DRAFT

Waughop Lake Management Plan
Grant G1400475

Prepared for
City of Lakewood, Washington
Prepared by
Brown and Caldwell
November 2016

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List of Abbreviations

°C	degree(s) Centigrade
µg/L	microgram(s) per liter
µS/cm	microsiemen(s) per centimeter
ac-ft	acre-foot/feet
alum	aluminum sulfate
As	arsenic
BC	Brown and Caldwell
$CaCO_3$	calcium carbonate
CERES	Clouds and the Earth's Radiant Energy System
City	City of Lakewood
cm	centimeter(s)
Cu	copper
CWSRF	Clean Water State Revolving Fund
DO	dissolved oxygen
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
FCZD	Flood Control Zone District
ft/ft	feet/foot vertical per 1-foot horizontal
ft^2	square foot/feet
g	gram(s)
g/m^2-yr	gram(s) per square meter per year
GIS	geographic information system
GPS	Global Positioning System
IEH	IEH Aquatic Research Analytical Laboratory
in.	inch(es)
kg	kilogram(s)
kPa/C	Pascal(s) per degree(s) Centigrade
L	liter(s)
LID	Lake Improvement District
LMD	Lake Management District
LMP	lake management plan
m	meter(s)
m^2	square meter(s)
m^3	cubic meter(s)
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
mg/m^3	milligram(s) per cubic meter
mL	milliliter(s)
N/A	not applicable
NALMS	North American Lake Management Society
NASA	National Aeronautics and Space Administration
ND	not detected
NRCS	Natural Resources Conservation Service
Pb	lead
PCD	Pierce Conservation District
ppb	part(s) per billion
QAPP	Quality Assurance Project Plan
Rn	mean net radiation
SEPA	State Environmental Policy Act
SRP	soluble reactive phosphate
su	standard unit(s)
SWC	Stormwater Calculator
TN	total nitrogen
TP	total phosphorus
TPCHD	Tacoma-Pierce County Health Department
TSI	Trophic State Index
ULID	Utility Local Improvement District
UPS	University of Puget Sound
USDA	U.S. Department of Agriculture
UWT	University of Washington-Tacoma
VEM	Vigorous Epilimnetic Mixing
WAC	Washington Administrative Code
WSU	Washington State University
WTP	willingness to pay

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Executive Summary

Waughop Lake is the centerpiece of the popular Fort Steilacoom Park in the city of Lakewood, Washington. The park is on state-owned land that is leased to the City of Lakewood (City). Waughop Lake has a long history of toxic blue-green algae growth that severely limits use of the lake. The City has made the protection of Waughop Lake a high priority. In 2013, the City received a grant from the Washington State Department of Ecology (Ecology) to develop a lake management plan (LMP) for Waughop Lake.

In 2014, a Quality Assurance Project Plan (QAPP) was developed to guide data collection in support of the Waughop LMP. The QAPP included monitoring the quality of the lake water, lake bottom sediment, stormwater, and groundwater to identify and quantify sources of phosphorus loading and support the evaluation of management measures.

The monitoring program was conducted from October 2014–15. The monitoring found that phosphorus is the limiting nutrient for blue-green algae and that the internal cycling of phosphorus from the lake bottom sediment is the primary source. The project team evaluated a wide range of potential management measures and identified four measures that appear suitable for Waughop Lake:

- Dredging to remove phosphorus-rich lake bottom sediment
- Application of aluminum sulfate (alum) or similar coagulant to the surface of the lake to inactivate phosphorus in the water column and sediment
- Installation of a lake aeration and mixing system to reduce phosphorus release because of anoxia and disrupt blue-green algae in the water column
- Installation of a pump and treatment system to remove phosphorus from lake water using a coagulation facility or a constructed wetland

The costs and potential benefits of these measures vary considerably. Dredging would provide the greatest long-term benefits but also has the highest initial cost. Alum would have the lowest initial cost but would likely need to be repeated every 3 to 10 years. Each measure would require additional data collection before it could be designed and implemented.

The City neither has the funds needed to implement the candidate measures, nor does it have a mechanism in place to generate the revenue needed for future implementation. Therefore, implementation of this LMP will depend on the ability to secure funding from other sources. Potential funding sources include state budget allocations and grants.

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Section 1
Introduction

Waughop Lake is a small lake located in the city of Lakewood, Washington (see Figure 1-1, below) and is the centerpiece of the popular Fort Steilacoom Park. The lake is used for fishing (for stocked fish), model boat racing, kayaking, canoeing, and bird watching. The shoreline area is heavily used by hikers, joggers, and dog walkers.

The lake has a surface area of approximately 33 acres, a mean depth of 7 feet, an approximate volume of 271,365 cubic meters (m^3) and catchment area of 497 acres (Ecology 1979). The contributing surface drainage area for Waughop Lake is about 217 acres. The Pierce College campus covers about 66 acres. Southwest of the lake is a residential area of approximately 130 acres, where the homes are served by septic systems.

Waughop Lake sits in a basin surrounded by slopes to the north, south, and west, with open flat meadows to the east. No creeks or other natural surface water channels flow into the lake. Stormwater runoff from a portion of the Pierce College campus is conveyed through a pipeline to the lake. There are no natural or man-made outlets to the lake; water leaves the lake via seepage and evaporation.

Waughop Lake is a glacial kettle lake that appears to be in direct contact with the shallow groundwater-flow system (see Figure 1-2, below). The surficial soils that surround the lake were formed in permeable recessional outwash material. Low-permeability glacial till underlies the surficial outwash soil and impedes the downward movement of water. Precipitation that infiltrates the surficial outwash soils tends to pond on top of the till, forming the A-1 aquifer, which provides much of the groundwater discharge to Waughop Lake (Tepper 2013).

Waughop Lake has a long history of toxic cyanobacteria (i.e., blue-green algae) blooms including species that produce the neurotoxin Microcystin and the liver toxin Saxitoxin. Cyanobacteria blooms have the potential to release toxic substances that are harmful to people, pets, and wildlife. The Tacoma-Pierce County Health Department (TPCHD) issues health advisories when potentially toxic blooms are observed to reduce the risk of adverse impacts to lake users. TPCHD algae advisories have been common for Waughop Lake during the past 10 years. In December 2015, TPCHD issued an advisory not to eat fish from the lake (TPCHD 2016). For a short period in 2011, toxin concentrations were so high that TPCHD closed the lake to all uses (City 2012).

Since 2007, toxicity data have been collected and maintained by Ecology on its Washington State Toxic Algae website. Of the 165 water samples collected from Waughop Lake from July 5, 2007, to May 25, 2016, 131 exceeded 6 micrograms per liter (µg/L), the state recreation guideline value for Microcystin (Ecology 2016).

Cyanobacteria blooms in surface waters are often associated with elevated nutrient loadings. Phosphorus is typically the nutrient that limits cyanobacteria growth in western Washington lakes.

Waughop Lake's water quality problems likely began more than 100 years ago when the surrounding area was first used to raise livestock and grow crops for the nearby state mental hospital. Manure and other agricultural wastes were discharged into the lake from about 1900–65 and likely contributed to the thick layer of fine, nutrient-rich sediment that now covers the lake bottom (Tepper 2013; LaFontaine 2012; City 2012). The thick bottom sediment layer has possibly reduced the rates of groundwater flow through the lake (see Figure 1-2).

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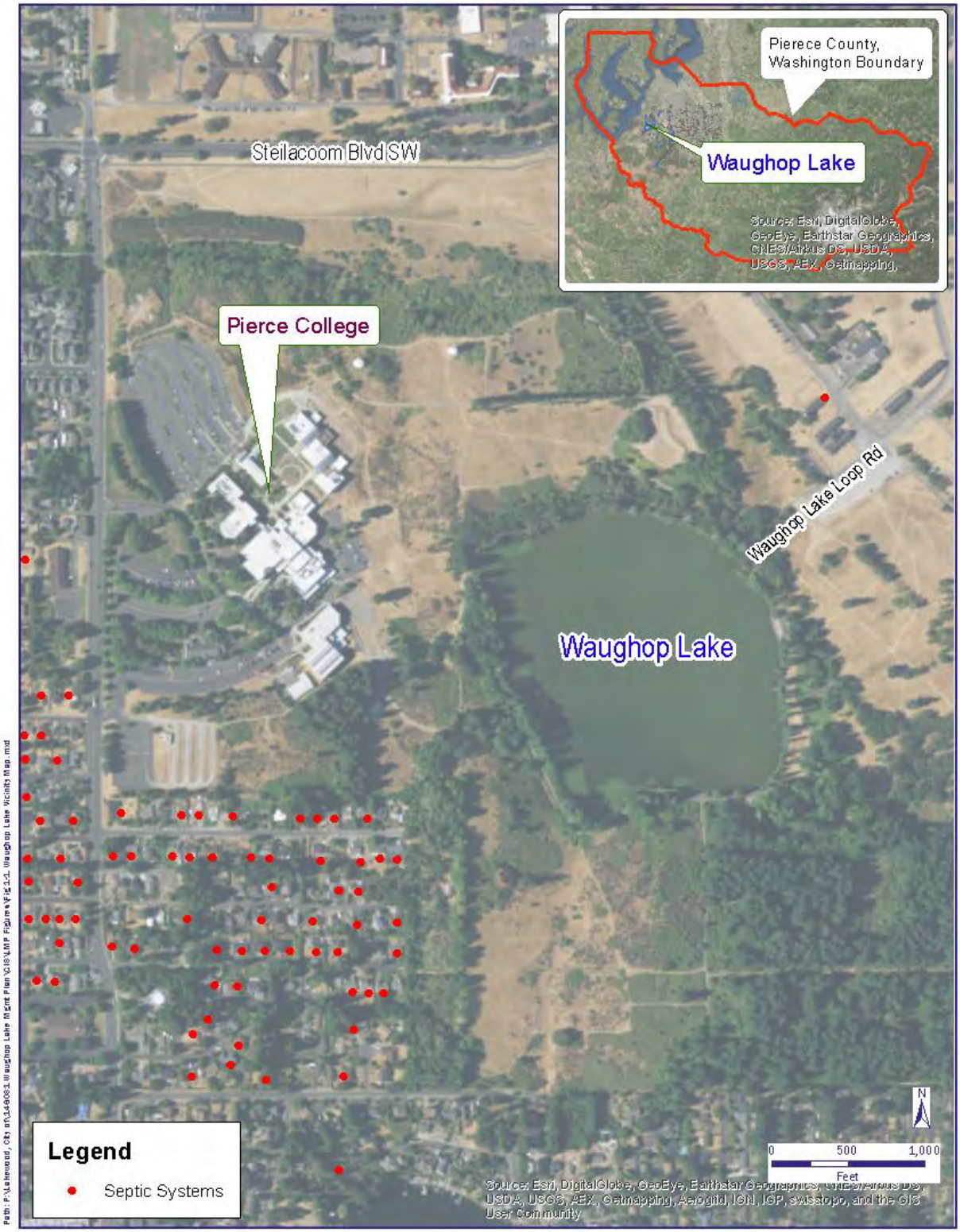

Figure 1-1. Areal map of Waughop Lake

Brown AND Caldwell

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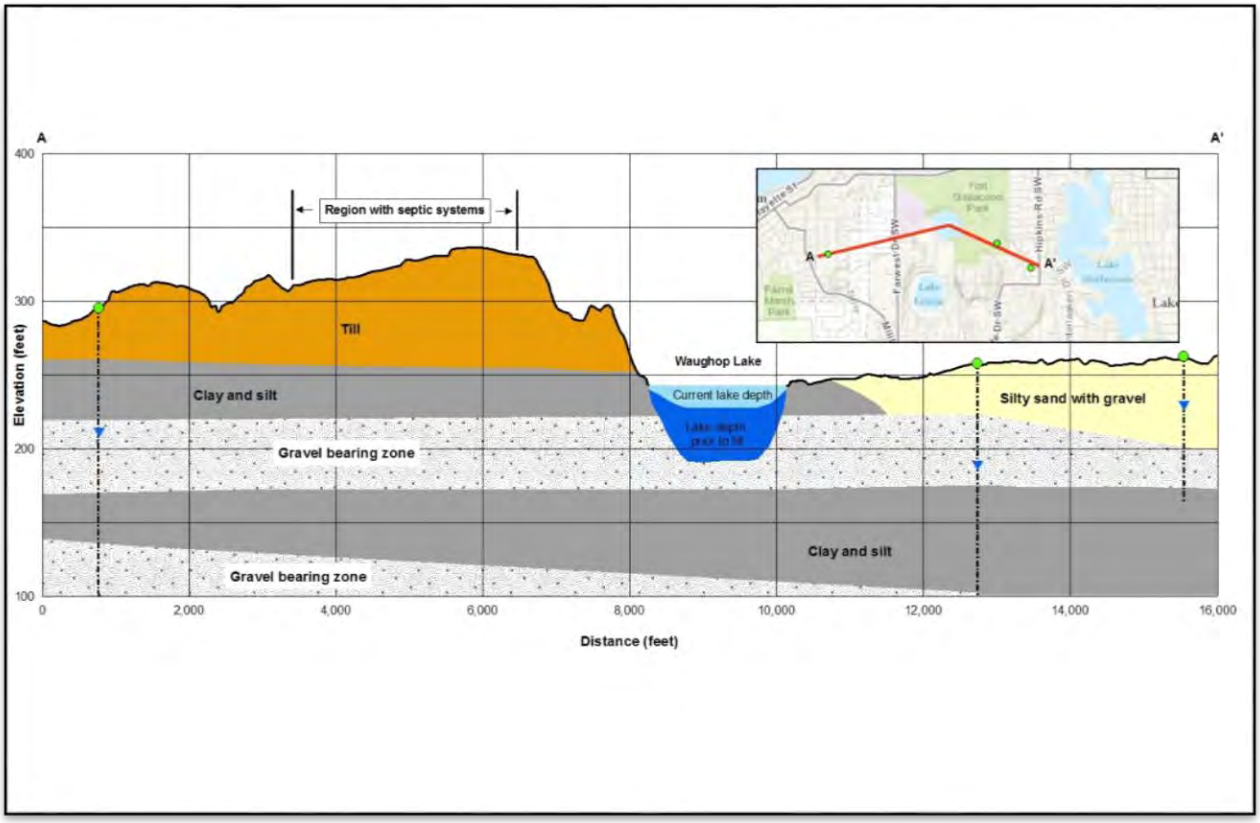

Figure 1-2. Regional geologic cross-section of Waughop Lake

1.1 Previous Water Quality Studies

Water quality studies have been conducted on Waughop Lake since the late 1960s. In 1968, the Pierce County Parks Department commissioned a biological survey of Waughop Lake to inform the Pierce County Parks Department in planning future uses of the lake. This study showed that the lake was rich in plant nutrients and capable of supporting numerous populations of rooted plants in addition to planktonic and filamentous algae (Carsner 1968).

Subsequent to this study, it became evident that the lake conditions were limiting the recreational potential of the lake. The lake was reported to be shallow and turbid with summer algae blooms common, and visibility often restricted to shallow depths of 3 feet or less. The first recorded algal bloom occurred in 1973 (Tepper 2013). In 1978, the Pierce County Parks Department commissioned a study to evaluate treatment options for the lake. The study found abundant aquatic weed growth along much of the shoreline area and a thick layer of organic sediments on the lake bottom (Entranco 1978). Although a remediation plan was proposed, no remedial action was undertaken following this study due to conflicts in ownership lease rights and the possible acquisition of the property between the Washington State Department of Natural Resources and U.S. Department of Interior, Bureau of Land Management Division (City 2012).

1.1.1 Groundwater

As noted above, Waughop Lake is a kettle lake that appears to extend below the elevation of the shallow groundwater-flow system. The Lakewood Water District monitors water elevations in

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Waughop Lake to serve as an indicator of groundwater elevations in the shallow A-1 aquifer. However, prior to conducting groundwater monitoring for this project, the City was not aware of any groundwater quality data for the shallow aquifer. Previous groundwater quality sampling focused on the deeper aquifers.

1.1.2 Water Column

Water column monitoring of Waughop Lake has been conducted since 2007 by the University of Washington-Tacoma (UWT), Ecology, Pierce Conservation District (PCD), and TPCHD. These studies have included monitoring for temperature, dissolved oxygen (DO), pH, conductivity, alkalinity and Secchi depth to measure water transparency. The lake has also been sampled for nutrients, including total phosphorus (TP), and algae. The current PCD monitoring program for Waughop Lake includes the sampling of additional analytical constituents, such as nitrates and nitrites.

The results from these previous water quality monitoring efforts and personal communication with Jim Gawel to Mike Milne in May 2014 suggest that Waughop Lake is eutrophic.

1.1.3 Sediment

Gawel and Mason (2008), Tepper (2013) and Gawel et al. (2013) documented sediment quality in Waughop Lake indicating that the top meter (m) of the lake bottom sediments have elevated levels of TP, as well as other harmful constituents including lead (Pb), copper (Cu), arsenic (As), and other metals.

1.1.4 Waterfowl

Waughop Lake provides habitat for several species of waterfowl. LaFontaine (2012) reported that more than 40 mallards have been observed on the lake, along with smaller numbers of coots and Canada geese.

1.2 Lake Management Plan

In 2013, the City received a grant from Ecology to prepare the LMP. The goal of the LMP is to develop strategies to improve and protect the lake uses rather than attain specific numeric water quality targets.

The City selected the Brown and Caldwell (BC) team, including UWT, to help develop the LMP. UWT staff performed the field monitoring and sampling. IEH Aquatic Research Analytical Laboratory (IEH) in Seattle, Washington, analyzed the groundwater, surface water, and sediment samples for nutrients. The remaining parameters were analyzed by the laboratory at UWT.

This LMP provides a summary of the monitoring activities that were conducted to characterize Waughop Lake water quality and identify and quantify nutrient sources that are affecting the lake. The LMP also identifies actions toward achieving the City's goals for the lake including recommendations for appropriate source control and/or treatment measures, including an implementation strategy.

Section 2 summarizes the results of the monitoring program. Sections 3 and 4 summarize the lake water and nutrient budgets, respectively. Section 5 describes the management measures and Section 6 discusses how the City may implement the measures.

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Section 2
Monitoring Results

A QAPP was developed to guide the collection of field data needed to develop the Waughop LMP. The QAPP called for a streamlined monitoring program to fill key data gaps while keeping within the limited budget that was allocated for monitoring and modeling. The overall goal was to obtain a broad understanding of the watershed processes and lake water and nutrient budgets, as well as the lake management measures that could be effective. The QAPP noted that additional monitoring and modeling may be needed to support the design and implementation of specific lake management measures (BC 2014). Ecology reviewed and approved the QAPP in October 2014.

2.1 Water Quality Monitoring Activities

Field data for the Waughop LMP were collected from October 2014–15, including:

- Four rounds of groundwater sampling in five monitoring wells installed around the lake
- Eighteen rounds of lake water quality vertical profiling
- Seventeen rounds of water sampling at one location in the lake
- One round of aquatic plant sampling at 12 locations during maximum plant growth
- One round of lakebed sediment sampling at 12 locations, made into one composite sample
- Twelve rounds of benthic flux sampling at various locations throughout the lake during the summer months
- Four rounds of storm event sampling from one location in the maintenance hole
- Year-round monitoring of waterfowl on a monthly basis

Figure 2-1 below shows the monitoring locations. Tables 2-1 and 2-2 list the LMP monitoring parameters and frequencies, respectively. Table 2-3 lists the minimum, average, and maximum observed values for key sample parameters. Appendix A provides copies of the field sheets, Appendix B provides copies of the laboratory results, and Appendix C provides copies of the monitoring logs and geologic cross-section diagrams.

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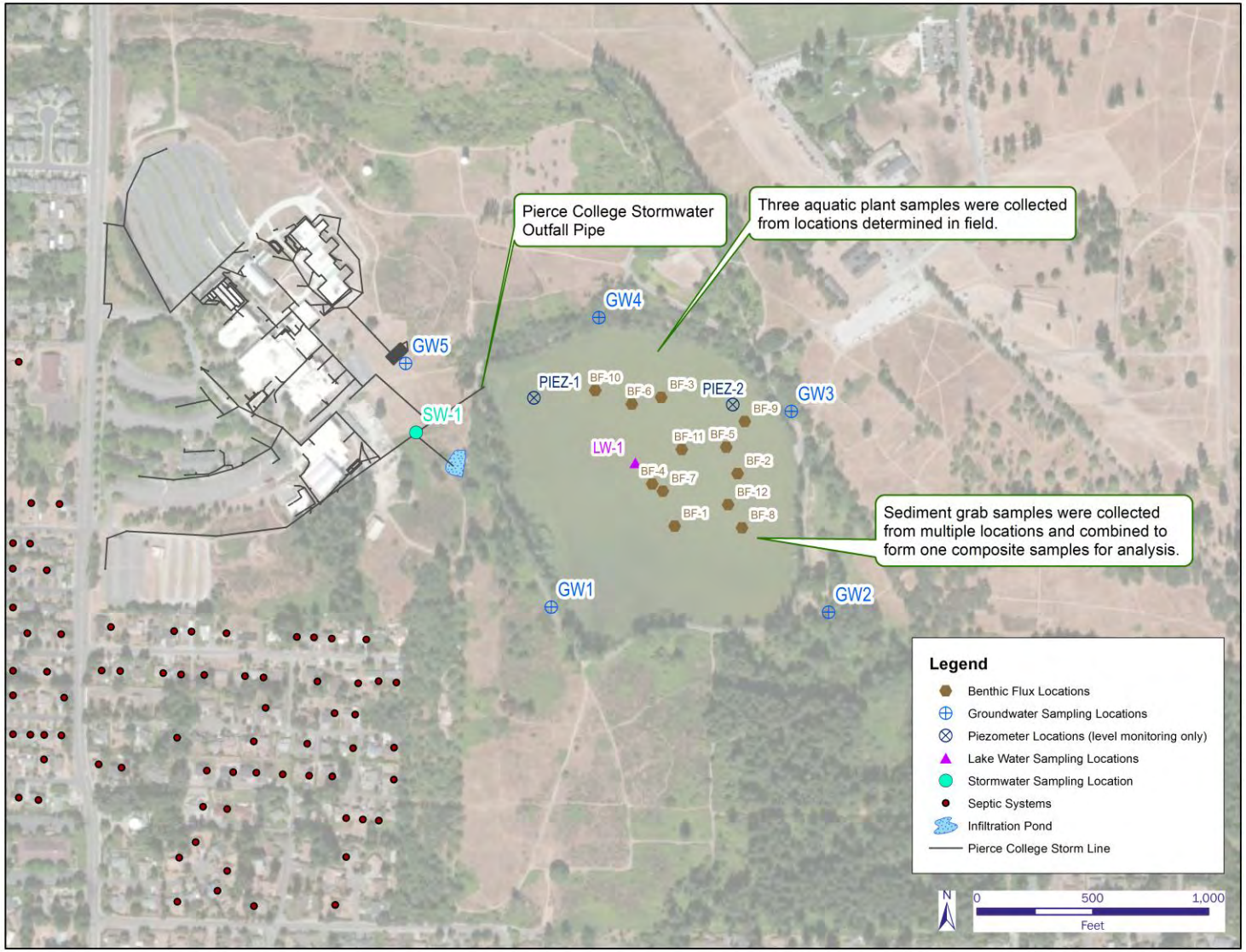

Figure 2-1. Waughop LMP monitoring locations

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Table 2-1. Waughop Lake Sampling Locations and Constituents

Sample type	Site ID	Level	TP	TN	Alkalinity	SRP	% solids	Particle size	Phytoplankton	Zooplankton	Chlorophyll-a	Water temperature	pH	DO	Conductivity	Transparency (Secchi depth)	Macrophyte species identification	Biomass estimates
Groundwater	GW-1, GW-2, GW-3, GW-4, GW-5	✓	✓									✓ [a]	✓ [a]	✓ [a]	✓ [a]			
Lake/ groundwater	Piez-1, Piez-2	✓																
	LW-1	✓	✓ [b]	✓ [b]	✓	✓ [b]			✓	✓	✓	✓	✓	✓	✓	✓		
Aquatic plants	Plant-1, Plant-2, Plant-3		✓	✓													✓	✓
Lakebed sediment	Sed-1		✓	✓			✓	✓										
Benthic flux (BF)	BF-1 to BF-12 [c]		✓	✓ [d]		✓						✓	✓	✓	✓			
Stormwater	SW-1		✓	✓		✓ [e]												

a. These parameters were monitored during purging and were recorded during sample collection. In addition, turbidity was monitored during purging only.

b. TP, TN, and SRP were sampled by IEH. Copies of the laboratory reports showing these results are included in Appendix B. The remaining parameters were sampled by the UWT field equipment and lab.

c. The QAPP called for 4 benthic flux sample locations. Instead, 12 sample locations were sampled throughout the summer months.

d. Benthic flux samples were sampled for TN, which was not called for in the QAPP.

e. Stormwater samples were sampled for SRP, which was not called for in the QAPP.

Table 2-2. Waughop Lake Sampling Locations and Frequencies

Media	Sampling location	Methods	Frequency
Groundwater	5 shoreline monitoring wells (GW-1, GW-2, GW-3, GW-4, and GW-5)	• Purge then collect grab sample using pump	• Quarterly
Waughop Lake water	LW-1: 1 location in the middle of the lake	• In-situ vertical (depth) profiling using datasonde • Grab sampling from surface and bottom [a]	• Twice per month during the summer months • Monthly during the remainder of the year
Aquatic plant	3 locations throughout the lake (Plant-1, Plant-2, Plant-3)	• Visual, plant rake	• Once during maximum plant growth (September 2015)
Lakebed sediment	3 grab sample locations combined to form 1 composite sample (Sed-1)	• Use clamshell sampler to collect 1 composite sample from each area	• Once during summer
Benthic flux	12 locations throughout lake (Flux-1–Flux-12) [b]	• Datasonde and grab (pump)	• During July, August, and September 2015
Stormwater	1 location from the Pierce College storm drainage line (SW-1)	• Grab sample	• 4 storm events [c]

a. Lake water depth profile and grab samples were measured twice in May instead of once.

b. The QAPP called for 4 benthic flux sample locations. Instead, 12 sample locations were sampled throughout the summer months.

c. The QAPP called for up to 6 storm event samples. Because of few storms occurring during the monitoring period, only 4 storms were sampled.

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Table 2-3. Waughop Lake Water Quality Results for Key Parameters

Sample type	Location	TP (mg/L)			SRP (mg/L)			TN (mg/L-nitrogen)			N:P ratio			Chlorophyll-a (mg/m³)			Secchi depth (m)		
		Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum
Groundwater	GW-1	0.01	0.03	0.08	0.004	0.01	0.01	1.68	3.56	6.95	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	GW-2	0.02	0.04	0.08	ND	0.002	0.003	0.67	1.64	3.82	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	GW-3	0.045	0.05	0.06	0.002	0.01	0.02	0.66	0.93	1.32	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	GW-4	0.001	0.003	0.04	ND	ND	ND	0.16	14.3	29.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	GW-5	0.02	0.02	0.04	0.01	0.01	0.02	0.56	0.69	0.69	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Lake water	LW-1 (surface)	0.03	0.08	0.17	ND	0.01	0.02	0.99	1.69	2.42	12.0	23.0	40	4.72	37.0	110	0.43	1.10	1.98
	LW-1 (bottom)	0.05	0.08	0.14	ND	0.005	0.02	1.04	1.61	1.96	14.0	20.0	25	4.58	33.0	80.0			
Benthic [a]	Benthic Flux-1 to Benthic Flux-12 (2 hour)	0.07	0.40	1.99	ND	0.01	0.12	1.44	4.40	13.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Benthic Flux-1 to Benthic Flux-12 (24 hour)	0.04	1.59	10.0	ND	0.01	0.11	1.73	10.0	52.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	Benthic Flux-1 to Benthic Flux-12 (48 hour)	0.07	5.73	43.4	0.003	0.04	0.19	0.52	12.0	77.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Stormwater	SW-1	0.03	0.13	0.37	0.0	0.04	0.14	0.19	0.61	0.93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:

Average values were calculated using half of the reporting limit for any sample results below the reporting limit.

ND = not detected.

a. Benthic Flux-5 was not included in this statistical summary due to a large amount of sediment material that entered into the sample.

Brown AND Caldwell

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2.2 Data Validation

As discussed in Section 1, the City prepared a QAPP to guide collection of the data needed to develop the Waughop LMP. The QAPP described in detail the following key elements of the sampling program:

- Goal and objectives for the LMP and summarizing the data needed to meet the project objectives
- Quality objectives pertaining to precision, bias, and lower reporting limits necessary to meet project objectives - Other considerations of quality objectives included representativeness and completeness.
- Field sampling and measurement procedures - The method(s) selected for this sampling and monitoring program had performance characteristics that met the measurement quality objectives for precision, bias, and sensitivity.
- Quality control (QC) measures that were integrated within the laboratory and field, as well as corrective actions.
- Data management procedures, including carefully maintaining field and laboratory analytical data from their production to their final use and archiving.
- Data review, verification, and validation and data quality (usability) assessment

A Data Validation Report summarizing the results of the data validation performed on the samples collected during this monitoring program is provided in Appendix E.

2.3 Groundwater Sample Results

Five shallow groundwater monitoring wells were installed around the lake (see Figure 2-1 above and Attachment C for copies of the monitoring well logs). Each groundwater well was sampled four times throughout the monitoring period: December 2014, February 2015, May 2015, and August 2015 (see Attachment A for copies of the field sheets). The August 2015 sample for GW-5 was collected with a bailer because the peristaltic pump was unable to draw enough water for a sample. The bailer was used instead, which caused significant turbidity in the sample, and yielded suspiciously high TP results. In September 2015, GW-5 was resampled with a peristaltic pump and yielded TP results that were comparable to the results observed from previous sampling events. The August 2015 sample results from GW-5 are thus omitted from this evaluation.

As shown in Table 2-3 above, the TP concentrations in the groundwater monitoring wells ranged from 0.001 to 0.080 milligram per liter (mg/L). The average TP concentration for the five groundwater wells combined was 0.032 mg/L. The narrative water quality criterion for TP is 0.02 mg/L. Figure 2-2 shows the TP concentrations measured in each monitoring well.

The soluble reactive phosphate (SRP) concentrations in the groundwater monitoring wells ranged from non-detect (less than 0.001) to 0.016 mg/L. The average SRP concentration for the five groundwater wells combined was 0.006 mg/L (see Table 2-3). Figure 2-3 below shows the SRP concentrations that were measured in each monitoring well.

Concentrations in groundwater wells surrounding the lake acted as an indicator of possible external sources of TP other than lakebed sediments and were more accurately determined as advective processes.

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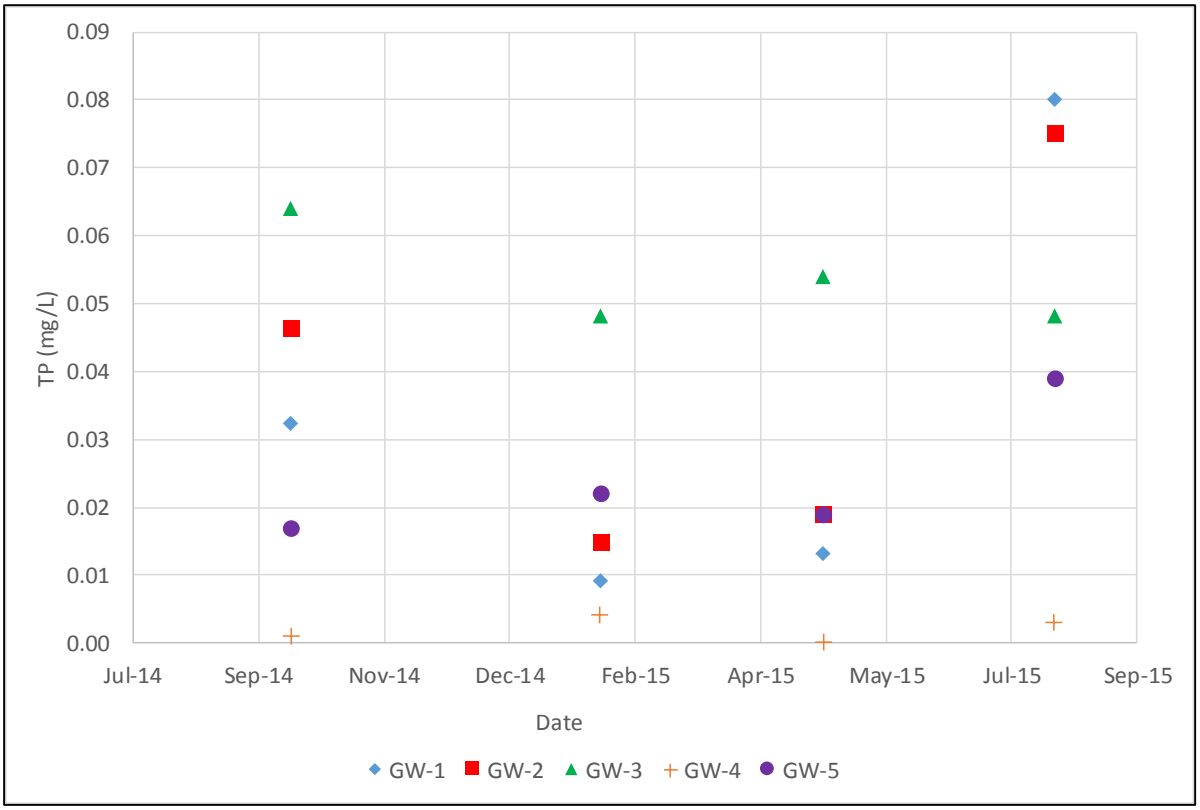

Figure 2-2. TP concentrations in groundwater samples collected near Waughop Lake

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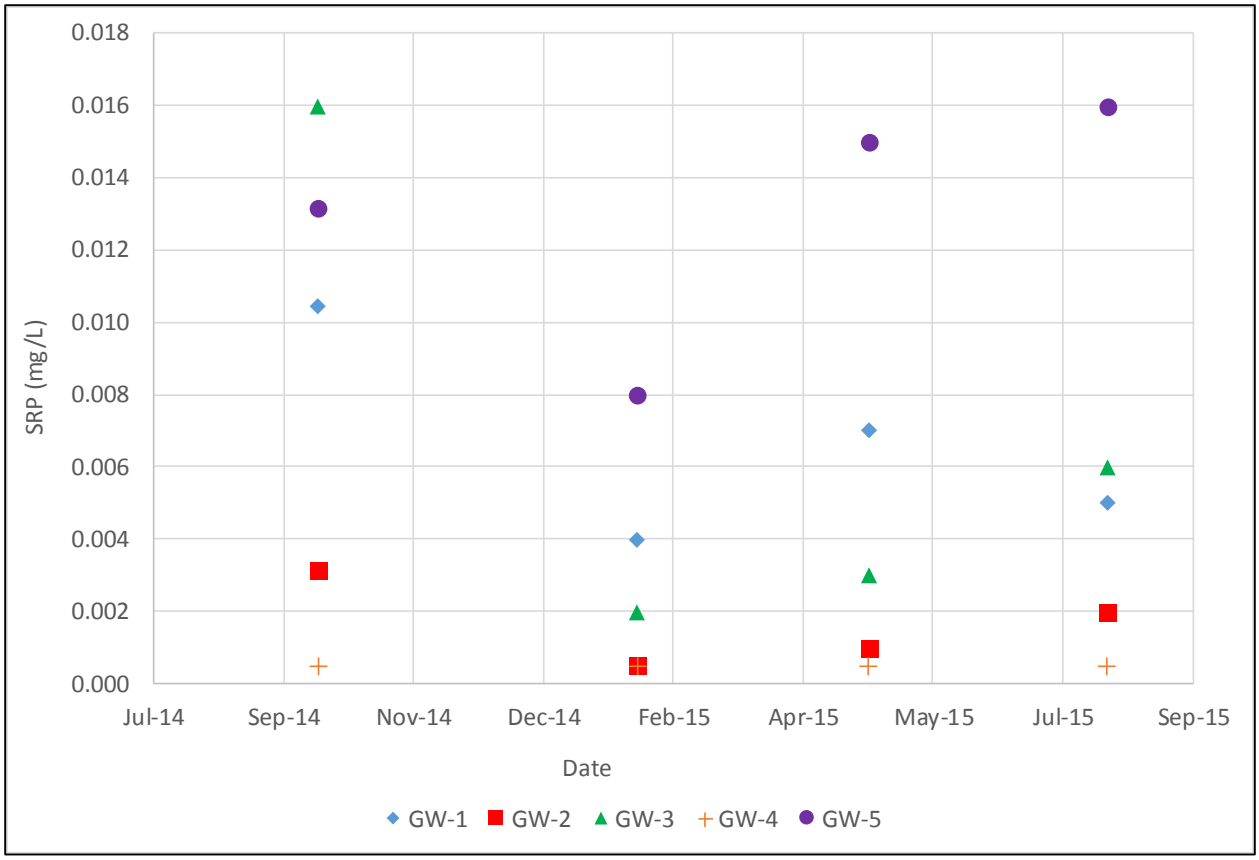

Figure 2-3. SRP concentrations in groundwater samples collected near Waughop Lake

As shown in Table 2-3 above, total nitrogen (TN) concentrations in the groundwater monitoring well samples ranged from 0.16 to 29 mg/L. The average TN concentrations for the five wells combined was 4.23 mg/L (see Figure 2-4 below). The highest concentrations were in GW-4, with an average concentration of 14 mg/L. Because of the high levels of TN in GW-4, in August 2015 GW-4 groundwater samples were also analyzed for species of nitrogen by UWT. The results were 0.086 and 0.022 milligram per nitrate nitrogen per liter (mg/NO_3-N/L) and 0.078 and 0.061 milligram per ammonia nitrogen per liter (mg/NH_3-N/L).

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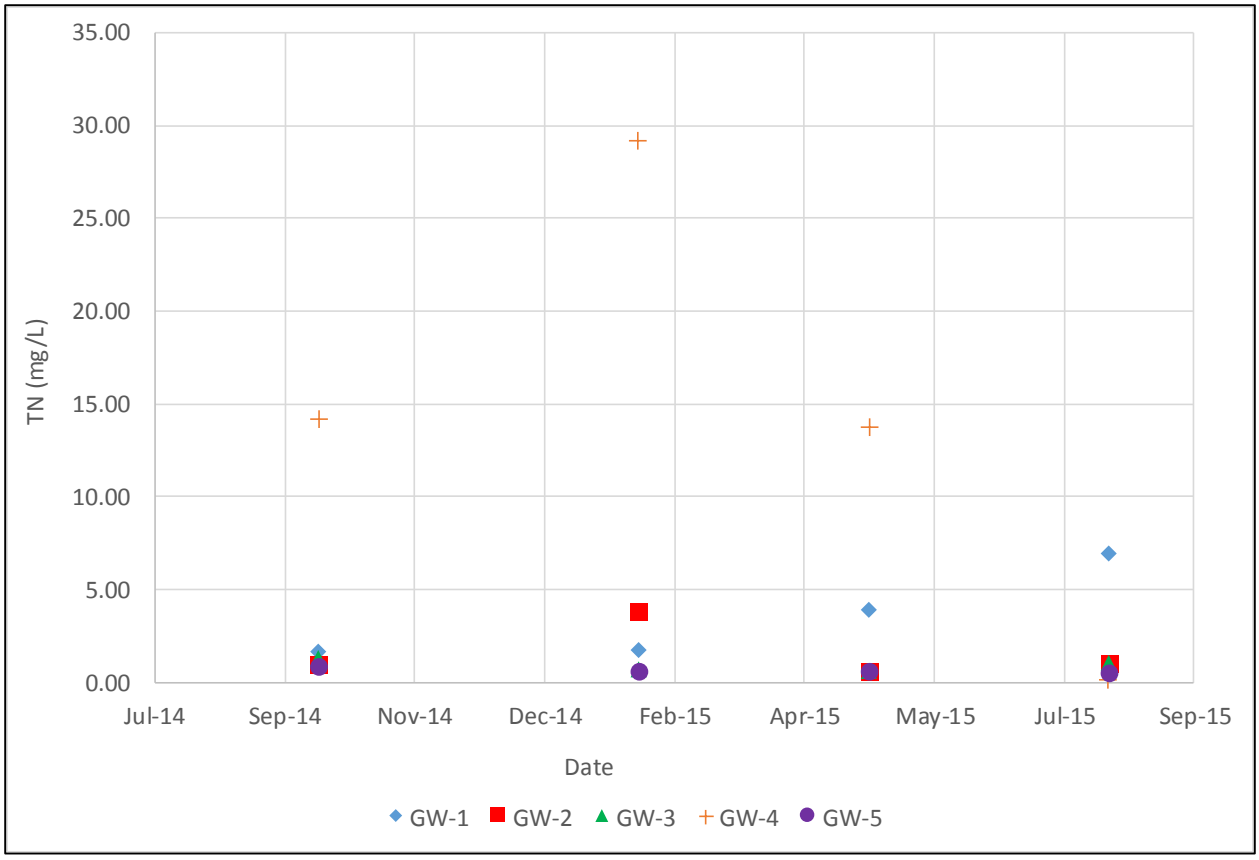

Figure 2-4. TN concentrations in groundwater samples collected near Waughop Lake

2.4 Lake Water Quality Vertical Profiling Results

Lake water quality was monitored in the deepest part of Waughop Lake (location LW-1 on Figure 2-1) from October 2014–15. This location was monitored for the analytes listed in Table 2-1. A multi-parameter datasonde was used to measure temperature, DO, pH, and conductivity at 0.5 m depth intervals throughout the water column at LW-1. A Secchi disk was used to measure water transparency. Water quality depth profiles were measured two times per month from June through October and one time per month between November and May. The water quality profiles that were collected in the summer and fall were used for characterizing seasonal anoxic conditions, internal phosphorus releases, and mixing.

During each profiling event, water grab samples were collected from two depths at LW-1; 0.1 m surface water (epilimnion) and near bottom water (hypolimnion if present). The samples were analyzed for TP, SRP, TN, alkalinity, and chlorophyll-a. Additionally, the water column was sampled for phytoplankton to estimate the presence of cyanobacteria.

Results from this study show that Waughop Lake does not strongly stratify because of its shallow bathymetry, but it does (weakly) stratify enough to result in anoxia in the near-bottom waters from May to early October. This is because of its organic-rich sediments and the high sediment surface area to lake volume ratio.

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During stratification, cooler, denser water in the bottom of the lake (hypolimnion) is prevented from mixing with the warmer, well-oxygenated surface water (epilimnion) by an abrupt temperature and water density transition (thermocline). DO within the hypolimnion becomes progressively depleted because of the decomposition of organic material in the sediment and the lack of re-aeration. By October, cooler surface temperatures eliminate this mixing barrier, allowing the lake waters to fully mix and reintroduce DO into the hypolimnion.

In the summer, more intense reducing conditions occur resulting in significant conductivity increases, suggesting rapid sediment remineralization and phosphorus release. In addition, intense summer photosynthesis and respiration result in pH values above 9 in the surface waters and below 6 in the bottom waters, potentially affecting aquatic life. Figure 2-5 shows the water quality parameter profiles that were measured once or twice per month in Waughop Lake during the monitoring period.

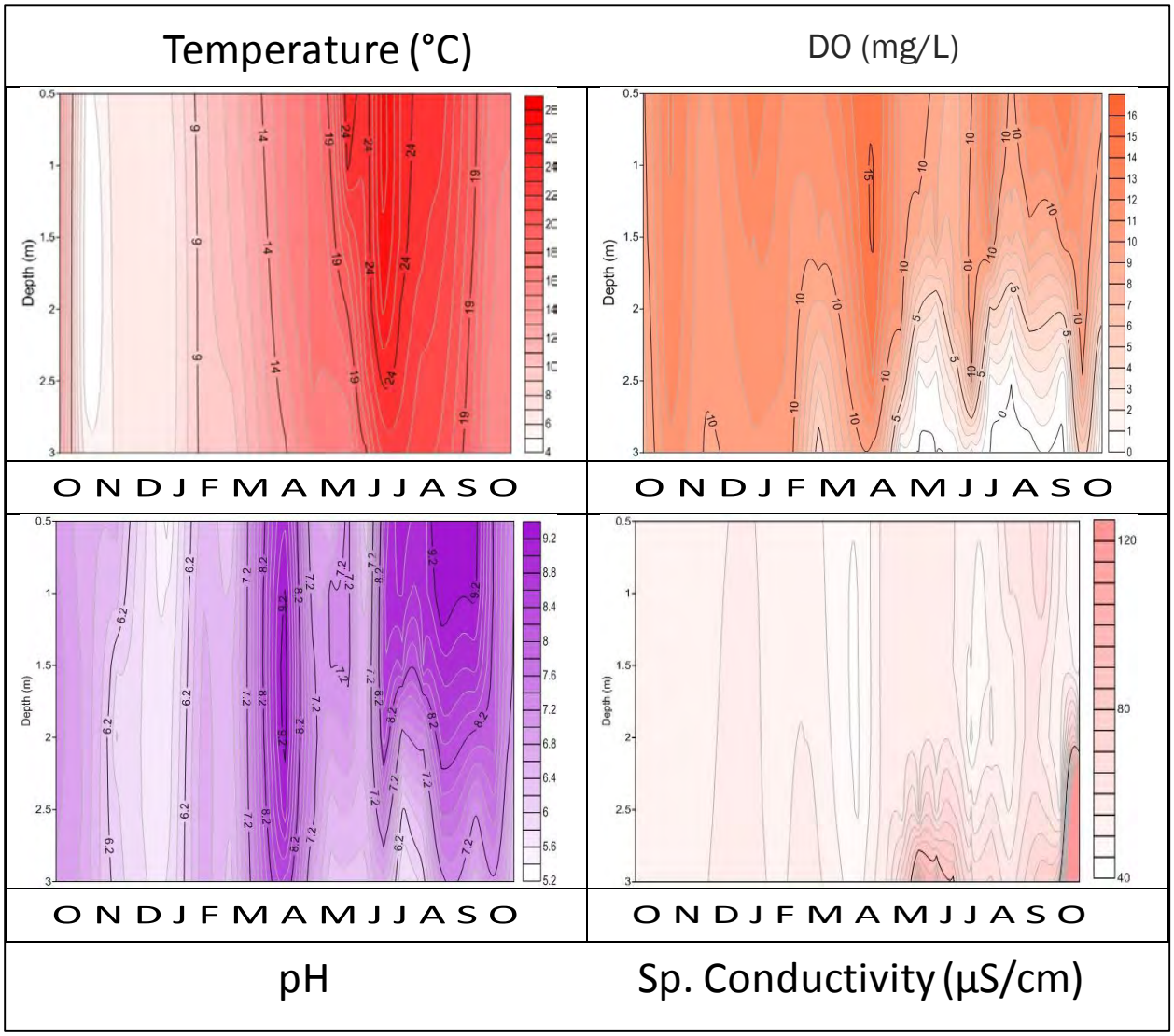

Figure 2-5. Water quality parameter profiles measured once or twice per month in Waughop Lake

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As shown by the temperature-depth profile in Figure 2-5, Waughop Lake undergoes summer thermal stratification that is typical for a lake of its size and depth. Stratification began in late April and ended in early October 2015. Water temperature monitoring conducted throughout the water column in the summer months of 2015 showed a range of 27.3 degrees Centigrade (°C) at the surface water (July) to 15.9°C at the near bottom water (June).

Previous water column parameter monitoring and personal communication with Jim Gawel of UWT to Mike Milne of BC in May 2014 have revealed weak summer stratification, most likely because of light absorption by large concentrations of plankton. Water temperature monitoring that was conducted throughout the water column in June 2014 showed a range of 21.7°C at the surface to 17.5°C at the bottom. Per personal communication with Isabel Ragland of PCD to Mike Milne of BC in May 2014, temperatures ranged from 16.2°C at the surface to 13.8°C. Monitoring conducted in 2007 by LaFontaine showed much less variation throughout most of the year, with a June average of 18.8°C at the surface and 18.6°C at the bottom (LaFontaine 2012).

Figure 2-5 above also shows the DO vertical profiles for Waughop Lake during the 2015 summer stratification period. These profiles show a clear progression of anoxia (i.e., DO less than 1 mg/L) developing in the hypolimnion (near-bottom water) during the summer, with anoxic conditions frequently observed at depths greater than 3 m. Low DO in the hypolimnion can create conditions that allow for the release of soluble phosphorus from the lakebed sediment into the water column, further degrading water quality. DO monitoring that was conducted throughout the water column in the summer months of 2015 showed a range of 13.2 mg/L at the surface (July) to 0.0 mg/L at the bottom (July).

Previous sampling for DO has revealed that DO concentrations throughout the water column vary greatly with depth. Monitoring that was conducted in May and June 2014 and personal communication with Isabel Ragland of PCD to Mike Milne of BC in May 2014 showed DO levels of 9.9 mg/L and 9.8 mg/L at the surface and 0.2 mg/L and 0.4 mg/L at the bottom, respectively.

Figure 2-5 above also shows the pH profiles that were observed in Waughop Lake. The highest pH levels were observed in the surface water during the stratification period. These relatively high pH levels are likely because of the algal uptake of dissolved carbon dioxide during photosynthesis. The lowest pH levels were observed in the hypolimnion, likely because of decomposition and a lack of vertical mixing. The lake water pH was occasionally outside of the state water quality criterion range of 6.5 to 8.5 standard units (su). Previous monitoring of pH has been conducted since 2007 and has shown a range of 6 to 10 su (LaFontaine 2012).

Vertical profiles of the specific conductivity were also evaluated during this monitoring program (see Figure 2-5). Conductivity increases as the concentrations of dissolved salts or ions increase. The conductivity results generally increased in the lake water toward the bottom after Waughop Lake stratified. This is likely due to the release of metals from the sediment when the hypolimnion is anoxic, and the decomposition of dead algae and other organic detritus. Decomposition generates carbon dioxide, which quickly dissolves to form bicarbonate or carbonate ions, thereby raising the dissolved ion concentration and conductivity of the water, and releasing phosphorus from organic matter. Decomposition can also reduce iron oxide solids and release adsorbed phosphorus, further increasing conductivity and phosphorus concentrations. Specific conductivity monitoring that was performed throughout the water column in the summer months of 2015 showed that June and July experienced the greatest variation with a range of 55.5 microsiemens per centimeter (µS/cm) at the surface to 114 µS/cm at the bottom.

Previous monitoring of conductivity has shown a range between 55 and 92 µS/cm. Conductivity levels measured at various depths within the lake water column showed an increasing trend with depth, suggesting reductive remobilization of ions from sediments (LaFontaine 2012).

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2.5 Lake Water Nutrient Sample Results

Lake water samples were collected from one location (LW-1) in the lake 17 times between October 2014 and October 2015. Grab samples were collected from the surface water (epilimnion) and near bottom water (hypolimnion) throughout the year.

As noted in Table 2-3 above and shown in Figure 2-6, TP concentrations in lake water samples ranged from 0.034 to 0.17 mg/L. Surface water samples were often similar to or higher than the near-bottom water samples from September to April. The higher surface water concentrations may be due to storm runoff inputs or greater waterfowl numbers. During summer months when the lake is stratified and waterfowl numbers are low, hypolimnetic phosphorus concentrations often exceed epilimnetic concentrations, suggesting phosphorus release from the sediments during anoxia.

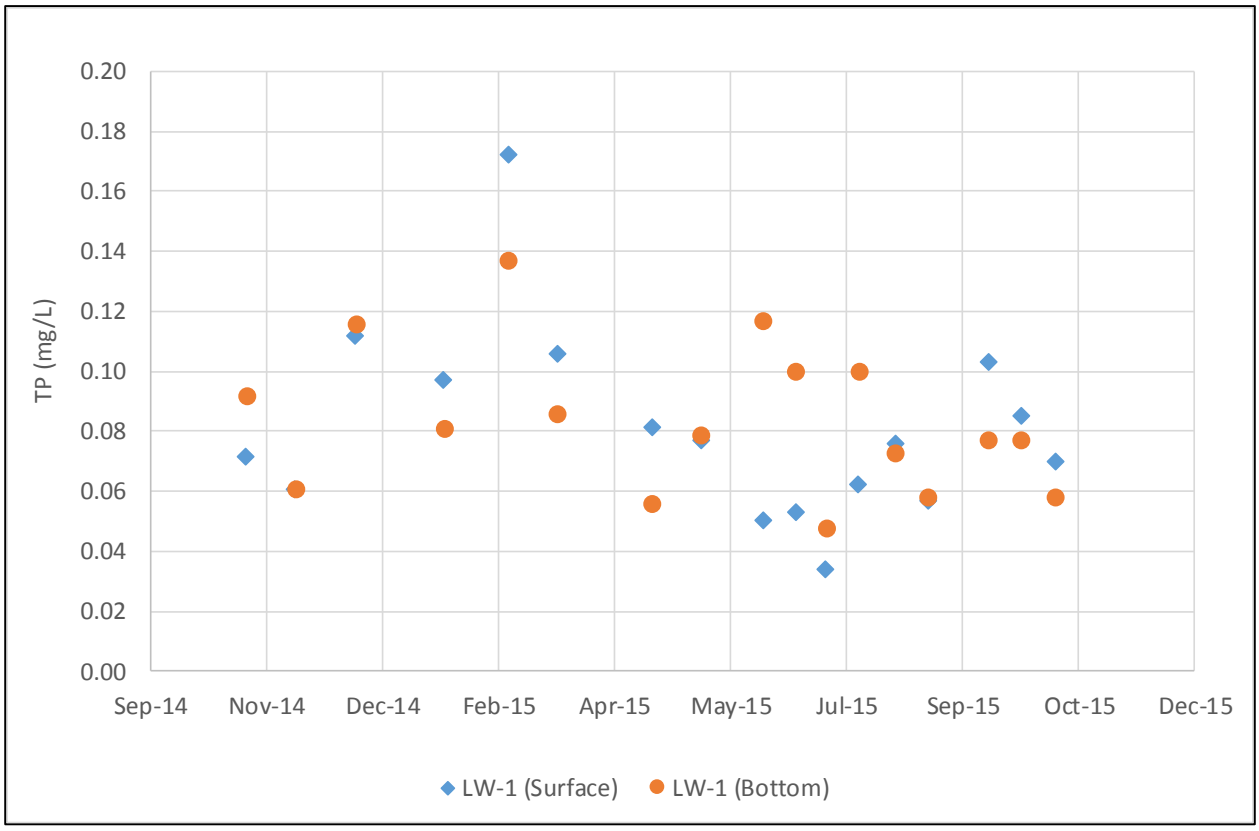

Figure 2-6. TP concentrations in Waughop Lake water samples collected at LW-1

The lake TP concentrations that were measured during this study were similar to the concentrations measured by others. LaFontaine monitored lake water quality from 2007–11. Water samples collected in summer 2007 contained TP concentrations as high as 0.085 mg/L (LaFontaine 2012). Personal communication with Isabel Ragland of PCD to Mike Milne of BC and samples collected between 2011 and 2014 by PCD showed an average TP concentration of 0.061 mg/L, with a maximum of 0.13 mg/L recorded in September 2012.

Between June and October 2012, TPCHD collected lake water samples from depths of 1.0, 1.5, and 2.5 m. As learned via personal communication with Ray Hanowell of TPCHD to Mike Milne of BC in

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March 2014, TP concentrations ranged from 0.036 to 0.553 mg/L (1.0 m depth), 0.045 to 0.27 mg/L (1.5 m depth), and 0.048 to 0.54 mg/L (2.5 m depth).

In November 2013, per personal communication with Jim Gawel of UWT to Mike Milne of BC in May 2014, water samples that were collected when the lake was isothermal contained TP concentrations as high as 0.10 mg/L. Washington State water quality regulations recommend that lake-specific studies be conducted for lakes in the Puget Sound lowlands with TP concentrations above 0.02 mg/L (Washington Administrative Code [WAC] 173-201A-230). A study conducted by LaFontaine in 2007 suggested a general increase in TP concentration with increasing depth (LaFontaine 2012).

During this monitoring period, lake water samples were also collected for SRP, as shown in Table 2-3 and Figure 2-7. SRP concentrations in lake water samples ranged from non-detect (less than 0.001 mg/L) to 0.016 mg/L. In general, SRP concentrations were higher in the winter, likely due to lower phosphorus uptake by plankton and increased stormwater runoff. Overall, comparing SRP to TP, very little dissolved phosphorus is found relative to particulate phosphorus.

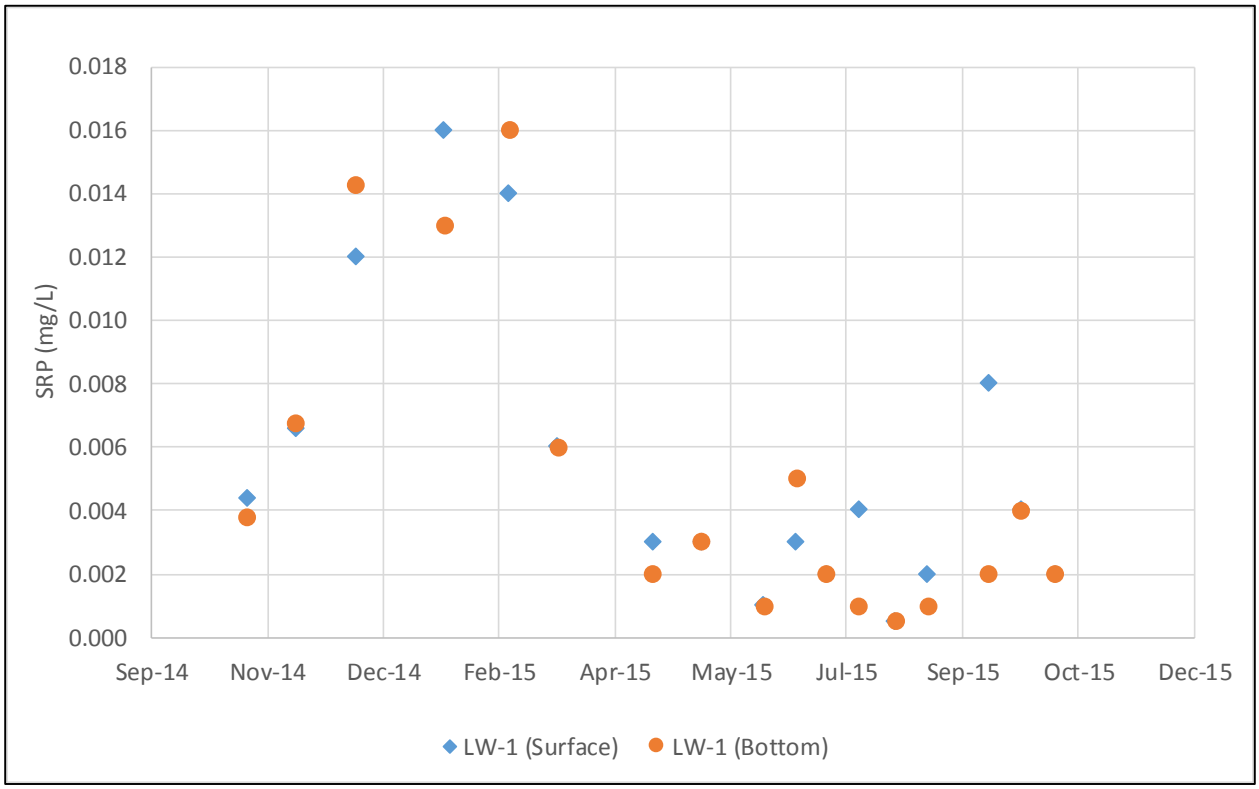

Figure 2-7. SRP concentrations in Waughop Lake water samples collected at LW-1

As shown in Table 2-3 above and Figure 2-8 below, TN concentrations ranged from 0.98 to 2.42 mg/L, with comparable results throughout the vertical water column. As communicated via personal communication with Ray Hanowell of TPCHD to Mike Milne of BC in March 2014, in a previous study TN ranged from 0.84 to 5.40 mg/L (1.0 m depth), 0.79 to 3.50 mg/L (1.5 m depth), and 1.0 to 5.0 mg/L (2.5 m depth).

Nitrates and nitrites have been collected in the shallow parts of the lake since 2011; however, only once was there a level above the detection limit: in May 2012, a nitrate level was recorded at 0.07 mg/L. Ammonia levels that were recorded in the shallow parts of the lake have shown an

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average of 0.1 mg/L, with a maximum observed level in May 2012, which corresponds to the maximum observed nitrate level.

Nitrogen to phosphorus (N:P) ratios ranged from 12 to 40. Usually N:P ratios higher than 20 to 30 are considered phosphorus limited. The observed N:P ratios indicate that phosphorus is the main nutrient that is limiting algal growth in the lake.

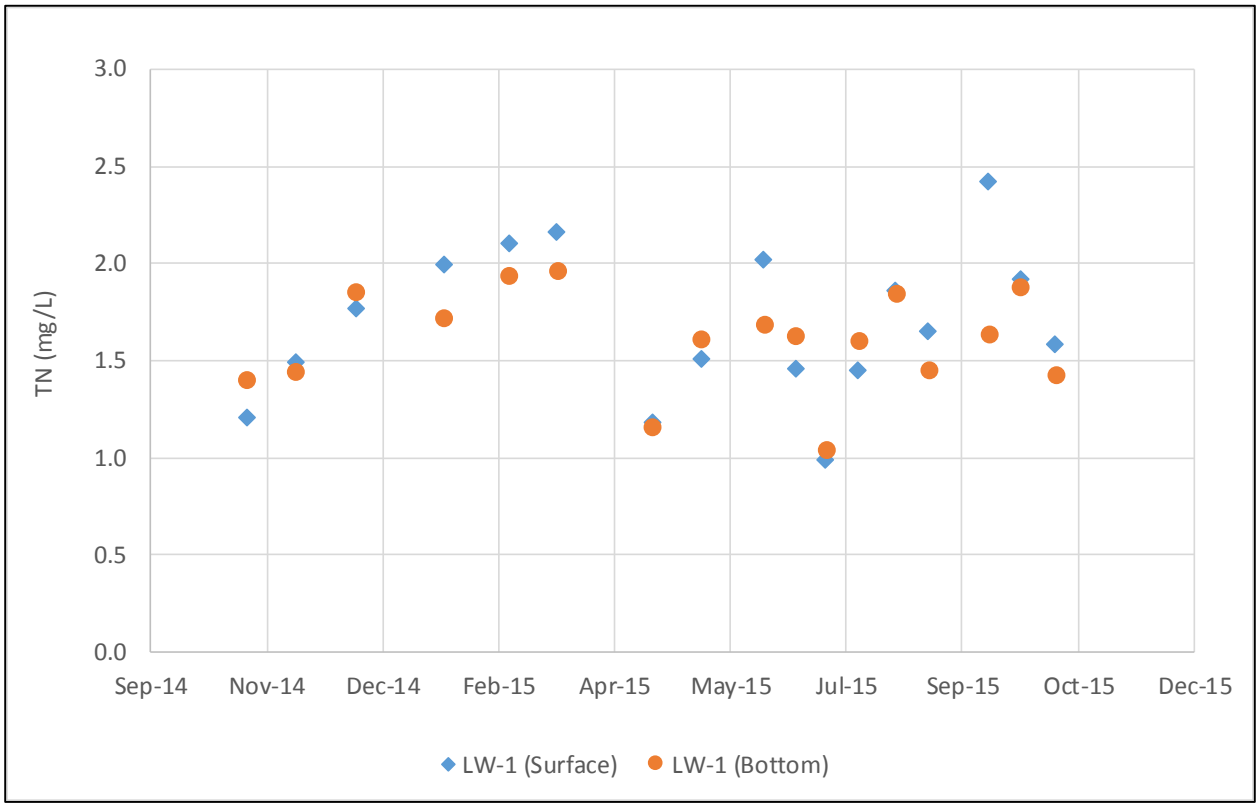

Figure 2-8. TN concentrations in Waughop Lake water samples collected at LW-1

Previous alkalinity samples had an average concentration of 26.8 mg/L as calcium carbonate ($CaCO_3$), with a range of 23.0 to 31.0 mg/L (PCD 2014).

Chlorophyll-a concentrations in this study ranged from 4.6 to 110.0 µg/L. The highest chlorophyll-a concentrations were found in the epilimnion (surface water) samples (see Figure 2-9 and Table 2-3). This is likely related to elevated TP concentrations and the algal blooms located at the surface of the lake.

As learned via personal communication with Ray Hanowell of TPCHD to Mike Milne of BC in March 2014, previous chlorophyll-a samples that were collected by TPCHD from June through October 2012 contained concentrations ranging between 5.5 and 93 µg/L.

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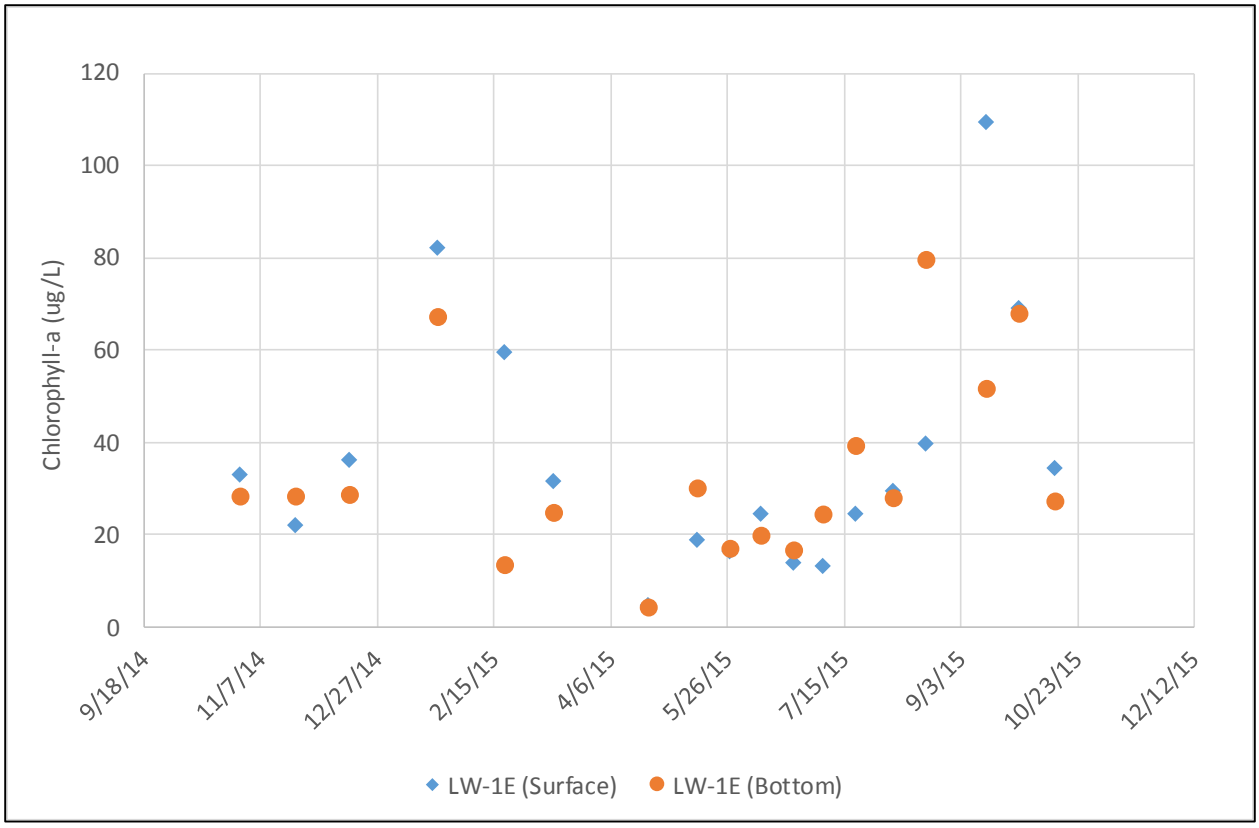

Figure 2-9. Chlorophyll-a concentrations in Waughop Lake water samples collected at LW-1

The phytoplankton community in Waughop Lake (see Table 2-4) was dominated in January and March, and from July through October by cyanobacteria (Cyanophyta), including Oscillatoria, Microcystis, and Anabaena. During the rest of the year, cyanobacteria were still a significant percentage in every sample, but the population was dominated by other phyla, including Chlorophyta and Chrysophyta.

Monitoring of algae within Waughop Lake has been conducted since 2007 by various agencies, including UWT, Ecology, PCD, and TPCHD. Monitoring has been conducted to identify the types and concentrations of cyanobacteria toxins. Since 2007, multiple cyanobacteria blooms have been observed with the three most common algae types identified as cyanobacteria, Microcystis aeruginosa, and Anabaena sp. And as mentioned above, at numerous times throughout the monitoring program, algae samples have shown levels above state recreational guidelines. In 2009, for example, more than 25 percent of the lake's algae samples had levels above state recreational guidelines (LaFontaine 2012). Algae counts collected by PCD in May 2014 noted heavy suspended algae with a recorded 21,200 algae count per milliliter (mL).

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Table 2-4. Percent Abundance of Phytoplankton in Waughop Lake		
Date	Cyanophyta	Other
10/2014	26%	74%
11/2014	17%	83%
12/2014	42%	58%
01/2015	64%	36%
02/2015	45%	55%
03/2015	53%	47%
04/2015	40%	60%
05/2015	43%	57%
06/2015	41%	59%
07/2015	87%	13%
08/2015	62%	38%
09/2015	81%	19%
10/2015	62%	38%

A Secchi disk was used to estimate lake water transparency during each sampling round and ranged from 0.4 to 2.0 m.

Measurements of transparency correspond to the levels of algae present: a high presence of algae corresponds to low visibility and after the algae blooms die off, visibility improves. During a UWT study in 2011, water transparency ranged from a low of 0.3 m in late May when there was an observed large algal bloom, to a maximum of 3.3 m in July 2011, after the algae were observed to have died off (LaFontaine 2012). In September 2013 per personal communication with Isabel Ragland of PCD to Mike Milne of BC in May 2014, PCD observed a Secchi depth of 0.6 m, which corresponded to a substantial presence of suspended algae. PCD collected two Secchi disk observations in May and June 2014 with recorded levels of 1.5 and 1.8 m, respectively.

2.6 Aquatic Plant Sample Results

Aquatic plant sampling was conducted to evaluate the potential impact of aquatic plants on TP cycling in Waughop Lake. The approximate macrophyte biomass was estimated based on regular sampling from a boat along transects across the lake. Measurement locations were recorded from Global Positioning System (GPS) coordinates. Plant samples were taken with a plant rake for species identification and biomass estimates in September 2015, during maximum plant growth. The total reservoir of TP and TN in aquatic macrophytes was estimated multiplying the average TP and TN content of the grab samples analyzed (mass phosphorus or nitrogen/sample area) by the total surface area of the lake. The total mass of phosphorus and nitrogen from aquatic plants was estimated at 163 kilograms (kg) and 534 kg, respectively.

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2.7 Lakebed Sediment Sample Results

Lakebed sediment samples were collected throughout the lake for chemical and grain size analysis. Throughout the lake 12 grab subsamples were collected from the top 10 centimeters (cm) to form one composite sample for TP and TN analysis. The results were 1,820 milligrams per kilogram (mg/kg) (or parts per million) dry weight of TP and 10,800 mg/kg dry weight of TN, which calculates to a total mass of TP and TN of 2,365 kg and 14,034 kg, respectively.

The sediment samples were collected to supplement the existing sediment grab and core data from previous studies, to support internal nutrient loading estimates, and the evaluation of potential management measures.

Previous studies of the sediment quality in Waughop Lake conducted by the University of Puget Sound (UPS) and UWT have revealed elevated levels of TP in approximately the top meter of lake bottom sediments. These studies have also identified elevated levels of Pb, Cu, As, and other metals, in that same top meter of lake bottom sediments (Tepper 2013).

Between 2003 and 2007, Waughop Lake was included in a study that was evaluating metal concentrations in sediment (As and Pb) using surface grab samples or sediment cores (Gawel et al. 2013). Sediment core metal concentrations were determined to reflect inputs from the ASARCO, LLC smelter in Ruston, Washington. In 2008, surface sediments were mapped and analyzed for TP and a suite of other metals for a study done by UWT contracted by the City. The resulting sediment phosphorus map, provided as Figure 2-10 below, suggested either a current or historical source of TP on the east side of the lake, possibly from the Western State Hospital farm that operated into the 1960s (LaFontaine 2012). TP levels in surface sediments showed a range from 741 µg/g to 3,443 µg/g (Gawel and Mason 2008). The lowest levels were located at the northwest and southeast corners of the lake and the highest levels were found near the public beach. Based on the sampling results, the upper 20 cm of lake bottom sediment contained about 2,267 kg phosphorus (Gawel and Mason 2008).

Students and faculty in the UPS Geology Department conducted a sediment core study at Waughop Lake in 2012. The study found that since 1900, the sediment accumulation rate at Waughop Lake rose from 2,000 to 6,000 grams per square meter per year (g/m^2-yr). As a result, Waughop Lake has become about 1 m shallower during the past century (Tepper 2013). Chemical analysis and ^{210}Pb dating of the core showed that TP concentrations were low during most of the lake's history, but increased almost tenfold beginning around 1900 (Tepper 2013). The increased TP coincided with higher nitrogen isotopic ratios, which are indicative of animal manure and agricultural waste. The study results suggest that bottom sediments are a significant source of the phosphorus that feeds the algal blooms in Waughop Lake (Tepper 2013).

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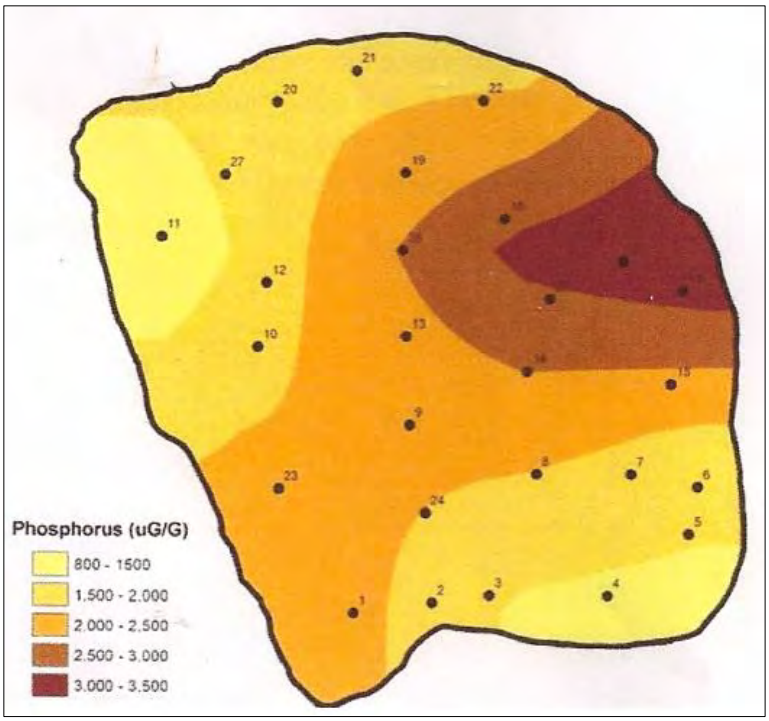

Figure 2-10. TP load in surface sediments collected in Waughop Lake in 2008

(Gawel and Mason 2008)

Three subsamples were collected throughout the lake for grain size analysis as shown in Table 2-5 and Figure 2-11. The particle size results indicate that the lake sediments are dominated by silt to very fine sand.

Table 2-5. Waughop Lake Sediment Sample % by Particle Size

Sample ID	Particle diameter (µm)									
	0.4	4	8	15	31	63	125	250	500	1,000
Subsample-1	0.82	1.6	4.7	15	28	29	16	3.5	0.27	0.00
Subsample-2	0.96	1.9	5.5	17	29	26	14	3.2	0.10	0.00
Subsample-3	1.00	2.1	6.0	18	30	25	13	2.2	0.92	0.01
Mean	0.94	1.8	5.4	16	29	27	14	3.0	0.43	0.01
Cumulative	0.94	2.8	8.3	25	54	81	96	99	99.00	100.00

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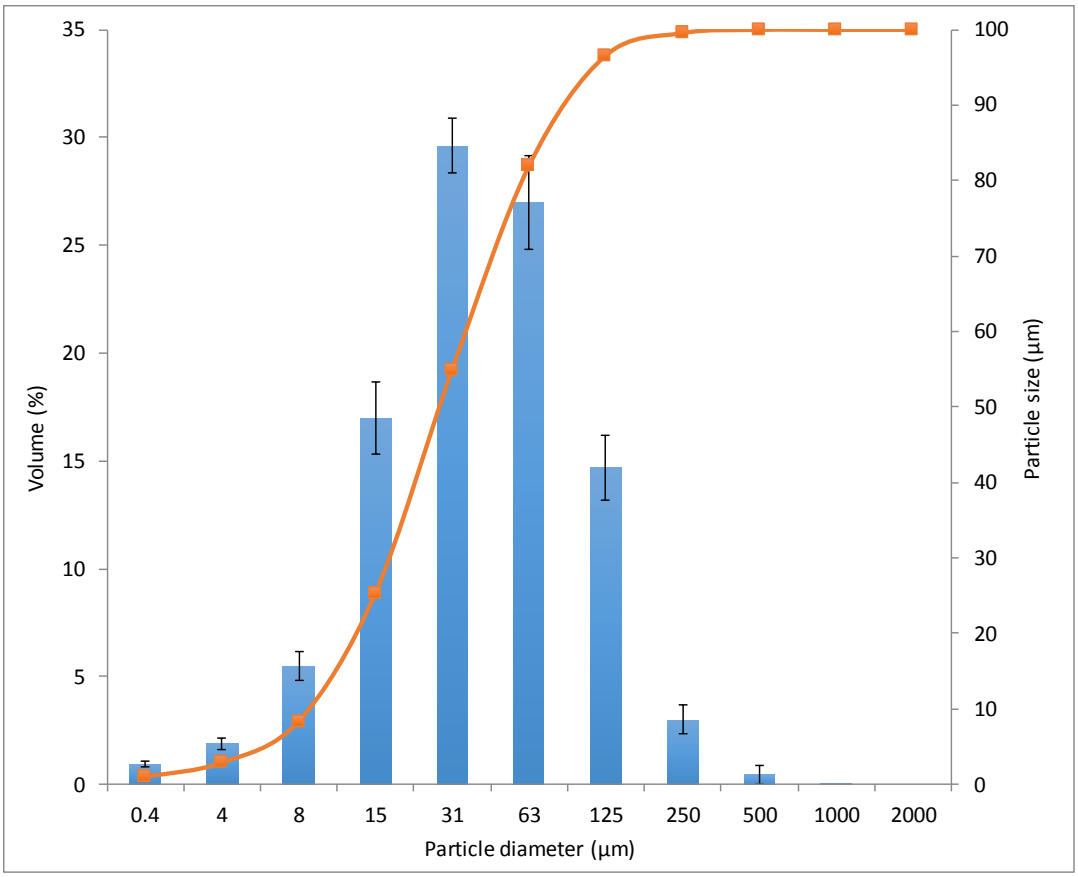

Figure 2-11. Mean particle size analysis from the three Waughop Lake sediment subsamples

2.8 Benthic Flux Sample Results

The internal loading of nitrogen and phosphorus from sediments in Waughop Lake to the water column was investigated using benthic flux chambers, modeled after a design developed by Ecology (Roberts 2015). Four flux chambers were randomly placed in the lake each month (July through September). Samples were collected at 2, 24, and 48 hours after deployment using a low-flow peristaltic pump. Some samples were not used in calculations as it was obvious that sediments were "floated" in the chambers by gas production, resulting in significant solids in the samples pumped from the chambers.

As noted in Table 2-3 above, TP concentrations in benthic water from the 2-hour, 24-hour, and 48-hour samples ranged from 0.07 to 1.99, 0.04 to 10.00, and 0.07 to 43.00 mg/L, respectively. TN concentrations in benthic water from the 2-hour, 24-hour, and 48-hour samples ranged from 1.44 to 13.00, 1.73 to 52.00, and 0.52 to 77.00 mg/L, respectively.

Flux rates were estimated per unit area using the difference between TN and TP concentrations in the chamber at 24 and 48 hours. The median flux rate from all chambers during all 3 months that were sampled was estimated and applied to the sediment surface area only for those months where bottom waters were anoxic (May through October) (see Figure 2-5 [DO profile figure]). In September and October one of two sampling periods showed anoxia, and so the median benthic flux was determined for half of each month. Table 2-6 below provides a summary of the calculated flux rates for TP, SRP, and TN.

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Table 2-6. Benthic Flux Rates for TP and TN in Waughop Lake			
Location	Month	TP flux rate (mg/day/m^2)	TN flux rate (mg/day/m^2)
Benthic Flux-1	July	86	18.10
Benthic Flux-2	July	9,909	-0.30
Benthic Flux-3	July	3192	-3.56
Benthic Flux-4	July	36	-2.37
Benthic Flux-6	August	12	1.19
Benthic Flux-7	August	2.1	1.19
Benthic Flux-8	August	2.9	0.89
Benthic Flux-9	September	17.8	0.30
Benthic Flux-10	September	8.3	0.59
Benthic Flux-11	September	241	55.80
Benthic Flux-12	September	2.6	0.59

2.9 Stormwater Sample Results

UWT collected stormwater samples from the Pierce College storm drainage line that discharges to Waughop Lake (see Figure 2-12). The outfall in the lake is often submerged and not accessible for sampling; therefore, the manhole closest to the lake, SW-1, was selected for sampling. SW-1 receives drainage from the entire outfall catchment area except for a small area (mostly rooftops, with some parking lot area) that is conveyed to manhole SW-2 and enters the storm drainage line downstream of SW-1. Water entering SW-1 initially flows into an infiltration pond located southwest of Waughop Lake. During large storms, stormwater fills the infiltration pond and additional flow discharges directly to Waughop Lake.

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Figure 2-12. Stormwater drainage at Pierce College

During the project monitoring period, a pressure sensor was installed in the manhole where stormwater enters and then is shunted to the infiltration basin. During the monitoring period, stormwater grab samples were collected from the manhole during rain events. (An autosampler was originally planned for use during this monitoring period to collect an integrated storm sampling event; however, because of an access ladder that blocked equipment installation, grab samples had to be collected instead.)

Table 2-7 below summarizes the grab samples that were collected by UWT during four storm events. For each of the storm events sampled, the stormwater flowed into the infiltration pond. The storm events were not large enough to cause a discharge directly into Waughop Lake. As shown in Table 2-7, this monitoring period was dryer than normal.

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Table 2-7. Antecedent Precipitation for Pierce College Outfall Storm Event Sampling

Storm event	Day	Precipitation (in.)	Total event precipitation (in.)
1/5/2015	1/4/2015	0.80	1.31
	1/5/2015	0.51	
2/5/2015	2/4/2015	0.28	0.93
	2/5/2015	0.65	
9/17/2015	9/16/2015	0.06	0.28
	9/17/2015	0.22	
10/7/2015	10/6/2015	0.00	0.32
	10/7/2015	0.32	

Grab samples from each storm event were analyzed for TP, SRP, and TN. As noted in Table 2-3 above and shown in Figure 2-13, concentrations of TP, SRP, and TN in lake water samples ranged from 0.03 to 0.37 mg/L, 0.003 to 0.140 mg/L and 0.190 to 0.930 mg/L, respectively.

Stormwater samples show that TP concentrations are elevated in the fall, and could be a significant source of new phosphorus to Waughop Lake. However, the pressure sensor measurements revealed that the infiltration basin system is highly efficient, and very little water volume likely escapes the system to enter the overflow into Waughop Lake.

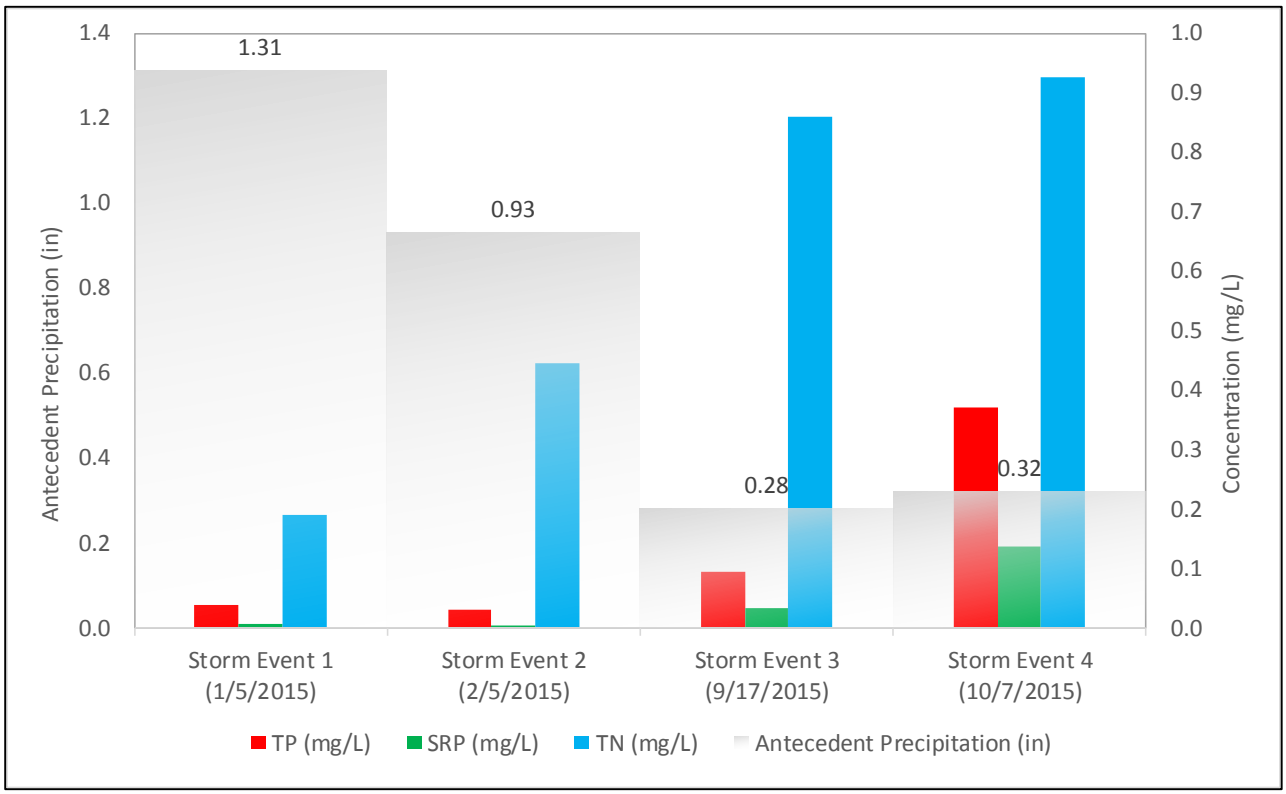

Figure 2-13. TP, SRP, and TN in stormwater samples collected at SW-1

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2.10 Waterfowl

Waughop Lake provides habitat for several species of waterfowl. Regular counts of waterfowl on Waughop Lake during the monitoring period (monthly or more frequently) observed a significant number of migratory ducks using the lake as a wintering ground. As many as 1,200 ducks were observed on the lake in December 2014. Relatively few waterfowl were observed using the lake in the summer. Nighttime roosting behavior was not analyzed. Ducks dominated the waterfowl population. Goose numbers throughout the year in Waughop Lake were very low compared to nearby Wapato Lake in a study conducted in 2010 (Chaichana et al. 2010).

Previous studies observed more than 40 mallards on the lake, along with smaller numbers of coots and Canada geese. As shown in Table 2-8, research has shown that the annual average of assumed phosphorus contributions for geese, ducks, and gulls is 490, 178, and 38 mg phosphorus per individual per day, respectively (Chaichana et al. 2010).

Phosphorus and nitrogen loading for this monitoring period from waterfowl were estimated using literature values and average waterfowl counts during a given time frame. Table 2-8 provides a summary of the estimated phosphorus and nitrogen that were contributed by waterfowl per month.

Table 2-8. Waterfowl Contributions of Phosphorus and Nitrogen per Month to Waughop Lake

Date	Total waterfowl phosphorus (kg/month) [a]	Total waterfowl nitrogen (kg/month) [b]
10/2014	3.8	12.1
11/2014	7.0	22.0
12/2014	2.5	7.9
01/2015	2.9	9.0
02/2015	3.7	11.7
03/2015	0.1	0.4
04/2015	0.2	0.6
05/2015	0.4	1.3
06/2015	0.7	2.2
07/2015	0.4	1.2
08/2015	0.8	2.5
09/2015	0.7	2.3
10/2015	3.8	12.1

a. *The annual average of phosphorus assumed for geese, ducks, and gulls: 490, 178, and 38 mg phosphorus/individual/day, respectively.*

b. *The annual average of nitrogen assumed for geese, ducks, and gulls: 1,570, 562, and 122 mg nitrogen/individual/day, respectively.*

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2.11 Monitoring Results Summary

UWT collected field data from October 2014–15 to support development of the Waughop LMP. Field data collection involved monitoring of groundwater, lake water, lakebed sediment, benthic flux, stormwater, and waterfowl. The key findings include:

- During the monitoring period, nearly all of the stormwater runoff from Pierce College was infiltrated in the stormwater pond and did not discharge to Waughop Lake.
- TP concentrations in the hypolimnion samples ranged from 0.048 to 0.137 mg/L, while epilimnion (surface water) samples ranged from 0.034 to 0.172 mg/L. TP results were similar to the concentrations measured by others.
- N:P ratios indicate that phosphorus is the primary nutrient that limits algal growth in the lake.
- Cyanobacteria dominated the phytoplankton in the lake from July to October.
- Secchi depths (i.e., transparency) ranged from 0.4 to 2.0 m.
- TP concentrations in benthic water from the 2-hour, 24-hour, and 48-hour samples ranged from 0.07 to 1.99, 0.04 to 10.00, and 0.07 to 43.00 mg/L, respectively.
- TP concentrations in the storm event samples collected from SW-1 ranged from 0.03 to 0.37 mg/L. The Pierce College pond infiltrated all of the flow sampled during this study period.
- The average TP concentrations in the five groundwater monitoring wells ranged from 0.001 to 0.080 mg/L, with an overall (combined) average of 0.032 mg/L.
- Lakebed sediment TP concentration from a composite of 12 stations contained 1,820 mg/kg (parts per million).
- Most of the lakebed sediment samples were predominantly composed of fine particles (e.g., silt to very fine sand).

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Section 3

Lake Water Budget

Elements of the water budget are based on model-derived data for stormwater runoff from the Waughop Lake catchment area and empirically derived data collected during the project monitoring period. Field data collection sites are identified in Figure 3-1. The water budget spans from January to October 2015 and is based on the period of record containing sufficient information to estimate each element of the water and nutrient budget. This interval is limited by lake stage data, piezometer readings, and groundwater monitoring well recordings.

Waughop Lake is a pluvial lake that does not receive surface water inflow or outflow from streams or creeks. Inflow is limited to precipitation on the lake, overland flow during high-intensity storm events, and groundwater influx. Outflow is predominately controlled by evaporation and groundwater flow. The lake is approximately 33 acres with a catchment area of 497 acres.

3.1 Precipitation

Precipitation data were downloaded from the Washington State University (WSU) Puyallup meteorological station located approximately 11 miles to the northeast of the site. A total of 21.9 inches (in.) of precipitation were recorded for the area from January to October 2015, which is below average conditions. Contribution to Waughop Lake from precipitation was estimated by multiplying the average monthly lake surface area by the total monthly precipitation (see Figure 3-1). Direct rainfall was the main water source to Waughop Lake. Groundwater and stormwater runoff were minor sources.

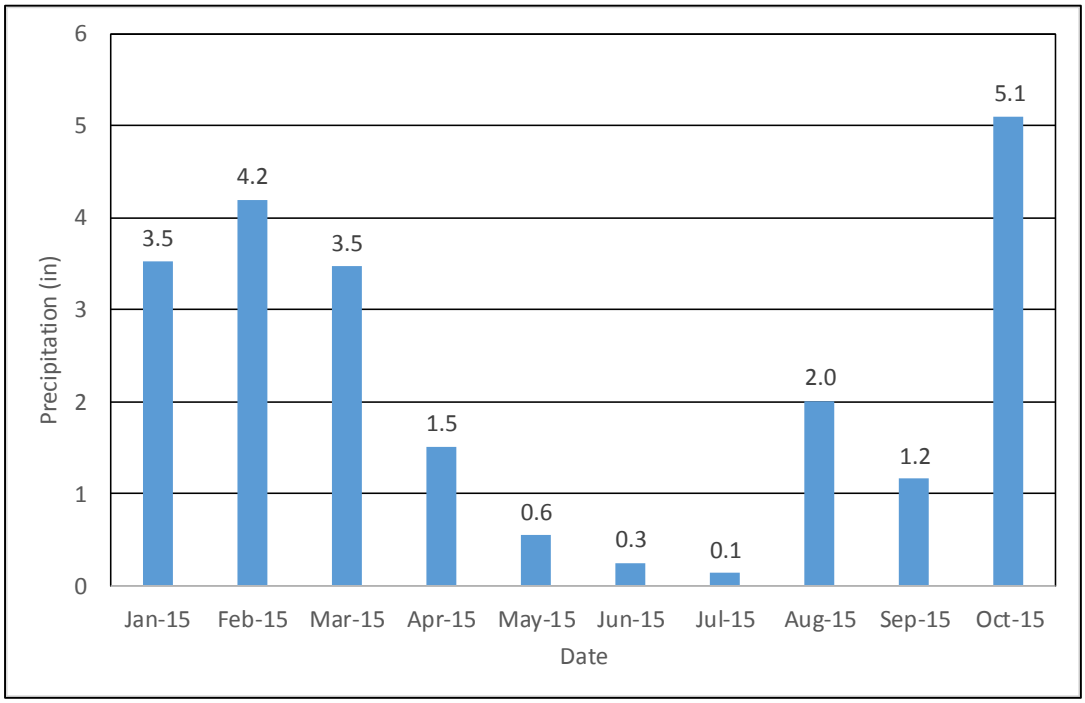

Figure 3-1. Precipitation measured from the WSU Puyallup weather station from January–October 2015

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3.2 Evaporation

Measurements of daily evaporation rates from the lake were not available. Instead, evaporation was estimated based on an energy balance equation that accounts for radiation, temperature, humidity, and land surface elevation (Priestly and Taylor 1972). The Priestly/Taylor equation was chosen for this analysis above several similar techniques because of its general acceptance in the literature, and its straightforward parameterization. This approach does not account for localized features such as wind, aspect, or shading. It assumes that the ground surface is relatively flat, and that the water body is exposed to sunlight over its entire length. The Priestly/Taylor equation is:

$$E = \alpha \frac{\Delta}{\Delta + \gamma} E_r$$

In which,

E is evaporation (in./month)

α is a constant (set to 1.3, unitless)

γ is a psychometric constant (60.1 Pascals per °C [kPa/C °], at 25°C and 500 feet elevation)

Δ is a function of temperature (kPa/C) equal to:

$$\Delta = \frac{2503878e^{\left(\frac{17.27T}{237.3+T}\right)}}{(237.3+T)^2}$$

Er is radiative energy (megajoule/day/m2) equal to:

$$Er = 0.353 * Rn$$

Rn is net radiation (Watt/m^2)

The resulting evaporation rates are based on average monthly temperatures from the WSU Puyallup meteorological station and mean net radiation (Rn) extracted from monthly averages complied from National Aeronautics and Space Administration's (NASA) Clouds and the Earth's Radiant Energy System (CERES) program (NASA NEO 2016).

Daily evaporation amounts for each month were estimated by prorating the average monthly evaporation amount by the number of days in each month. Monthly evaporation amounts are shown in Figure 3-2, below. More localized or short-term controls on evaporation, such as cloud cover or storm events, would be expected to produce daily fluctuations in evaporation rates, but data were insufficient to control for these features, and it is expected that they should average out over monthly time-scales (Farnsworth and Thompson 1982).

The average evaporation rate that was estimated during this period of analysis was 2.2 in. per month. The evaporation rate was transformed from a depth per unit area to a volumetric flux by multiplying over the surface area of the lake. The resulting total evaporation between January and October 2015 was 100 acre-feet (ac-ft).

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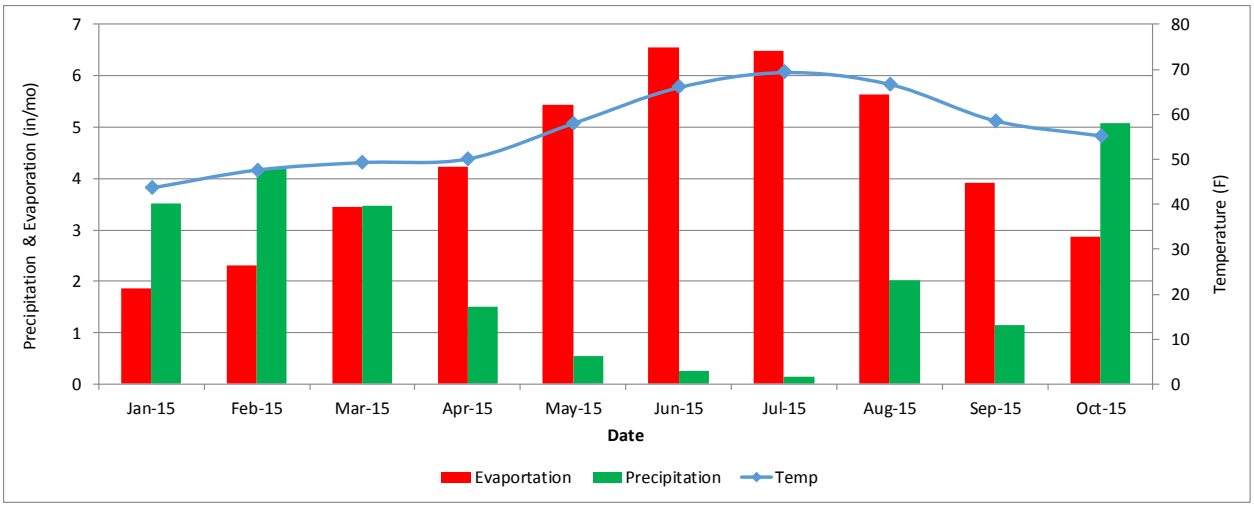

Figure 3-2. Evaporation, precipitation, and air temperature at Waughop Lake January–October 2015

3.3 Overland Flow

Runoff to Waughop Lake was estimated using the U.S. Environmental Protection Agency's (EPA) Stormwater Calculator (SWC). This application estimates the annual amount and frequency of runoff for a specific site, based on local soil conditions, user-defined land cover percentages, and climate data including precipitation and evapotranspiration. Soil data were sourced from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Soil Survey. SWC parameterization consisted of a selected soil type with low to moderately low runoff potential, soil drainage rates ranging from 0.3 to 4.4 in. per hour depending on slope and soil type reported by the NRCS Soil Survey, and land cover percentages estimated from aerial photographs (NRCS and USDA 2016). Results from the simulations (see Figure 3-3 below) show that 1 percent of the total precipitation over the catchment area would recharge Waughop Lake as runoff.

Approximately 27 impervious acres of the catchment are located on Pierce College and connected to a stormwater collection system. Water collected from Pierce College is routed to an infiltration basin near the lake. When the initial collection well tops 1.9 feet, waters will flow into Waughop Lake. In the 10-month monitoring period, the amount of water that flowed from the collection well into the lake was very low and was not included in final calculations.

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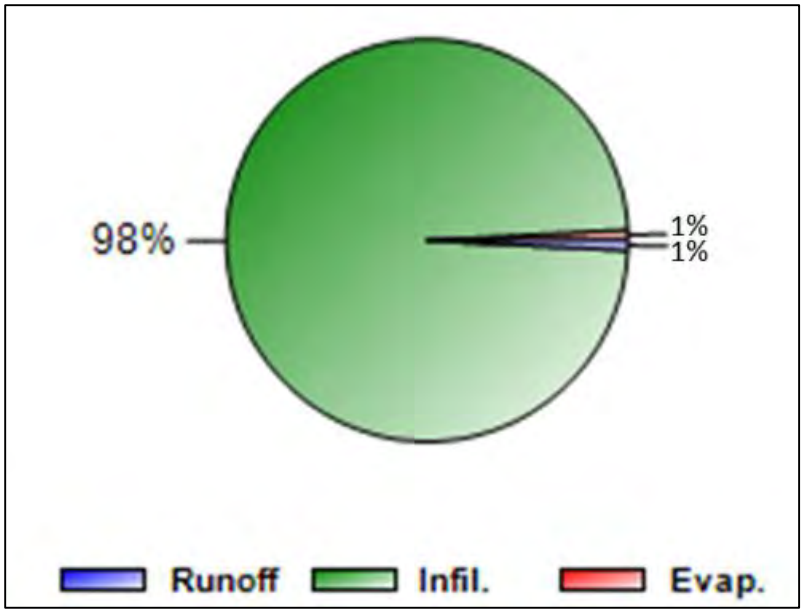

Figure 3-3. Results from the EPA SWC for the Waughop Lake catchment area

3.4 Lake Stage and Storage

Lake stage data consist of average elevations from readings on the outside of two piezometers installed in the lake. Lake storage estimates assume a simple cylindrical model with an effective radius of 672 feet. The stage-storage estimates show trends of gaining storage volume during the winter months and losing volume during the summer. The range of lake stage values is approximately 3 feet, indicating that lake storage varied by approximately 100 ac-ft during the monitoring period. Lake water levels collected in recent years by PCD varied between 3.2 and 7.5 feet, with the highest levels occurring mostly in May and July and the lowest levels observed during September and October (personal communication with Isabel Ragland, PCD, May 2014). The summer of 2015 was unusually dry, and water volume stored in the lake declined during the monitoring period (see Figure 3-4).

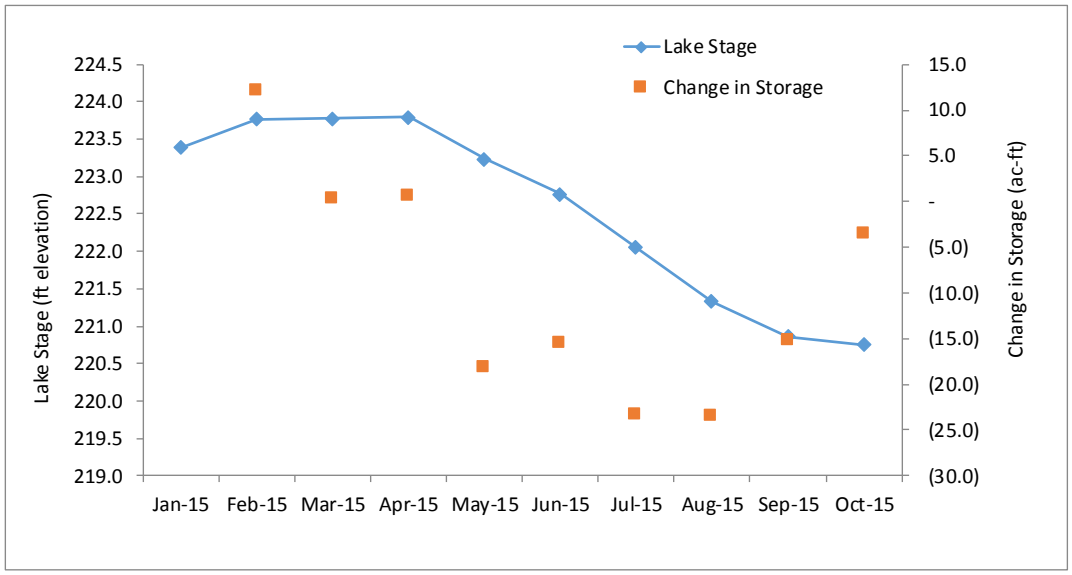

Figure 3-4. Waughop Lake stage and change in storage

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3.5 Groundwater Seepage

To estimate the trends in groundwater movement in the vicinity of the lake, groundwater-level monitoring data were used to estimate changes in the localized potentiometric surface. Based on interpretations of the potentiometric surface, the lake appears to recharge from groundwater along the southern margin of the lake, primarily during winter months. During the monitoring period, groundwater levels suggest that recharge begins in January, from the south-southwest area of the lake, and continues through approximately mid-June. The lake also receives direct recharge from precipitation during this period, and may also discharge to the groundwater system along the northern margin of the lake. Throughout the summer and fall, the lake appears to lose water to the groundwater system in a radial pattern skewed slightly to the north, following the regional groundwater gradient. Figures 3-5 and 3-6 below show plan views of the groundwater flow pattern direction around the lake in summer (July) and winter (February). These patterns show that there was a lot of variation in groundwater elevations in monitoring wells and the lake. The lake was generally losing water to groundwater. Phosphorus concentrations in groundwater were lower than the lake concentrations, and thus it did not appear that groundwater is the main source. (See Appendix C for copies of the monitoring logs and geologic cross-section diagrams.)

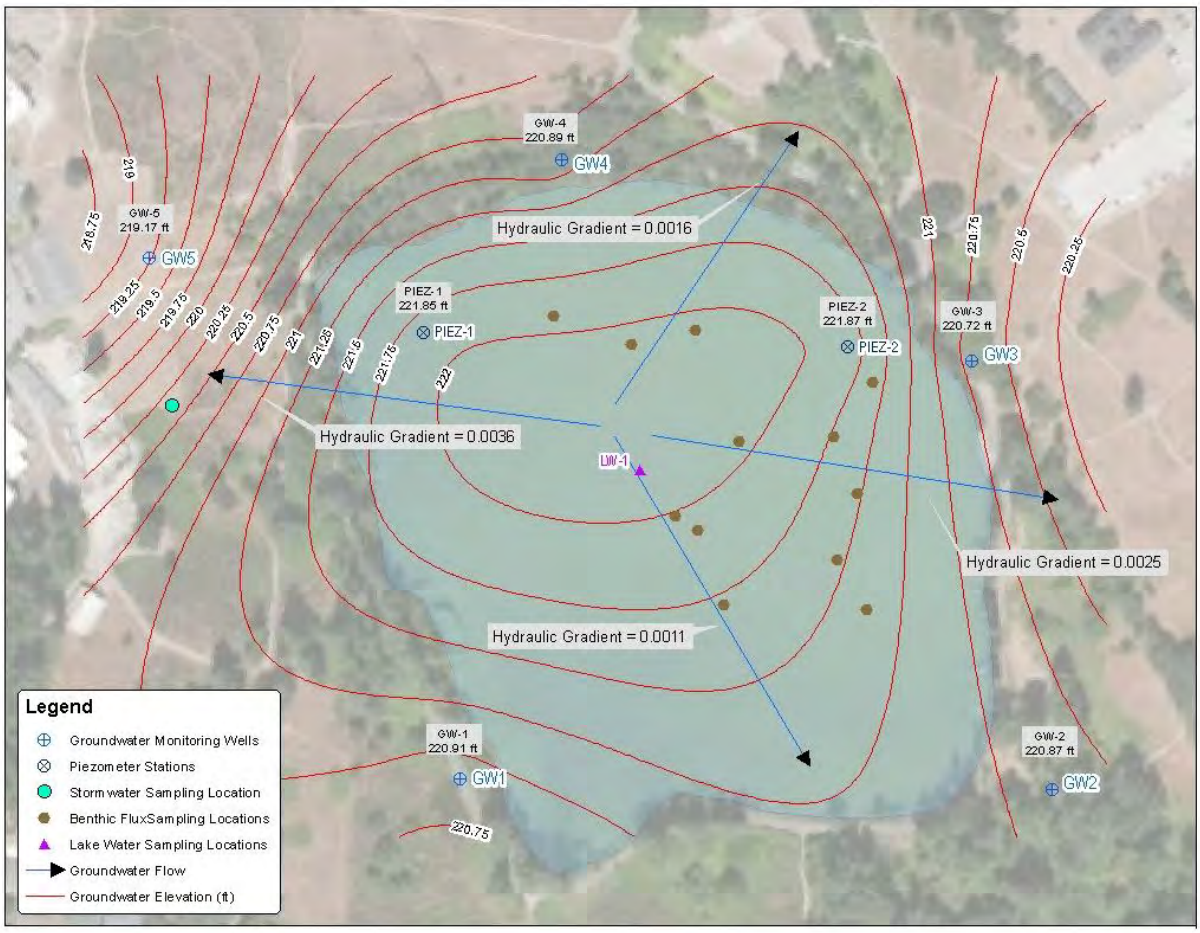

Figure 3-5. Plan view of groundwater flow direction around Waughop Lake in summer (July 2015)

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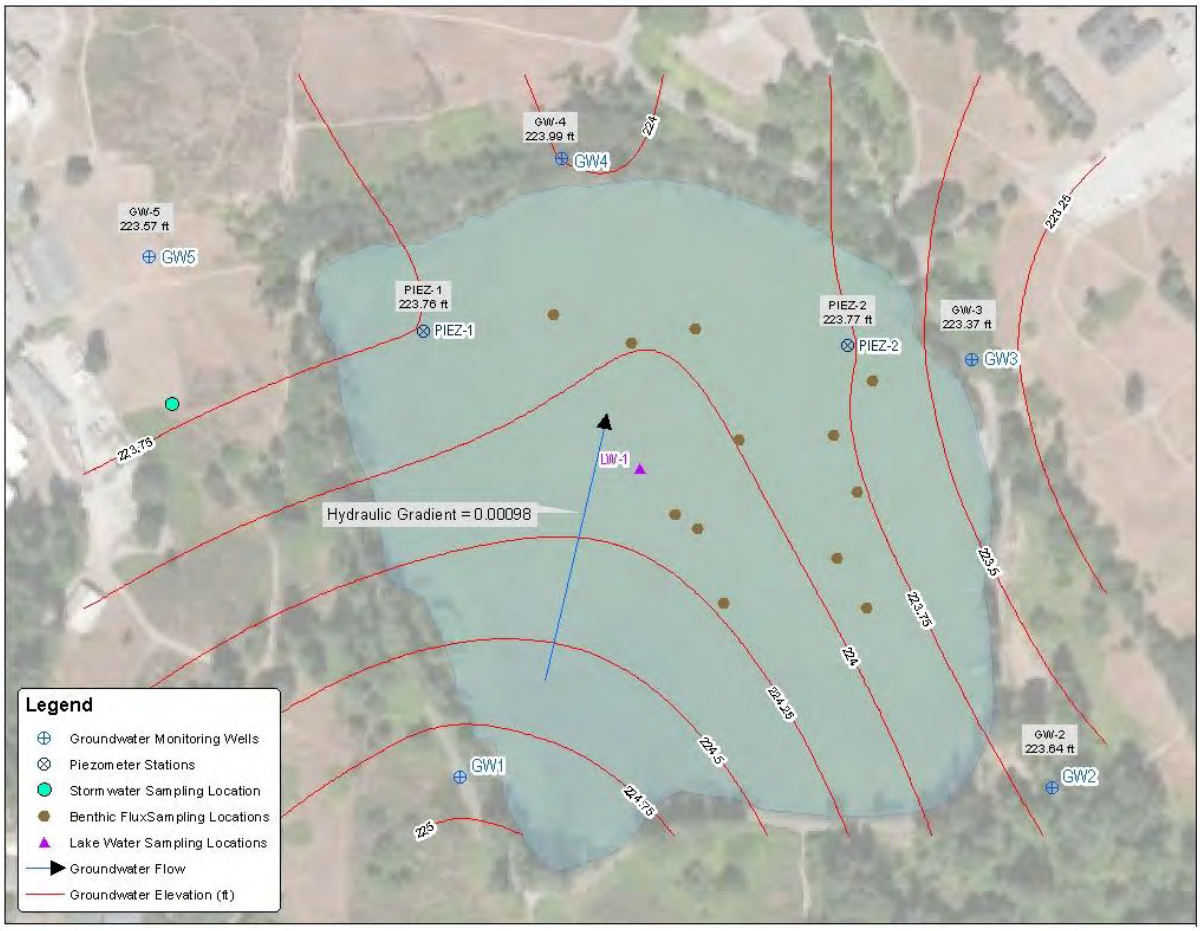

Figure 3-6. Plan view of groundwater flow direction around Waughop Lake in winter (February 2015)

Seepage (*Q*) into the lake was estimated from the flow through the cross-sectional area of the lake, perpendicular to the groundwater flow path. One half of the cross-sectional area was assumed for seepage calculations to account for the depth-narrowing profile of the lake. For months when the lake receives flow from the groundwater system, the hydraulic gradients ranged from 0.0013 to 0.0019 foot vertical per 1 foot horizontal (ft/ft). The cross-sectional area through which seepage occurs was assumed to range from 1,200 to 7,575 square feet (ft^2) based on seasonal variations in flow paths.

Horizontal groundwater flow through the upper 10 percent of the assumed cross-sectional area was estimated using the hydraulic conductivity of the aquifer material (100 feet per day), while the remaining 90 percent of the cross-sectional area was assumed to have a hydraulic conductivity of the lakebed sediments (1.28 feet per day). Conductivity values for lakebed sediments were estimated from particle size distributions of sediment samples (see Figure 3-7, below).

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A modified version of Darcy's Law was used to estimate flow:

$$Q = -KiA$$

In which:

K is hydraulic conductivity (feet/day)

i is the hydraulic gradient (ft/ft)

A is the cross-sectional area around the lake (ft^2)

Estimates of seepage out of the lake (losses) were estimated using the same Darcy equation noted above, but assumed a seepage reduced to 1,000,000 ft^2 (approximately 23 acres) to account for the lake bottom intersecting the groundwater table. Hydraulic gradients during periods where the lake is only discharging to groundwater ranged from 0.135 to 0.245 ft/ft. Figure 3-8 shows the lake stage and groundwater elevation from January to October 2015.

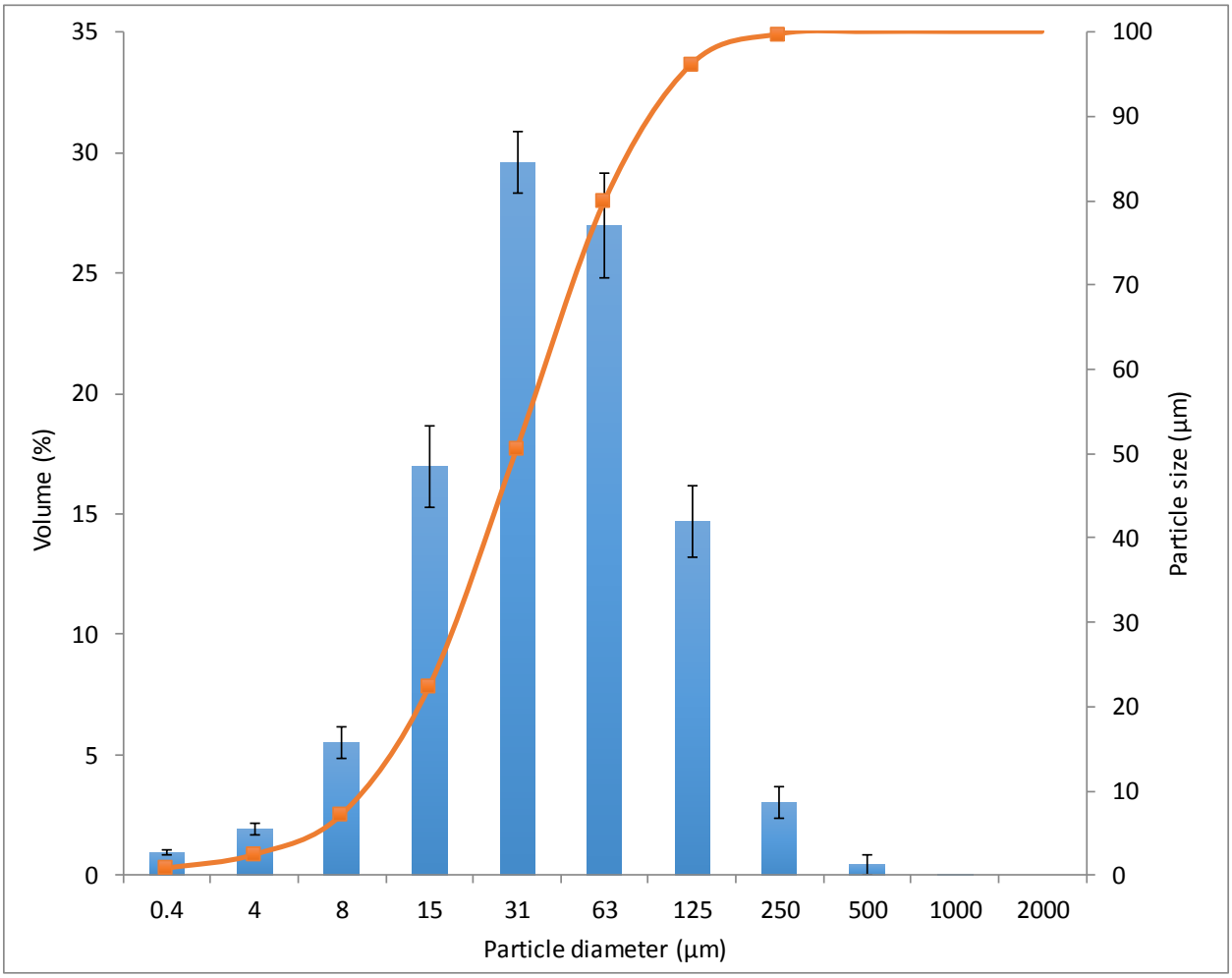

Figure 3-7. Particle size analysis from example Waughop Lake sediment sample 1

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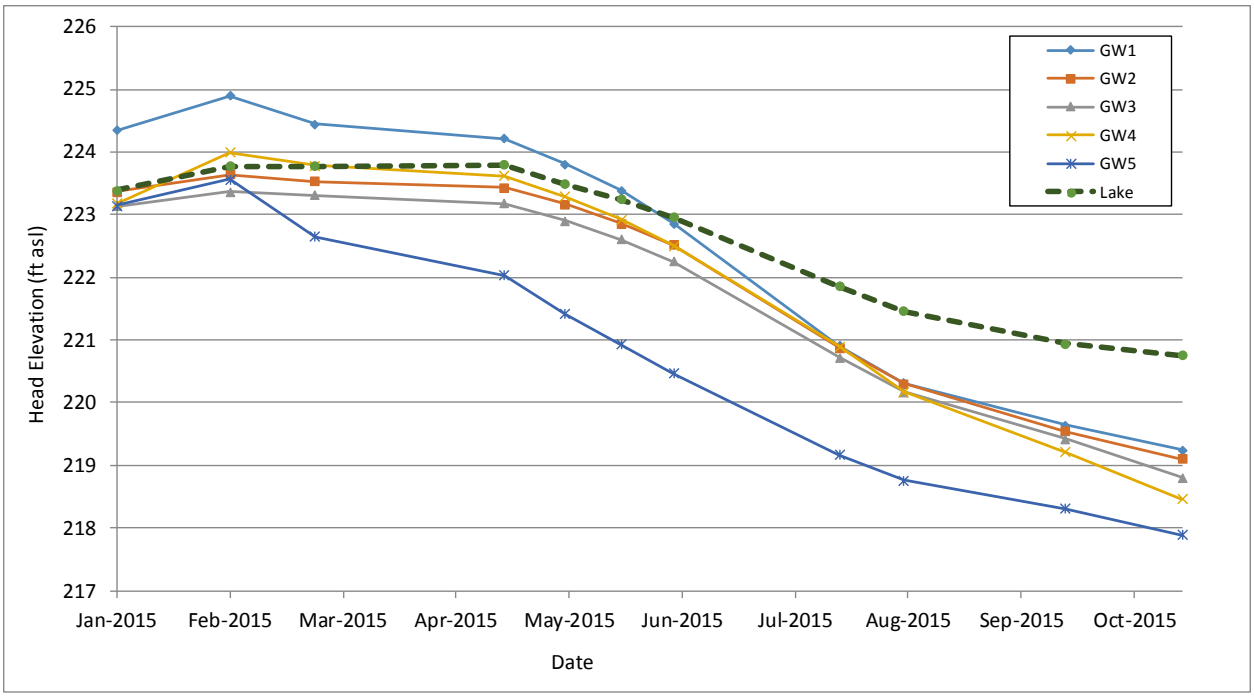

Figure 3-8. Waughop Lake stage and groundwater elevation from January–October 2015

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3.6 Water Budget Summary

Table 3-1 and Figures 3-9 and 3-10 below show the monthly Waughop Lake water budget summary for January through October 2015. In a perfectly balanced water budget, the sum of the flux terms should equal the change in storage of the lake; however, inaccuracies in the data or unaccounted flux terms can lead to discrepancies between the two. The stage data indicate that the lake may have lost additional water that was not accounted for in the water budget. Possible unaccounted sources include vertical groundwater seepage, or underestimation of evaporation. Alternatively, the stage-volume relationship of the lake may be overestimating the volume of lake water that was lost.

Table 3-1. Waughop Lake Water Budget Summary

Date	Lake stage (feet) [a]	Change in lake storage (ac-ft) [b]	Inflow	Outflow	Inflow	Inflow	Outflow	Total inflows (ac-ft)	Total outflows (ac-ft)	Net flux (inflows – outflows)
			Groundwater inflow (ac-ft)	Discharge to groundwater (ac-ft) [c]	Precipitation (ac-ft)	Inflow-runoff (ac-ft)	Evaporation (ac-ft)			
01/2015	223.4	-	0.14	-	8.87	1.29	4.69	10.30	4.69	5.61
02/2015	223.8	12.19	0.12	-	10.90	1.53	6.01	12.55	6.01	6.54
03/2015	223.8	0.33	0.09	-	9.04	1.27	9.00	10.41	9.00	1.41
04/2015	223.8	0.65	0.10	-	4.08	0.55	11.42	4.73	11.42	-6.68
05/2015	223.2	(18.13)	0.12	-	1.38	0.20	13.67	1.70	13.67	-11.97
06/2015	222.8	(15.44)	-	0	0.60	0.09	15.60	0.69	15.60	-14.91
07/2015	222.0	(23.24)	-	11.90	0.31	0.05	14.48	0.36	26.38	-26.02
08/2015	221.3	(23.48)	-	13.22	4.21	0.74	11.80	4.95	25.02	-20.07
09/2015	220.9	(15.11)	-	18.51	2.32	0.43	0.84	2.75	19.36	-16.60
10/2015	220.8	(3.49)	-	21.60	10.09	1.89	5.83	11.98	27.42	-15.44

a. *Lake stage was calculated using average outside piezometer readings for each month.*

b. *Change in lake storage was calculated assuming an effective lake radius of 671.5 feet.*

c. *January–May could potentially have both inflow from groundwater from the south, and outflow to groundwater toward the north. No outflow is assumed; however, this could be used to balance the difference between storage and flux.*

Notes:

Discharge to groundwater likely occurs in January–May. This could be used to better balance the water budget numbers during these months. Ideally, the net flux (inflows – outflows) should closely match the change in lake storage. Comparison of flux vs. change in storage highlights the monthly discrepancy in the water balance.

Note that groundwater levels were measured each month, however the October 2014 levels are suspicious. The hydrologic evaluation needed both the groundwater and piezometer levels, so only groundwater levels from January–October 2015 were used for this evaluation. Piezometers were installed in January 2015. Piezometer level readings are only available from January–October 2015.

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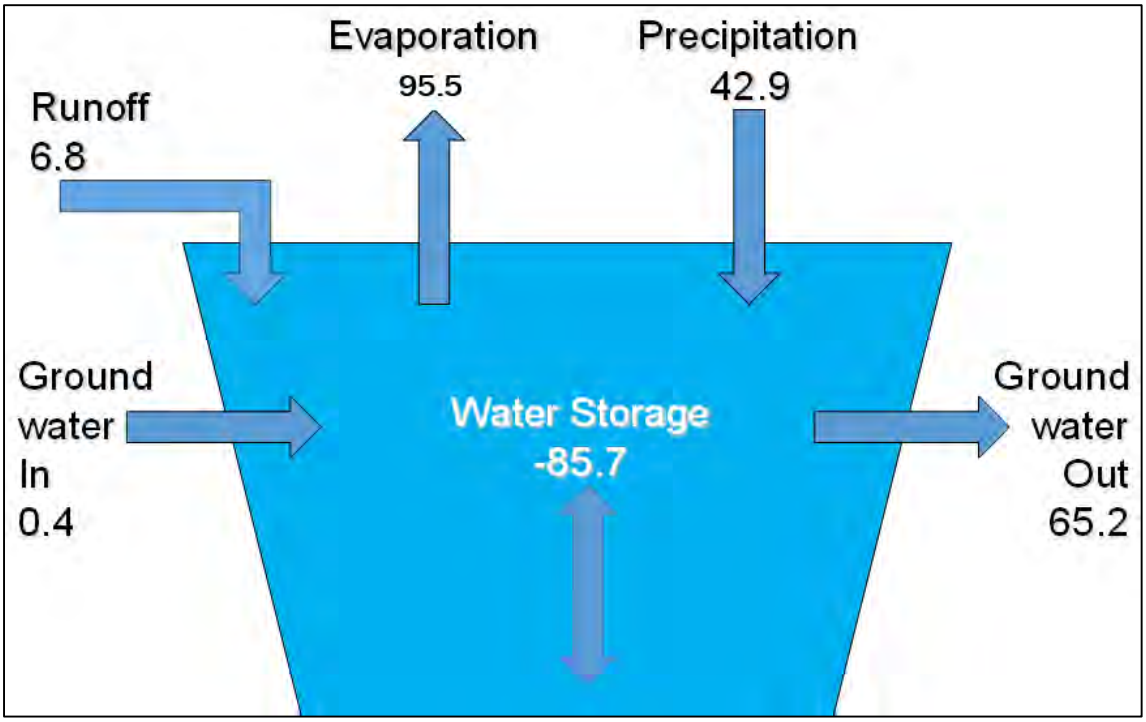

Figure 3-9. Waughop Lake Hydrology model summary (ac-ft)

Note that these numbers do not include data from January.

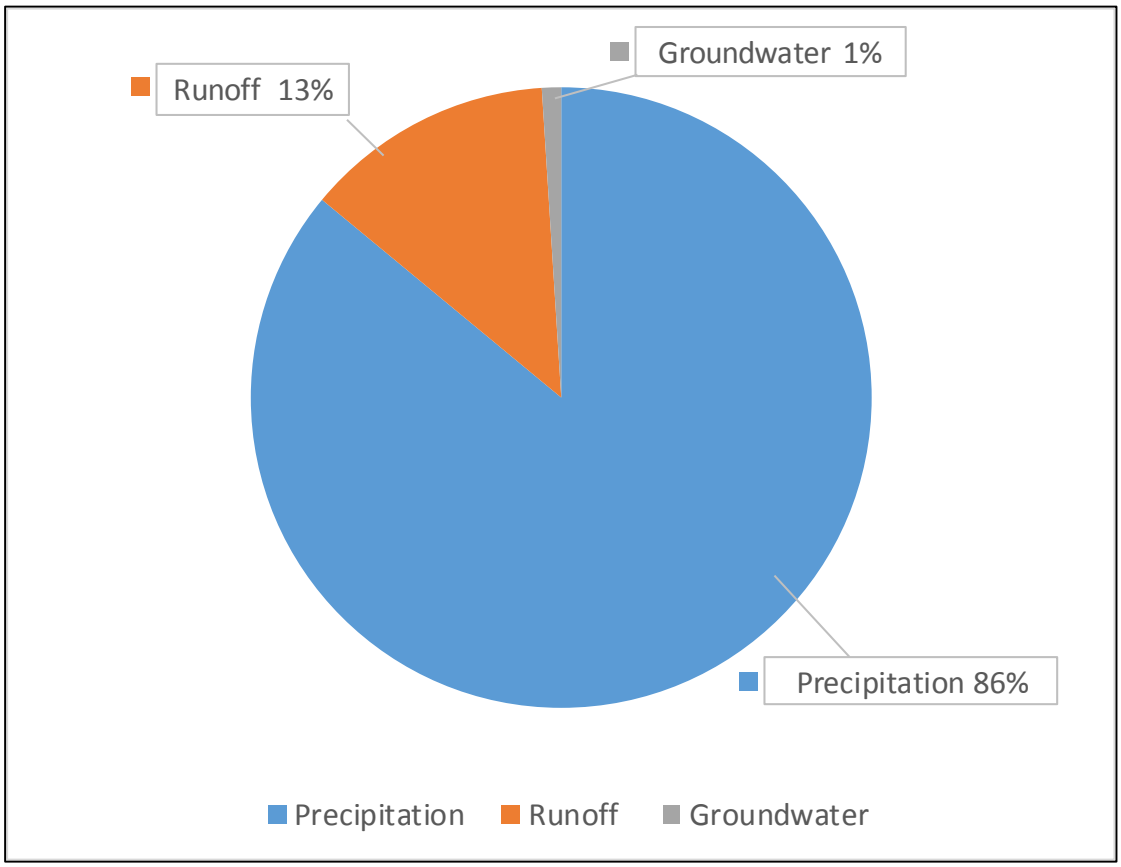

Figure 3-10. Waughop Lake water sources

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Section 4

Lake Nutrient Loading

The water quality data summarized in Section 2 and the lake water budget data described in Section 3 formed the basis of the nutrient budget for Waughop Lake. As noted in Section 2, the observed N:P ratios in lake water samples indicate that phosphorus is the limiting nutrient for algal productivity. However, contributions of nitrogen were also considered to be detrimental to the lake; therefore, the nutrient loading focused on phosphorus and nitrogen.

The nutrient loading for Waughop Lake consists of loading components attributed to groundwater, precipitation, waterfowl, runoff, benthic flux, and sedimentation. Septic systems would contribute through groundwater if significant. A simple mass balance model (see Figure 4-1) with a 1-month resolution was applied to Waughop Lake to characterize phosphorus and nitrogen reservoirs and fluxes into and out of the water column. This model was populated using measurements and literature-based estimates of TN and TP. All nitrogen and phosphorus chemical analyses were carried out by IEH on samples collected by UWT staff. The following sections describe how each component was estimated.

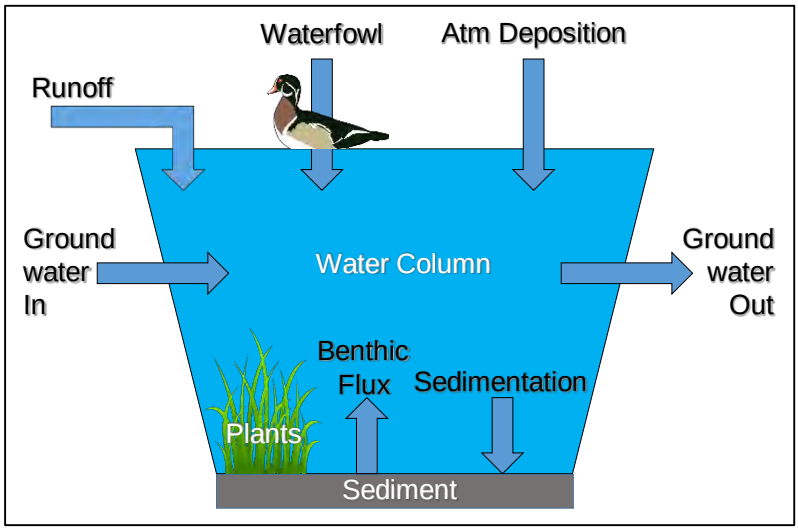

Figure 4-1. Conceptual nutrient model for Waughop Lake

(Note: reservoirs are depicted with white labels: water column, plants, and sediment.)

4.1 Trophic State Index and N:P Ratio

The lake water quality monitoring data were used to assess the trophic state of Waughop Lake. Lakes and ponds are typically categorized according to trophic states as follows:

- **Oligotrophic:** Low biological productivity. Oligotrophic lakes are very low in nutrients and algae, and typically have high water clarity and a nutrient-poor inorganic substrate. Oligotrophic water bodies are capable of producing and supporting relatively small populations of living organisms (e.g., plants, fish, and wildlife). If the water body is thermally stratified, hypolimnetic oxygen is usually abundant.

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- **Mesotrophic:** Moderate biological productivity and moderate water clarity. A mesotrophic water body is capable of producing and supporting moderate populations of living organisms (e.g., plant, fish, and wildlife). Mesotrophic water bodies may begin to exhibit periodic algae blooms and other symptoms of increased nutrient enrichment and biological productivity.
- **Eutrophic:** High biological productivity because of relatively high rates of nutrient input and nutrient-rich organic sediments. Eutrophic lakes typically exhibit periods of oxygen deficiency and reduced water clarity. Nuisance levels of macrophytes and algae may result in recreational impairments.
- **Hypereutrophic:** Dense growth of algae throughout the summer. These have dense macrophyte beds, but the extent of growth may be light-limited because of dense algae and low water clarity. Summer fish kills are possible.

Waughop Lake is considered to be eutrophic to hypereutrophic based on chlorophyll-a, TP, TN, and Secchi depth values measured during the monitoring period (See Table 2-3 and Figure 2-5 above). The water near the lake bottom becomes anoxic. When anoxic, the bottom sediments release large amounts of phosphorus into the lake water. Waughop Lake's trophic state is also characterized with the Carlson Trophic State Index (TSI), one of the most commonly used means of characterizing a lake's trophic state (Carlson 1977). As illustrated in Figure 4-2, the TSI assigns values that are based upon logarithmic scales, which describe the relationship between three parameters (TP, chlorophyll-a, and Secchi disk water clarity) and the lake's overall biological productivity. TSI scores below 40 are considered oligotrophic, scores between 40 and 50 are mesotrophic, scores between 50 and 70 are eutrophic, and scores from 70 to 100 are hypereutrophic as shown in Tables 4-1 and 4-2, below. The resultant mass balance models for TP and TN are provided in Tables 4-3 and 4-4. Figure 4-3 shows the Waughop Lake phosphorus sources. A discussion of these figures and tables are provided in the subsequent sections.

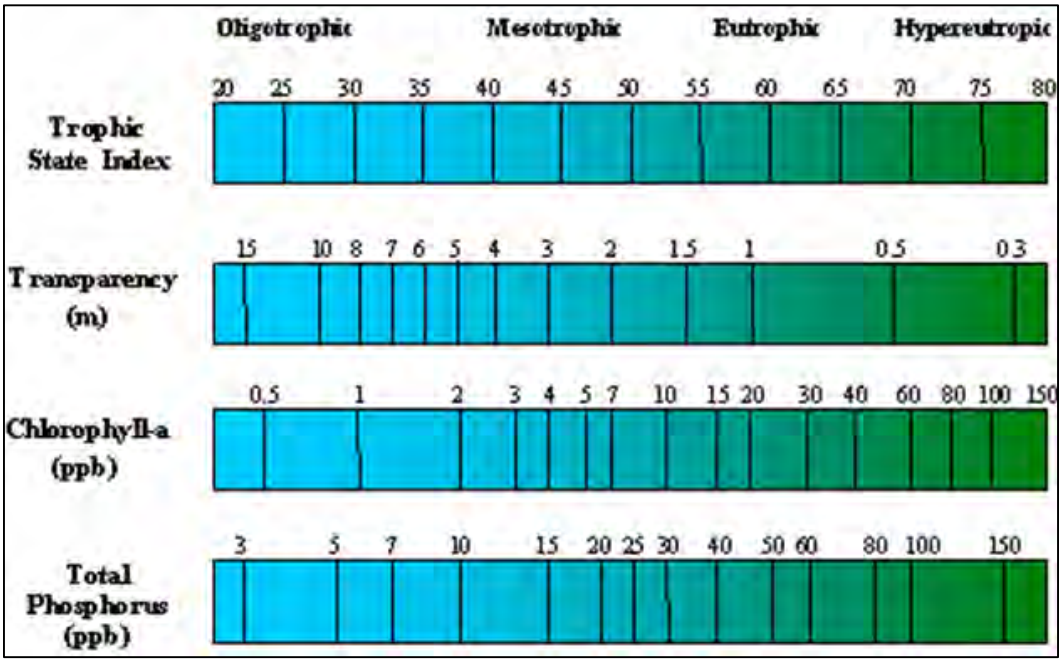

Figure 4-2. Carlson TSI

(EPA 1988)

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Table 4-1. TSI Ranges				
Trophic state	TSI	TP [a] (ppb)	Secchi disk (m)	Chlorophyll-a [b] (ppb)
Oligotrophic	<40	<12	>4.0	<2.6
Mesotrophic	40–50	12–24	4.0–2.0	2.6–7.3
Eutrophic	51–70	25–96	2.0–0.5	7.4–56.0
Hypereutrophic	>70	>96	<0.5	>56.0

a. *For TP, ppb = µg/L.*

b. *For chlorophyll-a, ppb = mg/m^3.*

Table 4-2. TSI Calculated for Waughop Lake using Chlorophyll-a, TP, TN, and Secchi Depth				
Date	TSI (using chlorophyll-a)	TSI (using TP)	TSI (using TN)	TSI (using Secchi depth)
10/29/2014	65	66	57	57
11/22/2014	61	63	60	56
12/15/2014	66	71	64	55
1/22/2015	74	70	64	59
2/19/2015	71	77	66	63
3/12/2015	64	71	66	58
4/22/2015	46	66	57	52
5/13/2015	59	67	60	61
6/9/2015	62	61	65	56
6/23/2015	56	62	59	50
7/6/2015	56	55	54	55
7/20/2015	62	64	60	58
8/5/2015	64	67	63	63
8/19/2015	67	62	62	62
9/14/2015	77	71	67	72
9/28/2015	72	68	64	68
10/13/2015	65	65	61	61

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Table 4-3. TP Mass Balance Model for Waughop Lake

Date	Groundwater input (kg-TP) [a, c]	Groundwater output (kg-TP) [b, c]	Precipitation (kg-TP) [d]	Waterfowl (kg-TP) [e]	Benthic flux (kg-TP) [f]	Runoff (kg-TP) [g]	Sedimentation (kg-TP) [h]	TP in (kg)	TP out (kg)
01/2015	0.002	0.00	0.26	2.51	0.00	0.11	7.62	2.89	7.62
02/2015	0.001	0.00	0.32	2.86	0.00	0.13	7.62	3.31	7.62
03/2015	0.001	0.00	0.27	3.71	0.00	0.10	7.62	4.08	7.62
04/2015	0.002	0.00	0.12	0.14	0.00	0.05	7.62	0.31	7.62
05/2015	0.002	0.00	0.04	0.17	73.70	0.02	7.62	73.93	7.62
06/2015	0.000	0.00	0.02	0.39	71.32	0.01	7.62	71.74	7.62
07/2015	0.000	0.62	0.01	0.69	73.70	0.00	7.62	74.40	8.24
08/2015	0.000	0.68	0.12	0.38	73.70	0.06	7.62	74.26	8.31
09/2015	0.000	0.96	0.07	0.80	35.66	0.04	7.62	36.56	8.58
10/2015	0.000	0.86	0.30	0.72	36.85	0.16	7.62	38.03	8.48

a. *Only GW-1 TP concentrations were used for inflows.*

b. *Average TP concentrations from GW-2–GW-5 were used for outflows.*

c. *Average nutrient concentrations (TP, TN) were calculated per quarter: October–December, January–March, April–June, and July–September.*

d. *Precipitation concentrations obtained from Roberts 2013 and Dion et al. 1983.*

e. *The majority of ducks in winter were feeding in the lake and were possibly recycling nutrients already there, but conservative literature values were used from Chaichana et al. 2010.*

f. *The median flux rate from all chambers during all 3 months that were sampled was determined and applied to the sediment surface area only for those months where bottom waters were determined to be anoxic (May through October) (Figure 2-5 [DO profile figure]). In September and October one of two sampling periods showed anoxia, and so the median benthic flux was determined for half of each month.*

g. *Runoff concentrations taken from WA Dept. of Ecology Publication No. 11-03-010 (Herrera 2011).*

h. *Flux to sediments amount were from estimates made by Jeff Tepper (personal communication with Jim Gawel May 2016) using the sediment core.*

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Table 4-4. TN Mass Balance Model for Waughop Lake

Date	Groundwater input (kg-TN) [a, c]	Groundwater output (kg-TN) [b, c]	Precipitation (kg-TN) [d]	Waterfowl (kg-TN) [e]	Benthic flux (kg-TN) [f]	Runoff (kg-TN) [g]	Sedimentation (kg-TN) [h]	TP in (kg)	TP out (kg)
01/2015	0.293	0.0	1.75	7.94	0	1.58	318	11.56	318
02/2015	0.247	0.0	2.15	9.03	0	1.88	318	13.30	318
03/2015	0.201	0.0	1.78	11.70	0	1.55	318	15.24	318
04/2015	0.503	0.0	0.80	0.44	0	0.67	318	2.42	318
05/2015	0.553	0.0	0.27	0.55	1,216	0.25	318	1,218.00	318
06/2015	0.000	0.0	0.12	1.26	1,177	0.11	318	1,178.00	318
07/2015	0.000	11.3	0.06	2.19	1,216	0.06	318	1,218.00	330
08/2015	0.000	12.6	0.83	1.19	1,216	0.91	318	1,219.00	331
09/2015	0.000	17.6	0.46	2.51	588	0.53	318	592.00	336
10/2015	0.000	116	1.99	2.29	608	2.32	318	615.00	434

a. *Only GW-1 TP concentrations were used for inflows.*

b. *Average TP concentrations from GW-2–GW-5 were used for outflows.*

c. *Average nutrient concentrations (TP, TN) were calculated per quarter: October–December, January–March, April–June, and July–September.*

d. *Precipitation concentrations obtained from Roberts 2013 and Dion et al. 1983.*

e. *The majority of ducks in winter were feeding in the lake and were possibly recycling nutrients already there, but conservative literature values were used from Chaichana et al. 2010.*

f. *The median flux rate from all chambers during all 3 months that were sampled was determined and applied to the sediment surface area only for those months where bottom waters were determined to be anoxic (May through October) (Figure 2-5 [DO profile figure]). In September and October one of two sampling periods showed anoxia, and so the median benthic flux was determined for half of each month.*

g. *Runoff concentrations taken from WA Dept. of Ecology Publication No. 11-03-010 (Herrera 2011).*

h. *Flux to sediments amount were from estimates made by Jeff Tepper (personal communication with Jim Gawel May 2016) using the sediment core.*

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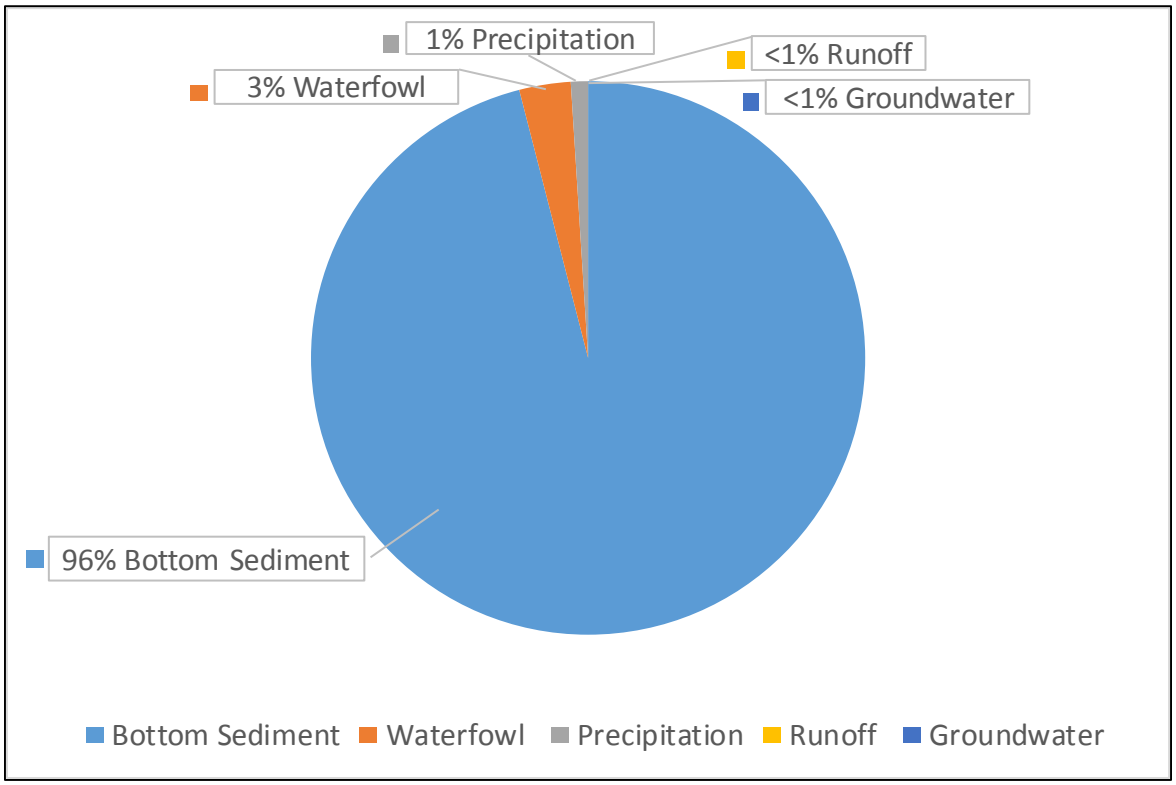

Figure 4-3. Waughop Lake phosphorus sources

4.2 Groundwater

As discussed in Section 3, the direction of groundwater flow in the vicinity of Waughop Lake is generally to the north, with groundwater levels at GW-1 (the southern monitoring well) as the up-gradient well. During high groundwater periods, generally from December to June, the lake receives recharge from the groundwater system from the southern shoreline area in the vicinity of GW-1. In mid-summer (mid-June during the 2015 monitoring period), groundwater levels drop below the lake surface elevation and seepage from the lake results in flux back to the groundwater system. Of the five monitoring wells installed around Waughop Lake, only GW-1 had greater head levels than the lake surface elevation from January to June. GW-4 had one greater head level in February. All other wells at all other times of the year had head levels that were lower than the lake surface from June to October. Thus, groundwater nutrient influx (i.e., inflow) was calculated using TN and TP concentrations measured in GW-1, and groundwater efflux (i.e., outflow) was calculated using the average TN and TP measured in GW-2 to GW-5. As groundwater samples were only analyzed quarterly, the quarterly values were applied to all months in that quarter. (Specifically, analytical results from groundwater samples collected in December 2014 were used to represent October to December, samples collected in February 2015 were used to represent January to March, samples collected in May 2015 were used to represent April to June, and samples collected in August 2015 were used to represent July to September.)

Overall, the hydrologic mass balance for Waughop Lake greatly influences the nutrient mass balance in the lake. Phosphorus concentrations in groundwater in the nearby aquifer are, in general, much less than in the lake's water column and the advective flux of groundwater into the lake is very low

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(see Table 4-3). This results in very little influence for groundwater on phosphorus loading into the lake. During the year the lake loses much more volume to groundwater than it gains. Moreover, measurements of TP in the groundwater suggest that concentrations in groundwater increase when the lake is losing water to the aquifer. Thus, groundwater acts as a net sink for phosphorus for the lake rather than a source.

Groundwater also acts as a net sink for nitrogen in the lake during the year (see Table 4-4). However, TN concentrations are in general higher in groundwater than in the lake's water column during most of the year, although concentrations were highly variable in the different monitoring wells. Trends in nitrogen in groundwater are very difficult to interpret without further measurements of nitrogen transformations and chemical speciation.

4.3 Precipitation

Concentrations of nitrogen and phosphorus in precipitation were not measured during this monitoring period. Rather, estimates for nitrogen and phosphorus loading in precipitation were garnered from published literature values (see Tables 4-3 and 4-4, above). Precipitation concentrations were taken from Roberts for phosphorus, and from Dion et al. for nitrogen (Roberts 2013; Dion et al. 1983).

Nutrient inputs to Waughop Lake in precipitation are greater than groundwater inputs, but less than waterfowl, and are comparable to runoff amounts. Greater certainty in estimating precipitation and dry deposition inputs of nutrients to the lake might be warranted in the future only if internal loading of nutrients from sediments is addressed.

4.4 Waterfowl

This evaluation estimates that waterfowl are the second-biggest source of nitrogen and phosphorus to Waughop Lake (after benthic flux); however, it is likely that this overestimates the contribution of these waterfowl (see Tables 4-3 and 4-4 above). For this study, it was found that during the winter the population of waterfowl was strongly dominated by Northern Shovelers. These are dabbling ducks that strain their food (e.g. small crustaceans) from the lake water column. They recycle nitrogen and phosphorus already in the lake, rather than importing nitrogen and phosphorus from external sources. Thus, the estimated winter nitrogen and phosphorus inputs from waterfowl are likely overestimated.

4.5 Benthic Flux

Internal loading of phosphorus to the water column as determined by benthic flux chambers was 30 times greater than any other source (see Table 4-3). Internal loading of nitrogen was 150 times greater (see Table 4-4). These estimates may overestimate nutrient fluxes from sediments by forcing lower oxygen levels in the chambers than occurs in the shallow lake otherwise, but the chambers may also underestimate the flux by depressing advective mixing or turbulent diffusion. These results are a strong indicator that internal loading of nitrogen and phosphorus to the lake is by far the greatest source of nutrients to Waughop Lake at this time.

4.6 Runoff

The amount of direct overland flow volume into Waughop Lake is likely very small due to the relatively flat, vegetated area that surrounds the lake and an asphalt walkway that separates the lake shore from the surrounding contributing area; stormwater runoff appears to be a minor source to the lake. The largest potential source of runoff into the lake is through the stormwater system that

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drains a large portion of the Pierce College parking lot and roof area with an outlet emptying directly into the lake.

Some of the stormwater samples collected at the inlet to the pond contained elevated TP concentrations. However, as discussed in Section 2, nearly all of the runoff from the Pierce College campus was retained in an infiltration pond. This facility is designed to bypass flows that exceed the storage and infiltration capacity of the pond. During the monitoring period for the Waughop LMP (Oct. 2014 – Oct. 2015), all of the inflow reaching the pond was infiltrated, so there was no bypass. Therefore, nitrogen and phosphorus inputs from runoff are estimated to be lower than inputs from precipitation and waterfowl, and much lower than inputs from lake bottom sediment (see Tables 4-3 and 4-4 above).

4.7 Sedimentation

Estimates of sedimentation rates for nitrogen and phosphorus were provided via personal communication with Dr. Jeff Tepper at UPS to Jim Gawel of UWT in May 2016. Dr. Tepper collected multiple sediment cores in a previous study using a piston corer. Cores were sectioned and dated using ^{210}Pb. The sedimentation rate for surface sediments was applied evenly across the year (see Tables 4-3 and 4-4) (Tepper 2013).

Overall, sedimentation rates for nitrogen and phosphorus are much greater than all inputs except benthic flux rates, further supporting internal loading from lake bottom sediment as the most significant source of nutrients to the water column. The mass of phosphorus lost to sedimentation during the period from January to October was approximately 20 percent of the estimated benthic flux, while the loss of nitrogen to sedimentation was about 50 percent of the benthic flux. A better estimate for sedimentation rates might be warranted in future work as sediment cores are not very good at estimating fluxes on an annual scale. Sediment traps would be a better choice for estimating the loss to sediments.

4.8 Reservoirs of Nutrients

The reservoir of nitrogen and phosphorus in sediments, aquatic macrophytes, and the water column was estimated. Water column values were determined by average TN and TP water column values. The sediment reservoir in the top 10 cm (assumed to be more easily available as a benthic source) was estimated by a composite sample collected from 12 regular sampling locations throughout Waughop Lake using a petit ponar dredge. The composite sample was well mixed, dried, digested, and analyzed for TN and TP. For aquatic macrophytes, sampling was conducted in August to estimate the maximum reservoir size at the assumed height of plant biomass production. Samples were collected using a plant rake that was rotated 360 degrees near the bottom from the boat at 12 regular sampling locations throughout the lake. Samples were composited into three samples, well rinsed to remove sediment, and then dried, ground, digested, and analyzed for TN and TP.

The nutrient reservoir in the surface sediments is about 100 times greater for phosphorus (2,400 kg phosphorus) and 30 times greater for nitrogen (14,000 kg nitrogen) than the average in the water column (24 kg phosphorus and 481 kg nitrogen). The maximum size for the nutrient reservoir in the aquatic macrophytes is approximately seven times greater for phosphorus (163 kg phosphorus) and only slightly greater for nitrogen (484 kg nitrogen) than the average in the water column. Thus, sediments represent a significant store of nitrogen and phosphorus for adding to the water column, while aquatic macrophytes may be significant only for phosphorus. Senescence of aquatic plants in the fall may result in a significant increase in phosphorus.

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Section 5
Management Measures

Using the information gathered from the 2014–15 monitoring study, an initial screening list of potential watershed and in-lake management measures to improve water quality of the lake, was developed and is summarized in Table 5-1 and Appendix D.

Table 5-1. Potential Waughop Lake Management Measures: Initial Screening

Watershed	In-lake	
Stormwater treatment/removal	Hypolimnetic aeration or oxygenation	Whole lake treatment, phosphorus inactivation
Septic system improvement or sewering	Vigorous epilimnetic mixing	Sediment oxidation
Waterfowl management	Circulation and destratification	Settling oxidation
Public education	Dilution and flushing	Settling agents
	Drawdown	Selective nutrient addition
	Dredging	Nutrient input reduction
	Light-limiting dyes and surface covers	Enhanced grazing (fish, zooplankton)
	Mechanical removal (algae/plants)	Bottom-feeding fish removal
	Selective water withdrawal	Fungal/bacterial/viral pathogens
	Algaecides	Competition and allelopathy
	Pump and treat system	Floating wetlands

The project team performed an initial screening evaluation of these measures based on the lake monitoring results. The City solicited input on the preliminary list from City staff, local citizens, TPCHD, and PCD. The City project manager briefed the City Parks and Recreation Advisory Board in September 2016. Based on the screening evaluation, the following measures were identified as high priority for additional analysis:

- Dredging
- Hypolimnetic aeration
- Vigorous epilimnetic mixing
- Pump and treat
- Whole lake treatment, phosphorus inactivation

As discussed in detail in Sections 2 through 4, the study results indicate that internal loading of phosphorus from the sediments is the dominant source of phosphorus to the water column of Waughop Lake. Near-bottom anoxia contributes to dissimilatory iron reduction, releasing adsorbed phosphorus into pore water and then into lake bottom waters. New phosphorus additions are small in comparison to the internal loading. Moreover, Waughop Lake is shallow so advection can move

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nutrients from near-bottom to the photic zone, where phytoplankton can use it throughout the summer.

Table 5-2 below provides a brief summary of these management measures, including initial and ongoing planning-level cost estimates, water quality benefits, the timeline over which benefits could be expected to occur, and duration of how long the benefits are expected to last. Appendix D contains fact sheets for each of these measures. The text below provides a brief discussion of the measures.

Each management measure will require additional investigation to support design, cost estimation, and bidding. Additionally, BC recommends long-term monitoring to evaluate the effectiveness of the selected lake management measures, and to inform decisions for adjustments to operational practices.

Before implementing any of the measures, the City will need to comply with the State Environmental Policy Act (SEPA) and other applicable regulatory requirements.

5.1 Dredging

Various types of dredging techniques could be used to remove the most phosphorus-rich sediment from the lake bottom to decrease internal loading and improving water quality. Permanent removal of phosphorus-enriched sediment through dredging may provide the greatest and most long-lasting water quality benefits. Additionally, removal of fine-grained sediments may increase hydraulic connectivity with the surrounding aquifer where phosphorus levels are relatively low, thereby increasing flushing and reducing hydraulic residence time. Other potential benefits include increased lake depth and fish habitat. Potential impacts include habitat disturbance during the dredging activity, odor from the dredge spoils, and the need for large areas for sediment dewatering and disposal. Off-site disposal (if required) could lead to short-term traffic congestion.

To provide benefit to the lake, removal of the upper 100 cm of sediment would result in approximately 121,000 cubic yards of sediment dredging. Dredging and handling of large sediment quantities results in high capital costs, especially if off-site disposal is required. The estimated cost to remove approximately 121,000 cubic yards from the bottom of Waughop Lake ranges from $2.7M to $15M, depending on the dredging method, dewatering, and disposal requirements. However, once the dredging has been completed no ongoing costs would remain.

5.1.1 Dredging Methods

A variety of methods and equipment could be used to accomplish dredging of Waughop Lake. Dredging methods are typically categorized as either hydraulic or mechanical with each method utilizing different methods of removal, dewatering, and transport within the process.

Hydraulic dredging uses a floating barge or floating line system on a boom, with a relatively smaller barge footprint than a mechanical dredge (Figures 5-1 and 5-2). The hydraulic dredge consists of a boom or ladder with a cutterhead that rotates/excavates material and pumps the sediment - water slurry through a pipe to a dewatering area. The spoils can discharge to a barge or the discharge line can be floated to shore and discharge directly to a dewatering area.

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Figure 5-1. Hydraulic dredging

(MSA Professional Services)

Figure 5-2. S.A.M.E. auger dredging, Australia

The additional water pumped during hydraulic dredging requires additional management. Settling basins are typically used for larger dredge discharge volumes, but mechanical dewatering, or geotextile tubes or geotubes can be used in areas where dewatering and sediment placement options are limited to small footprints.

Wet excavation, or mechanical dredging, typically includes a crane and clam bucket or dragline bucket. A hydraulic excavator may also be used. Excavated material is placed in nearby spoils area and transferred by pump or other trucks. Dredging from shore using heavy equipment is typically limited to approximately 40 to 50 feet from the shoreline without prior dewatering of the lake. With an average diameter greater than 1,000 feet, dredging from the shore will not accomplish the dredging goals for Lake Waughop. Mechanical dredging requires different pieces of equipment at different steps, handling, moving or loading sediment multiple times.

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Figure 5-3. Mechanical dredging equipment

(Royal IHC)

Dry excavation requires dewatering of the lake and removing the bottom sediments using land-based excavation equipment. Dry excavation approach could be difficult to implement at Waughop Lake due to the proximity of the groundwater system. The existing data suggest that the lake bed sediments are fine-grained and high in organic matter, so they may not dewater under gravity (i.e., as a result of lake level dewatering) to a consistency that would support excavation equipment. Additionally, draining the lake would take considerable time and would require identification of a suitable water discharge location. Dewatering the lake would likely increase the duration of lake disturbance and could have adverse short-term impacts on aquatic habitat.

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5.1.2 Sediment Dewatering and Disposal

After the sediment has been removed from the lake using one of the methods outlined above, it will require dewatering and proper disposal. The water removed from the sediment will contain nutrients and other pollutants and may need to be treated prior to discharge.

Sediment dewatering and water management can be designed as passive or mechanical systems. Passive dewatering uses settling ponds to allow sediment to settle and drain over time. This method can be cost-effective when sediment volumes are small, but requires the greatest amount of land surface area for long-term operations. Geotubes also are considered passive dewatering systems. The tubes are typically custom made for the project using polypropylene fabrics. Polymer flocculating agents can also be used to speed the settling process within the geotubes. However, for large sediment quantities, such as the 121,000 cubic yards from Waughop Lake, geotube-based dewatering provides little benefit over other methods.

Mechanical systems can separate water from the slurry using physical, mechanical, and integrated systems. Typical physical/mechanical methods include: centrifuges, hydrocyclones, thermal drying, filter press (belt or plate), and proprietary methods using a combination of methods in one consolidated unit. These technologies typically require the least land area but are costlier than passive dewatering. Many dewatering systems include in-line dewatering equipment, with final systems tailored to the attributes of the dredged sediments. Additional physical and chemical data will be needed to better define the sediments characteristics prior to selecting the best suited excavation and dewatering technology.

If sediments disposal cannot be accommodated in the vicinity of Waughop Lake, transportation and disposal costs will drive up the costs for excavation alternatives. At a quantity of 121,000 cubic yards, the excavated volume outpaces the annual maximum quantity of sediments disposed of at any of the local facilities in the Puget Sound area, requiring transfer to one of the larger regional facilities, such as Columbia Ridge or Roosevelt, which straddle the central Washington-Oregon border.

5.1.3 Treatment

Any water returned to the lake from the dewatering process may require treatment. Treatment may range from basic settling and filtration to more advanced treatment systems including coagulation and precipitation, and advanced filtration, for removal of potential contaminants.

As stated above, the City or its agents would need to collect additional data prior to selecting the dredging option. See Appendix D for fact sheets containing additional information on the dredging option.

5.2 Lake Aeration and Mixing

The lake aeration and mixing option would inject air near the lake bottom to produce oxic conditions (i.e., decreased phosphorus release from sediment under anoxic conditions) and create vertical currents that disrupt cyanobacteria (see Figure 5-4). Note that Figure 5-4 shows an idealized cross-section for a deeper lake where a significant hypolimnion may develop. In contrast, Waughop Lake is shallow and while it stratifies, it does not have a significant, cooler hypolimnion. The initial planning-level costs are $1.9M for construction and $20k per year for operation and maintenance of the system. This option would decrease phosphorus release from sediment, disrupt blue-green algae and increase DO for fish. An electric motor-driven blower housed in a small building would produce compressed air for mixing. Plastic pipes placed along the lake bottom would distribute air to diffusers that are spaced about 10 times the water depth apart. O&M costs are based on an

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assumed 8-month per year operation. See Appendix D for a fact sheet containing additional information this option.

Bottom aeration adds air into the lake, increasing the concentration of oxygen by transferring it from gas to liquid and generating a controlled mixing force. Aeration is used to prevent hypolimnetic anoxia (i.e., low oxygen in the bottom layer), thereby decreasing the release of phosphorus from the bottom sediments. Aeration also retards the buildup of undecomposed organic matter and compounds (e.g. ammonium) near the bottom of the lake, and can increase the amount of water that is available to zooplankton and fish living in the lower, colder waters. Hypolimnetic aeration typically has low potential for adverse side effects (NALMS 2001).

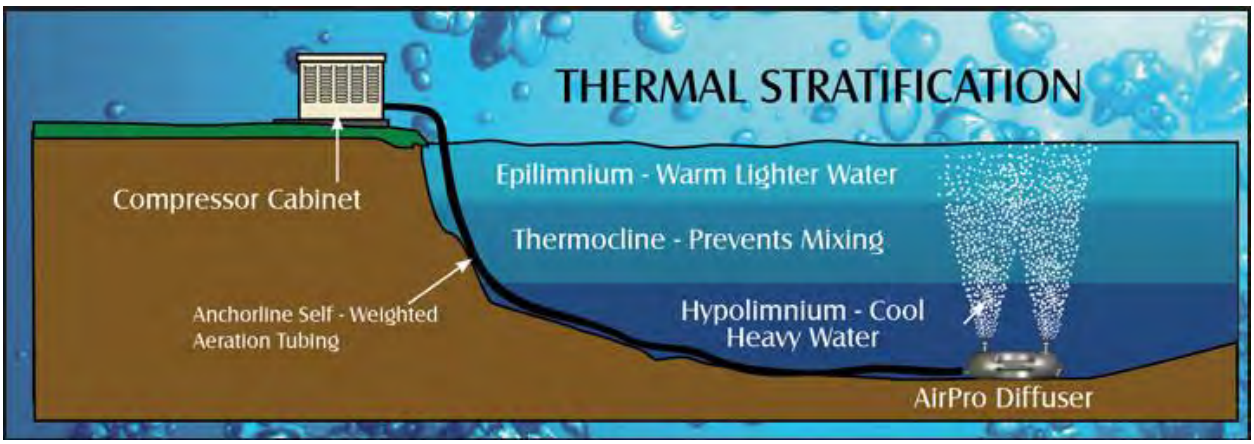

Figure 5-4. Example of lakebed aeration

(Aqua Control)

Vigorous Epilimnetic Mixing (VEM) is a form of aeration that creates vertical currents designed to reduce blue-green algae growth. VEM creates “tiny bubbles” that move lake water from the bottom depths to the surface. At the surface the water mixes with the atmosphere, fully oxygenating the water, which then cycles back to the bottom.

The hypolimnetic aeration has significant capital and operating costs, and requires adequate iron in the sediments to bind all the phosphorus. Aeration of bottom waters shows mixed results (Grochowska and Gawronska 2004; Engstron and Wright 2002; Ottolenghi et al. 2002). Some aeration methods increase the vertical mixing in the lake, exacerbating eutrophic conditions by more effectively transporting phosphorus to the photic zone while ineffectively aerating surface sediment pore water to prevent phosphorus release. Sediment resuspension during aeration also may be an issue in Waughop Lake because of the fine-grained, organic-rich nature of the sediments. Therefore, this treatment technique is considered to be less desirable than chemical treatment or dredging but in its VEM form may still have significant value for Waughop Lake owing to its capacity to discourage blue-green algae growth. The VEM will add significant oxygen at or near the lake’s bottom. Prior to implementing the lake aeration or VEM option, the City should collect additional data to understand better the complication factors of lake biology and chemistry.

5.3 Phosphorus Inactivation

Internal phosphorus loading in Waughop Lake may be controlled with alum, or similar coagulants, to inactivate phosphorus in the sediment. Applying alum to a lake is the most successful method used around the world to inactivate phosphorus in lake sediment, strip phosphorus from the water

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column, reduce internal loading, and mitigate algae problems. Whole-lake alum treatments have been used successfully throughout the United States since 1970 including numerous lakes in Washington (Burghdoff et al. 2012).

Alum is applied to the lake surface, usually from a boat or barge, with long arms to spread the alum into the lake from nozzles or trailing tubes. The treatment is typically done using computerized dosing control to apply the appropriate amount of alum for the water depth and volume at any point in the lake.

The aluminum in alum combines with phosphorus in the water column to form an aluminum phosphate precipitate, which settles to the bottom of the lake. Aluminum also reacts with particulate matter in the lake such as algae and suspended solids to form an aluminum hydroxide precipitate, which settles to the lake bottom. The aluminum hydroxide floc also captures pathogens and other pollutants in the lake water column. The floc resembles snowflakes. The aluminum in the precipitates binds the available phosphorus in the sediment to prevent the phosphorus from being released into the water column even under anoxic conditions (see Figure 5-5) (Burghdoff et al. 2012).

Figure 5-5. Alum treatment in Lake Stevens, Washington

(AquaTechnex)

Alum addition to a lake can rapidly lower pH levels of the water, making the lake more acidic, especially in lakes with soft water and low buffering capacity. For this reason, alum treatments are often buffered by adding another chemical, such as sodium aluminate, to balance the pH and prevent negative impacts to organisms living in the lake (Burghdoff et al. 2012). The successful whole-lake treatment on Green Lake included alum and sodium aluminate. Jar testing with the lake water and different coagulants and doses must be performed to determine the optimum mix of coagulants and doses.

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It is extremely important for an experienced and qualified firm to conduct the treatment. The North American Lake Management Society (NALMS) has determined that alum treatments are an effective and safe lake management tool (NALMS 2004).

As shown in Table 5-2 and in Appendix D, this management measure option assumes the addition of ~20,000 gallons of alum and ~10,000 gallons of sodium aluminate to remove phosphorus from the water column and form an alum floc layer on the sediment. These coagulant volumes are based on the amount of phosphorus in the lake and the top 10 cm of sediment. BC assumed that a lower dose may be needed subsequently, every 3 to 10 years. The initial planning-level cost estimates are $210k for preparation and initial treatment and $120k every 3 to 10 years. The water quality benefit would be high initially, with a slow decline over time. This option requires minimal infrastructure and does not conflict with other lake management options. However, it could increase macrophyte growth and the floc could negatively impact some filter feeder fish.

5.4 Pump and Treat

Two pump and treat management measures are considered viable alternatives for improving the lake: chemical treatment and treatment using constructed wetlands.

The chemical pump and treat system would pump water from the lake, add a coagulant to precipitate phosphorus (aluminum phosphate and aluminum hydroxide) in an offline settling basin, and return the treated water to the lake. Chemical treatment is capable of removing approximately 85 to 90 percent of the phosphorus and over 95 percent of pathogens.

The initial planning-level cost estimate is $1.5M for construction and $80k per year for operation and maintenance. This option is expected to provide only a medium level of water quality benefit and would require approximately 3 acres of land. The required infrastructure includes a wet settling pond, floc drying area, water intake and discharge pipes, water pump station, water flow meter, chemical feed system and storage tank, and a small equipment structure. This structure is typically a concrete block building with shingle or metal roof. The operation would be flexible and would have a higher treatment capacity than the constructed wetlands option. It would also be a good learning opportunity for Pierce College students to be involved in this type of treatment project. This option assumes that the system would be run at 2,500 gpm for approximately 6 months and assumes that the treatment facility could be sited within 1,000 feet of the lake. This option could be combined with a small constructed wetland treatment system. These cost estimates do not include the cost to purchase a dredge to pump floc from the settling pond to the dewatering basin.

The constructed wetland treatment system pump and treat option would pump water from the lake, treat it in an approximately 8-acre wetland treatment system, and discharge treated water to the lake. The initial planning-level cost estimate is $3.1M for construction and $100k per year for operation and maintenance. This option is expected to provide only a medium level of water quality benefit, and less than the chemical treatment option. When levee and access roads are considered, the constructed wetland treatment option would require approximately 9 acres of land. The required infrastructure includes intake and discharge pipes, a water pump station, and a constructed wetland. The operations would be flexible and would provide increased habitat for birds and other wildlife. It also could provide a good learning opportunity for students from PCC, UWT, and other nearby schools. The cost estimate for this option assumes that the wetland treatment system would be run at 1,000 gpm for approximately 6 months per year, and that the wetland system could be sited within 1,000 feet of the lake.

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5.5 Summary

Dredging is expected to have the greatest long-term benefit among the measures that passed the initial screening. Capital costs are high, but once dredging has been completed there would be no ongoing costs. Dredging could be performed using a variety of methods. The City may wish to specify the minimum performance standards in requests for bids so that contractors have the flexibility to develop creative and cost-effective approaches.

Alum treatment has been used to bind phosphorus in lake bottom sediment and to control nutrients and algae in lakes throughout the United States. This method has a relatively low initial treatment cost but would likely need to be repeated every 3 to 10 years.

Bottom aeration/VEM would have significant capital and operating expenses. Bottom aeration is a well-established method that has been used successfully on a number of lakes in the United States. VEM is a relatively new method that has worked well in several recent applications, especially for helping to control blue green algae. The system could be configured to include an alum emitter to provide additional treatment for phosphorus and pathogen.

The pump and treat systems would entail similar capital but higher operating costs than bottom aeration/VEM. Coagulant treatment can be very effective at removing phosphorus from the water column (e.g., 85 percent removal) with fecal bacteria removal as well. However, the water quality benefits for the lake could vary depending on the rate of phosphorus release from the lake bottom sediments.

All of the measures listed in Table 5-2 below would require additional investigation prior to design and implementation. For example, sediment core sampling and analysis would be needed to provide prospective bidders the information they would need to develop suitable approaches and cost estimates for dredging. These are summarized in the fact sheets in Appendix D.

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Table 5-2. Management Measures that Passed Initial Screening: Options for Control of Harmful Algae

Option	Planning-level cost estimates		20-year costs (capital+ ongoing)	Water quality benefit	How soon will water quality benefits occur?	How long will water quality benefits last?	Other potential benefits?	Other potential impacts/costs?
	Initial	Ongoing						
Lake aeration and mixing	$1.9M	$20k	2.3M	High. Reduce phosphorus release from sediment, disrupt blue greens, increase DO for fish. Cold be configured to include an alum emitter.	2 years	Long-term	Few conflicts with other uses. Increased DO should improve fish habitat.	Blower building would be required. Energy use. Addition of an alum emitter would increase capital costs by about $125,000.
Dredging: "wet" excavation, "dry" excavation, and hydraulic	Costs could vary based on dredging and disposal methods. Onsite disposal ranges from $2.7M–$12.0M. Offsite disposal ranges from $8.5M–$15.0M.	None	20-year costs will range from $2.7M-$15.0M, depending on disposal option	Highest. Would remove ~100 years of phosphorus enriched sediment.	<1 year	Long-term	Increased lake depth, more groundwater inflow, more fish habitat.	Habitat disturbance during dredging. Odor from dredge spoils. Onsite dewatering/ disposal would require large area. Equipment staging on shoreline.
Phosphorus inactivation	$210K for prep and initial treatment.	$120K every 3–10 years.	$0.7M (assumes follow-up treatment every 5 years)	High initially, slow decline over time.	Immediate	3–10 years	Minimal infrastructure, no conflicts with other lake uses.	Could increase macrophyte growth. Would need to be repeated every 3–10 yrs.
Pump and treat: chemical treatment	$1.5M	$80k/year	$3.1M	Medium	1 year	Long-term	Flexible operation. Higher treatment capacity than wetland treatment system. Learning opportunity for college students.	Would require ~3 acres of land. Temporary impacts during construction.
Pump and treat: constructed wetlands	$3.1M	$100k/year	$5.1M	Medium (less than chemical treatment)	1 year	Long-term	Flexible operation. Increased habitat for birds and other wildlife. Learning opportunity for college students.	Would require ~9 acres of land. Temporary impacts during construction.

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Section 6
Implementation

Section 5 identified various measures that could be implemented to improve water quality in Waughop Lake. As shown in Table 5-2, the measures vary considerably with regard to capital and ongoing costs and anticipated benefits. Dredging is expected to provide the greatest long-term benefit, but its capital costs could be considerably higher than the other options.

Some of the measures will require additional data collection before they can be implemented. For example, sediment cores would need to be collected and analyzed to help determine the appropriate dredging, dewatering, and disposal options. Each option would require a SEPA evaluation and acquisition of requisite permits before implementation.

Current City revenue sources such as the Parks and Recreation programs (General Fund) and the Stormwater Management Program (Utility Fund) are fully allocated and are not expected to provide appreciable funding for lake management activities. Therefore, implementation of this LMP will require new funding sources, and the availability of funding may determine which of the recommended measures can be implemented.

Some funding mechanisms may be more suited to initial startup actions, such as state grants or budget allocations. Other types of funding may be more advantageous for establishing more stable, long-term funding, such as those achieved through establishing a special benefit district. A successful lake management funding strategy may employ a number of different funding mechanisms for various purposes and at various times throughout the life of the lake management efforts.

A number of potential lake management funding mechanisms are discussed below.

6.1 Grants and Loans

Both federal and state grant programs are administered by Ecology. Grant and loan funding is limited, generally applies to specific types of projects/activities depending on the funding program, and the competition for funds can be significant. However, some of these funding sources could potentially be applied to Waughop Lake management efforts, including Centennial Clean Water grants, Section 319 Clean Water grants and Clean Water State Revolving Fund loans and non-traditional lake management funding sources, as discussed below. Additionally, there are Aquatic Invasive Plant Management grants and Freshwater Algae Control grants.

6.1.1 Centennial Clean Water Grants

The Centennial Clean Water program is a Washington State-funded grant program administered by Ecology. Local governments, special purpose districts, conservation districts, and federally recognized Tribes are eligible for these funds applicable to water quality infrastructure (e.g., wastewater treatment facilities) and non-point source pollution projects to improve and protect water quality. Non-point source pollution projects require a 25 percent match.

6.1.2 Section 319 Clean Water Grants

The federal EPA provides Section 319 grant funds to Washington State with the state required to provide a 40 percent match in funding. The Section 319 program provides grants to eligible non-

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point source pollution control projects similar to the state Centennial Clean Water program. Eligible projects include lake water quality planning and riparian and wetlands habitat restoration and enhancement as well other water quality improvement efforts. Non-profit organizations are also eligible for these funds. A 25 percent match is required and grants may be limited to $250k or $500k depending on the match type.

6.1.3 Clean Water State Revolving Fund Loans

The Clean Water State Revolving Fund (CWSRF) program is funded via an annual EPA capitalization grant, state matching funds, and principal and interest repayments on past CWSRF loans. This program provides low interest and forgivable principal loan funding for wastewater treatment construction projects, eligible non-point source pollution control projects, and eligible green projects. Local governments, special purpose districts, and Tribes can apply for these funds. No match is required and CWSRF loans can be used to match Centennial Clean Water and Section 319 grants. No more than 50 percent of the total available funds can go to any one applicant.

6.1.4 Non-traditional Lake Management Funding

There are also a number of giving foundations and charitable trusts operating within the state of Washington that are funded by one or more donors. Some of these foundations provide very significant grants for environmental works. Further research into these foundations as potential lake management funding sources may be worthwhile. It may be that partnering with non-profit organizations may enhance access to various grant funding opportunities.

6.2 Special Purpose Districts

Another option for the City to consider is the development of special purpose districts. Special purpose districts are generally created through the local legislative authority to meet a specific need of the local community. The needs may include new services or higher levels of existing services. Lake management efforts may be appropriate to the financing available through the creation of a special purpose district, such as a Lake Management District (LMD), Local Improvement District (LID) or Flood Control Zone District (FCZD).

Special-purpose districts can be political subdivisions of the state and come into existence, acquire legal rights and duties, and be dissolved in accordance with statutory procedures. Enabling legislation sets forth the purpose of the district, procedures for formation, powers, functions and duties, composition of the governing body, methods of finance, and other provisions. The districts may be quasi-municipal corporations, though some districts can be statutorily defined as municipal corporations. Although the general provisions for some special district statutes have been consolidated, such as for diking and drainage districts, there is no set of uniform provisions covering all special districts in Washington as there is with cities and counties.

As part of this project, BC provided support for stakeholder involvement by working with UWT to assess Lakewood residents' willingness to pay (WTP) for improvements in water quality in Waughop Lake. The survey team was led by Assistant Professor of Economics at UWT William McGuire.

Although 6,000 households were invited to participate in the survey, only 192 respondents (3.2 percent) completed the survey. Therefore, it is difficult to extrapolate the results of the survey to the wider Lakewood population. The UWT survey team believes it likely that these relatively few respondents self-selected into participating in the survey. As a result, the team concludes that this respondent group are likely already interested in the lake and are perhaps somewhat more willing to pay to improve it than would the average Lakewood resident. The question also arises as to whom should pay, because the lake is located in a park used by Lakewood residents and non-residents.

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Survey findings include an estimated mean WTP of about $46 per household per year. It found no significant differences in WTP by water quality level, or across sociodemographic groups. Because of the low survey response rate, the survey team noted that the $46 per household per year should be considered as a high-level cost estimate. The "true" WTP for the water quality improvements in the survey is likely less than that amount. Further survey information regarding survey methodology and results can be found in the *Measuring Lakewood Residents' Willingness to Pay for Improvements to Waughop Lake* (McGuire 2016).

6.2.1 Lake Management District

An LMD is a form of special-service district that funds lake management activities through charges on lake-area properties. An LMD can finance a range of activities, including:

- Controlling aquatic vegetation
- Improving water quality, including control of stormwater and agricultural runoff
- Performing water quality studies to pinpoint problems and identify solutions
- Maintaining ditches or streams associated with the lake
- Maintaining lake levels
- Maintaining beaches

An LMD is formed with property owners within the proposed district voting by mail, each granted one vote for each dollar they would be assessed under the proposed LMD. Both the City Council and affected property owners must approve that the district formation and revenues are collected by the County Treasurer as a specific item on the annual property tax statement. An LMD is established for a specific time frame, up to 10 years. Both private and publicly owned lakefront property and upland lots with access to community beach areas are commonly included. It may be possible to include the entire watershed in an LMD.

LMD assessments or charges can be based on any reasonable factors, including: benefit, use, front footage, acreage, improvements, and services to be provided. LMD charges may include differing benefit zones throughout the district. For example, upland lots with access to a community beach may be included at a lower rate than waterfront lots. Waterfront lots could be further designated into different zones, which reflect a reduced benefit where wetlands or other factors limit the shoreline use. Public and private recreational areas may be placed in a special class and assessed based on the benefit to users from the lake management program.

Income from LMD rates is used only for activities specified in the legislation establishing the LMD. Allowances may be included for low-income property owners. A separate elected commission is not necessary for an LMD—as there would be for a drainage district or water district—and the City Council may serve as the governing board. However, ongoing involvement by the lake property owners (in this case, Washington State) and users is crucial to a successful program. Forming a committee of lake users is the preferred way to achieve appropriate working relationships with City staff and elected officials in initiating and implementing an LMD program.

6.2.2 Local Improvement Districts

LIDs are a means of financing needed capital improvements through the formation of a special assessment district. Special assessment districts permit improvements to be financed and paid for over a period of time through assessments on the benefiting properties. A variation of the LID is the Utility Local Improvement District (ULID). The difference between ULIDs and LIDs is that utility revenues are pledged to the repayment of the ULID debt, in addition to the assessments on the benefiting properties. State statutes provide that an LID can be converted to a ULID after formation. The reverse is not possible.

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The LID financing mechanism is a process to finance infrastructure improvements and does not provide a mechanism to constructing those improvements. Construction projects must be managed by the City. LID project financing is based on the sale of bonds to investors and the retirement of those bonds via annual assessments on the property owners within a district. The assessment per parcel must not exceed the special benefit of the improvement to that parcel.

6.2.3 Flood Control Zone District

An FCZD can be used to fund actions addressing a broad range of watershed issues from flood control and water quality improvement to watershed management. The FCZD may include, but not be limited to, the extension, enlargement, construction, or acquisition of dikes and levees, drain and drainage systems, dams and reservoirs, or other flood control or storm water control improvements; widening, straightening, or relocating of stream or water courses; and the acquisition, extension, enlargement, or construction of any works necessary for the protection of stream and water courses, channels, harbors, life, and property.

An FCZD is governed by a board, which can be the local legislative authority. The board may initiate the creation of a zone or additional zones within the FCZD for the purpose of undertaking, operating, or maintaining flood control projects or stormwater control projects or groups of projects that are of special benefit to specified areas of the district. Formation of a zone may also be initiated by a petition signed by 25 percent of the electors within a proposed zone based on the vote cast in the last county general election.

In King County, a county-wide FCZD has been created for the purpose of undertaking, operating, and maintaining flood control projects or various stormwater control projects, among other powers. That district also contributes to efforts in local jurisdictions.

6.3 Future Considerations for Lake Management Financing

Implementation of the Waughop Lake management actions could require funding from multiple sources. For example, for some levels of grant funding, it may be necessary to procure capital investments prior to receiving grant funds. Short-term startup costs may need to be borne by a combination of utility revenues and grants, while long-term operations and maintenance may be appropriate to special benefit district funding or perhaps some level of funding within the City budget. There are a number of potential funding sources that warrant further investigation. Additionally, Waughop Lake ownership may affect some potential lake management funding opportunities. Legal review of potential funding mechanisms could include assessment of the need for interlocal agreements, memoranda of understanding, lease agreements, easements, etc. as may be necessary to establish specific lake management funding mechanisms.

The City and Washington State are discussing the potential transfer of the lake property to the City. Given the past agricultural use of Waughop Lake while under state ownership, perhaps the transfer agreement could include state funding for lake improvement measures.

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Section 7
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Appendix A: Field Sheets

This appendix contains copies of the field sheets from the 2014–15 monitoring study.

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Waughop Lake sampling log

Position	UTM
easting:	0533145
northing:	5224069

Date: 10 / 29 / 14
Time: 12 : 00 AM/PM

Secchi	Depth (ft)
Down:	4 ' 0 "
Up:	3 ' 10 "
Mean	3 . 11 '
Staff gauge:	5 . 25 '
Time:	13 : 00

Waterfowl count:
ducks: 139 (w/o BINOCULARS)
geese: —
gulls: —
Other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	13.21	50.5	6.92	24.64	9.80
1	13.12	50.2	7.06	28.27	9.68
1.5	13.01	50.3	7.11	30.65	9.56
2	12.91	50.3	7.08	13.56	9.05
2.5	12.82	50.3	7.03	22.92	8.61

Water samples

	Depth on tape (ft)	Check box after collection		Replicate (circle one)
Alkallinity	1, 6	✓	✓	
Chlorophyll	1, 6	✓	✓	
Nutrients (UF)	1, 6	✓	✓	upper/lower
Phytoplankton	5	✓	✓	
Zooplankton	5	✓	✓	

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 11/1/14
Time: 1:30 AM/PM

Secchi Depth (ft)
Down: ___'___"
Up: ___'___"
Mean ___.___'
Staff gauge: 5.38'
Time: 1:30 AM/PM

Waterfowl count:
ducks: 103
geese: ___
gulls: 9
Other: CORMORANT (2)

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5					
1					
1.5					
2					
2.5					

Water samples

	Depth on tape (ft)	Check box after collection		
Alkallinity	1, 6			Replicate (circle one)
Chlorophyll	1, 6			
Nutrients (UF)	1, 6			upper/lower
Phytoplankton	5			
Zooplankton	5			

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 11/19/14
Time: 12:00 AM/PM

Secchi Depth (ft)
Down: 4'4"
Up: 4'3"
Mean 4.35'
Staff gauge: 5.42'
Time: 11:30 AM/PM

Waterfowl count:
ducks: 961
geese: 157
gulls:
Other: CORMORANT (2)

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	4.89	54.0	6.65	31.84	13.07
1	4.78	54.0	6.75	33.24	13.06
1.5	4.62	54.0	6.79	29.52	12.73
2	4.63	54.0	6.79	27.87	12.66
2.5	4.56	53.9	6.80	30.95	12.60

Water samples

	Depth on tape (ft)	Check box after collection	
Alkallinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one)
upper/lower

Groundwater wells

Well	Head (ft @ top of well)	Time	Sample
GW1			
GW2			
GW3			
GW4			
GW5			

Comments: SWAPPED PRESSURE GAUGE @ 12:57

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 11/26/14
Time: ___:___AM/PM

Secchi Depth (ft)
Down: ___'___"
Up: ___'___"
Mean ___.___'
Staff gauge: 5.72'
Time: 1:30 AM/PM

Waterfowl count:
ducks: 643
geese: ___
gulls: ___
Other: CORMORANT (4)

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5					
1					
1.5					
2					
2.5					

Water samples

	Depth on tape (ft)	Check box after collection		
Alkallinity	1, 6			Replicate (circle one)
Chlorophyll	1, 6			
Nutrients (UF)	1, 6			upper/lower
Phytoplankton	5			
Zooplankton	5			

Groundwater wells

Well	Head (ft @ top of well)	Time	Sample
GW1	8.78	9:19	
GW2	5.39	10:16	
GW3	5.47	10:10	
GW4	13.32	10:06	
GW5	13.76	9:54	

Comments: GW1 MEASUREMENT BEFORE BAILING

Waughop Lake sampling log

Position	UTM
easting:	0533145
northing:	5224069

Date: 12/15/14
Time: 11:20 AM/PM

Secchi	Depth (ft)
Down:	4'6"
Up:	4'6"
Mean	4.6'
Staff gauge:	6.09'
Time:	11:00 AM/PM

Waterfowl count:
ducks: 1244
geese: —
gulls: —
other: CORMORANT - 2

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	6.89	52.3	6.64	13.86	10.71
1	6.78	52.3	6.51	18.48	10.50
1.5	6.70	52.3	5.78	11.60	10.42
2	6.74	52.2	6.02	18.22	10.39
2.5	6.44	52.5	6.10	9.51	10.06

Hobo retrieved: 11:08 AM/PM Hobo deployed: 11:09 AM/PM

* DEPTHS REVERSED FOR ALL PARAMETER

Water samples

	Depth on tape (ft)	Check box after collection	
Alkallinity	1, 6	X	X
Chlorophyll	1, 6	X	X
Nutrients (UF)	1, 6	X	X
Phytoplankton	5	X	X
Zooplankton	5	X	X

Replicate (circle one): upper/lower

Groundwater wells

ADD SCREEN DEPTH

Well	Level from top of well (ft)	Time	Sample
GW1			
GW2	5.00	1:16	
GW3	Dry	1:05	
GW4			
GW5			

< 1:22 PM PUMPING OFF
< WATER OVER TOP

Comments: Piezometer 1 ~~Gage~~ by pierce: 4ft water to sediment; 6-7 feet in sediment 30 yds from storm water drain

Piezometer 2: Approx. where vocal lake out, 6ft of sediment

* ADD TO INVENTORY PLASTIC GRAD. CYLINDER
1 L

~~1:22~~	TEMP	SPC	pH	LDO	PUMPING @ ~ 0.5L/MIN (PUMP SET @ 2)
1:28	12.68	278.1	~~6.07~~	~~2.4~~	
1:32	12.63	276.1	5.96	1.51	
			5.84	1.38	
1:36	12.31	272.6	5.96	1.45	VISIBLY CLEARER
1:44	12.26	272.5	5.98	1.65	

1:54 TOW 5.01 Ft.

(back of field sheet 12/15/14)

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 12/18/14
Time: 9:30 AM/PM

Secchi Depth (ft)
Down: ____'____"
Up: ____'____"
Mean ____.____'
Staff gauge: ____.____'
Time: ___:___ AM/PM

Waterfowl count:
ducks: 1285
geese: _____
gulls: _____
other: _____

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5					
1					
1.5					
2					
2.5					

Hobo retrieved: ___:___ AM/PM Hobo deployed: ___:___ AM/PM

Water samples

	Depth on tape (ft)	Check box after collection		Replicate (circle one)
Alkallinity	1, 6			
Chlorophyll	1, 6			
Nutrients (UF)	1, 6			upper/lower
Phytoplankton	5			
Zooplankton	5			

Groundwater wells

Well	Level from top of well (ft)	Time	Sample
GW1	7.22	10:00	✓
GW2	measured 12/15/14		
GW3	5.61	9:16 am	✓
GW4	11.26	11:48 am	✓
GW5	16.02	10:47 am	✓

added by JG from field notebook JG

Comments: _____

WALKHOB 12-18-14

DUCKS-1285

GW3

9:16 5.61' 950 5.62'

STARTED PUMPING @ .3 L/MIN @ 9:25

	TEMP	SPC	pH	LDO
930	15.73	199.8	3.72	2.00
935	14.60	117.8	5.36	1.57
938	14.38	116.9	5.62	0.92
942	14.26	116.2	5.82	2.48
945	14.15	116.4	5.89	1.15

H_2S SMELL NOTED DURING SAMPLING

GW 1

10:10 7.27' Started pump @ 10:12 10:35 8.30'

	Temp	Spc	pH	LDO
10:17	11.40	117.5	5.71	6.82
10:21	11.34	117.7	6.16	6.20
10:24	11.31	113.8	6.21	5.93
10:27	11.29	103.9	6.23	5.92
10:30	11.23	97.6	6.23	5.99

GW 5

10:47 16.02' 11:27 16.01'

STARTED PUMP @ 10:53

	TEMP	SPC	pH	LDO
11:02	10.41	38.1	7.16	8.79
11:06	10.52	35.2	7.52	8.04
11:09	10.98	33.5	7.11	7.95
11:12	11.09	32.6	7.67	7.91
11:16	11.20	31.6	7.56	7.76
11:20	11.28	30.8	7.66	7.73
11:22	11.30	30.5	7.56	7.69

Water in manhole started running @ 11:12

GW 4

11.26' → 11.31' 11:48 pumping @ 15 Qi

	Temp	SPC	pH	LDO
11:56	10.86	84.9	7.20	5.53
12:00	11.46	87.0	7.52	3.98
12:03	11.78	90.3	7.52	3.74
12:07	12.30	92.9	7.22	3.64
12:11	12.17	96.4	7.23	3.61

Rite in the Rain

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 1/22/15
Time: 10:30 AM/PM

Secchi Depth (ft)
Down: 3'7"
Up: 3'7"
Mean 3.7'
Staff gauge: ___.___' OVER MAX OF 6.65
Time: 11:47 AM/PM

Waterfowl count:
ducks: 453
geese: 1
gulls: 0
other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	6.82	56.4	5.33	48.44	13.50
1	6.53	56.3	5.62	45.36	13.24
1.5	6.50	57.0	5.71	28.56	11.98
2	6.42	57.0	5.71	27.42	11.56
2.5	6.38	57.0	5.70	26.35	11.42

Hobo retrieved: 10:35 AM/PM Hobo deployed: 10:46 AM/PM

Water samples

	Depth on tape (ft)	Check box after collection		
Alkallinity	1, 6	✓	✓	Replicate (circle one)
Chlorophyll	1, 6	✓	✓	
Nutrients (UF)	1, 6	✓	✓	upper/lower
Phytoplankton	5	✓		
Zooplankton	5	✓		

Groundwater wells

Well	Level from top of well (ft)	Time	Sample	
GW1	6.46	12:19		
GW2	4.46	12:14		
GW3	4.48	12:01		* WATER OVER TOP
GW4	9.82	12:31		
GW5	14.52	12:24		* WATER OVER TOP

Comments: PIEZOMETER (ADD 0.5" TO LEVEL TO MATCH SURVEY)

	INSIDE		OUTSIDE
* INNER DIAM 0.7" 1	1.58	11:30	1.60'
2	2.03'	11:45	1.98'

(ADD 0.55" TO LEVEL ")

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 2/19/15
Time: 9:55 AM/PM

Secchi Depth (ft)
Down: 2.8'
Up: 2.8'
Mean 2.8'
Staff gauge: .5' (ABOVE TOP OF GAUGE)
Time: 1:20 AM/PM

Waterfowl count:
ducks: 571
geese: 1
gulls: 0
other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	9.89	53.4	6.44	54.8	11.55
1	9.71	53.3	6.59	44.85	11.18
1.5	9.64	53.3	6.63	46.04	10.93
2	9.62	53.2	6.66	43.51	10.81
2.5	9.61	53.2	6.68	35.48	10.63

Hobo retrieved: 10:20 AM/PM
3.0 9.60 53.3 6.70 31.88 10.48

Hobo deployed: 11:41 AM/PM SAME HOBO

Water samples

	Depth on tape (ft)	Check box after collection	
Alkallinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one)
upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample	
GW1	5.91		1:03	✓	WATER VERY CLEAR
GW2	4.18		12:30	✓	FOAM IN WATER
GW3	4.75		11:44	✓	WATER OVER TOP
GW4	9.60		2:10	✓	
GW5	14.10		1:34	✓	WATER VERY CLEAR
Piezometer	Inside (ft)	Outside (ft)	Time	Sample	
1	1.17	1.23	11:11		
2	1.64	1.60	11:18		

Comments:

2/19

GW3 4.75' @ 1144

STARTED PUMP 1155 (PUMP AT SETTING #2)

	TEMP	SPC	pH	DO
1156	11.69	70.0	5.93	4.11
1200	11.44	75.3	5.98	1.69
1203	11.19	76.5	5.72	1.10
1206	11.05	77.1	5.87	0.91
1208	10.97	77.7	5.81	0.90
1211	10.92	77.5	5.88	0.85

GW2 4.18' @ 1230

STARTED PUMP @ 1233

1235	10.96	357.1	6.34	6.90
1238	10.99	351.3	6.47	5.01
1241	10.99	337.5	6.48	4.10
1244	11.00	361.1	6.49	2.49
1248	10.92	383.0	6.48	1.94
1251	10.88	391.7	6.58	2.07

GW1 5.91 @ 103

STARTED PUMP @ 105

108	11.40	120.8	6.70	8.16
111	11.33	97.3	6.50	7.06
114	11.09	83.8	6.23	6.50
117	10.92	79.6	6.26	6.14
120	10.76	79.4	6.19	5.96
123	10.85	78.5	6.24	5.81

GW5 STARTED PUMP @ 142 14.10' @ 134

	TEMP	SPC	pH	DO
145	11.94	44.1	6.36	9.77
148	11.80	38.5	6.20	9.86
151	11.60	32.8	6.18	10.60
154	11.51	32.3	6.18	10.25
157	11.53	32.4	6.19	10.10
200	11.46	31.8	6.14	11.22

GW4 STARTED PUMP @ 216 9.00' @ 210

217	11.92	182.7	5.55	7.07
220	11.78	198.3	5.52	6.09
223	11.83	204.8	5.45	5.79
226	11.85	209.4	5.45	5.66
229	11.86	213.0	5.44	5.80
232	11.85	211.1	5.39	6.08
235	11.81	211.5	5.40	6.09

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 3/12/15
Time: 9 : 57 AM/PM

Secchi Depth (ft)
Down: 3 ' 10 "
Up: 3 ' 8 "
Mean 3.9 '
Staff gauge: ___.___ ' 14.0 cm ABOVE
Time: 11 : 21 AM/PM

Waterfowl count:
ducks: 669
geese: 1
gulls: –
other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	11.50	54.4	6.23	16.44	11.62
1	11.39	54.3	6.45	21.55	11.54
1.5	11.16	54.2	6.58	21.53	11.08
2	10.78	54.9	6.53	13.71	8.73
2.5	10.08	57.1	6.44	13.32	6.36

Hobo retrieved: 10 : 20 AM/PM
3.0 9.49 57.7

Hobo deployed: 10 : 25 AM/PM
6.35 12.81 4.25

Water samples

	Depth on tape (ft)	Check box after collection		Replicate (circle one)
Alkallinity	1, 6	✓	✓	
Chlorophyll	1, 6	✓	✓	
Nutrients (UF)	1, 6	✓	✓	upper/lower
Phytoplankton	5	✓	✓	
Zooplankton	5	✓	✓	

Groundwater wells

Well	Level from top of well (ft)	Time	Sample
GW1	6.36	11:48	
GW2	4.30	11:42	
GW3	4.81	11:35 am	
GW4	~~[illegible]~~ 9.21	12:03	
GW5	15.02	1155	

Comments: WIND GENERATED WAVES MADE STAFF GAUGE MEASUREMENT DIFFICULT

	INSIDE	OUTSIDE	TIME
PIEZ1	1.16"	1.22"	1108
PIEZ2	1.66"	1.59"	1117

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 4 / 20 / 15
Time: 10 : 37 AM/PM

Secchi Depth (ft)
Down: 5 ' 8 "
Up: 5 ' 7 "
Mean ___.___'
Staff gauge: ___.___' 6" from top
Time: 12 : 09 AM/PM

Waterfowl count: 26
ducks: ___
geese: Na
gulls: Na
other: Na

Top of staff gauge 6.66 ft

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor ~~(mg/L)~~ µg/L?	DO (mg/L)
0.5	16.17	45.3	8.97	12.87	14.87
1	16.01	45.0	9.21	14.07	15.02
1.5	15.84	44.9	9.24	13.36	15.03
2	15.72	44.7	9.23	19.27	14.89
2.5	14.62	44.7	9.14	29.18	13.94

Hobo retrieved: 10:45 AM/PM
3.0 13.82 47.1 8.33 33.05 9.31

Hobo deployed: 10:59 AM/PM

Water samples

	Depth on tape (ft)	Check box after collection		Replicate (circle one)
Alkallinity	1, 6	✓	✓	
Chlorophyll	1, 6	✓	✓	
Nutrients (UF)	1, 6	✓	✓	upper/lower
Phytoplankton	5	✓	✓	
Zooplankton	5	✓	✓	

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1				
GW2				
GW3				
GW4				
GW5				
Piezometer	Inside (ft)	Outside (ft)	Time	Sample
1	1.13	1.20	11:53 am	
2	1.65	1.57	12:01 pm	

Comments: ___

Waughop Lake sampling log

Position	UTM
easting:	0533145
northing:	5224069

Date: 4/28/15
Time: ___:___AM/PM

Secchi	Depth (ft)
Down:	____'____"
Up:	____'____"
Mean	____.____'
Staff gauge:	____.____'
Time:	___:___ AM/PM

Waterfowl count:
ducks: _____
geese: _____
gulls: _____
other: _____
_____

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5					
1					
1.5					
2					
2.5					

Hobo retrieved: ___:___ AM/PM Hobo deployed: ___:___ AM/PM

Water samples

	Depth on tape (ft)	Check box after collection	
Alkallinity	1, 6		
Chlorophyll	1, 6		
Nutrients (UF)	1, 6		
Phytoplankton	5		
Zooplankton	5		

Replicate (circle one)
upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	6.60		1608	
GW2	4.39		1600	
GW3	4.94		1545	
GW4	9.37		1625	
GW5	15.64		1616	
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1				
2				

ELEVATION CORRECTIONS
SURVEY TO WELL (cm)
11.4
11.8
16.0
14.0
15.4

Comments: _____
_____

4/28/15

WELLS (Ft.)		TIME	CORRECTION (MM) LIP TO BOLT	LIP TO WELL *
GW1	6.60	1608	15	94
GW2	4.39	1600	15	98
GW3	4.94	1545	15	140
GW4	9.37	1625	15	120
GW5	15.64	1616	15	134

* ALSO SUBTRACT 5 MM FOR WIDTH OF RULER

TOTAL CORRECTION (MM)

GW1	74
GW2	78
GW3	120
GW4	100
GW5	114

L = LIP TO WELL - LIP TO BOLT - 5 MM
= CASE TO WELL

CORRECTION (Ft)

GW1	0.243
GW2	0.256
GW3	0.394
GW4	0.328
GW5	0.374

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 5/13/15
Time: 9:40 AM/PM

Secchi Depth (ft)
Down: 3'1"
Up: 3'1"
Mean 3.1'
Staff gauge: ___.___' 2.3" ABOVE MAX
Time: 10:10 AM/PM

Waterfowl count:
ducks: 16
geese: 1
gulls: ___
other: ___

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	17.31	57.1	6.85	10.10	10.98
1	17.32	56.8	7.07	11.18	11.03
1.5	17.29	57.0	7.28	8.96	11.03
2	17.29	56.7	7.43	10.94	11.07
2.5	17.25	57.0	7.38	10.68	7.51

Hobo retrieved: 9:57 AM/PM
3.0 15.90 57.7 6.72 39.18 0.01

Hobo deployed: 10:26 AM/PM

Water samples

	Depth on tape (ft)	Check box after collection	
Alkallinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	11:10 ✓	11:16 ✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one) upper/lower

- Used sample pole instead of rope

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	7.00		1027	
GW2	4.66		1023	
GW3	5.22		1016	
GW4	9.71		1104	
GW5	16.25		1033	
Piezometer	Inside (ft)	Outside (ft)	Time	Sample
1	1.50	1.51	10:01	
2	1.95	1.88	10:08	

Comments: ___

Waughop Lake sampling log

Position	UTM
easting:	0533145
northing:	5224069

Date: 5/27/15
Time: 10:00 AM/PM

Secchi	Depth (ft)
Down:	2' 4"
Up:	2' 6"
Mean	2.5'
Staff gauge:	6.60'
Time:	11:30 AM/PM

Waterfowl count:
ducks: 22
geese: 8
gulls:
other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (mg/L)	DO (mg/L)
0.5	19.46	56.9	6.54	3.29	10.66
1	19.03	56.7	7.35	4.52	10.66
1.5	18.23	56.9	7.21	9.28	9.0
2	17.82	57.5	6.88	7.51	5.20
2.5	~~17.~~ 16.97	56.4	6.51	30.88	0.36

Hobo retrieved: 10:14 AM/PM
3.0 16.01 79.4

Hobo deployed: 10:16 AM/PM
6.32 13.14 0.00

Water samples

10ft max

	Depth on tape (ft)	Check box after collection		
Alkallinity	1, ~~6~~ 7	✓	✓	Replicate (circle one)
Chlorophyll	1, ~~6~~ 7	✓	✓	
Nutrients (UF)	1, ~~6~~ 7	✓	✓	upper/lower
Phytoplankton	5	✓	✓	→ 153 µm NET
Zooplankton	5	✓	✓	

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	7.42		1300	✓
GW2	4.97		12:28	✓
GW3	5.51		1149	✓
GW4	10.07		14:45	
GW5	16.74		1:35	✓
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1	1.67	1.76	1122	—
2	2.21	2.13	1129	—

Comments: WATER VERY GREEN. RED/BROWN SCUM ALONG SHORELINE.

Waughop 5/27/15

Well 3 (GW3)	5.51'		0.28 L/min		
Time	Temp (°C)	Cond (µS)	pH ~~LDO~~	LDO	
11:51	—	—	—	—	Well diameter .175 ft
11:54	20.06	336.2	2.95	8.85	Depth water 10 ft
11:57	19.72	532.8	3.17	4.84	Vol. = $r^2 \pi h$
12.00	17.12	101.6	5.78	4.10	= 0.24 ft³
12.03	16.59	100.9	5.97	2.82	= 6098.92 cm³
12.06	16.50	101.2	5.92	2.37	2 gn parastaltic pump
12:10	16.36	101.2	6.02	1.43	
12:13	16.35	1025	5.91	1.33	
	GW-2	4.97'			
~~Time~~	Temp (°C)	Cond	pH	LDO	
12.29					0.33 L/min
12.32	17.14	102.8	6.01	3.07	pp @ 3
12.35	15.56	407.8	6.25	1.52	
12:38	13.97	404.2	6.24	1.13	
12.41	13.53	402.4	6.20	0.88	
12.44	13.57	402.3	6.19	0.85	
12.47	13.70	399.0	6.22	0.63	
	GW1	7.42'			
Time	Temp	Cond	pH	DO	
1303	—	—	—	—	
1307	18.26	257.1	6.21	3.67	
1310	17.97	235.0	6.08	4.67	
1313	17.33	131.1	5.95	5.10	
1316	17.51	120.4	5.90	5.06	
1319	17.70	108.8	5.95	5.00	
1323	17.68	100.9	5.85	4.60	
	GW5 - 16.74				
~~1338~~					1306
TIME	TEMP	SPC	pH	DO	MULTIPLE ATTEMPTS TO MAINTAIN SUCTION
~~1338~~					
1354	25.57	75.2	6.10	6.80	
~~1411~~					
1421	18.80	34.3	6.11	8.73	
1425	17.47	34.1	6.05	9.25	
1429	18.23	33.9	6.05	9.11	
1432	17.42	33.1	6.03	9.07	
1435	16.92	33.7	6.03	9.07	

GW-4 10.07'

Time	Temp (°C)	SpC	pH	DO
2:46				
2:49	22.85	64.3	5.85	7.83
2:52	16.63	140.6	5.45	4.62
2:55	16.02	150.8	5.36	4.65
2:58	15.73	154.3	5.40	4.53
3:01	15.47	155.0	5.40	4.34
3:04	15.28	153.7	5.39	4.47
3:05	15.13	155.7	5.42	4.43

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 6/9/15
Time: 11:00 AM/PM

Secchi Depth (ft)
Down: 4'6"
Up: 4'3"
Mean ___.___'
Staff gauge: 6.38'
Time: 12:00 AM/PM

Waterfowl count:
ducks: 12
geese: 16
gulls: 0
other: 0

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	24.86	56.9	7.26	1.79	9.32
1	24.20	56.8	7.24	1.88	9.00
1.5	20.71	56.2	7.28	3.08	9.54
2	19.08	57.9	7.01	5.38	3.42
2.5	17.52	58.1	6.60	4.62	0.62

Hobo retrieved: 11:05 AM/PM
3.0 15.95 114.8

Hobo deployed: 11:00 AM/PM
6.33 11.21 0.04

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1, 6, 7	✓	✓
Chlorophyll	1, 6, 7	✓	✓
Nutrients (UF)	1, 6, 7	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one)
upper/lower

USED OWN BOTTLE

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	7.95		1223	
GW2	5.31		1217	
GW3	5.87		1212	
GW4	10.49		1235	
GW5	17.20		1228	
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1	1.96	2.04	1152	
2	2.50	2.42	1158	

Comments:

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 6 / 23 / 15
Time: 9 : 30 AM/PM

Secchi Depth (ft)
Down: 6 ' 6 "
Up: 6 ' 6 "
Mean 6 . 6 '
Staff gauge: 5 . 94 '
Time: 10:40 AM/PM

Waterfowl count:
ducks: ~~24~~ 28
geese: 11 23
gulls: – –
other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	23.22	57.7	6.26	5.66	8.35
1	23.18	57.7	6.60	6.52	8.38
1.5	23.06	57.4	6.75	7.32	8.29
2	22.96	57.3	6.79	8.20	8.20
2.5	21.76	62.8	6.58	13.45	3.53

Hobo retrieved: 9 : 41 AM/PM
3.0 18.70 105.5
2.8 20.13 79.4

Hobo deployed: 9 : 49 AM/PM
6.35 7.06 0.26
6.41 1.06
37.44

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	✓✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one) upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1				
GW2				
GW3				
GW4				
GW5				
Piezometer	Inside (ft)	Outside (ft)	Time	Sample
1	2.33	2.42	1030	
2	~~2.42~~ 2.92	2.80	1039	

Comments:

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 7 / 6 / 15
Time: 1 : 10 AM/PM

Secchi Depth (ft)
Down: 4 ' 7 "
Up: 4 ' 9 "
Mean 4 . 8 '
Staff gauge: 5 . 90 '
Time: 2 : 21 AM/PM

Waterfowl count:
ducks: 84
geese: 27
gulls:
other: 11 on shore

Hydrolab

Depth of lake 10.7 ft

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	27.29	55.5	8.54	2.44	9.93
1	27.26	55.5	8.73	2.67	10.22
1.5	26.86	54.9	8.78	3.50	10.21
2	26.14	57.1	8.49	10.51	10.37
2.5	24.08	69.3	7.75	64.91	10.09

Hobo retrieved: ___:___ AM/PM

Hobo deployed: ___:___ AM/PM

3m	22.08	91.7	6.70	0.10	0.46
2.8m	22.46	78.2	6.54	6.41	3.60

Water samples

	Depth on tape (ft)	Check box after collection		
Alkalinity	1, 6 8	✓	✓	Replicate (circle one)
Chlorophyll	1, 6 8	✓	✓	
Nutrients (UF)	1, 6 8	Upper 1:35	Both 1:46	upper/lower
Phytoplankton	5	✓	✓	
Zooplankton	5	✓	✓	

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1				
GW2				
GW3				
GW4				
GW5				
Piezometer	Inside (ft)	Outside (ft)	Time	Sample
1	2.68	2.76	2:11 pm	
2	3.29	3.13	2:16 pm	

Comments:

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 7/20/15
Time: 10:30 AM/PM
WINDY

Secchi Depth (ft)
Down: 3 '9 "
Up: 3 '10 "
Mean 3.10 '
Staff gauge: 5.21 '
Time: 11:37 AM/PM

Waterfowl count:
ducks: 92
geese: –
gulls: –
other:

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	24.92	50.8	9.08	3.10	13.15
1	24.94	50.5	9.01	3.32	13.25
1.5	24.92	50.2	8.70	3.66	12.94
2	23.89	42.9	7.01	11.56	4.77
2.5	23.38	60.8	6.21	30.24	0.66

Hobo retrieved: 10:32 AM/PM Hobo deployed: 11:22 AM/PM

3.0 22.30 73.7 5.83 0.03 0.00

Water samples

	Depth on tape (ft)	Check box after collection		Replicate (circle one)
Alkalinity	1, 6	✓	✓	upper/lower
Chlorophyll	1, 6	✓	✓	
Nutrients (UF)	1, 6	✓	✓	
Phytoplankton	5 wrong on bottle	✓	✓	
Zooplankton	5	✓	✓	

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	9.90		2:37	
GW2	6.95		220	
GW3	7.40		1:02	
GW4	12.10		1:50	
GW5	18.50 – copy click this		1:18	
Piezometer	Inside (ft)	Outside (ft)	Time	Sample
1	3.06	3.14	1127	
2	3.69	3.51	1135	

-2 2:39
-2 2:22
-2 2:06
-2 1.52
-1:36; 1½/1.38 18.5

Comments: VERY WINDY

2.7 22.92 48.4 5.87 45.77 0.06

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 8/5/15
Time: 9 : 20 AM/PM

Secchi Depth (ft)
Down: 2' 6"
Up: 2' 7"
Mean ___.___'
Staff gauge: 4.81'
Time: 10 : 48 AM/PM

Waterfowl count:
ducks: 64
geese: –
gulls: –
other: –

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	23.29	51.9	8.81	13.32	9.36
1	23.38	52.2	8.94	13.74	9.32
1.5	23.33	50.6	8.80	13.29	8.71
2	22.65	48.6	7.32	7.05	2.85
2.5	21.59	62.9	6.59	16.84	0.05

Hobo retrieved: 9 : 40 AM/PM

Hobo deployed: 9 : 47 AM/PM

2.7 21.50 67.3 6.28 46.18 / 0.02

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1, ~~6~~ 7	✓	✓
Chlorophyll	1, ~~6~~ 7	✓	✓
Nutrients (UF)	1, ~~6~~ 7	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one) upper/lower

ALSO BOTTOM TEST 1 & 2
↳ PREFILTERED IN FIELD w/ 0.45µm

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	10.50		1204	✓
GW2	7.52		1136	✓
GW3	7.95		1100	✓
GW4	12.82		1254	✓
GW5	18.91		1235	✓
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1	3.46	3.53	1040	
2	4.13	3.93	1045	

→ USED BAILER ↳ HIGH TURBIDITY

Comments: _____

8/5/15

GW3	7.95	1100	STARTED PUMP	1105	
	TEMP	SpC	pH	DO	
1107	18.12	142.0	5.64	2.07	
1110	17.47	108.5	5.62	0.86	SULFUR SMELL
1113	17.57	111.7	5.63	0.68	IN WATER
1116	17.76	108.1	5.63	0.65	
1119	17.83	107.3	5.66	0.59	
1122	17.88	107.2	5.67	0.56	
1125	17.88	107.5	5.66	0.49	

GW2 7.52 1136 STARTED PUMP 1137

~~1137~~

1140	18.12	243.5	5.75	1.84
1143	15.61	357.1	5.78	0.60
1146	15.08	357.4	5.72	0.43
1150	14.75	354.4	5.71	0.39
1153	14.72	344.6	5.72	0.36
1156	14.76	343.1	5.77	0.37

GW1 10.40 @ 1204 START PUMP 1205

	TEMP	SPC	pH	DO	
1204	17.64	216.2	5.87	3.89	FINE SEDIMENT IN LINE...
1212	16.97	141.4	5.76	4.51	
1215	17.42	129.2	5.67	4.87	
1218	17.72	129.6	5.67	5.55	
1221	17.80	127.3	5.54	5.63	
1224	17.77	126.9	5.58	5.59	

GW5 18.91 @ 1235 * USED BAILER

1. 1236	14.41	40.9	6.22	9.96	LOTS of TURBIDITY
2. 1238	12.66	38.8	6.03	10.25	
3 1239	12.32	38.5	6.00	10.34	
4 1240	12.27	37.9	5.99	10.30	
5 1242	12.12	37.5	5.98	10.36	
6. 1243	12.03	37.2	5.94	10.42	

GW4 12.82 @ 1254 START: 1255

1257	20.31	77.5	5.88	4.32
1300	16.80	69.3	5.68	1.89
1303	15.79	69.1	5.60	1.31
1306	15.63	69.4	5.64	1.23
1309	15.60	69.0	5.52	1.15
1312	15.50	69.3	5.54	0.95
1315	15.47	68.9	5.64	0.91

Rite in the Rain...

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 8/19/15
Time: 10:30 AM/PM

Secchi Depth (ft)
Down: 2'10"
Up: 2'10"
Mean 2.10'
Staff gauge: 4.56'
Time: 11:30 AM/PM

Waterfowl count:
ducks: 73
geese: 0
gulls: 0
other:

Hydrolab

(QUANTA) 9.54

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	23.85	64	~~12.47~~ ~~9.54~~		12.47
1	23.14	60	9.47	—	11.44
1.5	22.42	52	8.88	—	9.46
2	21.82	51	8.43	—	6.38
2.5	21.36	55	7.90	—	1.99

Hobo retrieved: 10:30 AM/PM
2.7 21.27 56 7.45 — 0.31 AND DROPPING

Hobo deployed: 10:45 AM/PM

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one) upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1				
GW2				
GW3				
GW4				
GW5				
Piezometer	Inside (ft)	Outside (ft)	Time	Sample
1	3.73	3.79	1118	
2	4.42	4.18	1128	

Comments:

Waughop Lake sampling log

Position	UTM
easting:	0533145
northing:	5224069

Date: 9 / 14 / 15
Time: ___:___ AM/PM

Secchi	Depth (ft)
Down:	1 ' 5 "
Up:	1 ' 5 "
Mean	1 . 5 '
Staff gauge:	4 . 30 '
Time:	14 : 10 AM/PM

Waterfowl count:
ducks: 107
geese: 0
gulls:
other:

ADD 27.2 on 40 DEPTH (NEW MSL DRASC)

Hydrolab

Depth (m)	Temp (~~°C~~) °F	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	67.1	72.5	9.29	—	13.63
1	66.7	62.0	9.13	—	11.74
1.5	65.9	57.5	8.51	—	9.60
2	64.8	58.2	7.64	—	0.61
2.5	64.5	74.9	6.76	—	0.30

Hobo retrieved: 1 : 02 AM/PM Hobo deployed: 1 : 07 AM/PM

- Depth on borrowed Hydrolab logs a lot

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1.~~8~~7	✓	✓
Chlorophyll	1.~~8~~7	✓	✓
Nutrients (UF)	1.~~8~~7	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one) upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	11.17		12:18 pm	X
GW2	8.28		12:10 pm	X
GW3	8.70		12:36 pm	X
GW4	13.78		12:30 pm	X
GW5	19.36		12:25 pm	X
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1	4.01	4.05	1:53 pm	X
2	~~[illegible]~~ 4.73	4.94	2:07 pm	X

NO SAMPLES COLLECTED

Comments:

Waughop - 9/14/15

Benthic 9 - 12 - (2hrs)

~~Benthic~~	Temp °F	DO mg/L	Cond. µS/cm	pH	Time	GPS	
Benth 9	66.1	11.24	94.2	6.63	2:26 pm	marked	- sediment coming up
Benth 10	66.2	10.71	56.8	8.53	2:44 pm	marked	
Benth 11	65.5	10.34	54.6	8.47	2:58 pm	marked	
Benth 12	66.85	3.63	72.0	7.25	3:10 pm	marked	- some sediment
24hrs							
Benth 9	64.5	3.02	68.5	5.94	1:45 pm		
Benth 10	65.5	6.93	62.1	6.45	1:58 pm		
Benth 11	64.6	4.08	79.9	6.47	2:11 pm	- little sediment after settling	
Benth 12	65.6	1.87	83.0	6.38	2:24 pm		
48HRS							
Benth 9	64.3	0.90	72.1	5.86	1:41 pm		
Benth 10	64.9	1.92	70.6	6.18	1:55 pm		
Benth 11	64.1	0.31	173.9	5.97	2:07 pm		
Benth 12	65.0	0.84	84.8	6.46	2:18 pm		

9/22 GW-5 STARTED PUMP 1320

TEMP	DO	SPC	pH	TIME
~~[illegible]~~ 70.2	9.99	43.5	5.54	1330
66.1	9.35	41.2	5.71	1333
65.6	9.44	41.3	5.77	1336
65.4	9.49	41.3	5.79	1339
65.1	9.51	41.2	5.77	1342
65.1	9.54	41.1	5.77	1345
64.8	9.47	41.0	5.77	1348

Waughop Lake sampling log

Position	UTM
easting:	0533145
northing:	5224069

Date: 9 / 28 / 15
Time: ___:___ AM/PM

Secchi	Depth (ft)
Down:	1 ' 11 "
Up:	1 ' 9 "
Mean	1 . 10 '
Staff gauge:	4 . 16 '
Time:	1 : 17 AM/PM

Waterfowl count:
ducks: 166
geese: –
gulls: –
other: _____

Hydrolab

Depth (m)	Temp (°~~C~~ F)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	62.0	55.1	8.10	–	11.66
1	61.6	54.4	8.15	–	11.31
1.5	61.5	53.8	8.02	–	10.89
2	61.2	54.4	8.10	–	11.32
2.5	59.9	53.5	7.73	–	9.88

Hobo retrieved: 11 : 30 AM/PM
Hobo deployed: 1 : 42 AM/PM

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	✓	✓
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one) upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1				
GW2				
GW3				
GW4				
GW5				
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1	4.18	4.21	1217	
2	4.89	4.59	12:53	

Comments: 8' 10" TOTAL DEPTH

Waughop Lake sampling log

Position UTM
easting: 0533145
northing: 5224069

Date: 10 / 13 / 15
Time: 12 : 53 AM/PM

Secchi Depth (ft)
Down: 3 ' 0 "
Up: 2 ' 11 "
Mean ___ . ___ '
Staff gauge: 4 . 11 '
Time: 12 : 52 AM/PM

Waterfowl count:
ducks: 131
geese: ___
gulls: 5
other: 1

Hydrolab

Depth (m)	Temp (°C)	Cond (µS/cm)	pH	Chlor (µg/L)	DO (mg/L)
0.5	16.09	0.050	7.2		10.56
1	15.97	0.050	7.19		9.38
1.5	15.83	0.050	7.15		8.25
2	15.59	0.051	7.08		6.25
2.5	15.45	0.236	~~6.8~~ 6.45		0.25

Hobo retrieved: 12 : 56 AM/PM
Hobo deployed: ___ : ___ ~~AM/PM~~

Water samples

	Depth on tape (ft)	Check box after collection	
Alkalinity	1, 6	✓	✓
Chlorophyll	1, 6	✓	✓
Nutrients (UF)	1, 6	1:21 pm ✓	✓ 1:30
Phytoplankton	5	✓	✓
Zooplankton	5	✓	✓

Replicate (circle one)
upper/lower

Groundwater wells

Well	Level from top of well (ft)		Time	Sample
GW1	~~9.31~~ 11.56		~~2:11~~ 2:25	
GW2	8.72		2:17	
GW3	9.31		2:16	
GW4	14.53		2:40	
GW5	19.78		2:35	
Piezometer	**Inside (ft)**	**Outside (ft)**	**Time**	**Sample**
1	4.23	4.25	1238	
2	4.95	4.61	1249	

Comments: TOTAL DEPTH 8'11"

Appendix B: Laboratory Results

This appendix contains copies of the laboratory results from the 2014–15 monitoring study.

Use of contents on this sheet is subject to the limitations specified at the end of this document.
Draft Waughop Lake Management Plan_11-14-2016.docx

M15034-71

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: GAWEL - UWT
Address: 1900 Commerce St.
Box 358436, Tacoma, WA 98402
Contact: Jim Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax: 253-692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	SRP	TN	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number: Temp	Lab ID
10-29-14	1:42	SW	L1 - surf	1	✓	✓	✓					5.3°C	
10-29-14	1:42	SW	L1 - surf - dup	1	✓	✓	✓						
10-29-14	1:47	SW	L1 - bot	1	✓	✓	✓						
												(3) 20 ml	

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	10-29-14	3:20pm

Received By	Date	Time

Relinquished to Aquatic By (Signature)	Date	Time

Shipped By: Jim Gawel
Shipping Reference:
Received at Aquatic By:
Date: 10/29/14 Time: 5:00

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS034-71**		**PAGE 1**
REPORT DATE:	**12/09/14**		
DATE SAMPLED:	**10/29/14**	**DATE RECEIVED:**	**10/29/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
L1-SURF	0.071	0.004	1.21
L1-SURF-DUP	0.074	0.004	1.16
L1-BOT	0.092	0.004	1.40

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: **MIS034-71** **PAGE 2**

REPORT DATE: **12/09/14**

DATE SAMPLED: **10/29/14** **DATE RECEIVED:** **10/29/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	11/24/14	10/30/14	11/10/14
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	L1-BOT	BATCH
ORIGINAL	0.063	0.004	0.369
DUPLICATE	0.060	0.004	0.378
RPD	5.47%	2.67%	2.60%
SPIKE SAMPLE			
SAMPLE ID	BATCH	L1-BOT	BATCH
ORIGINAL	0.063	0.004	0.369
SPIKED SAMPLE	0.115	0.025	1.45
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	104.60%	104.00%	108.42%
QC CHECK			
FOUND	0.091	0.034	0.481
TRUE	0.090	0.033	0.490
% RECOVERY	100.58%	103.34%	98.16%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15034-82

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St Tacoma WA
Contact: Jim Gawel
Email: ~~(253) 651-2573~~ jimgawd@uw.edu
Phone: (253)651-2573 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☐ Email ☐ Mail

QC Data Reported
☐ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

LAB USE ONLY
Containers Received
Case File Number

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	SRP	TN	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Temp	Lab ID
11/19/14	12:19		S1 Surface	1	X	X	X				5.8°C	
11/19/14	12:19		S2 Bottom	1	X	X	X					
11/19/14	12:19		S3 Bottom Dup.	1	X	X	X					

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
[signature]	11/19/14	2:50pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference	
Received at Aquatic By [signature] (3) total	Date 11/19/14	Time 4:30

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS034-82**		**PAGE 1**
REPORT DATE:	**12/16/14**		
DATE SAMPLED:	**11/19/14**	**DATE RECEIVED:**	**11/19/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
S1 SURFACE	0.060	0.007	1.49
S2 BOTTOM	0.061	0.007	1.45
S3 BOTTOM DUP	0.068	0.007	1.71

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS034-82**		**PAGE 2**
REPORT DATE:	**12/16/14**		
DATE SAMPLED:	**11/19/14**	**DATE RECEIVED:**	**11/19/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	12/01/14	11/21/14	12/01/14
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.005	0.009	0.396
DUPLICATE	0.004	0.009	0.417
RPD	1.87%	3.37%	5.25%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.005	0.009	0.396
SPIKED SAMPLE	0.076	0.029	1.41
SPIKE ADDED	0.075	0.020	1.00
% RECOVERY	95.31%	102.73%	101.69%
QC CHECK			
FOUND	0.090	0.033	0.485
TRUE	0.090	0.033	0.490
% RECOVERY	100.00%	100.71%	99.02%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS035-04

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: James Gawel/UW Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax: 253-692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

Analysis Requested: PSI, PSI, PSI

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number: Temp	Lab ID
12/15/14	11:30am	SW	Waughop 1 SURF	1				1	0.9°C	
	11:31am	SW	Waughop 2 SURF DUP	1				1		
	11:59am	SW	Waughop 3 BOTTOM	1				1		
✓	1:50pm	GW	Waughop GW-2	1				1		
									(4) total	

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

	Date	Time
Sampled By: [signature]	12/15/14	3:00 pm
Received By		
Relinquished to Aquatic By (Signature)		

Shipped By:
Shipping Reference:
Received at Aquatic By: [signature]
Date: 12/15/14 Time: 4:30

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-04**		**PAGE 1**
REPORT DATE:	**12/24/14**		
DATE SAMPLED:	**12/15/14**	**DATE RECEIVED:**	**12/15/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP 1 SURF	0.112	0.012	1.77
WAUGHOP 2 SURF DUP	0.097	0.015	2.19
WAUGHOP 3 BOTTOM	0.116	0.014	1.86
WAUGHOP GW-2	0.046	0.003	0.993

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-04**		**PAGE 2**
REPORT DATE:	**12/24/14**		
DATE SAMPLED:	**12/15/14**	**DATE RECEIVED:**	**12/15/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	12/22/14	12/16/14	12/23/14
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.006	0.005	0.110
DUPLICATE	0.006	0.005	0.104
RPD	0.00%	0.11%	5.57%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.006	0.005	0.110
SPIKED SAMPLE	0.058	0.025	1.24
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	104.00%	100.61%	112.95%
QC CHECK			
FOUND	0.087	0.033	0.499
TRUE	0.090	0.033	0.490
% RECOVERY	96.67%	100.00%	101.76%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M1S035-08

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: UNIV OF WASHINGTON - TACOMA
Address: TACOMA, WA
Contact: JIM GAWEL
Email:
Phone: (253) 651-2573 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☐ Email ☐ Mail

QC Data Reported
☐ Yes ☐ No

Sample Disposal
☐ Hold ☐ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

LAB USE ONLY
Containers Received
Case File Number

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	P	SF	F	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
12-18-14	1033		GW1	1							1	3.4°C	
12-18-14	947		GW3	1									
12-18-14	1213		GW4	1									
12-18-14	1122		GW5	1									
												14	

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
[signature]	12/18/14	12:30pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By [signature]
Date 12/19/14 Time 9:30

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-08**		**PAGE 1**
REPORT DATE:	**01/06/15**		
DATE SAMPLED:	**12/18/14**	**DATE RECEIVED:**	**12/19/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
GW 1	0.032	0.010	1.68
GW 3	0.064	0.016	1.32
GW 4	<0.002	<0.001	14.2
GW 5	0.017	0.013	0.878

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-08**		**PAGE 2**
REPORT DATE:	**01/06/15**		
DATE SAMPLED:	**12/18/14**	**DATE RECEIVED:**	**12/19/14**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	12/29/14	12/19/14	01/06/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	GW 5	BATCH
ORIGINAL	0.009	0.013	0.347
DUPLICATE	0.009	0.013	0.341
RPD	1.29%	0.64%	1.85%
SPIKE SAMPLE			
SAMPLE ID	BATCH	GW 5	BATCH
ORIGINAL	0.009	0.013	0.347
SPIKED SAMPLE	0.061	0.033	1.37
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	102.72%	99.14%	102.59%
QC CHECK			
FOUND	0.090	0.033	0.490
TRUE	0.090	0.033	0.490
% RECOVERY	100.00%	100.00%	100.00%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS035-19

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: UWT -
Address: 1900 Commerce St. Box 358436
Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING			SAMPLE DESCRIPTION	Number of Containers	Analysis Requested														LAB USE ONLY		
Date (mm-dd-yy)	Time	Matrix**	(This Will Appear On The Report)		FP	SKP	FPN									Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number: Temp	Case File Number: Lab ID
01-05-15	11:18am	SW	WAUGHOP STORM-1	1															1	10.0°C	

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
James Gawel	1/5/15	
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference
Received at Aquatic By	Date / Time
	1/5/15 3:20

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-19**		**PAGE 1**
REPORT DATE:	**02/06/15**		
DATE SAMPLED:	**01/05/15**	**DATE RECEIVED:**	**01/05/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

One water sample was received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUCHOP STORM-1	0.038	0.007	0.190

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-19**		**PAGE 2**
REPORT DATE:	**02/06/15**		
DATE SAMPLED:	**01/05/15**	**DATE RECEIVED:**	**01/05/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	01/12/15	01/06/15	01/15/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.003	0.016	2.85
DUPLICATE	0.003	0.016	2.94
RPD	5.11%	0.26%	3.03%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.003	0.016	2.85
SPIKED SAMPLE	0.051	0.036	3.87
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	96.51%	97.08%	101.75%
QC CHECK			
FOUND	0.094	0.033	0.495
TRUE	0.094	0.033	0.490
% RECOVERY	100.00%	100.00%	101.02%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15039 01
~~M15039-01~~

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: JAMES GAWEL / UW TACOMA
Address: 1900 COMMERCE ST
CAMPUS BOX 358436, TACOMA, WA 98402
Contact: JAMES GAWEL
Email: jimgawel@uw.edu
Phone: (253) 692-5815 Fax: (253) 692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

Analysis Requested: TP, SRP, N2

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
01-22-15	1100 AM	SW	WAUGHOP SURFACE	1				1	3.9°C	
01-22-15	1103 AM	SW	WAUGHOP BOTTOMA	1				1		
01-22-15	1103 AM	SW	WAUGHOP BOTTOMB	1				1		

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

	Date	Time
Sampled By	1/22/15	1:30 PM
Received By		
Relinquished to Aquatic By (Signature)		

Shipped By
Shipping Reference
Received at Aquatic By
Date 1/23/15 Time 9:00

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-34**	**PAGE 1**	
REPORT DATE:	**02/06/15**		
DATE SAMPLED:	**01/22/15**	**DATE RECEIVED:**	**01/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP SURFACE	0.097	0.016	1.99
WAUGHOP BOTTOM A	0.081	0.013	1.72
WAUGHOP BOTTOM B	0.093	0.014	1.74

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-34**	**PAGE 2**	
REPORT DATE:	**02/06/15**		
DATE SAMPLED:	**01/22/15**	**DATE RECEIVED:**	**01/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	02/02/15	01/23/15	01/27/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	WAUGHOP BOTTOM B	BATCH
ORIGINAL	0.006	0.014	3.49
DUPLICATE	0.007	0.014	3.44
RPD	9.41%	0.72%	1.45%
SPIKE SAMPLE			
SAMPLE ID	BATCH	WAUGHOP BOTTOM B	BATCH
ORIGINAL	0.006	0.014	3.49
SPIKED SAMPLE	0.058	0.034	4.59
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	102.63%	98.66%	109.80%
QC CHECK			
FOUND	0.094	0.041	0.484
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	105.13%	98.78%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15035-53

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St, Box 358436
Tacoma, WA 98402
Contact: Jim Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax: 253-692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown & Caldwell
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

Analysis Requested: TP, SRP, TN

Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	SRP	TN	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
02-05-15	3pm	SW	STORm-1	1	↓	↓	↓				1	4.9°C	
02-05-15	4pm	SW	STORm-2	1							1	↓	
												(2) 2014	

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
James Gawel	2/5/15	4pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference
Received at Aquatic By	**Date / Time**
[signature]	2/6/15 11:20

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-53**	**PAGE 1**	
REPORT DATE:	**02/24/15**		
DATE SAMPLED:	**02/05/15**	**DATE RECEIVED:**	**02/06/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Two water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
STORM-1	0.030	0.003	0.446
STORM-2	0.044	0.006	0.543

IEH - AQUATIC RESEARCH

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-53**	**PAGE 2**	
REPORT DATE:	**02/24/15**		
DATE SAMPLED:	**02/05/15**	**DATE RECEIVED:**	**02/06/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	02/16/15	02/06/15	02/17/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.036	0.055	0.905
DUPLICATE	0.037	0.055	0.942
RPD	2.53%	0.83%	4.03%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.036	0.055	0.905
SPIKED SAMPLE	0.086	0.075	1.97
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	99.49%	98.95%	106.78%
QC CHECK			
FOUND	0.095	0.039	0.497
TRUE	0.094	0.039	0.490
% RECOVERY	101.06%	100.00%	101.43%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS035-60

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: Jim Gawel - UWT
Address: 1900 Commerce St. Campus Box 358436, Tacoma, WA 98402
Contact: Jim Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown & Caldwell
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	SRP TR TN	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
02-19-15	10:35	SW	LW1 SURFACE A	1	✓					4.6°C	
	10:35		LW1 SURFACE B	1							
	10:43		LW1 BOTTOM	1							
	1:23	GW	GW-1	1							
	12:55		GW-2	1							
	12:15		GW-3	1							
	2:33		GW-4	1							
	2:06		GW-5	1							
										(8) 20mL	

Analysis Requested

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	2/19/15	10:35am
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By:
Shipping Reference:
Received at Aquatic By:
Date: 2/20/15 Time: 9:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: **MIS035-60** **PAGE 1**

REPORT DATE: **03/03/15**

DATE SAMPLED: **02/19/15** **DATE RECEIVED:** **02/20/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Eight water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
LW1 SURFACE A	0.172	0.014	2.10
LW1 SURFACE B	0.133	0.020	2.35
LW1 BOTTOM	0.137	0.016	1.94
GW-1	0.009	0.004	1.73
GW-2	0.015	<0.001	3.82
GW-3	0.048	0.002	0.682
GW-4	0.004	<0.001	29.2
GW-5	0.022	0.008	0.660

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER: **MIS035-60** **PAGE 2**

REPORT DATE: **03/03/15**

DATE SAMPLED: **02/19/15** **DATE RECEIVED:** **02/20/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	03/02/15	02/20/15	02/24/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	GW-5	GW-5	GW-5
ORIGINAL	0.022	0.008	0.660
DUPLICATE	0.023	0.008	0.629
RPD	4.81%	5.42%	4.76%
SPIKE SAMPLE			
SAMPLE ID	GW-5	GW-5	GW-5
ORIGINAL	0.022	0.008	0.660
SPIKED SAMPLE	0.073	0.028	1.73
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	102.33%	99.04%	107.27%
QC CHECK			
FOUND	0.098	0.039	0.490
TRUE	0.094	0.039	0.490
% RECOVERY	104.26%	100.00%	100.00%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15035-83

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number: Temp	Lab ID
03-12-15	10:25am	SW	LW1 top	1	✓	✓	✓					7.5°C	
03-12-15	↓	↓	LW1 bottom A	1									
03-12-15	↓	↓	LW1 bottom B	1	↓	↓	↓						
												15:10	

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	3/12/15	1:08 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By:
Shipping Reference:
Received at Aquatic By:
Date: 3/12/15 Time: 4:25

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-83**	**PAGE 1**	
REPORT DATE:	**04/01/15**		
DATE SAMPLED:	**03/12/15**	**DATE RECEIVED:**	**03/12/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
LW1 TOP	0.106	0.006	2.16
LW1 BOTTOM A	0.086	0.006	1.96
LW1 BOTTOM B	0.084	0.006	2.57

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS035-83**	**PAGE 2**	
REPORT DATE:	**04/01/15**		
DATE SAMPLED:	**03/12/15**	**DATE RECEIVED:**	**03/12/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	EPA 365.1	EPA 365.1	SM204500NC
DATE ANALYZED	03/24/15	03/13/15	03/20/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	LW1 BOTTOM B	BATCH
ORIGINAL	0.045	0.006	0.984
DUPLICATE	0.044	0.006	0.931
RPD	1.19%	0.11%	5.44%
SPIKE SAMPLE			
SAMPLE ID	BATCH	LW1 BOTTOM B	BATCH
ORIGINAL	0.045	0.006	0.984
SPIKED SAMPLE	0.099	0.027	1.94
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	109.46%	104.62%	95.52%
QC CHECK			
FOUND	0.099	0.039	0.486
TRUE	0.094	0.039	0.490
% RECOVERY	105.32%	100.00%	99.09%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MI5036-27

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

Analysis Requested

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
04-22-15	11:15	SW	Waughop Surf A	1	1	1	1					7.9°C	
04-22-15	11:15	SW	Waughop Surf B	1	1	1	1						
04-22-15	11:20	SW	Waughop Bottom	1	1	1	1						

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	04-22-15	1:03 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By:
Shipping Reference:
Received at Aquatic By:
Date: 4/23/15 Time: 9:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-27**	**PAGE 1**	
REPORT DATE:	**05/05/15**		
DATE SAMPLED:	**04/22/15**	**DATE RECEIVED:**	**04/22/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP SUFT A	0.081	0.003	1.18
WAUGHOP SURF B	0.069	0.002	1.19
WAUGHOP BOTTOM	0.056	0.002	1.16

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-27**	**PAGE 2**	
REPORT DATE:	**05/05/15**		
DATE SAMPLED:	**04/22/15**	**DATE RECEIVED:**	**04/22/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	EPA 365.1	EPA 365.1	SM204500NC
DATE ANALYZED	05/04/15	04/23/15	05/01/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.035	0.078	0.309
DUPLICATE	0.035	0.078	0.321
RPD	0.52%	0.33%	4.02%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.035	0.078	0.309
SPIKED SAMPLE	0.087	0.097	1.45
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	103.39%	97.04%	114.52%
QC CHECK			
FOUND	0.095	0.039	0.513
TRUE	0.094	0.039	0.490
% RECOVERY	101.06%	100.00%	104.69%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15036-52

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax: 253-692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number: Temp	Lab ID
5/13/15	10:40	SW	Surf LW-1 Waughop	1	1	1	1					4.7°C	
5/13/15	11:00	SW	Bottom-A Waughop	1	1	1	1						
5/13/15	11:00	SW	Bottom-B Waughop	1	1	1	1						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	5/13/15	12:42 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By
Date 5/13/15 Time 3:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-52**	**PAGE 1**	
REPORT DATE:	**05/26/15**		
DATE SAMPLED:	**05/13/15**	**DATE RECEIVED:**	**05/13/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
SURF LW-1 WAUGHOP	0.077	0.003	1.51
BOTTOM-A WAUGHOP	0.079	0.003	1.61
BOTTOM-B WAUGHOP	0.078	0.003	1.80

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-52**	**PAGE 2**	
REPORT DATE:	**05/26/15**		
DATE SAMPLED:	**05/13/15**	**DATE RECEIVED:**	**05/13/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	05/18/15	05/15/15	05/20/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.036	0.010	0.661
DUPLICATE	0.037	0.009	0.695
RPD	3.97%	2.99%	4.94%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.036	0.010	0.661
SPIKED SAMPLE	0.087	0.030	1.81
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	101.21%	102.84%	115.07%
QC CHECK			
FOUND	0.100	0.040	0.496
TRUE	0.094	0.039	0.490
% RECOVERY	106.38%	102.56%	101.22%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M1S03671

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format: ☐ Fax ☑ Email ☐ Mail

QC Data Reported: ☑ Yes ☐ No

Sample Disposal: ☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*: ☐ Next Day ☐ 2 Business Day ☐ 3 Business Day ☑ Standard

Specific Date:

*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number: Temp	Lab ID
5/27/15	1:30	GW	GW-1		✓	✓	✓					4.6°C	
	12:50	GW	GW-2										
	12:00	GW	GW-3										
	3:20	GW	GW-4										
	2:36	GW	GW-5										
~~[illegible]~~	~~[illegible]~~	~~SW~~	~~LW-1 SURF~~									~~15.7°C~~	
~~[illegible]~~	~~[illegible]~~	~~SW~~	~~LW-1 SURF DUP~~										
~~[illegible]~~	~~[illegible]~~	~~SW~~	~~LW-1 BOTTOM~~										

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	5/27/15	4:00 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference	
Received at Aquatic By:	Date: 5/28/15	Time: 11:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-71**	**PAGE 1**	
REPORT DATE:	**06/12/15**		
DATE SAMPLED:	**05/27/15**	**DATE RECEIVED:**	**05/28/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Five water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
GW-1	0.013	0.007	3.89
GW-2	0.019	0.001	0.668
GW-3	0.054	0.003	0.661
GW-4	<0.002	<0.001	13.8
GW-5	0.019	0.015	0.650

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-71**	**PAGE 2**	
REPORT DATE:	**06/12/15**		
DATE SAMPLED:	**05/27/15**	**DATE RECEIVED:**	**05/28/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	06/08/15	05/28/15	06/02/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	GW-5	GW-5
ORIGINAL	0.053	0.015	0.650
DUPLICATE	0.053	0.015	0.624
RPD	0.35%	0.82%	4.13%
SPIKE SAMPLE			
SAMPLE ID	BATCH	GW-5	GW-5
ORIGINAL	0.053	0.015	0.650
SPIKED SAMPLE	0.105	0.035	1.68
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	103.97%	101.37%	102.88%
QC CHECK			
FOUND	0.092	0.039	0.475
TRUE	0.094	0.039	0.490
% RECOVERY	97.87%	100.46%	96.95%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15036-00

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

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Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number: Temp	Lab ID
6/9/15	~~11:30~~ 11:30	SW	Surface Waughop	1	/	/	/						
↓	11:35	SW	Bottom A Waughop	1	/	/	/						
↓	11:35	SW	Bottom dup - B Waughop	1	—	—	—						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	6/9/15	1:14
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference	Date	Time
Received at Aquatic By: [illegible] (8) total		6/9/15	5PM

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-88**	**PAGE 1**	
REPORT DATE:	**06/25/15**		
DATE SAMPLED:	**06/09/15**	**DATE RECEIVED:**	**06/09/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
SURFACE WAUGHOP	0.050	0.001	2.02
BOTTOM A WAUGHOP	0.117	0.001	1.69
BOTTOM DUP-B WAUGHOP	0.116	0.002	1.96

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-88**	**PAGE 2**	
REPORT DATE:	**06/25/15**		
DATE SAMPLED:	**06/09/15**	**DATE RECEIVED:**	**06/09/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	06/15/15	06/10/15	06/16/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.043	0.037	0.670
DUPLICATE	0.042	0.036	0.649
RPD	2.83%	3.33%	3.15%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.043	0.037	0.670
SPIKED SAMPLE	0.096	0.057	1.59
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	106.01%	99.02%	91.63%
QC CHECK			
FOUND	0.093	0.040	0.494
TRUE	0.094	0.039	0.490
% RECOVERY	98.94%	103.50%	100.82%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15036-98

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

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Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
06-23-15	10:03	SW	WAUGHOP SURF-A	1	↓	↓	↓						
↓	10:03	↓	WAUGHOP SURF-B	1	↓	↓	↓						
↓	10:07	↓	WAUGHOP BOTTOM	1	↓	↓	↓						

Analysis Requested

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	6/23/15	11:43 am
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference
Received at Aquatic By	Date: 6/23/15 Time: 5:30 pm

(3) total 7.8 °C

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-98**	**PAGE 1**	
REPORT DATE:	**07/03/15**		
DATE SAMPLED:	**06/23/15**	**DATE RECEIVED:**	**06/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP SURF-A	0.053	0.003	1.46
WAUGHOP SURF-B	0.056	0.002	1.25
WAUGHOP BOTTOM	0.100	0.005	1.63

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS036-98**	**PAGE 2**	
REPORT DATE:	**07/03/15**		
DATE SAMPLED:	**06/23/15**	**DATE RECEIVED:**	**06/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	06/27/15	06/24/15	06/28/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.050	0.013	0.329
DUPLICATE	0.046	0.012	0.328
RPD	7.35%	3.98%	0.45%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.050	0.013	0.329
SPIKED SAMPLE	0.099	0.033	1.44
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	97.91%	98.05%	110.99%
QC CHECK			
FOUND	0.096	0.039	0.480
TRUE	0.094	0.039	0.490
% RECOVERY	102.13%	100.00%	97.93%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-14

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
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Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
07-06-15	1:35	SW	WAUGHOP - SURF	1	↓	↓	↓						
↓	1:46	↓	WAUGHOP - BOTT	1									
↓	1:46	↓	WAUGHOP - BOTT DUP	1									

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	7/6/15	3:43pm
Received By		
Relinquished to Aquatic By (Signature)		

Shipped By
Shipping Reference
Received at Aquatic By
Date 7/7/15 Time 10:30

(3) total

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-14**	**PAGE 1**	
REPORT DATE:	**07/27/15**		
DATE SAMPLED:	**07/06/15**	**DATE RECEIVED:**	**07/07/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP-SURF	0.034	0.002	0.986
WAUGHOP-BOTT	0.048	0.002	1.04
WAUGHOP-BOTT DUP	0.047	0.002	0.958

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-14**	**PAGE 2**	
REPORT DATE:	**07/27/15**		
DATE SAMPLED:	**07/06/15**	**DATE RECEIVED:**	**07/07/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	07/20/15	07/08/15	07/27/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.009	<0.001	0.082
DUPLICATE	0.008	<0.001	0.096
RPD	11.50%	NC	15.44%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.009	<0.001	0.082
SPIKED SAMPLE	0.059	0.021	1.19
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	100.25%	105.00%	110.94%
QC CHECK			
FOUND	0.094	0.040	0.463
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	102.56%	94.49%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MI5037-31

IEH - Aquatic Research
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P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
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Contact: James Gawel
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INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
07-20-15	10:45	SW	WAUGHOP LW-1 surface	1	↓	↓	↓						
↓	10:50	↓	WAUGHOP LW-1 bottom-A	1									
	10:50		WAUGHOP LW-1 bottom-B	1									
↓	12:15	↓	WAUGHOP BENTHIC 1	1	↓	↓	↓						

Analysis Requested

LAB USE ONLY

Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments: deliver before 6pm

Sampled By	Date	Time
Jim Gawel	7/20/15	2:25pm
Received By	7/21/15	6:00
Relinquished to Aquatic By (Signature)		

Shipped By
Shipping Reference
Received at Aquatic By
Date
Time

(4) total
4.3°

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-31**	**PAGE 1**	
REPORT DATE:	**08/12/15**		
DATE SAMPLED:	**07/20/15**	**DATE RECEIVED:**	**07/21/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
LW-1 SURFACE	0.062	0.004	1.45
LW-1 BOTTOM - A	0.100	0.001	1.60
LW-1 BOTTOM - B	0.102	<0.001	1.35
BENTH IC 1	0.090	<0.001	1.92

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

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CASE FILE NUMBER:	**MIS037-31**	**PAGE 2**	
REPORT DATE:	**08/12/15**		
DATE SAMPLED:	**07/20/15**	**DATE RECEIVED:**	**07/21/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/08/15	07/22/15	08/04/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.007	<0.001	0.276
DUPLICATE	0.007	<0.001	0.283
RPD	1.81%	NC	2.40%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.007	<0.001	0.276
SPIKED SAMPLE	0.059	0.021	1.38
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	103.97%	105.00%	110.08%
QC CHECK			
FOUND	0.094	0.041	0.520
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	105.13%	106.12%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
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OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-32

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	LAB USE ONLY Containers Received	Case File Number Temp	Lab ID
7/21/15	1:30	SW	Benthic 1 24hr	1	↓	↓	↓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	7/21/15	2:38
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By (1) tot. 5.6
Date 7/21/15 Time 10:45

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-32**	**PAGE 1**	
REPORT DATE:	**08/12/15**		
DATE SAMPLED:	**07/21/15**	**DATE RECEIVED:**	**07/22/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

One water sample was received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTHIC 1	0.146	0.003	1.94

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-32**	**PAGE 2**	
REPORT DATE:	**08/12/15**		
DATE SAMPLED:	**07/21/15**	**DATE RECEIVED:**	**07/22/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/08/15	07/22/15	08/04/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.007	<0.001	0.276
DUPLICATE	0.007	<0.001	0.283
RPD	1.81%	NC	2.40%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.007	<0.001	0.276
SPIKED SAMPLE	0.059	0.021	1.38
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	103.97%	105.00%	110.08%
QC CHECK			
FOUND	0.094	0.041	0.520
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	105.13%	106.12%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-34

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP										Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	LAB USE ONLY Case File Number Temp	Lab ID
7/22/15	2:19	SW	Benthic 1 48hr	1	1	1	1															

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	7/22/15	4:25 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference	
Received at Aquatic By: Catherine Le 5500	Date 07/23/15	Time 12:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-34**	**PAGE 1**	
REPORT DATE:	**08/12/15**		
DATE SAMPLED:	**07/22/15**	**DATE RECEIVED:**	**07/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

One water sample was received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTHIC 1 48 HR	0.436	0.064	7.49

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-34**	**PAGE 2**	
REPORT DATE:	**08/12/15**		
DATE SAMPLED:	**07/22/15**	**DATE RECEIVED:**	**07/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/08/15	07/23/15	08/11/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.007	0.003	0.241
DUPLICATE	0.007	0.003	0.248
RPD	1.81%	5.03%	2.98%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.007	0.003	0.241
SPIKED SAMPLE	0.059	0.024	1.38
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	103.97%	104.06%	113.51%
QC CHECK			
FOUND	0.094	0.040	0.476
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	102.56%	97.14%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-41

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

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Seattle, WA
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Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
7/27/15	4:10	SW	Beuth 2 (2hrs)	1	✓	✓	✓						
7/27/15	4:15	SW	Beuth 3 (2hrs)	1	✓	✓	✓						
7/27/15	4:54	SW	Beuth 4 (2hrs)	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	7/27/15	5:02pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By: Shipping Reference:
Received at Aquatic By: 13.1° Date: 7/28/15 Time: 12:30

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-41**	**PAGE 1**	
REPORT DATE:	**08/26/15**		
DATE SAMPLED:	**07/27/15**	**DATE RECEIVED:**	**07/28/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BEUTH 2 (2 HRS)	0.157	<0.001	2.29
BEUTH 3 (2 HRS)	0.114	<0.001	1.91
BEUTH 4 (2 HRS)	0.321	0.117	7.57

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-41**	**PAGE 2**	
REPORT DATE:	**08/26/15**		
DATE SAMPLED:	**07/27/15**	**DATE RECEIVED:**	**07/28/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/17/15	07/29/15	08/11/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BEUTH 4 (2 HRS)	BATCH
ORIGINAL	0.013	0.117	0.241
DUPLICATE	0.013	0.116	0.248
RPD	3.17%	0.76%	2.98%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BEUTH 4 (2 HRS)	BATCH
ORIGINAL	0.013	0.117	0.241
SPIKED SAMPLE	0.066	0.136	1.38
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	105.59%	94.86%	113.51%
QC CHECK			
FOUND	0.092	0.038	0.476
TRUE	0.094	0.039	0.490
% RECOVERY	97.87%	97.44%	97.14%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037.42

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

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Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Case File Number Lab ID
7/28/15	1:38	SW	Benth 2 (24hrs)	1	✓	✓	✓						
7/28/15	1:25	SW	Benth 3 (24hrs)	1	✓	✓	✓						
7/28/15	1:35	SW	Benth 4 (24hrs)	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	7/28/15	3:06
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By 7/29/15 11:00 Date Time

12.8°

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-42**	**PAGE 1**	
REPORT DATE:	**08/26/15**		
DATE SAMPLED:	**07/28/15**	**DATE RECEIVED:**	**07/29/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTH 2 (24 HRS)	10.0	0.014	51.8
BENTH 3 (24 HRS)	6.24	0.024	31.4
BENTH 4 (24 HRS)	0.286	0.113	7.47

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-42**	**PAGE 2**	
REPORT DATE:	**08/26/15**		
DATE SAMPLED:	**07/28/15**	**DATE RECEIVED:**	**07/29/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/17/15	07/29/15	08/18/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.013	0.117	0.076
DUPLICATE	0.013	0.116	0.073
RPD	3.17%	0.76%	3.30%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.013	0.117	0.076
SPIKED SAMPLE	0.066	0.136	1.03
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	105.59%	94.86%	95.72%
QC CHECK			
FOUND	0.092	0.038	0.491
TRUE	0.094	0.039	0.490
% RECOVERY	97.87%	97.44%	100.20%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-44

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

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Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
7/29/15	1:52	SW	Benth 2 (48hrs)	1	1	1	1						
7/29/15	2:02	SW	Benth 3 (48hrs)	1	1	1	1						
7/29/15	2:18	SW	Benth 4 (48hrs)	1	1	1	1						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	7/29/15	3:38
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By: Shipping Reference:
Received at Aquatic By: (3) Lab 1730 Date: 7/30/15 Time: 12:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-44**	**PAGE 1**	
REPORT DATE:	**08/26/15**		
DATE SAMPLED:	**07/29/15**	**DATE RECEIVED:**	**07/30/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTH 2 (48 HRS)	43.4	0.013	77.0
BENTH 3 (48 HRS)	17.0	0.012	0.518
BENTH 4 (48 HRS)	0.409	0.105	9.58

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-44**	**PAGE 2**	
REPORT DATE:	**08/26/15**		
DATE SAMPLED:	**07/29/15**	**DATE RECEIVED:**	**07/30/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/22/15	07/30/15	08/18/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.057	<0.001	0.076
DUPLICATE	0.061	<0.001	0.073
RPD	6.11%	NC	3.30%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.057	<0.001	0.076
SPIKED SAMPLE	0.107	0.019	1.03
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	99.73%	95.00%	95.72%
QC CHECK			
FOUND	0.092	0.039	0.491
TRUE	0.094	0.039	0.490
% RECOVERY	97.87%	100.00%	100.20%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MI5037-52

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

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Client: University of Washington Tacoma
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Contact: James Gawel
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Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TR	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
08-05-15	10:02	SW	WAUGHOP SURF			✓							
	10:07		WAUGHOP BOTTOM-A			✓							
	10:07		WAUGHOP BOTTOM-B			✓							
	10:07		BOTTOM TEST 1										
	10:07		BOTTOM TEST 2										
	11:25	GW	GW-3			✓							
	1:15		GW-4			✓							
	12:48		GW-5			✓							
	12:25		GW-1			✓							
	11:57		GW-2		✓	✓	✓						

Analysis Requested

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	8/5/15	2:11 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference 89
Received at Aquatic By
Date 8/6/15 Time 8:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-52**	**PAGE 1**	
REPORT DATE:	**09/01/15**		
DATE SAMPLED:	**08/05/15**	**DATE RECEIVED:**	**08/06/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Ten water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP SURF	0.076	<0.001	1.86
WAUGHOP BOTTOM-A	0.073	<0.001	1.85
WAUGHOP BOTTOM-B	0.075	<0.001	1.86
BOTTOM TEST 1	0.017	<0.001	
BOTTOM TEST 2	0.018	<0.001	
GW-3	0.048	0.006	1.06
GW-4	0.003	<0.001	0.163
GW-5	2.95	0.021	0.845
GW-1	0.080	0.005	6.95
GW-2	0.075	0.002	1.09

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-52**	**PAGE 2**	
REPORT DATE:	**09/01/15**		
DATE SAMPLED:	**08/05/15**	**DATE RECEIVED:**	**08/06/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	08/31/15	08/06/15	08/25/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	GW-2	GW-2	GW-2
ORIGINAL	0.075	0.002	1.09
DUPLICATE	0.076	0.002	1.12
RPD	0.85%	3.80%	2.76%
SPIKE SAMPLE			
SAMPLE ID	GW-2	GW-2	GW-2
ORIGINAL	0.075	0.002	1.09
SPIKED SAMPLE	0.128	0.022	1.98
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	106.32%	101.71%	89.25%
QC CHECK			
FOUND	0.094	0.039	0.498
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	100.69%	101.63%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

~~MIS035-04~~

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

 MIS037-65

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
08-19-15	1054	SW	WAUGHOP SURFACE	1	✓	✓	✓						
	1057	SW	WAUGHOP BOTTOM-A	1	✓	✓	✓						
	1057	SW	WAUGHOP BOTTOM-B	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	8-19-15	1:57 PM
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By
Date
Time

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-65**	**PAGE 1**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/19/15**	**DATE RECEIVED:**	**08/19/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
WAUGHOP SURFACE	0.057	0.002	1.65
WAUGHOP BOTTOM-A	0.058	0.001	1.45
WAUGHOP BOTTOM-B	0.054	0.001	1.58

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-65**	**PAGE 2**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/19/15**	**DATE RECEIVED:**	**08/19/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	09/17/15	08/20/15	09/01/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.051	0.064	0.269
DUPLICATE	0.052	0.064	0.258
RPD	1.39%	0.40%	4.02%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.051	0.064	0.269
SPIKED SAMPLE	0.096	0.085	1.33
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	88.96%	103.62%	106.42%
QC CHECK			
FOUND	0.092	0.039	0.490
TRUE	0.094	0.039	0.490
% RECOVERY	97.87%	100.00%	100.00%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-69

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
8/24/15	4:20pm	SW	Bouth 5	1	1	1	1						
8/24/15	4:35pm	SW	Bouth 6	1	1	1	1						
8/24/15	4:47pm	SW	Bouth 7	1	1	1	1						
8/24/15	5:00	SW	Bouth 8	1	1	1	1						

LAB USE ONLY
Case File Number

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	8/24/15	5:57pm
Received By		
Relinquished to Aquatic By (Signature)		

Shipped By:
Shipping Reference:
Received at Aquatic By: 116 (4) Lot
Date: 8/25/15 Time: 11:30

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-69**	**PAGE 1**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/24/15**	**DATE RECEIVED:**	**08/25/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTH 5	0.110	0.002	2.44
BENTH 6	0.188	<0.001	3.73
BENTH 7	0.074	0.002	2.04
BENTH 8	0.123	<0.001	2.77

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-69**	**PAGE 2**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/24/15**	**DATE RECEIVED:**	**08/25/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	09/21/15	08/26/15	09/14/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.016	<0.001	0.243
DUPLICATE	0.015	<0.001	0.246
RPD	5.59%	NC	1.51%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.016	<0.001	0.243
SPIKED SAMPLE	0.065	0.022	1.26
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	98.83%	110.00%	101.27%
QC CHECK			
FOUND	0.094	0.040	0.475
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	102.56%	96.94%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-71

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	LAB USE ONLY: Containers Received	Case File Number: Temp	Lab ID
8/25/15	1:00	SCO	Bentk 5 (24hrs)	1	✓	✓	✓						
8/25/15	1:10	SCO	Bentk 6 (24hrs)	1	✓	✓	✓						
8/25/15	1:20	SCO	Bentk 7 (24hrs)	1	✓	✓	✓						
8/25/15	1:30	SCO	Bentk 8 (24hrs)	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	8/25/15	2:55
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By: | Shipping Reference:

Received at Aquatic By: [signature] | Date: 8/26/15 | Time: 10:30

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-71**		**PAGE 1**
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/25/15**	**DATE RECEIVED:**	**08/26/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTH 5	5.43	0.007	45.3
BENTH 6	0.059	<0.001	2.52
BENTH 7	0.072	<0.001	2.68
BENTH 8	0.056	<0.001	1.77

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-71**	**PAGE 2**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/25/15**	**DATE RECEIVED:**	**08/26/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	09/21/15	08/26/15	09/14/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.016	<0.001	0.243
DUPLICATE	0.015	<0.001	0.246
RPD	5.59%	NC	1.51%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.016	<0.001	0.243
SPIKED SAMPLE	0.065	0.022	1.26
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	98.83%	110.00%	101.27%
QC CHECK			
FOUND	0.094	0.040	0.475
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	102.56%	96.94%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15035-72
~~M15035-04~~

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
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Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

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Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TR	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
08/26/15	1345	SW	BENTHIC 5	1	✓	✓	✓						
08/26/15	1300	SW	BENTHIC 6	1	✓	✓	✓						
08/26/15	1315	SW	BENTHIC 7	1	✓	✓	✓						
08/26/15	1330	SW	BENTHIC 8	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

LAB USE ONLY
Case File Number

Comments:

	Date	Time
Sampled By: Jim Gawel	8/26/15	1600
Received By: Corey Kuch		
Relinquished to Aquatic By (Signature)		

Shipped By:
Shipping Reference:
Received at Aquatic By: Date 8/27/15 Time 10:30

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-72**	**PAGE 1**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/26/15**	**DATE RECEIVED:**	**08/27/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTHIC 5	76.8	0.043	512
BENTHIC 6	0.098	0.004	2.87
BENTHIC 7	0.079	0.004	4.87
BENTHIC 8	0.066	0.003	2.12

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-72**	**PAGE 2**	
REPORT DATE:	**10/12/15**		
DATE SAMPLED:	**08/26/15**	**DATE RECEIVED:**	**08/27/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	09/21/15	08/27/15	09/21/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BENTHIC 8	BATCH	BATCH
ORIGINAL	0.066	<0.001	0.331
DUPLICATE	0.065	<0.001	0.339
RPD	1.94%	NC	2.27%
SPIKE SAMPLE			
SAMPLE ID	BENTHIC 8	BATCH	BATCH
ORIGINAL	0.066	<0.001	0.331
SPIKED SAMPLE	0.116	0.022	1.52
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	100.24%	110.00%	118.91%
QC CHECK			
FOUND	0.094	0.040	0.455
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	102.56%	92.86%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15038-88

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: UW TACOMA
Address: 1900 COMMERCE ST. CAMPUS BOX 358436, TACOMA, WA 98402
Contact: JAMES GAWEL
Email: jimgawel@uw.edu
Phone: (253) 692-5815 Fax: (253) 692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☒ Email ☐ Mail

QC Data Reported
☒ Yes ☐ No

Sample Disposal
☐ Hold ☒ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

LAB USE ONLY
Containers Received
Case File Number
Temp
Lab ID

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Analysis Requested: PB	Analysis Requested: 3H	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
09-04-15		SD	WAUGHOP SEDIMENT 1	1	✓	✓						
↓		B	WAUGHOP PLANT 1	1	✓	✓						
		B	WAUGHOP PLANT 2	1	✓	✓						
↓		B	WAUGHOP PLANT 3	1	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
CORE KING	11-17-15	1:09 PM
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference
Received at Aquatic By	Date / Time
Paul Mc	11/18/15 3:30pm

(4) total RT

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-88**		**PAGE 1**
REPORT DATE:	**01/29/16**		
DATE SAMPLED:	**09/04/15**	**DATE RECEIVED:**	**11/18/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON SOIL AND PLANT SAMPLES FROM UW TACOMA

CASE NARRATIVE

Four solid samples were received by the laboratory in good condition. The water samples were analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. QA/QC data is retained by the laboratory.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/kg)	TOTAL-N (mg/kg)
WAUGHOP SEDIMENT 1	1820	10800
WAUGHOP PLANT 1	4420	31800
WAUGHOP PLANT 2	5115	8100
WAUGHOP PLANT 3	4280	5490

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MI5037-89
MI5035-04

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
09-14-15	127	SW	SURF.		✓	✓	✓						
09-14-15	128	SW	BOTTOM		✓	✓	✓						
09-14-15	128	SW	BOTTOM DUP		✓	✓	✓						
09-14-15	226	SW	BENTH 9 (2HRS)		✓	✓	✓						
09-14-15	244	SW	BENTH 10 (2HRS)		✓	✓	✓						
09-14-15	258	SW	BENTH 11 (2HRS)		✓	✓	✓						
09-14-15	310	SW	BENTH 12 (2HRS)		✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

	Date	Time
Sampled By: Jim Gawel	9/14/15	4:15 PM
Received By		
Relinquished to Aquatic By (Signature)		

Shipped By:
Shipping Reference:
Received at Aquatic By: [illegible] 16.8°
Date: 9/15/15 Time: 11:55

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-89**	**PAGE 1**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/14/15**	**DATE RECEIVED:**	**09/15/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Seven water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
SURF	0.103	0.008	2.42
BOTTOM	0.077	0.002	1.64
BOTTOM DUP	0.078	0.002	1.49
BENTH 9 (2 HRS)	1.17	0.002	8.89
BENTH 10 (2 HRS)	0.070	0.002	1.44
BENTH 11 (2 HRS)	0.119	0.002	2.57
BENTH 12 (2 HRS)	1.99	0.001	13.3

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-89**	**PAGE 2**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/14/15**	**DATE RECEIVED:**	**09/15/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/08/15	09/16/15	10/09/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	<0.001	0.952
DUPLICATE	0.015	<0.001	0.993
RPD	0.36%	NC	4.23%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	<0.001	0.952
SPIKED SAMPLE	0.068	0.021	1.81
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	106.08%	105.00%	85.62%
QC CHECK			
FOUND	0.097	0.041	0.506
TRUE	0.094	0.039	0.490
% RECOVERY	103.19%	105.13%	103.27%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS037-92

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format: ☐ Fax ☑ Email ☐ Mail

QC Data Reported: ☑ Yes ☐ No

Sample Disposal: ☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*: ☐ Next Day ☐ 2 Business Day ☐ 3 Business Day ☑ Standard

Specific Date:

*Advanced notice required for Rush Analysis

LAB USE ONLY
Containers Received
Case File Number
Temp° Lab ID

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)
9/15/15	1:45	SW	Benth 9 (24hrs)	1	✓	✓	✓			
9/15/15	1:58	SW	Benth 10 (24hrs)	1	✓	✓	✓			
9/15/15	2:11	SW	Benth 11 (24hrs)	1	✓	✓	✓			
9/15/15	2:24	SW	Benth 12 (24hrs)	1	✓	✓	✓			

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	9/15/15	3:15pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By: Shipping Reference:

Received at Aquatic By: 1:8° (-0)/04 Date: 9/16/15 Time: 10:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-92**	**PAGE 1**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/15/15**	**DATE RECEIVED:**	**09/16/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTH 9 (24 HRS)	0.066	0.002	3.27
BENTH 10 (24 HRS)	0.042	0.002	1.73
BENTH 11 (24 HRS)	0.477	0.003	6.25
BENTH 12 (24 HRS)	0.097	0.002	3.33

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-92**	**PAGE 2**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/15/15**	**DATE RECEIVED:**	**09/16/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/08/15	09/16/15	10/09/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	<0.001	0.952
DUPLICATE	0.015	<0.001	0.993
RPD	0.36%	NC	4.23%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	<0.001	0.952
SPIKED SAMPLE	0.068	0.021	1.81
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	106.08%	105.00%	85.62%
QC CHECK			
FOUND	0.097	0.041	0.506
TRUE	0.094	0.039	0.490
% RECOVERY	103.19%	105.13%	103.27%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

M15035-014/mw

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: University of Washington Tacoma
Address: 1900 Commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax:

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: Brown and Caldwell
Address:
Seattle, WA
Contact: Sharonne Park
Email: spark@BrwnCald.com
Phone: 206.749.2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☑ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	TN	SRP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
09-16-15	1:41PM	SW	BENTH 9 (48HRS)	1	✓	✓	✓						
09-16-15	1:55PM	SW	BENTH 10 (48HRS)	1	✓	✓	✓						
09-16-15	2:07PM	SW	BENTH 11 (48 HRS)	1	✓	✓	✓						
09-16-15	2:18PM	SW	BENTH 12 (48 HRS)	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Jim Gawel	9/16/15	4:24 PM
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By 0330
Date 9/17/15 Time 11:30

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-93**	**PAGE 1**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/16/15**	**DATE RECEIVED:**	**09/17/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Four water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
BENTH 9 (48 HRS)	0.126	0.003	3.34
BENTH 10 (48 HRS)	0.070	0.004	2.72
BENTH 11 (48 HRS)	1.29	0.191	16.0
BENTH 12 (48 HRS)	0.106	0.004	3.25

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-93**	**PAGE 2**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/16/15**	**DATE RECEIVED:**	**09/17/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/08/15	09/18/15	10/09/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	0.008	0.952
DUPLICATE	0.015	0.008	0.993
RPD	0.36%	0.45%	4.23%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	0.008	0.952
SPIKED SAMPLE	0.068	0.027	1.81
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	106.08%	98.64%	85.62%
QC CHECK			
FOUND	0.097	0.040	0.506
TRUE	0.094	0.039	0.490
% RECOVERY	103.19%	102.56%	103.27%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS035-04

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: JAMES GAWEL / UW TACOMA
Address: 1900 COMMERCE ST. CAMPUS BOX 358436, TACOMA, WA 98402
Contact: JAMES GAWEL
Email: JIMGAWEL@UW.EDU
Phone: 253 692-5815 Fax: 253 692 4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

LAB USE ONLY
Containers Received
Case File Number

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Analysis Requested: FRP	SRP	TP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
09/17/15	1043	SW	STORMWATER	1	1	1	1						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
[signature]	9/17/15	1:45 PM

Received By	Date	Time

Relinquished to Aquatic By (Signature)	Date	Time

Shipped By:
Shipping Reference:
Received at Aquatic By: [signature] (1) 10L 14.1°
Date: 9/17/15 Time: 4:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-96**	**PAGE 1**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/17/15**	**DATE RECEIVED:**	**09/17/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

One water sample was received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
STORMWATER	0.094	0.032	0.860

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS037-96**	**PAGE 2**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/17/15**	**DATE RECEIVED:**	**09/17/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/08/15	09/18/15	10/09/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	0.008	0.952
DUPLICATE	0.015	0.008	0.993
RPD	0.36%	0.45%	4.23%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.015	0.008	0.952
SPIKED SAMPLE	0.068	0.027	1.81
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	106.08%	98.64%	85.62%
QC CHECK			
FOUND	0.097	0.040	0.506
TRUE	0.094	0.039	0.490
% RECOVERY	103.19%	102.56%	103.27%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: UW TACOMA
Address: 1900 COMMERCE ST
CAMPUS BOX 358436, TACOMA, WA 98402
Contact: JAMES GAWEL
Email: JIMGAWEL@UW.EDU
Phone: 253 692 5815 Fax: 253 692 4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client: BROWN AND CALDWELL
Address: SEATTLE, WA
Contact: SHARONNE PARK
Email: SPARK@BROWNCALD.COM
Phone: 206 749 2892 Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

LAB USE ONLY
Case File Number

Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TSS	SRP	TP	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
09-22-15	1348	GW	GW-5	1	✓	✓	✓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
COREY KING	9/22/15	1430
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference	
Received at Aquatic By	Date	Time
9.0° (1) tot	9/23/15	10:00

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-08**	**PAGE 1**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/22/15**	**DATE RECEIVED:**	**09/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

One water samples was received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
GW-5	0.039	0.016	0.560

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-08**	**PAGE 2**	
REPORT DATE:	**10/22/15**		
DATE SAMPLED:	**09/22/15**	**DATE RECEIVED:**	**09/23/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/17/15	09/25/15	10/17/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	GW-5
ORIGINAL	0.073	0.005	0.560
DUPLICATE	0.075	0.005	0.550
RPD	2.86%	2.20%	1.76%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	GW-5
ORIGINAL	0.073	0.005	0.560
SPIKED SAMPLE	0.125	0.025	1.58
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	103.85%	97.19%	101.77%
QC CHECK			
FOUND	0.094	0.039	0.490
TRUE	0.094	0.039	0.490
% RECOVERY	100.11%	100.72%	100.00%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MIS 038-17

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: James Gawel / UW Tacoma
Address: 1900 commerce St.
Campus Box 358436, Tacoma, WA 98402
Contact: James Gawel
Email: jimgawel@uw.edu
Phone: 253-692-5815 Fax: 253-692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	TP	SRP	TN	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Case File Number Temp	Lab ID
9/28/15	12:07	SW	Surf	1	↓	↓	↓						
9/28/15	12:08	SW	Bottom-A	1	↓	↓	↓						
9/28/15	12:09	SW	Bottom-B	1	↓	↓	↓						

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
James Gawel	9/28/15	2:32pm

Received By	Date	Time

Relinquished to Aquatic By (Signature)	Date	Time

Shipped By:
Shipping Reference:
Received at Aquatic By: (3) Lot 6.9°
Date: 9/28/15 Time: 4:30

LAB USE ONLY

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-17**	**PAGE 1**	
REPORT DATE:	**11/05/15**		
DATE SAMPLED:	**09/28/15**	**DATE RECEIVED:**	**09/28/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
SURF	0.085	0.004	1.92
BOTTOM-A	0.077	0.004	1.88
BOTTOM-B	0.076	0.003	1.82

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-17**		**PAGE 2**
REPORT DATE:	**11/05/15**		
DATE SAMPLED:	**09/28/15**	**DATE RECEIVED:**	**09/28/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/22/15	10/01/15	10/20/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.036	0.028	0.387
DUPLICATE	0.038	0.028	0.401
RPD	5.13%	0.31%	3.53%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.036	0.028	0.387
SPIKED SAMPLE	0.087	0.047	1.50
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	101.24%	96.29%	111.81%
QC CHECK			
FOUND	0.093	0.041	0.458
TRUE	0.094	0.039	0.490
% RECOVERY	98.94%	105.13%	93.47%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MI5038-37

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

Page ____ of ____

REPORT TO:
Client: JAMES GAWEL / UW TACOMA
Address: 1900 COMMERCE ST. CAMPUS BOX 358436, TACOMA, WA 98402
Contact: JAMES GAWEL
Email: JIM GAWEL @ UW.EDU
Phone: (253) 692-5815 Fax: (253) 692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	F	~~[redacted]~~ on SRP	F											Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	LAB USE ONLY: Containers Received	Case File Number: Temp	Case File Number: Lab ID
10-07-15	0910	SW	STORMWATER	1	✓	✓	✓																

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
[signature]	10/7/15	1007

Received By	Date	Time

Relinquished to Aquatic By (Signature)	Date	Time

Shipped By	Shipping Reference

Received at Aquatic By	Date	Time
[signature] (1) tot 14.5°	10/7	4:55

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-37**	**PAGE 1**	
REPORT DATE:	**11/05/15**		
DATE SAMPLED:	**10/07/15**	**DATE RECEIVED:**	**10/07/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

One water sample was received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of this sample. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
STORMWATER	0.369	0.136	0.925

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LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-37**	**PAGE 2**	
REPORT DATE:	**11/05/15**		
DATE SAMPLED:	**10/07/15**	**DATE RECEIVED:**	**10/07/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	10/31/15	10/08/15	11/02/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.010	0.002	0.175
DUPLICATE	0.010	0.002	0.178
RPD	0.00%	0.00%	1.70%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.010	0.002	0.175
SPIKED SAMPLE	0.062	0.019	1.14
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	104.00%	85.00%	96.50%
QC CHECK			
FOUND	0.093	0.039	0.509
TRUE	0.094	0.039	0.490
% RECOVERY	98.94%	100.00%	103.88%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

Damien Gadomski

Damien Gadomski
Project Manager

MI5038-41

Page ____ of ____

IEH - Aquatic Research
3927 Aurora Ave N • Seattle • WA • 98103
P: 206-632-2715 F: 206-632-2417

Chain of Custody Form

REPORT TO:
Client: James Gawel / UW Tacoma
Address: 1900 Commerce ST
Campus Box 3584436, Tacoma WA 98402
Contact: James Gawel
Email: jlmgawel@uw.edu
Phone: 253-692-5815 Fax: 253-692-4639

INVOICE TO: (IF DIFFERENT FROM REPORT)
Client:
Address:
Contact:
Email:
Phone: Fax:

PROJECT INFORMATION
Quote No.:
Client PO:
Client Project:

Reporting/Invoicing Format
☐ Fax ☑ Email ☐ Mail

QC Data Reported
☑ Yes ☐ No

Sample Disposal
☐ Hold ☑ Dispose ☐ Return

Turn Around Time (TAT)*
☐ Next Day ☐ 2 Business Day
☐ 3 Business Day ☐ Standard

Specific Date:
*Advanced notice required for Rush Analysis

LAB USE ONLY
Containers Received
Case File Number
Temp
Lab ID

SAMPLING Date (mm-dd-yy)	Time	Matrix**	SAMPLE DESCRIPTION (This Will Appear On The Report)	Number of Containers	Analysis Requested: Pb	SRP	TN	Field pH (if applicable)	Field Temp (if applicable)	Metals Field Filtered (Y/N)	Containers Received	Temp	Lab ID
10/13/15	1:21	SW	Surface	1									
10/13/15	1:30	SW	Bottom-A	1									
10/13/15	1:30	SW	Bottom-B	1									

**Matrix: B=Biota, DW=Drinking Water, GW=Ground Water, P=Paint, S=Soil, SD=Sediment, SL=Sludge, SW=Surface Water, WW=Wastewater

Comments:

Sampled By	Date	Time
Kheem A. [illegible]	10/13/15	3:40 pm
Received By	Date	Time
Relinquished to Aquatic By (Signature)	Date	Time

Shipped By
Shipping Reference
Received at Aquatic By (3)lot 14.4°
Date 10/14
Time 12:20

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-41**	**PAGE 1**	
REPORT DATE:	**11/05/15**		
DATE SAMPLED:	**10/13/15**	**DATE RECEIVED:**	**10/14/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

CASE NARRATIVE

Three water samples were received by the laboratory in good condition and analyzed according to the chain of custody. No difficulties were encountered in the preparation or analysis of these samples. Sample data follows while QA/QC data is contained on the subsequent page.

SAMPLE DATA

SAMPLE ID	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
SURFACE	0.070	0.002	1.58
BOTTOM-A	0.058	0.002	1.43
BOTTOM-B	0.063	0.001	1.27

IEH ANALYTICAL LABORATORIES

LABORATORY & CONSULTING SERVICES

3927 AURORA AVENUE NORTH, SEATTLE, WA 98103

PHONE: (206) 632-2715 FAX: (206) 632-2417

CASE FILE NUMBER:	**MIS038-41**	**PAGE 2**	
REPORT DATE:	**11/05/15**		
DATE SAMPLED:	**10/13/15**	**DATE RECEIVED:**	**10/14/15**

FINAL REPORT, LABORATORY ANALYSIS OF SELECTED PARAMETERS ON WATER SAMPLES FROM GAWEL - UWT

QA/QC DATA

QC PARAMETER	TOTAL-P (mg/L)	SRP (mg/L)	TOTAL-N (mg/L)
METHOD	SM18 4500PF	SM18 4500PF	SM204500NC
DATE ANALYZED	11/04/15	10/14/15	11/02/15
REPORTING LIMIT	0.002	0.001	0.050
DUPLICATE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.093	0.028	0.175
DUPLICATE	0.092	0.027	0.178
RPD	1.29%	0.68%	1.70%
SPIKE SAMPLE			
SAMPLE ID	BATCH	BATCH	BATCH
ORIGINAL	0.093	0.028	0.175
SPIKED SAMPLE	0.149	0.048	1.14
SPIKE ADDED	0.050	0.020	1.00
% RECOVERY	112.10%	104.10%	96.50%
QC CHECK			
FOUND	0.094	0.042	0.509
TRUE	0.094	0.039	0.490
% RECOVERY	100.00%	107.69%	103.88%
BLANK	<0.002	<0.001	<0.050

RPD = RELATIVE PERCENT DIFFERENCE.
NA = NOT APPLICABLE OR NOT AVAILABLE.
NC = NOT CALCULABLE DUE TO ONE OR MORE VALUES BEING BELOW THE DETECTION LIMIT.
OR = RECOVERY NOT CALCULABLE DUE TO SPIKE SAMPLE OUT OF RANGE OR SPIKE TOO LOW RELATIVE TO SAMPLE CONCENTRATION.

SUBMITTED BY:

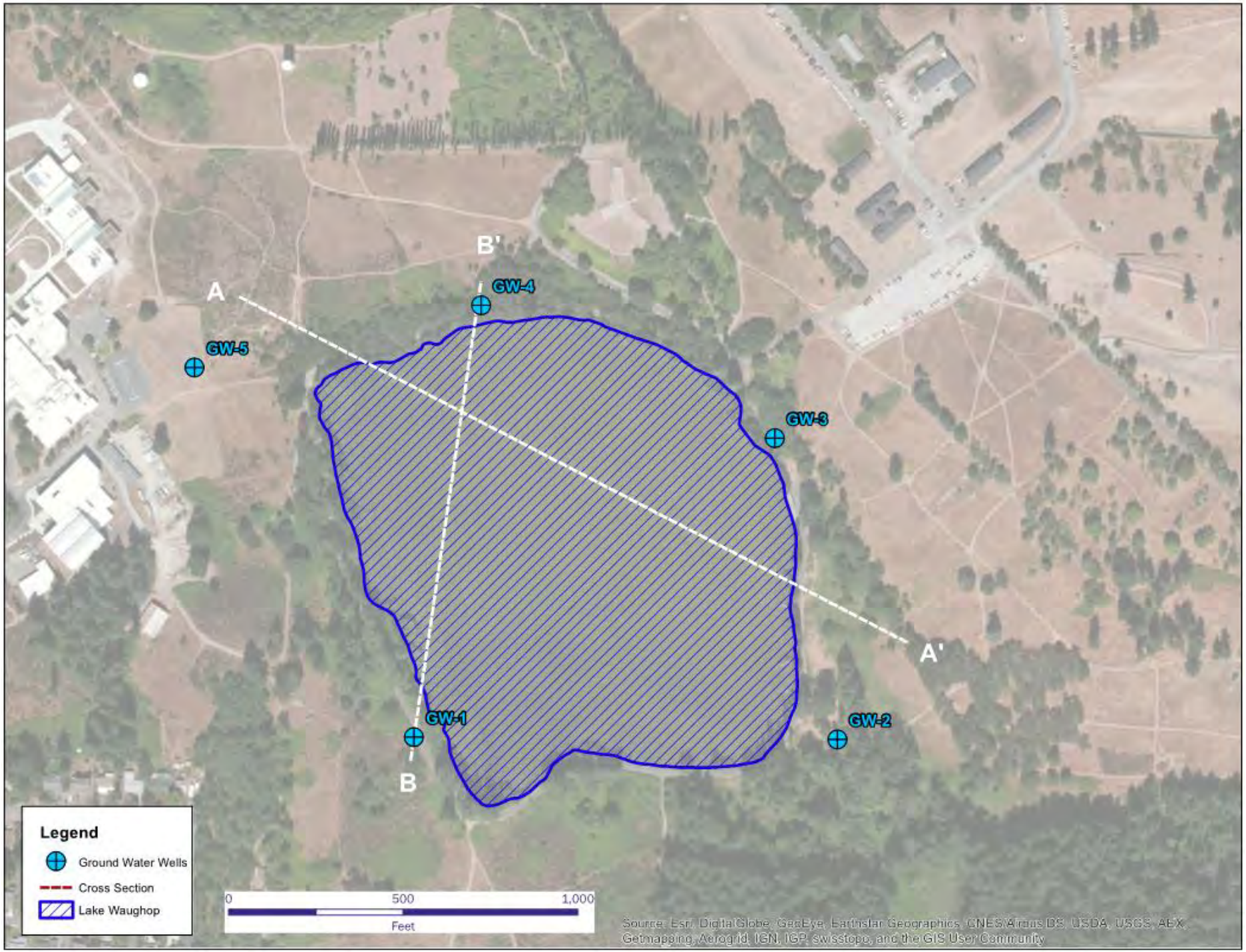
Damien Gadomski

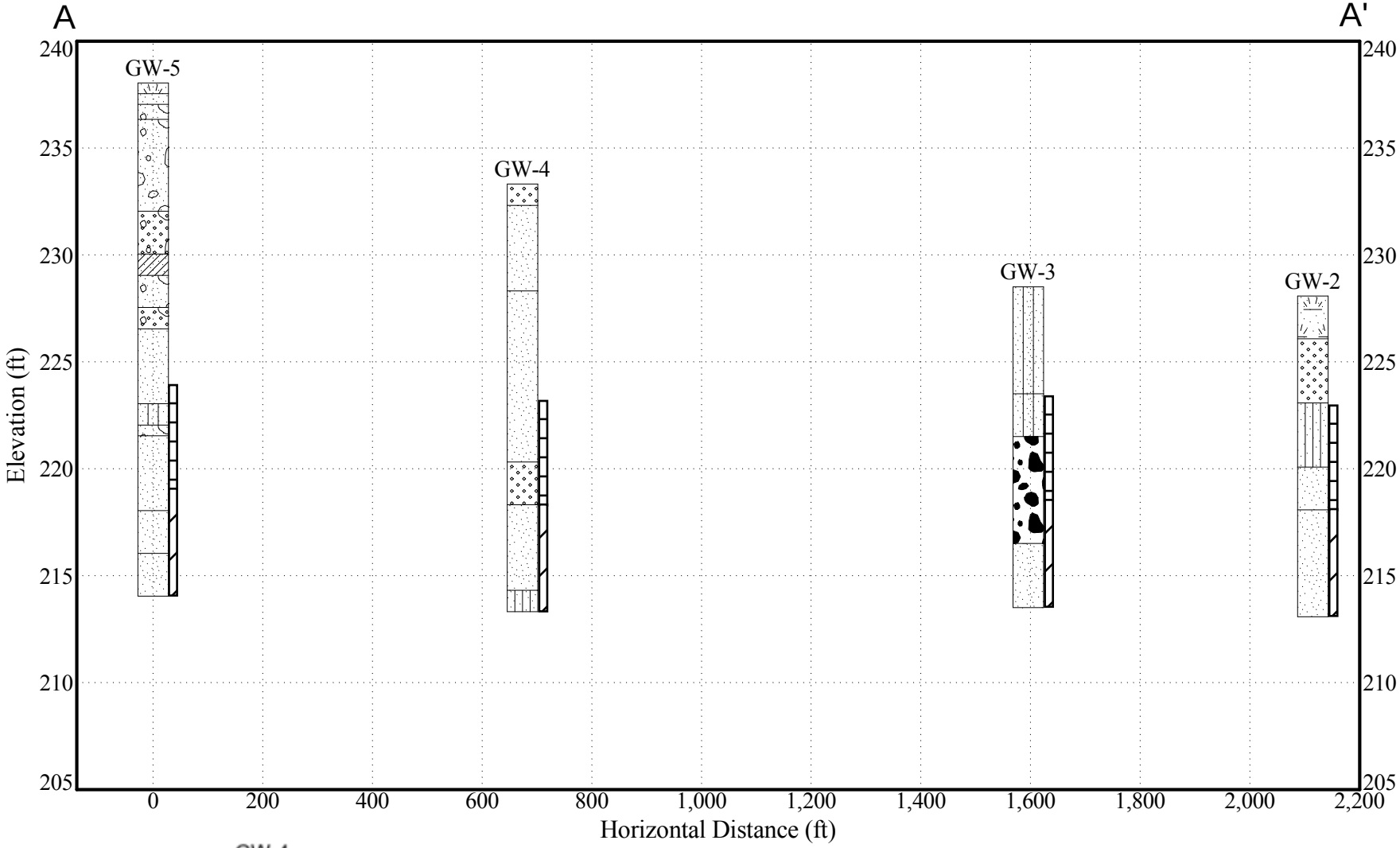
Damien Gadomski
Project Manager

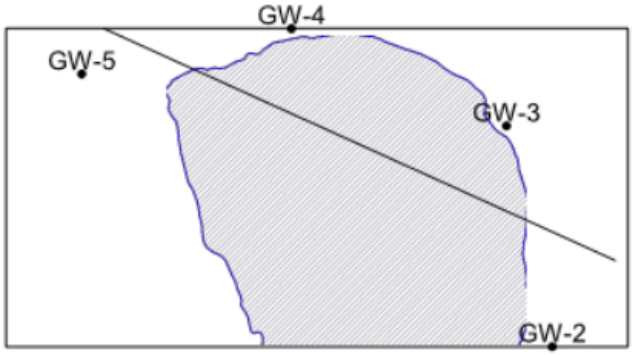
Appendix C: Monitoring Well Logs and Geologic Cross Section Diagrams

This appendix contains copies of the monitoring well logs from the 2014–15 monitoring study.

Use of contents on this sheet is subject to the limitations specified at the end of this document.


B'
A
GW-4
GW-5
GW-3
A'
GW-1
GW-2
B
Legend
Ground Water Wells
Cross Section
Lake Waughop
0
500
1,000
Feet
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



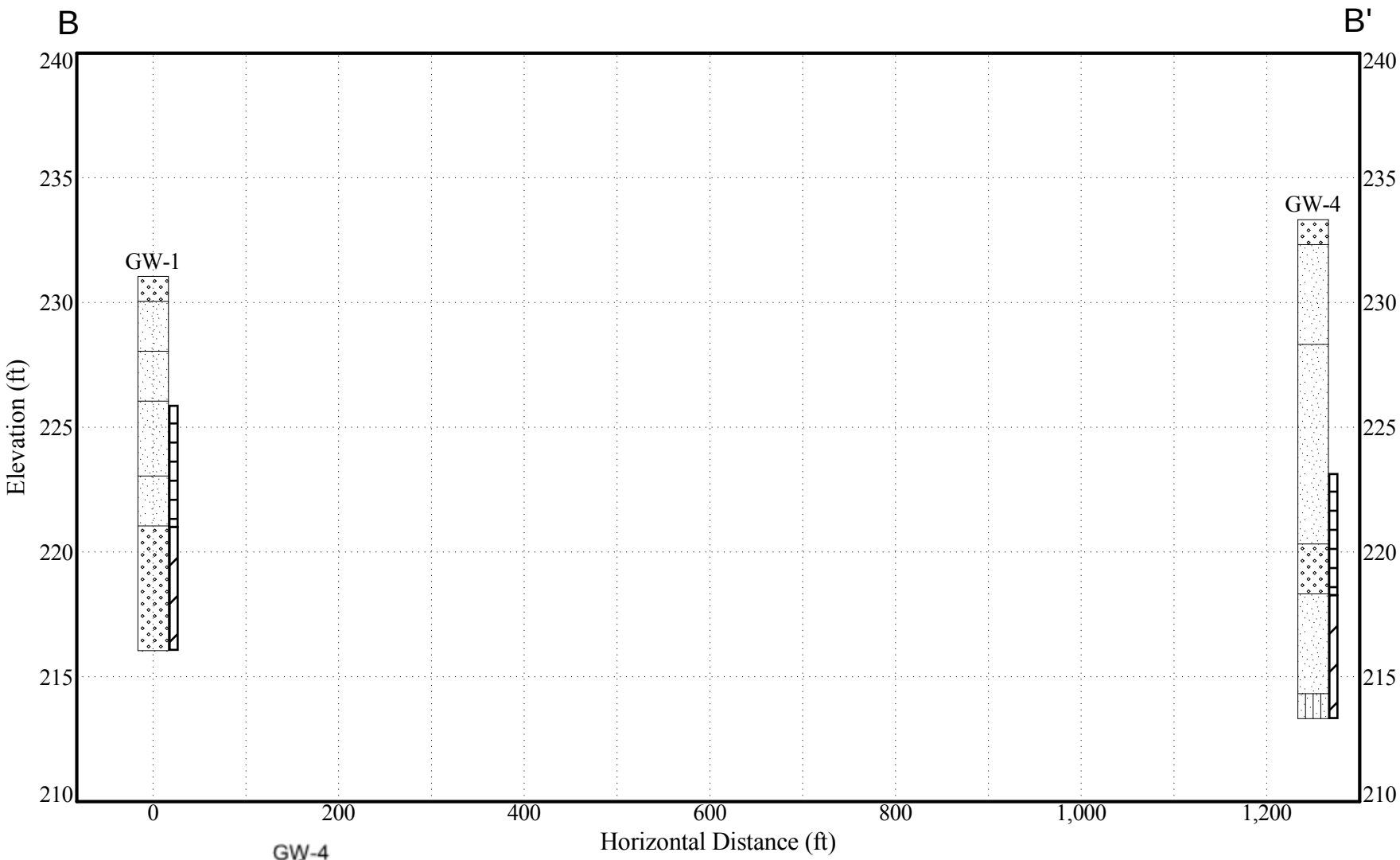


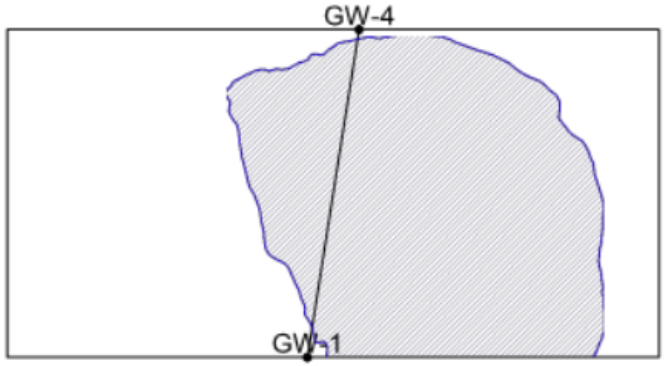
LEGEND

- Topsoil
- USCS Poorly-graded Sand
- USCS Poorly-graded Gravelly Sand
- 10 slot screen
- USCS Well-graded Sand
- USCS Silty Sand
- USCS Well-graded Gravelly Sand
- Prepacked screen
- USCS Sandy Silt
- USCS Well-graded Gravel
- USCS Low Plasticity Sandy Clay

BROWN AND CALDWELL

Cross Section Diagram		
Waughop Lake Management Plan Waughop Lake		
PROJECT NO.: 146081	DATE: March 10th, 2015	FIGURE:





LEGEND

- USCS Well-graded Sand
- USCS Poorly-graded Sand
- USCS Sandy Silt
- 10 slot screen
- Prepacked screen

BROWN AND CALDWELL

Cross Section Diagram		
Waughop Lake Management Plan Waughop Lake		
PROJECT NO.: 146081	DATE: March 10th, 2015	FIGURE:

BROWN AND CALDWELL

GW-1

Project Name: **Waughop Lake Management Plan** Project Number: **146081** Sheet **1** of **1**

Project Location: **Waughop Lake**		Logged By: **S. Park**	Checked By:
Drilling Contractor: **ESN**		Date Started: **11/10/14**	Date Finished: **11/10/14**
Drilling Equipment:	Driller: **ESN**	Total Boring Depth: (feet) **15.0**	Depth to Static Water: (feet) **10.00**
Drilling Method: **Geoprobe**	Borehole Diameter: **4"**	TOC Elevation(ft): **231.05**	Ground Elevation(ft): **231.05**
Sampling Method:		Diameter and Type of Well Casing: **2" Schedule 40 PVC**	
Comments:		Slot Size: **0.010"**	Filter Material: **10/20 sand**
		Development Method:	

Depth (feet)	Depth to Water	USC Soil Type	Lithology	Description	PID Readings	Sampled Interval	Recovery (feet)	Sample ID	Remarks
		SW		SAND. Fine to coarse sand with some silt; dark brown; moist.					1.0 Concrete
2		SP		SAND. Fine to medium sand with some silt, little gravel; red-brown.			2.5		3.0 Bentonite
4		SP		SAND. Fine to medium sand with trace gravel; tan.					
6		SP		SAND. Fine to medium sand with some silt and trace gravel; tan.			3.8		10 slot screen 5'-10'
8		SP		SAND. Fine sand with little silt and trace gravel; moist.					
10	▽	SW		SAND. Fine to coarse sand with little silt and gravel; tan; wet at 10'.			5.0		Prepacked screen 10'-15'
12									
14									15.0

This log should not be used separately from the original report.

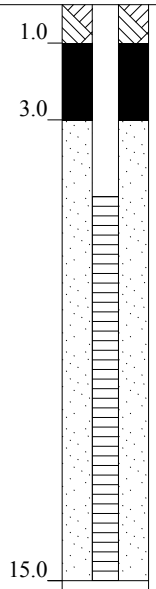
BROWN AND CALDWELL

GW-2

Project Name: **Waughop Lake Management Plan** Project Number: **146081** Sheet **1** of **1**

Project Location: **Waughop Lake**		Logged By: **S. Park**	Checked By:
Drilling Contractor: **ESN**		Date Started: **11/10/14**	Date Finished: **11/10/14**
Drilling Equipment:	Driller: **ESN**	Total Boring Depth: (feet) **15.0**	Depth to Static Water: (feet) **10.00**
Drilling Method: **Geoprobe**	Borehole Diameter: **4"**	TOC Elevation(ft): **228.08**	Ground Elevation(ft): **228.08**
Sampling Method:		Diameter and Type of Well Casing: **2" Schedule 40 PVC**	
Comments:		Slot Size: **0.010"**	Filter Material: **10/20 sand**
		Development Method:	

Depth (feet)	Depth to Water	USC Soil Type	Lithology	Description	PID Readings	Sampled Interval	Recovery (feet)	Sample ID	Remarks
				TOPSOIL. Organic matter, SILT, fine to coarse sand, and gravel. FILL at 2'; brick.			1.5		
2		SW		SAND. Fine to coarse sand with little silt and gravel; dark brown.					
4									
6				SILT. Silt with fine sand; dark brown; wet at 10'.			3.0		
8		SP		SAND. Fine to medium with trace oxidized roots; gray.					
10	▽	SP		SAND. Fine to medium sand with trace oxidized roots; gray. At 15' fine SAND and silt; light gray.			5.0		
12									
14									



This log should not be used separately from the original report.

BROWN AND CALDWELL

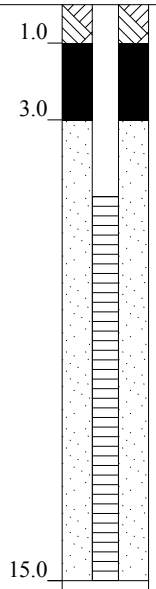
GW-3

Project Name: **Waughop Lake Management Plan** Project Number: **146081** Sheet **1** of **1**

Project Location: **Waughop Lake**		Logged By: **S. Park**	Checked By:
Drilling Contractor: **ESN**		Date Started: **11/10/14**	Date Finished: **11/10/14**
Drilling Equipment:	Driller: **ESN**	Total Boring Depth: (feet) **15.0**	Depth to Static Water: (feet) **7.00**
Drilling Method: **Geoprobe**	Borehole Diameter: **4"**	TOC Elevation(ft): **228.51**	Ground Elevation(ft): **228.51**
Sampling Method:		Diameter and Type of Well Casing: **2" Schedule 40 PVC**	
Comments:		Slot Size: **0.010"**	Filter Material: **10/20 sand**
		Development Method:	

Depth (feet)	Depth to Water	USC Soil Type	Lithology	Description	PID Readings	Sampled Interval	Recovery (feet)	Sample ID
2, 4		SM		Silty SAND. Silt and fine to coarse sand with little gravel; dark brown.			2.0	
6		SM		Silty SAND. Silt and fine to coarse sand, little gravel.			2.5	
6–8	▽	GW		GRAVEL. Gravel with little coarse sand; wet.			5.0	
12, 14		SP		SAND. Fine sand with silt; gray.				

Remarks



This log should not be used separately from the original report.

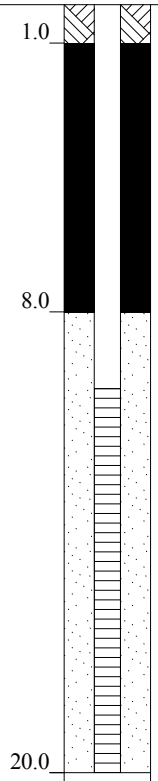
BROWN AND CALDWELL

GW-4

Project Name: **Waughop Lake Management Plan** Project Number: **146081** Sheet **1** of **1**

Project Location: **Waughop Lake**		Logged By: **S. Park**	Checked By:
Drilling Contractor: **ESN**		Date Started: **11/10/14**	Date Finished: **11/10/14**
Drilling Equipment:	Driller: **ESN**	Total Boring Depth: (feet) **20.0**	Depth to Static Water: (feet) **12.30**
Drilling Method: **Geoprobe /auger**	Borehole Diameter: **4"**	TOC Elevation(ft): **233.32**	Ground Elevation(ft): **233.32**
Sampling Method:		Diameter and Type of Well Casing: **2" Schedule 40 PVC**	
Comments:		Slot Size: **0.010"**	Filter Material: **10/20 sand**
		Development Method:	

Depth (feet)	Depth to Water	USC Soil Type	Lithology	Description	PID Readings	Sampled Interval	Recovery (feet)	Sample ID
		SW		SAND. Fine to coarse sand with little silt and gravel and organics; brown.				
2		SP		SAND. Medium sand; tan; moist.			2.5	
4								
6		SP		SAND. Fine to medium sand with little gravel; gray; moist.			3.0	
8								
10								
12	▽						3.8	
14		SW		SAND. Fine to coarse sand with some gravel and little silt gray; wet at 14'.				
16		SP		SAND. Coarse sand with little gravel; gray; wet.			5.0	
18								
20				Sandy SILT. Silt and medium sand; gray.				



Remarks

Concrete

Bentonite

10 slot screen 10'-15'

Prepacked screen 15'-20'

This log should not be used separately from the original report.

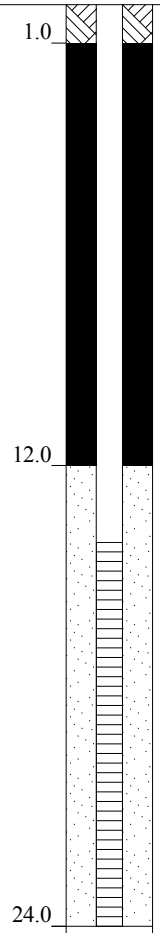
BROWN AND CALDWELL

GW-5

Project Name: **Waughop Lake Management Plan** Project Number: **146081** Sheet **1** of **1**

Project Location: **Waughop Lake**		Logged By: **J. Bethune**	Checked By:
Drilling Contractor: **ESN**		Date Started: **11/10/14**	Date Finished: **11/10/14**
Drilling Equipment:	Driller: **ESN**	Total Boring Depth: (feet) **24.0**	Depth to Static Water: (feet) **17.00**
Drilling Method: **Geoprobe**	Borehole Diameter: **4"**	TOC Elevation(ft): **238.04**	Ground Elevation(ft): **238.04**
Sampling Method:		Diameter and Type of Well Casing: **2" Schedule 40 PVC**	
Comments:		Slot Size: **0.010"**	Filter Material: **10/20 sand**
		Development Method:	

Depth (feet)	Depth to Water	USC Soil Type	Lithology	Description	PID Readings	Sampled Interval	Recovery (feet)	Sample ID	Remarks
				TOPSOIL.					
		SP		SAND. Poorly graed, fine sand with trace coarse sand and 10% silt; brown; moist.			2.5		
2				Gravelly SAND. 70% fine sand, 20% gravel to 1", 10% silt; brown; moist.					
4				Gravelly SAND. 70% fine sand, 30% gravel to 1.5"; gray; moist.					
6				Gravelly SAND. 60% well graded, fine to coarse sand, 40% gravel; gray; moist.			5.0		
8				Sandy CLAY. Clay with 40% sand; low plasticity, low toughness; brown; moist.					
10				Gravelly SAND. 60% fine to medium sand, 40% gravel to 1"; gray; moist.					
				Gravelly SAND. 70% well graded, fine to coarse sand, 20% gravel to 0.5", 10% silt; gray; moist.			5.0		
12		SP		SAND. Fine sand with silt and trace pea-sized gravel, 10% silt; gray; moist.					
14									
		SM		Silty SAND. 80% fine to medium sand, 20% silt, trace coarse sand; gray; moist.					
16							5.0		
	▽	SP		Gravelly SAND. 80% fine to medium sand, 20% gravel to 1"; gray; moist.					
18				SAND. Poorly graded, fine sand with 10% silt and trace gravel; wet at 17'. 2" layer of gravel at 18'.					
20		SP		SAND. Poorly graded, fine sand with trace silt and pea-sized gravel; wet.			4.0		
22		SP		SAND. Poorly graded, fine to medium sand with trace silt and gravel; wet.					
24									



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Appendix D: Management Measures Fact Sheets

This appendix contains a copy of the preliminary management measures matrix and fact sheets.

Use of contents on this sheet is subject to the limitations specified at the end of this document.

Waughop Lake Management Options for Control of Algae											
Option	Description	Required Infrastructure	Planning Level Cost Estimates1		Water Quality Benefit2	How Soon Will WQ Benefit Occur?	How Long Will WQ Benefit last?	Other Potential Benefits?	Other Potential Impacts/Costs?	What Pre-design Work Would be Needed?	Comments
			Initial	Ongoing							
1. Lake aeration and mixing	Inject air near lake bottom to create vertical currents that disrupt cyanobacteria and also reduce P release from sediment under anoxic conditions.	Small building with blowers, plastic pipes on lake bottom, etc.	$1.9M	$20K	High. Reduce P release from sediment, disrupt blue greens, increase dissolved oxygen for fish.	2 years	Long-term	Few conflicts with other uses. Increased DO should improve fish habitat.	Blower building would be required. Energy use.	Site survey, geotech, etc.	Operate 8 mos./yr
2. Dredging	Remove P enriched sediment (approx. 100 cm thick) from bottom of the 33 acre lake.	Varies based on type of dredging and whether on-site disposal is feasible.									
2.b."Wet" excavation	Use mechanical dredge to remove ~121,000 cy of sediment. Costs may vary substantially depending on whether sediment can be disposed on site and other factors. Lower cost if passive dewatering and on-site disposal. Higher cost if mechanical dewatering and off-site disposal are required.	Temporary pipes, mechanical dewatering system, and stockpile/dewatering area; temporary treatment facility for water draining from dredge spoils.	On-site disposal: $3.2M to $12.0M Off-site disposal: $9.0M to $17.9M	None	Highest. Would remove ~100 years of P enriched sediment	<1 year	Long-term	Increased lake depth, more groundwater inflow, more fish habitat	Habitat disturbance during dredging. Odor from dredge spoils. On-site dewatering/ disposal would require large area. Equipment staging on shoreline.	Sediment cores, % solids, chemical testing to determine disposal requirements	Passive dewatering impractical due to volume, odor. Disposal costs assume sediment is not hazardous.
2.c. Hydraulic removal	Use hydraulic dredge to remove ~121,000 cy of sediment. Costs may vary substantially depending on whether sediment can be disposed on site and other factors. Lower cost if passive dewatering and on-site disposal. Higher cost if mechanical dewatering and off-site disposal are required.	Temporary pipes, mechanical dewatering system, and stockpile/dewatering area; temporary treatment facility for water draining from dredge spoils.	On-site disposal: $2.7M to $9.4M Off-site disposal: $8.5M to $15M	None	Highest. Would remove ~100 years of P enriched sediment	<1 year	Long-term	Increased lake depth, more groundwater inflow, more fish habitat	Habitat disturbance during dredging (but less than mechanical). Odor from dredge spoils. On-site disposal would require large area.	Sediment cores, % solids, chemical testing to determine disposal requirements	Passive dewatering impractical due to volume, odor. Disposal costs assume sediment is not hazardous.
3. Phosphorus Inactivation	Add ~20,000 gallons of alum and ~10,000 gallons of sodium aluminate to remove P from water column and form layer on sediment. A lower dose may be needed every 3 to 10 years.	None	$210K for prep and initial treatment	$120K every 3 to 10 yrs	High initially, slow decline over time	Immediate	3-10 years	Minimal infrastructure, no conflicts with other lake uses	Could increase macrophyte growth. Would need to be repeated every 3-10 yrs.	Jar testing	May wish to consider macrophyte removal before treatment.
4. Pump and treat system	Pump water from lake, treat to remove P, return treated water to lake.									Sediment and water column testing to estimate future treatment needs.	Need for treatment may diminish over time.
4.a. Chemical treatment	Pump water from lake, add coagulant to remove P, return treated water to lake.	Intake and discharge pipes, pumps, chemical storage tank, small equipment structure settling pond	$1.5M	$80K/yr	Medium	1 year	Long-term	Flexible operation. Higher treatment capacity than wetland treatment system. Learning opportunity for college students.	Would require ~3 acres of land. Temporary impacts during construction.	Jar testing, floc dewatering testing, survey and geotech.	Run system ~6 mos./yr. Cost estimate assumes treatment facility can be sited within 1,000 ft of lake. Could combine with small wetland treatment system.
4.b. Constructed wetland	Pump water from lake, treat in a ~8-acre wetland system, discharge treated water to lake.	Intake and discharge pipes, pumps, constructed wetland	$3.1M	$100K/yr	Medium	1 year	Long-term	Flexible operation. Increased habitat for birds and other wildlife. Learning opportunity for college students.	Would require ~9 acres of land. Temporary impacts during construction.	Survey and geotech	Run system ~6 mos./yr. Cost estimate assumes treatment wetland can be sited within 1,000 ft of lake.

Notes:

[1] Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE) Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions. See attached.

[2] Long-term lake monitoring is recommended to evaluate the effectiveness of the selected lake management measure(s).

Lake Aeration and "Vigorous Mixing"	
Description	Inject air near lake bottom to (1) avoid anoxic conditions that foster P release from sediment, and (2) create vertical currents that disrupt cyanobacteria.
Objectives	Reduce P release from sediment, physically disrupt cyanobacteria
Initial planning level cost estimate[1]	$1.9M
Estimated annual operation and maintenance cost[2]	$20,000
Basis for preliminary sizing	200-12" diffusers, spaced approximately 10x the water depth apart
Water quality benefit[3]	High. Reduce P release from sediment, disrupt blue greens, increase dissolved oxygen for fish.
Approximate time to see water quality benefit	2 years
Duration/frequency	Long-term. Operate 8 mos/yr initially and adjust based on lake response.
Other potential benefits	Few conflicts with other uses. Increased DO should improve fish habitat.
Other potential impacts/costs	Blower building would be required. Energy use.
Required infrastructure	Small building with blowers, plastic pipes on lake bottom, etc.
Pre-design work needed	Site survey including bathymetery, geotech, etc.
Additional comments	Operate 8 mos./yr initially; adjust as needed based on lake response.

Basis of design/assumptions

Item	Units	Unit	Cost per Unit	Cost (1,000s)	Assumptions
Site Work					
Site Grading	lsum	1	$ 5,000	$ 5	
Building	sq ft	400	$ 210	$ 84	25.5 ft by 15.5 ft
Buried piping	lf	600	$ 70	$ 42	2-inch ID, Type 316 SST schedule 40; backfill with native
VEM manifolds	lf	16,300	$ 30	$ 489	2x2" HDPE, weights at 20' c-c
VEM 12-inch diameter diffusers	each	200	$ 240	$ 48	EDI Flexible Membrance plus dedicated pressure regulator for each diffuser, cost includes diver installation
			Subtotal	$ 668	
Mechanical					
Compressor	each	2	$ 20,000	$ 40	250 scfm each; 40 hp
Compressor installation	each	2	$ 2,500	$ 5	
Receiver	each	2	$ 4,500	$ 9	Two 500-gal galv steel tanks, incl. welds, straps, crane rent
Ventilation Fans	each	2	$ 3,000	$ 6	
Air manifold	each	1	$ 40,000	$ 40	Includes pressure regulators, isolation valves, and thermal mass flow meters
		Mechanical Subtotal		**$ 100**	
Electrical					
Electrical Service	each	1			600 amps, interior
Electrical Equipment	each	1			
Wiring	each	1			
EIC - Allowance	lsum	1	#######	$ 100	This includes all items above and SCADA/I&C
SCADA	each	1			
		Electrical Subtotal		**$ 100**	
		Construction Subtotal		**$ 868**	
Contractor's Mobilization/Overhead	percent	10	--	$ 087	
			Subtotal	**$ 955**	
Contractor's Mark Ups	percent	10	--	$ 095	
			Subtotal	**$ 1,050**	
Contingency	percent	40	--	$ 420	
			Subtotal	**$ 1,470**	
Contractor's Bonding and Insurance	percent	5	--	$ 074	
			Subtotal	**$ 1,544**	
Allowances	percent	20		$ 309	Engineering, Legal, Admin
		Total Capital Cost		$ 1,853	

Notes:

1. Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE) Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions.

2. Planning-level estimate of annual O&M costs in 2016 dollars

3. Long-term lake monitoring is recommended to evaluate the effectiveness of the selected lake management measure(s).

Dredging – "Wet" Excavation	
Description	Remove ~121,000 cy of sediment. Costs vary substantially depending on whether sediment can be disposed on site, as well as other factors. Lower cost for passive dewatering and on-site disposal. Higher cost for mechanical dewatering and off-site disposal.
Objectives	Remove P enriched sediment (approx. 100 cm thick) from bottom of the 33 acre lake.
Initial planning level cost estimate[1]	On-site disposal: $3.2M to $12.0M; Off-site disposal: $9.0M to $17.9M
Estimated annual operation and maintenance cost[2]	None
Basis for preliminary sizing	121,000 cubic yards
Water quality benefit[3]	Highest. Would remove ~100 years of P enriched sediment
Approximate time to see water quality benefit	<1 year
Duration/frequency	Long-term
Other potential benefits	Increased lake depth, more groundwater inflow, more fish habitat
Other potential impacts/costs	Habitat disturbance during dredging, odor from dredge spoils, on-site dewatering/ disposal would require large area, equipment staging on shoreline.
Required infrastructure	Varies based on type of dredging and feasibility of lake dewatering, disposal requriements, etc. Temporary pipes, mechanical dewatering system, and stockpile/dewatering area; temporary treatment facility for water draining from dredge spoils.
Pre-design work needed	Sediment core sampling, % solids analysis to evaluate dewatering needs, chemical testing to determine disposal requirements
Additional comments	Dewatering the lake may be impractical due to fine organic sediments, high groundwater, and aquatic habitat impacts. Passive dewatering of dredged material likley impractical due to volume, odor. Disposal costs assume sediment is not hazardous.

Basis of design/assumptions

Item	Low	High	Unit	Assumptions
Sediment Quantity	121,000		cy	
Equipment mobilization	20000	50000	LS	
Mechanical dredging	8	30	$/cy	
Dewatering	4	10	$/cy	Low - passive dewatering system, high - mechanical systems; May need to differentiate dewatering systems and include costs for geotubes
Polymer addititive	2	7	$/cy	
Offsite disposal	40	60	$/cy	Low - local disposal site, High - multiple handlings, distant disposal facility
Onsite disposal	5	25	$/cy	Low - land application/surface spreading, High - contained/capped

Cost Breakdown for Initial Planning Level Cost Estimates1

"Wet" Excavation: Mechanical Dredging, Onsite Disposal	Low	High		
Unit price dredge and disposal on-site	$ 19	$ 72		
Contractor fees	$ 2,319,000	$ 8,762,000		
Engineering fees and permitting	$ 347,850	$ 1,314,300		
Contingency	$ 533,370	$ 2,015,260		
Taxes (?)	$ 185,520	$ 700,960		
Total (no tax)	**$ 3,200,220**	**$ 12,091,560**		
"Wet" Excavation: Mechanical Dredging, Offsite Disposal	**Low**	**High**		
Unit price dredge and disposal on-site	$ 54	$ 107		
Contractor fees	$ 6,554,000	$ 12,997,000		
Engineering fees and permitting	$ 983,100	$ 1,949,550		
Contingency	$ 1,507,420	$ 2,989,310		
Taxes (?)	$ 524,320	$ 1,039,760		
Total (no tax)	**$ 9,044,520**	**$ 17,935,860**		

Notes:

1. Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE) Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions.
2. Planning-level estimate of annual O&M costs in 2016 dollars
3. Long-term lake monitoring is recommended to evaluate the effectiveness of the selected lake management measure(s).

Management Measure Option Name:	Dredging – Hydraulic Dredge
Description	Use hydraulic dredge to remove ~121,000 cy of sediment. Costs may vary substantially depending on whether sediment can be disposed on site and other factors. Lower cost if passive dewatering and on-site disposal. Higher cost if mechanical dewatering and off-site disposal are required.
Objectives	Remove P enriched sediment (approx. 100 cm thick) from bottom of the 33 acre lake.
Initial planning level cost estimate[1]	On-site disposal: $2.7M to $9.40M; Off-site disposal: $8.5M to $15M
Estimated annual operation and maintenance cost[2]	None
Basis for preliminary sizing	121,000 cubic yards
Water quality benefit[3]	Highest. Would remove ~100 years of P enriched sediment
Approximate time to see water quality benefit	<1 year
Duration/frequency	Long-term
Other potential benefits	Increased lake depth, more groundwater inflow, more fish habitat
Other potential impacts/costs	Habitat disturbance during dredging (but less than "Wet" Excavation option, odor from dredge spoils, on-site dewatering/ disposal would require large area, equipment staging on shoreline.
Required infrastructure	Varies based on type of dredging and whether on-site disposal is feasible. Temporary pipes, mechanical dewatering system, and stockpile/dewatering area; temporary treatment facility for water draining from dredge spoils.
Pre-design work needed	Sediment cores, % solids, chemical testing to determine disposal requirements
Additional comments	Passive dewatering impractical due to volume, odor. Disposal costs assume sediment is not hazardous.

Basis of design/assumptions

Item	Low	High	Unit	Assumptions
Sediment Quantity	121,000		cy	
Equipment mobilization	20000	50000	LS	
Hydraulic dredging	5	15	$/cy	
Dewatering	4	10	$/cy	Low - passive dewatering system, high - mechanical systems; May need to differentiate dewatering systems and include costs for geotubes
Polymer addititive	2	7	$/cy	
Offsite disposal	40	60	$/cy	Low - local disposal site, High - multiple handlings, distant disposal facility
Onsite disposal	5	25	$/cy	Low - land application/surface spreading, High - contained/capped

Cost Breakdown for Initial Planning Level Cost Estimates1

Hydraulic Dredge, Onsite Disposal	Low	High		
Unit price dredge and disposal on-site	$ 16	$ 57		
Contractor fees	$ 1,956,000	$ 6,947,000		
Engineering fees and permitting	$ 293,400	$ 1,042,050		
Contingency	$ 449,880	$ 1,389,400		
Taxes (?)	$ 156,480	$ 555,760		
Total (no tax)	**$ 2,699,280**	**$ 9,378,450**		
Hydraulic Dredge, Offsite Disposal	**Low**	**High**		
Unit price dredge and disposal on-site	$ 51	$ 92		
Contractor fees	$ 6,191,000	$ 11,182,000		
Engineering fees and permitting	$ 928,650	$ 1,677,300		
Contingency	$ 1,423,930	$ 2,571,860		
Taxes (?)	$ 495,280	$ 894,560		
Total (no tax)	**$ 8,543,580**	**$ 15,431,160**		

Notes:

1. Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE) Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions.
2. Planning-level estimate of annual O&M costs in 2016 dollars

Phosphorus Inactivation - Alum Treatment	
Description	Add ~20,000 gallons of alum and ~10,000 gallons of sodium aluminate to remove P from water column and form layer on sediment. A lower dose may be needed every 3 to 10 years.
Objectives	Control internal loading of P and mitigate algae problems.
Initial planning level cost estimate[1]	$210K for prep and initial treatment
Estimated annual operation and maintenance cost[2]	$120K every 3 to 10 yrs
Basis for preliminary sizing	Mass of phosphorus in top 10 cm of sediment and lake water; 4 moles of aluminum: 1 mole of phosphorus for dose
Water quality benefit[3]	High initially, slow decline over time
Approximate time to see water quality benefit	Immediate
Duration/frequency	3-10 years
Other potential benefits	Minimal infrastructure, no conflicts with other lake uses. Once 2nd treatment is complete, benefits are expected to continue for 3 to 10 years. "Benefit" does not mean that the lake will be algae or cyanobacteria free.
Other potential impacts/costs	Could increase macrophyte growth. Would need to be repeated every 3-10 yrs; When complete will be able to see everything on the lake bottom - trash, etc.; Flocculent could negatively impact some filter feeder fish; A highly qualified applicator must be used to avoid issues with water pH and alkalinity. Immediately after treatment, some algae may float to the surface for a day or two before settling.
Required infrastructure	None
Pre-design work needed	Jar testing
Additional comments	It would be beneficial to remove emergent vegetation in the lake prior to treatment. That cost is not included. Present Worth Cost: For cost comparison, suggest we assume that the treatment will need to be repeated every 5-10 years; Each of these applications should require less chemical, assume 50% of original amount.

Basis of design/assumptions and Cost Breakdown for Initial Planning Level Cost Estimates1

Item	Labor	Expenses	Total	Assumptions
Sediment analyses	$ 6,000.00	$ 3,500.00	$ 9,500.00	3 days x 2 x $125; 20 samples x $150
Lake Water Jar Testing	$ 6,000.00	$ 7,000.00	$ 13,000.00	3 days x 2 x $125; 40 samples x $150; YSI In-situ
Pre-application Planning	$ 20,800.00	$ 1,000.00	$ 21,800.00	40 hours x $150; 40 hours x $250; 40 hours x $120
Permitting (Costs for permitting are not included in this estimate)	TBD	TBD	TBD	
Observation/Testing during Application	$ 8,000.00	$ 7,000.00	$ 15,000.00	4 days x 2 x $125; 40 samples x $150; YSI In-situ
Application	$ 50,000.00	$ 80,000.00	$ 130,000.00	Contractor - cost breakdown estimated; split application
Post Treatment Testing	$ 8,000.00	$ 10,500.00	$ 18,500.00	8 events x 2 staff x 4 hours x $120; 64 samples x $150; YSI in-situ
Totals	**$ 98,800.00**	**$ 109,000.00**	**$ 207,800.00**	

Aluminum Treatment Calculation

Assumptions:				
Sediment (top 10 cm)		Total P in water	256	kg P
2365	kg P	Total P in sediment	2,365	kg P
Lake Volume		Total P	2,621	kg P
231	ac-ft	Total P	84,557	moles P
284,737,934	L	4 Al:1P molar ratio	338,228	moles Al
Overall dose to water			9,132,146	g Al
35	mg Al/L water	With 10% SF Use	10,000	Kg Al
			228,000,000	g alum
31 g P = 1 mole		Use	45,000	gal alum
27 g Al = 1 mole		Alum alone cannot be used due to low alkalinity		
4:1 ratio				
Use 19,621 gallons of alum and 9,810 gallons of sodium aluminate; apply 50% each in two applications; 2-3 days each application				

Notes:

1. Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE) Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions.
2. Planning-level estimate of annual O&M costs in 2016 dollars

Pump and Treat with Coagulant	
Description	Pump water from lake, add coagulant to remove P, return treated water to lake.
Objectives	Treat the water for P removal.
Initial planning level cost estimate[1]	$1.5M
Estimated annual operation and maintenance cost[2]	$80K/yr
Basis for preliminary sizing	Treat lake water flow rate of 2,500 gpm; coagulant dose assumed to be 5 mg aluminum/Liter of water
Water quality benefit[3]	Medium
Approximate time to see water quality benefit	1 year
Duration/frequency	Long-term
Other potential benefits	Would require ~3 acres of land. Temporary impacts during construction.
Other potential impacts/costs	Flexible operation. Higher treatment capacity than wetland treatment system. Learning opportunity for college students.
Required infrastructure	Intake and discharge pipes, pumps, chemical storage tank, small equipment structure settling pond.
Pre-design work needed	Sediment and water column testing to estimate future treatment needs. Jar testing, floc dewatering testing, survey and geotech.
Additional comments	Run system ~6 mos./yr. Cost estimate assumes treatment facility can be sited within 1,000 ft of lake. Could combine with small wetland treatment system. A design flow rate of 2,500 gpm was used for the coagulant treatment system. Cost does not include the cost to purchase a dredge to pump floc from the settling pond to the dewatering basin.

Basis of design/assumptions

Description	Est. Qty.	Unit	Unit Cost ($)	Total Cost ($)
Mobilization and Demobilization	1	LS	--	$ 111,600
Maintenance of Traffic	1	LS	--	$ 10,000
Project Construction Sign	1	EA	$ 1,000.00	$ 1,000
Water Management				$ 50,000
One-Year Warranty	1	LS	--	$ 10,000
Construction Stakeout and Surveys	1	LS	--	$ 10,000
Clearing and Grubbing (does not include tree removal > 12-inch DBH)	3	AC	$ 7,500.00	$ 22,500
Temporary Silt Fence – Type C	3,000	LF	$ 5.00	$ 15,000
Temporary Construction Entrance/Exit Drives	2	EA	$ 2,500.00	$ 5,000
Final Seeding	2.5	AC	$ 2,500.00	$ 6,250
Removal/disposal of buried trash, debris, concrete, etc	50	CY	$ 100.00	$ 5,000
Classified Stone (#57, #3, #4, etc)	50	CY	$ 100.00	$ 5,000
Grading Complete (earthwork - includes excavation, fill, compaction, final grading, removal of excess)				
Grading - Cut/Fill In place	10,000	CY	$ 20.00	$ 200,000
HDPE Liner	32,000	SF	$ 2.00	$ 64,000
2,500 GPM Water Pump Station and Intake	1	LS	--	$ 200,000
HDPE Intake Pipe	1000	LF	$ 75.00	$ 75,000
HDPE Discharge Pipe	1000	LF	$ 75.00	$ 75,000
Pond Outfall Structure	1	EA	$ 15,000.00	$ 15,000
Water Flow Measurement	--	LS	--	$ 25,000
Building Piping, Valves and Appurtenances	--	LS	--	$ 25,000
4,000-gallon Chemical Storage Tank	1	EA	$ 20,000.00	$ 20,000
Water Flow Meter Conduit and Coagulant Feed Piping	500	LF	$ 50.00	$ 25,000
Coagulant Pump and Control Panel	--	LS	--	$ 50,000
Coagulant Flow Meter	1	EA	$ 15,000.00	$ 15,000
Equipment and Controls Building	400	SF	$ 150.00	$ 60,000
Rapid Mix Tank/Mixer	--	LS	--	$ 35,000
Tree Cutting and Mulching (12-inch DBH and greater)	15	EA	$ 750.00	$ 11,250
Bare Root Tree	100	EA	$ 10.00	$ 1,000
Herbaceous Plants	500	EA	$ 10.00	$ 5,000
Electrical/HVAC	--	LS	--	$ 75,000
		Subtotal		$ 1,227,600
		20% Contingency		$ 245,520
			TOTAL AMOUNT:	**$ 1,473,120**

Estimated Average Annual Cost ($)

Mowing/General Maintenance	6 visits/year x 2 person crew x 4 hrs/visit x $50/hr	$ 2,400.00
System weekly testing/operations	52 weeks x 1 person x 4 hrs/week x $50/hr	$ 10,400.00
Equipment/Supplies	$100/visit x 52 visits /year	$ 5,200.00
Chemical purchase	4,900 gal x $4.50/gal	$ 22,050.00
Sediment removal/disposal	680 cubic yards x $20/cy	$ 13,600.00
Power	82,000 kwhrs x $0.08/kwhrs	$ 6,560.00
	Subtotal	$ 60,210.00
	20% contingency	$ 12,042.00
	Total	$ 72,252.00
	Equipment Renewal and Replacement ($250,000/30 years)	$ 8,333.00
	Total Estimated Average Annual O&M cost	**$ 80,585.00**

Notes:

1. Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE) Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions.

2. Planning-level estimate of annual O&M costs in 2016 dollars

Pump and Treat with Constructed Wetland	
Description	Pump water from lake, treat in a ~8-acre wetland system, discharge treated water to lake.
Objectives	Remove phosphorus from the lake water.
Initial planning level cost estimate[1]	$3.1M
Estimated annual operation and maintenance cost[2]	$100K/yr
Basis for preliminary sizing	Treat lake water flow rate of 1,000 gpm; assumed wetland HLR = 16 cm/day
Water quality benefit[3]	Medium
Approximate time to see water quality benefit	1 year
Duration/frequency	Long-term
Other potential benefits	Would require ~9 acres of land. Temporary impacts during construction.
Other potential impacts/costs	Flexible operation. Increased habitat for birds and other wildlife. Learning opportunity for college students.
Required infrastructure	Intake and discharge pipes, pumps, constructed wetland.
Pre-design work needed	Sediment and water column testing to estimate future treatment needs; Survey and geotech
Additional comments	Need for treatment may diminish over time. Run system ~6 mos./yr. Cost estimate assumes treatment wetland can be sited within 1,000 ft of lake. A design flow rate of 1,000 gpm was assumed for this treatment project.

Basis of design/assumptions

Description	Est. Qty.	Unit	Unit Cost ($)	Total Cost ($)
Mobilization and Demobilization	1	LS	--	$ 236,600
Maintenance of Traffic	1	LS	--	$ 10,000
Project Construction Sign	1	EA	$ 1,000	$ 1,000
Water Management				$ 50,000
One-Year Warranty and Maintenance	1	LS	--	$ 10,000
Construction Stakeout and Surveys	1	LS	--	$ 20,000
Clearing and Grubbing (does not include tree removal > 12-inch DBH)	9	AC	$ 7,500	$ 67,500
Temporary Silt Fence – Type C	4,500	LF	$ 5	$ 22,500
Temporary Construction Entrance/Exit Drives	2	EA	$ 2,500	$ 5,000
Temporary Seeding	8	AC	$ 2,500	$ 20,000
Removal/disposal of buried trash, debris, concrete, etc.	50	CY	$ 100	$ 5,000
Classified Stone (#57, #3, #4, etc.)	100	CY	$ 100	$ 10,000
Grading Complete (earthwork - includes excavation, fill, compaction, final grading, removal of excess)				
Grading - Cut/Fill In place	29,000	CY	$ 20	$ 580,000
Import Topsoil (6-inch depth)	6,500	CY	$ 20	$ 130,000
Export Excess soil	15,000	CY	$ 15	$ 225,000
HDPE Liner	350,000	SF	$ 2	$ 700,000
1,000 GPM Water Pump Station	1	LS	--	$ 150,000
HDPE Intake Pipe	1000	LF	$ 60	$ 60,000
HDPE Discharge Pipe	1500	LF	$ 60	$ 90,000
Type 1 and 3 Rip Rap	250	SY	$ 100	$ 25,000
Permanent Seeding	9	AC	$ 2,500	$ 22,500
Tree Cutting and Mulching (12-inch DBH and greater)	50	EA	$ 750	$ 37,500
Bare Root Tree	2500	EA	$ 10	$ 25,000
Herbaceous Plants	10,000	EA	$ 10	$ 100,000
		Subtotal		$ 2,602,60
		20% Contingency		$ 520,52
			TOTAL AMOUNT:	**$ 3,123,120**

Estimated Average Annual Cost ($)

Annual O&M	$10,000/acre x 8 acres	$ 80,000
	Subtotal	$ 80,000.00
	20% contingency	$ 16,000.00
	Subtotal	$ 96,000.00
	Equipment Renewal and Replacement ($150,000/30 years)	$ 5,000.00
	Total Estimated Average Annual O&M cost	**$101,000**

Notes:

1. Based on the planning-level information and concept development stage of this project, conceptual level costs were estimated following the Association for the Advancement of Cost Engineering (AACE Class 5 Cost Estimate Classification System, providing estimates in the range of-50% to +100% for the candidate actions.

2. Planning-level estimate of annual O&M costs in 2016 dollars

Appendix E: Data Validation Report

This appendix contains a copy of the Data Validation Report.

Use of contents on this sheet is subject to the limitations specified at the end of this document.
Draft Waughop Lake Management Plan_11-14-2016.docx

The Data Validation Report is currently being reviewed and will be provided with the final report.