Jefferson County Toxic Cyanobacteria Project

Final Report

Ecology grant number G1400003

June 30, 2015

Evan Dobrowski & Michael Dawson

JEFFERSON COUNTY PUBLIC HEALTH

615 Sheridan St • Port Townsend • WA 98368 • 360-385-9444 • www.jeffersoncountypublichealth.com

Distribution List

Lizbeth Seebacher
Freshwater Algae Control Program
Washington State Department of Ecology
PO Box 47775
Olympia, WA 98504-7775

Jared Keefer
Jefferson County Environmental Health
615 Sheridan St
Port Townsend, WA 98368

Matt Tyler
Jefferson County Public Works, Parks and Recreation
623 Sheridan St
Port Townsend, WA 98368

Aaron Terada
Olympic View Area Lead Ranger
Washington State Parks
10541 Flagler Road
Nordland, WA 98358

Mark Downen
District Fish Biologist, Region 6
Washington Department of Fish and Wildlife
48 Devonshire Road
Montesano, WA 98563

Contents

Background

Jefferson County Public Health (JCPH) has monitored toxic algae blooms annually in Jefferson County, Washington, lakes ever since two dogs died of anatoxin-a poisoning at Anderson Lake in June, 2006. This poisoning was attributed to toxins in the lake produced by cyanobacteria, also known as blue-green algae.

This report summarizes the toxic algae monitoring work done by JCPH in the two most recent years, 2013 and 2014. Previous years' work is summarized in a separate report (WSDOE 2010). This project focused on the three most highly used public recreation lakes in Jefferson County: Anderson Lake, Gibbs Lake, and Lake Leland. Each of these lakes has had a history of toxic algae blooms. Other lakes were monitored as needed (Figure 3, Jefferson County Lakes Map).

From 2006 until 2009 JCPH posted lakes with a caution (yellow) sign when cell density exceeded 30,000 cells/mL and a warning (red) sign when cell density exceeded 100,000 cells/mL. This was revised in 2010 and continued through 2014 to reflect toxin levels since we found that cell density and visible blooms are often not reliable indicators of toxin levels, i.e., clear waters with no visible algae bloom sometimes had very high toxin levels. The opposite of this is also true, i.e., very dense blooms of toxin-producing algae often produce little or no toxins.

JCPH works closely with state and local parks personnel in managing lake closures and advisories.

Anderson Lake

Figure 1, Anderson Lake

Anderson Lake is situated in a day use 410-acre state park surrounded by a forest of mixed cedar, Douglas fir, maple and alder. A freshwater marsh is found on the southern lake shore. There is very little development in the watershed, with the closest residence belonging to the park. Anderson Lake has a surface area of 60 acres, with maximum and average depths of 25 and 12 feet (7.6 and 3.7 meters, respectively). Public access is from a boat launch on the west side of the lake. In addition to recreational boating and fishing on the lake, there are 4.4 miles of hiking trails and 3.4 miles of bike trails. The lake is typically stocked with trout annually by the Washington Department of Fish and Wildlife. The fishing season has been cut short or not opened at all after toxic cyanobacterial blooms in every year since 2006 have closed the lake to recreational activity. These blooms have been dominated by *Anabaena* in the late spring that have produced the toxin anatoxin-a, and in one case, from June 2008, the highest level of this toxin ever recorded in the world. Anderson Lake has also had *Microcystis* blooms later in the year, but the microcystin toxin has never reached warning levels in this lake.

Gibbs Lake

Gibbs Lake is a 33 acre lake located in a 669 acre county park (Figure 2, Gibbs Lake). Gibbs is 8 miles south of Port Townsend in a heavily wooded area. The park has a hand-carry boat launch and a very popular swimming hole. The watershed is almost entirely timberland with very little residential development. Gibbs Lake has exceeded state guidelines for microcystin in 20011, 2012 and 2013.

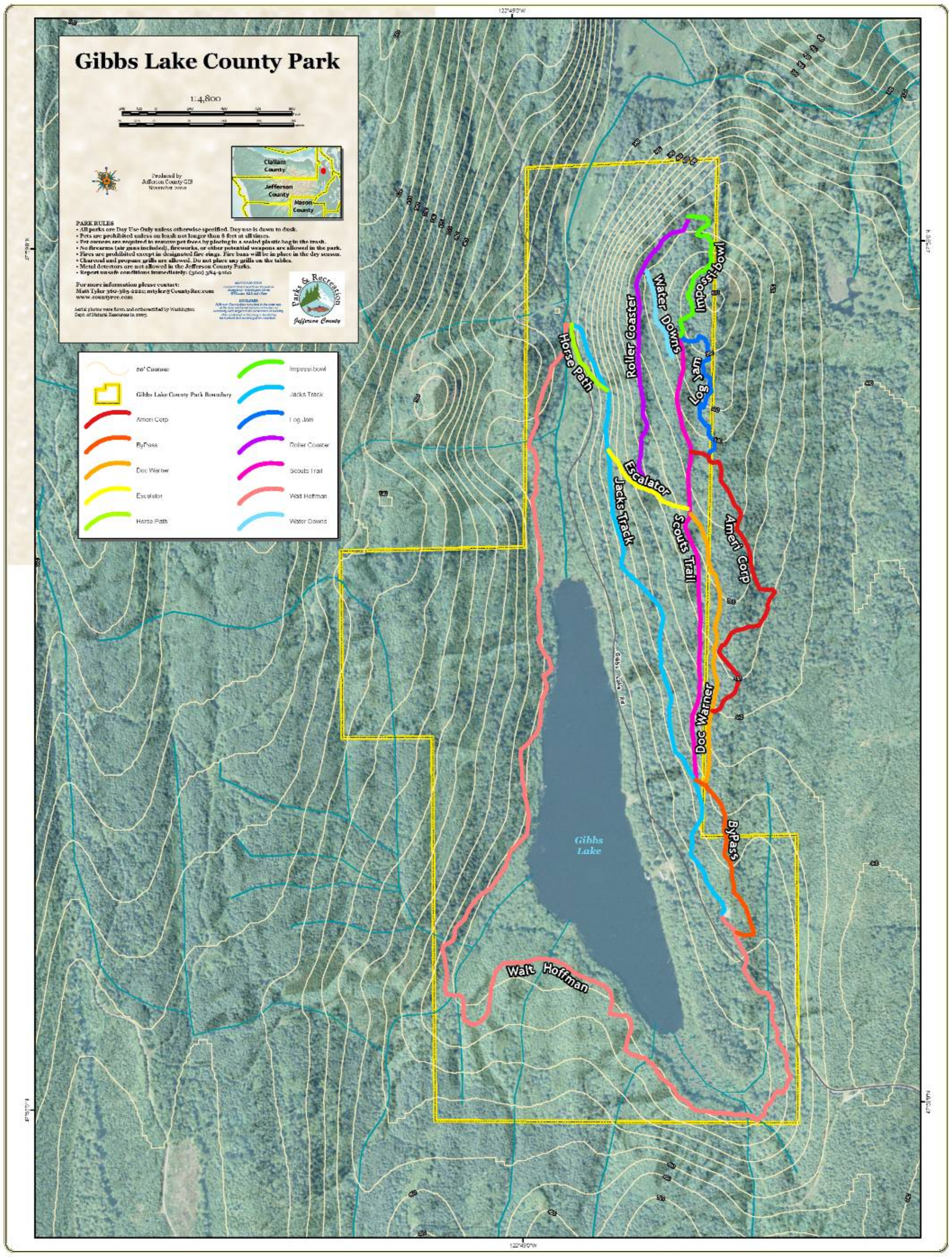


Figure 2, Gibbs Lake

Figure 3, Jefferson County Lakes Map

Lake Leland

Lake Leland (Figure 4, Lake Leland) is located in eastern Jefferson County five miles north of Quilcene, Washington. It is a 108 acre shallow lowland lake created by glacial processes. It is approximately 20 feet deep at its maximum. Roughly 60% of the 2.8 miles of shoreline is developed with residences, a private camp, and a Jefferson County Park. There is a boat ramp and a 22 campsite campground at the park located on the eastern shore. The lake drains slowly through a reed canary grass-dominated swamp into Leland Creek. Wetlands cover the north and south ends of the lake. The lake is also a source of domestic drinking water for some of the local residents, who have been contacted and warned not to use lake water for most domestic purposes. Leland has a history of *Microcystis* and *Anabaena*-dominated blooms producing microcystin and anatoxin at levels high enough to post warnings repeatedly for recreational use, but this lake has never been closed due to high algal toxin levels. In 2012, we saw the thickest algae blooms since 2006 in this lake, dominated by toxin-producing species, yet toxins remained very low for the entire season.

Figure 4, Lake Leland

Teal Lake

Teal Lake is a small lake in the Port Ludlow community north of the Hood Canal Bridge (Figure 3, Jefferson County Lakes Map). The lakefront is privately owned by Pope Resources, but there is a public access point maintained on the western shore off of Teal Lake Road. JCPH does not have any record of bluegreen algae blooms on Teal Lake.

In summer of 2014, JCPH received a phone call from a fishermen that frequents Teal Lake describing a visible bloom on Teal Lake. JCPH investigated and found no signs of algae. The report appeared to be mistaking common duckweed as an algae bloom.

Cyanobacteria

Cyanobacteria are naturally occurring and found in most bodies of water around the world. Some 2000 species of cyanobacteria occur globally in aquatic habitats. Generally, they are non- toxic and contribute to an ecosystem in a productive, positive way. They are able to survive under a wide range of environmental conditions and some produce potent toxins. Under favorable growing conditions, (i.e.: nutrient availability, light intensity, water temperature, species competition, wind patterns, water column mixing, and/or zooplankton predation), excessive growth can create a cyanobacterial bloom. Blooms may produce toxins that are potentially lethal to domestic pets, wildlife, livestock, and humans. Blooms most often take place in late summer or early fall, and may appear as a surface scum or flocculent masses floating in the water column.

Exposure to cyanobacterial blooms can cause rashes, skin and eye irritation, allergic reactions, gastrointestinal upset, and other effects. At high levels, exposure can result in serious illness or death. The exposure pathways for cyanobacterial toxins include recreational contact, contaminated drinking water, and ingestion of dietary supplements derived from blue-green algae (CDC, 2008). While multiple routes can lead to exposure, the focus of this study was the recreational pathway. Recreational pathways include but are not limited to: swimming, wind surfing, jet skiing, wading, boating, fishing, and water skiing. During recreational lake activities, it is inherent that recreationalists will be exposed to the water. Recreational water exposure includes: skin contact, inhalation, and ingestion. Moreover, Washington State estimates that a recreational lake user ingests 0.05L of water per hour (WSDOH, 2008).

Toxic blooms have been documented throughout Washington ponds, lakes, and reservoirs increasing throughout the past 25 years. Following are the most common genera of cyanobacteria identified in Washington State freshwater bodies:

- *Anabaena*
- *Aphanizomenon*
- *Cylindrospermopsis*
- *Gloeotrichia*
- *Lyngbya*
- *Microcystis*
- *Nostoc*
- *Oscillatoria/Planktothrix*

Of these, *Anabaena, Microcystis and Gloeotrichia* have posed problems in Washington lakes. Five of these genera have been identified in Anderson Lake: *Microcystis, Anabaena, Aphanizomenon, Oscillatoria,* and *Lyngbya.* Three of the above genera have been isolated from Lake Leland and Gibbs Lake: *Microcystis, Anabaena,* and *Aphanizomenon*. In addition, a genus of toxin-producing bluegreen algae*, Coelosphaerium,* that had not previously been detected in Jefferson County lakes, was identified in Anderson Lake in 2012.

Species of *Anabaena, Aphanizomenon*, and *Oscillatoria* are capable of producing a strong neurotoxin, anatoxin-a, which causes damage to the nervous system and has been responsible for many animal deaths worldwide. *Microcystis, Anabaena,* and *Oscillatoria* can produce microcystin, a long-term liver toxin which can cause liver failure after extended periods of ingestion; but it also has short-term effects such as skin rash and itching, nausea, vomiting and diarrhea.

Just a few years ago, it was believed that only about 10% of all algae blooms produced toxins. Recent studies have shown that the probability that an individual bloom containing *Anabaena, Microcystis,* and/or *Aphanizomenon* will be toxic is actually between 45 and 75% (WSDOE 2010b).

Microcystin

Microcystin is a toxin that has both short and long-term effects. Ingestion over long time periods can cause necrosis in liver tissue. Although unproven, studies indicate that microcystin is a liver carcinogen and increases the incidence of liver cancer from chronic exposure.

Short-term symptoms usually occur 30 minutes to 24 hours after exposure, and are a function of the person's size, the concentration of toxin, and the duration of the exposure. The symptoms may include jaundice, shock, abdominal pain/distention, weakness, nausea/vomiting, severe thirst, rapid/weak pulse, and death (WSDOH, 2008). Ingestion is the primary mode of exposure for microcystin, but this toxin can also cause itchy skin rashes on any area of the body exposed to it.

Anatoxin-a

Anatoxin-a is a potent acute neurotoxin. Anatoxin is perhaps one of the most toxic of the cyanobacterial toxins since the effects of ingestion can be lethal within 4 minutes, depending on the quantity consumed. This led to the compound being dubbed "Very Fast Death Factor."

Anatoxin-a is a potential human health hazard and has been responsible for numerous deaths of wildlife, livestock, and domestic animals (Jarema et al. 2008).

Human exposures may occur from recreational water activities and dietary supplements, but are primarily through drinking water (Rogers et al. 2005).

Symptoms of anatoxin exposure are loss of coordination, muscular fasciculation, convulsions and death by respiratory paralysis.

State guidance for recreation includes values for concentrations of microcystin and anatoxin-a in surface waters above which water-based recreation is not recommended (WSDOH 2008). These are 6 micrograms per liter for microcystin and 1 microgram per liter for anatoxin-a. See Recreational Lake Use Recommendations, page 8.

Project Description

This project continued the assessment of the ecology of three publicly accessible lakes for nutrient and limnological conditions from May 2013 to December 2014. Anderson and Gibbs Lakes and Lake Leland all experienced toxic cyanobacterial blooms that led to closures (Anderson Lake) or placement of Caution or Warning signage (all three lakes) in the five years prior to this study. In this final report we examine the nutrient and physical data and the algal toxin concentration and identification data collected from this project to determine the feasibility of possible control measures that could be taken to decrease toxic cyanobacterial blooms in these lakes and to make informed decisions to protect the public health.

Goals

This project had three main goals:

1. Provide information to make public health recommendations for lake users and managers.
2. Develop a comprehensive understanding of cyanobacterial cell density, toxins, lake conditions and nutrients to direct future monitoring and control efforts.
3. Use results of this project to help other agencies and jurisdictions prepare for and respond to cyanobacterial blooms.

Objectives

Specific objectives of the project included:

1. Learn the nutrient dynamics of each lake; which conditions contribute to cyanobacteria growth and toxin production; how the lakes compare to one another and compare seasonally; what changes are needed in our current monitoring plan; and what control and public health actions might be indicated. JCPH will consult with experienced limnologists in the development of any algal control measures.
2. Protect public health while informing the public about lake status. Sample Gibbs Lake, Anderson Lake and Lake Leland on a weekly basis during the recreational season – May through October – for toxin concentration and algae identification. Post lakes with warning signs as necessary, issue press releases, provide public information for weekly newspaper articles, and update the JCPH website as needed.
3. Provide education that targets the public, lake residents, users, park staff, and lake drinking water users that will address risks, appropriate precautions, and levels of caution.

Personnel

Jefferson County Public Health (JCPH)

- Jared Keefer, Environmental Health Director: Responsible for overall project management, supervision of staff, and interagency coordination
- Greg Thomasson, Evan Dobrowski and Michael Dawson, Environmental Health Specialists: Conduct sampling, collect and process samples, input and analyze data and prepare reports.

King County Environmental Laboratories (KCEL)

- Francis Sweeney, QA contact: Oversee QA/QC relating to cyanobacteria toxin concentration and identification, and reporting of results.

Results were reported to Michael Dawson, Water Quality Team Leader. He and other Environmental Health Specialists gathered the data, analyzed it, entered it into spreadsheets and the Department of Ecology's Environmental Information Management System (EIM) and wrote this final report.

Funding was provided at 75 percent by Ecology through the Freshwater Algae Control Program. The remaining 25 percent of matching funds were provided by JCPH.

Sampling Design

Anderson, Leland, and Gibbs lakes were sampled according to the following schedule:

- Cyanobacterial identification, toxin concentrations, and physical profiling
    - Weekly from the beginning of May through the end of October
- Nutrients
    - Monthly May through October

These three lakes are small enough that, for nutrient samples and physical profiles, we allowed a single mid-lake sampling station to represent conditions throughout the entire lake. Cyanobacteria identification and toxicity samples were taken just offshore in depths less than 1.0 meter to determine the potential for exposure to the public. Since we are only considering recreational exposure as the toxin pathway, and because exposure generally occurs at the surface, only surface samples were taken for cyanobacteria identification and toxin concentration.

In 2013 and 2014, a composite epilimnion sample from depths of 0.15, 1.0 and 2.0 meters was analyzed monthly for nutrients (total N, nitrite/nitrate-N, ammonium-N, total P) in each lake. Field measurements at this same station included Secchi depth, wind speed and direction, and vertical profiles of the following: temperature, pH, dissolved oxygen, and conductivity down to 8 meters.

For hypolimnetic samples, a single sample was taken each time from the hypolimnion, a half-meter above the lake bottom, with a Van Dorn sampler. Nutrient data was put into an Excel page and later uploaded to Ecology's EIM program.

Samples were shipped via UPS or FEDEX to Edge Analytical and Twiss Labs (for nutrient analyses) and to KCEL (for algae identification and toxin assays) the same day they were collected. Samples were disposed of by the associated lab where they were submitted. For Lab protocols, precision levels, sensitivities, etc., refer to the Quality Objectives section of the Quality Assurance Project Plan (QAPP) for this project.

Typically, visible blooms with scum are used to identify potential threats to public health from cyanobacteria. However, previous studies indicate that toxins may be present in lakes with less-visible blooms of cyanobacteria (Jefferson County Public Health 2010). Because of this disparity between cell counts and toxin levels, in May 2010 we revised our method for placement of caution and warning signage so that it is based on toxin levels (as measured by KCEL) primarily, not on cell counts. We continued this method in 2013 and 2014. Our protocol for these two years was as follows:

Recreational Lake Use Recommendations

<u>A Caution Sign</u> will be posted if:

- The results from KCEL show that potentially toxic cyanobacteria are present, but the anatoxin-a level is less than 1 microgram (µg) per liter (L) and the microcystin level is less than 6 µg/ L.
- In the absence of any toxin assay or algae ID information, a scum-forming bloom is present. In this case, a worst-case scenario will be assumed, i.e., that the bloom contains at least some toxic algae.
- The lake will continue to be sampled weekly and even if toxin levels remain low, as above, a Caution sign will still remain posted until the bloom dissipates and/or toxic species are no longer present.

<u>A Warning Sign</u> will be posted if:

- The results from KCEL show the sample is dominated by potentially toxic cyanobacteria, and anatoxin-a level is 1µg/L or higher or microcystin level is 6µg/L or higher.
- In the absence of any updated toxin assay or algae ID information, there is an extensive scum of a known or suspected toxic species.
- The lake will continue to be sampled weekly and the warning will remain in place until toxin levels drop below 1µg/L anatoxin-a and 6 µg/L microcystin for two consecutive samples taken at least one week apart. Then as long as a bloom still exists and toxic species are still present, a Caution sign will replace the warning sign (see Caution Sign section above).

Under certain circumstances, JCPH may work with land managers to close a lake for recreational use. These conditions include but are not limited to:

- High toxin concentrations
- A very dense bloom that covers much of the lake
- Reported human illness
- Confirmed pet illness or deaths
- Dense bloom and history of illnesses associated with the lake

For mid-lake sampling, in an attempt to discern the natural conditions of the water column the vertical profile was taken with the YSI multiprobe first, before the water column was disrupted (the multiprobe is least likely to disturb the water). Nutrient samples were taken second with the Van Dorn tube, and the Secchi depth was performed last.

Weekly determinations of public health cautions and warnings were made based on sampling data. One of the goals of this study was to gain information that will allow us to establish better criteria for recommendations on action levels such as caution and warning status to lake managers and the public. No regulatory decisions will be made based on this information; rather, public health warnings and advisories will be communicated to the public.

[NB: Due to the small scale of this project, a formal Systematic Planning Process was not used. The plan authors received input from involved parties in designing the process]

Quality Control

Field Measurements

Each day the YSI-556 was calibrated for Conductivity, 3-point calibration for pH, and Dissolved Oxygen before going out into the field and after coming back to determine if there had been any drift in the measurements.

Nutrients, Cyanobacteria Cell Counts and Toxin Levels

The labs that ran our samples do their own quality control testing for their equipment. They utilize quality control measures which enabled them to obtain their accreditation. One additional sample was taken for each parameter as a duplicate each sampling day and submitted to the respective laboratories.

Corrective Action

When quality control results indicated problems for field measurements, the YSI-556 instrument manual was referenced and the problem corrected accordingly. In addition, each lab had its own quality control measures to insure accuracy.

Data Management Procedures

Laboratory data from King County Environmental Labs (both years) and Twiss Labs (both years) were transmitted to JCPH. All problems or changes were noted and discussed.

Results were entered into an Excel spreadsheet and stored on the JCPH server. The server performed incremental backups whenever a file was updated, and the files were backed up offsite on a regular basis. After entry the data was printed and double-checked against the originals. Hardcopies of field and lab data will be archived a minimum of five years past the project completion date. Electronic data will be stored indefinitely.

Both electronic and paper copies of the data will be accompanied by full metadata on the project including sample site locations, sampling techniques, and analytical methods.

Data was entered into Ecology's EIM database as appropriate. Final entry was upon completion of the project.

Audits and Reports

Formal reporting to Dept. of Ecology during this project was in the form of semi-annual reports and this Project Completion Report; five paper copies and one electronic copy will be submitted. Evan Dobrowski and Michael Dawson were responsible for reporting and Susan Parke was responsible for auditing, but all were assisted by other JCPH staff.

We have kept our collaborators (including Ecology) and other area water quality groups updated on our activities and results through e-mail and phone calls.

Data Verification and Validation

Field data were checked for accuracy and completeness by field staff before leaving each sampling station and reviewed upon returning to the office. Lab data packets were reviewed upon receipt for completeness, including all QC data. JCPH followed up immediately when field or lab data appeared suspect.

Data Quality Assessment

Due to the small scale of this project and its statistical needs, we did not devote time and resources to a formal data quality assessment (DQA) Process. Staff most directly involved in each portion of the project conducted primary DQA for that data. Reports to Ecology contained a general DQA with any problems noted in detail.

Our main analytical and presentation tool is graphical representations of the data, including:

- Time series and day-of-year graphs of specific parameters
- Scatter plots relating two parameters, e.g. toxin levels over time.

Data Submission

JCPH profile measurements and nutrient data were submitted to Ecology's Environmental Information Management System (EIM) and, once reviewed, will be publically available at www.ecy.wa.gov/eim. Toxin analysis and algae genera were entered in the Toxic Algae Database by King County Environmental Labs and are publicly available at www.nwtoxicalgae.org.

Results and Conclusions

Toxin Levels, 2013 & 2014

Anderson, Leland and Gibbs Lakes

Anatoxin-a

In 2013, Anderson Lake's anatoxin levels peaked at 38.7 micrograms per Liter (µg/L) on May 28, with anatoxin levels at or above the 1.0 µ/L recreational value (RV) for 6 consecutive weeks (May 6- June 17) (Figure 5, Anderson Lake Toxins Plot). Anatoxin levels dropped below RV from the July 15 sample date through the year until May 5, 2014. Washington State Parks closed Anderson Lake to the public use from May 6 for the remainder of 2013.

In 2014, Anderson Lake's anatoxin levels peaked at 990.5 micrograms per Liter (µg/L) on May 5, with anatoxin levels at or above the 1.0 µg/L recreational value (RV) for 5 consecutive weeks (May 5 – June 9) (Figure 5, Anderson Lake Toxins Plot). Anatoxin levels dropped below RV from the July 7th sample date through the season until October 6, when levels went back up to 32.5. Washington State Parks closed Anderson Lake to the public use from May 5 for the remainder of the year.

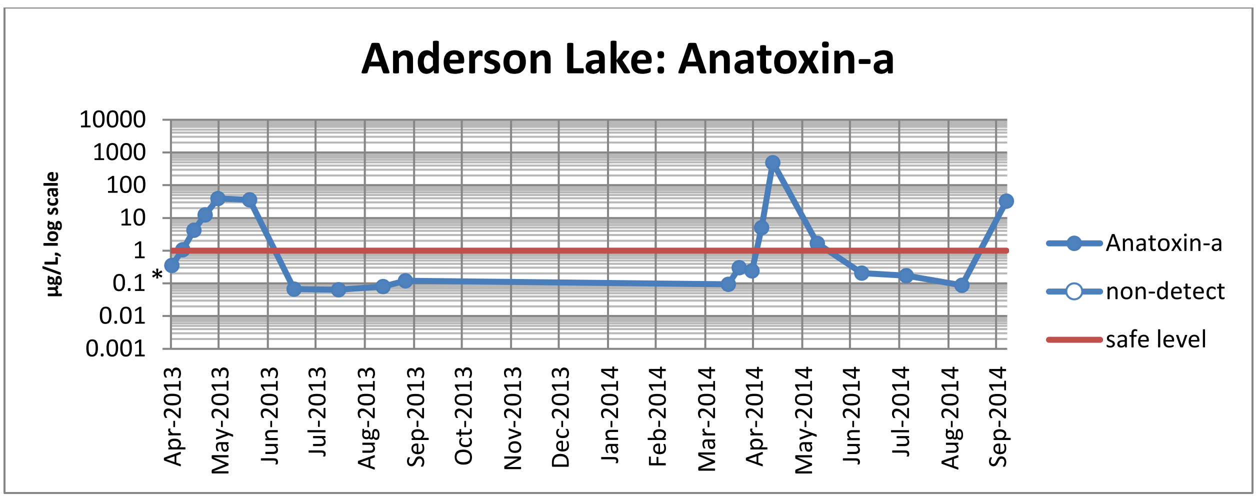
Anatoxin levels in Lake Leland and Gibbs Lake remained very low throughout both seasons, mostly less than detectible (Figure 6, Gibbs Lake Toxins Plot, and Figure 8, Lake Leland Toxins Plot). The highest anatoxin value for either lake was 0.258 µg/L in Lake Leland on May 5, 2014.

Microcystin

In 2013, microcystin levels remained less than detectable in Anderson Lake until the June 17 sample date when the value went up to 0.526 µg/L. Microcystin peaked at 3.01 µg/L on September 23, staying within safe levels for the season.

In 2014, microcystin levels remained less than detectable in Anderson Lake until the May 12 sample date when the value went up to 0.284 µg/L. The level stayed below recreational guidelines until October 6, when it climbed to 13.7 µg/L. This corresponded with a rise in anatoxin on the same date.

Microcystin levels in Lake Leland remained below detectable limits for the duration of both 2013 and 2014 seasons. Microcystin levels in Gibbs Lake remained very low in 2013, except for a five-week period from June 17 to August 12. During this time values rose to 6.8 µg/L (just above the warning level of 6.0 µg/L) on July 15, but then dropped below the warning level and continued to decline through the final sample day October 14. In the 2014 season Microcystin remained below the warning level in Gibbs Lake, Samples were taken from April 14 to October 7.



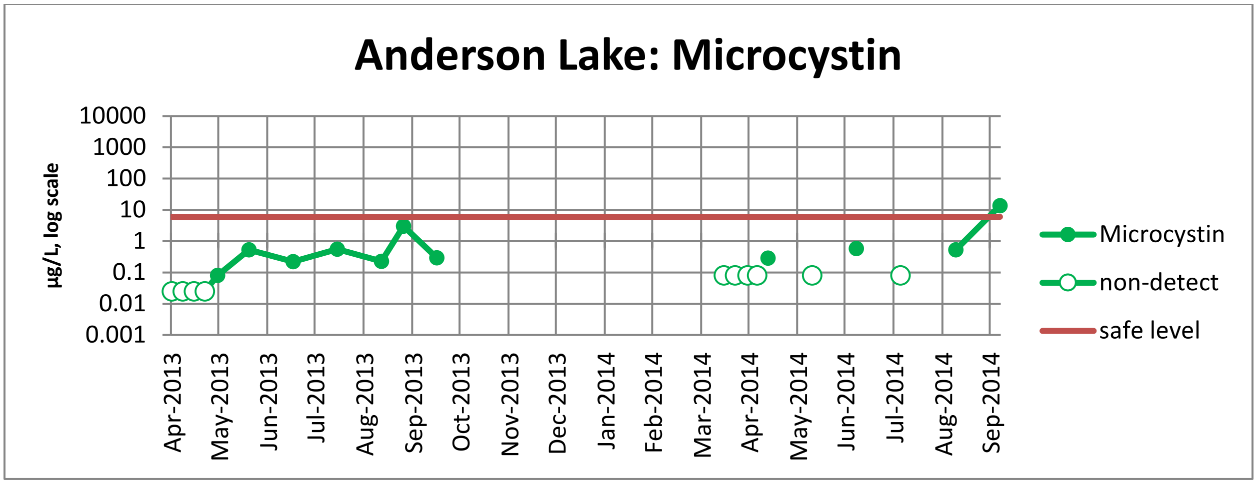


Figure 5, Anderson Lake Toxins

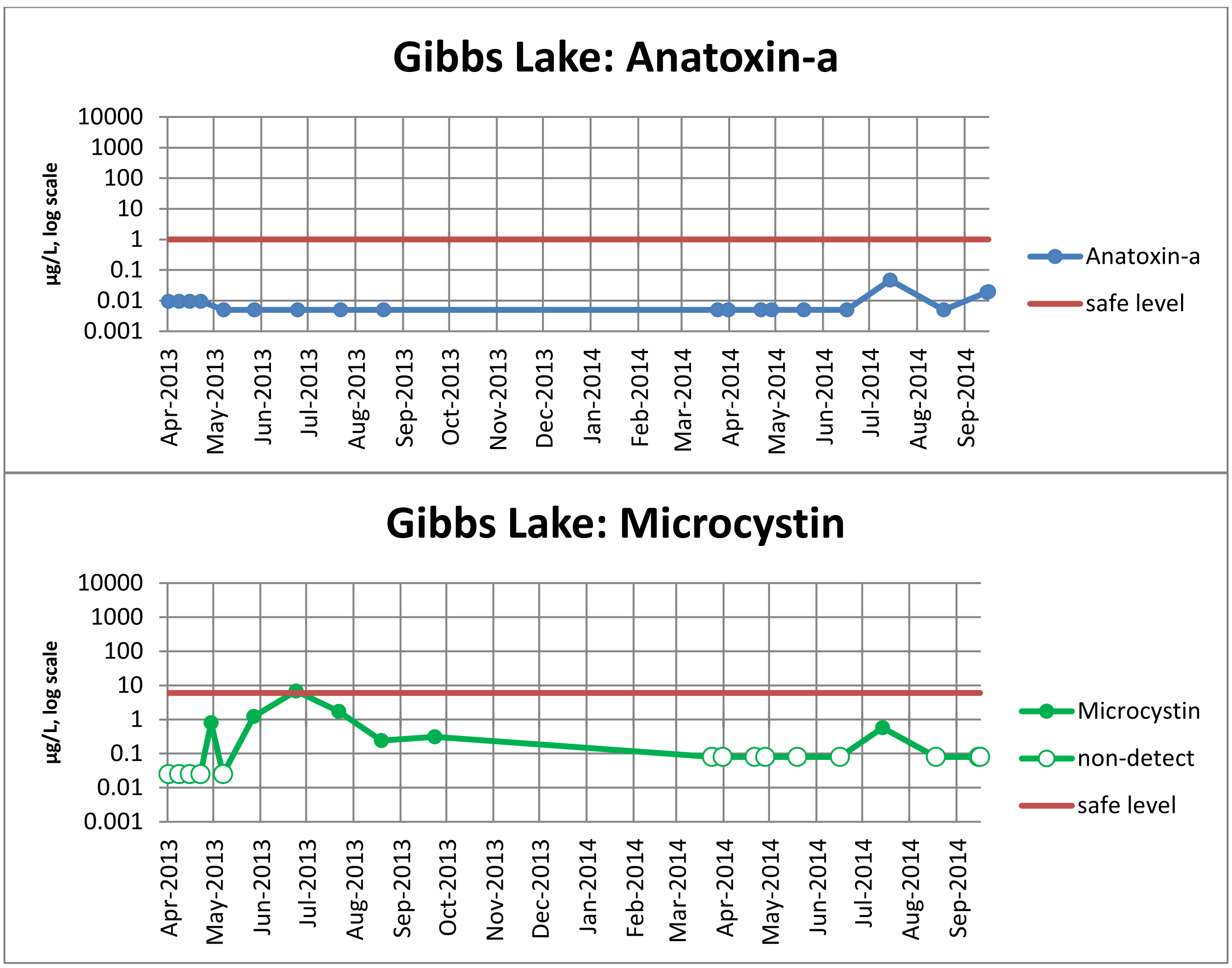


Figure 6, Gibbs Lake Toxins

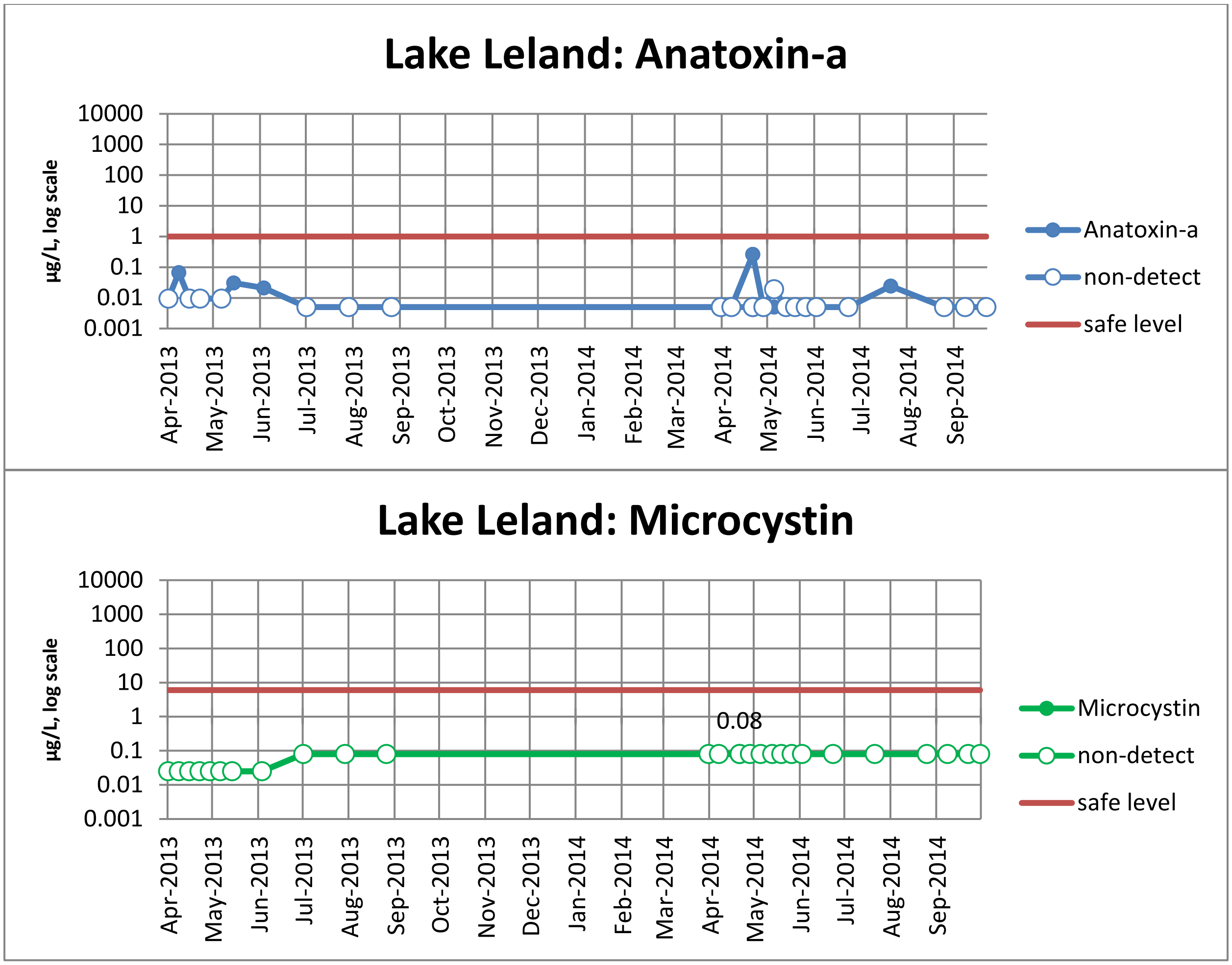


Figure 7, Lake Leland Toxins

Toxin Effects on Lake Recreation

2013 & 2014

Anderson Lake

In 2013, Anderson Lake opened for public recreation as scheduled on Saturday, April 27, and remained open for 10 days until May 6, before anatoxin levels above the warning level of 1.0 µg/L forced its closure by Washington State Parks Dept. The lake remained closed for the duration of the 2013 season.

In 2014, Anderson Lake opened for public recreation as scheduled on Saturday, April 26, and remained open for 10 days until May 5, before anatoxin levels above the warning level of 1.0 µg/L forced its closure by Washington State Parks Dept. The lake remained closed for the duration of the 2014 season.

Other Lakes

All other county lakes including Lake Leland and Gibbs Lake remained open both 2013 and 2014 with only microcystin in Gibbs Lake rising barely above the warning level, and this only on one sample date (6.8 µg/L on July 15th).

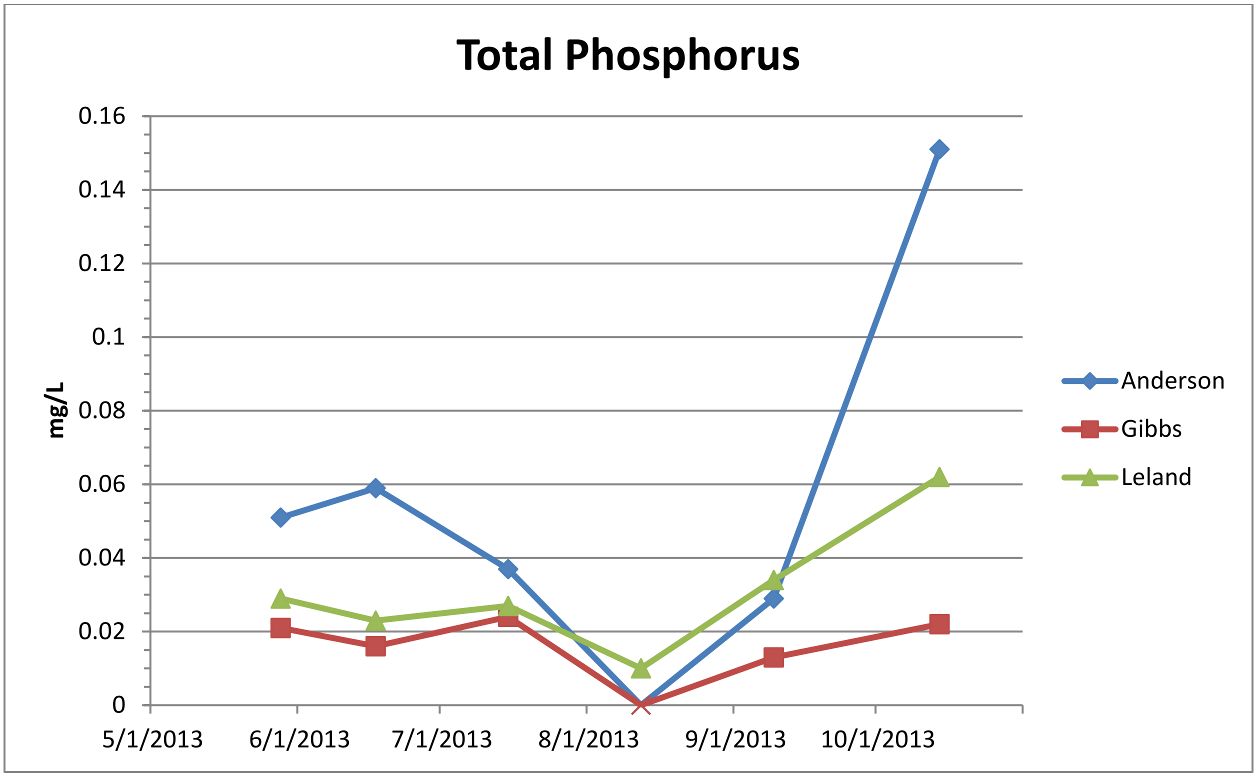
Annual Duration of Anatoxin Levels at or Above Warning Level in Anderson Lake

The annual length of time that anatoxin levels in Anderson Lake remained at or above the warning level of 1µg/L has varied from two weeks in 2010 to 24 weeks in 2012; in 2008, 2009, and 2011, this period ranged between 18 and 20 weeks. 2012 saw the longest period of anatoxin above the warning level in Anderson Lake during the seven years of these studies. In 2013 anatoxin levels were above the warning level in Anderson Lake for a total of 5 consecutive weeks. In 2014 anatoxin levels were above the warning level in Anderson Lake for a total of 3 consecutive weeks. In 2014 Anderson lake showed the highest level of Anatoxin of 990.5 µg/L for the 2013 and 2014 seasons.

Phosphorus Levels in Lakes

Nutrient samples were taken from 0.15 meters from the surface. Nitrogen and phosphorus were analyzed by Edge Analytical and Twiss Laboratories. Phosphorus is the primary nutrient in lakes causing large-scale algae blooms (Wetzel 2001). In our previous reports we found that phosphorus levels in Anderson Lake were higher than in Lake Leland or Gibbs Lake (Jefferson County Public Health 2010, 2013); this condition continued in 2013 and 2014 (Figure 8, Total Phosphorus Plot).

In mid-summer one sample was also taken from the hypolimnion in Anderson, Lake Leland, and Gibbs Lake during the 2014 season. However, due to the warmer than normal temperature the lakes were mixed well and the hypolimnion samples showed little difference from other nutrient samples. In our prior study, we found that phosphorus levels were higher at the surface in Anderson Lake than near the bottom, which is opposite the normal situation in lakes and opposite what we found in Leland and Gibbs Lakes. However, in 2011 to present, we found that the situation had corrected itself in Anderson Lake and phosphorus levels were lower near the surface than near the bottom, which is the norm. And, related to this, in our prior study we found that the shallow water phosphorus in Anderson Lake exceeded the recommended maximum for rivers and streams on four of five sample dates. It is very probable that since the lake aerator was turned off in 2011 bottom disturbance has reduced enough to account for this reduced phosphorus level overall in Anderson Lake and to allow for the normal situation of higher phosphorus levels in deep waters instead of shallow waters. For more information about aeration of Anderson Lake see the 2010 Lakes Final Report (Jefferson County Public Health, 2010).



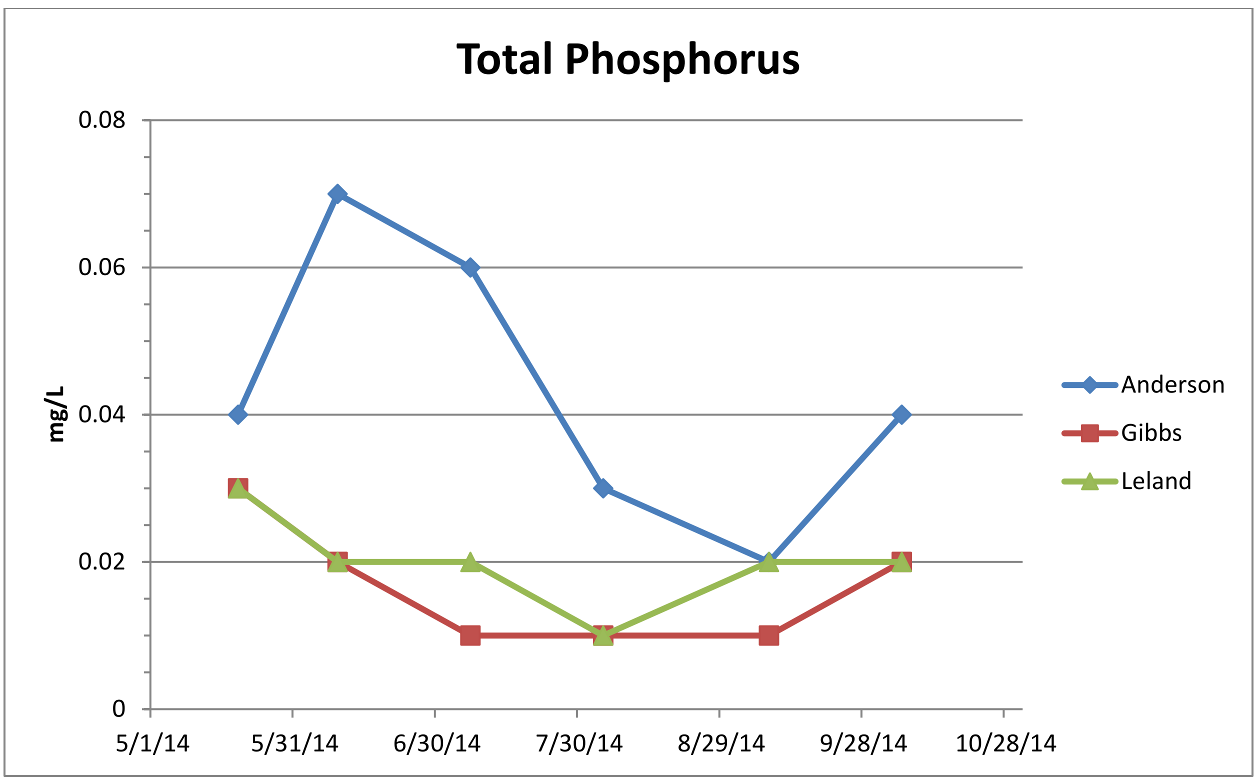


Figure 8, Total Phosphorus Plots

Cooperative Project in 2013

We collected eight algal bloom samples from Anderson Lake during the 2013 season and sent them to Dr. Theo Dreher of Oregon State University's (OSU) Dept. of Microbiology for use in studies to genetically identify strains of Anabaena in this lake. The 2013 study (organized by the Washington Dept. of Health under Dr. Joan Hardy, toxicologist, Olympia, WA) was to determine which cyanobacteria species in Anderson Lake are responsible for the remarkably high anatoxin levels, whether the strain is unique to Anderson Lake and what factors might be associated with toxin production.

After finishing our joint study with OSU we have not received any supporting documents. However, a webinar put on by Washington Dept. of Health and OSU explained the results. A specific Anabaena genome was found called Anabaena sp. WA102. This is a cyanobacteria that produces large amounts of anatoxin – a and is likely the culprit of Anderson Lake being closed for the majority of the season in the past years. Anabaena sp. WA102 is considered an anatoxin super-producer which means it can produce large amounts of anatoxin; which is likely why we have seen such high toxin levels in Anderson Lake.

Public Outreach

Jefferson County Public Health engaged in several outreach activities during the grant period. Four press releases were issued and regular phone calls with local newspapers resulted in approximately one dozen newspaper articles being published, including a special report by the Seattle Times on September 19, 2014 (Judd, 2014). Opening day of fishing season at Anderson Lake was attended by water quality staff and Department of Health bluegreen algae brochures were distributed. Regular emails were distributed to land and resource managers from Anderson Lake State Park, Gibbs Lake County Park and Washington Fish And Wildlife each week when results were received from the lab to keep managers up to date on conditions and make recommendations for public safety and recreational access. These email updates were delivered within 24 hours of receiving lab results and before the weekend so that if sign posting needed to change it could be done before heavy use periods. Signs were either posted by JCPH staff, or by State Park staff within 24 hours of any recommended change. The JCPH Lake Status webpage at http://jeffersoncountypublichealth.org/index.php?lake-water-quality was maintained each week and updated within 24 hours of any change in lake status (Figure 9, JCPH Lake Status Webpage). The webpage was updated 38 times during the project period.

LAKE STATUS

Toxic Algae Monitoring

2015 Monitoring began April 6

Some species of bluegreen algae (also known as cyanobacteria) can produce toxins harmful to human and animal health. The Jefferson County Water Quality Department monitors the following lakes for bluegreen algae: Anderson Lake, Gibbs Lake, and Lake Leland. These lakes are monitored monthly and sampled for toxins if bluegreen algae are suspected to be present. Results are generally obtained by Friday and lake status is updated on this page. For more information about toxic algae blooms, click here. To see a map of the lake location, click the name of the lake in the table below.

Name of Lake	Date Last Observed	Status	Notes
Anderson Lake	6/1/2015	DANGER LAKE CLOSED	• Heavy bloom with scum • Toxic species dominant • Toxin level high
Gibbs Lake	6/1/2015	CLEAR (NO SIGN AT SITE)	• No visible bloom
Lake Leland	6/1/2015	CLEAR (NO SIGN AT SITE)	• No visible bloom

Lake conditions can change rapidly and lake status may have changed since the last sample was taken. Regardless of what is posted here, if you observe a green paint-like scum or bloom on a lake follow the recommendations listed at the WARNING level. If you observe a bloom in a Jefferson County lake, please report it by calling (360) 385-9444.

Figure 9, JCPH Lake Status Webpage

References

Brown, N., Dreher, T., Hardy, J. 2015. *Anabaena sp. WA102 is the major source of anatoxin-a in Anderson Lake, Jefferson County, WA*. Available at: http://jeffersoncountypublichealth.org/picture/upload/file/Brown_Dreher_Hardy_2015.pdf

Jefferson County Public Health. 2013. *Jefferson County Lakes Toxic Algae Project*. Grant G1100251. Available at: http://www.jeffersoncountypublichealth.org/pdf/JeffCo_Lakes_2011-12_final_report.pdf

Jefferson County Public Health. 2010. *Final report for Jefferson County Lakes Monitoring Water Quality Assessment*. Grant G0800611. Available at: http://www.jeffersoncountypublichealth.org/pdf/2010_Jefferson_County_Lakes_G0800611_Final_Report.pdf

Judd, Ron. 2014. *Algae blooms that kill pose puzzles.* Available at: http://www.seattletimes.com/pacific-nw-magazine/algae-blooms-that-kill-pose-puzzles/

Wetzel, R.G. 2001. *Limnology , third edition.* Academic Press, San Diego. 1006 pp.