of 79 acre-feet in 2016 and 109 acre-feet in 2017 (see Table 1). Division of an aquifer volume of 4,000 acre-feet by a total pumping volume of 188 acre-feet yields a dilution ratio of 20. Thus, parameter concentrations in the infiltration water would be expected to be diluted approximately 20 times by groundwater over 2 years of pumping before discharging to Crisp Creek.

Water quality conditions and effects of the pumping project were evaluated for the following parameters of concern:

- Temperature
- Dissolved Oxygen
- pH
- Conductivity
- Hardness
- Orthophosphate Phosphorus
- Total Phosphorus
- Nitrite+Nitrate Nitrogen
- Ammonia Nitrogen
- Total Nitrogen
- Fecal Coliform Bacteria
- Aluminum, Dissolved
- Arsenic, Dissolved and Total
- Cadmium, Dissolved and Total
- Chromium, Dissolved and Total
- Copper, Dissolved and Total
- Lead, Dissolved and Total
- Nickel, Dissolved and Total
- Zinc, Dissolved and Total

The data were evaluated statistically and the results are presented for each data group in separate box and whisker plots, and summary tables for each parameter (Appendix A). One-half of the detection limit was used for undetected values. The box and whisker plots exhibit all data points, the median (line in box), 95 percent confidence interval for the median (notch in box), mean (red x), 25th and 75th percentiles (box ends), and minimum and maximum (whiskers for non-outliers within 1.5 times the 25th and 75th percentile, respectively) for each data group. Only data points and the mean are shown on plots when there are less than five values for a data group. In addition, the number of samples and letter representing the statistical group are listed for each data group on the box and whisker plots.

A Kruskal-Wallis and a multiple range test were used to analyze differences in medians of all parameters among data groups within each of the three types of data (ambient stream, pumping project surface water, and pumping project groundwater). These tests are the non-parametric version of an analysis of variance (ANOVA) used to analyze differences among group means. Statistical tests were performed using R according to Helsel and Hirsch (1992) and the statistical significance was assessed based on an alpha level of 0.05. Letters were assigned to each data group where groups with common letters are not significantly different and groups without common letters are significantly different.

Water Quality Evaluation Findings

Box and whisker plots and tables of statistics are presented separately for each water quality parameter in Appendix A. The mean, median, and range of each parameter of concern are presented for each station/period group in Table 7, which also includes Washington State surface water chronic criteria, groundwater quality criteria, and drinking water criteria for comparison. Undetected values are shown in Table 7 with a less than sign (<) in front of the highest detection limit reported for that parameter. Summary statistics in Appendix A are based on one-half of the detection limit for undetected values.

None of the water quality parameter values exceed surface water or groundwater criteria, with the exception of minimum dissolved oxygen at the mouth of Crisp Creek, mean fecal coliform bacteria at the mouth of Crisp Creek during storm flow, maximum dissolved copper in Horseshoe Lake in 2017, and total arsenic in all groundwater samples.

These findings generally indicate that monitored surface waters and groundwater were typically of acceptable quality for the parameters measured before, during, and after pumping in 2016 and 2017, with the exception of total arsenic in groundwater. Although groundwater sample concentrations exceed the groundwater quality criterion of 0.05 µg/l, they do not exceed the maximum contaminant level of 10 µg/L for drinking water or the chronic criterion of 190 µg/L for dissolved arsenic in surface waters. It is possible that water quality conditions may have exceeded surface water or groundwater quality criteria on occasion because all possible water quality parameters were not analyzed, a large number of samples were not collected at all possible locations, and water quality criteria established by other jurisdictions were not considered.

Spatial and temporal trends in surface water and groundwater quality are summarized for each of these parameters of concern in the following sections.

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Sample Temperature (degrees C)				Dissolved Oxygen (mg/L)				pH				Conductivity (umhos/cm)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	16	7-day daily maximim			9.5	1-day lowest minimum			6.5–8.5	within range			None			
WA Groundwater[b]	None				None				None				None			
WA Drinking Water[c]	None				None				None				700			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream																
Crisp Hatchery 1998-2008 Base	9.1	9.3	6.4	12.1	11.5	11.4	9.5	14.0	7.63	7.70	6.60	8.10	111	113	84	126
Crisp Hatchery 1998-2008 Storm	8.6	8.4	7.3	9.7	11.5	11.6	10.6	12.6	7.67	7.70	7.20	8.20	99	101	70	116
Crisp Hatchery 2013-2016 Base	9.4	9.6	5.3	12.6	11.5	11.4	10.8	12.7	7.74	7.77	7.04	7.97	112	113	54	134
Crisp Mouth 1998-2008 Base	9.5	9.6	5.3	15.2	10.7	10.6	8.4	12.3	7.42	7.40	6.60	8.26	121	121	92	146
Crisp Mouth 1998-2008 Storm	9.5	9.6	6.9	12.4	10.1	10.3	7.7	11.6	7.39	7.41	6.80	8.31	117	118	86	138
Crisp Mouth 2013-2016 Base	9.8	10.1	5.9	13.5	9.9	10.3	6.5	11.4	7.32	7.32	6.82	7.78	122	121	94	144
Pumping Project Surface Water																
Lake 2016 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Lake 2017 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pit 2016 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pit 2017 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetland 2016 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wetland 2017 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Crisp Hatchery 2016 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Crisp Hatchery 2017 Pump	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pumping Project Groundwater																
Shallow Near Wells 2016/17 Pump	10.5	10.6	9.7	10.9	10.5	11.0	8.5	11.4	6.24	6.23	6.04	6.46	67	68	49	84
Shallow Near Wells 2016/17 After	12.6	12.8	11.0	14.0	8.9	9.1	7.0	10.4	6.30	6.30	6.02	6.60	74	72	55	96
Shallow South Wells 2016/17 Pump	9.6	9.6	9.5	9.6	11.2	11.4	10.4	11.6	6.63	6.63	6.58	6.67	72	70	69	77
Shallow South Wells 2016/17 After	10.9	10.9	9.7	12.0	5.9	5.9	3.8	8.0	6.66	6.66	6.61	6.70	101	101	78	125
Deep West Wells 2016/17 Pump	10.2	10.1	9.7	10.7	7.9	8.0	5.1	10.3	6.76	6.72	6.41	7.18	136	149	86	169
Deep West Wells 2016/17 After	10.7	10.8	10.1	11.3	5.7	6.3	1.3	8.1	6.82	6.62	6.47	7.75	142	137	118	170

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Hardness (mg $CaCO_3$/L)				Orthophosphate Phos. (mg/L)				Total Phosphorus (mg/L)				Nitrite + Nitrate Nitrogen (mg/L)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	None				None				None				None			
WA Groundwater[b]	None				None				None				10			
WA Drinking Water[c]	None				None				None				10			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream																
Crisp Hatchery 1998-2008 Base	46	47	40	52	0.014	0.015	0.008	0.024	0.021	0.021	0.011	0.035	0.63	0.62	0.44	1.07
Crisp Hatchery 1998-2008 Storm	43	44	30	51	0.015	0.015	0.011	0.019	0.052	0.026	0.020	0.320	0.68	0.63	0.55	1.00
Crisp Hatchery 2013-2016 Base	NA	NA	NA	NA	0.011	0.011	0.008	0.017	0.026	0.018	0.014	0.420	0.77	0.75	0.63	2.09
Crisp Mouth 1998-2008 Base	50	52	42	56	0.026	0.025	0.014	0.078	0.047	0.044	0.020	0.170	0.74	0.73	0.52	1.28
Crisp Mouth 1998-2008 Storm	47	47	33	57	0.028	0.028	0.016	0.049	0.059	0.056	0.034	0.130	0.84	0.78	0.55	1.63
Crisp Mouth 2013-2016 Base	NA	NA	NA	NA	0.029	0.022	0.015	0.077	0.058	0.042	0.028	0.170	0.82	0.82	0.61	1.70
Pumping Project Surface Water																
Lake 2016 Pump	23	24	15	29	0.006	0.003	0.002	0.014	0.044	0.038	0.028	0.082	0.18	0.23	<0.01	0.35
Lake 2017 Pump	28	27	17	51	0.006	0.003	0.002	0.027	0.051	0.038	0.021	0.110	0.16	0.16	<0.01	0.36
Pit 2016 Pump	30	27	25	37	0.002	0.002	0.001	0.002	0.023	0.023	0.022	0.025	0.68	0.68	0.64	0.73
Pit 2017 Pump	27	27	26	29	0.002	0.002	0.002	0.004	0.027	0.023	0.022	0.036	0.38	0.44	0.26	0.44
Wetland 2016 Pump	35	34	30	39	0.004	0.005	0.002	0.006	0.011	0.010	0.007	0.017	0.62	0.65	0.53	0.70
Wetland 2017 Pump	37	38	31	42	0.005	0.005	0.003	0.010	0.013	0.011	0.009	0.023	0.52	0.53	0.43	0.59
Crisp Hatchery 2016 Pump	41	40	33	55	0.009	0.009	0.008	0.014	0.018	0.017	0.013	0.030	0.81	0.83	0.69	0.89
Crisp Hatchery 2017 Pump	40	41	24	48	0.008	0.009	0.002	0.011	0.023	0.019	0.016	0.054	0.62	0.65	0.37	0.75
Pumping Project Groundwater																
Shallow Near Wells 2016/17 Pump	26	28	18	32	0.004	0.004	0.003	0.006	0.038	0.025	0.011	0.092	2.40	2.52	1.74	2.82
Shallow Near Wells 2016/17 After	25	26	20	30	0.007	0.008	0.003	0.010	0.014	0.015	0.009	0.018	1.74	1.57	1.06	2.76
Shallow South Wells 2016/17 Pump	29	29	27	32	0.012	0.013	0.010	0.015	0.017	0.017	0.014	0.019	0.54	0.46	0.41	0.84
Shallow South Wells 2016/17 After	36	36	31	42	0.026	0.026	0.016	0.037	0.032	0.032	0.023	0.041	0.44	0.44	0.32	0.57
Deep West Wells 2016/17 Pump	58	64	33	80	0.008	0.008	0.006	0.009	0.013	0.012	0.011	0.015	1.47	1.60	0.69	2.22
Deep West Wells 2016/17 After	65	65	53	77	0.007	0.008	0.004	0.009	0.017	0.013	0.010	0.038	1.06	0.89	0.73	2.13

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Ammonia Nitrogen (mg/L)				Total Nitrogen (mg/L)				Fecal Coliform (CFU/100 ml)				Aluminum, Dissolved (µg/L)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	2.2	10 C, 7.7 pH, salmon			None				100	geometric mean			None			
WA Groundwater[b]	None				None				0				None			
WA Drinking Water[c]	None				None				0				None			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream																
Crisp Hatchery 1998-2008 Base	<0.01	<0.01	<0.01	0.02	0.70	0.69	0.36	1.34	9	5	<1	72	11	11	<2	22
Crisp Hatchery 1998-2008 Storm	<0.01	<0.01	<0.01	0.02	0.86	0.76	0.59	1.58	60	24	6	490	40	30	<2	113
Crisp Hatchery 2013-2016 Base	<0.01	<0.01	<0.01	0.01	0.89	0.83	0.69	3.64	26	9	<1	220	NA	NA	NA	NA
Crisp Mouth 1998-2008 Base	0.09	0.07	0.01	0.37	0.99	0.96	0.35	1.80	92	55	3	750	19	19	17	21
Crisp Mouth 1998-2008 Storm	0.09	0.09	0.02	0.18	1.18	1.08	0.75	2.25	490	215	29	4100	29	29	29	29
Crisp Mouth 2013-2016 Base	0.12	0.08	0.02	0.35	1.17	1.09	0.82	2.61	65	39	<1	330	NA	NA	NA	NA
Pumping Project Surface Water																
Lake 2016 Pump	0.03	<0.01	<0.01	0.22	0.86	0.93	0.54	1.21	NA	NA	NA	NA	37	33	15	62
Lake 2017 Pump	0.01	<0.01	<0.01	0.03	0.84	0.81	0.64	1.27	NA	NA	NA	NA	20	10	8	73
Pit 2016 Pump	0.10	0.10	0.10	0.11	1.04	1.03	1.01	1.07	NA	NA	NA	NA	21	21	19	23
Pit 2017 Pump	0.02	0.01	<0.01	0.03	0.77	0.79	0.71	0.81	NA	NA	NA	NA	11	11	10	13
Wetland 2016 Pump	<0.01	<0.01	<0.01	0.01	0.70	0.74	0.59	0.76	NA	NA	NA	NA	4	3	3	8
Wetland 2017 Pump	0.01	0.01	<0.01	0.01	0.63	0.64	0.52	0.71	NA	NA	NA	NA	9	6	3	25
Crisp Hatchery 2016 Pump	<0.01	<0.01	<0.01	<0.01	0.89	0.90	0.77	1.04	NA	NA	NA	NA	17	15	<2	32
Crisp Hatchery 2017 Pump	<0.01	<0.01	<0.01	0.01	0.78	0.75	0.71	0.92	NA	NA	NA	NA	16	15	8	23
Pumping Project Groundwater																
Shallow Near Wells 2016/17 Pump	<0.01	<0.01	<0.01	0.01	2.41	2.48	1.81	2.88	<1	<1	<1	<1	<2	<2	<2	4
Shallow Near Wells 2016/17 After	<0.01	<0.01	<0.01	<0.01	1.84	1.67	1.10	2.94	NA	NA	NA	NA	<2	<2	<2	<2
Shallow South Wells 2016/17 Pump	<0.01	<0.01	<0.01	<0.01	0.54	0.47	0.44	0.80	<1	<1	<1	<1	<2	<2	<2	<2
Shallow South Wells 2016/17 After	<0.01	<0.01	<0.01	0.02	0.47	0.47	0.35	0.58	NA	NA	NA	NA	<2	<2	<2	<2
Deep West Wells 2016/17 Pump	<0.01	<0.01	<0.01	0.01	1.48	1.57	0.71	2.27	<1	<1	<1	<1	3	<2	<2	10
Deep West Wells 2016/17 After	<0.01	<0.01	<0.01	<0.01	1.10	0.95	0.76	2.17	NA	NA	NA	NA	<2	<2	<2	<2

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Aluminum, Total (µg/L)				Arsenic, Dissolved (µg/L)				Arsenic, Total (µg/L)				Cadmium, Dissolved (µg/L)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	None				190	4-day average			None				0.52	hardness = 40		
WA Groundwater[b]	None				None				0.05				None			
WA Drinking Water[c]	None				None				10				None			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream																
Crisp Hatchery 1998-2008 Base	35	32	10	63	0.53	0.55	<0.5	0.57	0.55	0.56	0.48	0.62	<0.2	<0.2	<0.2	<0.2
Crisp Hatchery 1998-2008 Storm	47	43	11	69	0.57	0.57	0.52	0.61	0.61	0.60	0.38	0.94	<0.2	<0.2	<0.2	<0.2
Crisp Hatchery 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Crisp Mouth 1998-2008 Base	171	112	60	502	0.59	0.59	<0.5	0.64	0.66	0.62	0.51	0.95	<0.2	<0.2	<0.2	<0.2
Crisp Mouth 1998-2008 Storm	NA	NA	NA	NA	0.56	0.58	<0.5	0.71	0.79	0.72	0.51	1.30	<0.2	<0.2	<0.2	0.2
Crisp Mouth 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pumping Project Surface Water																
Lake 2016 Pump	NA	NA	NA	NA	0.66	0.65	<0.5	0.89	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2
Lake 2017 Pump	86	64	20	234	0.51	0.54	<0.5	0.60	0.64	0.65	0.30	0.95	<0.2	<0.2	<0.2	<0.2
Pit 2016 Pump	NA	NA	NA	NA	0.85	0.89	0.78	0.89	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2
Pit 2017 Pump	109	126	73	127	0.54	0.51	0.50	0.61	0.62	0.62	0.59	0.65	<0.2	<0.2	<0.2	<0.2
Wetland 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2
Wetland 2017 Pump	27	11	7	129	<0.5	<0.5	<0.5	<0.5	0.28	0.25	0.21	0.49	<0.2	<0.2	<0.2	<0.2
Crisp Hatchery 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	0.53	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2
Crisp Hatchery 2017 Pump	159	111	45	664	<0.5	<0.5	<0.5	<0.5	0.49	0.46	0.40	0.76	<0.2	<0.2	<0.2	<0.2
Pumping Project Groundwater																
Shallow Near Wells 2016/17 Pump	754	754	118	1390	<0.5	<0.5	<0.5	<0.5	0.29	0.29	0.17	0.40	<0.2	<0.2	<0.2	<0.2
Shallow Near Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2
Shallow South Wells 2016/17 Pump	7	7	3	10	<0.5	<0.5	<0.5	<0.5	0.15	0.15	0.13	0.17	<0.2	<0.2	<0.2	<0.2
Shallow South Wells 2016/17 After	NA	NA	NA	NA	0.54	0.54	<0.5	0.79	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2
Deep West Wells 2016/17 Pump	58	70	<2	102	<0.5	<0.5	<0.5	0.50	0.36	0.39	0.21	0.48	<0.2	<0.2	<0.2	<0.2
Deep West Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.2	<0.2	<0.2	<0.2

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Cadmium, Total (µg/L)				Chromium, Dissolved (µg/L)				Chromium, Total (µg/L)				Copper, Dissolved (µg/L)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	None				None				84	hardness = 40			5.2	hardness = 40		
WA Groundwater[b]	10				None				50				None			
WA Drinking Water[c]	5				None				100				None			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream																
Crisp Hatchery 1998-2008 Base	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8
Crisp Hatchery 1998-2008 Storm	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.4	<0.5	<0.5	<0.5	0.8
Crisp Hatchery 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Crisp Mouth 1998-2008 Base	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	1.3	<0.5	<0.5	<0.5	0.9
Crisp Mouth 1998-2008 Storm	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	0.7	0.6	<0.5	2.1	0.6	0.5	<0.5	1.7
Crisp Mouth 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pumping Project Surface Water																
Lake 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	2.1	2.1	1.1	3.2
Lake 2017 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	2.8	1.6	0.8	6.6
Pit 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	0.8	0.8	0.7	0.8
Pit 2017 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.0	1.0	0.9	1.0
Wetland 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5
Wetland 2017 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Crisp Hatchery 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	1.1
Crisp Hatchery 2017 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	0.5	0.5	<0.5	1.2	<0.5	<0.5	<0.5	0.9
Pumping Project Groundwater																
Shallow Near Wells 2016/17 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	0.5	1.9	1.9	0.9	2.8	<0.5	<0.5	<0.5	<0.5
Shallow Near Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	0.7	NA	NA	NA	NA	<0.5	<0.5	<0.5	0.8
Shallow South Wells 2016/17 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Shallow South Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5
Deep West Wells 2016/17 Pump	<0.2	<0.2	<0.2	<0.2	<0.5	<0.5	<0.5	<0.5	0.7	0.5	<0.5	1.1	<0.5	<0.5	<0.5	0.6
Deep West Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Copper, Total (µg/L)				Lead, Dissolved (µg/L)				Lead, Total (µg/L)				Nickel, Dissolved (µg/L)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	None				0.92	hardness = 40			None				72	hardness = 40		
WA Groundwater[b]	1000				None				50				None			
WA Drinking Water[c]	1300				None				15				None			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream																
Crisp Hatchery 1998-2008 Base	<0.5	<0.5	<0.5	1.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Crisp Hatchery 1998-2008 Storm	0.6	<0.5	<0.5	2.3	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5
Crisp Hatchery 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Crisp Mouth 1998-2008 Base	0.6	<0.5	<0.5	2.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.6
Crisp Mouth 1998-2008 Storm	1.2	1.2	<0.5	4.0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	<0.5	<0.5	1.0
Crisp Mouth 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pumping Project Surface Water																
Lake 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	0.5	<0.5	<0.5	0.9
Lake 2017 Pump	2.2	1.9	1.0	4.0	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	0.8
Pit 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5
Pit 2017 Pump	1.0	1.0	1.0	1.1	<0.5	<0.5	<0.5	<0.5	0.9	0.6	<0.5	2.2	0.6	0.5	<0.5	0.9
Wetland 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5
Wetland 2017 Pump	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6
Crisp Hatchery 2016 Pump	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5
Crisp Hatchery 2017 Pump	<0.5	<0.5	<0.5	1.4	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5
Pumping Project Groundwater																
Shallow Near Wells 2016/17 Pump	1.6	1.6	0.6	2.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.9	0.7	<0.5	2.1
Shallow Near Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	0.9	0.9	<0.5	1.5
Shallow South Wells 2016/17 Pump	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Shallow South Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5
Deep West Wells 2016/17 Pump	<0.5	0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5
Deep West Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Table 7. Water Quality Summary for the Horseshoe Lake Pumping Project.

	Nickel, Total (µg/L)				Zinc, Dissolved (µg/L)				Zinc, Total (µg/L)			
Water Quality Criteria	**Value**	**Condition**			**Value**	**Condition**			**Value**	**Condition**		
WA Surface Water Chronic[a]	None				48	hardness = 40			None			
WA Groundwater[b]	None				None				5000			
WA Drinking Water[c]	100				None				5000			
Station/Period	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**	**mean**	**median**	**min**	**max**
Ambient Stream												
Crisp Hatchery 1998-2008 Base	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5
Crisp Hatchery 1998-2008 Storm	<0.5	<0.5	<0.5	1.5	0.6	<0.5	<0.5	1.9	1.0	0.6	<0.5	5.4
Crisp Hatchery 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Crisp Mouth 1998-2008 Base	<0.5	<0.5	<0.5	1.2	0.7	0.7	<0.5	1.6	1.4	0.9	0.6	4.7
Crisp Mouth 1998-2008 Storm	0.7	0.6	<0.5	2.5	1.2	0.9	<0.5	4.0	2.8	2.5	0.6	8.3
Crisp Mouth 2013-2016 Base	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pumping Project Surface Water												
Lake 2016 Pump	NA	NA	NA	NA	6.0	6.0	<0.5	11.8	NA	NA	NA	NA
Lake 2017 Pump	0.7	0.6	<0.5	1.4	4.2	2.6	2.2	11.8	7.8	7.7	2.7	18.2
Pit 2016 Pump	NA	NA	NA	NA	6.5	6.7	5.2	7.5	NA	NA	NA	NA
Pit 2017 Pump	0.6	0.5	<0.5	0.7	8.6	8.9	7.6	9.4	8.1	8.3	6.8	9.1
Wetland 2016 Pump	NA	NA	NA	NA	0.7	0.7	<0.5	1.5	NA	NA	NA	NA
Wetland 2017 Pump	<0.5	<0.5	<0.5	<0.5	1.3	0.8	0.6	3.6	1.1	1.0	<0.5	2.4
Crisp Hatchery 2016 Pump	NA	NA	NA	NA	1.1	1.0	0.7	1.8	NA	NA	NA	NA
Crisp Hatchery 2017 Pump	<0.5	<0.5	<0.5	1.1	1.7	0.7	<0.5	8.6	3.4	1.9	0.7	10.8
Pumping Project Groundwater												
Shallow Near Wells 2016/17 Pump	2.0	2.0	1.2	2.7	<0.5	<0.5	<0.5	1.0	1.7	1.7	0.9	2.5
Shallow Near Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	0.7	NA	NA	NA	NA
Shallow South Wells 2016/17 Pump	<0.5	<0.5	<0.5	0.5	0.6	<0.5	<0.5	1.4	0.7	0.7	0.5	0.9
Shallow South Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	<0.5	NA	NA	NA	NA
Deep West Wells 2016/17 Pump	0.5	0.5	<0.5	0.8	0.7	<0.5	<0.5	2.6	1.1	1.0	1.0	1.3
Deep West Wells 2016/17 After	NA	NA	NA	NA	<0.5	<0.5	<0.5	0.9	NA	NA	NA	NA

[a] Water Quality Standards for Surface Waters of the State of Washington, Chapter 173-201A WAC

[b] Water Quality Standards for Groundwaters of the State of Washington, Chapter 173-200 WAC

[c] Group A Public Water Supplies, Chapter 246-290 WAC

NA = not analyzed

Temperature

Water temperatures in Crisp Creek were not significantly different among the different groups of monitoring stations (surface and ground), time periods (1998–2008, 2013–2016, and 2016/2017), and hydrologic conditions (base and storm) evaluated. Maximum temperatures did not exceed the surface water quality criterion of not to exceed 16°C for any surface or groundwater group. The 16°C criterion is based on a 7-day average of the daily maximum temperature (7-DADMax) for core summer salmonid habitat. Crisp Creek is designated for core summer salmonid habitat, and not for supplemental protection of salmonid spawning and incubation. For this evaluation, the criterion is compared to the maximum temperatures measured during grab sampling rather than 7-DADMax values because calculation of 7-DADMax values require continuous temperature monitoring data that was not collected at the Crisp Creek stations.

Median temperatures were typically lower in Crisp Creek (8.6 to 9.8°C) than groundwater (9.6 to 12.8°C), which was likely due to natural insulation of aquifer materials from cold air temperatures. No water temperature data were available for surface water stations during pumping for comparison to ambient stream and groundwater conditions.

Median groundwater temperatures were consistently higher after pumping (10.8 to 12.8°C) than during pumping (9.6 to 10.9°C)in each of the three groups of wells (shallow near, shallow south, and deep west), which is likely due to natural seasonal differences in temperatures between the winter/spring during pumping and the fall after pumping.

Dissolved Oxygen

Dissolved oxygen concentrations in Crisp Creek significantly decreased from upstream of the hatchery to the stream mouth (e.g., minimum value decreased from 10.8 to 6.5 mg/L in 2013–2016 base flow), possibly due to a high oxygen demand in hatchery effluent or the inflow of deep groundwater with low oxygen. Dissolved oxygen concentrations in Crisp Creek were generally not significantly different among the different groups of time periods and hydrologic conditions evaluated. However, dissolved oxygen at the stream mouth during base flow in the 1998–2008 period significantly decreased during storm flow in that period and during base flow in the 2013–2016 period. The minimum dissolved oxygen concentration in Crisp Creek met the surface water quality criterion of at least 9.5 mg/L above the hatchery, but not at the stream mouth.

Median dissolved oxygen concentrations were typically higher in Crisp Creek (10.3 to 11.4 mg/L) than in groundwater (5.9 to 11.4 mg/L), which is likely due to microbial respiration and a lack of oxygen sources in soils and aquifer materials. However, dissolved oxygen concentrations may have been lower at night in Crisp Creek than in groundwater due to diurnal variation in algae photosynthesis and respiration. No dissolved oxygen data were available for surface water stations during pumping for comparison to ambient stream and groundwater conditions.

Median dissolved oxygen concentrations in groundwater decreased after pumping in each group of wells, but the decrease was only significant in the shallow south wells (decrease from 11.4 to 5.9 mg/L). This temporal trend was likely due to natural seasonal differences in dissolved oxygen concentrations between the winter/spring during pumping and the fall after pumping.

pH

The pH in Crisp Creek significantly decreased from upstream of the hatchery to the stream mouth (e.g., median value decreased from 7.8 to 7.3 in 2013–2016 base flow), possibly due to a lower pH in hatchery effluent or stream tributaries. The pH in Crisp Creek was generally not significantly different among the different groups of time periods and hydrologic conditions evaluated. However, pH above the hatchery during base flow in the 1998–2008 period (median of 7.7) significantly increased in the 2013–2016 period (median of 7.8). All stream pH results met the water quality criterion of between 6.5 and 8.5.

The pH was typically higher in Crisp Creek (median values of 7.3 to 7.8) than in groundwater (median values of 6.2 to 6.7), which is likely due to more dissolved carbon dioxide (which is acidic) in groundwater caused by more microbial respiration (which produces carbon dioxide) in groundwater and primary productivity (algae growth consuming carbon dioxide) in Crisp Creek. Also, pH varied more in Crisp Creek (6.6 to 8.3) than in groundwater (6.0 to 7.8) due to the natural diurnal variation in stream algae photosynthesis and respiration. Pumping project data did not include pH in surface water samples for comparison to the pH in groundwater samples or ambient stream program samples.

Median pH values in groundwater were similar during and after pumping in each group of wells. Groundwater pH was lowest in the shallow near wells, but not significantly different than the other two groups of wells.

Conductivity

Conductivity in Crisp Creek was not significantly different among the different groups of monitoring stations, time periods, and hydrologic conditions evaluated. One exception is that the median conductivity during base flow significantly increased downstream from the hatchery (113 μmhos/cm in 2013–2016) to the stream mouth (121 μmhos/cm in 2013–2016), possibly due to a higher conductivity in stream tributaries or deep groundwater inflow.

The range in conductivity of Crisp Creek (54 to 146 μmhos/cm) was within the range observed in groundwater (49 to 170 μmhos/cm). No conductivity data were available for surface water stations during pumping for comparison to ambient stream and groundwater conditions.

Groundwater conductivity increased after pumping in the shallow south wells (median value increased from 70 to 101 μmohs/cm), but this increase was not significant; and no increase was observed in the shallow near or deep west wells. The conductivity increase after pumping in the shallow south wells was likely caused by seasonal differences in shallow groundwater recharge. Conductivity was significantly higher in the deep west wells than the other two groups of wells during pumping, due to a naturally higher dissolved solids content in deep than shallow groundwater.

Hardness

Hardness is the concentration of calcium and magnesium. Hardness in Crisp Creek was not significantly different among the different groups of monitoring stations, time periods, and hydrologic conditions evaluated. Median hardness slightly increased downstream from the hatchery (47 mg/L as $CaCO_3$ in 1998–2008 base flow) to the stream mouth (52 mg/L as $CaCO_3$ in 1998–2008 base flow), possibly due to a higher hardness in hatchery effluent, stream tributaries, or deep groundwater inflow.

The range in hardness of Crisp Creek (30-57 mg/L as $CaCO_3$) was within the range observed in groundwater (18 to 77 mg/L as $CaCO_3$). Water hardness at the surface water stations did not vary much between the 2016 and 2017 pumping events. Generally, hardness during pumping increased from the lake and infiltration pit (median ranging from 24 to 27 mg/L as $CaCO_3$) to the wetland and Crisp Creek (median ranging from 34 to 41 mg/L as $CaCO_3$), with significant differences observed only between the lake and Crisp Creek.

Groundwater hardness did not significantly decrease after pumping despite the significantly lower hardness of water pumped from the lake and the reduced natural recharge of groundwater during the summer/fall period after pumping. Hardness was significantly higher in the deep west wells (median ranging from 64 to 65 mg/L as $CaCO_3$) than the other two groups of wells (median ranging from 26 to 36 mg/L as $CaCO_3$), due to a naturally higher dissolved solids content in deep than shallow groundwater.

Orthophosphate Phosphorus

Orthophosphate (soluble reactive) phosphorus concentrations in Crisp Creek significantly increased from upstream of the hatchery to the stream mouth (e.g., median value increased from 0.011 to 0.022 mg/L in 2013–2016 base flow), likely due to orthophosphate in hatchery effluent. Orthophosphate phosphorus concentrations significantly decreased between the 1998–2008 and 2013–2016 time periods above the hatchery (e.g., median value decreased from 0.015 to 0.011 mg/L in base flow), but not below the hatchery at the stream mouth.

Orthophosphate phosphorus concentrations in Crisp Creek above the hatchery (0.008 to 0.024 mg/L) were within the range observed in groundwater (0.003 to 0.037 mg/L). Orthophosphate phosphorus concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events. Median orthophosphate phosphorus concentrations during pumping were significantly higher in Crisp Creek (0.009 mg/L) in comparison to concentrations measured at the infiltration pit (0.002 mg/L); concentrations measured at all other locations were not statistically different.

Orthophosphate phosphorus concentrations in groundwater increased after pumping in the shallow near and shallow south wells, but the increases were not significant and no increase was observed in the deep west wells. During pumping, median orthophosphate concentrations in groundwater at the shallow near and deep west wells (0.004 to 0.008 mg/L) were similar to those observed in Crisp Creek above the hatchery (0.009 mg/L).

Total Phosphorus

Total phosphorus concentrations in Crisp Creek significantly increased from upstream of the hatchery to the stream mouth (e.g., median value increased from 0.018 to 0.042 mg/L in 2013–2016 base flow), likely due to phosphorus in hatchery effluent. Median total phosphorus concentrations significantly increased from base to storm flow at both stations (i.e., increased from 0.021 to 0.026 mg/L above the hatchery and from 0.044 to 0.056 mg/L at the stream mouth), and significantly decreased from the 1998–2008 to 2013–2016 time periods during base flow at the hatchery station (i.e., decreased from 0.021 to 0.018 mg/L), but not at the stream mouth.

Total phosphorus concentrations in Crisp Creek above the hatchery (0.011 to 0.110 mg/L excluding outliers) were generally within the range observed in groundwater (0.009 to 0.092 mg/L) with the exception of occasional outlier values. Total phosphorus concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events. Median total phosphorus concentrations during pumping were significantly higher in the lake (0.038 mg/L) than the wetland (0.010 and 0.011 mg/L) or Crisp Creek above the hatchery (0.017 and 0.019 mg/L). Total phosphorus concentrations in the lake during pumping were similar to those observed during base flow in Crisp Creek below the hatchery at the stream mouth (e.g., median value of 0.042 mg/L in 2013–2016).

Total phosphorus concentrations in groundwater increased after pumping in the shallow south wells, but this increase was not significant and was not observed in the shallow near or deep west wells. During pumping, median total phosphorus concentrations in groundwater at the shallow near and deep west wells (0.012 to 0.025 mg/L) were similar to those observed in Crisp Creek above the hatchery (0.017 to 0.019 mg/L).

Nitrite+Nitrate Nitrogen

Nitrate+nitrite nitrogen concentrations in Crisp Creek were significantly different among the different groups of monitoring stations and time periods, but not between base and storm flow conditions. Median nitrate+nitrite nitrogen concentrations significantly increased downstream from above the hatchery to the stream mouth during base and storm flow (e.g., increased from 0.75 to 0.82 mg/L during base flow in 2013–2016 and from 0.63 to 0.78 mg/L during storm flow in 1998–2008), possibly due to higher concentrations in hatchery effluent, stream tributaries, or deep groundwater inflow. Nitrate+nitrite nitrogen concentrations significantly increased from the 1998–2008 to 2013–2016 time periods during base flow at both stream stations (i.e., increased from 0.62 to 0.75 mg/L above the hatchery and from 0.73 to 0.82 mg/L at the stream mouth).

Nitrate+nitrite nitrogen concentrations in Crisp Creek above the hatchery (0.44 to 2.09 mg/L) were within the range observed in groundwater (0.32 to 2.82 mg/L). Nitrate+nitrite nitrogen concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events at the lake or wetland, but were significantly higher in 2016 at the infiltration pit and in Crisp Creek above the hatchery. Median nitrate+nitrite nitrogen concentrations during pumping were lowest in the lake (0.16 and 0.23 mg/L), higher in the infiltration pit and wetland (0.44 to 0.68 mg/), and highest in Crisp Creek above the hatchery (0.65 and 0.83 mg/L).

Nitrate+nitrite nitrogen concentrations in groundwater were not significantly different between pumping and after pumping sampling events, but median concentrations in the shallow near and deep west wells decreased substantially from the winter/spring pumping period to the fall after pumping period (i.e., decreased from 2.52 to 1.57 mg/L in the shallow near wells and from 1.60 to 0.89 mg/L in the deep west wells). All nitrate+nitrite nitrogen concentrations in groundwater samples were well below the groundwater criterion of 10 mg/L.

Ammonia Nitrogen

Total ammonia nitrogen concentrations in Crisp Creek significantly increased from upstream of the hatchery to the stream mouth (e.g., median value increased from less than 0.01 to 0.08 mg/L in 2013–2016 base flow), likely due to high ammonia in hatchery effluent. Median ammonia nitrogen concentrations did not significantly change from the 1998–2008 to 2013–2016 time periods during base flow.

Ammonia nitrogen concentrations in Crisp Creek above the hatchery (less than 0.01 to 0.02 mg/L) were within the range observed in groundwater (less than 0.01 to 0.02 mg/L). Ammonia nitrogen concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events with the exception of unusually high ammonia concentrations (approximately 0.10 mg/L) observed in 2016 at the infiltration pit. This unusually high concentration may have been caused by a short-term lake source based on only one high ammonia concentration (0.216 mg/L) observed among the nine lake samples collected in 2016. Median ammonia nitrogen concentrations during pumping in 2016 were not detected at less than 0.01 mg/L in the lake, wetland, and Crisp Creek above the hatchery.

Ammonia nitrogen concentrations in groundwater generally did not increase after pumping in the shallow near or deep west wells, but ammonia in one sample from the shallow south wells was elevated (0.02 mg/L) after pumping. Median ammonia nitrogen concentrations in groundwater (less than 0.01 mg/L) were similar to those observed in Crisp Creek above the hatchery (less than 0.01 mg/L).

Total Nitrogen

Total nitrogen concentrations generally followed the same patterns observed for nitrate+nitrite nitrogen because the primary component of total nitrogen is nitrate in surface water and groundwater.

Total nitrogen concentrations in Crisp Creek were significantly different among the different groups of monitoring stations, time periods, and hydrologic conditions. Median total nitrogen concentrations significantly increased downstream from above the hatchery to the stream mouth during base and storm flow (e.g., increased from 0.83 to 1.09 mg/L during base flow in 2013–2016 and from 0.76 to 1.08 mg/L during storm flow in 1998–2008), possibly due to higher concentrations in hatchery effluent, stream tributaries, or deep groundwater inflow. Total nitrogen concentrations significantly increased from the 1998–2008 to 2013–2016 time periods during base flow at both stream stations (i.e., increased from 0.69 to 0.83 mg/L above the hatchery and from 0.96 to 1.09 mg/L at the stream mouth). Also, total nitrogen concentrations significantly increased from base to storm flow at both stream stations (i.e., increased from 0.69 to 0.76 mg/L above the hatchery and from 0.96 to 1.08 mg/L at the stream mouth).

Total nitrogen concentrations in Crisp Creek above the hatchery (0.36 to 3.64 mg/L) were generally within the range observed in groundwater (0.35 to 2.94 mg/L). Total nitrogen concentrations at the surface water stations did not vary significantly between the 2016 and 2017 pumping events at the surface water stations. Median total nitrogen concentrations during pumping were lowest in the wetland (0.64 and 0.74 mg/L), but generally not significantly different than the lake (0.81 and 0.93 mg/L), infiltration pit (0.79 and 1.03 mg/L), or Crisp Creek above the hatchery (0.75 and 0.90 mg/L).

Total nitrogen concentrations in groundwater were not significantly different between pumping and after pumping sampling events, but median concentrations in the shallow near and deep west wells decreased substantially from the winter/spring pumping period to the fall after pumping period (i.e., decreased from 2.48 to 1.67 mg/L in the shallow near wells and from 1.57 to 0.95 mg/L in the deep west wells).

Fecal Coliform Bacteria

Fecal coliform bacteria concentrations in Crisp Creek significantly increased from upstream of the hatchery to the stream mouth (e.g., median value increased from 9 to 39 CFU/100 mL in 2013–2016 base flow). Fecal coliform bacteria concentrations in Crisp Creek significantly increased from base to storm flow in the 1998–2008 period at above the hatchery (5 to 24 CFU/100 mL) and at the stream mouth (55 to 215 CFU/100 mL). Fecal coliform bacteria concentrations in Crisp Creek significantly increased from the 1998–2008 period to the 2013–2016 period at above the hatchery (5 to 9 CFU/100 mL), but not at the stream mouth. Median fecal coliform bacteria concentration in Crisp Creek only exceeded the surface water quality criterion of 100 CFU/100 mL for the geometric mean during storm flow at the stream mouth (215 CFU/100 mL).

Fecal coliform bacteria data were not available for surface water stations during pumping in 2016 or 2017.

Fecal coliform bacteria were not detected in groundwater samples during pumping in 2016 or 2017.

Aluminum, Dissolved

Dissolved aluminum concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Median dissolved aluminum concentrations in Crisp Creek increased from above the hatchery to the stream mouth during base flow in the 1998–2008 period (i.e., increased from 11 to 19 µg/L), and increased from the base to storm flow (i.e., increased from 11 to 30 µg/L above the hatchery and from 19 to 29 µg/L at the stream mouth).

Dissolved aluminum concentrations in Crisp Creek above the hatchery (less than 2 to 113 µg/L) were higher than the range observed in groundwater (less than 2 to 10 µg/L). Median dissolved aluminum concentrations at the surface water stations during the 2016 and 2017 pumping events were highest in the lake (33 and 10 µg/L) and lowest in the wetland in 2016 (3 and 6 µg/L), compared to Crisp Creek above the hatchery (15 µg/L).

Dissolved aluminum concentrations in groundwater typically were not detected in groundwater (less than 2 ug/L) during or after the 2016/2017 pumping events.

Aluminum, Total

Total aluminum concentrations in Crisp Creek significantly increased during base flow in the 1998–2008 period from above the hatchery (median value of 32 µg/L) to the stream mouth (median value of 112 µg/L). Total aluminum concentrations in the 1998–2008 period were not significantly different during base flow (median value of 32 µg/L) and storm flow (median value of 43 µg/L).

Total aluminum was not measured during the 2016 pumping event. Total aluminum concentrations during the 2017 pumping event were not significantly different among the surface water stations, but were lowest in the wetland (11 µg/L) and highest in Crisp Creek above the hatchery (111 µg/L), compared to the lake (64 µg/L).

Total aluminum in groundwater during the 2017 pumping event exhibited a wide range (less than 2 to 1,390 µg/L) that was similar to the range in Crisp Creek (10 to 502 µg/L) with the exception of one outlier at 1,390 µg/L for one of the shallow near wells.

Arsenic, Dissolved

Dissolved arsenic concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum dissolved arsenic concentrations in Crisp Creek did not exceed 1 µg/L, and were all well below the surface water chronic criterion of 190 µg/L.

Dissolved arsenic concentrations in Crisp Creek above the hatchery (less than 0.5 to 0.61 µg/L) were within the range observed in groundwater (less than 0.5 to 0.79 µg/L). Dissolved arsenic concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events at the lake or wetland, but were substantially higher in 2016 at the infiltration pit (0.78 to 0.89 µg/L). Median dissolved arsenic concentrations during pumping were lowest in the wetland, higher in in Crisp Creek above the hatchery, and highest in the lake and infiltration pit.

Dissolved arsenic concentrations in groundwater were not significantly different between pumping and after pumping sampling events with the exception of higher concentrations observed in the shallow south wells after pumping. Maximum dissolved arsenic concentrations in groundwater samples did not exceed 1 µg/L and were all well below the drinking water criterion of 10 µg/L for total arsenic. Dissolved arsenic was typically not detected in the groundwater samples at a detection limit of 0.5 µg/L, which exceeds the groundwater quality standard of 0.05 µg/L for total arsenic.

Arsenic, Total

Total arsenic concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum total arsenic concentrations in Crisp Creek did not exceed 1.3 µg/L, and were all well below the surface water chronic criterion of 190 µg/L for dissolved arsenic.

Total arsenic concentrations in Crisp Creek above the hatchery (0.38 to 1.30 µg/L) were generally less than the range observed in groundwater (0.13 to 0.48 µg/L). Total arsenic was only measured at the surface water stations during the 2017 pumping event. Median total arsenic concentrations during pumping were lowest in the wetland (0.25 µg/L), higher in in Crisp Creek above the hatchery (0.49 µg/L), and highest in the lake (0.65 µg/L) and infiltration pit (0.62 µg/L).

Total arsenic concentrations in groundwater were not measured after pumping events. Maximum total arsenic concentrations in groundwater samples did not exceed 0.5 µg/L and were all well below the drinking water criterion of 10 µg/L for total arsenic. Total arsenic was detected in all groundwater samples, and the minimum total arsenic concentration (0.13 µg/L) exceeds the groundwater quality standard of 0.05 µg/L for total arsenic.

Cadmium, Dissolved

Dissolved cadmium was not detected at any of the surface water or groundwater stations with the exception of the mouth of Crisp Creek, where the maximum concentration was less than 0.25 µg/L and below the surface water chronic criterion of 0.52 µg/L at an typical stream hardness of 40 mg/L (as calcium carbonate). All samples were below the groundwater criterion of 10 µg/L and the drinking water criterion of 5 µg/L for total cadmium.

Cadmium, Total

Total cadmium was not detected at any of the surface water or groundwater stations, and the detection limit of 0.2 µg/L was below the surface water chronic criterion of 0.52 µg/L for dissolved cadmium at an typical stream hardness of 40 mg/L (as calcium carbonate). All samples were below the groundwater criterion of 10 µg/L and the drinking water criterion of 5 µg/L for total cadmium.

Chromium, Dissolved

Dissolved chromium concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum dissolved chromium concentrations in Crisp Creek did not exceed 1 µg/L, and were all well below the surface water chronic criterion of 84 µg/L for trivalent or total chromium at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved chromium concentrations in Crisp Creek above the hatchery were within the range observed in groundwater. Dissolved chromium concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events, and were similarly low at all stations.

Dissolved chromium concentrations in groundwater were not significantly different between pumping and after pumping sampling events. Dissolved chromium concentrations were significantly higher in the shallow near and deep west wells than the shallow south wells during pumping. Maximum dissolved chromium concentrations in groundwater samples did not exceed 1 µg/L, and were all well below the groundwater criterion of 50 µg/L and the drinking water criterion of 100 µg/L.

Chromium, Total

Total chromium concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum total chromium concentrations in Crisp Creek did not exceed 2.1 µg/L, and were all well below the surface water chronic criterion of 84 µg/L for trivalent or total chromium at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total chromium concentrations in Crisp Creek above the hatchery (less than 0.5 to 2.1 µg/L) were similar to the range observed in groundwater (less than 0.5 to 2.8 µg/L). Total chromium concentrations during the 2017 pumping event were similarly low at all surface water stations.

Total chromium was not measured after the pumping events. Total chromium concentrations were highest in the shallow near wells during pumping. Maximum total chromium concentrations in groundwater samples did not exceed 3 µg/L, and were all well below the groundwater criterion of 50 µg/L and the drinking water criterion of 100 µg/L.

Copper, Dissolved

Dissolved copper concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum dissolved copper concentrations in Crisp Creek did not exceed 2 µg/L, and were all below the surface water chronic criterion of 5.2 µg/L at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved copper concentrations in Crisp Creek above the hatchery were within the range observed in groundwater. Dissolved copper concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events, and were significantly higher at the lake than the wetland or Crisp Creek above the hatchery. Median dissolved copper concentrations at the lake during pumping ranged from 1.6 to 2.1 µg/L and did not exceed the surface water quality criterion, but the maximum dissolved copper concentration of 6.6 µg/L exceeded the criterion at the lake during pumping in 2017.

Dissolved copper concentrations in groundwater were not significantly different between pumping and after pumping sampling events. Maximum dissolved copper concentrations in groundwater samples did not exceed 1 µg/L, and were all well below the groundwater criterion of 1,000 µg/L and the drinking water criterion of 1,300 µg/L for total copper.

Copper, Total

Total copper concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum total copper concentrations in Crisp Creek did not exceed 4.0 µg/L, and were all below the surface water chronic criterion of 5.2 µg/L for dissolved copper at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total copper concentrations in Crisp Creek above the hatchery (less than 0.5 to 4.0 µg/L) were similar to the range observed in groundwater (less than 0.5 to 2.7 µg/L). Total copper was only measured at the surface water stations during the 2017 pumping event, and was significantly higher at the lake than the wetland or Crisp Creek above the hatchery. Total copper concentrations at the lake during pumping ranged from 1.0 to 4.0 µg/L and did not exceed the surface water quality criterion for dissolved copper.

Total copper was not measured after pumping events. Maximum total copper concentrations in groundwater samples did not exceed 2.7 µg/L, and were all well below the groundwater criterion of 1,000 µg/L and the drinking water criterion of 1,300 µg/L for total copper.

Lead, Dissolved

Dissolved lead concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. One exception is that dissolved lead concentrations were higher during storm flow than base flow at the mouth of Crisp Creek. Maximum dissolved lead concentrations in Crisp Creek did not exceed 0.3 µg/L, and were all below the surface water chronic criterion of 0.92 µg/L at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved lead concentrations in Crisp Creek above the hatchery were within the range observed in groundwater. Dissolved lead concentrations at the wetland and Crisp Creek above the hatchery were low and did not vary between the 2016 and 2017 pumping events. Dissolved lead concentrations were elevated at the lake and infiltration pit during the 2017 pumping event, but the maximum concentration did not exceed 0.65 µg/L and was below the surface water chronic criterion of 0.92 µg/L at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved lead concentrations in groundwater were typically below the detection limit, and were not significantly different between pumping and after pumping sampling events. Maximum dissolved lead concentrations in groundwater samples did not exceed 0.3 µg/L, and were all well below the groundwater criterion of 50 µg/L and the drinking water criterion of 15 µg/L.

Lead, Total

Total lead concentrations in Crisp Creek significantly increased downstream from above the hatchery to the stream mouth during base flow and storm flow. Maximum total lead concentrations in Crisp Creek did not exceed 0.8 µg/L, and were all below the surface water chronic criterion of 0.92 µg/L for dissolved lead at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total lead concentrations in Crisp Creek above the hatchery (less than 0.5 to 0.8 µg/L) were similar to the range observed in groundwater (less than 0.5 µg/L). Total lead concentrations were low and typically not detected at the surface water stations during the 2017 pumping event with the exception that the maximum concentration at the infiltration pit (2.2 µg/L) exceeded the surface water chronic criterion of 0.92 µg/L for dissolved lead at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total lead concentrations in groundwater were all below the detection limit. Maximum total lead concentrations in groundwater samples were all well below the groundwater criterion of 50 µg/L and the drinking water criterion of 15 µg/L.

Nickel, Dissolved

Dissolved nickel concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated, with the exception of a significant increase from base to storm flow only at the stream mouth. Maximum dissolved nickel concentrations in Crisp Creek did not exceed 1 µg/L, and were all well below the surface water chronic criterion of 72 µg/L at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved nickel concentrations in Crisp Creek above the hatchery generally were within the range observed in groundwater. Dissolved nickel concentrations at the surface water stations did not vary between the 2016 and 2017 pumping events, and were similarly low at all stations.

Dissolved nickel concentrations in groundwater were not significantly different between pumping and after pumping sampling events. Dissolved nickel concentrations were significantly higher in the shallow near wells than the shallow south wells. Maximum dissolved nickel concentrations in groundwater samples did not exceed 2.1 µg/L, and were all well below the drinking water criterion of 100 µg/L for total nickel.

Nickel, Total

Total nickel concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated, with the exception of a significant increase from base to storm flow only at the stream mouth. Total nickel concentrations in Crisp Creek did not exceed 2.5 µg/L, and were all well below the surface water chronic criterion of 72 µg/L for dissolved nickel at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total nickel concentrations in Crisp Creek above the hatchery (less than 0.5 to 2.5 µg/L) were within the range observed in groundwater (less than 0.5 to 2.7 µg/L). Total nickel concentrations during the 2017 pumping event were similarly low at all surface water stations.

Total nickel was not measured after the pumping events. Total nickel concentrations were higher in the shallow near wells (1.2 to 2.7 µg/L) than the other wells (less than 0.5 to 0.8 µg/L). Maximum total nickel concentrations in groundwater samples did not exceed 2.7 µg/L, and were well below the drinking water criterion of 100 µg/L for total nickel.

Zinc, Dissolved

Dissolved zinc concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated. Maximum dissolved zinc concentrations in Crisp Creek did not exceed 4 µg/L, and were all well below the surface water chronic criterion of 48 µg/L at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved zinc concentrations in Crisp Creek above the hatchery (less than 0.5 to 4.0 µg/L) were similar to the range observed in groundwater (less than 0.5 to 2.6 µg/L). Dissolved zinc concentrations at the wetland and Crisp Creek above the hatchery were low and did not vary between the 2016 and 2017 pumping events. Dissolved zinc concentrations were elevated at the lake and infiltration pit during both pumping events, but the maximum concentration did not exceed 12 µg/L and was below the surface water chronic criterion of 48 µg/L at a typical stream hardness of 40 mg/L (as calcium carbonate).

Dissolved zinc concentrations in groundwater were low, and were not significantly different between pumping and after pumping sampling events. Maximum dissolved zinc concentrations in groundwater samples did not exceed 3 µg/L, and were all well below the groundwater and drinking water criterion of 5,000 µg/L for total zinc.

Zinc, Total

Total zinc concentrations in Crisp Creek were not significantly different among the two monitoring stations and hydrologic conditions evaluated, with the exception of a significant increase from base to storm flow only at the stream mouth. Maximum total zinc concentrations in Crisp Creek did not exceed 9 µg/L, and were all well below the surface water chronic criterion of 48 µg/L for dissolved zinc at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total zinc concentrations in Crisp Creek above the hatchery (less than 0.5 to 8.3 µg/L) were higher than the range observed in groundwater (0.5 to 2.5 µg/L). Total zinc concentrations during the 2017 pumping event were elevated at the lake and infiltration pit during the pumping event, but the maximum concentration did not exceed 18 µg/L and was below the surface water chronic criterion of 48 µg/L for dissolved zinc at a typical stream hardness of 40 mg/L (as calcium carbonate).

Total zinc was not measured after the pumping events. Maximum total zinc concentrations in groundwater samples did not exceed 3 µg/L, and were all well below the groundwater and drinking water criterion of 5,000 µg/L for total zinc.

Conclusions

Water quality monitoring results show no indication that the pumping project has impacted surface or groundwater quality to date. Typical concentrations observed in surface and groundwater samples did not exceed surface or groundwater quality criteria for parameters of concern, with the exception total arsenic in all groundwater samples. Although groundwater sample concentrations exceed the groundwater quality criterion of 0.05 µg/l, they do not exceed the maximum contaminant level of 10 µg/L for drinking water or the chronic criterion of 190 µg/L for dissolved arsenic in surface waters. It is possible that water quality conditions may have exceeded surface water or groundwater quality criteria on occasion because all possible water quality parameters were not analyzed, a large number of samples were not collected at all possible locations, and water quality criteria established by other jurisdictions were not considered.

Parameter concentrations in the lake samples were typically within the range observed in the groundwater and stream samples. Exceptions include occasional elevated copper, lead, and zinc in the lake samples compared to the groundwater and other surface water samples. However, maximum concentrations of these metals did not exceed any surface water chronic criteria and would be diluted in groundwater before discharging to Crisp Creek.

Estimated travel times indicate that the majority of pumped lake water would not reach the monitoring wells, wetland, or Crisp Creek monitoring stations within a year of pumping. Travel times to Crisp Creek ranged from 1 to 43 years. Thus, substantial effects of pumping in 2016 and 2017 on surface and groundwater quality may not be evident in the data collected to date. However, the results do indicate that, under current conditions, the Horseshoe Lake pumping project will not impact the water quality of Crisp Creek in the future due to the low parameter concentrations in lake water, substantial dilution of infiltrated lake water with groundwater, and the long travel times through the aquifer to Crisp Creek.

RECOMMENDATIONS

The development agreement requires surface and groundwater monitoring through 2020 or until the pit is approved to accept stormwater from the proposed new developments, and did not specify if it was required only in pumping years. Surface and groundwater quality monitoring conducted in 2016 and 2017 should be continued each year through 2020 to provide additional travel time for evaluation of potential water quality impacts. No changes to monitoring locations, parameters, or frequency are recommended. Monitoring for pumping project impact evaluation should continue regardless of whether lake pumping is occurring in that year to evaluate impacts of previous pumping events.

Water level monitoring data collected at wells during and after pumping should be used to estimate travel times for comparison to those estimated by aquifer material characteristics.

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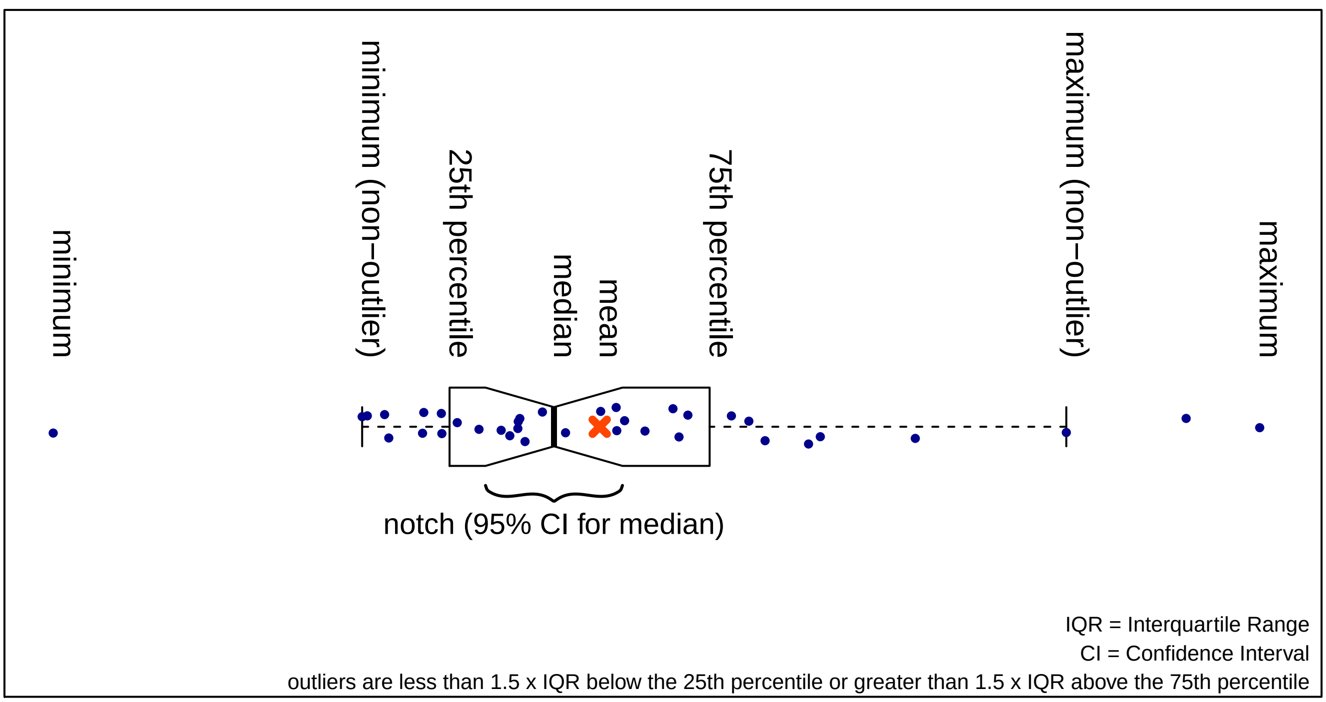
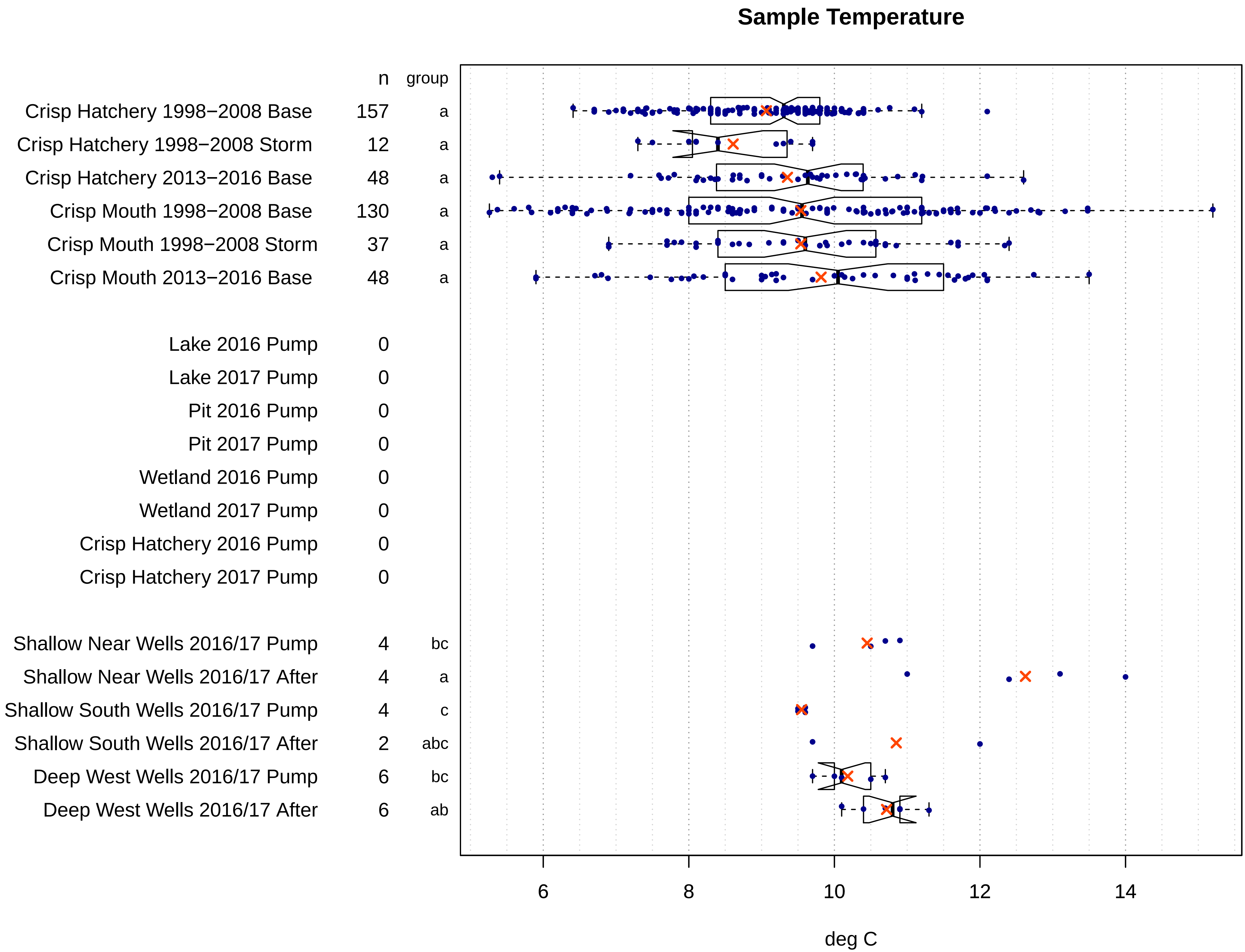
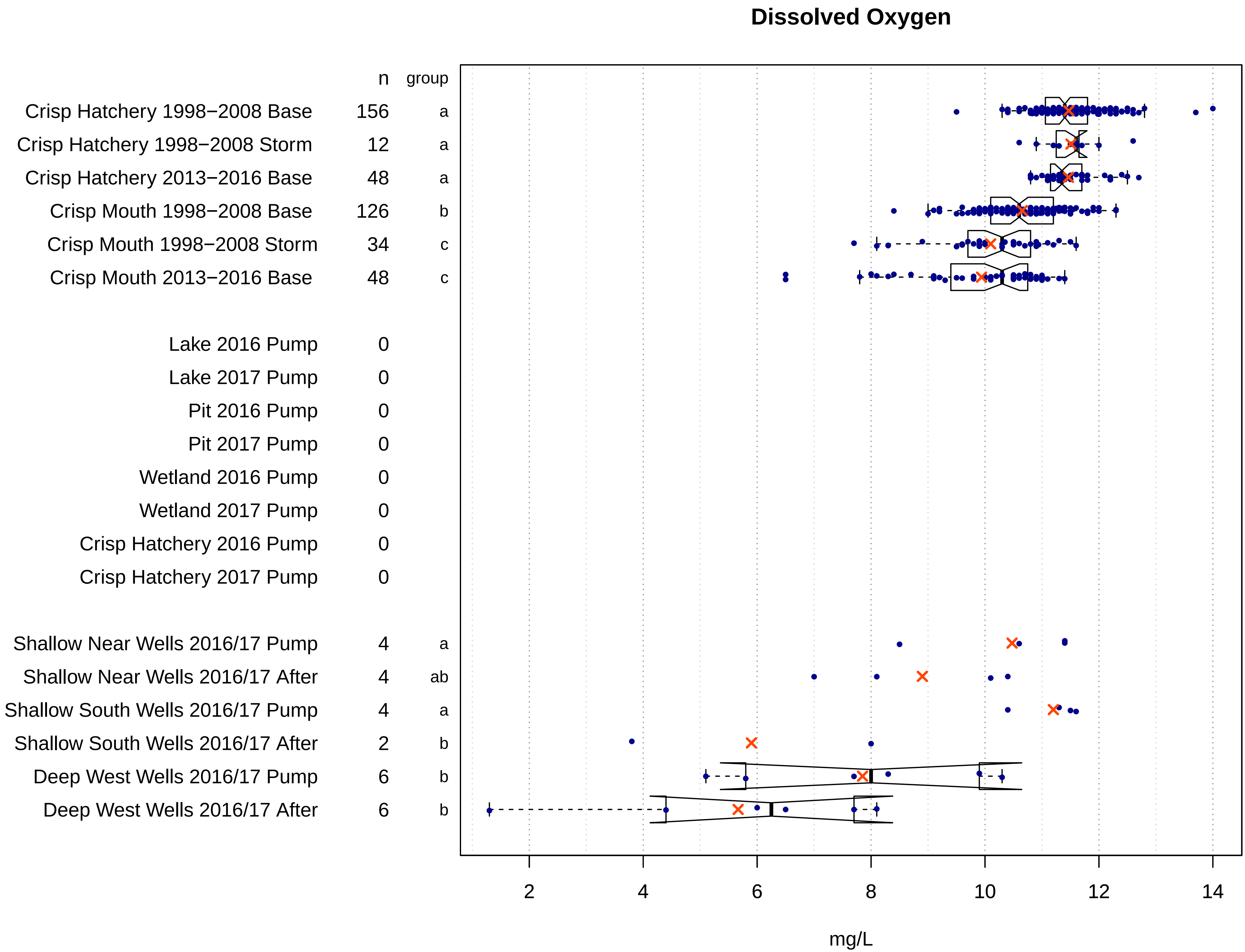
APPENDIX A

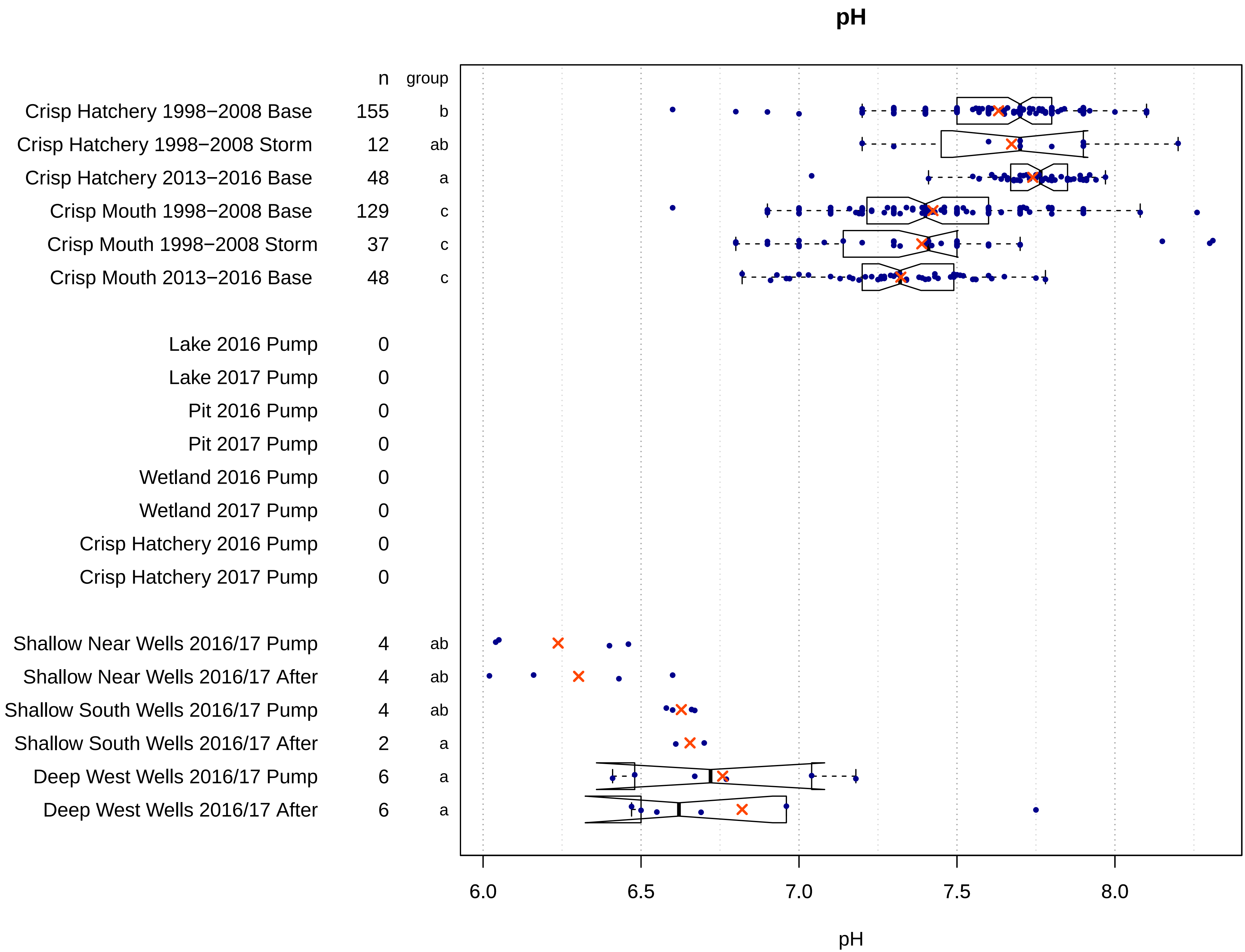
Box Plots and Statistics Tables

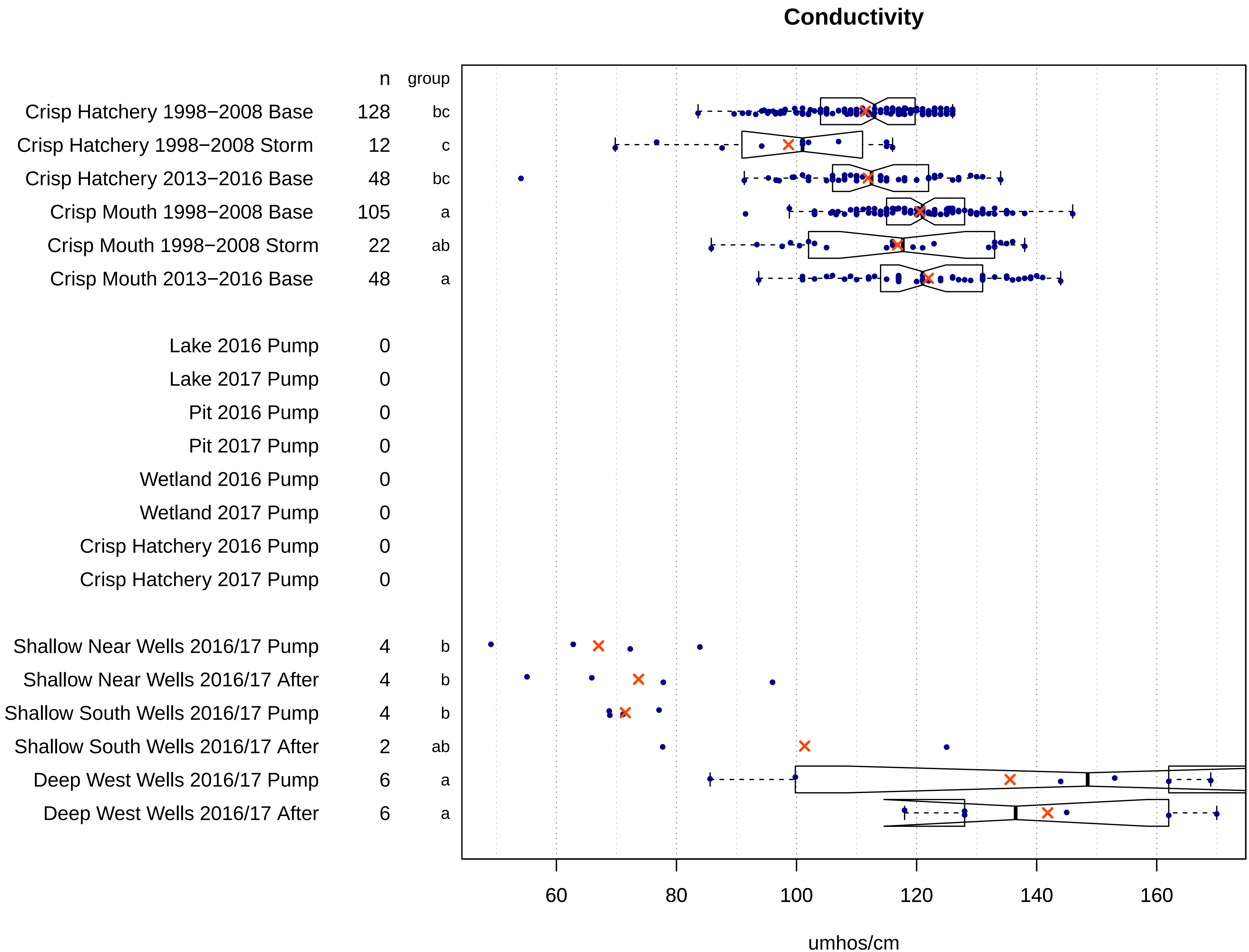
Horseshoe Lake Pumping Project
Water Quality Analysis Box Plots




Sample Temperature
n
group
Crisp Hatchery 1998−2008 Base
157
a
Crisp Hatchery 1998−2008 Storm
12
a
Crisp Hatchery 2013−2016 Base
48
a
Crisp Mouth 1998−2008 Base
130
a
Crisp Mouth 1998−2008 Storm
37
a
Crisp Mouth 2013−2016 Base
48
a
Lake 2016 Pump
0
Lake 2017 Pump
0
Pit 2016 Pump
0
Pit 2017 Pump
0
Wetland 2016 Pump
0
Wetland 2017 Pump
0
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
0
Shallow Near Wells 2016/17 Pump
4
bc
Shallow Near Wells 2016/17 After
4
a
Shallow South Wells 2016/17 Pump
4
c
Shallow South Wells 2016/17 After
2
abc
Deep West Wells 2016/17 Pump
6
bc
Deep West Wells 2016/17 After
6
ab
6
8
10
12
14
deg C


Dissolved Oxygen
n
group
Crisp Hatchery 1998−2008 Base 156 a
Crisp Hatchery 1998−2008 Storm 12 a
Crisp Hatchery 2013−2016 Base 48 a
Crisp Mouth 1998−2008 Base 126 b
Crisp Mouth 1998−2008 Storm 34 c
Crisp Mouth 2013−2016 Base 48 c
Lake 2016 Pump 0
Lake 2017 Pump 0
Pit 2016 Pump 0
Pit 2017 Pump 0
Wetland 2016 Pump 0
Wetland 2017 Pump 0
Crisp Hatchery 2016 Pump 0
Crisp Hatchery 2017 Pump 0
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 ab
Shallow South Wells 2016/17 Pump 4 a
Shallow South Wells 2016/17 After 2 b
Deep West Wells 2016/17 Pump 6 b
Deep West Wells 2016/17 After 6 b
2
4
6
8
10
12
14
mg/L


pH
n
group
Crisp Hatchery 1998–2008 Base
155
b
Crisp Hatchery 1998–2008 Storm
12
ab
Crisp Hatchery 2013–2016 Base
48
a
Crisp Mouth 1998–2008 Base
129
c
Crisp Mouth 1998–2008 Storm
37
c
Crisp Mouth 2013–2016 Base
48
c
Lake 2016 Pump
0
Lake 2017 Pump
0
Pit 2016 Pump
0
Pit 2017 Pump
0
Wetland 2016 Pump
0
Wetland 2017 Pump
0
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
0
Shallow Near Wells 2016/17 Pump
4
ab
Shallow Near Wells 2016/17 After
4
ab
Shallow South Wells 2016/17 Pump
4
ab
Shallow South Wells 2016/17 After
2
a
Deep West Wells 2016/17 Pump
6
a
Deep West Wells 2016/17 After
6
a
6.0
6.5
7.0
7.5
8.0
pH


Conductivity
n
group
Crisp Hatchery 1998−2008 Base
128
bc
Crisp Hatchery 1998−2008 Storm
12
c
Crisp Hatchery 2013−2016 Base
48
bc
Crisp Mouth 1998−2008 Base
105
a
Crisp Mouth 1998−2008 Storm
22
ab
Crisp Mouth 2013−2016 Base
48
a
Lake 2016 Pump
0
Lake 2017 Pump
0
Pit 2016 Pump
0
Pit 2017 Pump
0
Wetland 2016 Pump
0
Wetland 2017 Pump
0
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
0
Shallow Near Wells 2016/17 Pump
4
b
Shallow Near Wells 2016/17 After
4
b
Shallow South Wells 2016/17 Pump
4
b
Shallow South Wells 2016/17 After
2
ab
Deep West Wells 2016/17 Pump
6
a
Deep West Wells 2016/17 After
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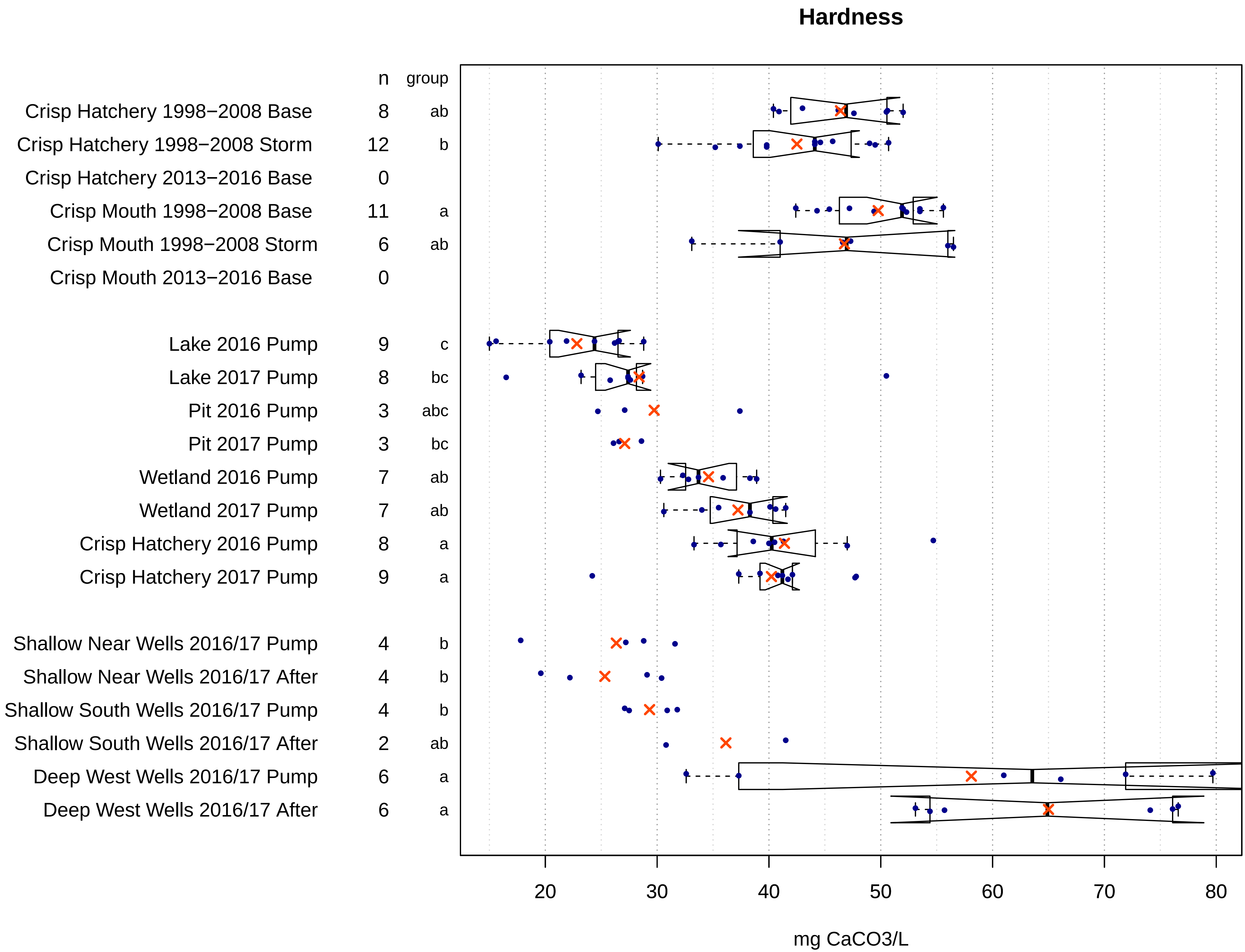
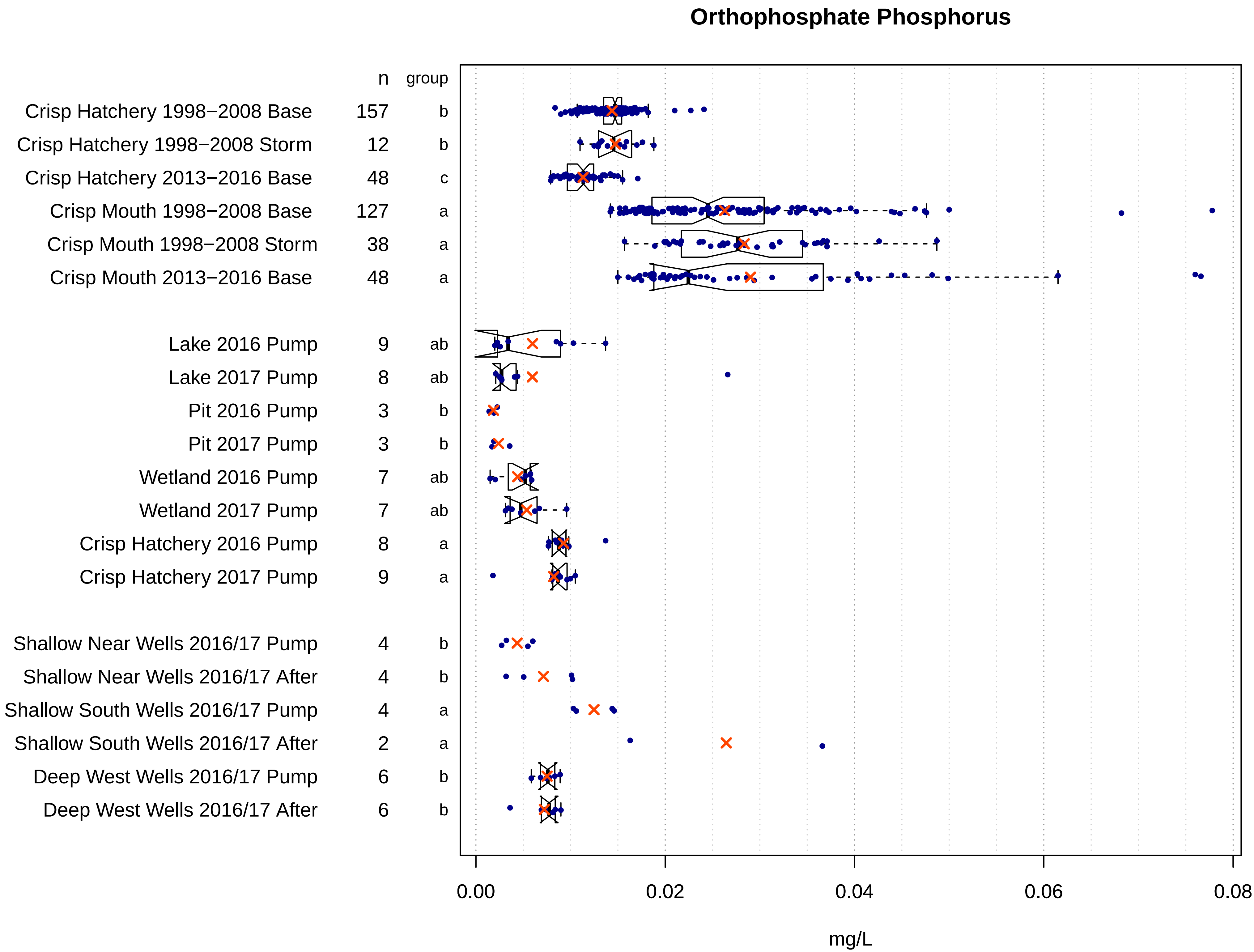
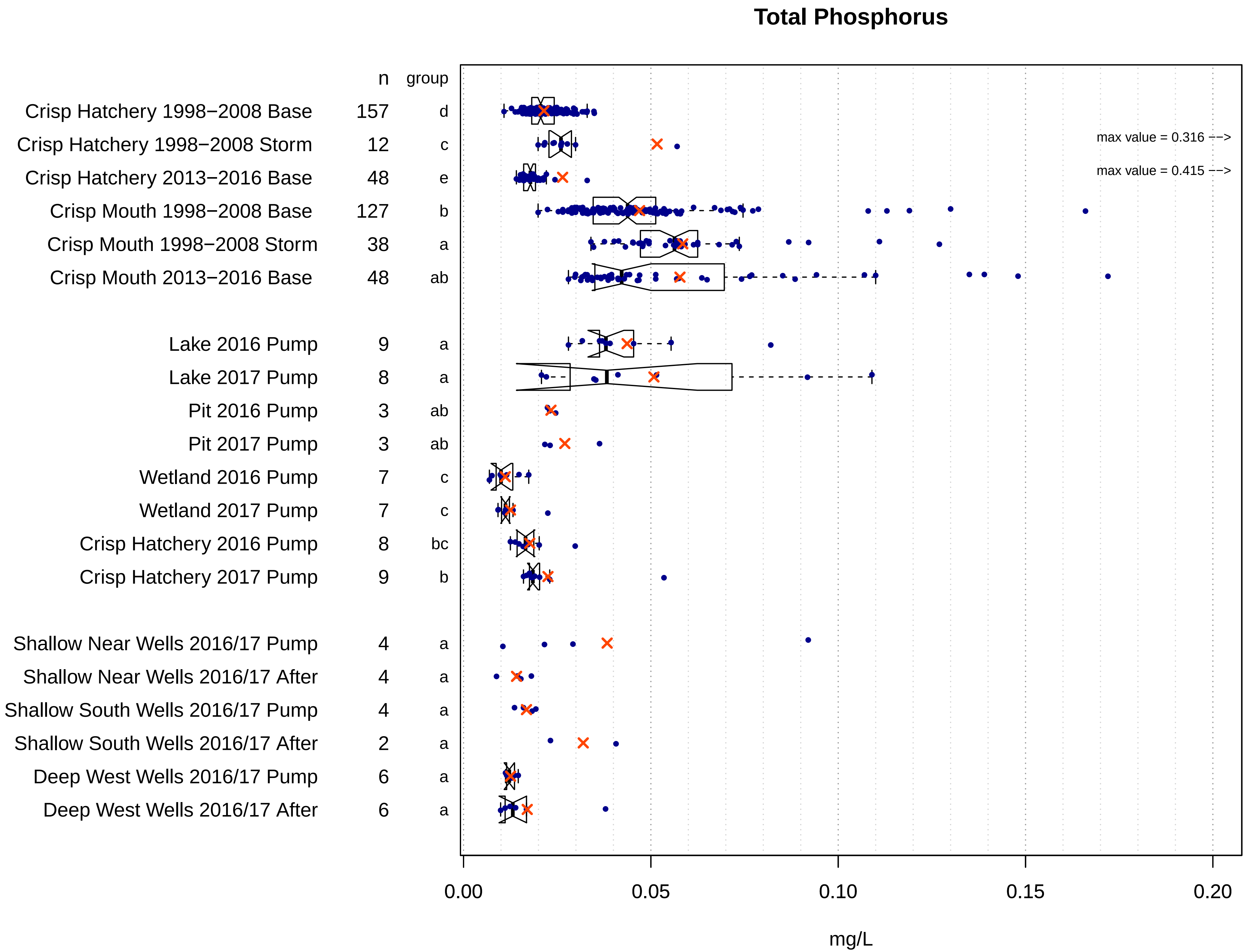
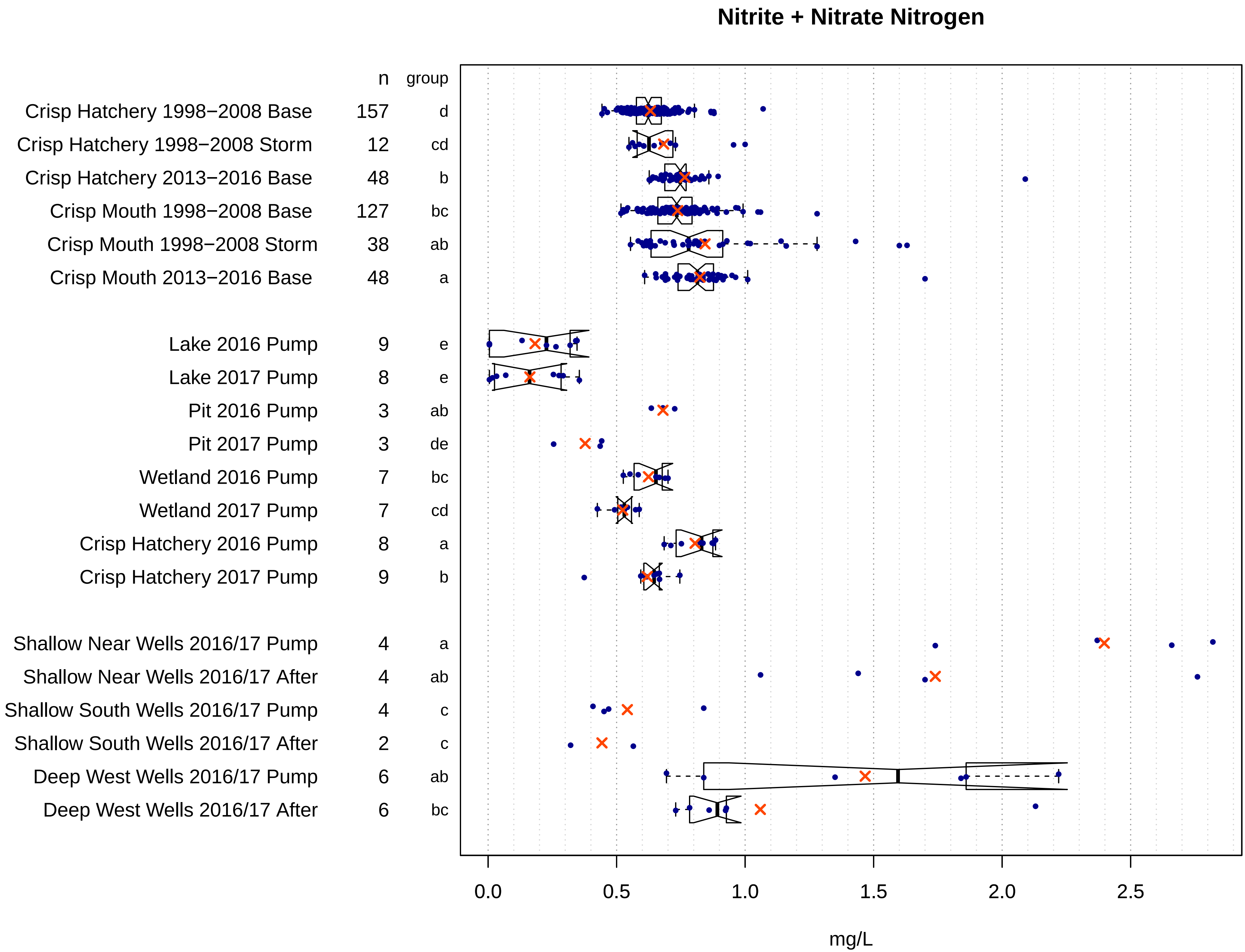
60
80
100
120
140
160
umhos/cm

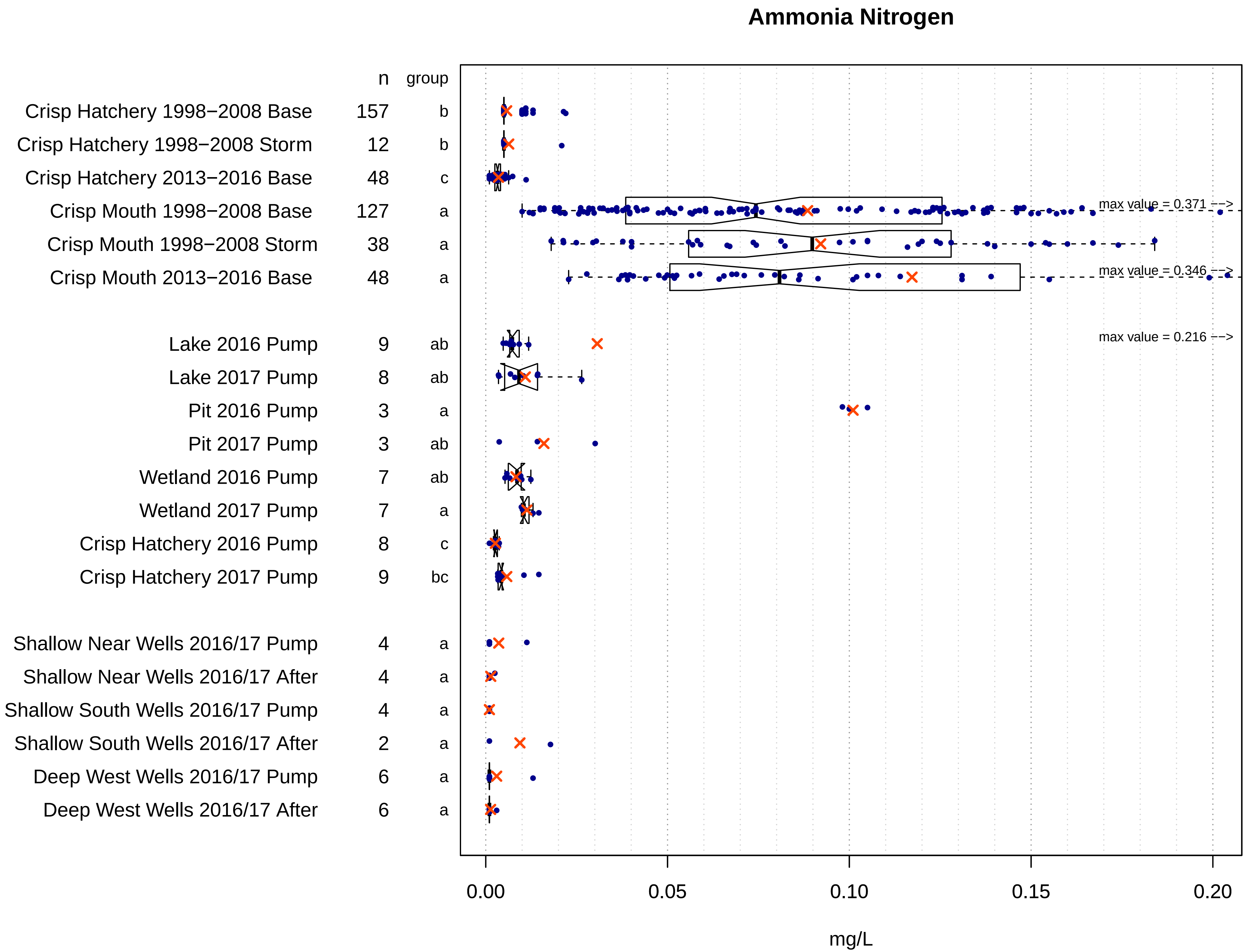

Hardness
n group
Crisp Hatchery 1998−2008 Base 8 ab
Crisp Hatchery 1998−2008 Storm 12 b
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 a
Crisp Mouth 1998−2008 Storm 6 ab
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 c
Lake 2017 Pump 8 bc
Pit 2016 Pump 3 abc
Pit 2017 Pump 3 bc
Wetland 2016 Pump 7 ab
Wetland 2017 Pump 7 ab
Crisp Hatchery 2016 Pump 8 a
Crisp Hatchery 2017 Pump 9 a
Shallow Near Wells 2016/17 Pump 4 b
Shallow Near Wells 2016/17 After 4 b
Shallow South Wells 2016/17 Pump 4 b
Shallow South Wells 2016/17 After 2 ab
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 a
20 30 40 50 60 70 80
mg CaCO3/L

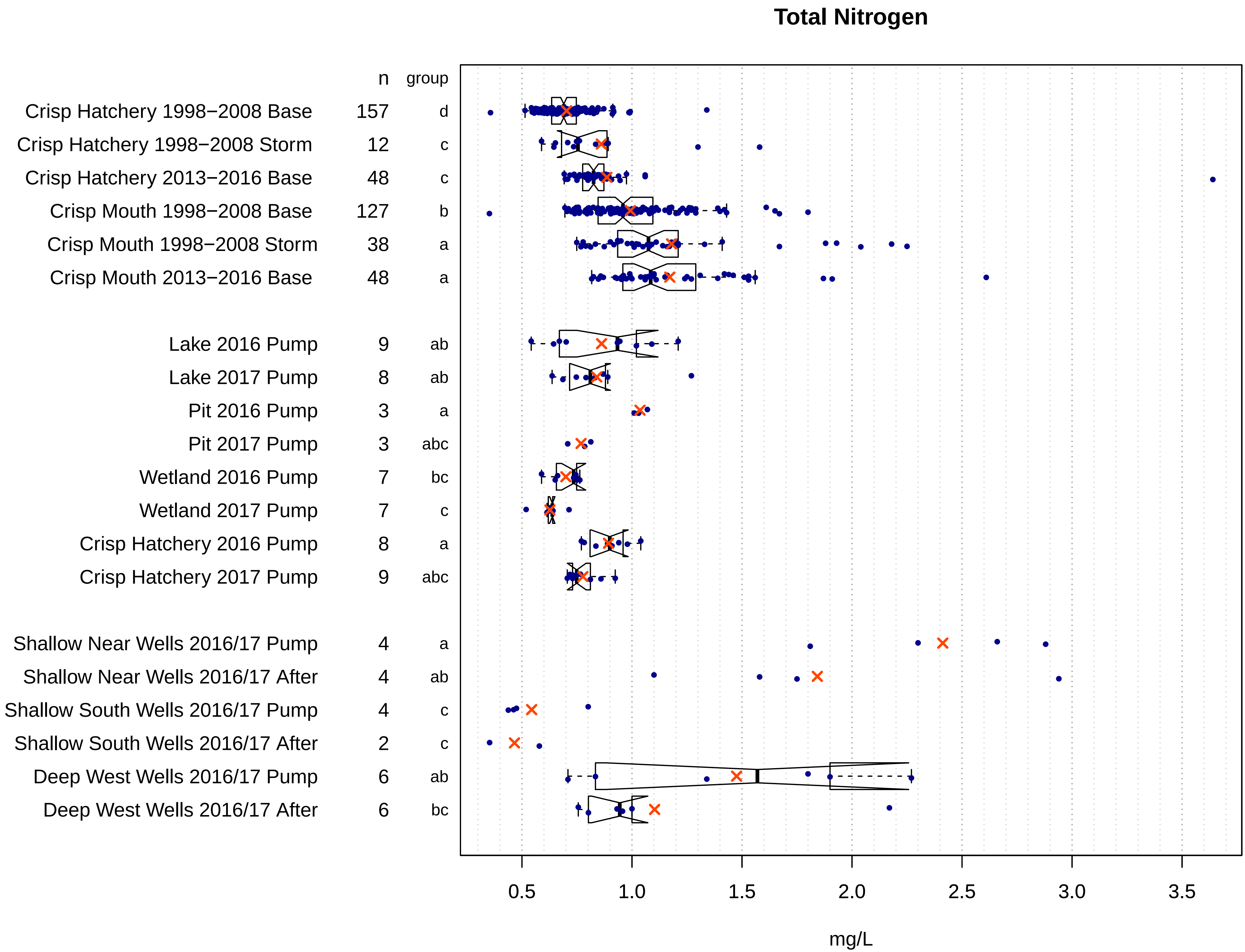

Orthophosphate Phosphorus
n
group
Crisp Hatchery 1998−2008 Base 157 b
Crisp Hatchery 1998−2008 Storm 12 b
Crisp Hatchery 2013−2016 Base 48 c
Crisp Mouth 1998−2008 Base 127 a
Crisp Mouth 1998−2008 Storm 38 a
Crisp Mouth 2013−2016 Base 48 a
Lake 2016 Pump 9 ab
Lake 2017 Pump 8 ab
Pit 2016 Pump 3 b
Pit 2017 Pump 3 b
Wetland 2016 Pump 7 ab
Wetland 2017 Pump 7 ab
Crisp Hatchery 2016 Pump 8 a
Crisp Hatchery 2017 Pump 9 a
Shallow Near Wells 2016/17 Pump 4 b
Shallow Near Wells 2016/17 After 4 b
Shallow South Wells 2016/17 Pump 4 a
Shallow South Wells 2016/17 After 2 a
Deep West Wells 2016/17 Pump 6 b
Deep West Wells 2016/17 After 6 b
0.00
0.02
0.04
0.06
0.08
mg/L

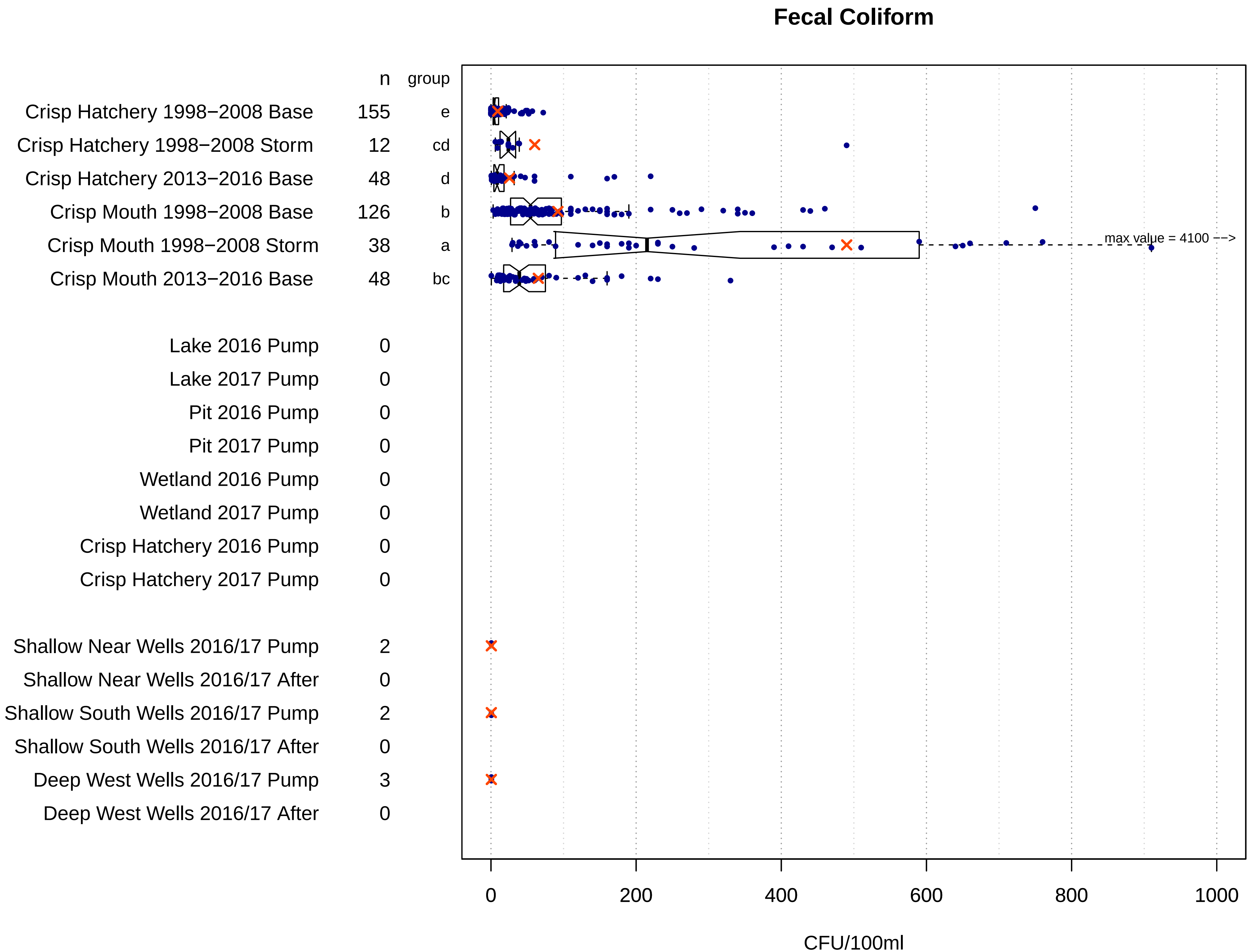

Total Phosphorus
n
group
Crisp Hatchery 1998−2008 Base
157
d
Crisp Hatchery 1998−2008 Storm
12
c
Crisp Hatchery 2013−2016 Base
48
e
Crisp Mouth 1998−2008 Base
127
b
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
48
ab
Lake 2016 Pump
9
a
Lake 2017 Pump
8
a
Pit 2016 Pump
3
ab
Pit 2017 Pump
3
ab
Wetland 2016 Pump
7
c
Wetland 2017 Pump
7
c
Crisp Hatchery 2016 Pump
8
bc
Crisp Hatchery 2017 Pump
9
b
Shallow Near Wells 2016/17 Pump
4
a
Shallow Near Wells 2016/17 After
4
a
Shallow South Wells 2016/17 Pump
4
a
Shallow South Wells 2016/17 After
2
a
Deep West Wells 2016/17 Pump
6
a
Deep West Wells 2016/17 After
6
a
max value = 0.316 −−>
max value = 0.415 −−>
0.00
0.05
0.10
0.15
0.20
mg/L



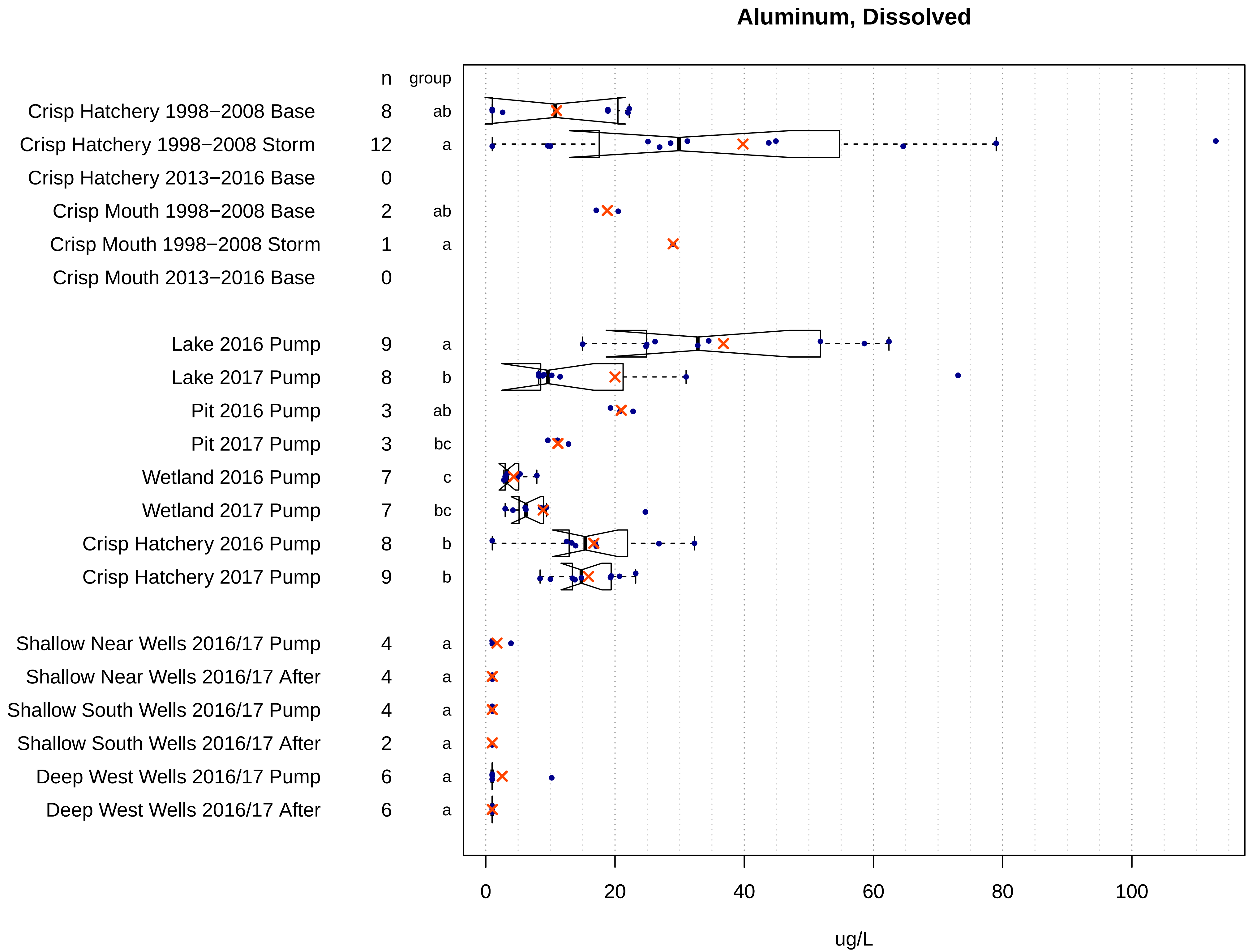
Nitrite + Nitrate Nitrogen
n group
Crisp Hatchery 1998−2008 Base 157 d
Crisp Hatchery 1998−2008 Storm 12 cd
Crisp Hatchery 2013−2016 Base 48 b
Crisp Mouth 1998−2008 Base 127 bc
Crisp Mouth 1998−2008 Storm 38 ab
Crisp Mouth 2013−2016 Base 48 a
Lake 2016 Pump 9 e
Lake 2017 Pump 8 e
Pit 2016 Pump 3 ab
Pit 2017 Pump 3 de
Wetland 2016 Pump 7 bc
Wetland 2017 Pump 7 cd
Crisp Hatchery 2016 Pump 8 a
Crisp Hatchery 2017 Pump 9 b
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 ab
Shallow South Wells 2016/17 Pump 4 c
Shallow South Wells 2016/17 After 2 c
Deep West Wells 2016/17 Pump 6 ab
Deep West Wells 2016/17 After 6 bc
0.0
0.5
1.0
1.5
2.0
2.5
mg/L


Ammonia Nitrogen
n
group
Crisp Hatchery 1998−2008 Base
157
b
Crisp Hatchery 1998−2008 Storm
12
b
Crisp Hatchery 2013−2016 Base
48
c
Crisp Mouth 1998−2008 Base
127
a
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
48
a
Lake 2016 Pump
9
ab
Lake 2017 Pump
8
ab
Pit 2016 Pump
3
a
Pit 2017 Pump
3
ab
Wetland 2016 Pump
7
ab
Wetland 2017 Pump
7
a
Crisp Hatchery 2016 Pump
8
c
Crisp Hatchery 2017 Pump
9
bc
Shallow Near Wells 2016/17 Pump
4
a
Shallow Near Wells 2016/17 After
4
a
Shallow South Wells 2016/17 Pump
4
a
Shallow South Wells 2016/17 After
2
a
Deep West Wells 2016/17 Pump
6
a
Deep West Wells 2016/17 After
6
a
max value = 0.371 -->
max value = 0.346 -->
max value = 0.216 -->
0.00
0.05
0.10
0.15
0.20
mg/L

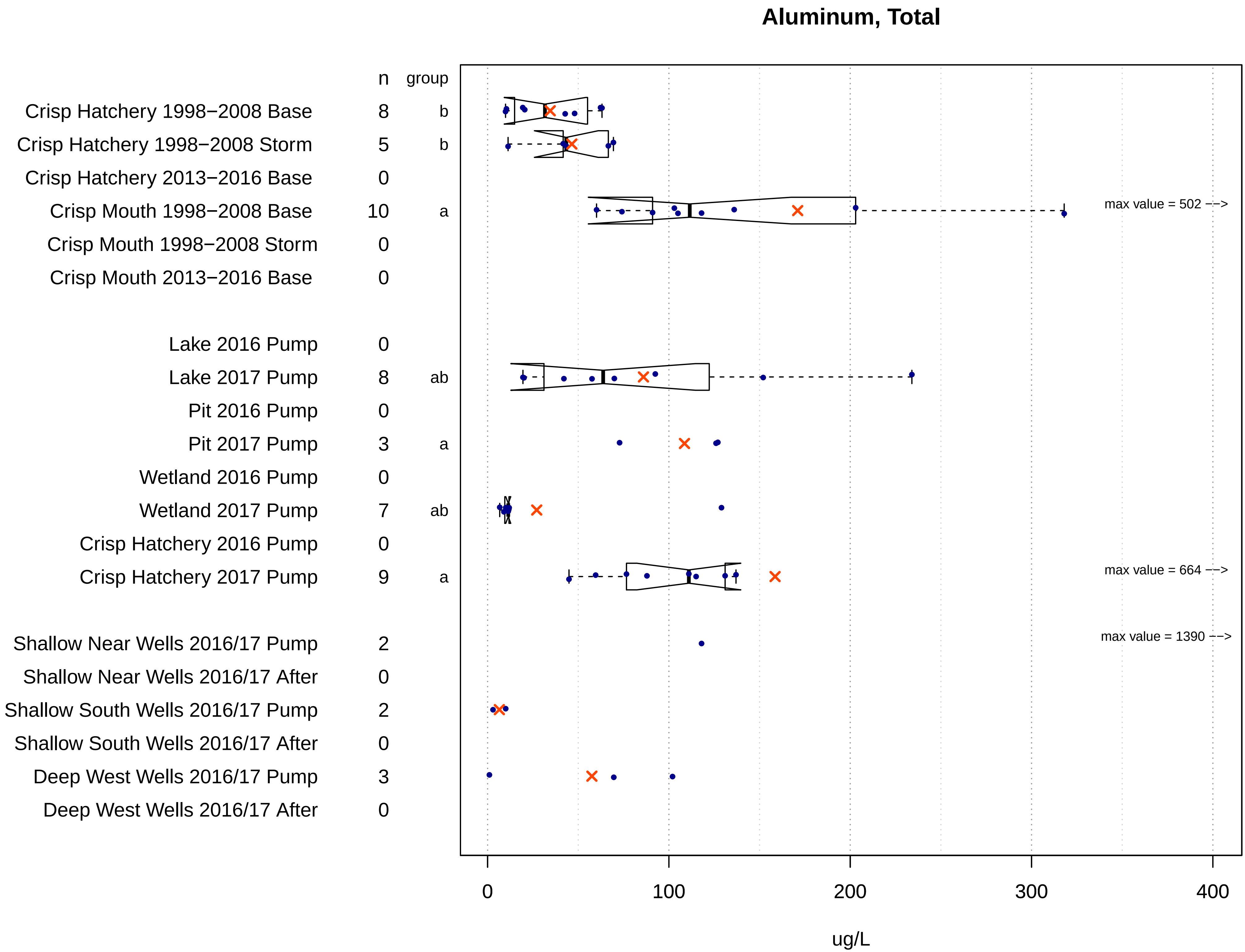

Total Nitrogen
n
group
Crisp Hatchery 1998−2008 Base
157
d
Crisp Hatchery 1998−2008 Storm
12
c
Crisp Hatchery 2013−2016 Base
48
c
Crisp Mouth 1998−2008 Base
127
b
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
48
a
Lake 2016 Pump
9
ab
Lake 2017 Pump
8
ab
Pit 2016 Pump
3
a
Pit 2017 Pump
3
abc
Wetland 2016 Pump
7
bc
Wetland 2017 Pump
7
c
Crisp Hatchery 2016 Pump
8
a
Crisp Hatchery 2017 Pump
9
abc
Shallow Near Wells 2016/17 Pump
4
a
Shallow Near Wells 2016/17 After
4
ab
Shallow South Wells 2016/17 Pump
4
c
Shallow South Wells 2016/17 After
2
c
Deep West Wells 2016/17 Pump
6
ab
Deep West Wells 2016/17 After
6
bc
0.5
1.0
1.5
2.0
2.5
3.0
3.5
mg/L



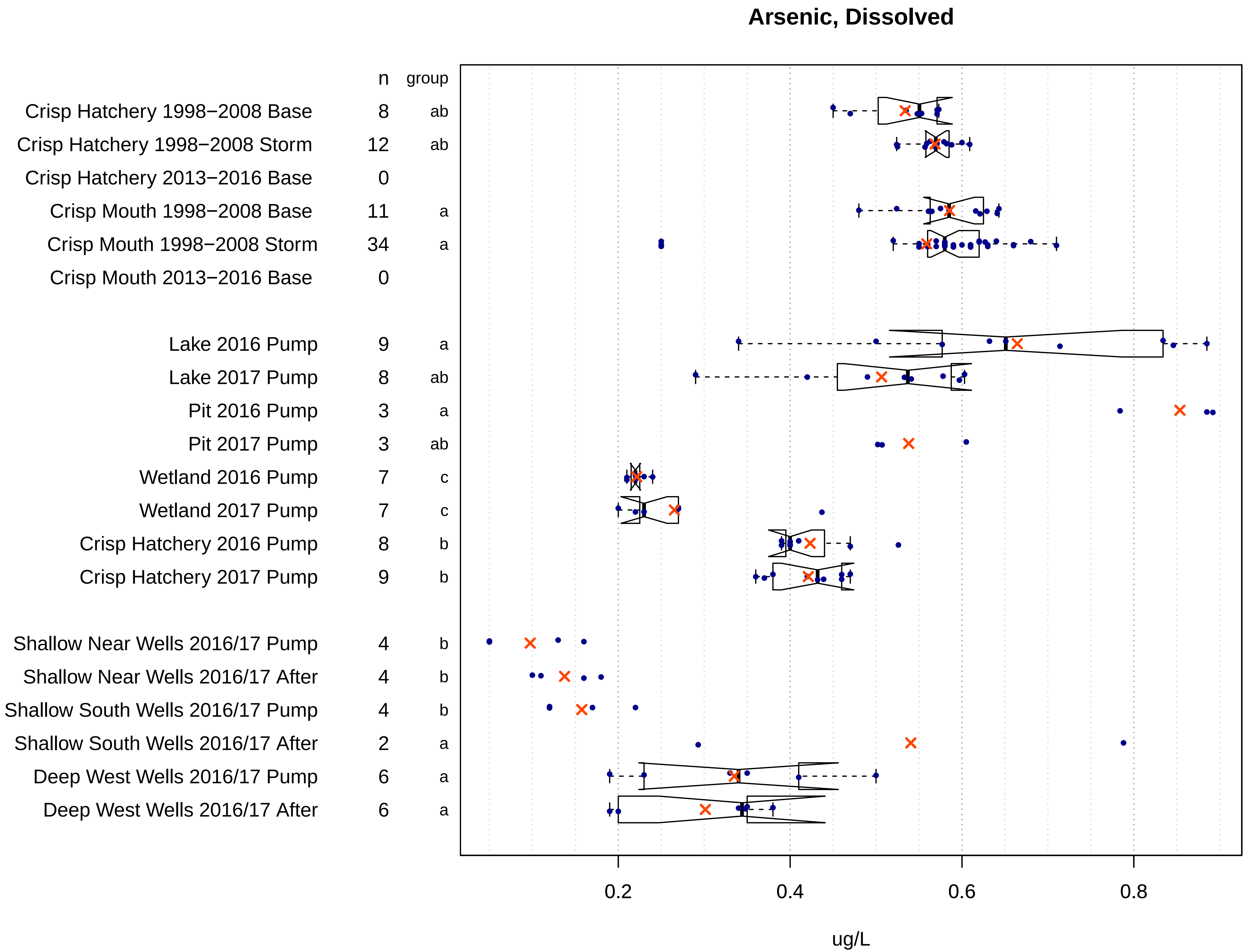
Fecal Coliform
n
group
Crisp Hatchery 1998−2008 Base
155
e
Crisp Hatchery 1998−2008 Storm
12
cd
Crisp Hatchery 2013−2016 Base
48
d
Crisp Mouth 1998−2008 Base
126
b
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
48
bc
Lake 2016 Pump
0
Lake 2017 Pump
0
Pit 2016 Pump
0
Pit 2017 Pump
0
Wetland 2016 Pump
0
Wetland 2017 Pump
0
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
0
Shallow Near Wells 2016/17 Pump
2
Shallow Near Wells 2016/17 After
0
Shallow South Wells 2016/17 Pump
2
Shallow South Wells 2016/17 After
0
Deep West Wells 2016/17 Pump
3
Deep West Wells 2016/17 After
0
max value = 4100 −−>
0
200
400
600
800
1000
CFU/100ml



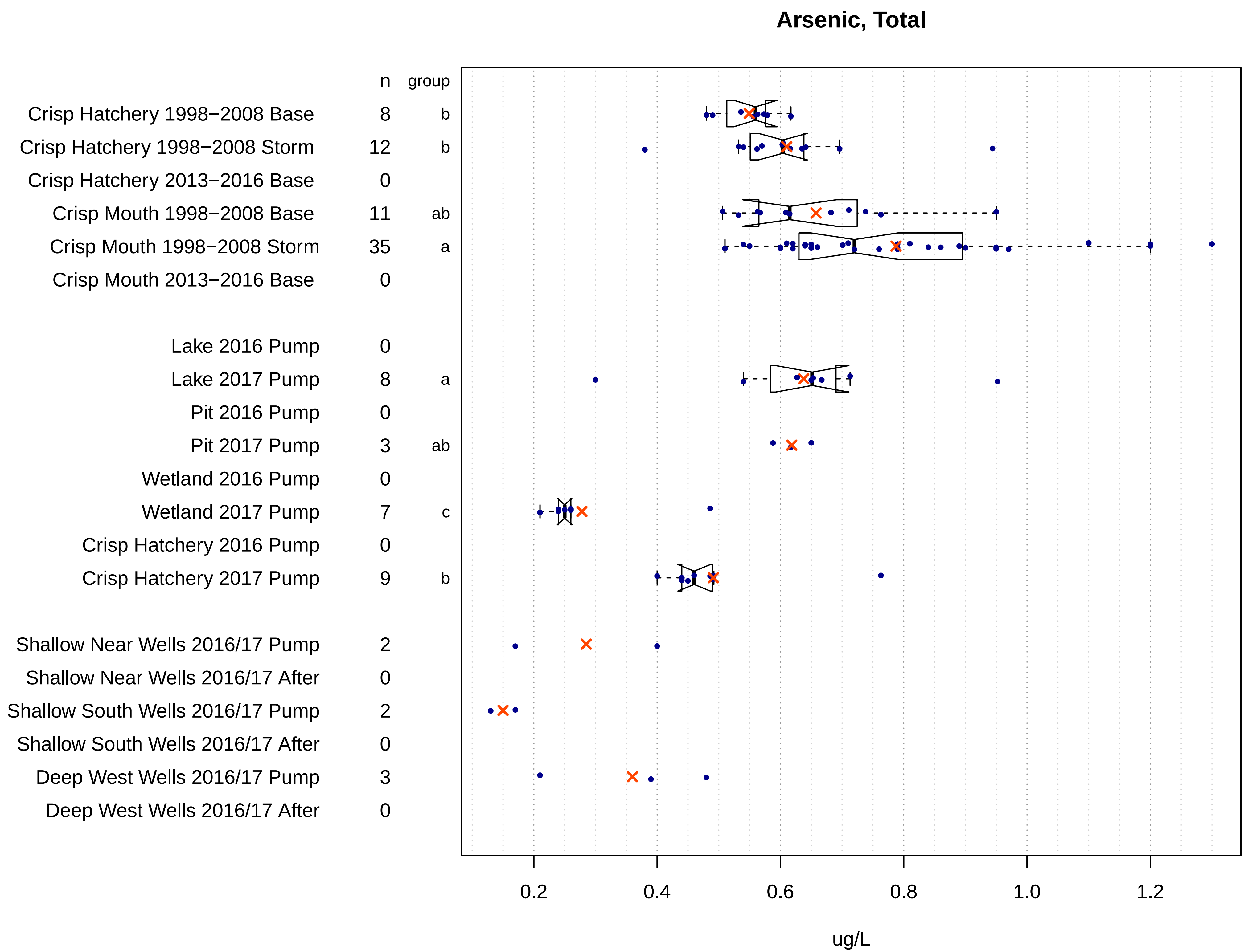
Aluminum, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 ab
Crisp Hatchery 1998−2008 Storm 12 a
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 2 ab
Crisp Mouth 1998−2008 Storm 1 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 a
Lake 2017 Pump 8 b
Pit 2016 Pump 3 ab
Pit 2017 Pump 3 bc
Wetland 2016 Pump 7 c
Wetland 2017 Pump 7 bc
Crisp Hatchery 2016 Pump 8 b
Crisp Hatchery 2017 Pump 9 b
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 a
Shallow South Wells 2016/17 Pump 4 a
Shallow South Wells 2016/17 After 2 a
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 a
0
20
40
60
80
100
ug/L

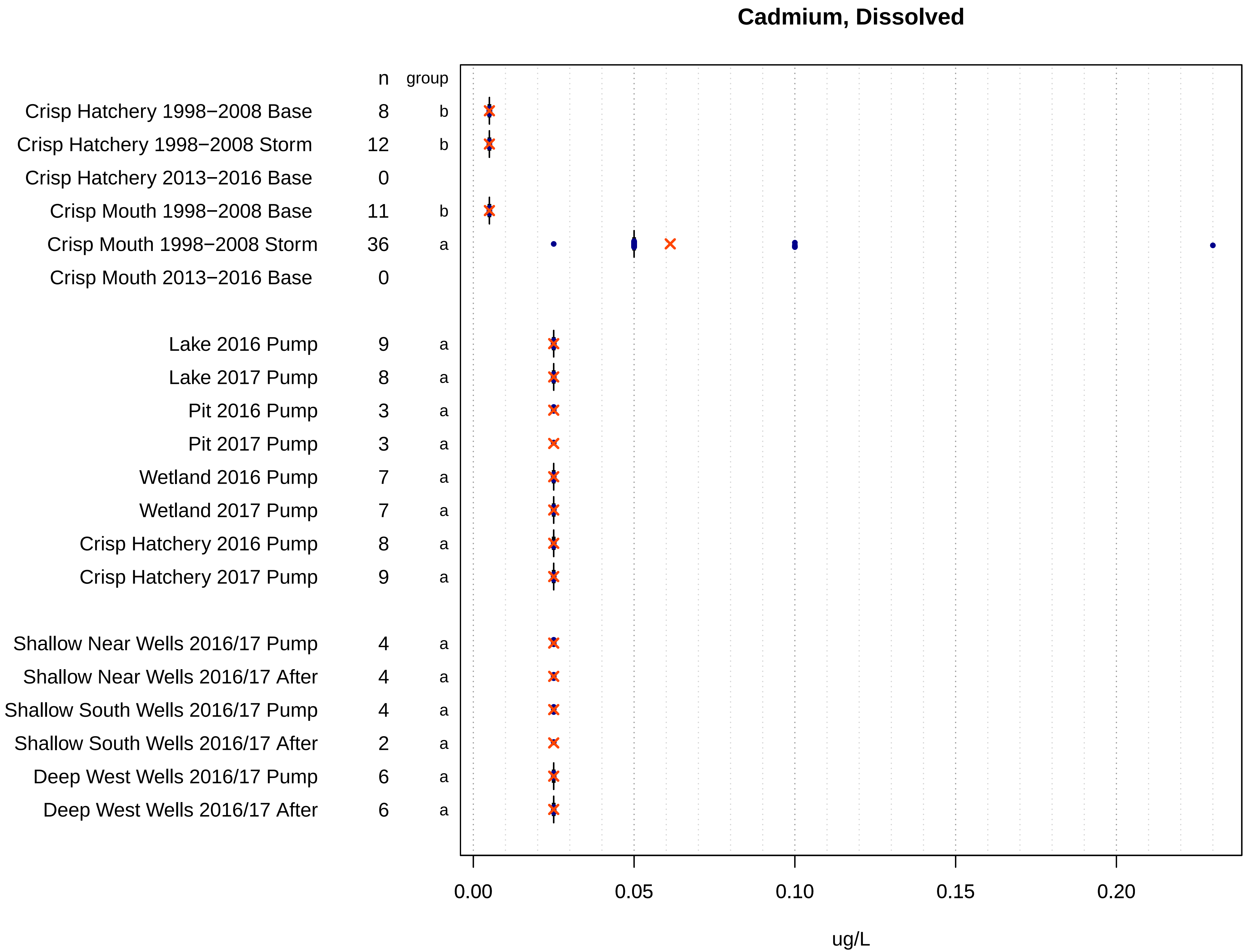


Aluminum, Total
n group
Crisp Hatchery 1998−2008 Base 8 b
Crisp Hatchery 1998−2008 Storm 5 b
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 10 a
Crisp Mouth 1998−2008 Storm 0
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 0
Lake 2017 Pump 8 ab
Pit 2016 Pump 0
Pit 2017 Pump 3 a
Wetland 2016 Pump 0
Wetland 2017 Pump 7 ab
Crisp Hatchery 2016 Pump 0
Crisp Hatchery 2017 Pump 9 a
Shallow Near Wells 2016/17 Pump 2
Shallow Near Wells 2016/17 After 0
Shallow South Wells 2016/17 Pump 2
Shallow South Wells 2016/17 After 0
Deep West Wells 2016/17 Pump 3
Deep West Wells 2016/17 After 0
max value = 502 −−>
max value = 664 −−>
max value = 1390 −−>
0
100
200
300
400
ug/L

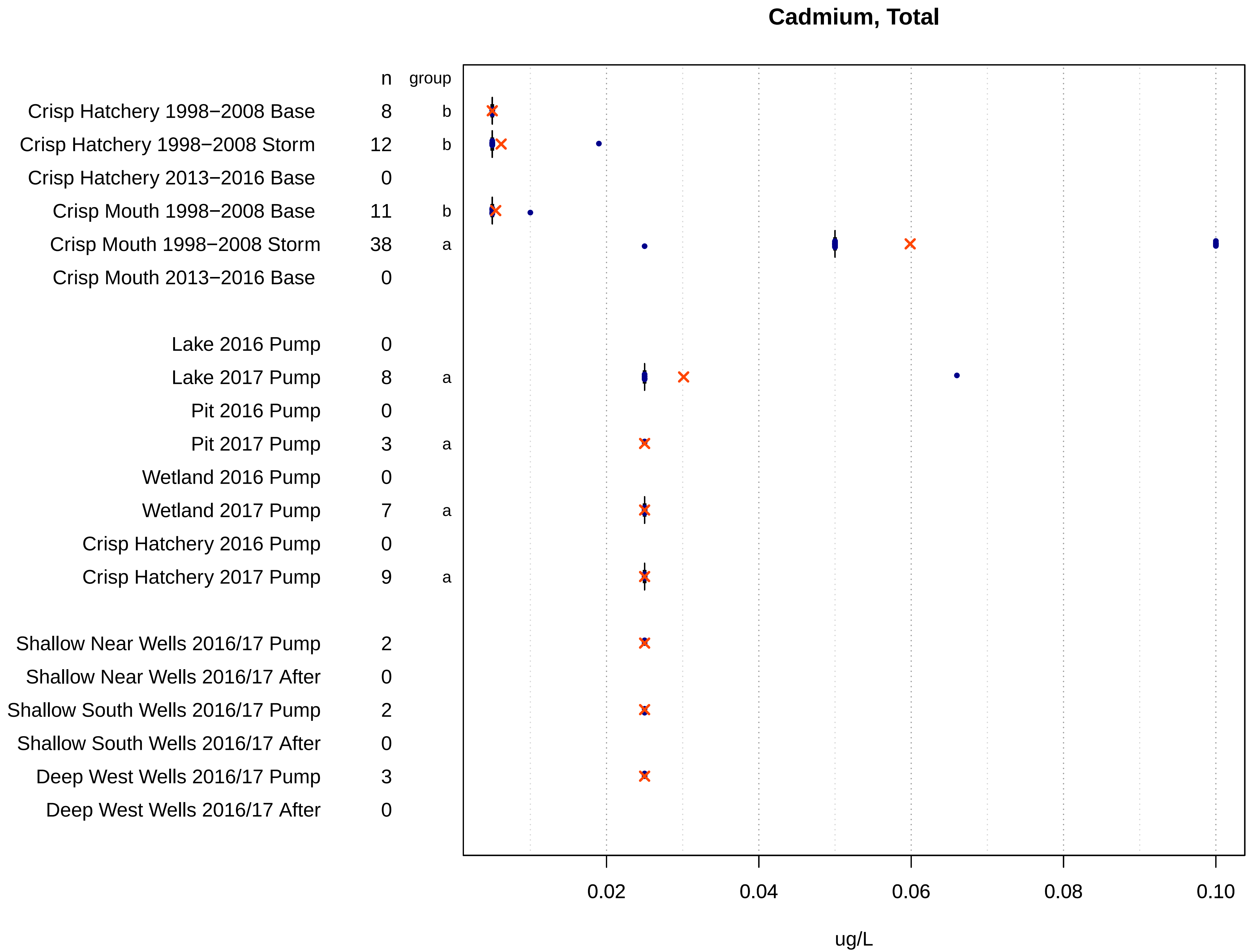


Arsenic, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 ab
Crisp Hatchery 1998−2008 Storm 12 ab
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 a
Crisp Mouth 1998−2008 Storm 34 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 a
Lake 2017 Pump 8 ab
Pit 2016 Pump 3 a
Pit 2017 Pump 3 ab
Wetland 2016 Pump 7 c
Wetland 2017 Pump 7 c
Crisp Hatchery 2016 Pump 8 b
Crisp Hatchery 2017 Pump 9 b
Shallow Near Wells 2016/17 Pump 4 b
Shallow Near Wells 2016/17 After 4 b
Shallow South Wells 2016/17 Pump 4 b
Shallow South Wells 2016/17 After 2 a
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 a
0.2
0.4
0.6
0.8
ug/L

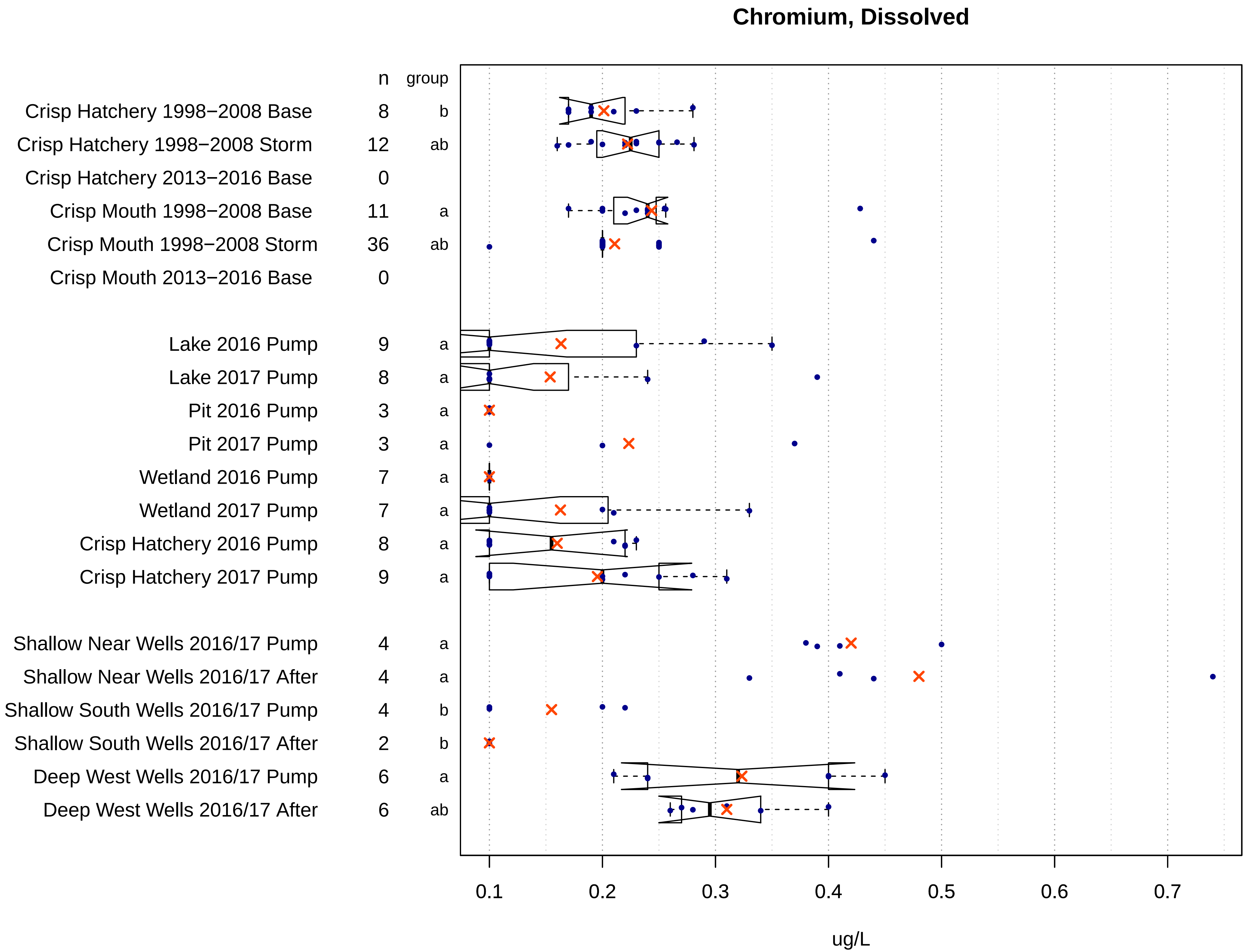

Arsenic, Total
n
group
Crisp Hatchery 1998−2008 Base
8
b
Crisp Hatchery 1998−2008 Storm
12
b
Crisp Hatchery 2013−2016 Base
0
Crisp Mouth 1998−2008 Base
11
ab
Crisp Mouth 1998−2008 Storm
35
a
Crisp Mouth 2013−2016 Base
0
Lake 2016 Pump
0
Lake 2017 Pump
8
a
Pit 2016 Pump
0
Pit 2017 Pump
3
ab
Wetland 2016 Pump
0
Wetland 2017 Pump
7
c
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
9
b
Shallow Near Wells 2016/17 Pump
2
Shallow Near Wells 2016/17 After
0
Shallow South Wells 2016/17 Pump
2
Shallow South Wells 2016/17 After
0
Deep West Wells 2016/17 Pump
3
Deep West Wells 2016/17 After
0
0.2
0.4
0.6
0.8
1.0
1.2
ug/L



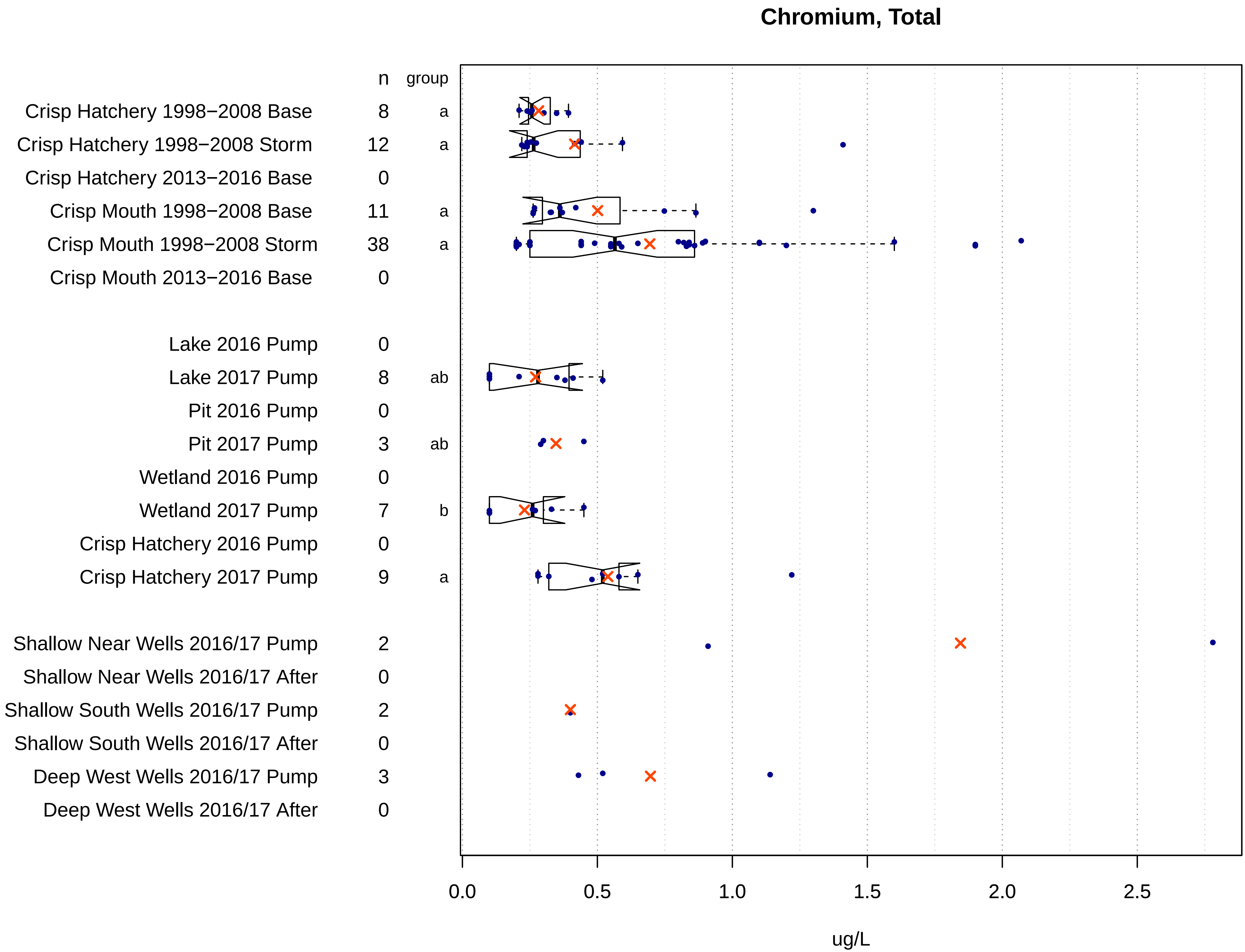
Cadmium, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 b
Crisp Hatchery 1998−2008 Storm 12 b
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 b
Crisp Mouth 1998−2008 Storm 36 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 a
Lake 2017 Pump 8 a
Pit 2016 Pump 3 a
Pit 2017 Pump 3 a
Wetland 2016 Pump 7 a
Wetland 2017 Pump 7 a
Crisp Hatchery 2016 Pump 8 a
Crisp Hatchery 2017 Pump 9 a
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 a
Shallow South Wells 2016/17 Pump 4 a
Shallow South Wells 2016/17 After 2 a
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 a
0.00
0.05
0.10
0.15
0.20
ug/L

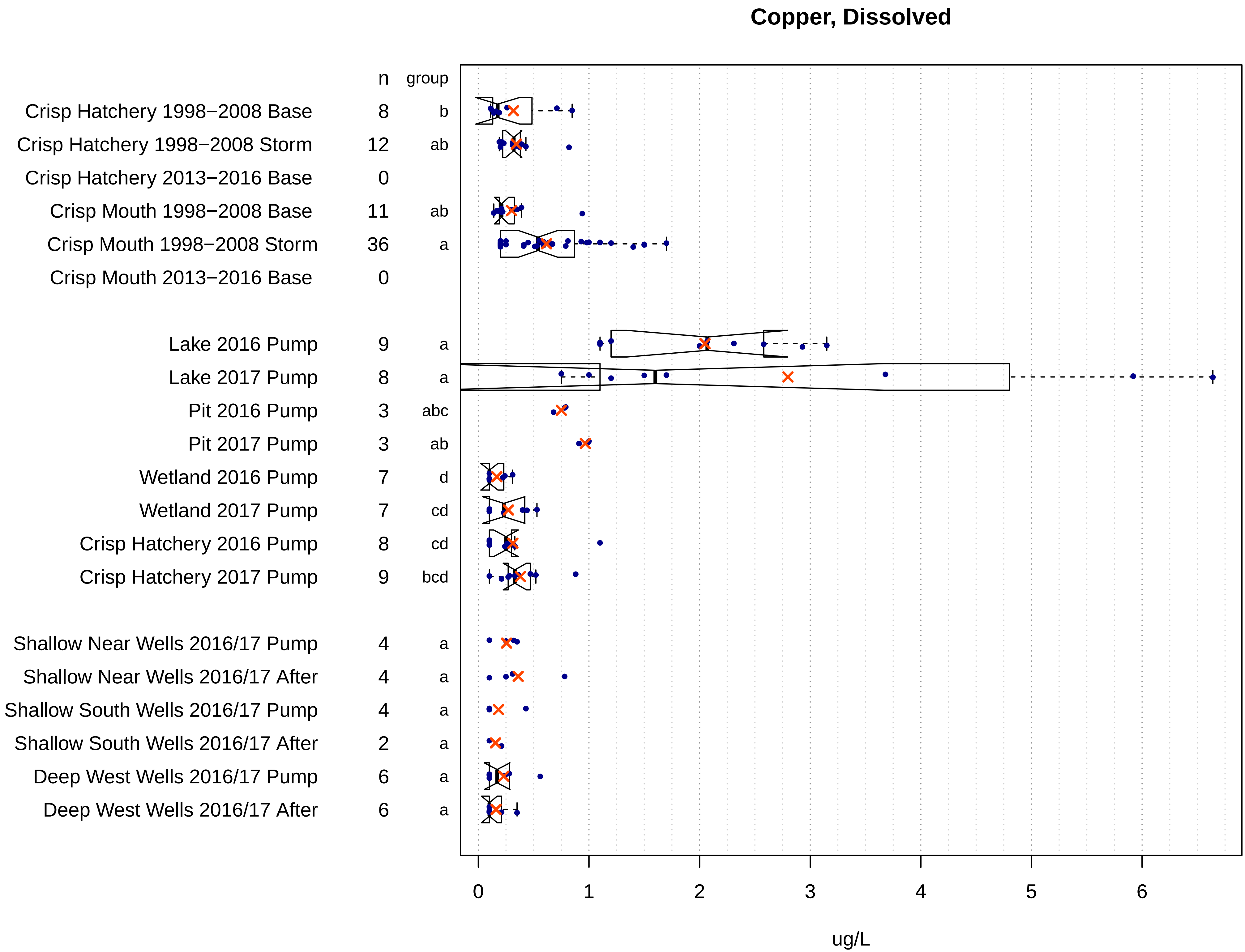


Cadmium, Total
n
group
Crisp Hatchery 1998−2008 Base
8
b
Crisp Hatchery 1998−2008 Storm
12
b
Crisp Hatchery 2013−2016 Base
0
Crisp Mouth 1998−2008 Base
11
b
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
0
Lake 2016 Pump
0
Lake 2017 Pump
8
a
Pit 2016 Pump
0
Pit 2017 Pump
3
a
Wetland 2016 Pump
0
Wetland 2017 Pump
7
a
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
9
a
Shallow Near Wells 2016/17 Pump
2
Shallow Near Wells 2016/17 After
0
Shallow South Wells 2016/17 Pump
2
Shallow South Wells 2016/17 After
0
Deep West Wells 2016/17 Pump
3
Deep West Wells 2016/17 After
0
0.02
0.04
0.06
0.08
0.10
ug/L

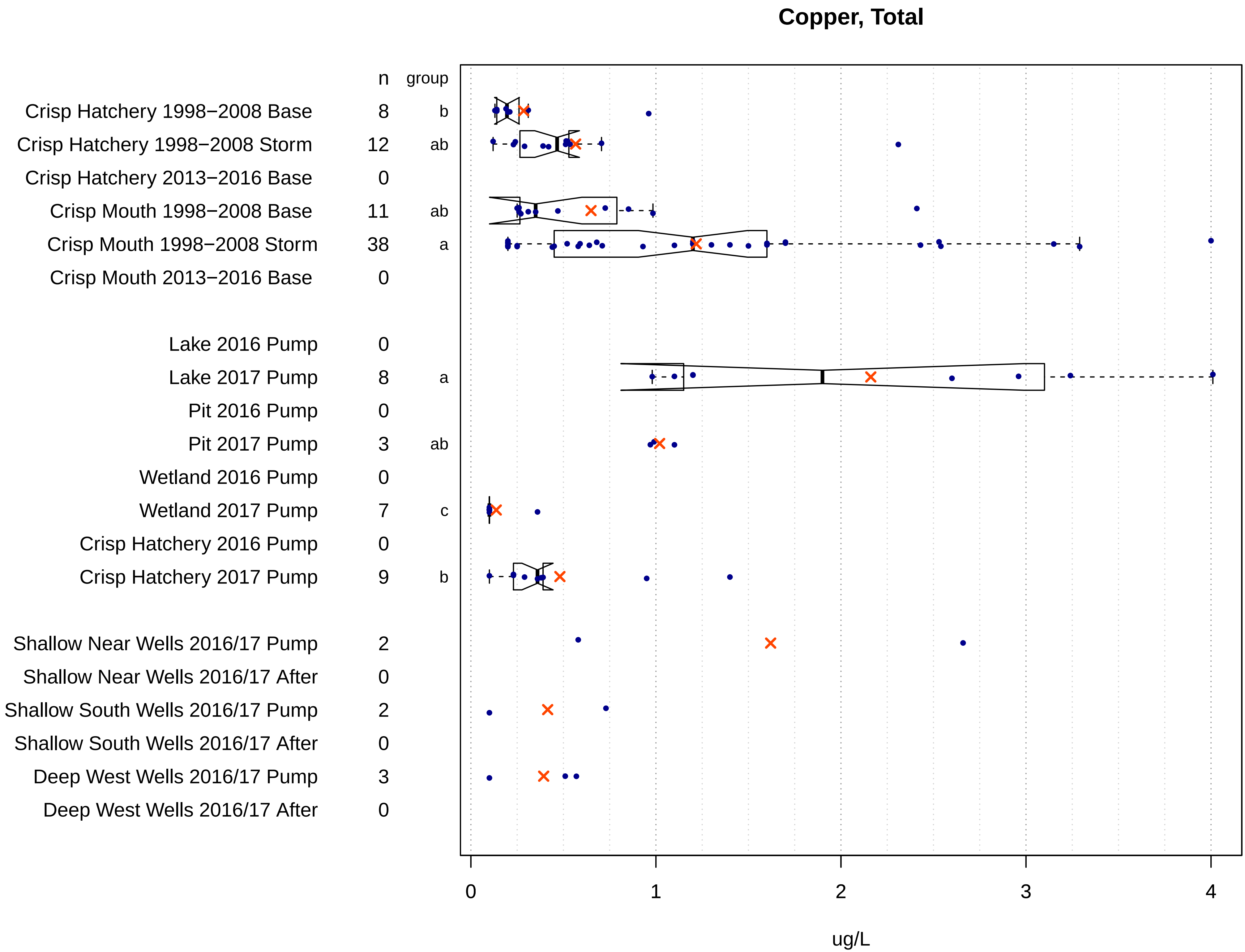


Chromium, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 b
Crisp Hatchery 1998−2008 Storm 12 ab
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 a
Crisp Mouth 1998−2008 Storm 36 ab
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 a
Lake 2017 Pump 8 a
Pit 2016 Pump 3 a
Pit 2017 Pump 3 a
Wetland 2016 Pump 7 a
Wetland 2017 Pump 7 a
Crisp Hatchery 2016 Pump 8 a
Crisp Hatchery 2017 Pump 9 a
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 a
Shallow South Wells 2016/17 Pump 4 b
Shallow South Wells 2016/17 After 2 b
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 ab
0.1
0.2
0.3
0.4
0.5
0.6
0.7
ug/L

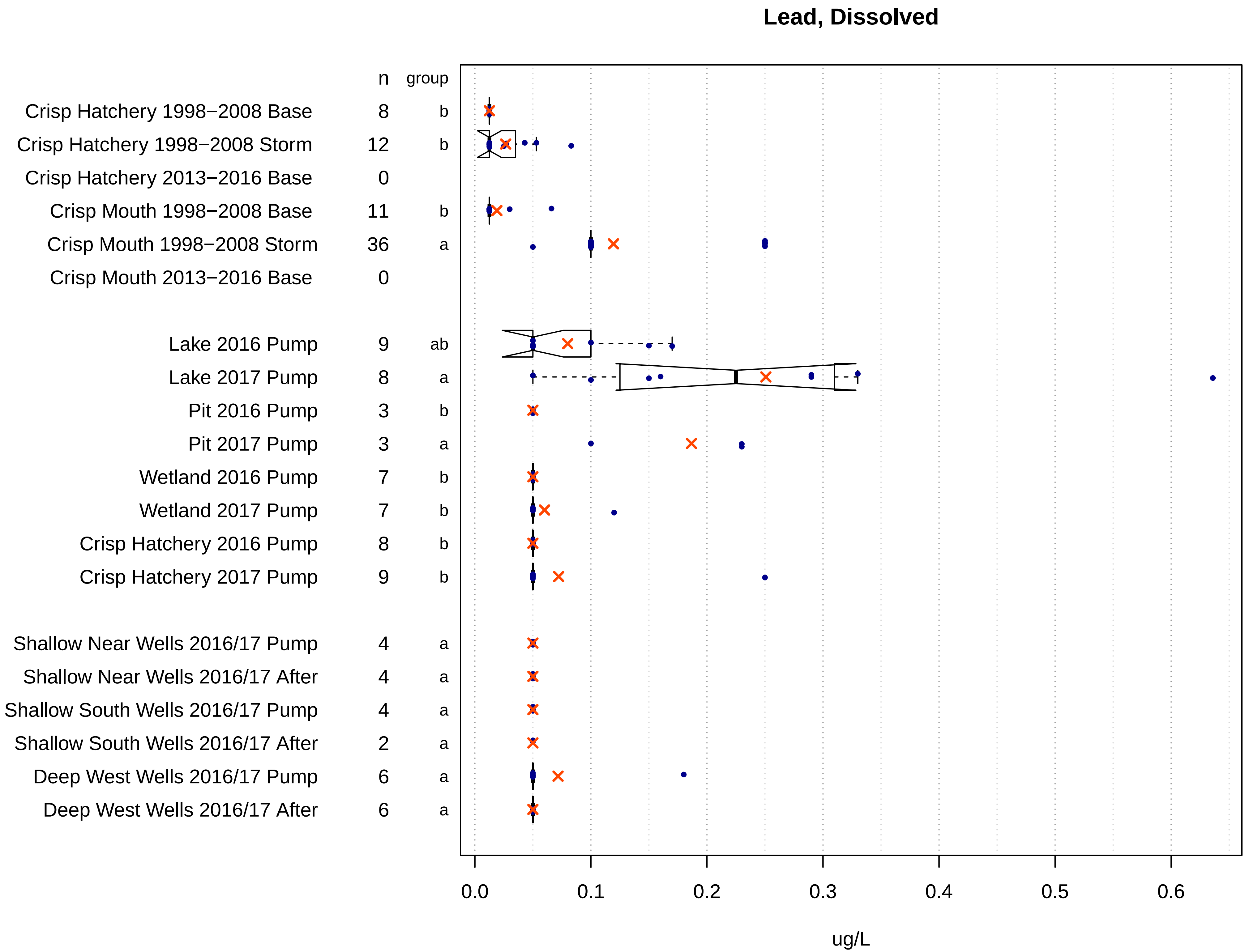

Chromium, Total
n
group
Crisp Hatchery 1998−2008 Base
8
a
Crisp Hatchery 1998−2008 Storm
12
a
Crisp Hatchery 2013−2016 Base
0
Crisp Mouth 1998−2008 Base
11
a
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
0
Lake 2016 Pump
0
Lake 2017 Pump
8
ab
Pit 2016 Pump
0
Pit 2017 Pump
3
ab
Wetland 2016 Pump
0
Wetland 2017 Pump
7
b
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
9
a
Shallow Near Wells 2016/17 Pump
2
Shallow Near Wells 2016/17 After
0
Shallow South Wells 2016/17 Pump
2
Shallow South Wells 2016/17 After
0
Deep West Wells 2016/17 Pump
3
Deep West Wells 2016/17 After
0
0.0
0.5
1.0
1.5
2.0
2.5
ug/L



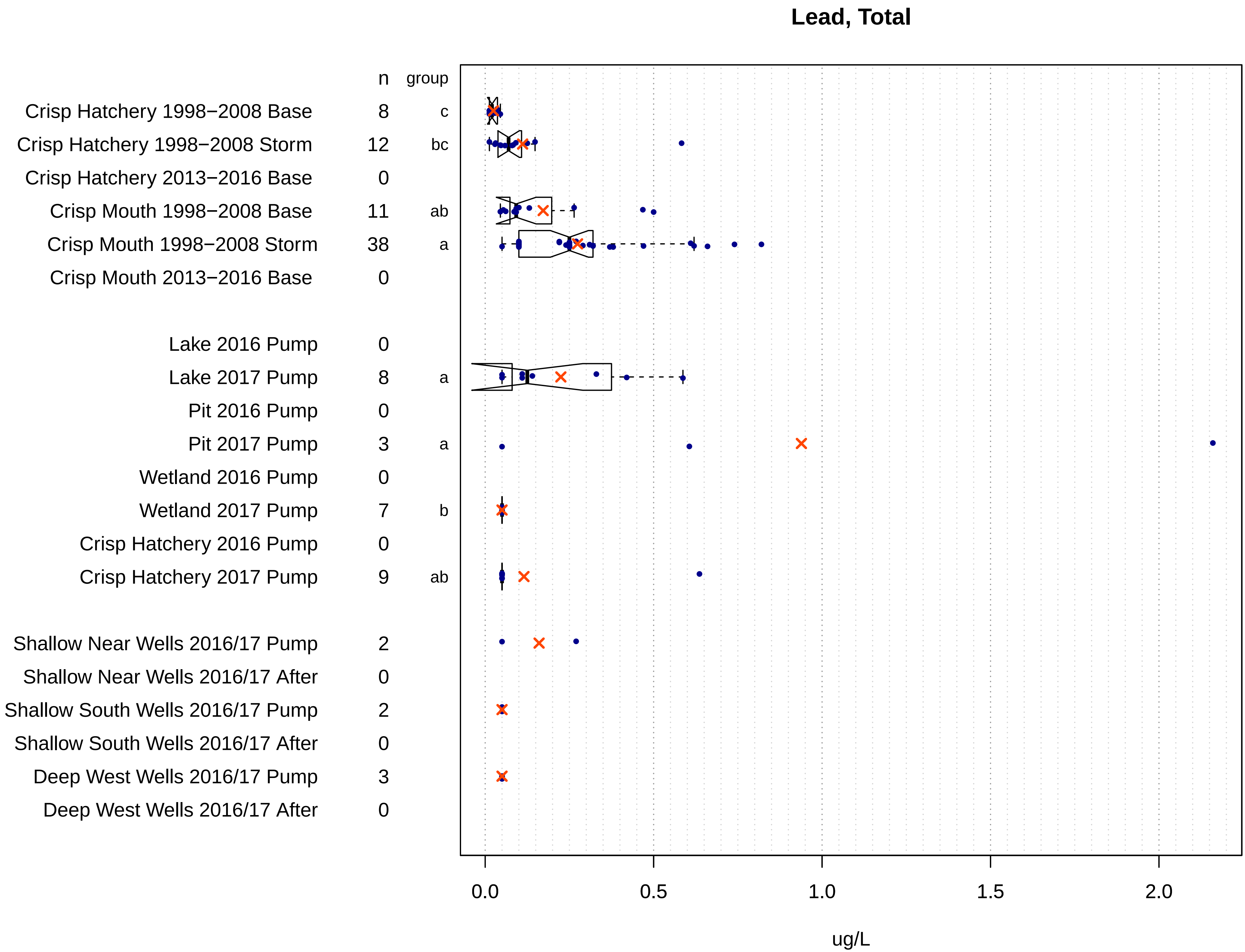
Copper, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 b
Crisp Hatchery 1998−2008 Storm 12 ab
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 ab
Crisp Mouth 1998−2008 Storm 36 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 a
Lake 2017 Pump 8 a
Pit 2016 Pump 3 abc
Pit 2017 Pump 3 ab
Wetland 2016 Pump 7 d
Wetland 2017 Pump 7 cd
Crisp Hatchery 2016 Pump 8 cd
Crisp Hatchery 2017 Pump 9 bcd
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 a
Shallow South Wells 2016/17 Pump 4 a
Shallow South Wells 2016/17 After 2 a
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 a
0
1
2
3
4
5
6
ug/L

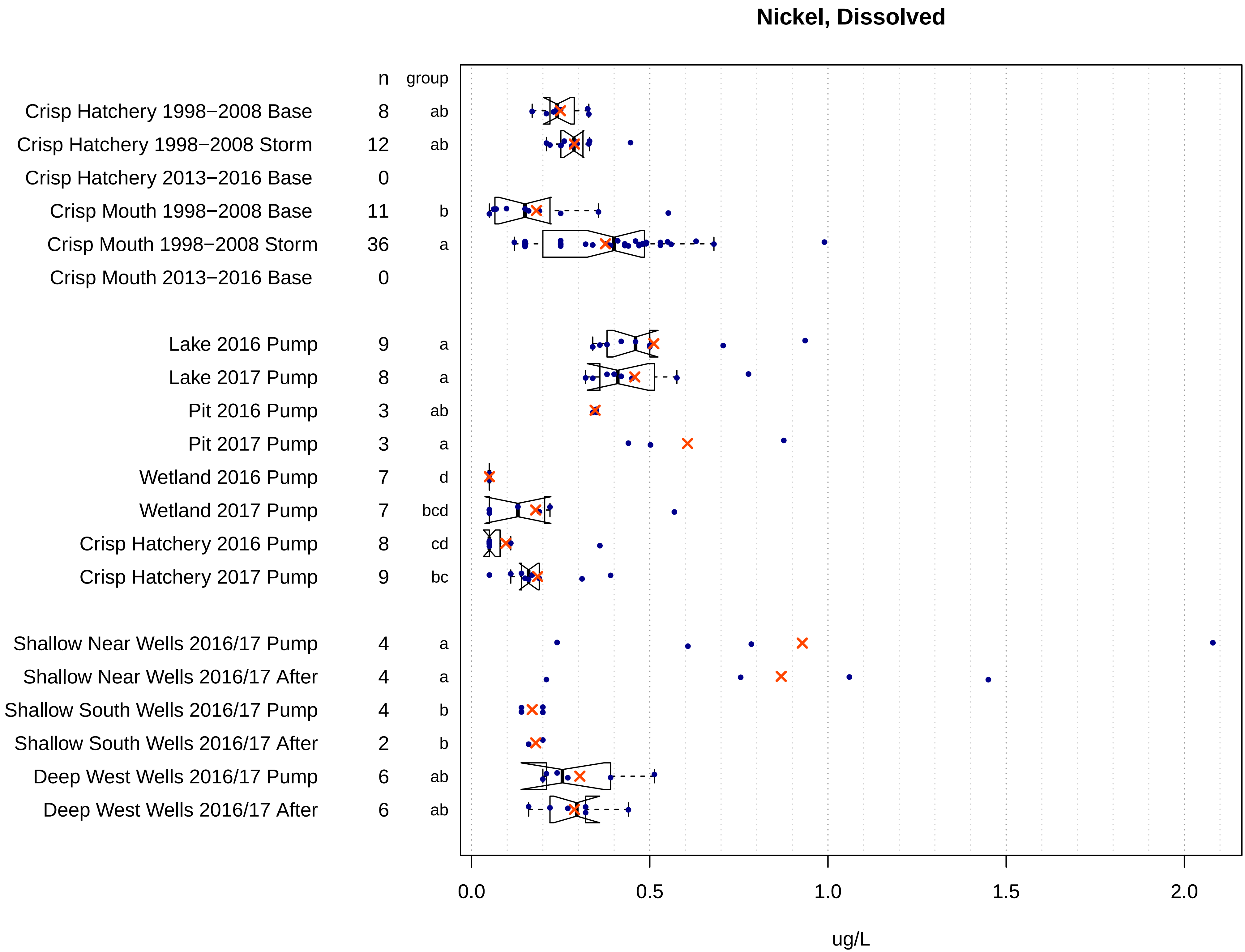


Copper, Total
n
group
Crisp Hatchery 1998−2008 Base
8
b
Crisp Hatchery 1998−2008 Storm
12
ab
Crisp Hatchery 2013−2016 Base
0
Crisp Mouth 1998−2008 Base
11
ab
Crisp Mouth 1998−2008 Storm
38
a
Crisp Mouth 2013−2016 Base
0
Lake 2016 Pump
0
Lake 2017 Pump
8
a
Pit 2016 Pump
0
Pit 2017 Pump
3
ab
Wetland 2016 Pump
0
Wetland 2017 Pump
7
c
Crisp Hatchery 2016 Pump
0
Crisp Hatchery 2017 Pump
9
b
Shallow Near Wells 2016/17 Pump
2
Shallow Near Wells 2016/17 After
0
Shallow South Wells 2016/17 Pump
2
Shallow South Wells 2016/17 After
0
Deep West Wells 2016/17 Pump
3
Deep West Wells 2016/17 After
0
0
1
2
3
4
ug/L

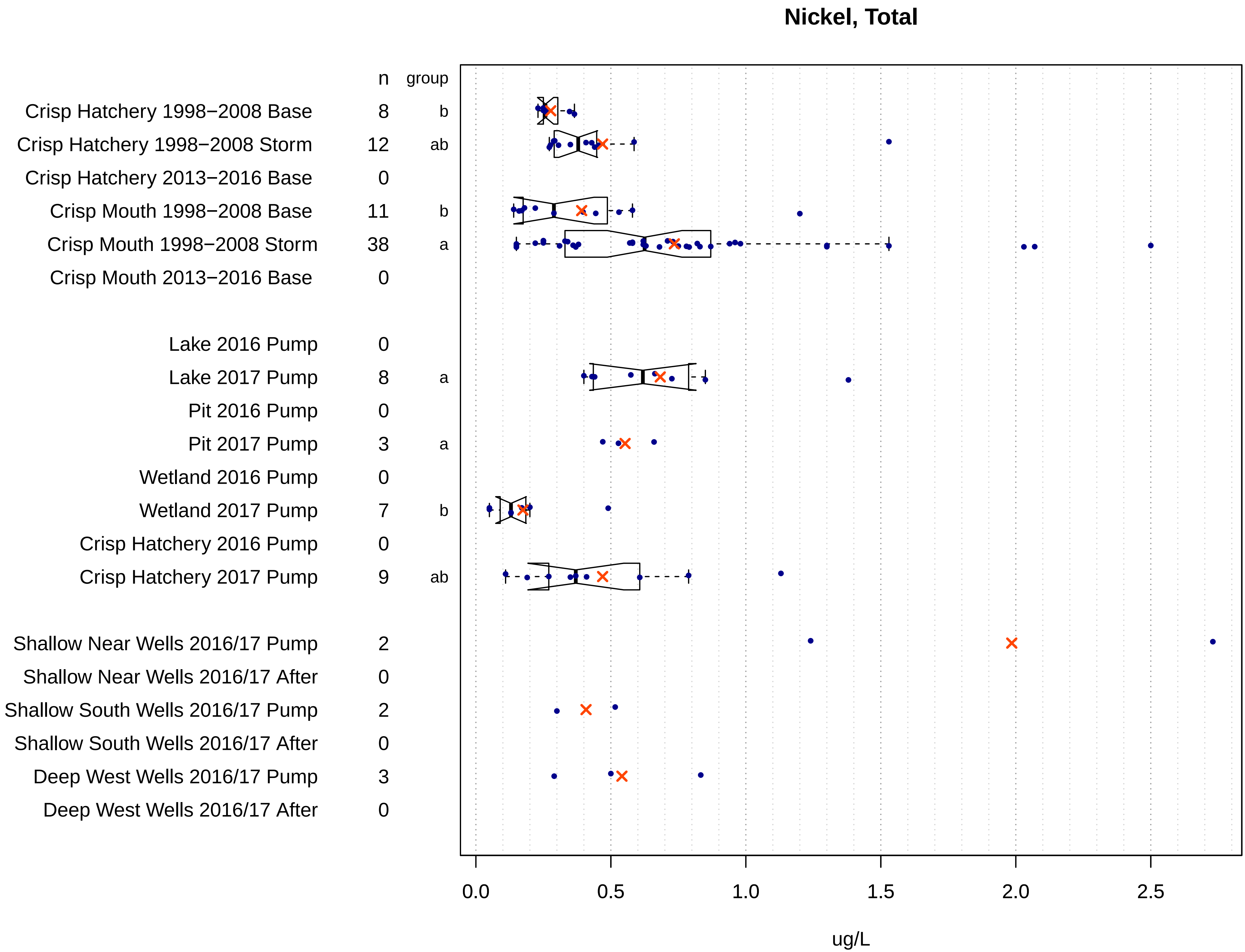


Lead, Dissolved
n
group
Crisp Hatchery 1998−2008 Base
8
b
Crisp Hatchery 1998−2008 Storm
12
b
Crisp Hatchery 2013−2016 Base
0
Crisp Mouth 1998−2008 Base
11
b
Crisp Mouth 1998−2008 Storm
36
a
Crisp Mouth 2013−2016 Base
0
Lake 2016 Pump
9
ab
Lake 2017 Pump
8
a
Pit 2016 Pump
3
b
Pit 2017 Pump
3
a
Wetland 2016 Pump
7
b
Wetland 2017 Pump
7
b
Crisp Hatchery 2016 Pump
8
b
Crisp Hatchery 2017 Pump
9
b
Shallow Near Wells 2016/17 Pump
4
a
Shallow Near Wells 2016/17 After
4
a
Shallow South Wells 2016/17 Pump
4
a
Shallow South Wells 2016/17 After
2
a
Deep West Wells 2016/17 Pump
6
a
Deep West Wells 2016/17 After
6
a
0.0
0.1
0.2
0.3
0.4
0.5
0.6
ug/L

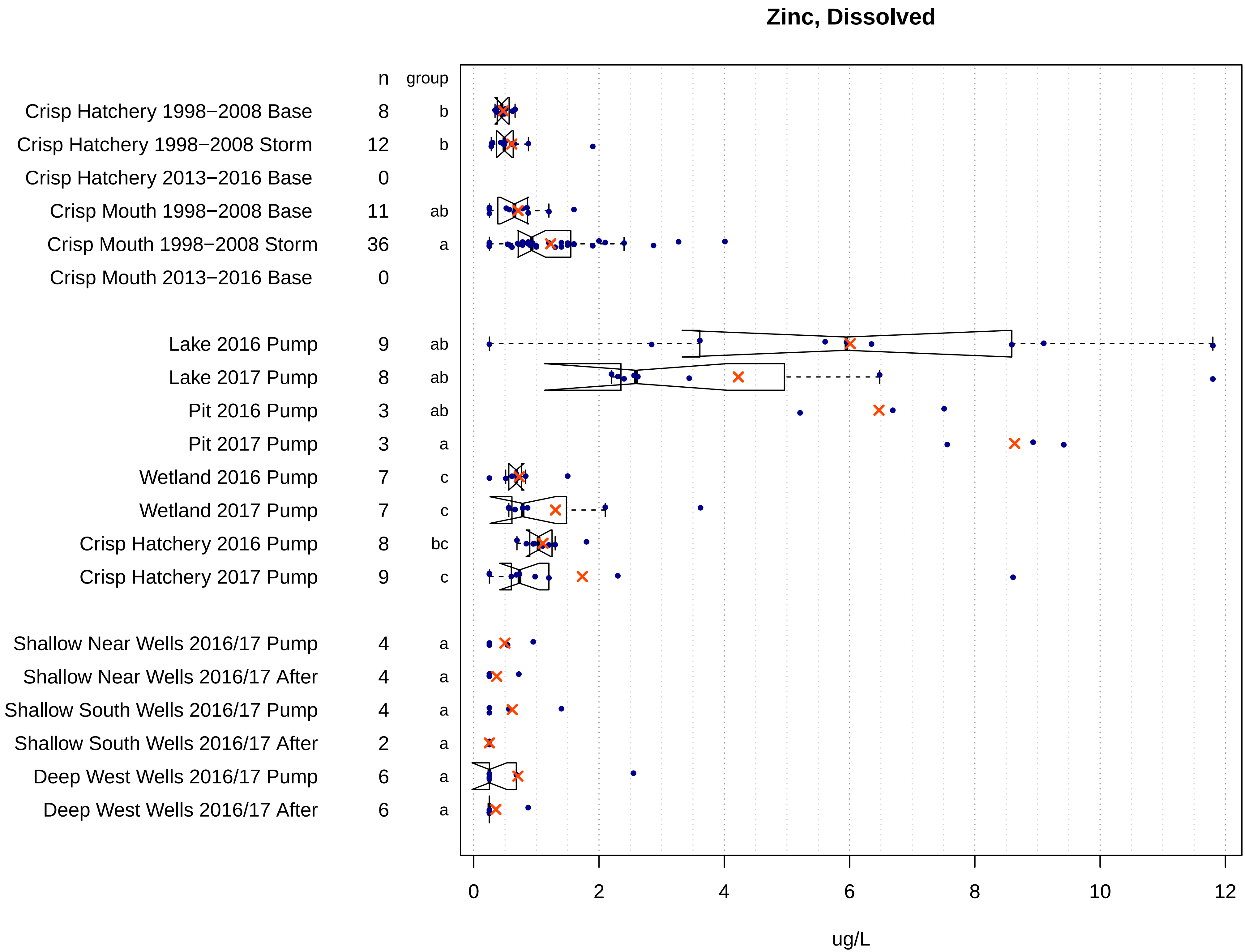

Lead, Total
n
group
Crisp Hatchery 1998−2008 Base 8 c
Crisp Hatchery 1998−2008 Storm 12 bc
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 ab
Crisp Mouth 1998−2008 Storm 38 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 0
Lake 2017 Pump 8 a
Pit 2016 Pump 0
Pit 2017 Pump 3 a
Wetland 2016 Pump 0
Wetland 2017 Pump 7 b
Crisp Hatchery 2016 Pump 0
Crisp Hatchery 2017 Pump 9 ab
Shallow Near Wells 2016/17 Pump 2
Shallow Near Wells 2016/17 After 0
Shallow South Wells 2016/17 Pump 2
Shallow South Wells 2016/17 After 0
Deep West Wells 2016/17 Pump 3
Deep West Wells 2016/17 After 0
0.0
0.5
1.0
1.5
2.0
ug/L



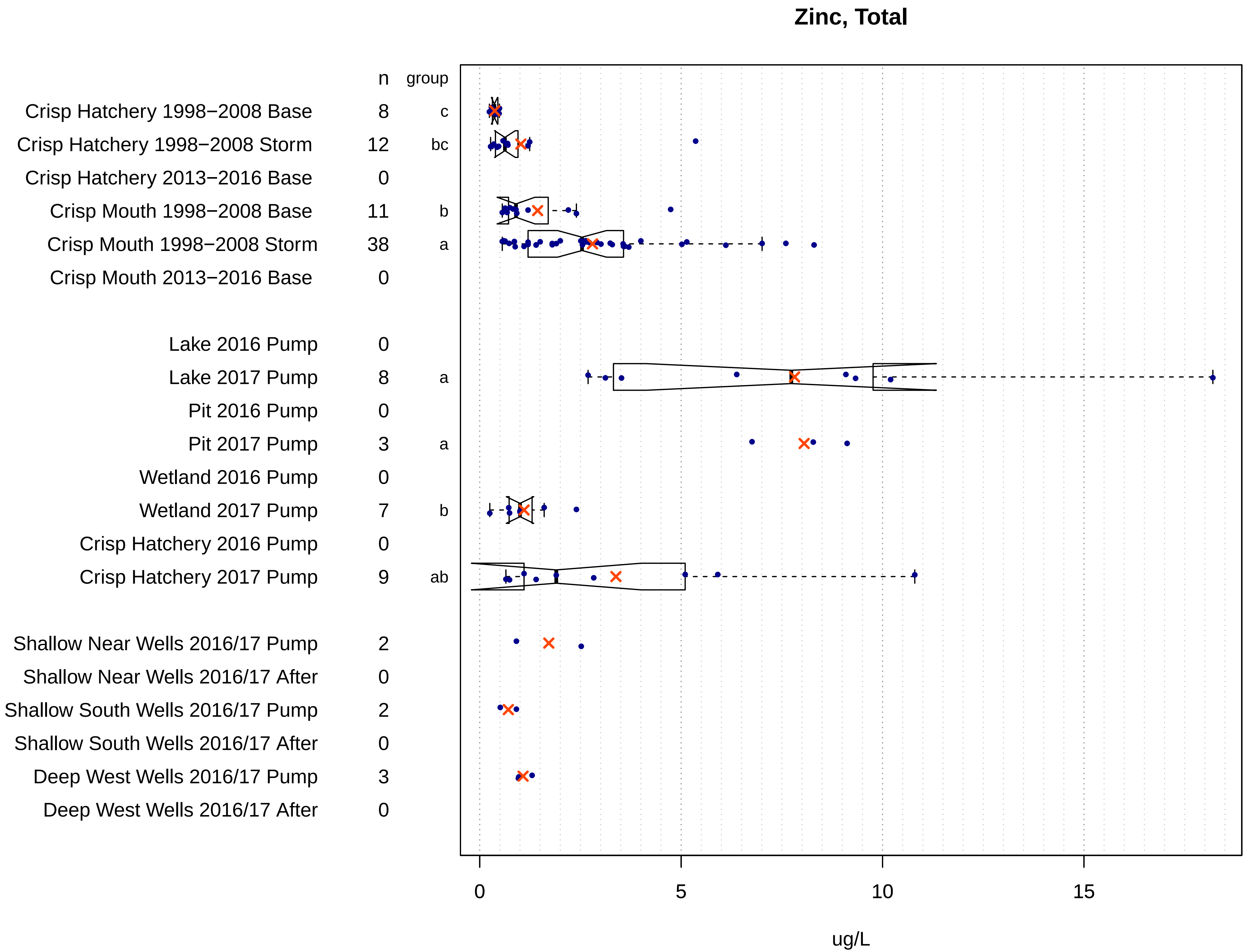
Nickel, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 ab
Crisp Hatchery 1998−2008 Storm 12 ab
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 b
Crisp Mouth 1998−2008 Storm 36 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 a
Lake 2017 Pump 8 a
Pit 2016 Pump 3 ab
Pit 2017 Pump 3 a
Wetland 2016 Pump 7 d
Wetland 2017 Pump 7 bcd
Crisp Hatchery 2016 Pump 8 cd
Crisp Hatchery 2017 Pump 9 bc
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 a
Shallow South Wells 2016/17 Pump 4 b
Shallow South Wells 2016/17 After 2 b
Deep West Wells 2016/17 Pump 6 ab
Deep West Wells 2016/17 After 6 ab
0.0
0.5
1.0
1.5
2.0
ug/L



Nickel, Total
n
group
Crisp Hatchery 1998−2008 Base 8 b
Crisp Hatchery 1998−2008 Storm 12 ab
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 b
Crisp Mouth 1998−2008 Storm 38 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 0
Lake 2017 Pump 8 a
Pit 2016 Pump 0
Pit 2017 Pump 3 a
Wetland 2016 Pump 0
Wetland 2017 Pump 7 b
Crisp Hatchery 2016 Pump 0
Crisp Hatchery 2017 Pump 9 ab
Shallow Near Wells 2016/17 Pump 2
Shallow Near Wells 2016/17 After 0
Shallow South Wells 2016/17 Pump 2
Shallow South Wells 2016/17 After 0
Deep West Wells 2016/17 Pump 3
Deep West Wells 2016/17 After 0
0.0
0.5
1.0
1.5
2.0
2.5
ug/L



Zinc, Dissolved
n
group
Crisp Hatchery 1998−2008 Base 8 b
Crisp Hatchery 1998−2008 Storm 12 b
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 ab
Crisp Mouth 1998−2008 Storm 36 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 9 ab
Lake 2017 Pump 8 ab
Pit 2016 Pump 3 ab
Pit 2017 Pump 3 a
Wetland 2016 Pump 7 c
Wetland 2017 Pump 7 c
Crisp Hatchery 2016 Pump 8 bc
Crisp Hatchery 2017 Pump 9 c
Shallow Near Wells 2016/17 Pump 4 a
Shallow Near Wells 2016/17 After 4 a
Shallow South Wells 2016/17 Pump 4 a
Shallow South Wells 2016/17 After 2 a
Deep West Wells 2016/17 Pump 6 a
Deep West Wells 2016/17 After 6 a
0
2
4
6
8
10
12
ug/L



Zinc, Total
n
group
Crisp Hatchery 1998−2008 Base 8 c
Crisp Hatchery 1998−2008 Storm 12 bc
Crisp Hatchery 2013−2016 Base 0
Crisp Mouth 1998−2008 Base 11 b
Crisp Mouth 1998−2008 Storm 38 a
Crisp Mouth 2013−2016 Base 0
Lake 2016 Pump 0
Lake 2017 Pump 8 a
Pit 2016 Pump 0
Pit 2017 Pump 3 a
Wetland 2016 Pump 0
Wetland 2017 Pump 7 b
Crisp Hatchery 2016 Pump 0
Crisp Hatchery 2017 Pump 9 ab
Shallow Near Wells 2016/17 Pump 2
Shallow Near Wells 2016/17 After 0
Shallow South Wells 2016/17 Pump 2
Shallow South Wells 2016/17 After 0
Deep West Wells 2016/17 Pump 3
Deep West Wells 2016/17 After 0
0
5
10
15
ug/L

Summary Statistics Tables

Table A1. Temperature Summary Statistics (values in degrees C).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	157	a	9.1	9.3	6.4	12.1	1.0	7.5	8.3	9.8	10.1	1.5
Crisp Hatchery 1998-2008 Storm	12	a	8.6	8.4	7.3	9.7	0.9	7.5	8.1	9.4	9.7	1.3
Crisp Hatchery 2013-2016 Base	48	a	9.4	9.6	5.3	12.6	1.5	7.7	8.4	10.4	10.9	2.0
Crisp Mouth 1998-2008 Base	130	a	9.5	9.6	5.3	15.2	2.1	6.6	8.0	11.2	12.1	3.2
Crisp Mouth 1998-2008 Storm	37	a	9.5	9.6	6.9	12.4	1.5	7.8	8.4	10.6	11.6	2.2
Crisp Mouth 2013-2016 Base	48	a	9.8	10.1	5.9	13.5	1.9	7.3	8.5	11.5	11.9	3.0
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	0											
Pit 2016 Pump	0											
Pit 2017 Pump	0											
Wetland 2016 Pump	0											
Wetland 2017 Pump	0											
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	0											
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	bc	10.5	10.6	9.7	10.9	0.5	9.9	10.3	10.8	10.8	0.4
Shallow Near Wells 2016/17 After	4	a	12.6	12.8	11.0	14.0	1.3	11.4	12.1	13.3	13.7	1.3
Shallow South Wells 2016/17 Pump	4	c	9.6	9.6	9.5	9.6	0.1	9.5	9.5	9.6	9.6	0.1
Shallow South Wells 2016/17 After	2	abc	10.9	10.9	9.7	12.0	1.6	9.9	10.3	11.4	11.8	1.2
Deep West Wells 2016/17 Pump	6	bc	10.2	10.1	9.7	10.7	0.4	9.9	10.0	10.4	10.6	0.4
Deep West Wells 2016/17 After	6	ab	10.7	10.8	10.1	11.3	0.4	10.3	10.5	10.9	11.1	0.4

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.
IQR = Interquartile range

Table A2. Dissolved Oxygen Summary Statistics (values in mg/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	156	a	11.5	11.4	9.5	14.0	0.6	10.8	11.1	11.8	12.2	0.7
Crisp Hatchery 1998-2008 Storm	12	a	11.5	11.6	10.6	12.6	0.5	10.9	11.3	11.7	12.0	0.4
Crisp Hatchery 2013-2016 Base	48	a	11.5	11.4	10.8	12.7	0.4	11.1	11.2	11.7	12.2	0.5
Crisp Mouth 1998-2008 Base	126	b	10.7	10.6	8.4	12.3	0.7	9.8	10.1	11.2	11.5	1.1
Crisp Mouth 1998-2008 Storm	34	c	10.1	10.3	7.7	11.6	1.0	8.5	9.7	10.8	11.2	1.1
Crisp Mouth 2013-2016 Base	48	c	9.9	10.3	6.5	11.4	1.2	8.2	9.5	10.7	11.0	1.3
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	0											
Pit 2016 Pump	0											
Pit 2017 Pump	0											
Wetland 2016 Pump	0											
Wetland 2017 Pump	0											
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	0											
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	10.5	11.0	8.5	11.4	1.4	9.1	10.1	11.4	11.4	1.3
Shallow Near Wells 2016/17 After	4	ab	8.9	9.1	7.0	10.4	1.6	7.3	7.8	10.2	10.3	2.4
Shallow South Wells 2016/17 Pump	4	a	11.2	11.4	10.4	11.6	0.5	10.7	11.1	11.5	11.6	0.4
Shallow South Wells 2016/17 After	2	b	5.9	5.9	3.8	8.0	3.0	4.2	4.9	7.0	7.6	2.1
Deep West Wells 2016/17 Pump	6	b	7.9	8.0	5.1	10.3	2.1	5.5	6.3	9.5	10.1	3.2
Deep West Wells 2016/17 After	6	b	5.7	6.3	1.3	8.1	2.5	2.9	4.8	7.4	7.9	2.6

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A3. pH Summary Statistics.												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	155	b	7.63	7.70	6.60	8.10	0.23	7.40	7.50	7.80	7.90	0.30
Crisp Hatchery 1998-2008 Storm	12	ab	7.67	7.70	7.20	8.20	0.32	7.20	7.45	7.90	7.90	0.45
Crisp Hatchery 2013-2016 Base	48	a	7.74	7.77	7.04	7.97	0.16	7.57	7.68	7.85	7.90	0.18
Crisp Mouth 1998-2008 Base	129	c	7.42	7.40	6.60	8.26	0.27	7.10	7.22	7.60	7.79	0.38
Crisp Mouth 1998-2008 Storm	37	c	7.39	7.41	6.80	8.31	0.36	6.96	7.14	7.50	7.70	0.36
Crisp Mouth 2013-2016 Base	48	c	7.32	7.32	6.82	7.78	0.22	6.99	7.21	7.49	7.57	0.29
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	0											
Pit 2016 Pump	0											
Pit 2017 Pump	0											
Wetland 2016 Pump	0											
Wetland 2017 Pump	0											
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	0											
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	ab	6.24	6.23	6.04	6.46	0.22	6.04	6.05	6.42	6.44	0.37
Shallow Near Wells 2016/17 After	4	ab	6.30	6.30	6.02	6.60	0.26	6.06	6.13	6.47	6.55	0.35
Shallow South Wells 2016/17 Pump	4	ab	6.63	6.63	6.58	6.67	0.04	6.59	6.60	6.66	6.67	0.07
Shallow South Wells 2016/17 After	2	a	6.66	6.66	6.61	6.70	0.06	6.62	6.63	6.68	6.69	0.04
Deep West Wells 2016/17 Pump	6	a	6.76	6.72	6.41	7.18	0.30	6.45	6.53	6.97	7.11	0.45
Deep West Wells 2016/17 After	6	a	6.82	6.62	6.47	7.75	0.49	6.49	6.51	6.89	7.36	0.38

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A4. Conductivity Summary Statistics (values in umhos/cm).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	128	bc	111	113	84	126	10	97	104	120	123	16
Crisp Hatchery 1998-2008 Storm	12	c	99	101	70	116	15	77	91	111	115	20
Crisp Hatchery 2013-2016 Base	48	bc	112	113	54	134	13	99	106	122	127	16
Crisp Mouth 1998-2008 Base	105	a	121	121	92	146	10	107	115	128	131	13
Crisp Mouth 1998-2008 Storm	22	ab	117	118	86	138	16	98	102	133	135	31
Crisp Mouth 2013-2016 Base	48	a	122	121	94	144	12	106	115	131	138	17
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	0											
Pit 2016 Pump	0											
Pit 2017 Pump	0											
Wetland 2016 Pump	0											
Wetland 2017 Pump	0											
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	0											
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	b	67	68	49	84	15	53	59	75	80	16
Shallow Near Wells 2016/17 After	4	b	74	72	55	96	18	58	63	82	91	19
Shallow South Wells 2016/17 Pump	4	b	71	70	69	77	4	69	69	73	75	4
Shallow South Wells 2016/17 After	2	ab	101	101	78	125	33	82	90	113	120	24
Deep West Wells 2016/17 Pump	6	a	136	149	86	169	35	93	111	160	166	49
Deep West Wells 2016/17 After	6	a	142	137	118	170	21	123	128	158	166	30

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A5. Hardness Summary Statistics (values in mg CaCO3/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	ab	46.4	46.9	40.4	52.0	4.6	40.8	42.5	50.5	51.0	8.1
Crisp Hatchery 1998-2008 Storm	12	b	42.5	44.1	30.1	50.7	6.2	35.4	39.2	46.5	49.5	7.3
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	a	49.8	51.9	42.4	55.6	4.3	44.3	46.3	52.9	53.5	6.6
Crisp Mouth 1998-2008 Storm	6	ab	46.8	47.0	33.1	56.5	8.9	37.1	42.4	53.8	56.3	11.4
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	c	22.8	24.4	15.0	28.8	5.0	15.5	20.4	26.5	27.0	6.1
Lake 2017 Pump	8	bc	28.4	27.4	16.5	50.5	9.8	21.2	25.2	27.9	35.2	2.7
Pit 2016 Pump	3	abc	29.7	27.1	24.7	37.4	6.7	25.2	25.9	32.3	35.3	6.4
Pit 2017 Pump	3	bc	27.1	26.6	26.1	28.6	1.3	26.2	26.4	27.6	28.2	1.3
Wetland 2016 Pump	7	ab	34.6	33.7	30.3	38.9	3.2	31.5	32.6	37.1	38.5	4.6
Wetland 2017 Pump	7	ab	37.2	38.3	30.6	41.5	4.0	32.6	34.8	40.4	41.0	5.6
Crisp Hatchery 2016 Pump	8	a	41.4	40.3	33.3	54.7	6.7	35.0	37.9	42.7	49.3	4.8
Crisp Hatchery 2017 Pump	9	a	40.2	41.2	24.2	47.8	7.0	34.7	39.2	42.1	47.7	2.9
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	b	26.4	28.0	17.8	31.6	6.0	20.6	24.9	29.5	30.8	4.7
Shallow Near Wells 2016/17 After	4	b	25.3	25.7	19.6	30.4	5.2	20.4	21.6	29.4	30.0	7.9
Shallow South Wells 2016/17 Pump	4	b	29.3	29.2	27.1	31.8	2.4	27.2	27.4	31.1	31.5	3.7
Shallow South Wells 2016/17 After	2	ab	36.2	36.2	30.8	41.5	7.6	31.9	33.5	38.8	40.4	5.4
Deep West Wells 2016/17 Pump	6	a	58.1	63.6	32.6	79.7	19.0	35.0	43.2	70.5	75.8	27.2
Deep West Wells 2016/17 After	6	a	65.0	64.9	53.1	76.6	11.7	53.8	54.7	75.6	76.4	20.9

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A6. Orthophosphate Phosphorus Summary Statistics (values in mg/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	157	b	0.014	0.015	0.008	0.024	0.002	0.012	0.014	0.015	0.016	0.002
Crisp Hatchery 1998-2008 Storm	12	b	0.015	0.015	0.011	0.019	0.002	0.013	0.013	0.016	0.018	0.003
Crisp Hatchery 2013-2016 Base	48	c	0.011	0.011	0.008	0.017	0.002	0.009	0.010	0.012	0.014	0.003
Crisp Mouth 1998-2008 Base	127	a	0.026	0.025	0.014	0.078	0.010	0.017	0.019	0.030	0.037	0.012
Crisp Mouth 1998-2008 Storm	38	a	0.028	0.028	0.016	0.049	0.007	0.020	0.022	0.034	0.037	0.012
Crisp Mouth 2013-2016 Base	48	a	0.029	0.022	0.015	0.077	0.015	0.017	0.019	0.036	0.046	0.018
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	ab	0.006	0.003	0.002	0.014	0.004	0.002	0.002	0.009	0.011	0.007
Lake 2017 Pump	8	ab	0.006	0.003	0.002	0.027	0.008	0.002	0.003	0.004	0.011	0.002
Pit 2016 Pump	3	b	0.002	0.002	0.001	0.002	0.000	0.002	0.002	0.002	0.002	0.000
Pit 2017 Pump	3	b	0.002	0.002	0.002	0.004	0.001	0.002	0.002	0.003	0.003	0.001
Wetland 2016 Pump	7	ab	0.004	0.005	0.002	0.006	0.002	0.002	0.003	0.006	0.006	0.002
Wetland 2017 Pump	7	ab	0.005	0.005	0.003	0.010	0.002	0.003	0.004	0.006	0.008	0.003
Crisp Hatchery 2016 Pump	8	a	0.009	0.009	0.008	0.014	0.002	0.008	0.008	0.009	0.011	0.001
Crisp Hatchery 2017 Pump	9	a	0.008	0.009	0.002	0.011	0.003	0.007	0.008	0.010	0.010	0.002
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	b	0.004	0.004	0.003	0.006	0.002	0.003	0.003	0.006	0.006	0.003
Shallow Near Wells 2016/17 After	4	b	0.007	0.008	0.003	0.010	0.004	0.004	0.005	0.010	0.010	0.006
Shallow South Wells 2016/17 Pump	4	a	0.012	0.013	0.010	0.015	0.002	0.010	0.011	0.014	0.015	0.004
Shallow South Wells 2016/17 After	2	a	0.026	0.026	0.016	0.037	0.014	0.018	0.021	0.032	0.035	0.010
Deep West Wells 2016/17 Pump	6	b	0.008	0.008	0.006	0.009	0.001	0.006	0.007	0.008	0.009	0.001
Deep West Wells 2016/17 After	6	b	0.007	0.008	0.004	0.009	0.002	0.005	0.007	0.008	0.009	0.001

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A7. Total Phosphorus Summary Statistics (values in mg/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	157	d	0.021	0.021	0.011	0.035	0.004	0.016	0.018	0.024	0.027	0.006
Crisp Hatchery 1998-2008 Storm	12	c	0.052	0.026	0.020	0.316	0.084	0.022	0.023	0.028	0.054	0.005
Crisp Hatchery 2013-2016 Base	48	e	0.026	0.018	0.014	0.415	0.057	0.016	0.016	0.019	0.021	0.003
Crisp Mouth 1998-2008 Base	127	b	0.047	0.044	0.020	0.166	0.021	0.030	0.035	0.051	0.069	0.017
Crisp Mouth 1998-2008 Storm	38	a	0.059	0.056	0.034	0.127	0.019	0.041	0.047	0.062	0.078	0.015
Crisp Mouth 2013-2016 Base	48	ab	0.058	0.042	0.028	0.172	0.035	0.032	0.035	0.067	0.108	0.032
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	0.044	0.038	0.028	0.082	0.016	0.031	0.036	0.045	0.061	0.009
Lake 2017 Pump	8	a	0.051	0.038	0.021	0.109	0.032	0.022	0.032	0.062	0.097	0.030
Pit 2016 Pump	3	ab	0.023	0.023	0.022	0.025	0.001	0.023	0.023	0.024	0.024	0.001
Pit 2017 Pump	3	ab	0.027	0.023	0.022	0.036	0.008	0.022	0.022	0.030	0.034	0.007
Wetland 2016 Pump	7	c	0.011	0.010	0.007	0.017	0.004	0.007	0.009	0.013	0.016	0.004
Wetland 2017 Pump	7	c	0.013	0.011	0.009	0.023	0.005	0.009	0.010	0.012	0.017	0.002
Crisp Hatchery 2016 Pump	8	bc	0.018	0.017	0.013	0.030	0.005	0.013	0.015	0.018	0.023	0.003
Crisp Hatchery 2017 Pump	9	b	0.023	0.019	0.016	0.054	0.012	0.017	0.018	0.020	0.029	0.003
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.038	0.025	0.011	0.092	0.037	0.014	0.019	0.045	0.073	0.026
Shallow Near Wells 2016/17 After	4	a	0.014	0.015	0.009	0.018	0.004	0.010	0.013	0.016	0.017	0.003
Shallow South Wells 2016/17 Pump	4	a	0.017	0.017	0.014	0.019	0.003	0.014	0.015	0.019	0.019	0.003
Shallow South Wells 2016/17 After	2	a	0.032	0.032	0.023	0.041	0.012	0.025	0.028	0.036	0.039	0.009
Deep West Wells 2016/17 Pump	6	a	0.013	0.012	0.011	0.015	0.001	0.011	0.012	0.013	0.014	0.002
Deep West Wells 2016/17 After	6	a	0.017	0.013	0.010	0.038	0.011	0.011	0.011	0.016	0.027	0.005

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A8. Nitrite + Nitrate Nitrogen Summary Statistics (values in mg/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	157	d	0.63	0.62	0.44	1.07	0.09	0.54	0.58	0.67	0.72	0.10
Crisp Hatchery 1998-2008 Storm	12	cd	0.68	0.63	0.55	1.00	0.15	0.56	0.58	0.71	0.93	0.13
Crisp Hatchery 2013-2016 Base	48	b	0.77	0.75	0.63	2.09	0.20	0.65	0.69	0.77	0.83	0.08
Crisp Mouth 1998-2008 Base	127	bc	0.74	0.73	0.52	1.28	0.11	0.60	0.66	0.79	0.84	0.13
Crisp Mouth 1998-2008 Storm	38	ab	0.84	0.78	0.55	1.63	0.27	0.61	0.64	0.91	1.20	0.27
Crisp Mouth 2013-2016 Base	48	a	0.82	0.81	0.61	1.70	0.16	0.69	0.74	0.88	0.92	0.14
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	e	0.18	0.23	0.01	0.35	0.15	0.01	0.01	0.32	0.34	0.31
Lake 2017 Pump	8	e	0.16	0.16	0.01	0.36	0.14	0.01	0.03	0.28	0.31	0.25
Pit 2016 Pump	3	ab	0.68	0.68	0.64	0.73	0.05	0.64	0.66	0.70	0.72	0.05
Pit 2017 Pump	3	de	0.38	0.44	0.26	0.44	0.11	0.29	0.35	0.44	0.44	0.09
Wetland 2016 Pump	7	bc	0.62	0.65	0.53	0.70	0.07	0.54	0.57	0.68	0.69	0.11
Wetland 2017 Pump	7	cd	0.52	0.53	0.43	0.59	0.05	0.47	0.50	0.56	0.58	0.05
Crisp Hatchery 2016 Pump	8	a	0.81	0.83	0.69	0.89	0.08	0.70	0.74	0.87	0.88	0.13
Crisp Hatchery 2017 Pump	9	b	0.62	0.65	0.37	0.75	0.10	0.55	0.61	0.67	0.68	0.06
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	2.40	2.52	1.74	2.82	0.48	1.93	2.21	2.70	2.77	0.49
Shallow Near Wells 2016/17 After	4	ab	1.74	1.57	1.06	2.76	0.73	1.17	1.35	1.97	2.44	0.62
Shallow South Wells 2016/17 Pump	4	c	0.54	0.46	0.41	0.84	0.20	0.42	0.44	0.56	0.73	0.12
Shallow South Wells 2016/17 After	2	c	0.44	0.44	0.32	0.57	0.17	0.35	0.38	0.50	0.54	0.12
Deep West Wells 2016/17 Pump	6	ab	1.47	1.60	0.69	2.22	0.61	0.77	0.97	1.86	2.04	0.89
Deep West Wells 2016/17 After	6	bc	1.06	0.89	0.73	2.13	0.53	0.76	0.80	0.93	1.53	0.12

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A9. Ammonia Nitrogen Summary Statistics (values in mg/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	157	b	0.006	0.005	0.005	0.022	0.002	0.005	0.005	0.005	0.010	0.000
Crisp Hatchery 1998-2008 Storm	12	b	0.006	0.005	0.005	0.021	0.005	0.005	0.005	0.005	0.005	0.000
Crisp Hatchery 2013-2016 Base	48	c	0.004	0.003	0.001	0.011	0.002	0.002	0.003	0.004	0.005	0.002
Crisp Mouth 1998-2008 Base	127	a	0.089	0.074	0.010	0.371	0.064	0.021	0.039	0.126	0.156	0.087
Crisp Mouth 1998-2008 Storm	38	a	0.092	0.090	0.018	0.184	0.049	0.028	0.056	0.127	0.157	0.071
Crisp Mouth 2013-2016 Base	48	a	0.117	0.081	0.023	0.346	0.091	0.039	0.051	0.143	0.282	0.092
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	ab	0.031	0.007	0.005	0.216	0.070	0.005	0.007	0.009	0.053	0.003
Lake 2017 Pump	8	ab	0.011	0.009	0.004	0.026	0.008	0.004	0.006	0.014	0.018	0.008
Pit 2016 Pump	3	a	0.101	0.100	0.098	0.105	0.004	0.098	0.099	0.103	0.104	0.003
Pit 2017 Pump	3	ab	0.016	0.014	0.004	0.030	0.013	0.006	0.009	0.022	0.027	0.013
Wetland 2016 Pump	7	ab	0.008	0.009	0.005	0.012	0.003	0.006	0.006	0.010	0.011	0.004
Wetland 2017 Pump	7	a	0.011	0.011	0.010	0.015	0.002	0.010	0.010	0.012	0.014	0.002
Crisp Hatchery 2016 Pump	8	c	0.003	0.003	0.001	0.004	0.001	0.002	0.002	0.003	0.004	0.001
Crisp Hatchery 2017 Pump	9	bc	0.006	0.004	0.003	0.015	0.004	0.003	0.003	0.005	0.011	0.001
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.004	0.001	0.001	0.011	0.005	0.001	0.001	0.004	0.008	0.003
Shallow Near Wells 2016/17 After	4	a	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.002	0.000
Shallow South Wells 2016/17 Pump	4	a	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.001	0.001	0.000
Shallow South Wells 2016/17 After	2	a	0.009	0.009	0.001	0.018	0.012	0.003	0.005	0.014	0.016	0.008
Deep West Wells 2016/17 Pump	6	a	0.003	0.001	0.001	0.013	0.005	0.001	0.001	0.001	0.007	0.000
Deep West Wells 2016/17 After	6	a	0.001	0.001	0.001	0.003	0.001	0.001	0.001	0.001	0.002	0.000

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A10. Total Nitrogen Summary Statistics (values in mg/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	157	d	0.70	0.69	0.36	1.34	0.11	0.59	0.64	0.75	0.82	0.11
Crisp Hatchery 1998-2008 Storm	12	c	0.86	0.75	0.59	1.58	0.29	0.65	0.69	0.88	1.26	0.19
Crisp Hatchery 2013-2016 Base	48	c	0.89	0.83	0.69	3.64	0.41	0.73	0.78	0.87	0.94	0.09
Crisp Mouth 1998-2008 Base	127	b	0.99	0.96	0.35	1.80	0.22	0.76	0.85	1.10	1.26	0.25
Crisp Mouth 1998-2008 Storm	38	a	1.18	1.08	0.75	2.25	0.40	0.81	0.94	1.21	1.90	0.27
Crisp Mouth 2013-2016 Base	48	a	1.17	1.09	0.82	2.61	0.33	0.86	0.96	1.28	1.53	0.32
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	ab	0.86	0.93	0.54	1.21	0.23	0.62	0.67	1.02	1.11	0.35
Lake 2017 Pump	8	ab	0.84	0.81	0.64	1.27	0.19	0.67	0.73	0.87	1.00	0.14
Pit 2016 Pump	3	a	1.04	1.03	1.01	1.07	0.03	1.01	1.02	1.05	1.06	0.03
Pit 2017 Pump	3	abc	0.77	0.79	0.71	0.81	0.05	0.72	0.75	0.80	0.81	0.05
Wetland 2016 Pump	7	bc	0.70	0.74	0.59	0.76	0.07	0.63	0.66	0.75	0.76	0.09
Wetland 2017 Pump	7	c	0.63	0.64	0.52	0.71	0.06	0.58	0.62	0.64	0.67	0.02
Crisp Hatchery 2016 Pump	8	a	0.89	0.90	0.77	1.04	0.09	0.78	0.82	0.95	1.00	0.13
Crisp Hatchery 2017 Pump	9	abc	0.78	0.75	0.71	0.92	0.07	0.72	0.73	0.81	0.87	0.08
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	2.41	2.48	1.81	2.88	0.47	1.96	2.18	2.72	2.81	0.54
Shallow Near Wells 2016/17 After	4	ab	1.84	1.67	1.10	2.94	0.78	1.24	1.46	2.05	2.58	0.59
Shallow South Wells 2016/17 Pump	4	c	0.54	0.47	0.44	0.80	0.17	0.45	0.46	0.56	0.70	0.10
Shallow South Wells 2016/17 After	2	c	0.47	0.47	0.35	0.58	0.16	0.38	0.41	0.52	0.56	0.11
Deep West Wells 2016/17 Pump	6	ab	1.48	1.57	0.71	2.27	0.62	0.77	0.96	1.88	2.09	0.91
Deep West Wells 2016/17 After	6	bc	1.10	0.94	0.76	2.17	0.53	0.78	0.83	0.99	1.59	0.15

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A11. Fecal Coliform Bacteria Summary Statistics (values in CFU/100mL).

Station/Period	n	Group	Mean	Median	Min.	Max.	StdDev.	10th %	25th %	75th %	90th %	IQR
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	155	e	9	5	0	72	12	1	3	11	21	8
Crisp Hatchery 1998-2008 Storm	12	cd	60	24	6	490	136	9	13	32	39	19
Crisp Hatchery 2013-2016 Base	48	d	26	9	1	220	46	3	4	18	60	14
Crisp Mouth 1998-2008 Base	126	b	92	55	3	750	113	17	27	97	235	69
Crisp Mouth 1998-2008 Storm	38	a	490	215	29	4100	784	40	97	570	805	473
Crisp Mouth 2013-2016 Base	48	bc	65	39	1	330	70	11	18	73	160	55
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	0											
Pit 2016 Pump	0											
Pit 2017 Pump	0											
Wetland 2016 Pump	0											
Wetland 2017 Pump	0											
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	0											
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2	NA	0.50	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.50	0.00
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2	NA	0.50	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.50	0.00
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3	NA	0.50	0.50	0.50	0.50	0.00	0.50	0.50	0.50	0.50	0.00
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A12. Dissolved Aluminum Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	ab	11.0	10.8	1.0	22.2	10.3	1.0	1.0	19.7	22.1	18.7
Crisp Hatchery 1998-2008 Storm	12	a	39.8	29.9	1.0	113.0	32.2	9.6	21.3	49.8	77.6	28.5
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	2	ab	18.8	18.8	17.1	20.5	2.4	17.4	18.0	19.7	20.2	1.7
Crisp Mouth 1998-2008 Storm	1	a	29.0	29.0	29.0	29.0	NA	29.0	29.0	29.0	29.0	0.0
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	36.8	32.8	15.0	62.4	16.8	22.8	24.9	51.8	59.4	26.9
Lake 2017 Pump	8	b	20.0	9.6	8.2	73.1	22.8	8.2	8.7	16.4	43.6	7.7
Pit 2016 Pump	3	ab	21.0	20.8	19.3	22.8	1.8	19.6	20.1	21.8	22.4	1.8
Pit 2017 Pump	3	bc	11.2	11.1	9.6	12.8	1.6	9.9	10.4	12.0	12.5	1.6
Wetland 2016 Pump	7	c	4.3	3.3	2.8	7.9	1.9	2.9	3.0	5.1	6.3	2.1
Wetland 2017 Pump	7	bc	8.9	6.2	3.0	24.7	7.3	3.7	5.2	9.0	15.5	3.8
Crisp Hatchery 2016 Pump	8	b	16.7	15.4	1.0	32.3	9.5	9.1	13.1	19.5	28.5	6.4
Crisp Hatchery 2017 Pump	9	b	15.9	14.8	8.4	23.2	5.0	9.7	13.4	19.4	21.2	6.0
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	1.7	1.0	1.0	3.9	1.5	1.0	1.0	1.7	3.0	0.7
Shallow Near Wells 2016/17 After	4	a	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0
Shallow South Wells 2016/17 Pump	4	a	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0
Shallow South Wells 2016/17 After	2	a	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0
Deep West Wells 2016/17 Pump	6	a	2.5	1.0	1.0	10.2	3.8	1.0	1.0	1.0	5.6	0.0
Deep West Wells 2016/17 After	6	a	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	0.0

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A13. Total Aluminum Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	34.6	31.7	9.9	63.1	22.2	10.3	17.2	51.6	62.5	34.4
Crisp Hatchery 1998-2008 Storm	5	b	46.5	43.4	11.3	69.4	23.5	23.5	41.7	66.6	68.3	24.9
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	10	a	171.0	111.5	60.1	502.0	138.8	72.7	94.0	186.3	336.4	92.3
Crisp Mouth 1998-2008 Storm	0											
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	ab	86.0	63.8	19.5	234.0	73.7	19.9	36.6	107.4	176.6	70.8
Pit 2016 Pump	0											
Pit 2017 Pump	3	a	108.6	126.0	72.8	127.0	31.0	83.4	99.4	126.5	126.8	27.1
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	ab	27.1	11.4	6.7	129.0	45.0	8.1	9.5	11.8	58.7	2.3
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	a	158.6	111.0	44.9	664.0	192.1	56.7	76.6	131.0	242.4	54.4
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		754.0	754.0	118.0	1390.0	899.4	245.2	436.0	1072.0	1262.8	636.0
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		6.5	6.5	3.0	10.0	4.9	3.7	4.8	8.3	9.3	3.5
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		57.5	69.6	1.0	102.0	51.6	14.7	35.3	85.8	95.5	50.5
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A14. Dissolved Arsenic Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	ab	0.53	0.55	0.45	0.57	0.05	0.46	0.52	0.57	0.57	0.05
Crisp Hatchery 1998-2008 Storm	12	ab	0.57	0.57	0.52	0.61	0.03	0.53	0.56	0.58	0.60	0.03
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	a	0.59	0.59	0.48	0.64	0.05	0.52	0.56	0.63	0.64	0.06
Crisp Mouth 1998-2008 Storm	34	a	0.56	0.58	0.25	0.71	0.12	0.33	0.56	0.62	0.65	0.06
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	0.66	0.65	0.34	0.89	0.18	0.47	0.58	0.83	0.85	0.26
Lake 2017 Pump	8	ab	0.51	0.54	0.29	0.60	0.11	0.38	0.47	0.58	0.60	0.11
Pit 2016 Pump	3	a	0.85	0.89	0.78	0.89	0.06	0.80	0.83	0.89	0.89	0.05
Pit 2017 Pump	3	ab	0.54	0.51	0.50	0.61	0.06	0.50	0.50	0.56	0.59	0.05
Wetland 2016 Pump	7	c	0.22	0.22	0.21	0.24	0.01	0.21	0.22	0.23	0.23	0.01
Wetland 2017 Pump	7	c	0.27	0.23	0.20	0.44	0.08	0.21	0.23	0.27	0.34	0.05
Crisp Hatchery 2016 Pump	8	b	0.42	0.40	0.39	0.53	0.05	0.39	0.40	0.43	0.49	0.03
Crisp Hatchery 2017 Pump	9	b	0.42	0.43	0.36	0.47	0.04	0.37	0.38	0.46	0.46	0.08
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	b	0.10	0.09	0.05	0.16	0.06	0.05	0.05	0.14	0.15	0.09
Shallow Near Wells 2016/17 After	4	b	0.14	0.14	0.10	0.18	0.04	0.10	0.11	0.17	0.17	0.06
Shallow South Wells 2016/17 Pump	4	b	0.16	0.15	0.12	0.22	0.05	0.12	0.12	0.18	0.21	0.06
Shallow South Wells 2016/17 After	2	a	0.54	0.54	0.29	0.79	0.35	0.34	0.42	0.66	0.74	0.25
Deep West Wells 2016/17 Pump	6	a	0.34	0.34	0.19	0.50	0.11	0.21	0.26	0.40	0.46	0.14
Deep West Wells 2016/17 After	6	a	0.30	0.34	0.19	0.38	0.08	0.20	0.24	0.35	0.37	0.11

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A15. Total Arsenic Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.55	0.56	0.48	0.62	0.05	0.49	0.52	0.57	0.59	0.05
Crisp Hatchery 1998-2008 Storm	12	b	0.61	0.60	0.38	0.94	0.13	0.53	0.56	0.64	0.69	0.08
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	ab	0.66	0.62	0.51	0.95	0.13	0.53	0.57	0.72	0.76	0.16
Crisp Mouth 1998-2008 Storm	35	a	0.79	0.72	0.51	1.30	0.21	0.60	0.63	0.90	1.16	0.27
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	a	0.64	0.65	0.30	0.95	0.18	0.47	0.61	0.68	0.78	0.07
Pit 2016 Pump	0											
Pit 2017 Pump	3	ab	0.62	0.62	0.59	0.65	0.03	0.59	0.60	0.63	0.64	0.03
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	c	0.28	0.25	0.21	0.49	0.09	0.23	0.24	0.26	0.35	0.02
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	b	0.49	0.46	0.40	0.76	0.11	0.43	0.44	0.49	0.55	0.05
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		0.29	0.29	0.17	0.40	0.16	0.19	0.23	0.34	0.38	0.12
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.15	0.15	0.13	0.17	0.03	0.13	0.14	0.16	0.17	0.02
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		0.36	0.39	0.21	0.48	0.14	0.25	0.30	0.44	0.46	0.14
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A16. Dissolved Cadmium Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.005	0.005	0.005	0.005	0.000	0.005	0.005	0.005	0.005	0.000
Crisp Hatchery 1998-2008 Storm	12	b	0.005	0.005	0.005	0.005	0.000	0.005	0.005	0.005	0.005	0.000
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	b	0.005	0.005	0.005	0.005	0.000	0.005	0.005	0.005	0.005	0.000
Crisp Mouth 1998-2008 Storm	36	a	0.061	0.050	0.025	0.230	0.034	0.050	0.050	0.050	0.100	0.000
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Lake 2017 Pump	8	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Pit 2016 Pump	3	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Pit 2017 Pump	3	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Wetland 2016 Pump	7	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Wetland 2017 Pump	7	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Crisp Hatchery 2016 Pump	8	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Crisp Hatchery 2017 Pump	9	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Shallow Near Wells 2016/17 After	4	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Shallow South Wells 2016/17 Pump	4	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Shallow South Wells 2016/17 After	2	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Deep West Wells 2016/17 Pump	6	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Deep West Wells 2016/17 After	6	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A17. Total Cadmium Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.005	0.005	0.005	0.005	0.000	0.005	0.005	0.005	0.005	0.000
Crisp Hatchery 1998-2008 Storm	12	b	0.006	0.005	0.005	0.019	0.004	0.005	0.005	0.005	0.005	0.000
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	b	0.005	0.005	0.005	0.010	0.002	0.005	0.005	0.005	0.005	0.000
Crisp Mouth 1998-2008 Storm	38	a	0.060	0.050	0.025	0.100	0.021	0.050	0.050	0.050	0.100	0.000
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	a	0.030	0.025	0.025	0.066	0.014	0.025	0.025	0.025	0.037	0.000
Pit 2016 Pump	0											
Pit 2017 Pump	3	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	a	0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		0.025	0.025	0.025	0.025	0.000	0.025	0.025	0.025	0.025	0.000
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A18. Dissolved Chromium Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.20	0.19	0.17	0.28	0.04	0.17	0.17	0.22	0.25	0.05
Crisp Hatchery 1998-2008 Storm	12	ab	0.22	0.23	0.16	0.28	0.04	0.17	0.20	0.25	0.26	0.05
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	a	0.24	0.24	0.17	0.43	0.07	0.20	0.21	0.25	0.26	0.04
Crisp Mouth 1998-2008 Storm	36	ab	0.21	0.20	0.10	0.44	0.05	0.20	0.20	0.20	0.25	0.00
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	0.16	0.10	0.10	0.35	0.10	0.10	0.10	0.23	0.30	0.13
Lake 2017 Pump	8	a	0.15	0.10	0.10	0.39	0.11	0.10	0.10	0.14	0.29	0.04
Pit 2016 Pump	3	a	0.10	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.00
Pit 2017 Pump	3	a	0.22	0.20	0.10	0.37	0.14	0.12	0.15	0.29	0.34	0.14
Wetland 2016 Pump	7	a	0.10	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.00
Wetland 2017 Pump	7	a	0.16	0.10	0.10	0.33	0.09	0.10	0.10	0.21	0.26	0.11
Crisp Hatchery 2016 Pump	8	a	0.16	0.16	0.10	0.23	0.06	0.10	0.10	0.22	0.22	0.12
Crisp Hatchery 2017 Pump	9	a	0.20	0.20	0.10	0.31	0.08	0.10	0.10	0.25	0.29	0.15
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.42	0.40	0.38	0.50	0.05	0.38	0.39	0.43	0.47	0.05
Shallow Near Wells 2016/17 After	4	a	0.48	0.43	0.33	0.74	0.18	0.35	0.39	0.52	0.65	0.13
Shallow South Wells 2016/17 Pump	4	b	0.16	0.15	0.10	0.22	0.06	0.10	0.10	0.21	0.21	0.11
Shallow South Wells 2016/17 After	2	b	0.10	0.10	0.10	0.10	0.00	0.10	0.10	0.10	0.10	0.00
Deep West Wells 2016/17 Pump	6	a	0.32	0.32	0.21	0.45	0.10	0.23	0.24	0.40	0.43	0.16
Deep West Wells 2016/17 After	6	ab	0.31	0.30	0.26	0.40	0.05	0.27	0.27	0.33	0.37	0.06

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A19. Total Chromium Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	a	0.28	0.26	0.21	0.39	0.06	0.23	0.25	0.31	0.36	0.07
Crisp Hatchery 1998-2008 Storm	12	a	0.42	0.26	0.22	1.41	0.33	0.23	0.24	0.43	0.58	0.19
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	a	0.50	0.36	0.26	1.30	0.33	0.26	0.30	0.58	0.87	0.29
Crisp Mouth 1998-2008 Storm	38	a	0.69	0.57	0.20	2.07	0.51	0.20	0.25	0.86	1.32	0.61
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	ab	0.27	0.28	0.10	0.52	0.17	0.10	0.10	0.39	0.44	0.29
Pit 2016 Pump	0											
Pit 2017 Pump	3	ab	0.35	0.30	0.29	0.45	0.09	0.29	0.30	0.38	0.42	0.08
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	b	0.23	0.26	0.10	0.45	0.14	0.10	0.10	0.30	0.38	0.20
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	a	0.54	0.52	0.28	1.22	0.29	0.28	0.32	0.58	0.76	0.26
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		1.85	1.85	0.91	2.78	1.32	1.10	1.38	2.31	2.59	0.94
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.40	0.40	0.40	0.40	0.00	0.40	0.40	0.40	0.40	0.00
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		0.70	0.52	0.43	1.14	0.39	0.45	0.48	0.83	1.02	0.36
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A20. Dissolved Copper Summary Statistics (values in ug/L).												
Station/Period	n	Group	Mean	Median	Min.	Max.	StdDev.	10th %	25th %	75th %	90th %	IQR
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.32	0.18	0.11	0.85	0.29	0.12	0.14	0.37	0.75	0.24
Crisp Hatchery 1998-2008 Storm	12	ab	0.34	0.32	0.19	0.82	0.17	0.20	0.23	0.38	0.43	0.15
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	ab	0.30	0.21	0.14	0.94	0.23	0.17	0.19	0.33	0.39	0.14
Crisp Mouth 1998-2008 Storm	36	a	0.62	0.54	0.20	1.70	0.44	0.20	0.20	0.84	1.30	0.64
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	2.05	2.07	1.10	3.15	0.78	1.10	1.20	2.58	2.97	1.38
Lake 2017 Pump	8	a	2.80	1.60	0.75	6.64	2.33	0.93	1.15	4.24	6.14	3.09
Pit 2016 Pump	3	abc	0.75	0.78	0.68	0.79	0.06	0.70	0.73	0.79	0.79	0.06
Pit 2017 Pump	3	ab	0.97	0.99	0.91	1.00	0.05	0.93	0.95	1.00	1.00	0.05
Wetland 2016 Pump	7	d	0.17	0.10	0.10	0.31	0.09	0.10	0.10	0.23	0.27	0.13
Wetland 2017 Pump	7	cd	0.27	0.23	0.10	0.53	0.18	0.10	0.10	0.42	0.48	0.32
Crisp Hatchery 2016 Pump	8	cd	0.31	0.25	0.10	1.10	0.33	0.10	0.10	0.29	0.56	0.19
Crisp Hatchery 2017 Pump	9	bcd	0.38	0.33	0.10	0.88	0.23	0.19	0.27	0.47	0.59	0.20
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.26	0.29	0.10	0.35	0.11	0.15	0.21	0.33	0.34	0.12
Shallow Near Wells 2016/17 After	4	a	0.36	0.28	0.10	0.78	0.29	0.15	0.21	0.43	0.64	0.22
Shallow South Wells 2016/17 Pump	4	a	0.18	0.10	0.10	0.43	0.17	0.10	0.10	0.18	0.33	0.08
Shallow South Wells 2016/17 After	2	a	0.16	0.16	0.10	0.21	0.08	0.11	0.13	0.18	0.20	0.06
Deep West Wells 2016/17 Pump	6	a	0.23	0.17	0.10	0.56	0.18	0.10	0.10	0.27	0.42	0.17
Deep West Wells 2016/17 After	6	a	0.16	0.10	0.10	0.35	0.10	0.10	0.10	0.18	0.28	0.08

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A21. Total Copper Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.29	0.20	0.13	0.96	0.28	0.14	0.14	0.24	0.51	0.10
Crisp Hatchery 1998-2008 Storm	12	ab	0.57	0.47	0.12	2.31	0.57	0.23	0.28	0.53	0.69	0.25
Crisp Hatchery 2013-2016 Base												
Crisp Mouth 1998-2008 Base	11	ab	0.65	0.35	0.25	2.41	0.64	0.26	0.27	0.79	0.98	0.52
Crisp Mouth 1998-2008 Storm	38	a	1.22	1.20	0.20	4.00	0.95	0.20	0.47	1.60	2.53	1.13
Crisp Mouth 2013-2016 Base												
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	a	2.16	1.90	0.98	4.01	1.18	1.06	1.18	3.03	3.47	1.86
Pit 2016 Pump	0											
Pit 2017 Pump	3	ab	1.02	0.99	0.97	1.10	0.07	0.97	0.98	1.05	1.08	0.06
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	c	0.14	0.10	0.10	0.36	0.10	0.10	0.10	0.10	0.20	0.00
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	b	0.48	0.36	0.10	1.40	0.42	0.20	0.23	0.39	1.04	0.16
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		1.62	1.62	0.58	2.66	1.47	0.79	1.10	2.14	2.45	1.04
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.42	0.42	0.10	0.73	0.45	0.16	0.26	0.57	0.67	0.32
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		0.39	0.51	0.10	0.57	0.26	0.18	0.31	0.54	0.56	0.24
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A22. Dissolved Lead Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.01	0.01	0.01	0.01	0.00	0.01	0.01	0.01	0.01	0.00
Crisp Hatchery 1998-2008 Storm	12	b	0.03	0.01	0.01	0.08	0.02	0.01	0.01	0.03	0.05	0.02
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	b	0.02	0.01	0.01	0.07	0.02	0.01	0.01	0.01	0.03	0.00
Crisp Mouth 1998-2008 Storm	36	a	0.12	0.10	0.05	0.25	0.05	0.10	0.10	0.10	0.25	0.00
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	ab	0.08	0.05	0.05	0.17	0.05	0.05	0.05	0.10	0.15	0.05
Lake 2017 Pump	8	a	0.25	0.23	0.05	0.64	0.18	0.09	0.14	0.30	0.42	0.16
Pit 2016 Pump	3	b	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Pit 2017 Pump	3	a	0.19	0.23	0.10	0.23	0.08	0.13	0.17	0.23	0.23	0.07
Wetland 2016 Pump	7	b	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Wetland 2017 Pump	7	b	0.06	0.05	0.05	0.12	0.03	0.05	0.05	0.05	0.08	0.00
Crisp Hatchery 2016 Pump	8	b	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Crisp Hatchery 2017 Pump	9	b	0.07	0.05	0.05	0.25	0.07	0.05	0.05	0.05	0.09	0.00
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Shallow Near Wells 2016/17 After	4	a	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Shallow South Wells 2016/17 Pump	4	a	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Shallow South Wells 2016/17 After	2	a	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Deep West Wells 2016/17 Pump	6	a	0.07	0.05	0.05	0.18	0.05	0.05	0.05	0.05	0.12	0.00
Deep West Wells 2016/17 After	6	a	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A23. Total Lead Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	c	0.02	0.02	0.01	0.05	0.01	0.01	0.01	0.04	0.04	0.02
Crisp Hatchery 1998-2008 Storm	12	bc	0.11	0.07	0.01	0.58	0.15	0.03	0.04	0.10	0.15	0.06
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	ab	0.17	0.09	0.05	0.50	0.17	0.05	0.07	0.20	0.47	0.12
Crisp Mouth 1998-2008 Storm	38	a	0.27	0.25	0.05	0.82	0.19	0.10	0.10	0.32	0.61	0.22
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	a	0.22	0.13	0.05	0.59	0.20	0.05	0.10	0.35	0.47	0.26
Pit 2016 Pump	0											
Pit 2017 Pump	3	a	0.94	0.61	0.05	2.16	1.09	0.16	0.33	1.38	1.85	1.06
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	b	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	ab	0.12	0.05	0.05	0.64	0.20	0.05	0.05	0.05	0.17	0.00
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		0.16	0.16	0.05	0.27	0.16	0.07	0.11	0.22	0.25	0.11
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A24. Dissolved Nickel Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	ab	0.25	0.24	0.17	0.33	0.05	0.20	0.23	0.27	0.33	0.04
Crisp Hatchery 1998-2008 Storm	12	ab	0.29	0.29	0.21	0.45	0.06	0.22	0.25	0.30	0.33	0.05
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	b	0.18	0.15	0.05	0.55	0.15	0.06	0.07	0.22	0.36	0.15
Crisp Mouth 1998-2008 Storm	36	a	0.38	0.40	0.12	0.99	0.19	0.15	0.23	0.48	0.56	0.26
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	a	0.51	0.46	0.34	0.94	0.19	0.36	0.38	0.50	0.75	0.12
Lake 2017 Pump	8	a	0.46	0.41	0.32	0.78	0.15	0.33	0.37	0.48	0.64	0.11
Pit 2016 Pump	3	ab	0.35	0.35	0.34	0.35	0.01	0.34	0.35	0.35	0.35	0.01
Pit 2017 Pump	3	a	0.61	0.50	0.44	0.88	0.24	0.45	0.47	0.69	0.80	0.22
Wetland 2016 Pump	7	d	0.05	0.05	0.05	0.05	0.00	0.05	0.05	0.05	0.05	0.00
Wetland 2017 Pump	7	bcd	0.18	0.13	0.05	0.57	0.19	0.05	0.05	0.21	0.36	0.16
Crisp Hatchery 2016 Pump	8	cd	0.10	0.05	0.05	0.36	0.11	0.05	0.05	0.07	0.19	0.02
Crisp Hatchery 2017 Pump	9	bc	0.19	0.16	0.05	0.39	0.10	0.10	0.14	0.19	0.33	0.05
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.93	0.70	0.24	2.08	0.80	0.35	0.52	1.11	1.69	0.59
Shallow Near Wells 2016/17 After	4	a	0.87	0.91	0.21	1.45	0.52	0.37	0.62	1.16	1.33	0.54
Shallow South Wells 2016/17 Pump	4	b	0.17	0.17	0.14	0.20	0.03	0.14	0.14	0.20	0.20	0.06
Shallow South Wells 2016/17 After	2	b	0.18	0.18	0.16	0.20	0.03	0.16	0.17	0.19	0.20	0.02
Deep West Wells 2016/17 Pump	6	ab	0.30	0.26	0.20	0.51	0.12	0.21	0.22	0.36	0.45	0.14
Deep West Wells 2016/17 After	6	ab	0.29	0.30	0.16	0.44	0.10	0.19	0.23	0.32	0.38	0.09

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A25. Total Nickel Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.28	0.26	0.23	0.37	0.05	0.24	0.25	0.28	0.35	0.03
Crisp Hatchery 1998-2008 Storm	12	ab	0.47	0.38	0.27	1.53	0.35	0.28	0.29	0.44	0.57	0.15
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	b	0.39	0.29	0.14	1.20	0.31	0.16	0.18	0.49	0.58	0.31
Crisp Mouth 1998-2008 Storm	38	a	0.74	0.63	0.15	2.50	0.55	0.24	0.33	0.86	1.37	0.53
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	a	0.68	0.62	0.40	1.38	0.32	0.42	0.44	0.76	1.01	0.32
Pit 2016 Pump	0											
Pit 2017 Pump	3	a	0.55	0.53	0.47	0.66	0.10	0.48	0.50	0.59	0.63	0.10
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	b	0.17	0.13	0.05	0.49	0.15	0.05	0.09	0.19	0.32	0.10
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	ab	0.47	0.37	0.11	1.13	0.32	0.17	0.27	0.61	0.86	0.34
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		1.99	1.99	1.24	2.73	1.05	1.39	1.61	2.36	2.58	0.75
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.41	0.41	0.30	0.52	0.15	0.32	0.35	0.46	0.49	0.11
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		0.54	0.50	0.29	0.83	0.27	0.33	0.40	0.67	0.77	0.27
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A26. Dissolved Zinc Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	b	0.47	0.45	0.34	0.66	0.12	0.35	0.38	0.54	0.63	0.16
Crisp Hatchery 1998-2008 Storm	12	b	0.61	0.49	0.28	1.90	0.44	0.29	0.40	0.62	0.85	0.22
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	ab	0.71	0.65	0.25	1.60	0.42	0.25	0.39	0.86	1.20	0.48
Crisp Mouth 1998-2008 Storm	36	a	1.23	0.93	0.25	4.01	0.87	0.25	0.72	1.53	2.25	0.81
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	9	ab	6.01	5.95	0.25	11.8	3.52	2.32	3.61	8.59	9.64	4.98
Lake 2017 Pump	8	ab	4.23	2.59	2.20	11.8	3.37	2.27	2.38	4.20	8.08	1.83
Pit 2016 Pump	3	ab	6.47	6.69	5.21	7.51	1.17	5.51	5.95	7.10	7.35	1.15
Pit 2017 Pump	3	a	8.64	8.93	7.56	9.42	0.96	7.83	8.25	9.18	9.32	0.93
Wetland 2016 Pump	7	c	0.73	0.68	0.25	1.50	0.39	0.41	0.56	0.77	1.10	0.21
Wetland 2017 Pump	7	c	1.31	0.78	0.56	3.62	1.15	0.56	0.61	1.48	2.71	0.87
Crisp Hatchery 2016 Pump	8	bc	1.11	1.04	0.69	1.80	0.34	0.80	0.92	1.23	1.45	0.30
Crisp Hatchery 2017 Pump	9	c	1.73	0.73	0.25	8.61	2.65	0.25	0.60	1.20	3.56	0.60
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	4	a	0.50	0.40	0.25	0.95	0.33	0.25	0.25	0.64	0.83	0.39
Shallow Near Wells 2016/17 After	4	a	0.37	0.25	0.25	0.72	0.24	0.25	0.25	0.37	0.58	0.12
Shallow South Wells 2016/17 Pump	4	a	0.62	0.41	0.25	1.40	0.54	0.25	0.25	0.77	1.15	0.52
Shallow South Wells 2016/17 After	2	a	0.25	0.25	0.25	0.25	0.00	0.25	0.25	0.25	0.25	0.00
Deep West Wells 2016/17 Pump	6	a	0.71	0.25	0.25	2.55	0.92	0.25	0.25	0.57	1.62	0.32
Deep West Wells 2016/17 After	6	a	0.35	0.25	0.25	0.87	0.25	0.25	0.25	0.25	0.56	0.00

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range

Table A27. Total Zinc Summary Statistics (values in ug/L).												
Station/Period	**n**	**Group**	**Mean**	**Median**	**Min.**	**Max.**	**StdDev.**	**10th %**	**25th %**	**75th %**	**90th %**	**IQR**
Ambient Stream Stations												
Crisp Hatchery 1998-2008 Base	8	c	0.37	0.37	0.24	0.49	0.09	0.28	0.33	0.44	0.48	0.11
Crisp Hatchery 1998-2008 Storm	12	bc	1.02	0.63	0.27	5.36	1.40	0.30	0.41	0.83	1.24	0.42
Crisp Hatchery 2013-2016 Base	0											
Crisp Mouth 1998-2008 Base	11	b	1.44	0.90	0.56	4.74	1.26	0.63	0.72	1.70	2.40	0.99
Crisp Mouth 1998-2008 Storm	38	a	2.80	2.54	0.56	8.30	1.97	0.82	1.25	3.57	5.43	2.32
Crisp Mouth 2013-2016 Base	0											
Pumping Project Surface Water Stations												
Lake 2016 Pump	0											
Lake 2017 Pump	8	a	7.82	7.74	2.69	18.2	5.16	2.99	3.42	9.55	12.60	6.13
Pit 2016 Pump	0											
Pit 2017 Pump	3	a	8.05	8.28	6.76	9.12	1.20	7.06	7.52	8.70	8.95	1.18
Wetland 2016 Pump	0											
Wetland 2017 Pump	7	b	1.10	1.00	0.25	2.40	0.70	0.53	0.73	1.30	1.92	0.57
Crisp Hatchery 2016 Pump	0											
Crisp Hatchery 2017 Pump	9	ab	3.38	1.90	0.65	10.80	3.36	0.72	1.10	5.10	6.89	4.00
Pumping Project Groundwater Stations												
Shallow Near Wells 2016/17 Pump	2		1.72	1.72	0.91	2.52	1.14	1.07	1.31	2.12	2.36	0.81
Shallow Near Wells 2016/17 After	0											
Shallow South Wells 2016/17 Pump	2		0.71	0.71	0.51	0.91	0.28	0.55	0.61	0.81	0.87	0.20
Shallow South Wells 2016/17 After	0											
Deep West Wells 2016/17 Pump	3		1.08	0.97	0.96	1.30	0.19	0.96	0.97	1.14	1.23	0.17
Deep West Wells 2016/17 After	0											

Group = Statistical group determined by a Kruskal Wallace test at alpha=0.05, where stations with different letters are significantly different.

IQR = Interquartile range