Fairview Lake Monitoring Report
# Table of Contents

List of Figures ................................................................................................................................. ii
List of Tables .................................................................................................................................. ii
Appendices ...................................................................................................................................... ii
Introduction ..................................................................................................................................... 1
   A brief introduction to *Elodea canadensis* ................................................................................. 1
      Propagation and methods of spreading ................................................................................... 2
   Objective of the project............................................................................................................... 2
   Project Activities......................................................................................................................... 2
      Vegetation Sampling............................................................................................................... 2
      Water Quality Monitoring..................................................................................................... 3
      Quality Assurance and Quality Control................................................................................ 3
         Map 1. Water Quality Sampling Locations in Fairview Lake ............................................. 4
Results and Discussion ................................................................................................................... 5
   Vegetation Survey....................................................................................................................... 5
   Phytoplankton Analysis ............................................................................................................. 5
   Water Chemistry Monitoring................................................................................................... 7
      Temperature and dissolved oxygen ....................................................................................... 7
      Secchi transparency ............................................................................................................... 8
      Chlorophyll-a ........................................................................................................................ 9
      Conductivity .......................................................................................................................... 10
      pH ...................................................................................................................................... 10
      Total Suspended Solids......................................................................................................... 11
      Phosphorus .......................................................................................................................... 12
         Orthophosphates ............................................................................................................... 13
      Nitrogen ................................................................................................................................ 13
         Nitrates .............................................................................................................................. 14
      Trophic State Index (TSI) ..................................................................................................... 15
Conclusions and Recommendations ............................................................................................. 16
Acknowledgements ....................................................................................................................... 17
References ...................................................................................................................................... 18
List of Figures

Figure 1. Surface Temperature (°C) in Fairview Lake in 2008 .............................................................. 7
Figure 2. Dissolved oxygen concentration (mg/L) in Fairview Lake .................................................. 8
Figure 3. Dissolved oxygen saturation (%) in Fairview Lake in 2008 .................................................. 8
Figure 4. Secchi transparency (ft) in Fairview Lake in 2008 .............................................................. 9
Figure 5. Chlorophyll-a (µg/L) in Fairview Lake in 2008 ................................................................. 9
Figure 6. Conductivity (µS) in Fairview Lake in 2008 ........................................................................ 10
Figure 7. Fairview Lake pH in 2008 .................................................................................................. 11
Figure 8. Total Suspended Solids (TSS, mg/L) in Fairview Lake in 2008 .......................................... 11
Figure 9. Total phosphorus (mg/L) in Fairview Lake in 2008 .......................................................... 12
Figure 10. Orthophosphates (mg/L) in Fairview Lake in 2008 ....................................................... 13
Figure 11. Total Nitrogen (mg/L) in Fairview Lake in 2008 ............................................................. 14
Figure 12. Nitrates (mg/L) in Fairview Lake in 2008 ...................................................................... 15
Figure 13. The 2008 summer TSI value of Chlorophyll-a (CHL), Secchi depth (SD) and Total Phosphorus (TP) in Fairview Lake. ................................................................. 16

List of Tables

Table 1. Dominant Phytoplanktons present in Fairview Lake in summer of 2008. ......................... 6
Table 2. Relation of TP, TN and Productivity of a Lake (Wetzel, 1983) ............................................ 15

Appendices

Appendix A: Vegetation Sampling Points in Fairview Lake............................................................. 19
Appendix B: Types, Volume of Cells (µm³/cell) and Percentage of phytoplankton in Fairview Lake .............................................................................................................................................. 20
Appendix C: Trophic State Index (TSI) ............................................................................................... 28
TSI for Fairview Lake .......................................................................................................................... 28
Appendix D: Water Quality Data of Fairview Lake ......................................................................... 29
Appendix E: Water Quality Analyses Report (From CCAL Lab) ...................................................... 30
Appendix F: Photos of Fairview Lake ................................................................................................. 31
Fairview Lake Monitoring Report

Introduction

Fairview Lake is located in the eastern Portland metropolitan area, just south of the Columbia River and a mile west of the Sandy River delta. Fairview Creek collects the storm water from Gresham, Wood Village and Fairview, an area of about 6.5 square miles and empties into Fairview Lake, which drains into the eastern portion of the Columbia Slough, much of which is pumped into the Columbia River. Fairview Lake is 106 acres and has a consistent depth of 4.5 feet in the summer and 0.5 to 1.5 feet in the winter when it does not store storm water runoff. (http://www.oregonlakes.org/gallery/fairview/fairview.html)

Although Fairview Lake is shallow, high water turbidity inhibited the establishment of plants in the past. Strong winds, large populations of common carp and yellow bullhead catfish contributed to silt resuspension, which created light-limited condition in the lake, making it impossible for aquatic plants to establish.

This situation changed recently. The carp population decreased due to excessive fish extraction. As a result, sediment suspension has receded and the water cleared up. These conditions increased light penetration of the water and allowed the establishment of rooted aquatic plants. The lake is now infested with Elodea canadensis (native American waterweed). Although Elodea canadensis (E. canadensis) is a native plant to the US, its biology allows it to grow profusely and create nuisance conditions. If left uncontrolled and unmanaged, it is possible that the entire lake will be infested, inhibiting recreational activities in the lake.

A brief introduction to Elodea canadensis

E. canadensis is a perennial, submerged macrophyte, belonging to the family Hydrocharitaceae. It is native to most of North America. Due to its availability in the aquarium trade, it has been introduced to several countries where it is not native, and is now considered a noxious weed in those regions (parts of Europe, Australia, Africa, Asia, and New Zealand).

The leaves are bright green, 6-17 mm long and 1-4 mm broad, borne in whorls of three (rarely two or four) round the stem. It lives entirely underwater, the only exception being the small white or pale purple flowers, which float at the surface and are attached to the plant by delicate stalks. It is dioecious, with male and female flowers on different plants.

E. canadensis is usually fairly easy to distinguish from its more notorious relatives, Brazilian elodea (Egeria densa) and hydrilla (Hydrilla verticillata). All of them have leaves in whorls around the stem, however, E. canadensis has three leaves per whorl, whereas hydrilla and Brazilian elodea almost always have more

Source: http://upload.wikimedia.org
than three leaves per whorl. Brazilian elodea is also a much larger, bushy plant with longer leaves. *E. canadensis* also looks very much like another native elodea, *Elodea nuttalli*, which generally also has three narrower leaves per whorl.

**Propagation and methods of spreading**

*E. canadensis* produces winter buds from the stem tips in late summer, which overwinter on the lake bottom. It also often overwinters as an evergreen plant in mild climates. In the fall leafy stalks will detach from the parent plant, float away, root, and start new plants. Vegetative propagation is the most important method of spreading, with seed production playing a relatively minor role.

Silty sediments and water rich in nutrients favor the growth of *E. canadensis*. In nutrient-rich shallow lakes, it is sometimes perceived as a nuisance. However, it will grow in a wide range of conditions, from very shallow to deep water, and in many sediment types. It can even continue to grow unrooted, as floating fragments. One of the mechanisms for rapid spread of the *E. canadensis* occurs from recreational activities. Boat propellers break off pieces of plant and under favorable conditions it establishes into a new plant.

**Objective of the project**

The objective of this study was to characterize water quality and the aquatic plant community that has become established in Fairview Lake to inform lake management decisions.

**Project Activities**

**Vegetation Sampling**

An intensive vegetation sampling was done on July 28, 2008. A stratified random sampling design was used, with sampling intensity proportional to area. One hundred random sampling points were computer generated using GIS (Appendix A). Sampling points were located in the field using GPS. At each sampling location, a plant rake mounted on a pole was lowered to the lake bottom from a boat, rotated 180 degrees, and pulled up back to the boat. Plants recovered from the rake tines were identified to species in the field and assigned an abundance ranging from 1 (sparse) to 5 (very abundant). Abundance was based roughly on the biomass of plants of each species present in the sample.
**Water Quality Monitoring**

Water quality samples were collected from approximately 0.25-m depth at three different stations on the lake (eastern, middle and western parts of the lake, Map 1) and composited for analysis. The water samples were collected in July, August and September 2008. In July, an individual sample from the eastern canal site (where the water appeared very green) was taken to compare it with the rest of the lake’s composite sample. The individual sample was collected for total phosphorus, total nitrogen, total suspended solids, phytoplankton and chlorophyll-a. This comparative analysis was done only on July samples because of limited budget.

Composite, unfiltered samples for total phosphorus (TP), total nitrogen (TN), and Total Suspended Solids (TSS) were collected in 1-L, acid-washed and de-ionized-water rinsed bottles. About 100 ml of filtered composite sample was collected for SRP (soluble reactive phosphorous or orthophosphate) and nitrate analyses. Samples were shipped on the same day as they were collected to the Chemical Analytical Laboratory, a cooperative laboratory operated by Oregon State University and the U.S. Department of Agriculture (USDA) Forest Service, for analysis using standard methods.

Additional samples were collected for phytoplankton and chlorophyll-a (chl-a) analyses to determine the productivity of the lake and to identify algal species. Chlorophyll-a samples were collected in 250-ml opaque bottles and stored on ice until they were filtered (Whatman GF-C filters) under reduced light conditions at the site. Filtered chlorophyll-a samples were frozen prior to methanol extraction and fluorescence measurement on a Turner Designs Trilogy Flurometer. A composite sample for phytoplankton was collected in 1000-ml bottles and preserved in Lugol solution and sent to lab for analysis.

Dissolved oxygen (DO), pH, temperature, and specific conductivity were measured at the surface and at 0.5 m using a Hydrolab Quanta. Transparency was measured with a 20-cm black and white Secchi disk.

**Quality Assurance and Quality Control**

The Hydrolab Quanta was calibrated in the Portland State University Lab on each sampling date prior to use according the manufacturer’s recommendations. Replicate samples were collected for chlorophyll-a analysis.
Map 1. Water Quality Sampling Locations in Fairview Lake

Sampling Locations in Fairview Lake:

- Western, Middle, and Eastern sampling sites
- Eastern canal sampling site (July)
Results and Discussion

Vegetation Survey

Altogether 100 location sites were sampled (Appendix A). Only 5 of the 100 sampling locations contained *E. canadensis* (Appendix A). Most of the *E. canadensis* collected were floating fragments at the southern shoreline. A dense algae mat was prominent in the eastern part of the lake. A few sprigs of floating *E. canadensis* were found along the eastern part of the lake too (most likely transported there by the wind).

A preliminary field sampling done in June 23, 2008, indicated that the plants were localized to the northwestern shorelines and near the western part (near dam area) of the lake. The vegetation sampling done in July 28, 2008 confirmed that the plants were localized in the northwestern shoreline and has not been established in the other parts of the lake yet. But the lake needs to be monitored routinely for any new infestation in other parts of the lake.

Phytoplankton Analysis

Phytoplankton is a good indicator of the productivity and trophic status of lake. Phytoplankton analysis indicated that Fairview Lake contained of diverse group algae.

Cyanophyta (blue-green algae) was the dominant group in July (99 percent total number of all cell) and August (71.5 percent total number of all cell) in Fairview Lake. Chrysophyta (golden algae) was dominant in September (76.5 percent total number). Cyanophyta abundance decreased to 8 percent in September. Chlorophyta (green algae) was present in all samples in a moderate quantity. Cryptophyta, euglenophyta, and pyrrhophyta were also present in Fairview Lake, but first two were more prevalent in September samples.

Among cyanophyta, *Anabaena* sp., *Oscillatoria* sp., *Aphanizomenon* sp., were the dominant genera in July, August and September respectively (Table 1). The samples from east canal in July had high total number of cyanophyta assemblage (99.9 percent). For detailed information on phytoplanktons present in Fairview Lake, refer to Appendix B.
Table 1. Dominant Phytoplanktons present in Fairview Lake in summer of 2008.

<table>
<thead>
<tr>
<th>Phytoplanktons</th>
<th>July (cells/ml)</th>
<th>August (cells/ml)</th>
<th>September (cells/ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ECS</td>
<td>Composite</td>
<td></td>
</tr>
<tr>
<td><strong>Cyanophyta</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Anabaena sp</em></td>
<td>347,875</td>
<td>112,750</td>
<td>-</td>
</tr>
<tr>
<td><em>Oscillatoria sp</em></td>
<td>9,075</td>
<td>12,220</td>
<td>3,500</td>
</tr>
<tr>
<td><em>Aphanizomenon sp</em></td>
<td>770</td>
<td>35</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Number/ml</strong></td>
<td>357,800</td>
<td>131,608</td>
<td>3,500</td>
</tr>
<tr>
<td><strong>Total percent</strong></td>
<td>99.9</td>
<td>99.6</td>
<td>71.5</td>
</tr>
<tr>
<td><strong>Chlorophyta</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ankistrodesmus falcatus</em></td>
<td>11</td>
<td>2</td>
<td>11</td>
</tr>
<tr>
<td><em>Closterium sp.</em></td>
<td>-</td>
<td>-</td>
<td>132</td>
</tr>
<tr>
<td><em>Pediastrum sp</em></td>
<td>11+</td>
<td>16+</td>
<td>55+</td>
</tr>
<tr>
<td><strong>Total Number/ml</strong></td>
<td>77</td>
<td>212</td>
<td>462</td>
</tr>
<tr>
<td><strong>Total percent</strong></td>
<td>0.02</td>
<td>0.16</td>
<td>9.4</td>
</tr>
<tr>
<td><strong>Chrysophyta</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Melosira sp.</em></td>
<td>77</td>
<td>22</td>
<td>55</td>
</tr>
<tr>
<td><em>Synedra sp.</em></td>
<td>-</td>
<td>-</td>
<td>55</td>
</tr>
<tr>
<td><em>Cyclotella sp.</em></td>
<td>-</td>
<td>-</td>
<td>22</td>
</tr>
<tr>
<td><em>Fragilaria sp.</em></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total Number/ml</strong></td>
<td>141</td>
<td>158</td>
<td>917</td>
</tr>
<tr>
<td><strong>Total percent</strong></td>
<td>0.04</td>
<td>0.12</td>
<td>18.7</td>
</tr>
</tbody>
</table>

**Note:**
ESC- East Canal Site
The table does not represent the entire phytoplankton community present in the Fairview Lake. Appendix B provides the complete list.
Total percent is the total number of entire cells/ml present in a sample.
Water Chemistry Monitoring

*Temperature and dissolved oxygen*

Water temperature in Fairview Lake ranged from 16°C to 23°C (Figure 1, Appendix D). The lake was well mixed with no significant evidence of thermal stratification during the study period, which is quite natural for a shallow lake that is under influence of wind.

Dissolved oxygen (DO) is the amount of oxygen that is dissolved in water and is essential to healthy streams and lakes. The dissolved oxygen level can be an indication of how polluted the water is and how well the water can support aquatic plant and animal life. Generally, a higher dissolved oxygen level indicates better water quality. If dissolved oxygen levels are too low, some fish and other organisms may not be able to survive. The amount of oxygen that can dissolve in water also depends on temperature. Colder water can hold more oxygen in it than warmer water.

Dissolved oxygen in the Fairview Lake ranged from 4.6 mg/L to 10.3 mg/L (Figure 2). Mean dissolved oxygen concentrations in the lake in for July, August and September of 2008 was 6.5 mg/l. Dissolved oxygen saturation ranged from 51 percent to 110 percent (Figure 3).

Dissolved oxygen is one of the limiting factors for fish. Recommended oxygen levels for all spawning salmonids is a minimum of 80 percent saturation with temporary levels no lower than 5mg/l (Deas and Orlob. 1999). Trout would live at lower levels (< 5mg/L), but would be stressed. Combined with the higher temperatures, Fairview Lake is not a good place for trout (Graybill, 2008).

![Figure 1. Surface Temperature (°C) in Fairview Lake in 2008](image)
Secchi transparency

Secchi transparency ranged from 6 inches (0.5 feet) to 14 inches (1.2 feet) (Figure 4). The water was very turbid and green during July sampling. The phytoplankton analysis done for this time period indicates high volume of phytoplankton.
**Secchi Transparency**

Figure 4. Secchi transparency (ft) in Fairview Lake in 2008

**Chlorophyll-a**

Chlorophyll-a is the pigment that makes plants and algae green. It is a way to indirectly measure the amount of photosynthesizing algae and phytoplankton in the water column. Concentration of Chlorophyll-a determines the productivity of the lake. Chlorophyll-a concentration in Fairview Lake ranged from 10 µg/L to 127 µg/L (Figure 5). Measured concentrations indicated that Fairview Lake would be classified as a eutrophic lake. High nutrients, good sun exposure and minimal competition with aquatic macrophytes for nutrients contributes to high algal abundance in the lake.

**Chlorophyll-a**

Figure 5. Chlorophyll-a (µg/L) in Fairview Lake in 2008
**Conductivity**

Conductivity is a rapid, inexpensive measurement that provides an indication of the concentration of total dissolved ions. The greater amount of salts, acids and bases are in the water, the greater the conductivity. For this reason, conductivity is closely related to salinity (the sum of ionic compounds in water) and total dissolved solids (the weight of solids that are filtered out of water).

Conductivity of Fairview Lake ranged from 172.5 µS/cm to 201 µS/cm (Figure 6). Higher conductivity later in the summer may relate to the influence of evaporation on salt concentrations in the lake. A more complete water balance is required to confirm this supposition.

![Conductivity Graph](Figure 6. Conductivity (µS) in Fairview Lake in 2008)

**pH**

The pH of a lake is strongly influenced by primary productivity of macrophytes and phytoplankton. The pH of Fairview Lake ranged from 8.4 to 9.5 (Figure 7). The pH measured at three different locations of the lake was fairly consistent on July and August. However, a slightly high pH (10.6) was recorded at the western site of the lake in September.
**Total Suspended Solids**

Total suspended solids (TSS) is the amount of organic and inorganic particles suspended in the water column. TSS measures the weight of the particles and high values can have implications on light penetration, recreational value, and habitat value. Total suspended solids (TSS) in Fairview Lake ranged from 19.78 mg/L to 74.5 mg/L (Figure 8, Appendix E).
Phosphorus

Phosphorus is necessary for plant and animal growth and is often the limiting nutrient in aquatic systems. As a result, small increases in phosphorus in lake water can cause substantial increases in aquatic plants and algae. When phosphorus levels in lakes increase due to human activities (e.g. fertilizer, animal waste, soil erosion) eutrophication can occur.

Total phosphorus concentration in Fairview Lake ranged from 0.16 mg/L to 0.68 mg/L. The highest concentrations occurred in July in both composite and individual sample (eastern canal site of the lake) (Figure 9, Appendix E). The high concentration of total phosphorous in Fairview Lake indicates hypereutrophy (See Table 2).

![Total Phosphorus Graph]

Figure 9. Total phosphorus (mg/L) in Fairview Lake in 2008.

Sources of Phosphorus

Phosphorus comes from both point and nonpoint sources. Point sources include municipal waste treatment plants, industrial discharge, large confined livestock operations, and urban stormwater. These sources are regulated by federal and state laws. They are generally required to have environmental controls such as waste handling and treatment systems and nutrient management plans.

Nonpoint sources of phosphorus include soil erosion and water runoff from cropland, lawns and gardens, home waste treatment systems, livestock pastures, rangeland, and even forests. Urban areas may produce significant nonpoint source phosphorus runoff due to over-application of fertilizer to lawns and gardens. Homeowners who apply fertilizer without following soil test recommendation eventually build up very high soil test phosphorus levels that can become significant sources of phosphorus in runoff. And most importantly, fertilizer, pet waste, and lawn clippings left on driveways, sidewalks, or streets are a direct source of pollution through storm drains in urban areas.
Orthophosphates

Orthophosphorous is the inorganic, dissolved, ionic form of phosphorous taken up by plants and algae. Much of the orthophosphate is complexed into organic compounds or bound into plant and animal tissues. The orthophosphate analysis measures the portion of that phosphate that is readily available to plants and animals. It is often referred to as 'inorganic' or 'reactive' phosphate. Orthophosphate is so quickly taken up by a growing algal population that it often is found only in low concentrations in lakes.

In Fairview Lake, Soluble Reactive Phosphorous (orthophosphate) ranged from 0.002 mg/L to 0.29 mg/L (Figure 10).

![Orthophosphates](image)

Figure 10. Orthophosphates (mg/L) in Fairview Lake in 2008

Nitrogen

Nitrogen is second most important component after phosphorus to aquatic plant and algal growth. Nitrogen concentrations can vary widely temporally and spatially but are often related to local land use. Humans can increase nitrogen in the watershed through waste treatment plants, fertilizers and runoffs.

The total nitrogen concentration ranged from 1.0 mg /L to 4.9 mg /L (Figure 11). The September sampling indicated that both total phosphorus and total nitrogen was comparatively lower than in previous months.
Nitrates

Nitrates are the major source of nitrogen for aquatic plants. Nitrate is highly soluble in the water and does not bind to soils or particles in the water and is therefore easily transported along with water. During rainy periods, nitrate not taken up by plants in surface soils will travel downwards through the soil and be carried away by groundwater, or will be carried overland to surface waters. If nitrate (NO3-) ends up in waters with very little dissolved oxygen, it is converted to nitrite (NO2-), and ultimately to nitrogen gas (N2), which can then escape to the atmosphere. In well-oxygenated waters, nitrate is readily taken up by aquatic plants and algae and used for growth. Generally, nitrate tends to be the dominant form of nitrogen in waters with normal levels of dissolved oxygen.

Nitrates are released to surface waters from diffuse sources such as atmospheric deposition and agricultural and domestic runoff than from point sources such as municipal wastewater effluents or industrial discharges. One of the major non-point sources of nitrates to surface water is from fertilizers (nitrate is used extensively in the production of fertilizers because it is readily taken up by plants for growth). Additionally, presence of large numbers of birds that live in or around a body of water can also increase nitrates level in the water (when bird excretions get into the water).

In Fairview Lake, Nitrate concentration ranged from 0.003 mg/L to 0.008 mg/L (Figure 12).
The total phosphorous and total nitrogen concentration in Fairview Lake indicated the lake is hypereutrophic lake (Table 2).

<table>
<thead>
<tr>
<th>Concentration of TP (mg/L)</th>
<th>Concentration of TN (mg/L)</th>
<th>Lake Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.01 mg/L</td>
<td>&lt; 0.4 mg/L</td>
<td>Oligotrophic</td>
</tr>
<tr>
<td>0.01 mg/L to &lt;0.025 mg/L</td>
<td>0.4-0.6 mg/L</td>
<td>Mesotrophic</td>
</tr>
<tr>
<td>&gt;0.025 mg/L-0.150 mg/L</td>
<td>0.6-1.5 mg/L</td>
<td>Eutrophic</td>
</tr>
<tr>
<td>&gt;0.150 mg/L</td>
<td>&gt;1.5 mg/L</td>
<td>Hypereutrophic</td>
</tr>
</tbody>
</table>

**Trophic State Index (TSI)**

Trophic State Index (TSI) of Carlson (1977) uses algal biomass as the basis for trophic state classification of waterbody. Three variables, chlorophyll pigments, secchi depth, and total phosphorus, independently estimate algal biomass (Carlson and Simpson 1996). Carlson’s TSI measures range from a scale of 20-80 (Carlson and Simpson, 1996). Degrees of eutrophication typically range from oligotrophic water (maximum transparency, minimum chlorophyll-a, and minimum phosphorus) through mesotrophic, eutrophic, to hypereutrophic water (minimum transparency, maximum chlorophyll-a, maximum phosphorus).

Carlson’s TSI (1977) was used to evaluate trophic state of Fairview Lake in summer of 2008. The values of TSI variables were plotted in the graph (Figure 13). The mean summer secchi depth TSI, chlorophyll-a TSI, and total phosphorus TSI was 80, 67, and 91 respectively. The TSI values of TP (>80) and Secchi Depth (>70) indicated Fairview Lake as a hypereutrophic lake. TSI Value of chlorophyll-a (>60) indicated eutrophy (Appendix C for more information). The relatively low chlorophyll-a index indicates that non-algal turbidity (suspended sediments) contributed substantially to water clarity and total phosphorus concentration in July and August.
Conclusions and Recommendations

This study found that *Elodea canadensis* has a limited distribution along the northwestern shoreline of Fairview Lake. There were a few floating fragments of unestablished *E. canadensis* in the other parts of the lakes during intensive July sampling (Appendix A). The homeowners of the Fairview Lake are proactive and have been aggressive in keeping the lake free of nuisance plants. Continued monitoring and control of the plants in the lake is necessary to prevent large-scale establishment.

The water quality analysis done in the lake during study period, determined that Fairview Lake has low dissolved oxygen and transparency, and high total phosphorus, total nitrogen and chlorophyll-a concentrations. Trophic State Index (TSI) analysis on water quality data from summer of 2008 indicated Fairview Lake as a hypereutrophic lake.

The TN:TP ratio ranged from 4.2 to 7.3, indicating marginally nitrogen-limited conditions. These conditions favor nitrogen-fixing cyanobacteria, which can form toxic blooms. Because nitrogen-fixing cyanobacteria can overcome nitrogen limitation, lake managers typically focus on management of phosphorus input into lakes. Reducing phosphorus loading to the lake would, however, increase water clarity and stimulate rooted plant growth.

Since removal of common carp by anglers corresponded with the establishment of *E. canadensis* in the lake it seems likely that maintaining a large population of carp in the lake will prevent plant establishment through uprooting plants and generating turbidity. Homeowners could petition the Oregon Department of Fish and Wildlife to institute a catch-and-release policy for carp in the lake. Such a program would, perhaps, be preferable to allowing rooted plants to
become established and the subsequent chemical treatments or harvesting efforts that would be required to maintain recreational use of the lake.

Acknowledgements

We would like to thank Jim Graybill of Fairview Lake for his continuous support throughout this project. He volunteered several hours providing assistance to the sampling process and collection of field data. Furthermore, Jim Graybill and Carl Marking provided their boat for the study.
References


Appendix A: Vegetation Sampling Points in Fairview Lake

Fairview Lake
100 random points
50m minimum distance between points
Generated by Rich Miller using Hawth's Tools
7/23/08

0 250 500 1,000 Meters

N
# Appendix B: Types, Volume of Cells (µm³/cell) and Percentage of phytoplankton in Fairview Lake

**FAIRVIEW LAKE**

**LAKE PHYTOPLANKTON**

**DATE:** 7/28/2008  
**SAMPLE STATUS:** Lugol preserved  
**STATION:** East (surf grab)  
**NOTE:** fine detrital particles

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Cells/ml</th>
<th>µm³/cell</th>
<th>µm³/ml</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanophyta (Cyanobacteria)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Anabaena flos-aquae/circinalis/spiroides asmlg</em></td>
<td>347,875.00</td>
<td>179.50</td>
<td>62,444,722</td>
<td>short coils&amp; spirals;young col</td>
</tr>
<tr>
<td>+ <em>Aphanizomenon spp.</em></td>
<td>770.00</td>
<td>1,256.00</td>
<td>967,120</td>
<td>no heterocysts;short fil;tapered&amp;blunt tip</td>
</tr>
<tr>
<td><em>Coelosphaerium/Snowella spp. grp</em></td>
<td>80.00</td>
<td>22.44</td>
<td>1,795</td>
<td>tiny cell grps @ col edge;fibrils?</td>
</tr>
<tr>
<td>+ Oscillatoriales:Pseudoanabaenaceae (prev. Oscillatoria spp.)enta</td>
<td>9,075.00</td>
<td>7,850.00</td>
<td>71,238,750</td>
<td>solit long fil;cy cells;no hetero/no akinetes</td>
</tr>
</tbody>
</table>

**Taxon Subtotal** 357800 134,652,387

| Chlorophyta                                |           |          |          |                                                                          |
| *Ankistrodesmus falcatus*                  | 11.00     | 419      | 4,605    |                                                                          |
| *Pediastrum duplex*                        | 11.00     | 2,307.90 | 25,387   |                                                                          |
| *Pediastrum duplex*                        | 11.00     | 6,410.83 | 70,519   |                                                                          |
| *Pediastrum simplex*                       | 11.00     | 6,410.83 | 70,519   |                                                                          |
| *Scenedesmus sp.*                          | 11.00     | 732.67   | 8,059    | 4-cell colony                                                           |
| uncell (sph) nannoplktin                    | 22.00     | 1,436.03 | 31,593   | lamellate cell                                                           |

**Taxon Subtotal** 77.00 210,682

| Chrysophyta                                |           |          |          |                                                                          |
| filamentous chrysophyte                     | 64.00     | 678.24   | 43,407   |                                                                          |
| Bacillariophyceae                          |           |          |          |                                                                          |
| *Melosira sp.*                              | 77.00     | 1,130.40 | 87,041   | some w/term spine                                                        |

**Taxon Subtotal** 141 130,448

| Cryptophyta                                |           |          |          |                                                                          |
| *Cryptomonas spp.*                         | 11.00     | 1,714.44 | 18,859   |                                                                          |

**Taxon Subtotal** 11.00 18,859
**FAIRVIEW LAKE**  
**LAKE PHYTOPLANKTON**  
**DATE:** 7/28/2008  
**STATION:** Comp (surf grab)  

**NOTE:** most cells deteriorated; espec fil cyanophytes

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Cells/ml</th>
<th>µm3/cell</th>
<th>µm3/ml</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cyanophyta (Cyanobacteria)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Anabaena flos-aquae/circinalis/spiroides asmblg</em></td>
<td>112,750.00</td>
<td>179.50</td>
<td>20,239,001</td>
<td>short coils &amp; spirals; young col</td>
</tr>
<tr>
<td>+ <em>Aphanizomenon spp.</em></td>
<td>35.00</td>
<td>1,256.00</td>
<td>43,960</td>
<td>no heterocysts; short fil; tapered &amp; blunt tip</td>
</tr>
<tr>
<td><em>Coelosphaerium/Snowella spp. grp</em></td>
<td>6,600.00</td>
<td>22.44</td>
<td>148,090</td>
<td>tiny cell grps @ col edge; fibrils?</td>
</tr>
<tr>
<td>+ Oscillatoriales</td>
<td>3.00</td>
<td>989.10</td>
<td>2,967</td>
<td>threadlike filaments</td>
</tr>
<tr>
<td>+ Oscillatoriales: Pseudoanabaenaceae (prev. Oscillatoria spp.) tenta</td>
<td>12,220.00</td>
<td>7,850.00</td>
<td>95,927,000</td>
<td>solit deterior fil; cyl cells; no hetero/no akinetes</td>
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<tr>
<td><strong>Taxon Subtotal</strong></td>
<td>131,608</td>
<td></td>
<td>116,361,018</td>
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<tr>
<td><strong>Chlorophyta</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ankistrodesmus falcatus</em></td>
<td>2.00</td>
<td>586</td>
<td>1,172</td>
<td></td>
</tr>
<tr>
<td><em>Dictyosphaerium sp.</em></td>
<td>32.00</td>
<td>124.34</td>
<td>3,979</td>
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<tr>
<td><em>Oocystis sp.</em></td>
<td>4.00</td>
<td>1,013.17</td>
<td>4,053</td>
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</tr>
<tr>
<td><em>Oocystis sp.</em></td>
<td>8.00</td>
<td>143.92</td>
<td>1,151</td>
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<tr>
<td><em>Pediastrum duplex</em></td>
<td>16.00</td>
<td>2,307.90</td>
<td>36,926</td>
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<tr>
<td><em>Pediastrum duplex</em></td>
<td>16.00</td>
<td>9,231.60</td>
<td>147,706</td>
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<tr>
<td><em>Pediastrum duplex</em></td>
<td>2.00</td>
<td>13,083.33</td>
<td>26,167</td>
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</table>

**Total Number/ml**  
358,029  
**Total Volume**  
135,012,377  
**% Cyanophyta**  
99.94  
**% Chlorophyta**  
0.02  
**% Chrysophyta**  
0.04  
**% Cryptophyta**  
0.00  
**% Euglenophyta**  
0.00  
**% Pyrrhophyta**  
0.00  
**% Undetermined**  
0.00

*= colony/ml  
+= filament/ml  

**mm3/L**
<table>
<thead>
<tr>
<th>Taxon</th>
<th>Subtotal</th>
<th>Total Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>colonial nannoplankton (sph)</td>
<td>64.00</td>
<td>523.33</td>
</tr>
<tr>
<td>unicell (sph) nannoplanktn</td>
<td>44.00</td>
<td>1,436.03</td>
</tr>
<tr>
<td>Chrysophyta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>* Pediastrum simplex</td>
<td>12.00</td>
<td>6,410.83</td>
</tr>
<tr>
<td>* Scenedesmus sp.</td>
<td>2.00</td>
<td>678.24</td>
</tr>
<tr>
<td>* Scenedesmus sp.</td>
<td>10.00</td>
<td>256.43</td>
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<tr>
<td>filamentous chrysophyte</td>
<td>55.00</td>
<td>678.24</td>
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<tr>
<td>Epithemia sp.</td>
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<td>12,693</td>
</tr>
<tr>
<td>Melosira sp.</td>
<td>60.00</td>
<td>957.45</td>
</tr>
<tr>
<td>Melosira sp.</td>
<td>22.00</td>
<td>4,000.36</td>
</tr>
<tr>
<td>Nitzschia sp.</td>
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<td>1,230.88</td>
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<tr>
<td>Pinnularia /Rhopalodia spp.</td>
<td>2.00</td>
<td>4,396.00</td>
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<td>Synedra sp.</td>
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<td>241.78</td>
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<td>Synedra sp.</td>
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<td>460.53</td>
</tr>
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<td>Synedra sp.</td>
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<td>1,000.88</td>
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<tr>
<td>Synedra sp.</td>
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<td>1,308.33</td>
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<tr>
<td>Cryptophyta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cryptomonas spp.</td>
<td>55.00</td>
<td>1,714.44</td>
</tr>
<tr>
<td>Euglenophyta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceratium hirundinella</td>
<td>2.00</td>
<td>60,000.00</td>
</tr>
<tr>
<td>Undetermined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Number/ml</td>
<td>132,035</td>
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<tr>
<td>Total Volume</td>
<td>117,191,489</td>
<td>117.191</td>
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</tbody>
</table>
Percent Undetermined  0.00  % Undetermined  0.00
* = colony/ml  += filament/ml

FAIRVIEW LAKE
LAKE PHYTOPLANKTON
DATE:  8/19/2008
SAMPLE STATUS: lugol preserved
STATION: Comp (surf grab)
NOTE: much small detrital particles

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Cells/ml</th>
<th>µm³/cell</th>
<th>µm³/ml</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyanophyta (Cyanobacteria)</td>
<td></td>
<td></td>
<td></td>
<td>* Oscillatoriales:Pseudoanabaenaceae/Phormidiaceae (prev.</td>
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<tr>
<td>Oscillatoria spp.</td>
<td>3,500.00</td>
<td>7,850.00</td>
<td>27,475,000</td>
<td>straight fil;cyl cells;no hetero/akinete</td>
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<tr>
<td>Taxon Subtotal</td>
<td>3500</td>
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<td>27,475,000</td>
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<tr>
<td>Chlorophyta</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ankistrodesmus falcatus</td>
<td>11.00</td>
<td>586</td>
<td>6,447</td>
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</tr>
<tr>
<td>Closterium sp.</td>
<td>132.00</td>
<td>741.83</td>
<td>97,921</td>
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<tr>
<td>Oocystis sp.</td>
<td>11.00</td>
<td>1,013.17</td>
<td>11,145</td>
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</tr>
<tr>
<td>Oocystis sp.</td>
<td>44.00</td>
<td>226.08</td>
<td>9,948</td>
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<tr>
<td>* Pediastrum boryanum</td>
<td>11.00</td>
<td>1,177.50</td>
<td>12,953</td>
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<tr>
<td>* Pediastrum duplex</td>
<td>22.00</td>
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<td>50,774</td>
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<tr>
<td>* Pediastrum simplex</td>
<td>55.00</td>
<td>3,815.10</td>
<td>209,831</td>
<td>deteriorated cells</td>
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<tr>
<td>* Scenedesmus sp.</td>
<td>11.00</td>
<td>401.92</td>
<td>4,421</td>
<td>4-cell colony</td>
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<tr>
<td>* Scenedesmus arcautas</td>
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<td>678.24</td>
<td>7,461</td>
<td>8-cell colony</td>
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<td>Staurastrum chaetocerus (tenta)</td>
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<td>759.89</td>
<td>8,359</td>
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<tr>
<td>Tetraedron sp.</td>
<td>11.00</td>
<td>2,989.44</td>
<td>32,884</td>
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<tr>
<td>Tetraedron sp.</td>
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<td>1,914.90</td>
<td>21,064</td>
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<tr>
<td>colonial nannoplankton (sph)</td>
<td>88.00</td>
<td>113.04</td>
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<tr>
<td>unicell (sph) nannopltn</td>
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<td>1,436.03</td>
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<td>Taxon Subtotal</td>
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<tr>
<td>Chrysophyta</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>filamentous chrysophyte</td>
<td>450.00</td>
<td>678.24</td>
<td>305,208</td>
<td></td>
</tr>
<tr>
<td>Bacillariophyceae</td>
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<tr>
<td>Amphora sp.</td>
<td>11.00</td>
<td>3,956</td>
<td>43,520</td>
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</tr>
<tr>
<td>Cyclotella sp.</td>
<td>22.00</td>
<td>1,004.80</td>
<td>22,106</td>
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</tr>
<tr>
<td>Taxon</td>
<td>Subtotal</td>
<td>(μm³/cell)</td>
<td>(mm³/L)</td>
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</tr>
<tr>
<td>-----------------------------------------</td>
<td>----------</td>
<td>------------</td>
<td>---------</td>
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</tr>
<tr>
<td>Melosira sp.</td>
<td>55.00</td>
<td>1,406.72</td>
<td>77,370</td>
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<tr>
<td>Pinnularia / Rhopalodia spp.</td>
<td>11.00</td>
<td>7,693.00</td>
<td>84,623</td>
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<tr>
<td>Synedra ulna</td>
<td>1.00</td>
<td>3,136.00</td>
<td>3,136</td>
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<tr>
<td>Synedra sp.</td>
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<td>1,308.33</td>
<td>71,958</td>
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<tr>
<td>Surirella sp.</td>
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<td>24,617.60</td>
<td>73,853</td>
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<tr>
<td>undet pennate diatom</td>
<td>1.00</td>
<td>7,912.80</td>
<td>7,913</td>
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</tr>
<tr>
<td>undet pennate diatom</td>
<td>308.00</td>
<td>262.50</td>
<td>80,850</td>
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<tr>
<td>Taxon Subtotal</td>
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<td>770,537</td>
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<tr>
<td>Cryptophyta</td>
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<td></td>
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<tr>
<td>Cryptomonas spp.</td>
<td>10.00</td>
<td>1,714.44</td>
<td>17,144</td>
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<tr>
<td>Taxon Subtotal</td>
<td>10.00</td>
<td>17,144</td>
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<tr>
<td>Euglenophyta</td>
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<td></td>
</tr>
<tr>
<td>Euglena sp.</td>
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<td>9,420.00</td>
<td>9,420</td>
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<tr>
<td>euglenoid</td>
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<td>48,984</td>
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</tr>
<tr>
<td>Pyrrhophyta</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceratium hirundinella</td>
<td>4.00</td>
<td>60,000.00</td>
<td>240,000</td>
<td></td>
</tr>
<tr>
<td>Taxon Subtotal</td>
<td>4.00</td>
<td>240,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Undetermined</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Total Number/ml</td>
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<tr>
<td>Total Volume</td>
<td>29,082</td>
<td>29.082</td>
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</tr>
</tbody>
</table>

* = colony/ml  + = filament/ml
**FAIRVIEW LAKE**  
**LAKE PHYTOPLANKTON**  
**DATE:**  9/29/2008  
**SAMPLE STATUS:** lugol preserved  
**NOTE:** much small org particles/empty diatom frustules

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Cells/ml</th>
<th>µm³/cell</th>
<th>µm³/ml</th>
<th>comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cyanophyta (Cyanobacteria)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Aphanizomenon sp.</em></td>
<td>400.00</td>
<td>166.22</td>
<td>66,490</td>
<td>few heterocysts; short fil w/tapered tip</td>
</tr>
<tr>
<td>+ Oscillatoriales</td>
<td>3.00</td>
<td>812.48</td>
<td>2,437</td>
<td>threadlike filaments</td>
</tr>
<tr>
<td>+ Oscillatoriales:Pseudoanabaenaceae/Phormidiaceae</td>
<td>1.00</td>
<td>7,789.16</td>
<td>7,789</td>
<td>linear fil; cyl cells; no hetero/no akinetes</td>
</tr>
<tr>
<td>filamentous cyanophyte</td>
<td>100.00</td>
<td>137.38</td>
<td>13,738</td>
<td>short fil, ends taper, Aphanizomenon-like</td>
</tr>
<tr>
<td><strong>Taxon Subtotal</strong></td>
<td>504.00</td>
<td></td>
<td>90,454</td>
<td></td>
</tr>
<tr>
<td><strong>Chlorophyta</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ankistrodesmus falcatus</em></td>
<td>11.00</td>
<td>544</td>
<td>5,987</td>
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</tr>
<tr>
<td>Closterium sp.</td>
<td>11.00</td>
<td>1,832</td>
<td>20,148</td>
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</tr>
<tr>
<td>Closterium sp.</td>
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<td>35,260</td>
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<tr>
<td>*Coelastrum microporum</td>
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<td>11,488.21</td>
<td>126,370</td>
<td>small colonies</td>
</tr>
<tr>
<td>*Oocystis sp.</td>
<td>11.00</td>
<td>949.85</td>
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<td>*Pediastrum simplex</td>
<td>22.00</td>
<td>6,410.83</td>
<td>141,038</td>
<td>deteriorated cells</td>
</tr>
<tr>
<td>*Pediastrum simplex</td>
<td>11.00</td>
<td>13,083.33</td>
<td>143,917</td>
<td>deteriorated cells</td>
</tr>
<tr>
<td><em>Scenedesmus sp.</em></td>
<td>11.00</td>
<td>256.43</td>
<td>2,821</td>
<td>4-cell colony</td>
</tr>
<tr>
<td>colonial nannoplankton (ell)</td>
<td>44.00</td>
<td>157.00</td>
<td>6,908</td>
<td></td>
</tr>
<tr>
<td>colonial nannoplankton (sph)</td>
<td>176.00</td>
<td>65.42</td>
<td>11,513</td>
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<tr>
<td><strong>Chrysophyta</strong></td>
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<td></td>
</tr>
<tr>
<td><em>Mallomonas sp.</em></td>
<td>11.00</td>
<td>47,476.80</td>
<td>522,245</td>
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<tr>
<td>Tribonematales</td>
<td>1,820.00</td>
<td>621.72</td>
<td>1,131,530</td>
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<tr>
<td>chrysophyte (unicell)</td>
<td>33.00</td>
<td>2,143.57</td>
<td>70,738</td>
<td></td>
</tr>
</tbody>
</table>

**Bacillariophyceae**

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Cells/ml</th>
<th>µm³/cell</th>
<th>µm³/ml</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Amphora sp.</em></td>
<td>11.00</td>
<td>3,956</td>
<td>43,520</td>
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<tr>
<td>*Asterionella formosa</td>
<td>440.00</td>
<td>530.53</td>
<td>233,435</td>
<td></td>
</tr>
<tr>
<td>Taxon</td>
<td>Subtotal</td>
<td>µm³/cell</td>
<td>mm³/L</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----------</td>
<td>----------</td>
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</tr>
<tr>
<td>Cocconeis sp.</td>
<td>11.00</td>
<td>1,758.40</td>
<td>19,342</td>
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<tr>
<td>Cyclotella sp.</td>
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<td>769.30</td>
<td>698,524</td>
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<tr>
<td>Cyclotella sp.</td>
<td>33.00</td>
<td>5,306.60</td>
<td>175,118</td>
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<td>2,473</td>
<td>54,401</td>
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<td>Fragilaria sp.</td>
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<td>750.00</td>
<td>115,500</td>
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<tr>
<td>Gyrosigma/Pleurosigma spp.</td>
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<td>Melosira sp.</td>
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<tr>
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<tr>
<td>Nitzschia sp.</td>
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<td>8,415.00</td>
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<tr>
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<td>Surirella sp.</td>
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<td>197,820</td>
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<td>103,620</td>
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<tr>
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<td>Cryptophyta</td>
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<tr>
<td>Cryptomonas spp.</td>
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<td>Rhodomonas spp.</td>
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<td>Euglenophyta</td>
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<td>Taxon Subtotal</td>
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<tr>
<td>Pyrrhophyta</td>
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<td></td>
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<td></td>
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<td>Total Number/ml</td>
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<td>7,742,938</td>
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<tr>
<td>Total Volume</td>
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<tr>
<td>Percent Cyanophyta</td>
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<td></td>
<td>1.17</td>
<td></td>
</tr>
<tr>
<td>Percent Chlorophyta</td>
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<td></td>
<td>6.51</td>
<td></td>
</tr>
<tr>
<td>Percent Chrysophyta</td>
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<td>90.38</td>
<td></td>
</tr>
<tr>
<td>Percent Cryptophyta</td>
<td>9.97</td>
<td></td>
<td>1.50</td>
<td></td>
</tr>
</tbody>
</table>

*Note: Some cells have term spine, naviculoid cell, chain of cells.*
<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
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<tbody>
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<td>0.44</td>
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<tr>
<td>Percent Pyrrhophyta</td>
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<td>0.00</td>
</tr>
<tr>
<td>Percent Undetermined</td>
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* = colony/ml
+= filament/ml
Appendix C: Trophic State Index (TSI)
(Source: http://dipin.kent.edu/tsi.htm#A%20Trophic%20State%20Index)

A list of possible changes that might be expected in a north temperate lake as the amount of algae changes along the trophic state gradient.

<table>
<thead>
<tr>
<th>TSI</th>
<th>Chl (ug/L)</th>
<th>SD (m)</th>
<th>TP (ug/L)</th>
<th>Attributes</th>
<th>Water Supply</th>
<th>Fisheries &amp; Recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;30</td>
<td>&lt;0.95</td>
<td>&gt;8</td>
<td>&lt;6</td>
<td>Oligotrophy: Clear water, oxygen throughout the year in the hypolimnion</td>
<td>Water may be suitable for an unfiltered water supply.</td>
<td>Salmonid fisheries dominate</td>
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<tr>
<td>30-40</td>
<td>0.95-2.6</td>
<td>8-4</td>
<td>6-12</td>
<td>Hypolimnia of shallower lakes may become anoxic</td>
<td></td>
<td>Salmonid fisheries in deep lakes only</td>
</tr>
<tr>
<td>40-50</td>
<td>2.6-7.3</td>
<td>4-2</td>
<td>12-24</td>
<td>Mesotrophy: Water moderately clear; increasing probability of hypolimnetic anoxia during summer</td>
<td>Iron, manganese, taste, and odor problems worsen. Raw water turbidity requires filtration.</td>
<td>Hypolimnetic anoxia results in loss of salmonids. Walleye may predominate</td>
</tr>
<tr>
<td>50-60</td>
<td>7.3-20</td>
<td>2-1</td>
<td>24-48</td>
<td>Eutrophy: Anoxic hypolimnia, macrophyte problems possible</td>
<td></td>
<td>Warm-water fisheries only. Bass may dominate</td>
</tr>
<tr>
<td>60-70</td>
<td>20-56</td>
<td>0.5-1</td>
<td>48-96</td>
<td>Blue-green algae dominate, algal scums and macrophyte problems</td>
<td>Episodes of severe taste and odor possible.</td>
<td>Nuisance macrophytes, algal scums, and low transparency may discourage swimming and boating</td>
</tr>
<tr>
<td>70-80</td>
<td>56-155</td>
<td>0.25-0.5</td>
<td>96-192</td>
<td>Hypereutrophy: (light limited productivity). Dense algae and macrophytes</td>
<td></td>
<td>Rough fish dominate; summer fish kills possible</td>
</tr>
<tr>
<td>&gt;80</td>
<td>&gt;155</td>
<td>&lt;0.25</td>
<td>192-384</td>
<td>Algal scums, few macrophytes</td>
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</tr>
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</table>

**TSI for Fairview Lake**

<table>
<thead>
<tr>
<th></th>
<th>TSI(SD)</th>
<th>TSI(CHL)</th>
<th>TSI(TP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>July</td>
<td>87</td>
<td>76</td>
<td>98</td>
</tr>
<tr>
<td>Aug</td>
<td>78</td>
<td>54</td>
<td>97</td>
</tr>
<tr>
<td>Sep</td>
<td>75</td>
<td>70</td>
<td>77</td>
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<tr>
<td>Mean</td>
<td>80</td>
<td>67</td>
<td>91</td>
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## Appendix D: Water Quality Data of Fairview Lake

<table>
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<th>Date</th>
<th>Time</th>
<th>Temp. °C</th>
<th>SC µS/cm</th>
<th>DO mg/l</th>
<th>DO %Sat</th>
<th>pH</th>
<th>Depth m</th>
<th>Secchi depth ft</th>
<th>Location</th>
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<td>172</td>
<td>5.32</td>
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### Chlorophyll-a data

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E – East Canal Sample  
C – Composite Sample
## Appendix E: Water Quality Analyses Report (From CCAL Lab)

### Fairview Lake
Updated 10/27/2008, kat

<table>
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<th>Sample Number</th>
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<th>Date SSED Determined</th>
<th>Sample NO3/NO2-N (mg/L)</th>
<th>Date NO3/NO2-N Determined</th>
<th>Sample PO4-P (mg/L)</th>
<th>Date PO4-P Determined</th>
<th>Unfiltered Total N (mg/L)</th>
<th>Date UTN Determined</th>
<th>Unfiltered Total P (mg/L)</th>
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Appendix F: Photos of Fairview Lake