



# Working Together for Lake Whatcom

**Tim Douglas, Mayor**  
City of Bellingham  
210 Lottie Street  
Bellingham, WA 98225  
(360) 676-6979

**Pete Kremen, Executive**  
Whatcom County  
County Courthouse  
Bellingham, WA 98225  
(360) 676-6717

**Jim Neher, Manager**  
Lake Whatcom Water and Sewer District  
1010 Lakeview Street  
Bellingham, WA 98229  
(360) 734-9224

## **Summary of Findings and Associated Management Actions: “Lake Whatcom Monitoring 2004/2005 Final Report”**

November 2006

The Institute for Watershed Studies (IWS) at Western Washington University published the Lake Whatcom Monitoring 2004/2005 Final Report in April 2006. Because of the complexities and length of the report, council members requested staff to summarize the findings and explain their meaning. The Lake Whatcom Interjurisdictional Coordinating Team (ICT), comprised of staff representatives from the City of Bellingham, Whatcom County, and the Lake Whatcom Water and Sewer District, took on the task.

This report follows the same chapter headings and numbers for easy reference to the IWS Report. Because the findings are already stated in the report, this summary is meant to explain the findings and the management actions being implemented to address them.

To help understand this report, a glossary of technical terms has been added as an appendix on page 11. Each word in the glossary is underlined the first time it appears in the report.

The IWS report lists four lake monitoring sites that are referenced throughout the document. For the location of the monitoring sites and creek locations, refer to the attached map on page 10.

## **2.3 Lake Whatcom Monitoring Results**

### **2.3.1 Water Temperature**

#### Findings

The 2005 surface water temperatures were warmer than usual during February and May, but most other months were close to historic median temperatures. The lake was stratified by the first week in May.

#### What It Means

When the lake is stratified, the cool bottom layer, the hypolimnion, is starved of oxygen so respiration of plants and animals cannot occur. The water column mixes, or

destratifies, during the fall, winter and early spring. Destratification enables the lake to mix from top to bottom, increasing the level of dissolved oxygen in the hypolimnion.

This process is referred to as thermal stratification and is influenced by season and weather. Warm conditions lead to stratification when surface waters increase in temperature while the hypolimnion remains cool and dense.

Destratification occurs abruptly in Basins 1 and 2, and more gradually in Basin 3 which is considerably larger and deeper. Basins 1 and 2 destratify by the end of October, while Basin 3 is often still stratified in November or early December. Complete destratification probably occurs in late December or early January in Basin 3, so that by February, water temperatures, dissolved oxygen concentrations, pH levels, and conductivity are fairly uniform from the surface to the bottom of the lake.

Stratification, or the separation of the water column into distinct layers, may begin as early as April, but is often not stable until May or early June. All sites, except for the Intake, which is too shallow to develop a stable stratification, are usually stratified by June. The lake stratifies into the warm surface layer (epilimnion), the cool bottom layer (hypolimnion), and the transition zone (metalimnion).

Temperature is a concern because warmer lake temperatures increase biological productivity and respiration, which depletes dissolved oxygen.

#### What We're Doing

To date, management efforts have not been specifically directed at reducing lake temperatures because it is largely a factor of seasonal temperatures. Actions that cool tributary and runoff waters may influence lake temperatures, but additional work would be needed to evaluate the role of climate and land use on lake temperatures.

### **2.3.2 Dissolved Oxygen**

#### Findings

The levels of hypolimnetic dissolved oxygen (DO) have been declining over time at Site 1. The low DO levels resulted in the lake listed as a 303(d) body of water in 1998. The Clean Water Act Section 303(d) requires listing water bodies that don't meet water quality standards.

As in previous years, Sites 1 and 2 developed severe hypolimnetic oxygen deficits by mid-summer. When the lake stratifies, it isolates the hypolimnion from the surface. Consequently, DO in the hypolimnion decreases. Depletion of DO continues due to algal and phytoplankton growth and decay which consumes the remaining DO.

#### What It Means

Biological activity (algal growth and decay) increases when there is an abundance of phosphorus and warm water. Although Site 3 experiences decreased hypolimnetic DO during stratification, algae and other photosynthesizing plants have less influence on

DO than at Sites 1 and 2 because Site 3 has relatively lower concentrations of phosphorus.

Low oxygen conditions are associated with a number of unappealing water quality problems in lakes, including: loss of aquatic habitat; release of nutrients and metals from sediments; increased rates of algal production from nutrient releases; increased drinking water treatment costs; increased taste and odor problems in drinking water; and increased risks associated with disinfection by-products created during the drinking water treatment process.

### What We're Doing

Although DO decreases in the hypolimnion naturally during stratification, the extreme low levels that occur in the lake are exacerbated by high concentrations of algae that use the abundant phosphorus and deplete DO during their life cycle.

Efforts to minimize DO depletion are focused on phosphorus controls. These include the following:

- Monitoring and modeling to determine sources and levels of phosphorus.
- Restricting phosphorus sources through a ban on phosphorus-containing fertilizers.
- Restricting and managing construction to minimize the transport of phosphorus-containing soil.
- Purchasing land to retain vegetation, decrease erosion, minimize sources of phosphorus and to moderate temperature increases from development runoff.
- Identifying onsite septic systems (OSS) and planning to require sewer hook-ups in some areas and preventing new ones in the city limits.
- Conducting education about sources of phosphorus including pet waste and detergents.
- Pursuing stormwater treatment technologies that remove phosphorus.
- Utilizing regenerative air street sweepers for reducing phosphorus inputs via stormwater runoff from roads.
- Continuing the interim subdivision moratorium in the County's portion of the watershed while evaluating other land use and management actions.

## **2.3.3 Conductivity and pH**

### Findings

The Hydrolab conductivity and pH data followed typical trends for Lake Whatcom, with only small differences between sites and depths. The decreasing conductivity trend is the result of changing to increasingly sensitive equipment over the past two decades. It appears the data is consistent with previous years.

### What It Means

Conductivity is a measure of water's ability to conduct electrical current. Measurements of conductivity provide a general indication of water quality. The geology of a lake's

watershed establishes the normal ranges for conductivity in a lake. Some pollution discharges and polluted runoff into lakes can cause changes in conductivity especially if the pollutants include inorganic dissolved solids such as ions: bicarbonate, sulfate, chloride, calcium, magnesium, sodium, potassium, and phosphate.

pH is a measure of acidity or alkalinity. The pH scale ranges from 0 to 14. A pH of 7 is considered to be neutral. Substances with a pH of less than 7 are acidic and substances with a pH greater than 7 are basic.

When pollution results in higher algal and plant growth, pH levels may increase, as allowed by the buffering capacity of the lake, or the lake's ability to respond to changes. Although these small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms in the lake and may aggravate nutrient problems. For example, a change in pH may increase the solubility of phosphorus, making it more available for plant growth and resulting in a greater long-term demand for dissolved oxygen.

#### What We're Doing

There are no indications from the data that any actions need to be taken at this time.

### **2.3.4 Alkalinity and Turbidity**

#### Findings

The alkalinity values were fairly low at most sites and depths because Lake Whatcom leans toward the alkaline end of the pH scale. The turbidity values were mostly low except during late summer in samples from the lower depths at Sites 1 and 2, and occasionally Site 3. The high turbidity levels near the bottom of the lake are an indication of increasing turbulence in the lower hypolimnion as the lake nears turnover. It appears the data is consistent with previous years.

#### What It Means

Alkalinity is the measure of the acid neutralizing capacity of water. Waters with high alkalinity are considered to be protected (well buffered) against acidic inputs. Streams that are well buffered are able to absorb and neutralize acidic sources such as acid rain, decomposing organic matter and industrial effluent.

Turbidity is a measurement of the visual clarity of a water sample and often indicates the presence of fine suspended particulate matter including soil particles, algae, microbes, and other substances.

#### What We're Doing

Management actions taken to address DO may assist to reduce turbidity. Refer to the list of actions in section 2.3.2.

### 2.3.5 Nitrogen and Phosphorus

#### Findings

Hypolimnetic nitrate concentrations fell at Sites 1 and 2. Nitrate reduction (the conversion by bacteria of nitrate to nitrite and nitrogen gas) has been common at Site 1 and then at Site 2 beginning in 1999.

High hypolimnetic concentrations of ammonia and phosphorus were found at Sites 1 and 2 (this is consistent with low DO conditions).

#### What It Means

Lake Whatcom has not been a very nutrient-rich lake which can also be described as relatively unproductive (biologically). Therefore, it is particularly susceptible to eutrophication (becoming more biologically productive) from phosphorus inputs. In other words, activities that increase phosphorus “feed” the algae in the lake and lead to reduction in water quality.

Elevated levels of phosphorus were found during stratification because when DO is low, insoluble phosphorus (bound to sediments) becomes soluble and leaches in the water becoming available to algae. When the lake de-stratifies, or mixes, in the fall, any phosphorus not used by algae will become insoluble.

Ammonia, another source of nitrogen, is produced by the decomposition of organic matter (algae, etc.) and accumulates in the absence of DO.

#### What We're Doing

Management actions taken to address DO also address nitrogen and phosphorus reduction. Refer to the list of actions in section 2.3.2.

### 2.3.6 Chlorophyll, Plankton, and Secchi Depth

#### Findings

Site 1 has the highest chlorophyll concentrations of all the sites. Since 1994, algal densities and chlorophyll concentrations have increased significantly throughout the lake.

#### What It Means

Chlorophyll is the green molecule in plant cells that carries out the bulk of energy fixation in the process of photosynthesis. Chlorophyll measurements are a widely used estimator of algal biomass in lakes and streams.

One of the most important indicators of eutrophication in Lake Whatcom is the increasing algal densities that are apparent at all sites. The Cyanophyta increase is disturbing because cyanobacteria are often indicators of water quality deterioration. Eutrophication is the term used to describe a lake becoming more biologically productive.

### What we're going

Management actions taken to address DO also address chlorophyll and plankton reduction. Refer to the list of actions in section 2.3.2.

## **2.3.7 Coliform Bacteria**

### Findings

All but one of the mid-basin (Sites 1-4) and Intake values for fecal coliforms and *E. coli* counts were less than 10cfu/100 mL and passed the freshwater *Extraordinary Primary Contact Recreation* bacteria standard set by Washington Administrative Code. Of the total samples, the single outlier occurred at Site 1 on November 3, when the fecal coliform count was 12 cfu/100 mL. The Bloedel-Donovan counts, which were collected near the dock offshore from the swimming area, were higher than site 1 counts, but the average of the samples passed standards.

### What It Means

Fecal coliform bacteria are a group of bacteria that are passed through the fecal excrement of humans, livestock and wildlife. The most common member type of fecal coliform bacteria is *E. coli*. Large quantities of fecal coliform bacteria in water may indicate a higher risk of pathogens being present in the water.

### What We're Doing

Management actions to eliminate coliform inputs to the lake are as follows:

- Identifying onsite septic systems (OSS) and planning to require sewer hook-ups in some areas and preventing new ones in the city limits.
- Continuing implementation of the Interlocal agreement between the City of Bellingham and Whatcom County Health Department to: conduct routine inspections, monitor pumping and installation activities, distribute information and education, and keep record databases. This fall, the WCHD is planning to conduct a dye trace study on the Silver Beach drainage area to locate possible contamination sources.
- Conducting education and programs directed towards reducing pet waste pollution.
- Monitoring fecal coliform found in stormwater systems to trace contamination to source areas.

## **2.3.8 Metals**

### Findings

Most of the metals concentrations were near or below detection limits, or were within normal concentrations ranges for the lake. However, it was reported that chromium, copper, and nickel were detected in many of the samples, which is unusual. Most of the detections were near the limit of detection, so it is not clear whether this represents an actual increase in metals concentrations in the lake or just variation in low level

analytical analysis. Mercury and lead were detected in a few samples, but because the concentrations were at or near detection levels, it is unlikely that these detections represent an increase in metals concentrations in the lake.

#### What It Means

In 1999, the testing lab contractor, AmTest, upgraded their equipment and analytical procedures for most metals. As a result, many of the analyses now have lower detection limits, resulting in fewer “below detection” data. These newly detectable metals probably do not represent increases in the metals concentrations in the lake.

#### What We’re Doing

Management actions to reduce metal inputs to the lake are as follows:

- Car washing education.
- Transportation options education.
- Utilizing regenerative air street sweepers to remove heavy metals via stormwater runoff from roads

### **2.3.9 Total Organic Carbon and Disinfection By-Products**

#### Findings

The 2004/2005 total organic carbon (TOC) concentrations were below detection at most sites; however, the long-term data suggest that the concentrations may actually be increasing over time. TOC concentrations may also be increasing at the City’s raw water gatehouse, which is the structure that connects the intake in Lake Whatcom with a pipe to the water treatment plant. In addition, Trihalomethanes (THMs), disinfection by-products, are increasing in Bellingham’s treated drinking water, particularly during the fall.

#### What It Means

Algae excrete dissolved organic carbon that can react with chlorine to form disinfection by-products, predominately chloroform and other THMs. TOC concentrations, along with plankton and chlorophyll data, are used to help assess the likelihood of developing potentially harmful disinfection by-products through the reaction of chlorine with organic compounds during the drinking water treatment process.

#### What We’re Doing

The city conducted tests and selected a different water treatment coagulant to apply to water prior to filtration. This has resulted in a reduction of the organic matter in treated water. This organic matter is an essential component for THM formation. The polymer selected is more costly, but it is more effective at removing organic materials during treatment. In addition, management actions taken to address DO also address TOC and THMs.

### 3.3 Creek Monitoring Results

#### Findings

Fifteen sites on 13 creeks were sampled monthly during the 2004/2005 sampling season which represents a substantial increase in the level of effort directed toward collecting tributary data in the watershed. Smith Creek, located at the midpoint of the lake on the north shore, was chosen as a reference because it is a major tributary to the lake and has a history of being relatively unpolluted.

In the creeks, total phosphorus concentrations were usually much higher than soluble phosphate concentrations. Soluble phosphate is quickly consumed from water by algae and phytoplankton, as described in section 2.3.5. High levels would indicate a near-by source. None of the creeks had significantly higher soluble phosphate concentrations as compared to Smith Creek. However, Carpenter, Euclid, Millwheel, Park Place and Silver Beach Creeks had significantly higher total phosphorus concentrations compared to Smith Creek.

High coliform counts are a good indicator of residential pollution. Only Silver Beach Creek had significantly higher coliform counts relative to Smith Creek. However, most sites (including Smith Creek) failed to meet the Part B coliform surface water standards set by WAC 173-201A, but passed Part A. Notably, the same creeks that had elevated total phosphorus levels failed both parts of the surface water standards for coliform. Only upper Beaver Creek, Blue Canyon Creek, and Whatcom Creek passed both parts of the standard.

#### What It Means

In general, the water quality in Austin, Beaver, and Olsen Creeks were similar to Smith Creek. Silver Beach Creek, located in a very developed portion of the watershed, has significantly higher values for alkalinity, conductivity, pH, turbidity, total solids, total phosphorus, and coliforms, as compared to Smith Creek.

#### What We're Doing

Management actions to reduce impacts to tributary water quality are as follows:

- Identification of OSS in the watershed
- An illicit discharge monitoring program
- A phosphorus hotspot monitoring program
- Improved regulation of all tributaries through city and county Critical Areas Ordinances
- An enhanced tributary monitoring program to commence in early 2007 to aid in pollutant loading identification
- Administering the Silver Beach Ordinance and County development regulations.

## **4.0 Lake Whatcom Hydrology**

### Findings

The major inputs into Lake Whatcom during Water Year 2005 included surface and subsurface runoff (74.1%), direct precipitation (16.2%) and water diverted from the Middle Fork of the Nooksack (9.6%). Outputs included Whatcom Creek (74%), the City of Bellingham (9.8%), evaporation (7.2%), Georgia Pacific (5.3%), the Whatcom Falls Hatchery (3.1%), and the Lake Whatcom Water and Sewer District (0.6%).

### What It Means

A water balance was applied to Lake Whatcom to identify its major water inputs and outputs and to examine runoff and storage. IWS recording hydrographs are installed in Anderson, Austin, and Smith Creeks. This is in addition to the six USGS hydrograph sites at Brannian, Carpenter, Euclid, Mill Wheel, Olsen, and Silver Beach Creeks. The runoff values are rough estimates.

### What We're Doing

Jurisdictions are evaluating to what extent the water budget can explain changes in the lake and how this data can be used in further modeling and management.

## **5.0 Stormwater Treatment**

### Findings

The two stormwater facilities in the Lake Whatcom watershed that were monitored provided virtually no phosphorus removal and minimal removal of solids. The control site at WWU (South Campus), in contrast, provided consistent phosphorus removal.

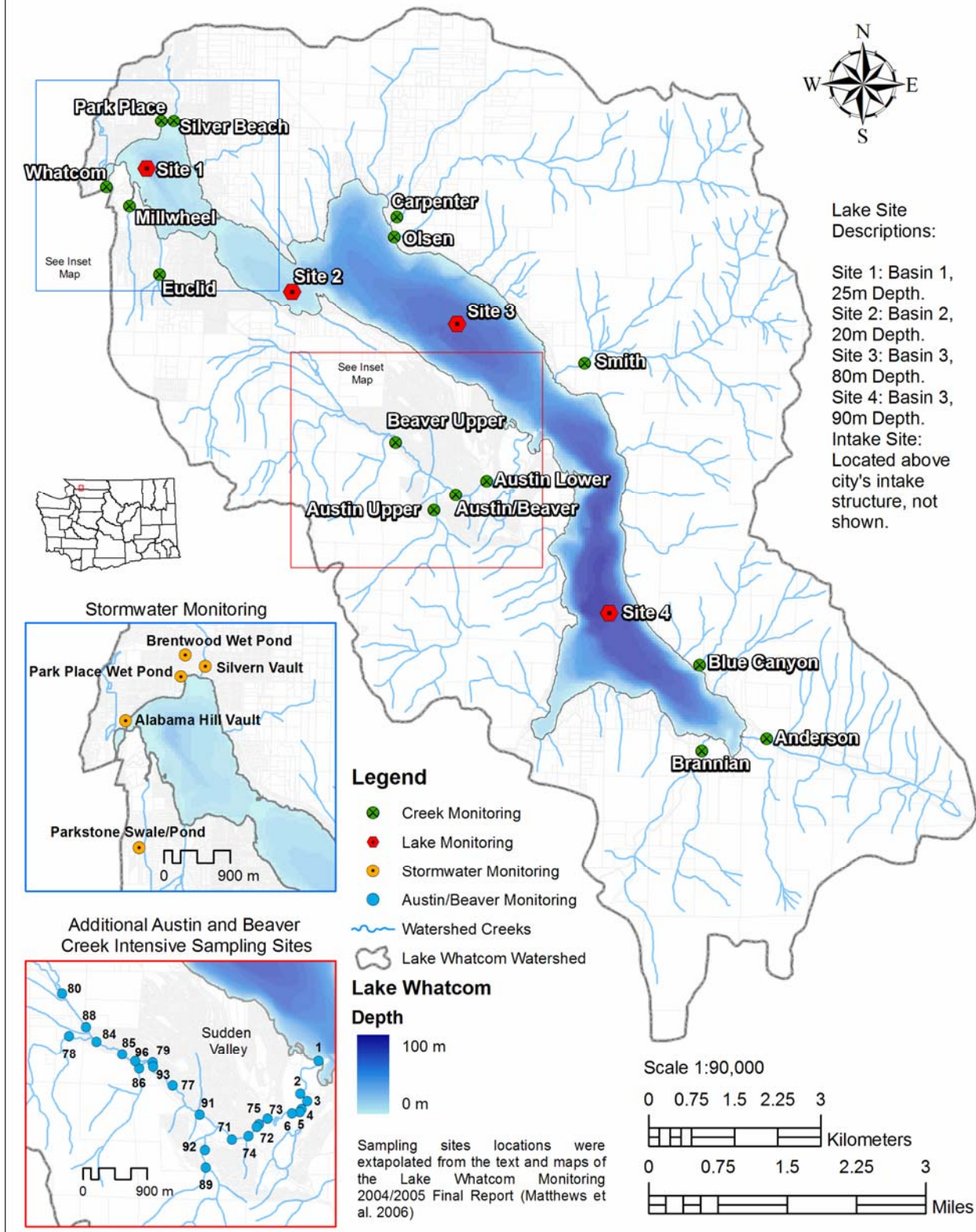
### What It Means

Only two of the 14 stormwater facilities in the City portion of the watershed were monitored for this report. However, five stormwater facilities in the city portion of the watershed have been monitored to some degree over the past ten years. The results were similar to those of this year. The facilities were unsuccessful in removing phosphorus.

### What We're Doing

The City is evaluating some of the systems in place to see where improvements can be made. The County is installing several stormwater facilities in the Geneva neighborhood. These systems are specifically designed to remove residential pollutants with particular emphasis on phosphorus. Please see the stormwater section of the 2006 Work Plan Accomplishments for a more detailed description.

# 2004/2005 Approximate IWS Sampling Sites



## GLOSSARY

**303(d):** Washington State's Water Quality Assessment lists the status of water quality for a particular location in one of 5 categories recommended by EPA. This Assessment represents the Integrated Report for Sections 303(d) and 305(b) of the Clean Water Act. Categories 1 – 4 represent the status of waters for the 305(b) Report, while Category 5 represents those waters placed on the 303(d) list. Waters placed in Category 5 require the preparation of Water Quality Improvement Projects (TMDLs).

**Algae:** Algae encompass several groups of relatively simple living aquatic organisms that capture light energy through photosynthesis, using it to convert inorganic substances into organic matter.

**Alkalinity:** The capacity of bases to neutralize acids.

**Chlorophyll:** A compound in plants that converts radiant energy to chemical energy through the process of photosynthesis.

**Cyanophyta:** Prokaryotic organisms sometimes considered a class or phylum or subkingdom; coextensive with the Cyanophyceae: cyanobacteria. Cyanobacteria are a phylum of bacteria that obtain their energy through photosynthesis. They are often referred to as blue-green algae, even though it is now known that they are not related to any of the other algal groups, which are all eukaryotes.

**Conductivity:** A measure of water's ability to conduct electrical current.

**Destratification:** Vertical mixing within a lake or reservoir to totally or partially eliminate separate layers of temperature, plant, or animal life.

**Detection Limit:** An estimate of concentration at which there is some certainty a compound is present.

**Disinfection By-Product:** A compound formed by the reaction of a disinfectant, such as chlorine, with organic material in the water supply; a chemical byproduct of the disinfection process.

**Dissolved Oxygen:** The amount of freely available oxygen dissolved in water.

**Epilimnion:** The top-most layer in a thermally stratified lake, occurring above the deeper hypolimnion. It is warmer and typically has a higher pH and dissolved oxygen concentration than the hypolimnion.

**Eutrophication:** Eutrophication is caused by the enrichment of an ecosystem with chemical nutrients, typically compounds containing nitrogen or phosphorus.

**Fecal Coliform:** Bacteria from the colons of warm-blooded animals which are released in fecal material. The most common member type of fecal coliform bacteria is *E. coli*.

**Hydrograph:** A record through time of discharge (flow) in a stream.

**Hypolimnion:** The bottom and most dense layer of water in a thermally-stratified lake. It is the layer that lies below the thermocline, or metalimnion.

**Metalimnion:** The middle layer of a thermally stratified lake or reservoir. In this layer there is a rapid decrease in temperature with depth. Also called thermocline.

**pH:** A measure of acidity or alkalinity. The pH scale ranges from 0 to 14. A pH of 7 is considered to be neutral. Substances with a pH of less than 7 are acidic and substances with a pH greater than 7 are basic.

**Phytoplankton:** The autotrophic component of the plankton that drift in the water column.

**Stratification:** The separation of the water column into distinct layers.

**Total Organic Carbon:** The amount of carbon bound in an organic compound, often used as a non-specific indicator of water quality. Total organic carbon concentrations, along with plankton and chlorophyll data, are used to assess the likelihood of developing potentially harmful disinfection by-products.

**Total Solids:** A term used to describe all the matter suspended or dissolved in water.

**Trihalomethanes:** Trihalomethanes, or THMs, are produced when water is disinfected with chlorine and the chlorine reacts with organic matter. As algal densities increase, we expect to see an increase in THMs.

**Turbidity:** A measurement of the visual clarity of a water sample and often an indication of the presence of fine suspended particulate matter including soil particles, algae, microbes, and other substances.