City of Lakewood
Volunteer Lake Monitoring Program
2020 Season Report

Introduction

The City of Lakewood initiated a volunteer lake monitoring program in 2000 with the goals of promoting lake stewardship through citizen participation in the monitoring program, and to provide water quality data to assist in tracking and better understanding of conditions of American, Gravelly, Louise, Carp, Steilacoom (added in 2004), and Waughop (added in 2011) lakes and make appropriate management decisions. Carp Lake and Steilacoom Lake no longer participate in the volunteer lake program.

While conditions may vary from year to year, long-term data collection is the key to tracking trends in water quality over time. Volunteer monitoring this year was challenging and began several months late on three of the lakes due to COVID restrictions. This report summarizes the data collected during the 2020 lake monitoring season on Louise and Waughop lakes (July – Oct) and American Lake (Aug – Oct, Dec).

Lake Descriptions

The monitored lakes vary in size and depth – American Lake is the largest at 1,100 acres and 90 feet at maximum depth, Lake Louise is 39 acres and 35 feet at maximum depth, and Waughop Lake at 33 acres and 14 feet at maximum depth. Gravelly Lake, 160 acres and 55 feet maximum depth, was not monitored this year. These lakes are in the Chambers-Clover Watershed within the city limits of Lakewood.

Seven volunteers participated in the 2020 monitoring program and contributed a total of 64 hours of volunteer time.

This year Waughop received two whole lake alum (aluminum sulfate) treatments; one in late March and one in mid-July to reduce and inactivate phosphorus concentrations and reduce occurrence of toxic algae blooms.

Sampling Program

Water chemistry and physical characteristics of lakes vary both seasonally and with depth. Lake volunteers record observations and collect physical data (secchi depth, lake stage, weather conditions); record temperature and dissolved oxygen profile measurements; and measure pH on a monthly basis beginning in July and ending in late October on Lake Louise and Waughop Lake. Monitoring on American Lake was also conducted monthly August through October with one final session in December once the fall turn-over of the lake was completed.

Samples for pH measurement were collected from one meter (shallow sample) below the surface of the lakes at each monitoring session. Two times during the monitoring season (August, October, and December for American) an additional sample for pH measurement was collected at one meter above the lake bottom (deep sample) from American and Louise lakes; Waughop is a shallow, well-mixed lake and no additional deep sample was collected. Monitoring data for 2020 can be found in Table 1 at the end of the report.

The City agreed to a volunteer request to collect a post-turnover sample in American Lake at 1-meter below the lake surface for lab analysis for total phosphorus, nitrate nitrogen, and ammonia nitrogen. This sampling will be conducted every few years to determine if nutrient levels are changing over time.

Dissolved Oxygen and Water Temperature Profiles

Dissolved oxygen and temperature are important attributes of a lake ecosystem and both are critically important to determining the types of aquatic life found in lakes. The amount of oxygen dissolved in water is affected by the water temperature – all other factors being equal, cold water holds more oxygen than warm water. The amount of dissolved oxygen present in water will determine where in the lake plants and animals can live.

With the onset of warmer weather in spring and early summer, deep lakes will begin to separate into a warmer, low-density layer at the surface, known as the epilimnion, and a cooler, high-density layer at the bottom, known as the hypolimnion. Between the epilimnion and the hypolimnion is a layer of rapidly changing temperature called the thermocline. This process is called thermal stratification. Once this condition is fully developed in deeper lakes, usually in summer, there is no vertical mixing of the upper and lower layers because of their density differences. Shallower lakes may also separate into these layers although the layers may not remain separate throughout the entire summer. These shallower lakes will mix on windy or stormy days.

With the arrival of cooler weather in the fall, the thermal stratification begins to break down and the shallow and deep layers of water begin to mix vertically once again. This phenomenon is usually called turnover.

The 2020 temperature profiles for American Lake indicate that stratification was well established in August and remained strongly stratified until turnover in December. Lake Louise shows very little thermal stratification in July and August, and no stratification in September and October. Waughop Lake did not show any stratification in 2020.

Like temperature profiles, dissolved oxygen levels vary with depth and over time. The upper layer of water (epilimnion) has abundant oxygen as a result of the diffusion of oxygen from the atmosphere and the presence of algae that produce oxygen as a byproduct of photosynthesis. Meanwhile, as spring and summer progresses the lower layer (hypolimnion) has reduced or no oxygen. This is the result of decomposition of organic matter that settles into that layer, no diffusion of oxygen from the atmosphere, and not enough sunlight to support oxygen-producing plant life. These low oxygen conditions will remain until the lake mixes again at the time of fall turnover. These conditions occur even though the general rule is cold water can hold more dissolved oxygen than warm water.

The 2020 dissolved oxygen profiles for American are like its temperature profiles showing stratification in August, and remaining stratified until after the fall turn-over in December. American Lake also showed a mid-depth increase in oxygen due to the presence of algae undergoing photosynthesis at that depth. Dissolved oxygen profiles for Louise displayed a decline in oxygen near the lake bottom during July and August; while in September and October profiles were uniform top to bottom like the temperature profiles. The dissolved oxygen profiles for Waughop while like its temperature profiles, did show a decrease in oxygen levels at depth in July and August. Individual lake temperature and dissolved oxygen profiles are displayed below in Figure 1.

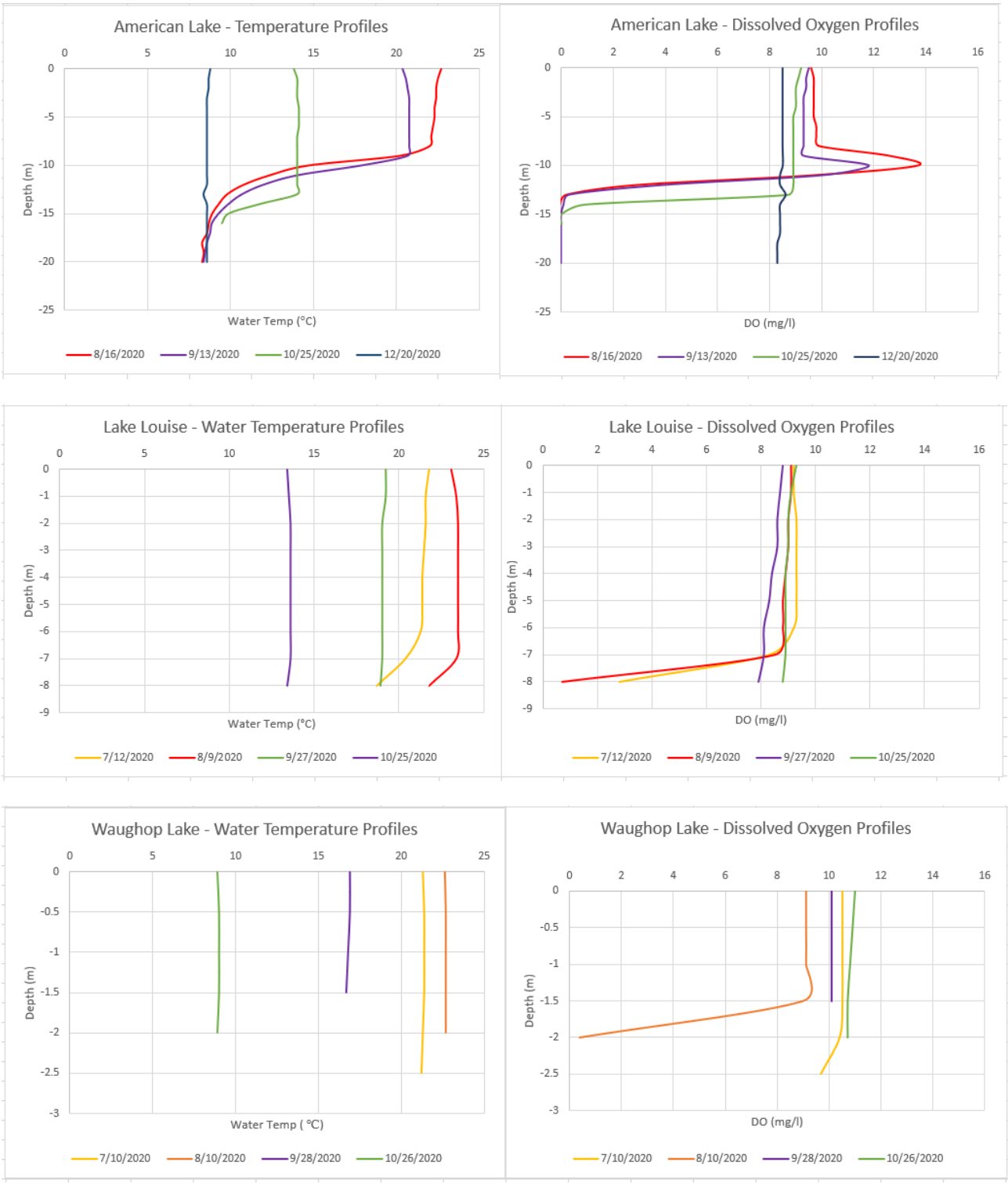


Figure 1.

Lake Stage

Lake stage, water surface level in the lake, varies seasonally and year to year. While precipitation and evaporation are the main causes of fluctuating lake levels, water levels are also affected by watershed area, land uses in the watershed, vegetation types and cover, presence of wetlands, geology, surface and subterranean hydrology, and type of outflow structure (if present). The source, amount, and composition of the water flowing into a lake also impact the water quality of that lake.

Lake monitors recorded lake stage from staff gauges (calibrated in feet) located on American, Louise, and Waughop each sampling session. The staff gauges on American and Louise have been surveyed so that elevation above sea level is known. While there is a gauge on Waughop, its actual elevation with respect to sea level is unknown; therefore, the data presented for that lake reflects relative changes only.

American, Louise, and Waughop Lakes showed a typical lake stage fluctuation pattern of declining through the summer to a seasonal low in fall. Precipitation data is collected for the Lakewood area at Joint Base Lewis-McChord, and total recorded precipitation for water year (Oct-Sept) 2020 was 33.76 inches. Annual precipitation since 2000 is displayed in Figure 2 below for comparison. Lake stage data was collected July through October for Louise and Waughop, and August through October and in December for American Lake. Recorded lake stage this year fluctuated 1.1 ft. in American Lake, 1.34 ft. in Louise Lake, and 2.35 feet in Waughop in summer through fall. The individual lake level graphs can be found in Appendix 1 at the end of the report.

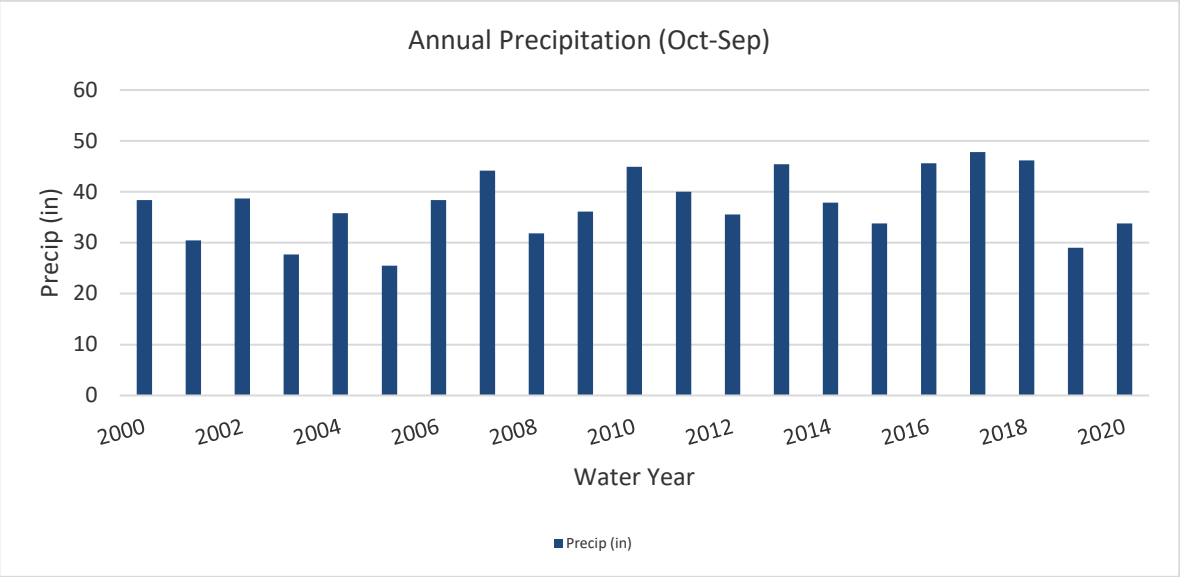


Figure 2.

Water Transparency

Water transparency is measured with an eight-inch diameter, black and white secchi disk and is traditionally reported as secchi depth, in meters (1 meter = 3.3 feet). Transparency is influenced by several factors such as dissolved substances, algae, and sediment particles. Transparency readings can also be affected by waves, wind, and glare at the water surface. Deeper secchi depth readings indicate clearer water (more transparent) while shallower secchi depth readings indicate more turbid water. Clear water allows more light to penetrate deeper into the lake, allowing photosynthesis in aquatic plants and algae to occur; this leads to higher levels of dissolved oxygen. A decrease in transparency is often seen with an increase in algal density, or an influx of sediment and detritus due to a major storm event in the watershed. Secchi depth is used primarily as an approximate indicator of algal abundance.

Secchi depth measurements in 2020 for American Lake ranged from 5.5 meters to 9.5 meters with greater transparency occurring in September. The summer averages for secchi depths in American Lake over all the years of data collection are shown below in Figure 3.

Note: The 2020 secchi depth average was calculated with only 4 monthly readings for all three lakes, while in previous years 7-8 monthly readings were used to calculate the averages.

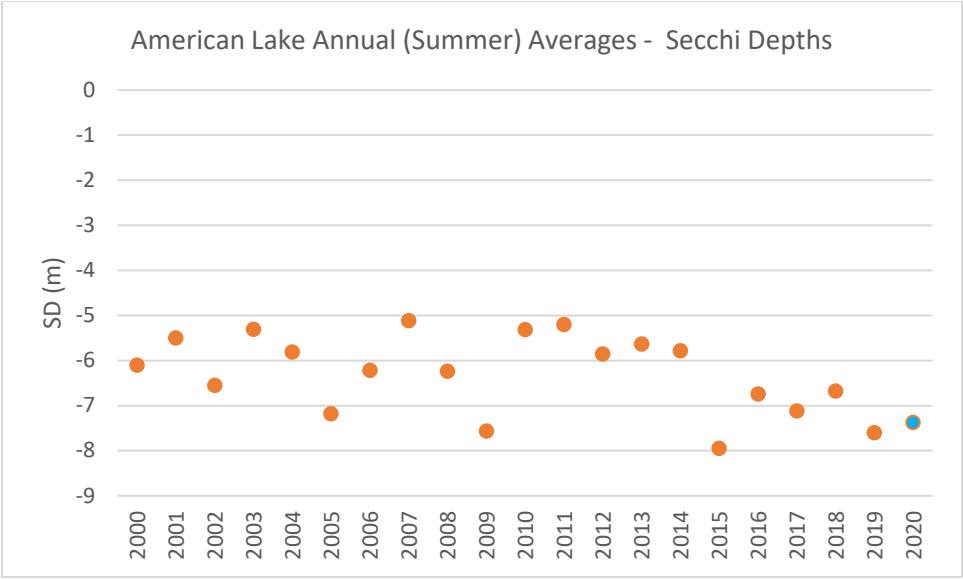


Figure 3.

Secchi depth measurements in Lake Louise ranged from 3.1 meters to 7.4 meters with greater transparency occurring in July. Summer averages for secchi depths in Lake Louise are displayed below in Figure 4.

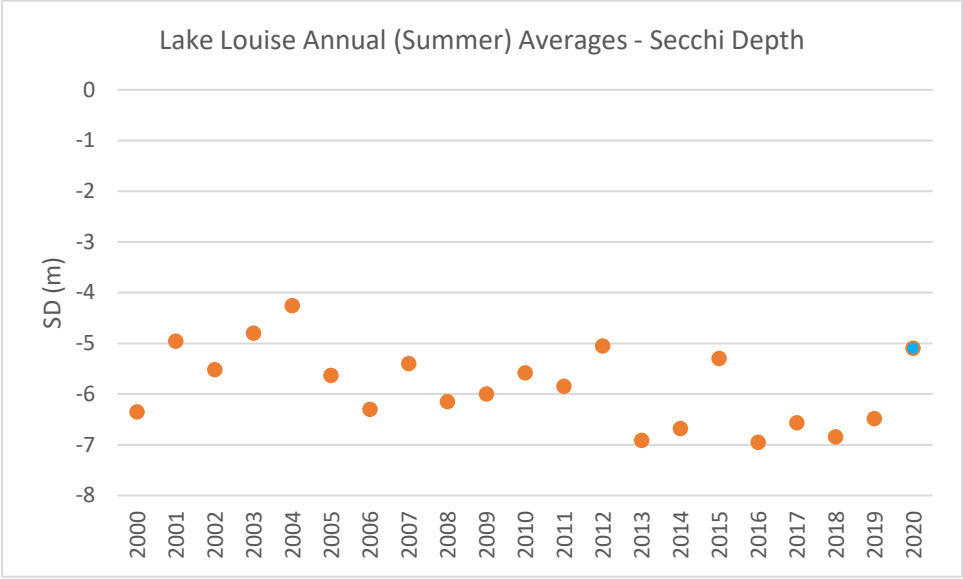


Figure 4.

Waughop Lake, the shallowest lake, received two alum treatments this year – one in March and one in July. This had a significant impact on clarity in the lake. Waughop had secchi depths that varied from 2.0 meters to 2.4 meters. Transparency was greatest in October, and in three of the four measurements in Waughop the secchi disk could be seen on the lake bottom. Summer averages for secchi depth in Waughop Lake are found below in Figure. 6.

Graphs of secchi depths for all years in the lakes are displayed in Appendix 1 at the end of the report.

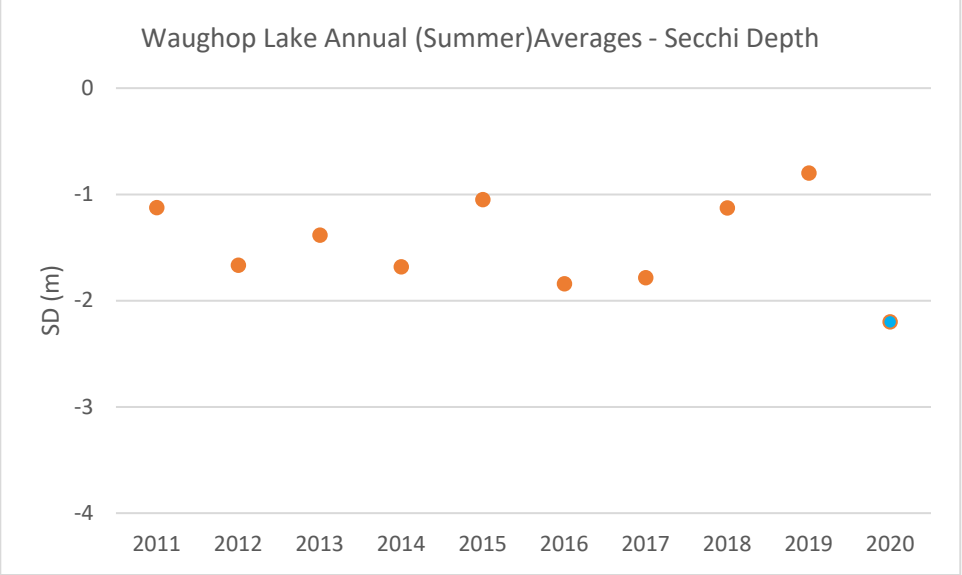


Figure 5.

Nutrients

Nutrients are necessary for the growth of algae, aquatic plants, and fish in a lake. Phosphorus and nitrogen are the main nutrients of concern in a lake system. In many lakes, phosphorus is the limiting nutrient in the system, which means it is only available to plants and algae in very limited quantities; once the limited supply of phosphorus is exhausted, the algal population will stop expanding. However, too many nutrients, especially phosphorus, can create problems leading to unpleasant algae and plant growth. Nutrients enter lakes through stormwater runoff or from streams flowing into lakes. Sources of nutrients include fertilizers, pet and animal wastes, poorly maintained septic systems, and erosion from land-clearing and construction activities.

In lakes that stratify, phosphorus concentrations in the hypolimnion increase and remain higher there than in the epilimnion until the time of turnover. This increase of phosphorus in the lake's hypolimnion is caused by the decomposition of organic matter and the release of phosphorus from bottom sediments in low-oxygen environments. When mixing eventually occurs in the lake, nutrients that have accumulated in the hypolimnion are brought to the surface and it is not unusual for algal blooms to develop in the epilimnion at this time from the sudden influx of nutrients from below.

Nitrogen is usually more abundant in the environment than phosphorus but can be limiting to algal growth when phosphorus levels are high. Various forms of nitrogen can be found in water. Organic nitrogen includes proteins and amino acids from plants and animals; while inorganic forms include nitrate, nitrite, ammonia, and nitrogen gas (atmosphere) and come from sources other than plants and animals. Generally, algae and plants can directly use inorganic forms of nitrogen. Like phosphorus, nitrogen may enter the lake by way of precipitation, stormwater runoff, and ground-water inflow. Sources of nitrogen related to land use practices include fertilizers (from lawns and agricultural uses), animal/pet wastes, and inefficient septic systems.

In 2020, volunteers collected a shallow sample in American Lake after fall turnover for lab analysis for total phosphorus, nitrate-nitrogen, and ammonia-nitrogen. Results for total phosphorus and nitrate-nitrogen levels were like previous years. Ammonia-nitrogen levels were higher than previous years' post-turnover results. Graphs for post-turnover results for American Lake from all years collected can be found in Appendix 1.

pH

pH is a measure of the hydrogen ion concentrations in water and indicates whether water is acidic, basic, or neutral. The pH scale goes from 0 to 14 with 7 being neutral. pH above 7 is considered basic and pH below 7 is considered neutral. The pH scale is logarithmic, meaning that a change of one whole number on the scale is a tenfold change in acidity. pH affects nearly every water function where chemistry is involved.

Volunteers measured pH levels at one-meter below the surface each month and at depth (one-meter above the bottom) in August, and October. An additional pH measurement (shallow and deep) was collected in American Lake after the fall turnover. Results of the shallow pH measurement for the lakes were near neutral (pH range = 6.6 to 7.5), see Figure 6 below. The pH levels for Waughop were not as high (basic) as seen in previous years. The deeper pH results ranged from near neutral to more acidic (pH range = 7.5 to 6.2). At the time of the fall turnover in Louise and American Lakes there was no difference between shallow and deep pH results. pH results for the lakes are in Table 1. Graphs of pH results for all the years of collection can be found in Appendix 1.

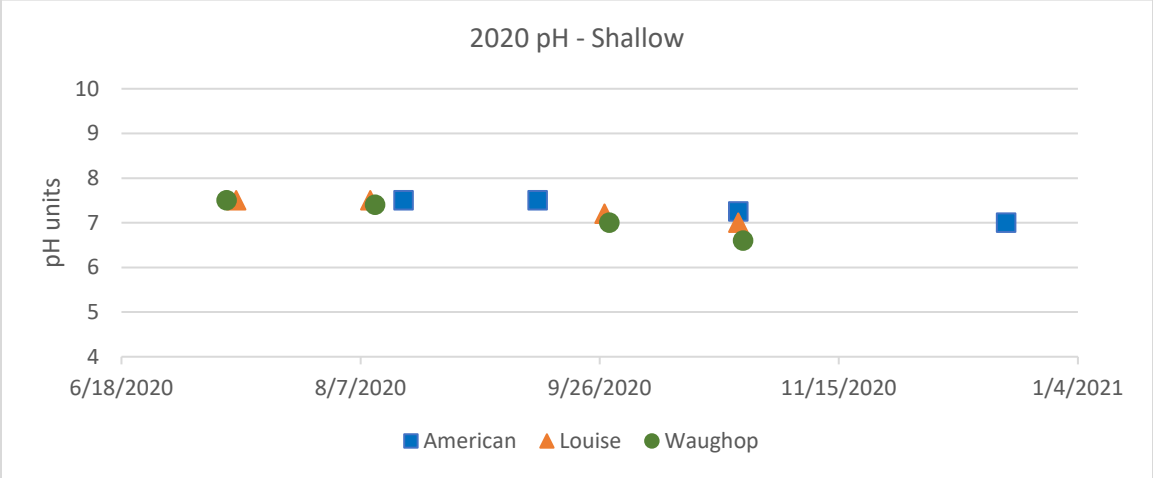


Figure 6.

Algae

For the last several years the Tacoma Pierce County Health Department has not routinely monitored algae. However, they do encourage lake homeowners to report suspected toxic algae blooms to Washington State Department of Ecology. There were no reported algal toxin levels exceeding state guidelines for these lakes in 2020.

Summary

Lake monitoring in 2020 started late and was conducted only on American, Louise, and Waughop lakes in Lakewood due to COVID restrictions. Lake monitor volunteers collected data monthly beginning in July and ending in October for Louise and Waughop lakes; and beginning in August through October with one final monitoring session in December for American Lake. The data are summarized as follows:

- Temperature and dissolved oxygen stratification were already established in American lake in August at the time of the first monitoring session. Lake Louise showed very little thermal stratification in July and August and none in September and October. Waughop did not thermally stratify; however, the dissolved oxygen profiles showed low oxygen levels at depth during the summer months.

- 2020 was not as dry a year as 2019; however, lake levels in the three lakes in 2020 remained among the lowest recorded since the program began.

- There were fewer Secchi depth measurements for 2020 however secchi depths in American and Louise lakes were like depths in 2019. Waughop Lake was treated with alum twice in 2020 (March, July) and had deeper (more transparent) secchi depths than previous years. In three of the four measurements in Waughop the secchi disk could be seen on the lake bottom.

- Shallow pH in the three lakes ranged from 6.6 to 7.5 pH units. Deep pH results for American and Louise lakes ranged from 6.2 to 7.9 pH units. pH in Waughop was not as high as previous years.

Lake conditions vary from year to year with the change in seasons, weather patterns, and climate conditions. Long-term lake monitoring helps us to understand how our lakes are doing and if they are degrading over time. Additional graphs displaying the data collected for the three lakes monitored this year are in Appendix 1.

Recommendations

Lakes reflect their watershed. They receive water, dissolved substances carried in water, and sediment from its watershed. Lakes also receive particulates and gases from the atmosphere, and energy from the sun and wind. The condition of a lake at any one time is determined by what is already in the lake, and by what is coming into the lake – attesting to the fact that lakes are complex ecosystems.

Lake management is a complicated job that takes the combined efforts of local government, community groups, individuals, and landowners. To be effective lake management is a long-term commitment and investment.

Many lakes suffer from too many nutrients (phosphorus and nitrogen), entering a lake with stormwater, soil erosion, or groundwater from the surrounding watershed. When it rains nutrients wash into ditches and down storm drains eventually ending up in the lake. This can lead to problems such as excessive aquatic plant growth, nuisance and/or toxic algae blooms, lower water clarity, stressed fish and wildlife, and lower property values.

Here are some voluntary actions that can be taken to protect the health of the lake:

Avoid fertilizer. If you do fertilize choose phosphorus-free products.

- Scoop pet waste, bag it and toss it in the trash.
- Divert runoff from roofs and driveways into stable vegetated areas.
- If you have a septic system, schedule routine inspections.
- Cover bare soil area with mulch or plants.
- Fix eroding areas in the yard, driveway, and parking areas.

- Maintain existing natural shorelines – these areas provide additional wildlife benefits for birds, turtles, frogs and other aquatic life.
- If you are a boater or angler prevent the spread of aquatic invasive species in your lake using the Clean/Drain/Dry method recommended by Washington State Department of Fish & Wildlife. Check here for more information: https://wdfw.wa.gov/ais/youcanhelp.html.

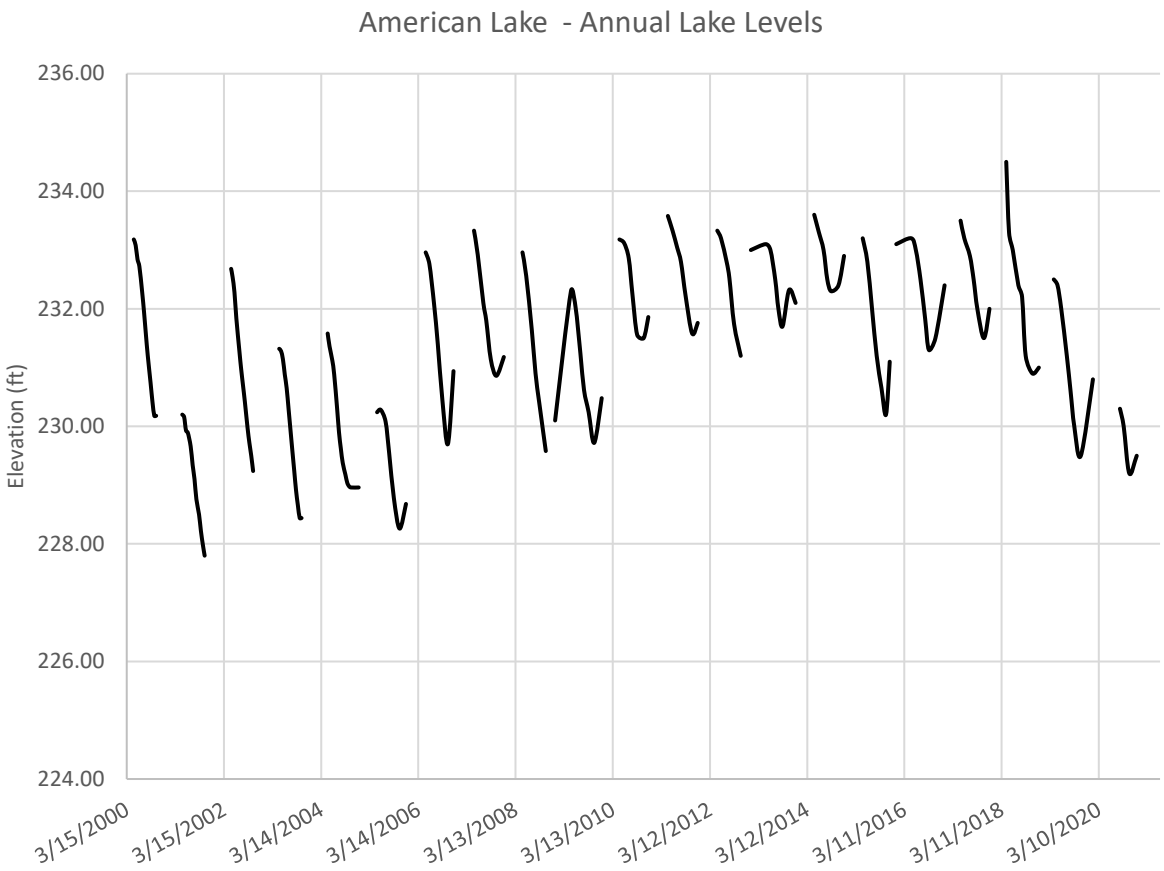
Table 1. Lakewood Lake Data 2020

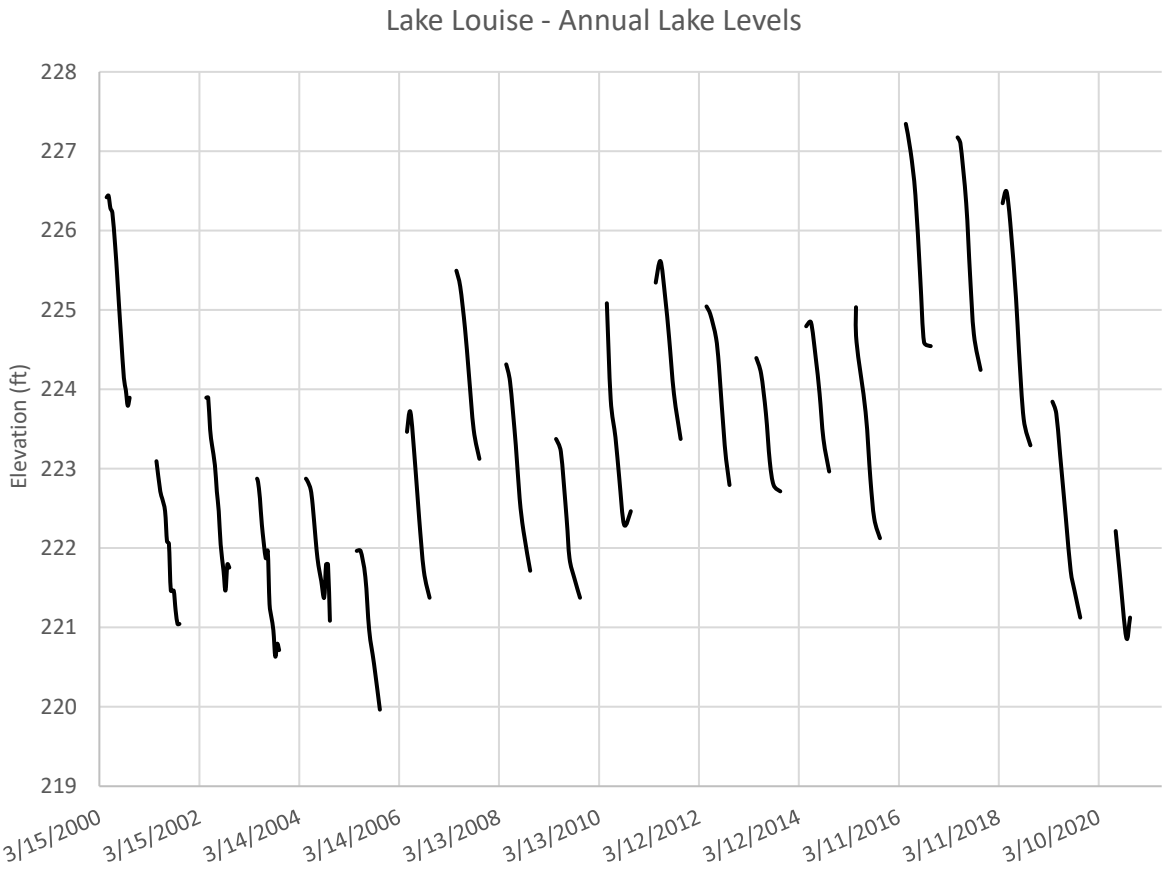
Lake	Date	Time	Site Depth (m)	Secchi Depth (m)	Air Temp (C)	Water Temp (°C) Top	Dissolved Oxygen (mg/l) Top	Water Temp (°C) Bottom	Dissolved Oxygen (mg/l) Bottom	Lake Level (ft.)	Suspended Algae	pH (1 m)	pH (deep)	Comments/Observations
American	8/16/2020	10:30 AM	26.5	7.5	26.1	22.7	9.6	8.3	-2	230.3	light	7.5	7.5	Wind cond: light, W; clear weather; ripples; strong sunlight. No odor, no odor at depth; 2 ospreys; 25 boats, 6 people fishing, multiple swimmers/waders. Did not calibrate meter, low O2 levels seemed weird, no odor in water collected at depth.
	9/13/2020	10:00 AM	26.5	9.5	14.1	20.4	9.5	8.4	0	230	light	7.5	6.5	Wind cond: calm; current weather: fog & smoke, poor visibility (150 yds); water surface- calm; light cond: fog & smoke, hazy sunlight. Rotten egg odor. Herons & crows present. 1 boat, 2 people fishing.
	10/25/2020	10:30 AM	25.7	7	9.2	13.8	9.2	9.5	0	229.2	light	7.25	6.2	Wind cond: strong; NNE; current weather: partly cloudy; water surface cond: moderate waves; light conditions: strong sunlight; rotten egg odor; dozens of coots, grebes, mergansers, cormorants present. 2 boats, 2 people fishing, no waders/swimmers. Difficult to get probe below 16 meters due to windy conditions blowing barge off anchor (meter at 45° angle). Gauge photo included.
	12/20/2020	10:15 AM	22	5.5	10	8.8	8.5	8.6	8.3	229.5	light	7	7	Wind cond: breezy; overcast; small waves; overcast light conditions. No water odor. Buffleheads, cormorants, mallards, and eagle present; 1 boat; 2 people fishing. A shallow sample was collected for lab analysis: TP = 0.048 mg/l; NH3N = 0.353 mg/l; NO3N = <0.05* (below detection) mg/l.

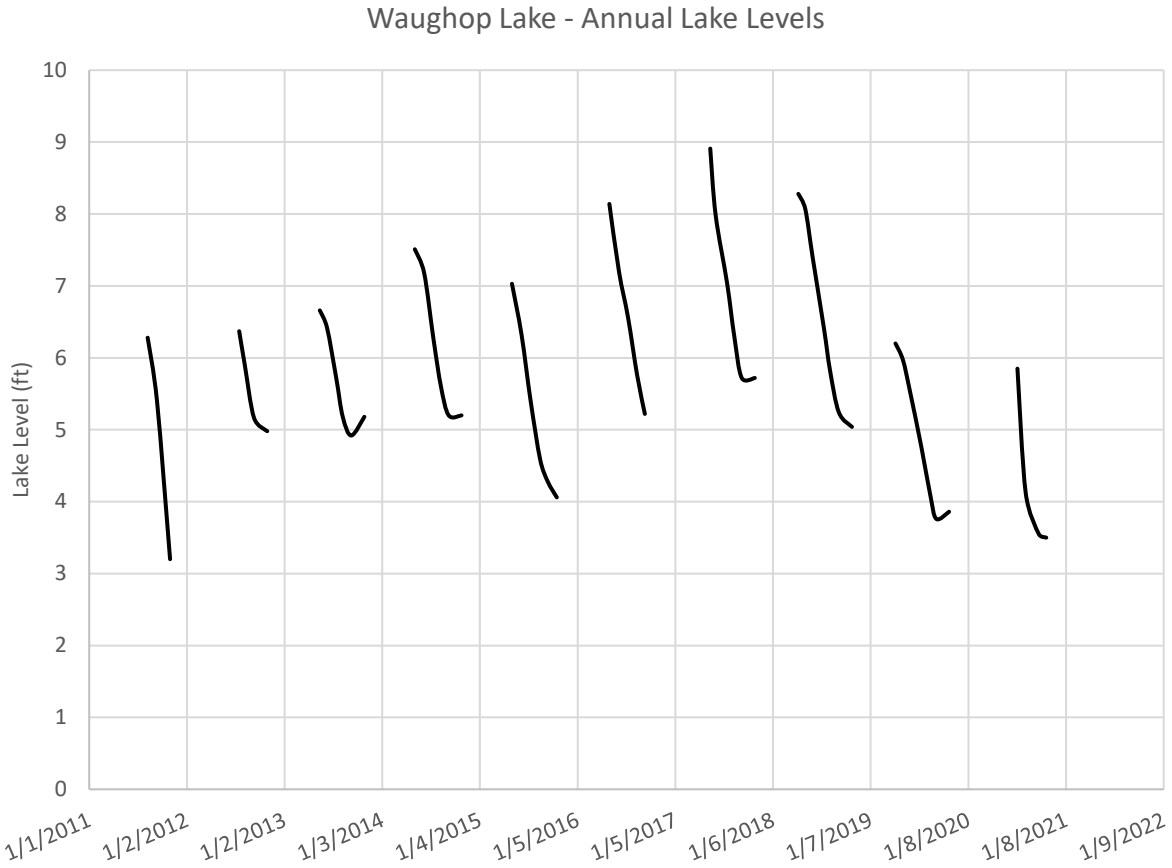
Lake	Date	Time	Site Depth (m)	Secchi Depth (m)	Air Temp (C)	Water Temp (°C) Top	Dissolved Oxygen (mg/l) Top	Water Temp (°C) Bottom	Dissolved Oxygen (mg/l) Bottom	Lake Level (ft.)	Suspended Algae	pH (1 m)	pH (deep)	Comments/Observations
Louise	7/12/2020	1:00pm	9.1	7.4	24.6	21.8	9.2	18.7	2.8	-2.08	None	7.5		Light breeze, NW; partly cloudy; water surface - ripples; strong sunlight; no odor; 8 geese; 2 swimmers/waders.
	8/9/2020	9:45am	8.9	6	19.6	23.1	9.1	21.8	0.7	-2.58	Light	7.5		Light breeze, NW; clear weather, water surface - ripples, strong sunlight; fishy odor; 2 boats; 2 people fishing.
	9/27/2020	12:02 PM	8.9	3.1	19.1	19.2	8.8	18.9	7.9	-3.42	moderate	7.2	7.0	Wind cond: breezy, NW; weather: clear; water surface: ripples; light conditions: strong sunlight. No water odor. No waterfowl; 1 boat; 2 people fishing.
	10/25/2020	11:30 AM	8.6	3.9	9.6	13.4	9.3	13.4	8.8	-3.17	light	7	7	wind cond: strong, N; current weather: partly cloudy; water surface cond: small waves; light cond: strong sunlight; No odor; 40 coots, 12 geese. No boats, no people fishing, no swimmers/waders

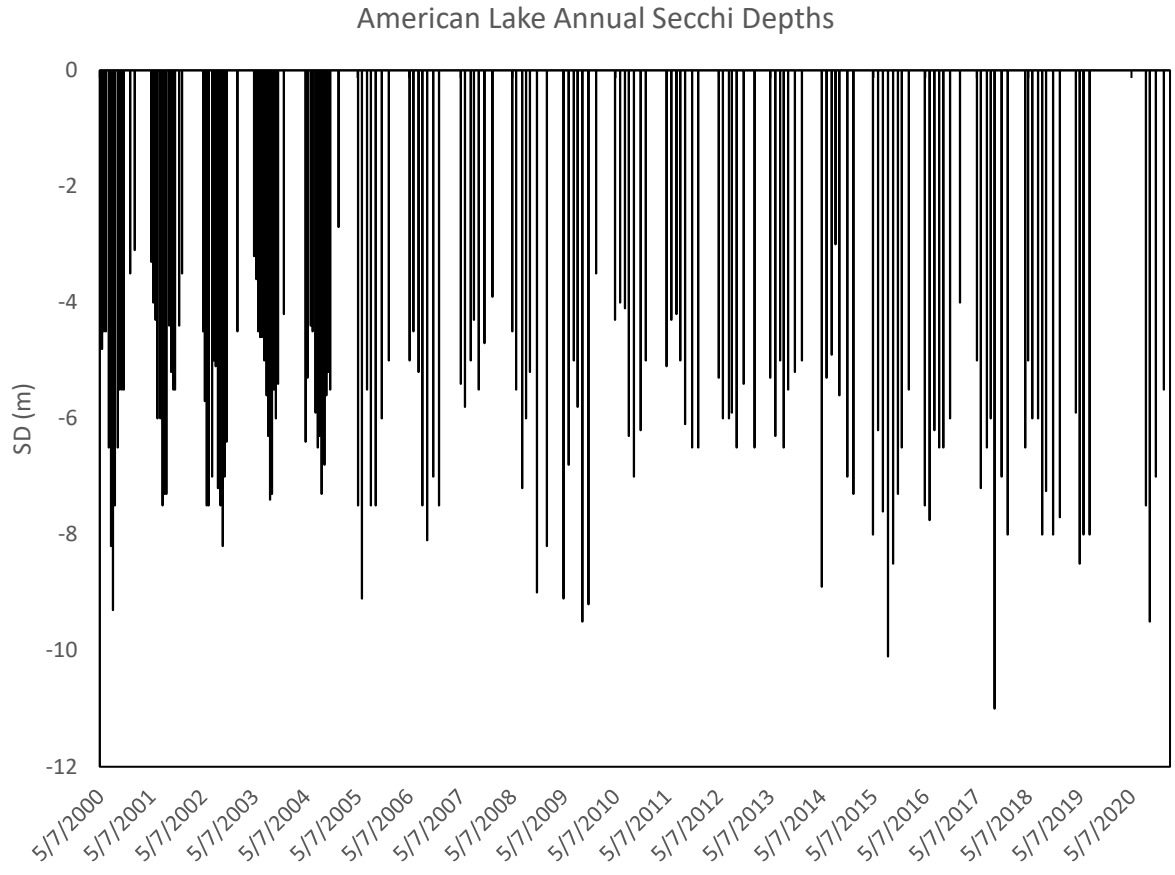
Lake	Date	Time	Site Depth (m)	Secchi Depth (m)	Air Temp (C)	Water Temp (°C) Top	Dissolved Oxygen (mg/l) Top	Water Temp (°C) Bottom	Dissolved Oxygen (mg/l) Bottom	Lake Level (ft.)	Suspended Algae	pH (1 m)	pH (deep)	Comments/Observations
Waughop	7/10/2020	11:30am	2.9	2	18.6	21.3	10.5	21.2	9.7	5.85	Light	7.5		Breezy, W; partly cloudy; water surface - ripples; bright cloud conditions, no water odor; 14 geese; 1-person fishing. Water is much clearer than in the past thanks to alum treatment in April 2020. Secchi disk disappeared at 2 m. close to the bottom and perhaps more a function of entering the fluffy bottom area vs. general water turbidity.
	8/10/2020	9:15am	2.2	2.2	24	22.6	9.1	22.7	0.4	4.12	moderate	7.4		Wind - calm; clear weather; calm water surface; strong sunlight; rotten egg odor. 3 mallards, 2 kingfishers; 0 boats, 4 people fishing, 0 swimmers/waders. H2S gas bubbles breaking surface on their own and much more so upon disturbance by our anchor and the lead weight.
	9/28/2020	10:15 AM	2.2	2.2	18.6	16.9	10.1	16.7	10.1	3.55	None	7		Wind cond: light, NE; weather: clear, water surface: calm; light cond: strong sunlight. No water odor, 1 goose; 1-person fishing. Note: weight hit bottom at 1.9 meters. Sediments are pretty fluffy, so the lead weight sank another 0.3 m before finding enough support.
	10/26/2020	9:15 AM	2.4	2.4	7.6	8.9	11	8.9	10.7	3.5	None	6.6		Wind cond: calm; weather: overcast; water surface cond: calm; light conditions: overcast. No odor. Secchi disk hit bottom. 10 coots, 8 northern shovelers, 6 mallards. 1 boat; no fishermen, no swimmers/waders. Bottom was visible throughout; noticed a great number of green globules tentatively identified as *Ophrydium versatile* by Don Russell under microscope.

Appendix 1. Lake Data

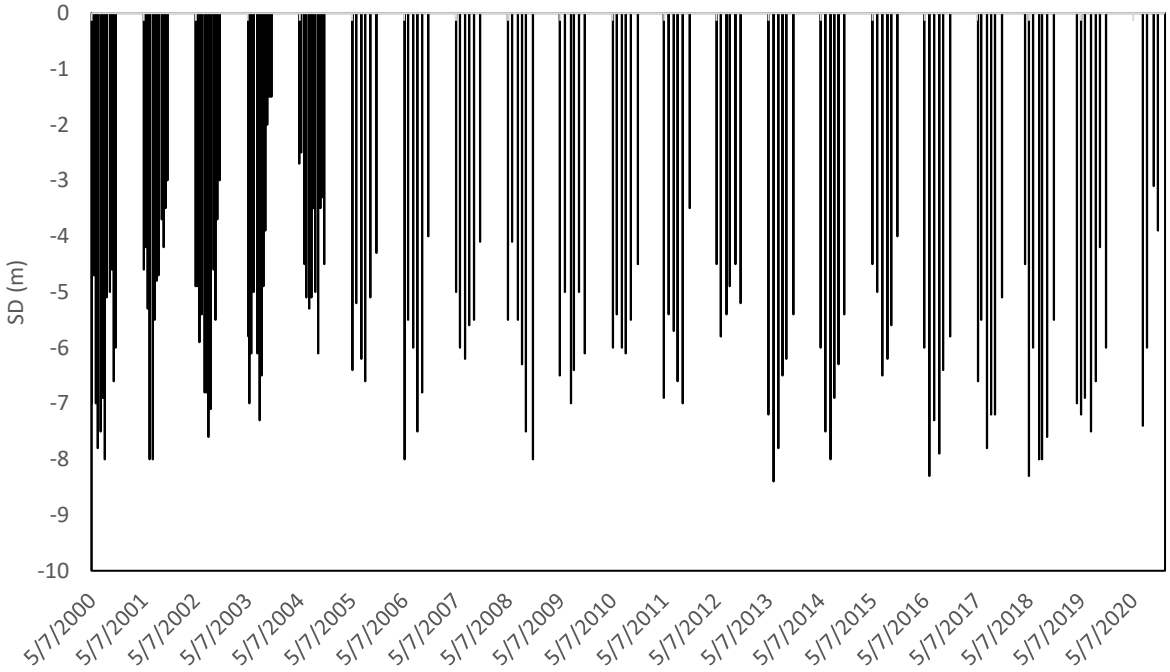




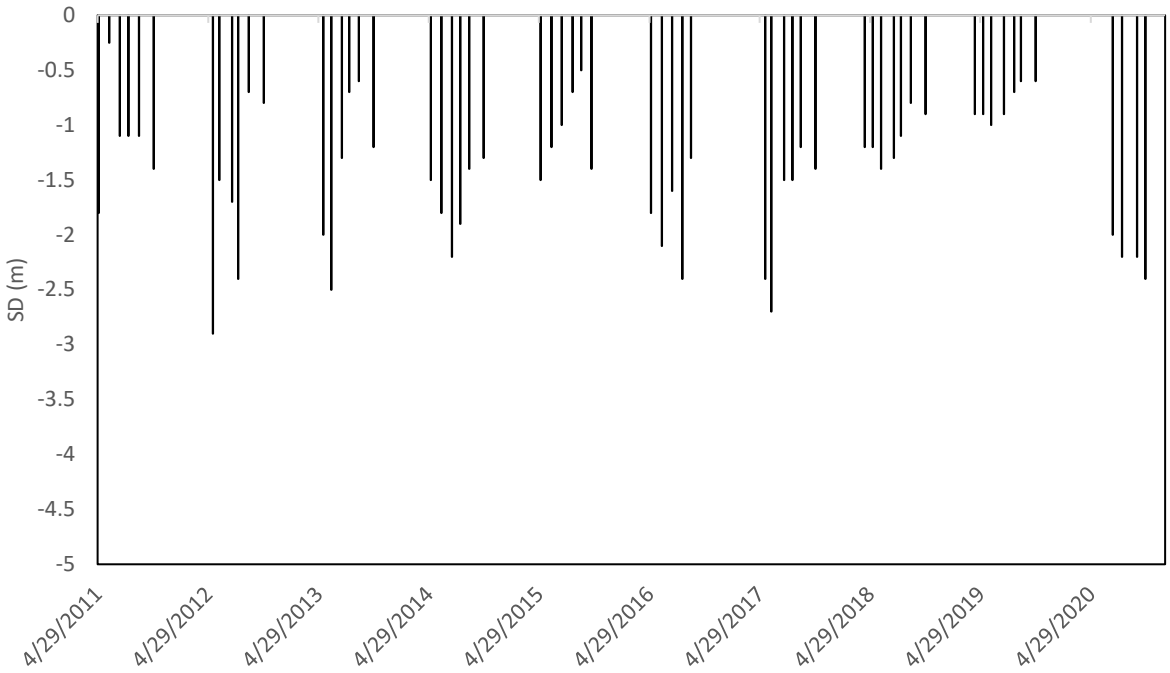

Waughop Lake - Annual Lake Levels
Lake Level (ft)
10
9
8
7
6
5
4
3
2
1
0
1/1/2011
1/2/2012
1/2/2013
1/3/2014
1/4/2015
1/5/2016
1/5/2017
1/6/2018
1/7/2019
1/8/2020
1/8/2021
1/9/2022

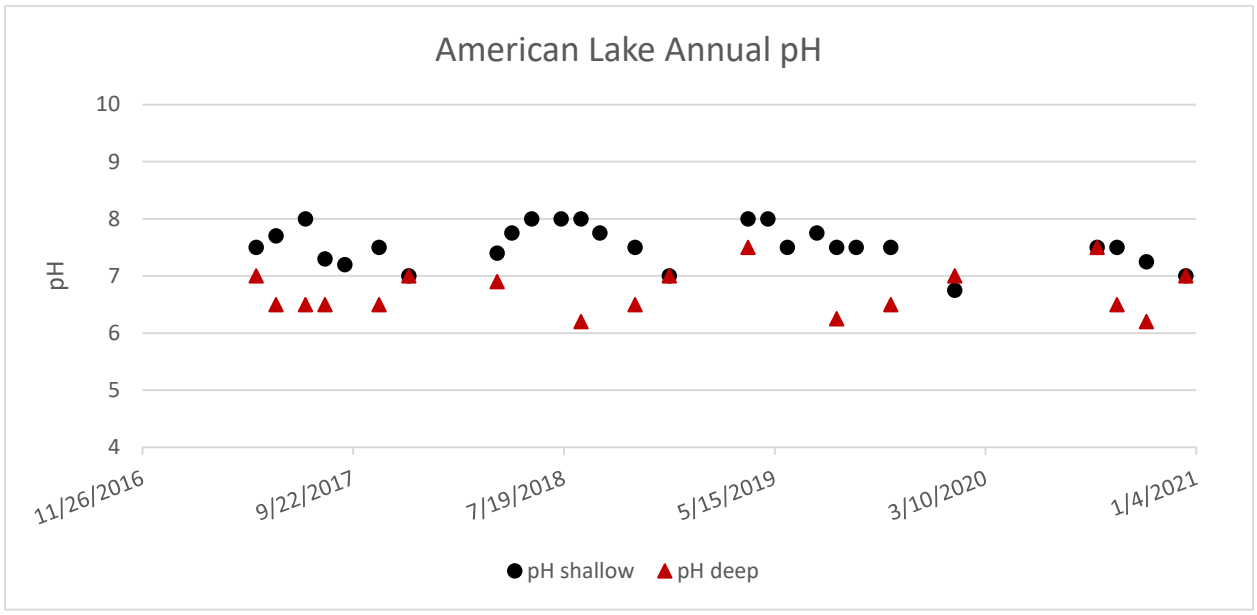

American Lake Annual Secchi Depths
SD (m)
0
-2
-4
-6
-8
-10
-12
5/7/2000
5/7/2001
5/7/2002
5/7/2003
5/7/2004
5/7/2005
5/7/2006
5/7/2007
5/7/2008
5/7/2009
5/7/2010
5/7/2011
5/7/2012
5/7/2013
5/7/2014
5/7/2015
5/7/2016
5/7/2017
5/7/2018
5/7/2019
5/7/2020

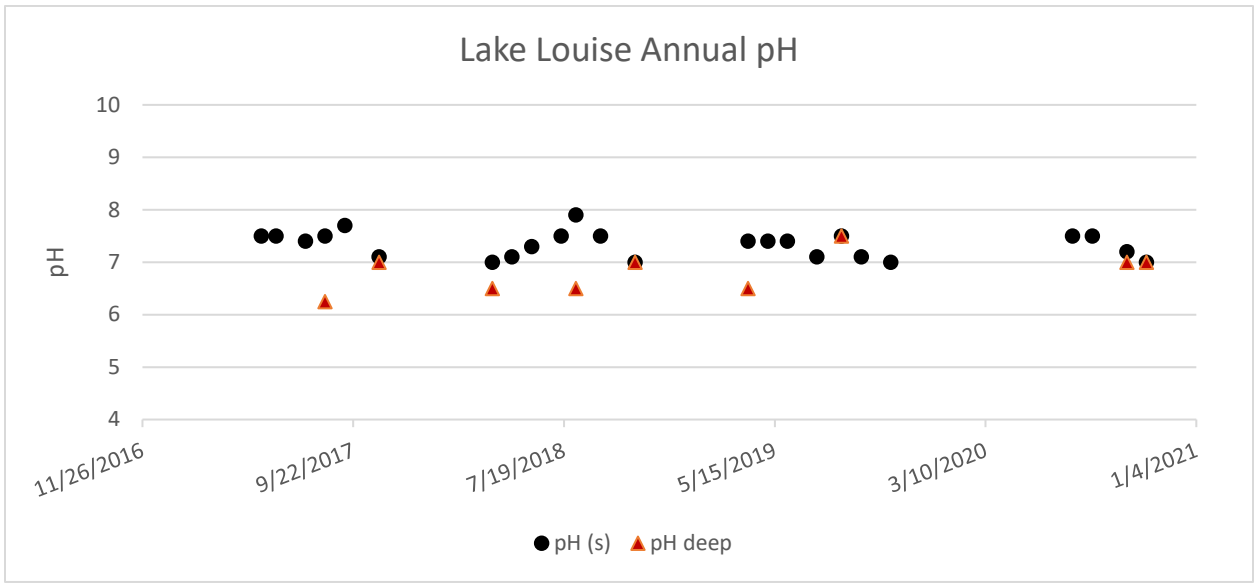
Lake Louise Annual Secchi Depths

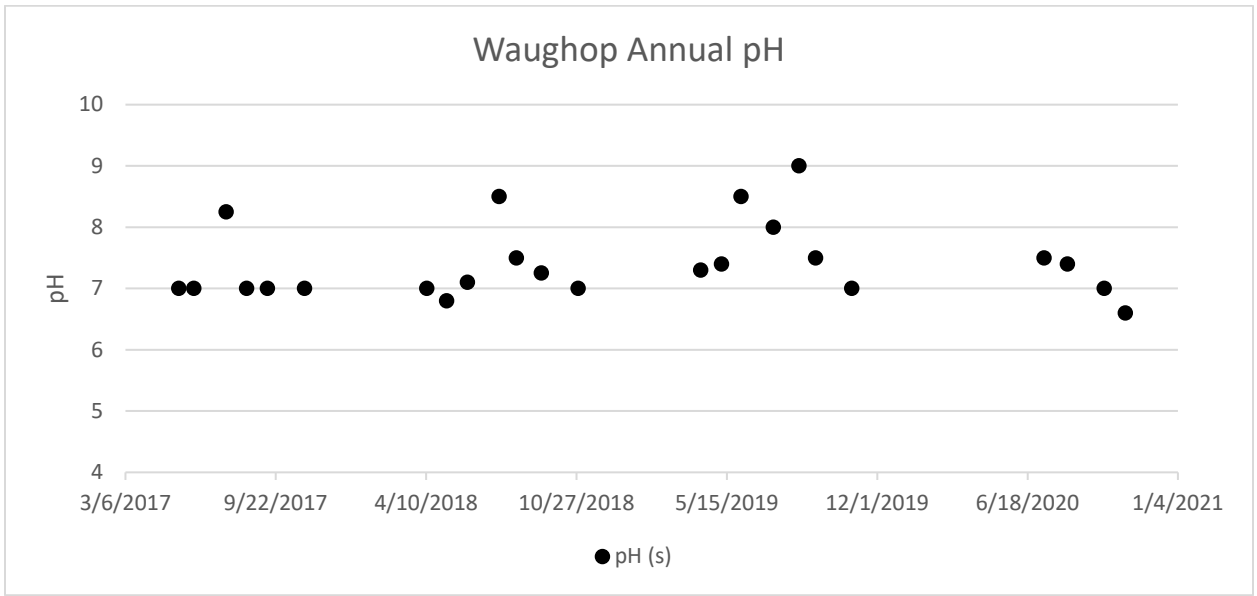


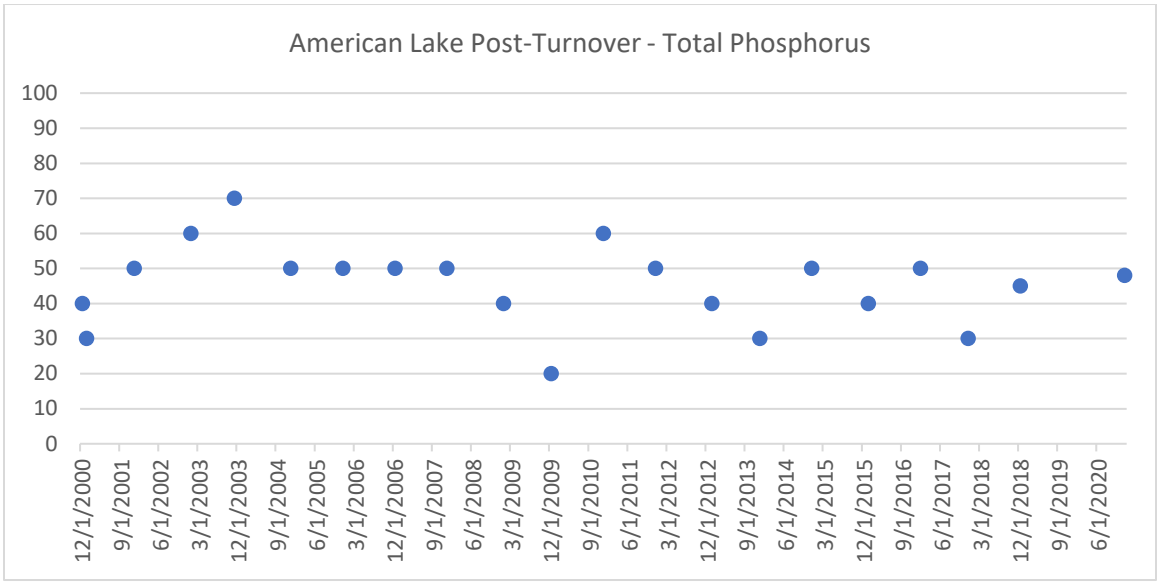
Waughop Lake Annual Secchi Depths

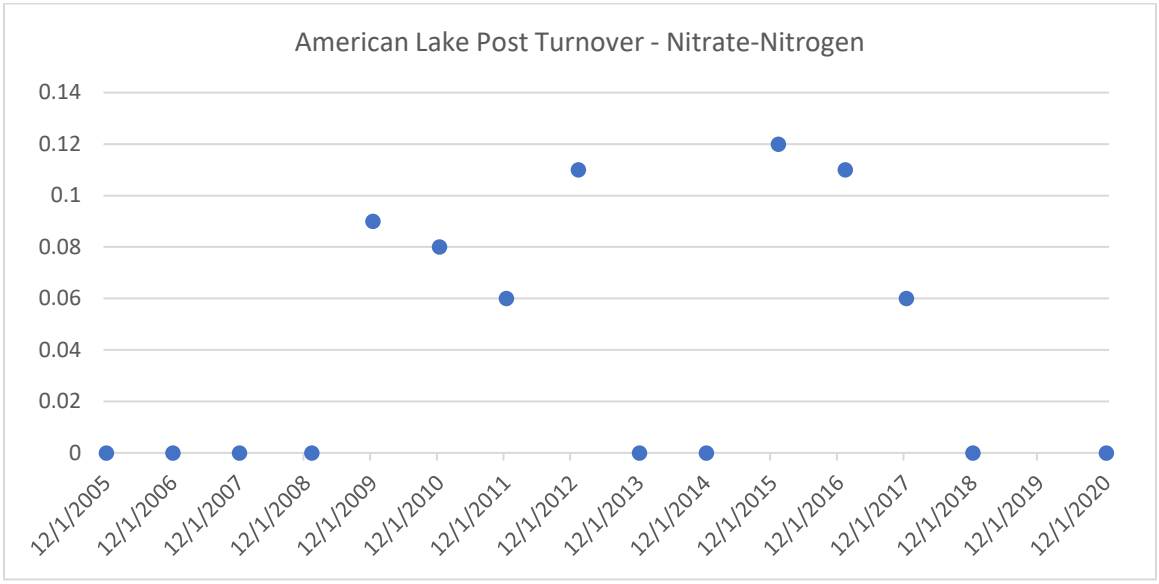


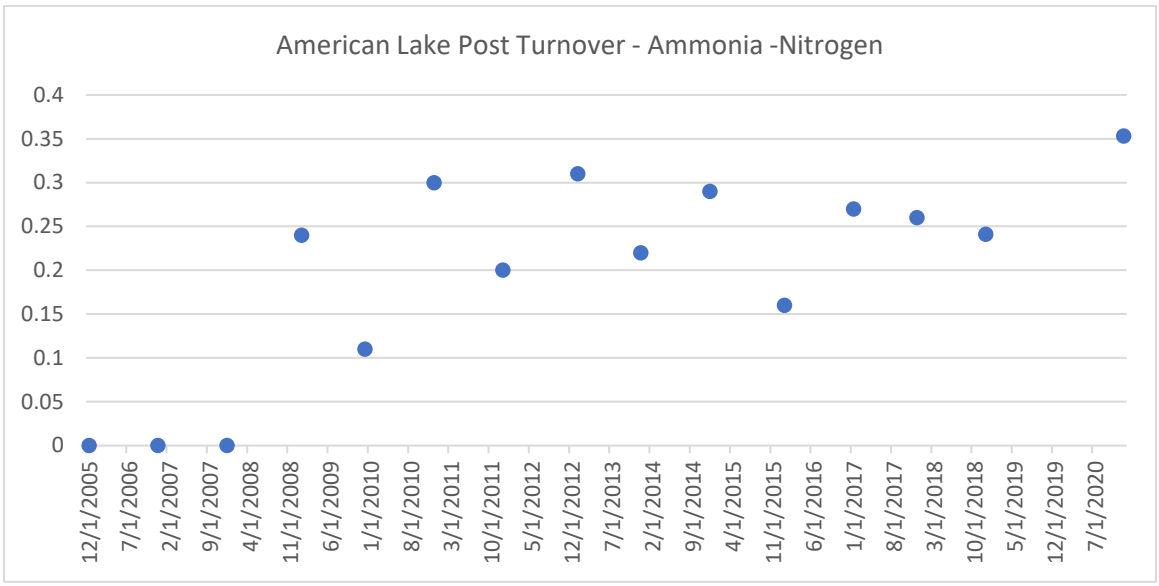

American Lake Annual pH
10
9
8
7
6
5
4
pH
11/26/2016
9/22/2017
7/19/2018
5/15/2019
3/10/2020
1/4/2021
pH shallow
pH deep


Lake Louise Annual pH
10
9
8
7
6
5
4
pH
11/26/2016
9/22/2017
7/19/2018
5/15/2019
3/10/2020
1/4/2021
pH (s)
pH deep


Waughop Annual pH
10
9
8
7
6
5
4
pH
3/6/2017
9/22/2017
4/10/2018
10/27/2018
5/15/2019
12/1/2019
6/18/2020
1/4/2021
pH (s)


American Lake Post-Turnover - Total Phosphorus
100
90
80
70
60
50
40
30
20
10
0
12/1/2000
9/1/2001
6/1/2002
3/1/2003
12/1/2003
9/1/2004
6/1/2005
3/1/2006
12/1/2006
9/1/2007
6/1/2008
3/1/2009
12/1/2009
9/1/2010
6/1/2011
3/1/2012
12/1/2012
9/1/2013
6/1/2014
3/1/2015
12/1/2015
9/1/2016
6/1/2017
3/1/2018
12/1/2018
9/1/2019
6/1/2020


American Lake Post Turnover - Nitrate-Nitrogen
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
12/1/2005
12/1/2006
12/1/2007
12/1/2008
12/1/2009
12/1/2010
12/1/2011
12/1/2012
12/1/2013
12/1/2014
12/1/2015
12/1/2016
12/1/2017
12/1/2018
12/1/2019
12/1/2020


American Lake Post Turnover - Ammonia -Nitrogen
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
12/1/2005
7/1/2006
2/1/2007
9/1/2007
4/1/2008
11/1/2008
6/1/2009
1/1/2010
8/1/2010
3/1/2011
10/1/2011
5/1/2012
12/1/2012
7/1/2013
2/1/2014
9/1/2014
4/1/2015
11/1/2015
6/1/2016
1/1/2017
8/1/2017
3/1/2018
10/1/2018
5/1/2019
12/1/2019
7/1/2020