Cottage Lake Phosphorus Reduction Project: Final Report on Grant G0600071

June 2011

King County

Department of Natural Resources and Parks
Water and Land Resources Division
Science Section
King Street Center, KSC-NR-0600
201 South Jackson Street, Suite 600
Seattle, WA 98104

Alternate Formats Available

206-296-7380 TTY Relay: 711

Cottage Lake Phosphorus Reduction Project

Grant G0600071

Prepared for:

Washington State Department of Ecology

Submitted by:

Beth leDoux and Sally Abella
King County Water and Land Resources Division
Department of Natural Resources and Parks

Funded in part by Washington State Department of Ecology Clean Water Fund Grant

King County
Department of
Natural Resources and Parks
Water and Land Resources Division

Acknowledgements

The background work for this project involved numerous volunteers, King County employees, Washington State Department of Ecology staff, and members of Friends of Cottage Lake. In particular, much of the important planning and implementation were carried out by Sally Abella, Beth (Cullen) leDoux, and Michael Murphy, while financial tracking has been overseen by Kerry Thrasher and Susan Worden. Numerous interns and staff have helped with data collection, activity implementation and organization over the years, but we would particularly like to thank the Lake Stewardship Volunteer Ed Grubbs; the Friends of Cottage Lake Board including Sally Maimoni, Jim Fleek, Mary and Matt McCain, and Susie Egan; and all the employees from Microsoft who participated in the Microsoft Day of Caring. In particular, we would like to thank Jonathan Morrison, President of the Friends of Cottage Lake, for his continued dedication to Cottage Lake and the community. We thank Debra Bouchard and Jim Simmonds for their editing of the document and internal reviews. We also would like to thank the Washington State Department of Ecology for funding the grant and the series of WDOE staff who acted as liaisons with King County to keep the project on track.

Citation

King County. 2011. Cottage Lake Phosphorus Reduction Project. Prepared by Beth leDoux and Sally Abella, Water and Land Resources Division. Seattle, Washington.

Table of Contents

1.0. Executive Summary 1
1.1 Education 2
1.2 Restoration 2
1.3 Monitoring 2
2.0 History of Phosphorus at Cottage Lake 3
3.0 Total Maximum Daily Load (TMDL) 3
4.0 Cottage Lake Phosphorus Reduction Project Overview 4
4.1 Public Education 4
4.2 Restoration 5
4.3 Monitoring and Assessment 5
4.4 Project Amendments 5
5.0 Project Framework and Approach 6
5.1 Lakeshore and in stream habitat assessments 6
5.2 King County WLRD protocols for shoreline restoration 6
5.2.1 Planting Plans 8
5.3 Cottage Lake Watershed Survey 8
5.4 Sampling Analysis Plan 9
6.0 Project Summary by Task 9
6.1 Task 1: Project Management 9
6.1.1 Meetings 9
6.1.2 Progress Reports 10
6.1.3 Billing 10

6.2 Task 2: Education and Outreach 10
6.2.1 Survey 11
6.2.2.1 Survey Results 12
6.2.3 Workshops 14
6.2.4 Signage 16
6.2.5 Publications 19
6.3 Task 3: Restoration 21
6.3.1 Cottage Lake Park Restoration 21
6.3.2 Private Restoration 25
6.3.3 Shoreline Assessment for additional restoration sites 26
6.3.4 Farm Restoration 31
6.3.5 Summary 31
6.4 Task 4: Monitoring and Assessment 32
6.4.1 EIM 34
6.4.2 Water Quality Results and Analysis 34
7.0 Conclusion 46
7.1 Evaluation 46
7.2 Possible Future Actions 47
8.0 References 49

Figures

Figure 1. Road Crossing sign 16
Figure 2. Wet garden sign at Cottage Lake Park 17
Figure 3. 50 Ways to Love Your Lake education sign 18

Figure 4. Cottage Lake Park historical timeline 18

Figure 5. Final wrap up sign 19

Figure 6. Welcome to the Lake Book 20

Figure 7. Sampling Stations at Cottage Lake and its tributaries 33

Figure 8. Average total phosphorus during the wet and dry seasons for 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake. 36

Figure 9. Wet season and dry season averages for Cottage Lake Creek at COT1 at entry to Cottage Lake. 37

Figure 10. Wet season and dry season averages at 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake. 38

Figure 11. Wet season and dry season averages at Cottage Lake Creek at COT1 at entry to Cottage Lake. 38

Figure 12A. Wet season averages at 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake 39

Figure 12B. Wet season and dry season averages at 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake 40

Figure 12. Wet season and dry season averages at Cottage Lake Creek at COT1 at entry to Cottage Lake. 40

Figure 13. Three parameters measured at Cottage Lake between June and September. Secchi transparency is expressed in meters depth. Chlorophyll-a and total phosphorus are both expressed as micrograms / Liter. Phosphorus has a correction factor for the years before 1997 because of change in laboratory methods. 41

Figure 14. Total phosphorus measured in water taken from 4 depths in Cottage Lake compared over 3 water years: 1993, 2006, and 2010. 43

Figure 15. Ammonia measured in water taken from 4 depths in Cottage Lake compared over 3 water years: 1993, 2006, and 2010. 44

Figure 16. pH measured in water at 4 depths in Cottage Lake compared over 3 water years: 1993, 2006, and 2010. 45

Tables

Table 1. Comparison of responses in citizen surveys on water quality and ecosystem condition 12

Table 2. Evaluation of shrub survival at park restoration in 2008, one year after planting 24

Table 3. Summary characteristics of Cottage Lake shoreline..... 28

Table 4. Slope of land at shoreline around Cottage Lake..... 29

Table 5: Total Linear and Square Footage of Restoration 31

Table 6. Average depth of anoxic zone during thermal stratification in Cottage Lake..... 44

Appendices

Appendix A. Education and Outreach
- Guidebook
- Newsletters
- Signs
- Survey
- Welcome to the Lake
- Workshops

Appendix B. Restoration
- Cottage Lake Park Restoration
- Private Restoration
- Restoration Protocols
- Shoreline Survey

Appendix C. Monitoring and Assessment
- Final SAP
- TEC Memo

1.0. Executive Summary

Cottage Lake is a 63-acre lake located partially in northern King County and partially in Snohomish County, 1.5 miles east of the City of Woodinville. Its watershed is 4275 acres within Watershed Resource Inventory Area (WRIA) 8. The headwaters of Cottage Lake originate at Crystal Lake, just north of the Snohomish County/King County line. Crystal Lake drains into Daniels Creek, one of the main tributaries to Cottage Lake, which enters on the northwest shore of the lake. The other main tributary is Cottage Lake Creek, which comes in on the north east side of the lake. The outlet, also called Cottage Lake Creek, flows from the lake into Bear Creek.

Since the early 1970s Cottage Lake has been characterized as a biologically productive, eutrophic system with subsequent algal blooms and low water clarity. A high level of total phosphorus was identified as the cause of these problems. To address community concerns regarding the increasing impairment of Cottage Lake, King County sampled the lake and two inlets (Daniels Creek and Cottage Lake Creek) in 1993, producing a Lake Management Plan that was subsequently adopted by the King County Council. The year-long study resulted in the Cottage Lake Management Plan and the listing of Cottage Lake on the Washington State 303(d) list for impaired waters in 1996, 1998, and again in 2002/4 for high total phosphorus. Data from the management plan aided in the development of the approved 2004 Cottage Lake Total Maximum Daily Load (TMDL) for phosphorus.

In 2004, King County again sampled the creeks and lake to assess any changes in phosphorus levels. The data suggested that although values were lower than in the early 1990s, further reduction was needed to meet allocation levels established by the TMDL. The monitoring also detected an increase in total fecal coliform concentrations in both inlet creeks.

A Washington Department of Ecology (Ecology) Centennial Clean Water Fund Grant was awarded to King County Water and Land Resources (WLRD) in 2005 to assess phosphorus and fecal coliform concentrations in the lake and tributaries and to work towards reduction in phosphorus in the lake. There were three main components of the proposed project: education, water quality monitoring and assessment, and restoration. These three components were implemented throughout the six year timeline of the project, with the goal of reducing the amount of phosphorus reaching the lake through residents' stewardship and restoration efforts along the lake and in the surrounding watershed.

All three components of the grant were ultimately successful in communicating important information about water quality issues, providing simple suggestions to change peoples'

behaviors, resulting in improved water quality in the inlets and ultimately leaving lasting visible effects toward improved conditions in Cottage Lake.

1.1 Education

A watershed wide survey was the main tool to evaluate the education efforts provided by the grant. From the comparison of the 2005 and 2010 survey results it was discovered that the main education points, like using no/low phosphorus lawn fertilizer, were communicated effectively and resulted in some attitude and behavioral changes. As a community, the residents began to gain a greater understanding of how their behaviors can affect the total phosphorus levels in the lake. Also, excellent educational resources were developed that can be used for years to come in the watershed.

1.2 Restoration

Restoration was the most visible part of the grant and the legacy piece of the work. Over the course of the six years, 1331 linear feet (representing 35,627 square feet) along the shoreline of Cottage Lake have been planted with native plants. Cottage Lake Park was a major beneficiary of the restoration work, and the piece that garnered the greatest volunteer help. It has been an ongoing volunteer effort beginning with prepping and planting, and continuing with maintaining the site. This restoration is definitely the most visible legacy of the grant and one that connects the community to the lake on an everyday basis.

1.3 Monitoring

Monitoring was essential to track and quantify improvements made in water quality that might be due to efforts in the watershed from the grant activities. While positive changes were seen in the tributaries in decreasing total phosphorus, an equivalent change was not seen in the lake. Interactions in lakes are complex and cannot always be directly linked to observed changes in the watershed. For example, physical factors such as climate change that affect the amount of water coming into the lake, water temperature and the duration of stratification also play major roles in phytoplankton abundance. Changes in herbivore species and populations related to fish populations or invasion by alien species can also play a part. Finally, it is hard to be sure that all changes in activities related to nutrient generation have been detected within a watershed, such as road improvements or changes in septic systems. However, sustained decreases in the delivery of nutrients to the lake over time should lead eventually to improvements in water clarity and decreases in phytoplankton abundance.

2.0 History of Phosphorus at Cottage Lake

In the 1996 Cottage Lake Management Plan, water quality in Cottage Lake was classified as eutrophic based on concentrations of the nutrient phosphorus, concentrations of the plant pigment chlorophyll, and lake water transparency (Secchi depth).

Eutrophic lakes are characterized as lakes with high concentrations of nutrients and algae, which are generally accompanied by low water transparencies. A lake's productivity is influenced by a variety of natural factors that interact, including watershed size and geology, lake depth and surface area, climate, direction and strength of the prevailing winds, the quality and quantity of water entering and leaving the lake and catastrophic events such as earthquakes and volcanic eruptions. At any particular point in time, lakes may be naturally eutrophic, mesotrophic, or oligotrophic, based on the characteristics and stability of the surrounding watershed (King County, 2006)

Eutrophication may be a "natural" state in some lakes, but often in the urban areas, eutrophication can be produced by human activities. Land use activities, including home building and habitation, commercial and industrial development, agriculture, landscaping, gardening, and animal keeping all have the potential to contribute increased concentrations of nutrients into surface and ground waters. (King County 2006)

King County has monitored Cottage Lake since the early 1970s and through the early 2000s through both the volunteer King County Lake Stewardship Monitoring Program and special projects, such as the Lake Management Plan. Cottage Lake has consistently been characterized as eutrophic with high levels of phosphorus and chlorophyll a, accompanied by low Secchi transparencies. The eutrophication at Cottage Lake is likely due to human activities – agriculture, development in the watershed, home gardening practices, septics and more, but the shallow nature of the lake also contributes to easy circulation of nutrients into the zone of algal growth.

3.0 Total Maximum Daily Load (TMDL)

TMDLs are calculations of allowable amounts of a particular substance entering a receiving water body, contained in reports that study a particular pollution problem in a body of water. In the case of the Cottage Lake TMDL the focus was on the nutrient phosphorus, which was

stimulating large amounts of algae growth. The TMDL set a water quality standard for Cottage Lake so it might achieve appropriate levels of phosphorus to control the amount of algae in the lake.

The Cottage Lake TMDL was written in June 2004 by Ecology and the analysis set a 20 ug/L total phosphorus target concentration for the lake in summer, with allocations set separately for the known sources of phosphorus. Therefore, 20 ug/L is the water quality - concentration goal for the upper 1 meter of the Cottage Lake water column during the summer period, defined by Ecology as June through August. This TMDL was submitted and approved by the Environmental Protection Agency in 2004.

4.0 Cottage Lake Phosphorus Reduction Project Overview

Considering information about why Cottage Lake is eutrophic, as well as the problems involved with improving water quality and being listed on the 303(d) list, the grant was developed with the basic thought that if education and outreach could increase individual knowledge of the water quality issues, when combined with tools to make attractive lake friendly behavioral changes , perhaps the amount of phosphorus entering the lake could be controlled and water quality improvements could be measured over time. The Cottage Lake Centennial Clean Water Fund Grant project outlined a three part project that took six years to implement. The three main components to the grant were education and outreach, restoration, and water quality monitoring.

4.1 Public Education

The education campaign targeted Cottage Lake watershed residents within King County by utilizing a survey to better understand what the community knew regarding phosphorus pollution, what activities they participate in that would hurt and/or help water quality, and which activities to improve water quality they were interested in learning more about. The results of the survey guided the project team in an educational campaign targeted at phosphorus reduction that included brochures, flyers, booklets, signage, and topical workshops that gave the community practical and helpful information on how they could reduce the amount of phosphorus entering the lake through individual actions.

4.2 Restoration

Restoration was identified as an on-the-ground way to divert phosphorus from surface runoff before it reached the tributaries and Cottage Lake. By encouraging the planting of buffers along the lake and stream shorelines, phosphorus could be taken up and utilized by plants before entering the nearby water. Restoration occurred along the shoreline of six privately owned parcels both along the lake and tributaries, in addition to a large restoration effort in the riparian zone at Cottage Lake Park, a county park that is heavily utilized by the residents of the Cottage Lake watershed.

4.3 Monitoring and Assessment

Monitoring and assessment was a critical component in determining if education and behavioral changes resulted in a reduction in phosphorus in Cottage Lake and its tributaries by monitoring for the duration of the project, both in Cottage Lake and the two inlet streams (Cottage Lake Sampling Analysis Plan, King County 2005). The monitoring focused on nutrients in the lake and tributaries, as well as fecal coliform concentrations in the tributaries. A full suite of sampling occurred during the first year of the grant (Water Year 2006) and then reduced monitoring occurred during the 2007, 2008 and 2009 water years. In 2010 another full suite of monitoring occurred at all stations established in 2006. The lack of lake monitoring in 2007–2009 was an adjustment made by amendment to account for an additional year of work on the grant, in addition to meeting unexpected increases in lab costs.

4.4 Project Amendments

Two grant contract amendments were completed over the course of the project: one in 2007 and another in 2011. The purpose of both amendments was to formalize changes to deliverables and to transfer money between tasks.

The original grant contract included a heavy reliance on the residents in the Cottage lake community to provide in-kind matching funds through community participation in education and restoration of property along the shorelines of the lake and inlet streams. As the project progressed, it became clear that the goals were overambitious in terms of what the community as a whole could achieve, although a number of the residents were very dedicated and worked hard through the life of the grant. Ultimately, negotiations between King County and Ecology resulted in agreement on changes to deliverables and dollars allotted to the grant contract tasks in recognition of the difficulties in carrying out the project as originally intended. This was a successful exercise in adaptive management in order to gain the best possible outcome for Cottage Lake from the efforts of King County, the citizens of the watershed, and Ecology.

In May of 2007, the first amendment included educational deliverables such as workshop topics and road signage as well as enhanced some of the restoration work, prompted by the need to put more money into education and restoration while decreasing the amount of the monitoring budget.

The second amendment was completed towards the end of the project in 2011 and again redistributed funds between project tasks. Money was increased into the project management and restoration tasks and reduced to education, as well as monitoring and assessment. This amendment also clarified points in the contract regarding restoration deliverables, a few education deliverables, and some points on project management deliverables.

5.0 Project Framework and Approach

The goal of this project was to help achieve the TMDL goal as set forward by Ecology and the Environmental Protection Agency. This report reviews each task set forward by the Centennial Clean Water Fund Grant, summarizing by task each deliverable and in the final section evaluate the overall success of the grant.

5.1 Lakeshore and in stream habitat assessments

King County WLRD staff followed protocols used by ecologists at King County for habitat surveys. In the Cottage Lake project, the set of protocols that was used most were the Stream Habitat Restoration Guidelines (see Appendix B) written by the Washington Department of Fish and Wildlife (WDFW). In fact, the Small Habitat Restoration Program at King County uses the WDFW stream protocols to perform their stream restoration projects, and that is what was used at the Derby Farms restoration project along Daniels Creek in 2007.

When assessing areas for restoration, other resources were referred to in effort to identify the best areas for habitat enhancement. These protocols include Ecology's Functional Assessment method (http://www.ecy.wa.gov/programs/sea/wetlands/wfap/index.html#West), as well as other methods that were discussed with King County ecologists. However, the two main protocols relied on for the project were the WDFW and Ecology habitat assessments.

5.2 King County WLRD protocols for shoreline restoration

King County WLRD staff developed protocols to guide the in-lake survey done to identify properties of high priority where water quality improvement could be achieved by planting a

shoreline buffer. The protocols were looking for very specific characteristics to rank each property according to priority for restoration. The ideal properties included these characteristics, although lacking one or more did not automatically exclude a parcel from consideration:

- Shoreline without bank armoring–this ensured there was a connection between the property and the lake, and that planting a buffer would have a direct impact in keeping direct runoff out of the lake. This connection also allowed the restoration to maximize habitat benefit by planting species that might eventually overhang the water, thus providing refuge for fish and other animals, providing shade and helping control lake temperatures in the shallow shorezone and allow for wave action to be diffused and thereby reduce erosion potential.

- Lawns maintained down to the ordinary high water mark (OHWM)–by removing the lawn at the shoreline and installing a native buffer in its place, the impact of capturing runoff and associated pollutants from the lawn would be greatest compared to sites that may have already had some vegetation buffer between lawns and the lake. Properties with this characteristic were ones where it was felt a great improvement could be made.

- Steepness of slope and/or evidence of bank erosion–properties with these characteristics were priorities for restoration because a buffer of native plants can hold back soils and reduce erosion, thus keeping excess phosphorus out of the lake.

- Apparent homeowner use of the lake and need for access–prior to approaching properties regarding restoration it was imperative to assess what the homeowner used the lake shore for, such as boat launch, swimming or a privacy screen. This affects how large of a restoration would be possible on the site and if the restoration goals would be compatible with the homeowner use.

- Presence of plants on the King County noxious weed list - if noxious weeds were present on the property the benefits of restoration increased because, by removing these noxious weeds and replanting with natives, the habitat quality and the overall Cottage Lake ecosystem are improved.

While not all of the properties that were eventually planted along the lake shoreline had every one of the criteria listed above, this list contains the main considerations used in determining which parcels would be targeted for restoration. For example, one of the properties did have a low armor of rocks along the shoreline that prevented erosion of the soil at high lake level, but

it was determined there were still major benefits to be gained from carrying out the restoration.

5.2.1 Planting Plans

While the above points helped King County WLRD staff determine what residences would provide the greatest benefit for restoration and which property owners to approach first, staff also had to consider what would be critical when developing the planting plans for the selected sites. Six critical components were determined:

- Must address lake issues–the restoration must have a tangible effect on trying to stop excess phosphorus from entering the lake over the long term. This would certainly occur in situations where lawn was being removed in favor of planting native shrubs or erosion was being controlled by getting plants into the ground that would ultimately resist wave action along the shoreline. Should increase wildlife habitat, including refuge, food, and nesting sites;
- Should provide for homeowner access to the water and not interfere with usual use of the lake;
- Should be aesthetically pleasing and fit in with the homeowner's landscaping;
- Should need minimal maintenance by the property owner to maintain appearance and functionality; and
- Should send a message about homeowner "caring" about the lake and surrounding environment to the community.

These were the major decision components that went in to assessing private properties for restoration as well as what was needed to help direct the planting plans. These methods helped WLRD to approach private landowners and communicate how and why King County WLRD would like to work on their specific property and what the outcome was hoped to be.

5.3 Cottage Lake Watershed Survey

The survey was a critical tool to not only help evaluate the success of the project but also was critical in determining where to focus education and outreach. By understanding what the residents wanted to learn more about or what activities they wanted to participate in helped King County WLRD staff create thoughtful and pointed education and to put on workshops that would generate the greatest interest. By doing the survey first, project staff were able to put together educational pieces that got key messages out in several different ways and appeal to the greatest audience.

5.4 Sampling Analysis Plan

The Sampling Analysis Plan (SAP) was written prior to monitoring as required by the grant contract. A SAP provides a cohesive and planned out sampling protocol to ensure water quality monitoring was done at the highest standards, that monitoring can be duplicated by other groups, and that all aspects follow EPA certified methods.

The SAP explains site selection, the parameters selected, and how samples were to be analyzed by the lab. (Appendix C)

6.0 Project Summary by Task

6.1 Task 1: Project Management

Project Management was one of the four tasks set forward by the grant. The deliverables for this task were orientated towards record keeping, budget maintenance, and information sharing.

Project Management can be broken down to three primary activities: meetings, progress reports, and billing.

6.1.1 Meetings

King County staff began meeting with stakeholders in the watershed as soon as the grant began in 2005. Meetings were held with the Woodinville Water District, Seattle Public Utilities and the Friends of Cottage Lake Board–as well as other area non-profits like Upper Bear Creek Council and Water Tenders.

While all of these stakeholders were aware of the grant and the educational efforts, the most active partner in this effort was the Friends of Cottage Lake (FOCL). Throughout the grant FOCL and King County staff met periodically to review grant activities, strategize next steps, and talk about other issues concerning the lake residents.

Most of the meetings occurred at the Woodinville Library, but occasionally the meeting would occur at a Board member's house. Often representatives from FOCL went to other area community groups such as Water Tenders and the Upper Bear Creek Council to report on activities surrounding the grant, recruit for volunteers and stay informed about what else was occurring in the watershed.

6.1.2 Progress Reports

Progress reports were a required deliverable and were submitted by King County WLRD staff to the Ecology Project and Financial Managers. In the beginning, the grant reports were submitted quarterly and summarized all the grant activities for that quarter. As the project progressed, Ecology managers required monthly reports to track the final deliverables and tasks more closely. In the monthly reports, annual cumulative totals of achievements were also tracked, such as linear footage restored, number of water quality samples taken, and other milestones.

6.1.3 Billing

Billing occurred every six months, initiated by King County. WLRD project staff would submit receipts and volunteer match documents to King County WLRD budget staff, who would then prepare a billing and submit it to the Ecology financial manager assigned to the Cottage Lake project.

Billings were itemized by task and these totals were reported in the progress reports submitted to Ecology as they were updated.

As of May 27, 2011 the totals for spent by task are as follows:

Task	**Billed as of 12/31/2010**	**Costs Incurred January 2011–May 2011**	**Total**
Task 1. Project Management	$ 10,823.84	$2,157.81	$ 12,981.65
Task 2. Education and Outreach	$ 63,839.06	$ 9,086.88	$ 72,925.94
Task 3. Restoration	$ 79,379.84	$ 7,818.04	$ 87,197.88
Task 4. Monitoring	$ 108,597.85	$ 4,134.53	$ 112,732.38

These totals include items that will be submitted to Ecology at the close of this project in June 2011. These numbers do not represent the total amounts for the grant, as there are still some bills to be posted to the project, but are fairly close to what will be the final figures. The final tally of costs covered by King County, Ecology, and matched by the community through cash and in-kind will be completed for the last billing that King County compiles for the project.

6.2 Task 2: Education and Outreach

An important goal of the Cottage Lake Phosphorus Reduction project grant was to educate residents of the Cottage Lake watershed about water quality issues facing the lake and streams.

It was felt that if people learned about the phosphorus problem and what they could do to decrease their individual impact, behaviors in the watershed could be changed and ultimately reduce the amount of phosphorus entering the waterways. Several different tactics to provide education to residents included workshops, printed materials, signs, and the survey.

6.2.1 Survey

The first thing the grant team wanted to do in this project is assess what the resident in the Cottage Lake watershed understood with regards to the water quality problems facing the lake, what activities contributed to the problem, and what lake friendly behaviors residents currently participated in.

During the first quarter of the grant, a survey was developed with the help of two professional social scientists. The initial survey was administered before any education, outreach, or restoration work began in the watershed. It was developed with the knowledge it would be re-administered toward the end of the grant to measure if attitudes and/or perception of problems facing the lake had changed over the course of the project.

The survey targeted 781 residents who lived along the lake and streams, across the street from the lake, the Cottage Lake Beach Club neighborhood, and randomly percentage of residents living in the watershed away from the lake were selected through a randomization process. A total of 511 surveys were sent to households with addresses on the lake, a tributary, or within a ¼ mile of the lake, while 270 surveys were sent to the randomly chosen households to ensure that the people who do not live near the lake or streams were represented. The survey was put on-line and also was sent out in hard copy.

On November 3, 2005, five days prior to distribution of the initial survey, postcards announcing the survey were sent to the 781 households to advertise the online survey and upcoming mailing. Hard copies of the survey were sent out on November 9, 2005. Two weeks after the survey was sent out a reminder postcard was mailed to encourage a higher return rate. In total, 202 of the 2005 surveys were returned which corresponds to a 26% return rate.

In November of 2010, the survey was done again and sent to the same address list to measure the change in knowledge about the issues facing Cottage Lake and the attitudes towards the water quality problems since the project began. Again, a post card announcing the arrival of the survey went out to all the households with the on-line address. The hard copy of the survey went out a week before the Thanksgiving holiday while a reminder post card went out two weeks later. In January, volunteers from FOCL went around to the lakeshore neighbors and reminded them to complete and return the survey.

In total, 176 of the 2010 surveys were returned which corresponds to a 23% return rate. While not as many surveys were returned as in the 2005 survey, the response rate was comparable and allowed King County staff to perform comparative analysis on the results. (Detailed survey data is found in Appendix A)

6.2.2.1 Survey Results

Some interesting results were found comparing the 2005 and 2010 survey. In both surveys the majority of the respondents said that they lived within a "short walk" of Cottage Lake. Nearly a quarter of the respondents were people who "lived on the shore" of Cottage Lake making them the second most prominent group responding to the survey.

- In 2005, 54.3% of the respondents were "very" or at least "somewhat" familiar with the water quality issues facing Cottage Lake. In contrast, by 2010 there were 63.8% of the respondents who were "very" or at least "somewhat" familiar with the water quality issues facing Cottage Lake. This result suggests that the education and outreach performed by this grant was successful in increasing the number of people familiar with the water quality issues facing the lake.

- The majority of Respondents still think the water quality and ecosystem are in "fair" condition but more people in the 2010 survey now consider them to be "very good" (Table 1).

Table 1. Comparison of responses in citizen surveys on water quality and ecosystem condition

Cottage Lake Water Quality

	2005	2010
Excellent	0.52%	0.0%
Very Good	9.79%	16.6%
Fair	57.22%	62.7%
Poor	27.84%	18.9%
Very Poor	4.64%	1.8%

Cottage Lake Ecosystem

	2005	2010
Excellent	0.52%	0.6%
Very Good	13.61%	28.2%
Fair	64.92%	60.6%
Poor	16.75%	10.0%
Very Poor	4.19%	0.6%

- In 2005 respondents felt that the top three threats to water quality were fecal bacteria from water fowl, algae blooms and fertilizer (note: fertilizers and pesticides only differed by 0.2%). The top two perceived threats were the same in 2010 but the threat of pesticides was ranked a greater threat than fertilizer by 1.7%. There was a significant decrease in the perception of threat from activities such as new development in the watershed, trash and illegal dumping, and poor agriculture practices. Fertilizers, fecal bacteria from pet waste and septics are ranked very similarly between the two surveys.

- Fecal bacteria from water fowl and fertilizers are seen as the largest contributors to algae problems in the lake; although the thought that detergents play an important role increased by 10% and new development in the watershed has decreased by 11% as a cause. These results suggest that people recognize yard care practices as contributing to algae problem and while fecal coliform is not directly a link to algae blooms, the respondents recognize that water fowl waste can contribute nutrients that can exacerbate algae blooms in the lake.

- In 2010, more people are scooping pet waste, using low or no-phosphorus fertilizer and attending workshops about lake issues. It seems that with the grant education and outreach component there has been an increase in behaviors that will improve water quality over the long term. This also suggests that the topics of the workshops were correctly chosen and successful.

- The results from the 2010 survey suggests that the grant was also successful in getting information out regarding planting native plants and using no or low phosphorus fertilizer with a 7.7% and 14.1% (respectively) increase of people who currently participate in these activities. This could be due in large part to the well-attended natural yard care seminar series given at the beginning of the grant, as well as the messages in the Welcome to the Lake book mailed to residents.

- As in 2005, respondents still don’t feel like they have the time to participate in community activities, although more people in 2010 said they would try to attend and participate in the future. However, they also said they were not very interested in learning more about these activities. These results seem to suggest that while people have the best of intentions to participate in community activities, they typically find themselves too busy when the opportunity arises.

- There was an increase in respondents who will "definitely" or "probably" participate in septic maintenance, native plants/buffers, and using appropriate fertilizer in the future. In 2010, people seemed less likely to remove noxious weeds, down 19.4% from the 2005 survey.

- If there were to be more education/outreach done, respondents would like to get more information regarding planting native plants in their gardens and as a shoreline buffer as well as noxious weed removal.

Performing this survey was an excellent way for the project team to assess the impacts of education and outreach on the residents in the watershed. This is particularly important because of the high level of effort put into education and outreach, and because it is often very difficult to measure the effects of those efforts through the short-term environmental monitoring.

The survey suggested that watershed residents paid attention to the education materials and outreach efforts that were performed during the grant and that the messages that were repeated (e.g., the use of organic/no-phosphorus forms of fertilizer) stuck. Outreach efforts worked best when given directly to the residents versus asking them to attend a meeting or workshop, since the survey suggested most people didn't have the time and/or were not very interested in community events and workshops. Overall, the survey results show that the education and outreach work had some effect in informing the residents about issues facing Cottage Lake and getting more people to participate in lake friendly behaviors.

6.2.3 Workshops

6.2.3.1 Natural Yard Care

One of the first educational activities in the grant was bringing the King County workshop series "Natural Yard Care" to the Cottage Lake community. The workshop consisted of a three evening workshop that addressed several issues surrounding the topic of natural yard care. The workshops were held at Molbak's, a nursery in Woodinville, and each night showcased two presenters covering different yard care topics. The schedule was as follows:

March 15, 2006: Basic Natural Yard Care

Ladd Smith from In Harmony spoke about basic aspects of Natural Yard Care.

EJ Hook from Woodland Park Zoo spoke about "Good Bug, Bad Bug" informing people how to deal with garden pests without having to use pesticides.

March 29, 2006: Plants and Watering

Debbie Natelson spoke about Smart Watering and how to use less water in your lawn and garden.

Gregg Rabourn from King County spoke about "Right Plant, Right Place."

April 12, 2006: Soil Magic

Lisa Taylor from Seattle Tilth talked about improving the soil for lawns and plants.

Darcy Batura from WSU Extension Education spoke about composting at home.

The workshops were targeted at the Cottage Lake watershed, and invitation letters went to all households in the watershed. To encourage attendance, Friends of Cottage Lake volunteers, with the help of the public relations firm that assisted in putting on the workshops, went door-knocking around and near the lake to register people for the workshops. Focusing on residents who lived near the lake was important as it was felt this was the group that would most benefit the lake by adopting natural yard care practices.

The Woodinville Weekly newspaper published an article about the workshops, which was well received and generated a lot of interest from the community. At the end of the registration period 180 people were interested in attending the workshops. To encourage the most people to attend, a flyer and an e-mail was sent to each registrant, while volunteers made phone calls one or two nights prior to each workshop as a reminder.

Raffles were held at each workshop that gave away prizes to encourage people to adopt the behavior changes set forward during the workshops. Several local nurseries and businesses donated materials for door prizes and every night at the end of the workshop several gardening items were given out to attendees. The prizes ended each evening on a light and fun note and encouraged people to come back to the next workshop.

These tactics seemed to work very well as the natural yard care workshop was incredibly well attended. The attendance numbers were as follows, March 15 – 115 people, March 29 – 73 people, April 12 – 72 people. These attendance numbers were record setting for the entire Natural Yard Care Program.

6.2.3.2 Green Building Workshop

A green building/low impact development workshop was held at the Woodinville, King County Library on January 24, 2008 for Cottage Lake watershed residents. The workshop was put on by King County Green Building staff, Steve Foley and Dan Farrell. These staff members worked on

green building issues and low impact development on several different types of projects within the County. The focus of this presentation was on saving money through efficient energy and water choices, green building materials, and how to reduce a household's impact on the environment. Ten people attended the workshop.

6.2.3.3 Septic Workshop

Terri King from Sea Grant hosted a one night septic system workshop for the residents of Cottage Lake and the surrounding watershed, including residents of Crystal Lake. This was a joint effort between the neighboring lakes as Crystal Lake in Snohomish County is the head waters for Cottage Lake. The event was held at Crystal Lake Community Club on February 10, 2009 and 28 people attended. There was snow that evening which may have kept the number of attendees low but there was a lot of great discussion and interest generated to hold another meeting and expand the information on how to plant on drain fields. Unfortunately, scheduling conflicts with SeaGrant prevented this from happening.

6.2.4 Signage

6.2.4.1 Road Signs

In the first grant contract amendment signed in May of 2007, Ecology added road signs as a deliverable to the Education and Outreach task. These signs were designed by King County graphics and incorporated the Friends of Cottage Lake logo. They were posted on road crossings for Daniels Creek and Cottage Lake Creek to alert people on the road that they were entering the Cottage Lake Watershed in order to put the area in the context of the lake and remind people of the issues.

Figure 1. Road crossing sign

The signs were posted along Cottage Lake Creek at the culvert on Woodinville Duvall Road. On Daniels Creek they were posted at three sites, one is on 185th street by the blueberry farm, another on Woodinville Duvall Road by the Safeway, and the third is at 176th Ave NE.

6.2.4.2 Park Signs

Educational signs were designed for the Cottage Lake Park, one of the most popular and highly used sites on Cottage Lake. The signs ranged in purpose, some were directly related to the restoration work done in the park, while others were geared towards general public education. Three of the signs were installed at the park in 2009 and the last one was installed in 2011.

One sign was designed to educate visitors about the demonstration wet garden that was built in the park as part of the restoration efforts. Since many of the residents around the Cottage Lake watershed have wet, soggy areas in their yards, a demonstration garden was planted to show residents what kind of native plants grow well in the these conditions. The sign was created so visitors could learn the plants and consider planting them the wet areas on their property.

Figure 2. Wet garden sign at Cottage Lake Park

The second sign had a broader educational slant. It has an image of the Cottage Lake watershed with statistics about the lake and then also lists of “ways to love Cottage Lake”; suggestions of how to enjoy and protect Cottage Lake adapted from the popular Lake Stewardship publication “50 Ways to Love your Lake.”

The intention of this sign was an orientation for people to the Cottage Lake watershed and some of the fun facts regarding the lake, as well as to provide easy suggestions for lake friendly

activities for people to participate in. This sign was installed in 2009 at a wooden kiosk by the public dock.

Figure 3. 50 Ways to Love Your Lake education sign

The third sign at the park was done with large help from a FOCL volunteer. It is a sign that provides a timeline of the rich history of the Cottage Lake Park. This timeline provides a sense of place and connection to the wonderful history of Cottage Lake and always leads to reminiscent conversations among the older park patrons and residents of the watershed. It went up in 2009 and is also posted at the kiosk by the public dock.

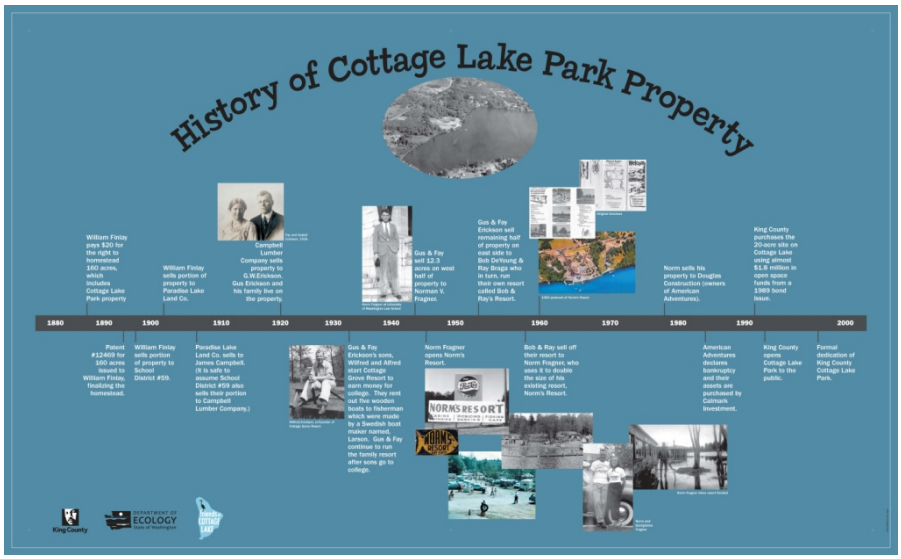


Figure 4. Cottage Lake Park historical timeline

One additional sign with a simple message was posted in early 2011 at the path through the park restoration site built during the restoration effort. It reminds viewers why the restoration was done and also gives credit to the different groups who collaborated on this project, making sure their names and efforts are recognized by the larger community. The design relates back to the watershed signs posted on the roads.

Figure 5. Final wrap up sign

6.2.5 Publications

6.2.5.1 Newsletter and Website

At the beginning of the project, the FOCL president put together a website to help get information out to the residents about the grant and all the opportunities associated with it. It became the go-to site for volunteer projects, latest community meetings, workshop announcements, and monitoring data. Over the years it has expanded to keep people informed about the many other projects the Cottage Lake community has undertaken, such as invasive weed control.

Another way FOCL helped to keep residents and FOCL members informed was a community newsletter called the Cottage Lake Connection. The topics ranged from community events such as neighborhood holiday parties and weather events to wildlife common around the lake and specific water quality issues. Each issue featured a FOCL membership form as well as a community calendar of things happening in the watershed. FOCL often had guest columnists from around the watershed, other volunteer groups and King County that wrote feature articles about issues pertinent to the lake and the grant. (Newsletters are located in Appendix A.)

The first issue went out in April 2006 and was a quarterly newsletter through October of 2007. The 8 page newsletters were both mailed and put on the FOCL website for people to read and enjoy. The newsletter helped the community to generate match dollars for the grant because FOCL paid for printing, mailing and posting the newsletter on the FOCL website, in addition to many volunteer hours generated in putting the newsletter together and publishing it.

By the time the October 2007 issue was completed, it was clear that the few volunteers working on putting the newsletter together were burnt out. It was an enormous amount of time and effort, which was not sustainable for the few volunteers working on it. It was hard to generate more interest to have people work on it even though it was a popular addition to how information was shared in the area. October 2007 was the last issue for the newsletter, but all the issues still remain on line at http://www.friendsofcottagelkae.org/thecottagelakeconnection.htm.

6.2.5.2 Welcome to the Lake Book

One of the most significant deliverables for this grant was the creation of the "Welcome to the Lake" book. The goal and purpose of this book was to provide the residents in the watershed with information to better understand their lake and streams and its ecosystem, as well as how to adapt behaviors that are lake friendly and reduce the individual's impact on the water quality of Cottage Lake.

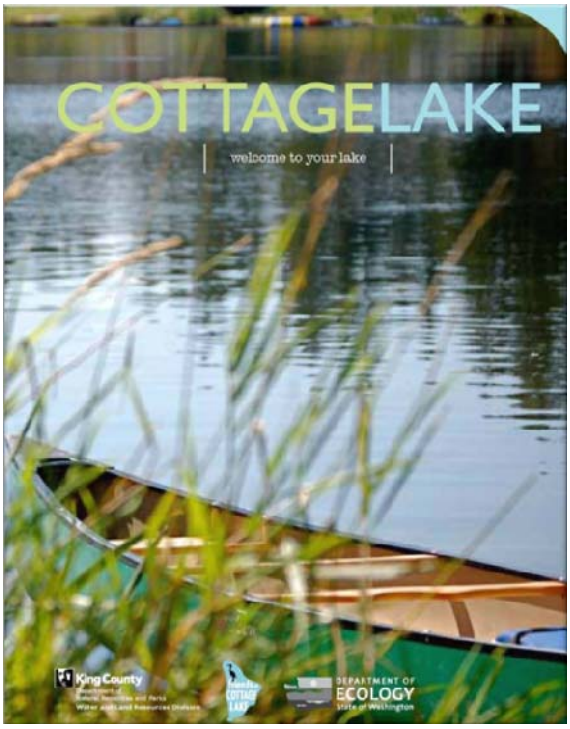


Figure 6. Welcome to the Lake Book

The contents of the book include the history of the lake, statistics about the lake (e.g. watershed size and lake depth), the problem with phosphorus, the plants and animals that live in and around the lake, and behaviors that residents can adopt to improve water quality in the lake. It is a comprehensive reference document that is specific to Cottage Lake but also provides excellent information on the environment and behaviors that pertain to all lakes and residents along waterbodies.

In the fall of 2010, the "Welcome to the Lake" Book was printed and distributed to 779 residents living along the lake shore, inlet creeks, and other places in the watershed. Hard copies were given to Jonathan Morrison, who is president of Friends of Cottage Lake and a primary contact for residents in the watershed. The electronic .pdf copy was also given to Jonathan Morrison of FOCL for posting on their website. Copies were also given to the King County library in Woodinville as well as the Woodinville Sewer and Water District to distribute to interested parties.

6.2.5.3 Guidebook and Presentation

A presentation was given by Beth leDoux at the 24 annual Washington State Lakes Protection Association (WALPA) conference. The presentation focused on the different tasks in the grant and what the successes and challenges of each task have been. The main points of the presentation focused on lessons learned by the King County WLRD staff specifically related to tasks and activities done in conjunction with the Cottage Lake Phosphorus Reduction project.

To accompany the presentation, a guidebook was written as one of the last education deliverables for the project. The purpose of the guidebook was to summarize the tips and reminders King County WLRD staff learned while facilitating an education focused, multi-year project. The Guidebook is intended as a resource for lake managers, local governments, citizen groups and anyone who may be working on long-term educational grants.

6.3 Task 3: Restoration

Restoration was one of the most visible pieces of the grant. The restoration effort included removal of noxious weeds, the planting of native plants, and building shoreline buffers to reduce phosphorus in surface run off to the lake.

6.3.1 Cottage Lake Park Restoration

6.3.1.1 Work in 2006

In the summer of 2006, King County WLRD staff met with King County Parks and walked the Cottage Lake Park to discuss potential restoration activities. It was agreed that the community

could do a restoration project to enhance the buffer area along the lake shoreline. After the site visit, several different planting plans were designed and taken to the FOCL board for input and then presented to the King County Parks for approval.

In the fall of 2006, the stretch of shoreline from the public dock at Cottage Lake Park to the wetland area just east was selected as the location for the restoration. King County project staff worked with Greg Rabourn, a King County natural yard care specialist, to create the designs and ensure the right plant was going in the right place.

By winter of 2006, designs for the Cottage Lake Park restoration were completed and approved. The plans included removing noxious weeds present at the park, mainly yellow flag iris and purple loosestrife, and to enhance the native vegetation already present at the park. The plan also included a demonstration wet garden, designed by Greg Rabourn. The demonstration wet garden was included to help visitors and watershed residents identify native plants that would grow well in gardens that were wet, which is a typical scenario in the Cottage Lake watershed.

6.3.1.2 Work in 2007

By late winter, early spring of 2007, work on the restoration project focused on ordering and pricing plants needed for the restoration from different nurseries. Three volunteer work parties were set up at the FOCL Board Meeting – June 16, July 21 and August 18 all from 9 to noon, dedicated to prepping the site for planting.

Twenty volunteers attended the first work party. The area was mowed and grass was covered with cardboard and then mulch was spread on the top of the cardboard to suppress the grass. The noxious weed, yellow flag iris, was also removed with shovels but due to the level of infestation it was determined that the site needed to be treated with glyphosate. On June 27, 2007 yellow flag iris was treated using a 2% solution of Aquamaster. The permit was issued by Department of Agriculture and the treatment was done by a licensed aquatic pesticide applicator from King County.

The second work party on July 21, 2007 had 10 adults and two children attend. The herbicide treatment on the iris had been completed so the volunteers mowed it and placed cardboard and mulch on top of it to smother the plants. Ten cubic yards of mulch were laid on top of the cardboard spread out along the shoreline. At this event, construction began on the new main path to provide access to the lake.

The third work party on August 18 with 11 people attending had 15 yards of mulch spread out along the shoreline in order to be ready for planting.

On September 21, 2007, the FOCL set up the first of several United Way/Microsoft Day of Caring to help with the restoration site. 25 people attend, mostly from Microsoft, and accomplished a tremendous amount of work. The group spread 20 yards of mulch, turned over and put mulch on the wet garden, finished the main path (grading, putting in edging and 5 yards of crushed gravel) and grubbed and edged the second path by the public boat launch.

Several staff hours were used, both through the King County Lake Stewardship Program and King County Parks Department, for finishing up mulching tasks and make sure tasks were done prior to the planting event.

The planting day occurred on October 27, 2007 and during the days prior all 1156 plants plus 20 coir logs (rope logs stuffed with coconut fibers and planted with sedges and rushes) were delivered to the park. 483 of these plants were in very small sizes and bare-root, designated for the demonstration wet garden.

Twenty volunteers and three King County staff members attended the October 27 event and worked from 9 a.m. until 3 p.m. An estimated 1000 plants, including grasses, sedges, ferns, and wet garden perennials, and all pre-planted coir logs were put into place that day. More crushed gravel was also put onto the path which had compacted and needed more height to prevent water inundation during the winter months. Mulch was also spread around plants and put on exposed cardboard areas in the restoration site. Coir logs were placed directly along the 200 foot shoreline. The plants in the coir logs were expected to grow through the coir logs and put roots into the shoreline, with the goal being that over time the “logs” will decompose and leave healthy rooted plants along the shoreline. Two additional staff days were used to finish spreading mulch and placing plants in the ground. Some plants were handed off to FOCL to store over winter to be used as replacements for any plants that died over winter.

6.3.1.3 Work in 2008

Throughout the spring and summer of 2008, work parties were held to help with maintenance of the restoration site. Typically between 5 and 10 people showed up for these work parties and the bulk of the work focused on spreading mulch around the new plantings, weeding, replanting plants that did not survive and removing invasive species (mainly yellow-flag iris). Throughout the summers, watering was performed by the King County Parks Staff at Cottage Lake using a water truck at the restoration site.

To help with maintenance and to make the restoration fit in with the look of the park, as well as send a positive message about the beauty of restorations, a stone/brick mowing strip was put around the wet garden and split rail fence was installed to keep the newly restored shoreline from being vandalized by people and animals. The fence also helped direct visitors to use the new paths built to give people access to the lake.

Table 2. Evaluation of shrub survival at park restoration in 2008, one year after planting

	Restoration shrub tally		
	Dead	**stressed**	**vandalized**
Dogwood	1	1	1
Willow spp	2		
Vine maple	2	3	1
Snowberry		1	
crab apple		1	
Ninebark	1		
highbush cranberry	1	3	
rose spp		2	2
Can't identify	8		
Totals	15	11	4
Planted			
494	0.030	0.022	0.008
per cent	**3.04**	**2.23**	**0.81**

On August 8, 2008 a mortality count of the planting of the previous year was carried out. Table 2 shows the survival rate of the plants in the restoration area along the shoreline. Of the 494 shrubs planted in 2007, 3% died, 2% were stressed and 0.8% were vandalized. These are excellent survival numbers, demonstrating that plants were planted correctly and the right plants were put in the right place. It also attests to the effectiveness of the fencing in giving the restoration a “special” look as recommended by experts (University of New Hampshire 2007).

The President of FOCL again organized a Microsoft Day of Caring event at the park for September 12, 2008. Twenty-three Microsoft employees came to participate in the six hour event. Several tasks were completed during this event: 385 linear feet of split rail fence were installed; the wet garden was weeded, mulched and replanted; the shoreline area was weeded, mulched and replanted; established trees and shrubs were pruned; and noxious weeds were removed.

One final volunteer work party was held on October 28, 2008. Five people attended and worked for 4 hours in the restoration site. Accomplishments included, weeding, replanting dead plants, and putting a border around the wet garden.

6.3.1.4 Work in 2009

Maintenance of the restoration site picked up again in the spring of 2009. In late May a local Girl Scout troop (16 girls and 2 troop leaders) worked for two hours to help maintain the

restoration. They pulled the invasive yellow flag iris, weeded the wet garden and replanted where needed.

Microsoft Day of Caring once again participated in the Cottage Lake Park Restoration maintenance project . On September 11, 2009, 65 volunteers from Microsoft came to work on the park project for five hours. The shoreline was weeded, yellow-flag iris was removed and the site was mulched. The wet garden was weeded and 100 feet of split rail fence was installed around it to deter animals from digging up the plants. Blackberries in the park's other wetland areas were also targeted for removal.

In 2009, a gas spill occurred elsewhere in the Cottage Lake Watershed, and Associated Petroleum was mandated by Ecology to mitigate for the spill. Associated Petroleum chose to donate some of the money ($8,000) to a local watershed community group doing restoration, which turned out to be Friends of Cottage Lake. On November 4, 2009 Associated Petroleum, Friends of Cottage Lake, King County WLRD, and Ecology met to talk about how the money would be distributed and utilized in the watershed. It was determined that it could be used for restoration efforts in the Cottage Lake Park since that would provide the greatest public good.

6.3.1.5 Work in 2010

On February 9, 2010 WLRD met with Mike Crandell of King County Parks and Jonathan Morrison of FOCL to look at the eastern shoreline canoe pull-out at the King County Cottage Lake Park to evaluate its restoration potential. It was agreed that while an area for canoe launching needed to be maintained, plants could be used to reduce erosion on either side of the canoe area and split rail fence could be installed to help keep people out of the wetland.

On September 24, 2010 Microsoft Day of Caring was again utilized, and it was one of the largest maintenance events in the park. Volunteers worked on the restoration on the east side of the park at the canoe launch. This is a match portion of the grant to use some of the $8000 given by United Petroleum. 18 people (both from the community and Microsoft) came to perform maintenance restoration on the park and began the restoration on the east side of the park.

6.3.2 Private Restoration

At a FOCL community meeting in April 2009, King County staff solicited residents to participate in shoreline restoration to be done as part of the grant. Six residents expressed interest in participating in shoreline restoration.

After initial discussions, five residents agreed to participate in private residence shoreline restoration. A King County Water and Land Resources Division intern who was studying with the University of Washington Landscape Architecture Program visited the five properties with King County staff and put together planting plans based on input from the property owners.

Unfortunately, due to logistical issues and project delays, work on the private restoration did not begin until October 2010 and because of that three of the five residents who initially agreed to participate backed out.

One of the larger properties, the McCain community property, started their restoration work in October of 2010. The property, located on the south side of the lake, was very wet and covered in blackberries and other unwanted weedy plants. To help clear the 86 linear feet of shoreline a Washington State Conservation Corps crew was hired. After the site was prepped, the homeowners managed to get some plants in the ground by the end of October and the rest of the site was covered with cardboard and mulch to prevent weeds and invasive plants from taking over. Since then, the owners have continued to plant as they find time and money to complete the project.

6.3.3 Shoreline Assessment for additional restoration sites

In mid 2010, it was agreed among the project team that another effort should be made to find additional private property owners who would be interested in restoration activities along their shoreline. King County wanted to maximize the potential for increasing shoreline function by making a habitat assessment of the shoreline around the lake and using that data to prioritize properties where restoration might be welcomed and the resulting contribution to shoreline protection and habitat improvement would be more certain.

6.3.3.1 Methods

King County staff talked with a number of county ecologists and wetlands specialists to identify a protocol that might be used as a template for the assessment, keeping in mind that the issues raised for Cottage Lake would be somewhat different from standard wildlife assessments.

The shoreline assessment was carried out by Sally Abella and Beth leDoux by canoe on October 15, 2010. Completion of the fieldwork took about 6.5 hours. Identifying properties was accomplished by consulting maps with the most recent aerial photos available, overlain with parcel boundaries and parcel identification numbers (PIN). Assessment included the following steps:

- Individual parcels were identified by location and characteristics visible on the map. A photo of each property/reach was taken from about 50’ offshore close to the midpoint of the shoreline, and the location of the photo was tied to a GPS waypoint for later mapping and evaluation.
- Estimates were made for each category on a prepared field sheet (see Appendix B for an example) that contained standardized categories for noting and/or evaluating the

following attributes, based on protocols followed in wetland habitat evaluations (KC staff wetland and habitat experts K. Richter and J. Latterell, personal communication):

- Docks–number, width, shape, construction material;
- Bank armoring - % coverage, height, and construction material and relation to ordinary high water mark;
- Beach - % coverage and nature of any introduced materials;
- Vegetation along shoreline - % of total length, class of vegetation type, canopy coverage and % non-natives;
- Presence of lawn extending to the waterline;
- Identification of noxious weed infestations and extent, both onshore and in the water;
- Notes on presence of large woody debris, structures, or other features not covered in standardized assessment

- Each staff person was responsible for a specific assessment in order to keep the scores referable to each other around the lake. However, staff consulted with each other on most of the scores to make sure that important observations were not missed and to maximize consistency. Assessment categories were intentionally broad as well, with 4 scores representing ranges from 0 to 100 assigned by percent occurrence or coverage: 0-1, 2-25, 26-50, 51-75, 76-100.

6.3.3.2 Results of Shoreline Survey

In total, 79 reaches were evaluated for habitat value. Nearly all of these were single family residential parcels, with dwellings and sometimes other structures located on the property. In a couple of cases, several adjacent parcels in a natural condition that belonged to one property owner were lumped together. Another exception was in dividing the shoreline of the King County Park into 4 sections that represented differing land cover, shoreline characteristics, and usage in order to make a more precise delineation.

The total lake shoreline was measured at 7415 linear feet. Some of the characteristics measured have been mapped as well as summarized, and an example of these maps may be found in Appendix B.

Table 3. Summary characteristics of Cottage Lake shoreline

Characteristic	No. of parcels	% total parcels	linear feet	% entire shoreine
Dock	52	65.8	172	2.3
Armoring	32	40.5	1693	22.8
Lawn to water	16	20.2	623	8.4
Lawn within buffer	24	30.4		
Artifical beach	6	7.6	476	6.4
Overhanging trees	31	40.8		
Grasses and forbs	50	65.8		
Shrubs	39	51.3		
Identified noxious weeds	79	100		
Yellow flag iris	33	43.4		
Eurasian watermilfoil	7	9.2		

A significant majority of properties had a functional dock on the shoreline, including almost 66% of the parcels evaluated (Table 1). This was far more than the number of parcels that had bulkheads (40.5%), manicured lawns down to the water's edge (20.2%), or constructed beaches (7.6%).

It appears as though docks are the main way that residents access the water of the lake, both for swimming and for boating. However, adding together all the widths of the docks around the lake showed that they covered only 172 linear feet of shoreline, which is just over 2% of the entire shoreline, so water access by dock does not represent a big footprint.

While the majority of the lake shoreline is not armored, nearly a quarter of the footage does have some type of armoring, which may be enough to affect some land-water processes. Most of the bulkheads are of stone or concrete and are emplaced at or below the ordinary high water mark, thus changing energy and movement of wave action along the shoreline. In several places logs are tethered to the shore or are present without anchoring devices, but for the most part large woody debris is missing as part of shoreline structure around the lake.

Although many of the properties did have lawn between the house and the water, the lawn generally gave way to a fringe of taller, un-mown grasses and forbs at the meeting of land and water. This most often consisted of a mixture of native and non-native plants, and there were no properties around the lake without at least some presence of noxious weeds. The most common alien invasive species seen included reed canary grass, yellow flag iris, English ivy, and blackberries. Very little purple loosestrife was seen during the survey, which is an indication that the King County Noxious Weed Program's efforts to control it continue to be successful at Cottage Lake.

There were fewer shrubs and trees along the shoreline than fringes of smaller plants, and of these, most were not large enough to overhang the water as a source of shade or food for fish, such as insects. There were even fewer snags distributed around the shoreline. However, many of the trees present were native species, such as cedar, alder, cottonwood, Douglas fir and willow species. The shrubs were a mix of both native and introduced horticultural species.

The color of the water made estimating aquatic macrophytes somewhat problematic. However, the continued presence of Eurasian watermilfoil was noted, even though it is much reduced from several years ago when it was first identified in the lake. Milfoil was found offshore from 7 properties and is very likely somewhat more abundant than that.

Another characteristic that can affect shoreline processes, as well as the land use to which the shoreline is put, is the slope of the land down to the water. Slope was estimated as flat to slight, moderate, or steep, with steep being considered as land that requires more than 5 steps on a stairway or a switch-back pathway to access the beach (Table 2).

Table 4. Slope of land at shoreline around Cottage Lake

Shoreline slope:	# properties	linear feet	% shoreline
Rated	66	6764	91.2
Not rated	13	651	8.8
Flat/low	40	4535	67.1
Moderate	18	1552	22.9
Steep	8	677	10.0

Not all of the properties were rated, as in several cases the land was so thickly vegetated that slope could not be determined. Additionally, there were several properties where the bulkhead was built high enough that the natural lay of the land was not determinable. However, 91% of the properties could be rated, and it is clear that the majority of the land is only slightly sloped or even almost flat along the shoreline. This makes beaver activities downstream a serious concern to residents because rising lake levels make large inroads on properties, causing soggy grass and gardens, as well as blocking access to docks.

The lack of moderate to steep banks did correlate with only small amounts of bank erosion visible when the survey was conducted. The one area where bank erosion was quite noticeable was at the park, where fishermen have particular places along the shoreline where they return to cast their lines and wait. The coir logs put in place during the park restoration are still present and may in the end allow native plants to grow back along the edge, but at this time some seem to have become new places for the fishermen to stand. However, this does take

some pressure off the natural shoreline and may allow some sedges and grasses to infill in the small space between the coir log and the shore

6.3.3.3 Shoreline Survey Summary

The shoreline survey identified 22 shoreline residences as priority locations that would benefit the lake by adding or improving a shoreline buffer. During December 2010 a letter was drafted to solicit these properties participation for a spring planting. From that initial letter solicitation, one property owner who owns 154 linear feet along the north end of Cottage Lake agreed to let King County WLRD work on their property.

To encourage more residents to participate in the shoreline restoration, King County staff went door to door to those residents identified in the survey on January 16, 2011 and a second property owner along the east side of the lake also agreed to participate in restoration. The property is 80 linear feet of shoreline. The neighbor adjacent to this property also agreed to be part of the restoration effort, as did the FOCL president.

By February 2011, a total of five properties had agreed to work with King County to plant buffers along their shorelines to improve habitat and water quality along the lake. By the end of the outreach effort, the following properties agreed to restoration planting along their shorelines:

- Olix property – 140 linear feet
- Glaser property – 80 linear feet
- Morrison property – 85 linear feet
- Waldie/Otte property – 80 linear feet
- McCain property – 86 linear feet

Thus the total private linear footage of private restoration equaled 471 feet.

King County WLRD staff talked with Cottage Lake Beach Club board members to see if any restoration would be possible on the community property, but due to recreational activities on the property (swimming beach, dock, and boat launch), there was no logical place to do restoration.

The restoration on McCain community property was started in 2009 using WCC crew to clear the site, while the McCains carried out the planting plan. The other four private residences were scheduled between March 21 and 23. To help expedite the work, Washington Conservation Crews were hired to help prepare and plant the sites. The work began on the Glaser and Waldie/Otte properties on March 21, moved to the Olix property, and finished up on the Morrison property on March 24.

The private restoration was a final push by the grant team to restore some key shoreline areas with native vegetation and create a more cohesive landscape on the lake. Planting plans and maintenance plans are in Appendix B. Plans that were prepared for several owners that have not yet been implemented are also included.

6.3.4 Farm Restoration

Sampling Daniels Creek in the early part of the project led to a great connection at one of the hobby farms along the Creek. King County WLRD staffed identified high potential for stream restoration at Derby Farms, a small hobby horse farm on Daniels Creek near the Woodinville-Duvall Road. King County WLRD staffed approached them in the spring of 2005 about possibly working with King County's Small Habitat Restoration Program to improve the habitat along the creek in fall of 2006.

The owners of Derby Farms were very open to the restoration ideas brought forward by the Small Habitat Restoration Program (SHRP) and by fall 2006 restoration was done along 240 linear feet of the creek and 7700 square feet. Maintenance was done by SHRP once a year for two years after the completion of the project.

6.3.5 Summary

Table 5. Total Linear and Square Footage of Restoration

	Linear feet	Square Feet
Cottage Lake Park (west side)	330	13, 200
Cottage Lake Park (east side)	50	2327
Derby Farms	480	7700
McCain Property	86	7881
Olix Property	140	2868
Glaser Property	80	397
Morrison Property	85	781
Waldie/Otte	80	473
TOTAL	**1331**	**35,627**

* observations taken while monitoring and surveying the lake, measured footage on ArcGIS

6.4 Task 4: Monitoring and Assessment

All lake and stream monitoring for the Cottage Lake phosphorus reduction project followed a Sampling Analysis Plan (SAP) written by King County WLRD staff and approved in 2005. The SAP set forward how and what would be sampled and analyzed. According to the SAP, stations were set to be sampled monthly, and three storm samples per water year were to be collected: two in the wet season (November–April) and one in the dry season (May–October). Stations were set as follows: seven stations along Daniels Creek, three stations along Cottage Lake Creek and two stations in Cottage Lake itself (Figure 5). Sample sites were chosen based on where sampling occurred for the 1995 Management plan and the goal was to be able to compare results between the 1995 effort and the Centennial Clean Water Fund Grant effort. The SAP was approved in June of 2005 and sampling started at the beginning of the 2006 water year (October 2005).

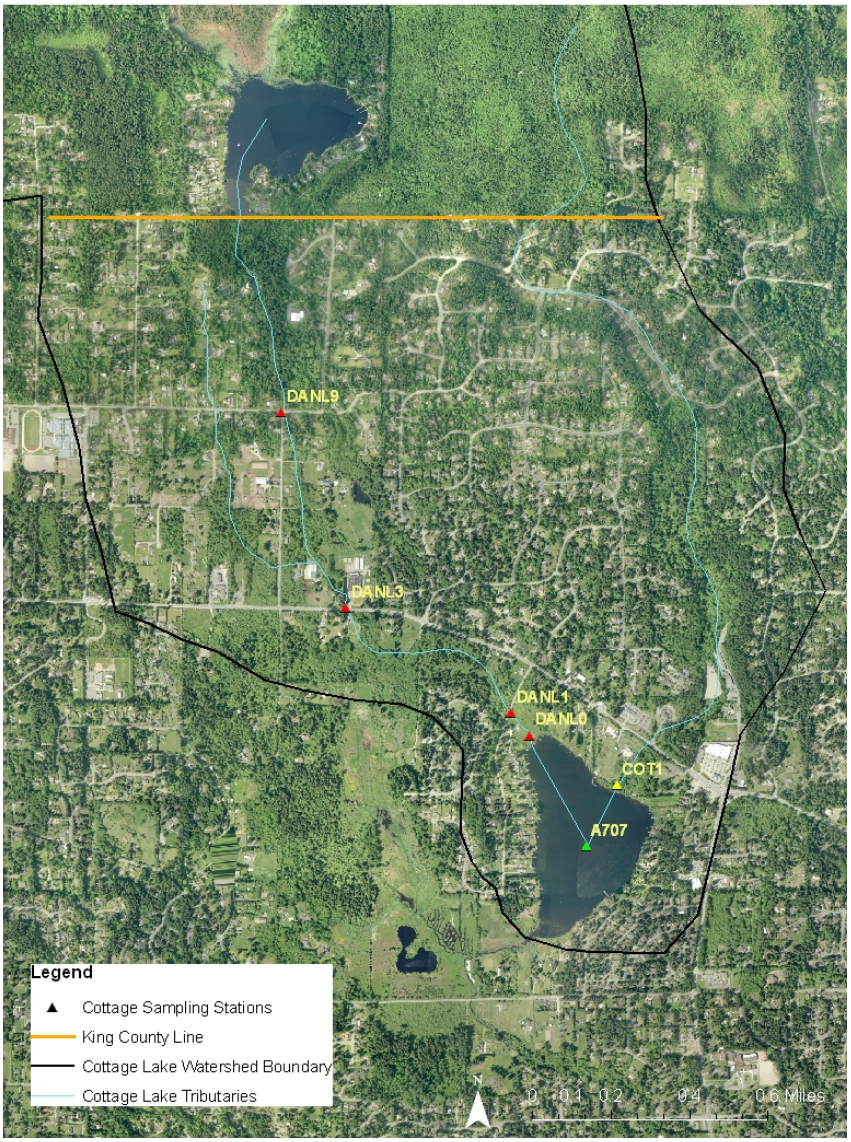


Figure 7. Sampling Stations at Cottage Lake and its tributaries

The 2006 water year followed the SAP closely, with 12 routine events and two storms sampled.

In December 2006 Ecology and WLRD staff agreed to a reduction in the 2007 monthly sampling sites (as documented in a letter to Ecology dated January 25, 2007). The reduction was agreed upon because there was a desire to extend the amount of monitoring time to see if changes in behaviors and practices in the watershed could be detected in the water quality data. It was agreed that while sampling would be reduced in water years 2007, 2008 and 2009, the 2010 water year would mimic the full 2006 water year monitoring effort.

In 2007, 2008 and 2009 four tributary stations were monitored: three on Daniels Creek and one on Cottage Lake Creek. The lake was sampled at the mid-lake station only after 2006 because

the 2006 data showed that there was little or no difference between the two in-lake stations. In 2007, the lake was no longer monitored on a monthly basis. Instead profiles were done in March and December by King County staff, while the King County Lake Stewardship Volunteer program gathered lake data twice a month during May–October. This was done to leverage the effort of the King County Lake Stewardship monitoring program. This worked for the 2007 and 2008 water year.

In 2009, the King County Lake Stewardship Program budget was reduced significantly. That meant that there was no longer funding for the volunteer monitoring effort that was supporting the lake water quality monitoring effort for this project. From May through September in 2009, King County WLRD staff went out once a month to collect total phosphorus and orthophosphate from the mid station of the lake in order to avoid a gap in the record.

In October 2009, the beginning of the 2010 water year, the full sampling protocol was reinstated to compare the first and last years of sampling for the project. DANL6 was dropped after January 2010 due to price increases for lab analysis.

6.4.1 EIM

Several downloads were made into Ecology's database, EIM, to enter water quality data collected as part of the Cottage Lake Centennial Clean Water Fund project. The first download occurred in the middle of 2007 and data through 2007 was uploaded in early 2008.

On the advice of the EIM managers at Ecology headquarters, King County attended a one-day training on May 12, 2010 to learn updates to EIM data submission process since much had changed since the last upload in 2008. By December 2010, all data collected as part of the Cottage Lake phosphorus reduction project was transferred into the Ecology EIM database.

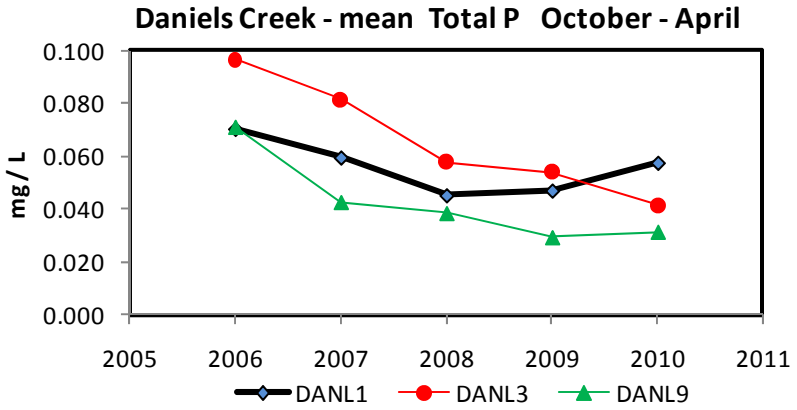
6.4.2 Water Quality Results and Analysis

A water quality statistical memo was written by Taylor Associates (now TEC) at the end of December (Appendix C). The memo compared the 2006 water year to the 2010 water at 4 stations for 3 parameters, using Welch's t-test. Initial results showed a significant decline in orthophosphate at the mouth of Daniels Creek at the 95% confidence level, but no other significant differences were validated at the same level. However, when the confidence level was lowered to 85%, all the total phosphorus and orthophosphate values were significantly different for sites along Daniels Creek. No differences were validated for Cottage Lake Creek between the two years. The orthophosphate level was also different for the shallow water of Cottage Lake, but as an increase rather than a decrease. Information from this memo also helped to guide what parameters would be the focus of the following water quality summary.

6.4.2.1 Inlet streams

The data were divided into wet (October–April) and dry (May–September) seasons, and average (mean) values by year were charted for total phosphorus and orthophosphate in Daniels Creek and Cottage Lake Creek. Fecal coliform data were charted by geomeans to account for the wide range of variability within the data sets. Regression analyses for trends were carried out, but will not be reported here because the number of years (2006 through 2010) was not enough to give statistical validation to the curves generated.

Dividing the data into wet and dry seasons shows that average winter concentrations of total phosphorus have declined slightly more over time than average summer concentrations, suggesting that surface water runoff may be carrying less phosphorus into the lake during the wet season than when the project was started (Figure 8). The decline is more pronounced in the upper reaches of Daniels Creek than just before the creek enters the lake, which indicates that the water from side tributaries may have changed less than the water coming in from the upper watershed. Site DANL3, which is located just downstream from the former Futurity Farms equestrian stables, shows the largest phosphorus decline. This is consistent with the change in land use on the property from an equestrian business with manure management activities onsite to a site currently not in active use, being prepared for construction of a church and school facility.



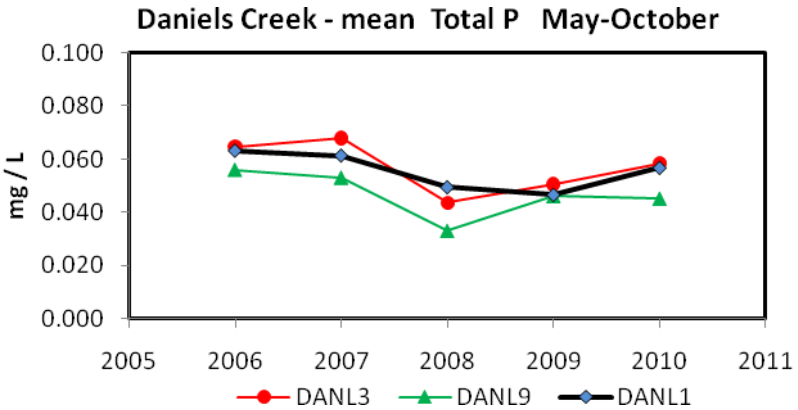


Figure 8. Average total phosphorus during the wet and dry seasons for 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake.

In contrast, Cottage Lake Creek showed little difference over time between the mouth in the park and the upstream sites. In comparing wet season to dry season, there were differences apparent, but overall the values appeared to be relatively stable over time (Figure 9). The high value in 2010 is largely due to a wet weather sample date in May of that year.

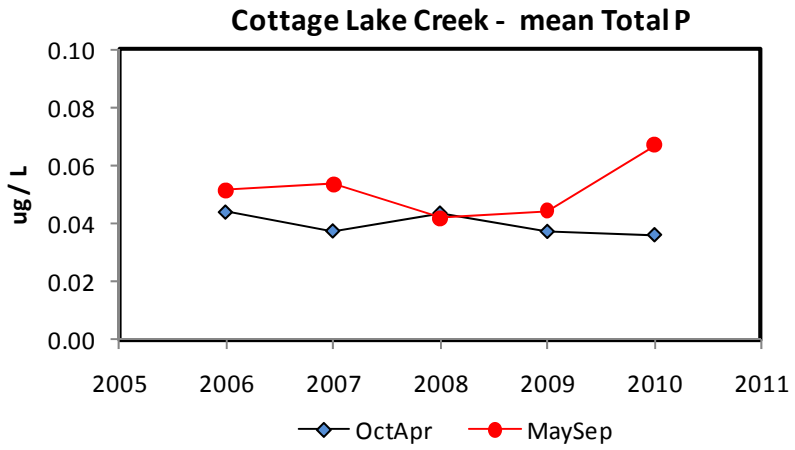


Figure 9. Wet season and dry season averages for Cottage Lake Creek at COT1 at entry to Cottage Lake.

Orthophosphate values were less noisy than total phosphorus, likely because dissolved material in water is not affected by patchiness of the distribution of particles in a sample. It must also be remembered that water during the wet season has a large component of surface runoff, while water in the dry season has generally had some residence time in area soils and therefore contains a larger fraction of soil leachates. The orthophosphates in Daniels creek reflect these considerations (Figure 10), with the average values in summer higher overall than the values in winter. One exception is the values for DANL3 in 2006 and 2007 before Futurity Farms was closed down, when the orthophosphates at that site were considerably higher than at the other sites. The drop in orthophosphate over time is most conspicuous in the wet season data.

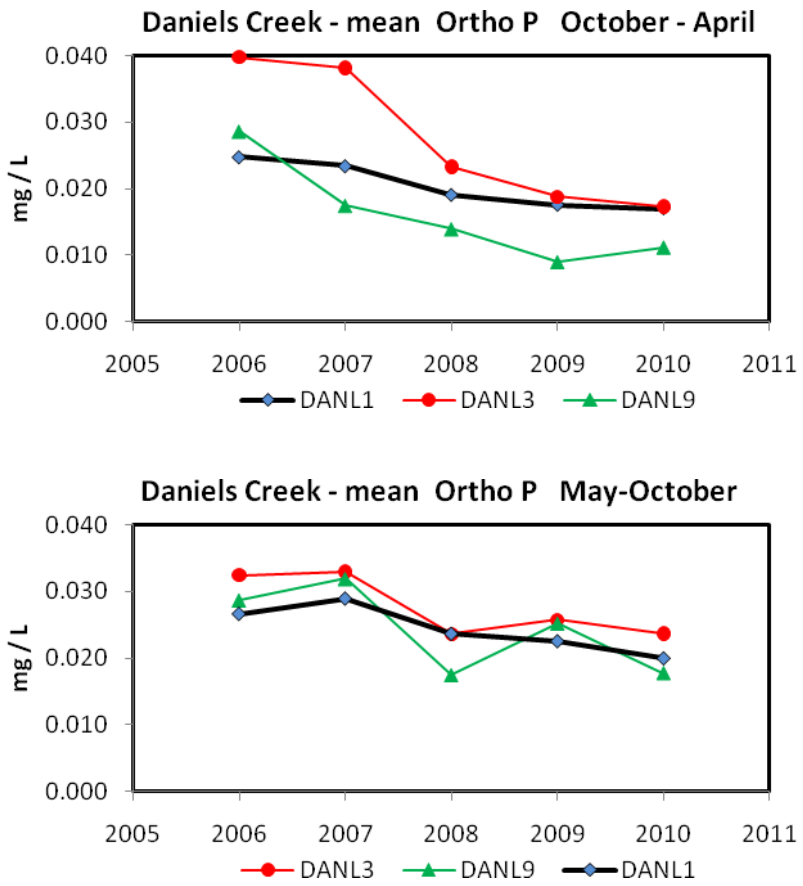


Figure 10. Wet season and dry season averages at 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake.

Cottage Lake Creek showed a consistent difference between wet and dry seasons that was highly stable from year to year, with no change apparent over time (Figure 11).

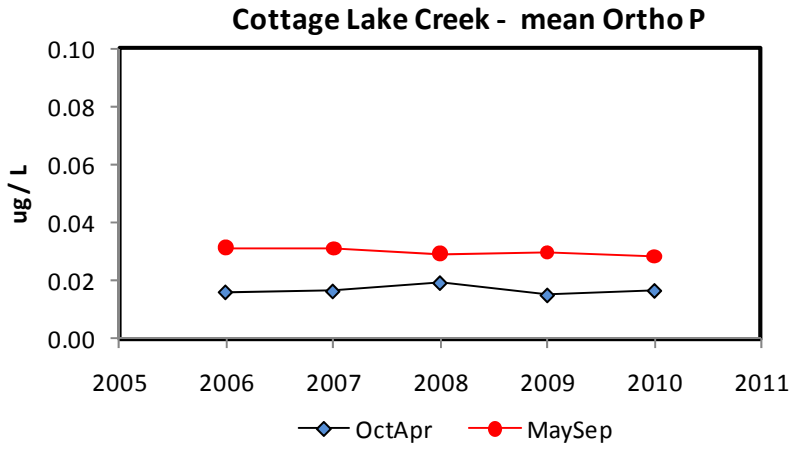


Figure 11. Wet season and dry season averages at Cottage Lake Creek at COT1 at entry to Cottage Lake.

Although fecal coliform bacteria were not addressed in the TMDL on Cottage Lake, historic data indicated that high coliform counts had been found in the inlets in the past, particularly along Daniels Creek. Therefore, samples for fecal coliform bacteria evaluation were collected along with the nutrient samples. Data were summarized as geomeans rather than straight mean averages to be consistent with state guidelines for freshwater (WAC 173-201A).

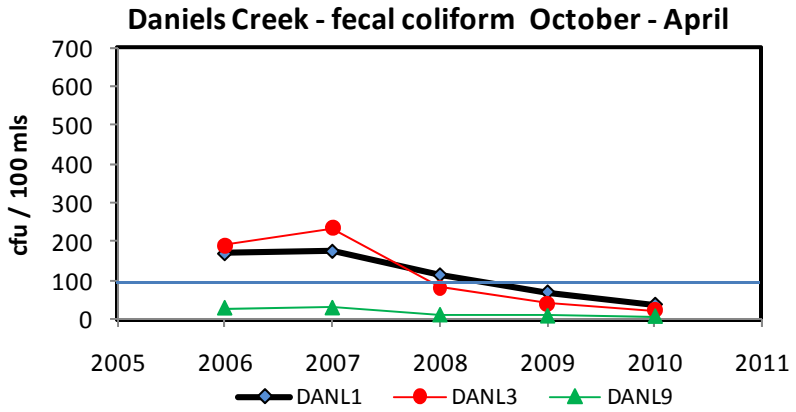


Figure 12A. Wet season averages at 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake

Although the standard was violated during the wet season in 2006 and 2007 for routine samples at the mouth and at the Woodinville-Duvall Road sites, by the last 3 years of the study all the stations were at or below the water quality threshold.

This was not true for the dry season samples (Figure 12B). The station highest in the watershed, DANL9, which is above all the equestrian stables in the area, was only slightly raised above the wet season values and largely met the water quality criteria over time. The lower two samples dropped rapidly from high values in 2006 and 2007, appearing to be on-track to meet water quality criteria as well, but a large increase at both sites occurred in 2010. Examination of the raw data showed that, while the wet May sample did have high values, it was not the only date with large numbers and the higher numbers were sustained over the whole season. It appears that something may have changed recently along the creek that is once again producing high fecal coliform values, this has not been identified as yet.

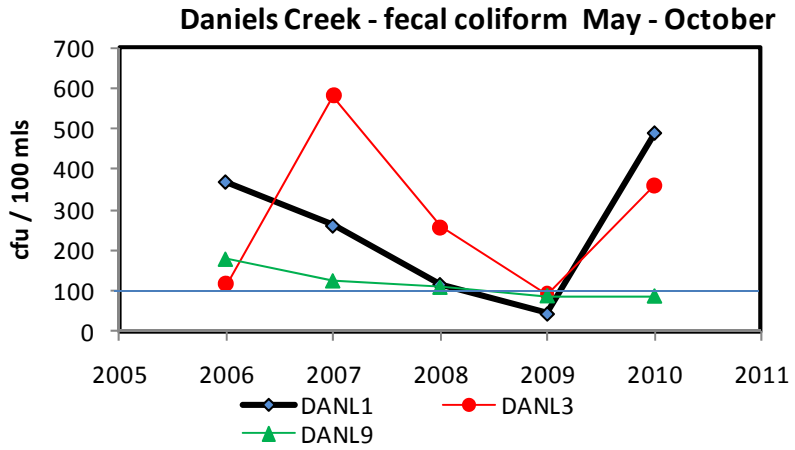


Figure 12B. Wet season and dry season averages at 3 stations along Daniels Creek. DANL1 is the closest to Cottage Lake

Cottage Lake Creek also showed a consistent difference between wet and dry seasons with the dry season having higher values than the wet, but the pattern over time is not directional (Figure 12). There were some concerns that a change in wastewater management at the Safeway complex upstream at the intersection of the Avondale with the Woodinville-Duvall Road might have impacted the creek. Some sampling was done on either side of the complex to test this idea, but the data were not sufficient to reach a definite conclusion.

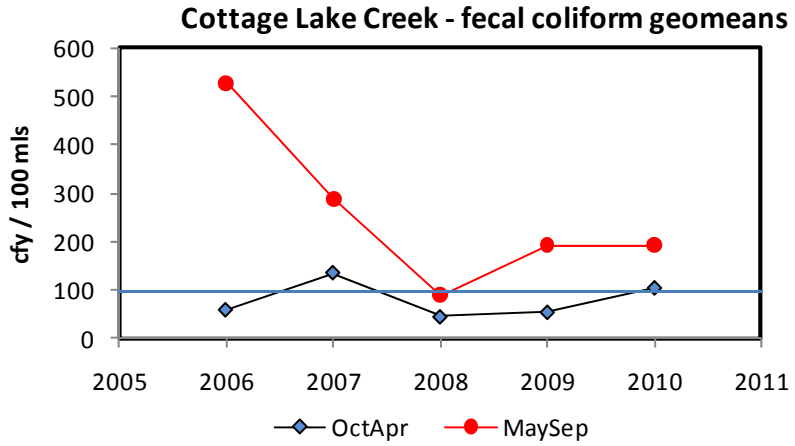


Figure 12. Wet season and dry season averages at Cottage Lake Creek at COT1 at entry to Cottage Lake.

6.4.2.2 Lake Monitoring

Although no statistical difference by t-test was found for Cottage Lake phosphorus by Taylor Associates for the years 2006 and 2010, data from the volunteer monitoring efforts carried out between May and October for the King County Lake Stewardship Program could be used to look

for trends over time because sufficient years of data were available to make trend analysis more robust. Unfortunately, the program lost funding at the end of 2008, and the volunteer monitoring at Cottage Lake was discontinued. Samples from the Centennial Clean Water Fund program filled in for 2010, while a small separate funding source was found to pick up several samples during the 2009 season to fill the projected time gap for phosphorus.

Three parameters were chosen for analysis: total phosphorus, chlorophyll-a, and Secchi transparency. These three parameters were also used by Carlson (1977) to calculate the trophic state indicators that are referenced for phosphorus in the state water quality guidelines (WAC 173-201A).

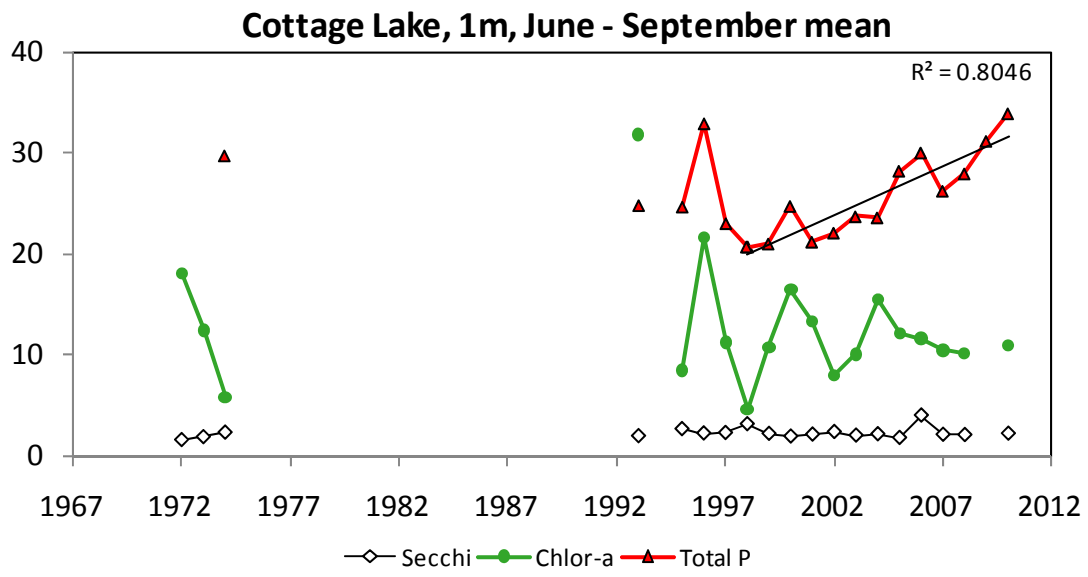


Figure 13. Three parameters measured at Cottage Lake between June and September. Secchi transparency is expressed in meters depth. Chlorophyll-a and total phosphorus are both expressed as micrograms / Liter. Phosphorus has a correction factor for the years before 1997 because of change in laboratory methods.

Values going back to 1972–1974 indicate that Cottage Lake's high algal productivity is not recent in origin, but has a history going back at least 40 years. The chlorophyll data bounces between high and low over the years without a discernable trend, but has been relatively stable since 2005. Secchi transparency has varied little over the years, but is likely related to water color as well as to algal abundance because the lake water is stained moderately yellow by tannins coming from wetlands in the watershed.

Phosphorus data over time is intriguing and somewhat alarming. High values in the early 1990s decreased in 1997–1998, but have been climbing since then. A regression line drawn from 1998

through 2010 has a correlation coefficient of 0.8046, indicating that the increase in summer of phosphorus in the 1 m water over time is well substantiated. If the data set is rearranged so that months of the year are compared to each other over the time span of the measurements, most monthly total phosphorus data have no observed trend over time (for example comparing May values for each year over time results in a regression line with a correlation coefficient of 0.0221, showing no trend). This means that the peak phosphorus concentrations are occurring in different months each year, but that the average concentrations are increasing each summer producing the overall upward. However, comparing August phosphorus concentrations over time does show a validated upwards trend over the period, although the correlation coefficient is 0.239, not a particularly strong correlation.

Making the connection between total phosphorus and algal abundance is reasonable, as phosphorus is most likely to be contained in algal biomass rather than detrital inputs from the watershed. The definition of nutrient limitation is that no more of the nutrient is available for uptake; therefore, it is most likely already contained within the biomass of the algae or it is unavailable, contained in mineral fragments or organic material coming in from outside of the lake (allochthonous detritus such as leaves and insects). This is because the inlet discharges are at very low levels in the summer and therefore contribute little sediment to the lake, and the winds are also light and therefore not adding material from shoreline erosion or dustfall. We also know from the shoreline habitat survey that there is little evidence along the lake shore of bank erosion, and most properties are either armored or vegetated down to the shoreline. Therefore, the upwards trend of phosphorus in August could signal that other mid to late summer conditions are somehow becoming more hospitable to algal growth, either through changes in physical parameters such as temperature, solar radiation, or winds impacting the depth of the thermocline that might mix nutrients up from the hypolimnion.

That chlorophyll-a does not follow this same upward trend is somewhat unexpected. However, it is known that many cyanobacterial species use other pigments, such as phycocyanin and phycoerythrin, to capture light and thus have only very small amounts of chlorophyll-a in order to photosynthesize successfully. Therefore, if the increased biomass is due to growth of cyanobacteria, it may not be expressed in the chlorophyll-a content of the water.

Water samples from the lake were taken by King County staff during WY 2006 at the beginning of the study and again in WY 2010 during the last water year of the life of the grant. These data could be compared to the data collected in 1994 for the Lake Management Plan to see if vertical profiles and lake processes throughout the year have also remained about the same. For this summary, total phosphorus, ammonia, pH, and the duration and depth of the anoxic zone were compared.

Total phosphorus was measured monthly in water taken at 4 depths in the lake: 1 m, 2 m, 4 m, and 6 m. In 1993, water was taken closer to the surface than 1 m, but still should be generally comparable (Figure 13). The deep water showed an increase in phosphorus in every year during the summer months due to thermal stratification resulting in anoxia from biological oxygen demand, which promotes recycling of phosphorus from the sediments back into the deep water. The concentrations were higher in 1993 during data collection for the Lake Management Plan than they were in either 2006 or 2010, suggesting that internal cycling has changed since the plan was created in the mid 1990s or alternatively that partial stratification breakdown might have occurred during the later years, allowing some mixing into the upper water. Note that the deep water values are more than 5-10x higher than what is found in the surface waters at any time of the year, with the values for 1, 2, and 4 m all plotting near the bottom of the charts.

The 1996 Lake Management Plan identified the relative contributions of various sources of phosphorus to Cottage Lake. Of these, 51% was estimated to come directly from Daniels Creek inflows, while 29% came from internal cycling from the bottom sediments acted upon by the deoxygenated waters of the hypolimnion. If in fact, the build-up of phosphorus in the hypolimnion in 2006 and 2010 is less because of escape of recycled phosphorus from the hypolimnion to the euphotic zone where algae could take it up for growth and reproduction, then there is a plausible explanation of the upward trend of phosphorus in the month of August over time.

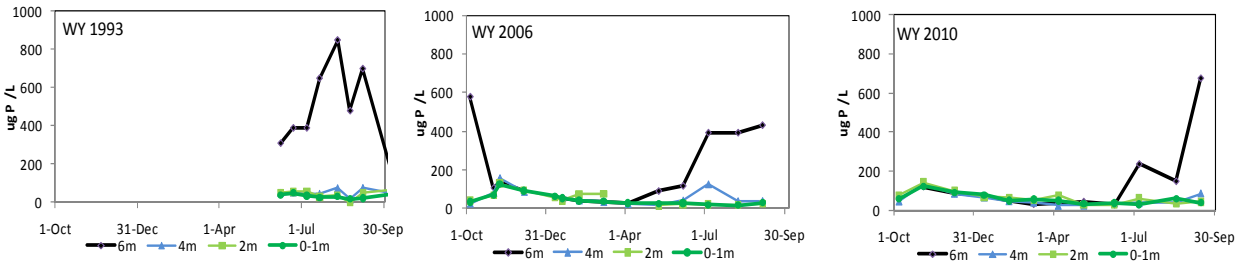


Figure 14. Total phosphorus measured in water taken from 4 depths in Cottage Lake compared over 3 water years: 1993, 2006, and 2010.

Ammonia (NH_3) was also measured monthly and its concentrations can be used as a surrogate for anoxic conditions because in oxygenated environments most ammonia will be converted to nitrate or nitrite (Figure 15). Clearly the highest ammonia build-up occurred in 1993, compared to 2006 and 2010, suggesting that anoxia was not as pronounced in more recent years, which could again be either in volume of water affected by anoxia or in longevity of complete stratification.

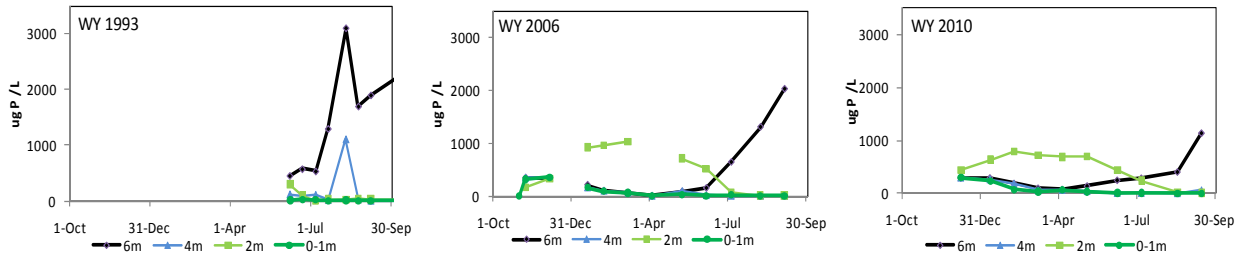


Figure 15. Ammonia measured in water taken from 4 depths in Cottage Lake compared over 3 water years: 1993, 2006, and 2010.

Oxygen was measured by a field probe for all three years. A Hydrolab Sonde MS5 was used in 2006 and 2010. It is not known what instrument was used in 1993. Examination of the data showed that some degree of anoxia was present from May through October all 3 years. The monthly character of the sampling events made it impossible to measure the length of stratification more closely than that. We then averaged the depths over time at which anoxia was detected for each of the three years (Table 5). No systematic difference is apparent, but it is interesting that in 2010, the average depth of anoxia was the deepest of the three years. However, they are all relatively close in value and differentiating this parameter between years would have taken much more frequent sampling than was carried out for this project.

Table 6. Average depth of anoxic zone during thermal stratification in Cottage Lake

WY	depth (m)
1993	3.9
2006	3.6
2010	4.1

When algae bloom in soft water lakes, the magnitude of the bloom is often mirrored in an increased pH of the water because nutrient uptake changes the ionic balance in the water and the lack of buffering leads to an effect on the concentrations of hydrogen ions. The pH values over the 3 years of measurement show this very clearly (Figure 16). By this measure, it looks as if the algae uptake of nutrients affected pH much more in 2010 than in either 1993 or 2006, suggesting that the bloom was larger, agreeing with the evidence of the phosphorus data and not the chlorophyll data. It is also clear that the algae are affecting the pH in the top 2 m of the water column and are not affecting the ion balance in the deeper water, consistent with the steady Secchi measurements of about 2 m and the resultant penetration of sunlight.

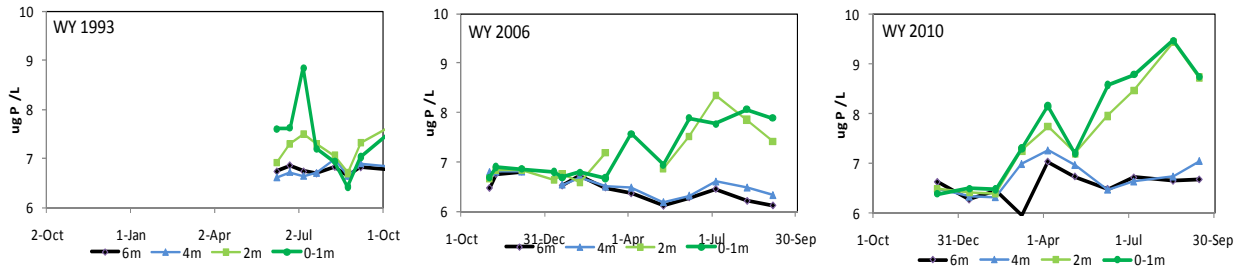


Figure 16. pH measured in water at 4 depths in Cottage Lake compared over 3 water years: 1993, 2006, and 2010.

6.4.2.3 Summary

Our data indicate that phosphorus concentrations are either remaining steady in Cottage Lake Creek appear to be declining in Daniels Creek, which was identified as the main contributor of phosphorus to Cottage Lake in the Lake Management Plan. However, the algae populations as represented by the total phosphorus concentrations appear to be increasing in the summer months in Cottage Lake. There is some indication that a change in internal cycling and hypolimnetic build-up of phosphorus during the summer could be implicated in providing more nutrients to algae, but not enough is known about conditions to verify the idea.

Some other avenues might be explored to explain this increase over time, Factors could include such things as changes in land use immediately around the lake due to the redevelopment of properties from summer cottages to large year-round homes, changes in direct stormwater runoff both from the Avondale and Woodinville-Duvall roads and businesses along them, annual control of the waterlilies and Eurasian milfoil may have caused phosphorus inputs both from the dying vegetation and from the floating islands created by tuber decomposition, and last, possible changes in aging septic systems close to the lake. A climatic explanation that might be explored is increased windiness that might create thermal instability and mix the deep water up more frequently than in the past during the growing season; this might also explain the decrease in hypolimnetic oxygen build-up during the summer. A further possibility related to global warming is that an increase in the length of time of stratification could lengthen the time that cyanobacteria have to grow and reproduce, particularly in the fall, which would allow a larger standing population to overwinter in the lake and get a jump start on the summer season.

7.0 Conclusion

7.1 Evaluation

Overall, the Centennial Clean Water Fund Grant was an ambitious project that proved to be successful in carrying out restoration and educational work in the Cottage Lake watershed.

The education pieces were great vehicles to reiterate key messages to the watershed. This was done through the workshops, the Welcome to the Lake Book, and the signs. The educational pieces of the project were heavily tailored to fit what educational interests people expressed during the initial survey. Native plants and natural yard care were ranked as one of the items people wanted to learn more about and by bringing in the King County Natural Yard Care workshop, a large group of people were reached who were very interested in the topic. While the Natural Yard Care workshop was the best attended workshop in the project, the other workshops brought great information into the community as well.

The most critical part of the education piece was the pre and post surveys. The pre-survey helped guide the project team in what workshops to bring to the community, what messages should be focused on, and aided in the strategy devised to help people best understand the issues facing Cottage Lake. The post survey allowed the overall project to be evaluated for success. It was clear from the post survey results that the six years of work in the watershed did have an effect on the watershed residents' perception of the water quality problems in Cottage Lake are and that there are some activities they participate in to make more sustainable choices for the lake. King County WLRD staff discovered that the key messages from the grant did stick, such as using low, organic fertilizer in yards, pumping septic systems every two to three years and planting native plants. It is fair to say the six years worth of effort did have a measurable effect on the watershed residents.

Restoration was definitely one of the most labor intensive, but most visibly powerful activities accomplished as part of this grant over the long term. Restoration was also the most popular and visible activity the community participated in throughout the whole project. Survey results showed that the most popular way to use Cottage Lake is visit the park. When restoration of the shoreline began at the park, King County WLRD and FOCL had the most interaction with other residents in the area who were interested in what was going on and how restoration would help. The restoration was an activity that allowed individuals, families and groups of people participate in the work being done. It was quickly realized by FOCL and the project team that residents very much enjoyed being able to help out for a few hours now and again to feel connected to the lake and community and also feel like they are accomplishing something tangible.

The restoration effort also became one of the key pieces that was easily transitioned from WLRD to the FOCL. Over the years of working on the park restoration the FOCL became very well versed in how to organize a work party and how to maintain the restoration site, so they were able to take the lead in recruiting volunteers, talking with King County park staff and determining activities that needed to be done at the site. Restoration and site maintenance is something that has empowered the community group at Cottage Lake and given them ownership of the project. It is very possible that restoration efforts at the park will continue into the future under their leadership.

Private restoration was a difficult to sell, but became a successful highlight of the project. The amount of time and effort needed to recruit private property owners to participate was huge. WLRD staff had not anticipated that lake residents would be as skeptical as they proved to be of the government offering to work on their property. It was helpful to have FOCL talk to neighbors and start conversations between neighbors because that seemed to make the idea more appealing than a government official approaching the individuals. Feedback from one of the participants suggested that a packet of information should be developed for the property owners that includes a summary of what is being asked and why, what the resident will gain from the work and what obligations, if any, there are as a recipient of this work. If private restoration were to continue in the watershed, this should be the next step.

Through the habitat survey, King County WLRD staff was able to pinpoint residences that would have the greatest impact on water quality if restored and then targeted those homes specifically. Once the homeowners were set to have their shorelines restored, it was key to have a group like the Washington Conservation Corps on hand with a team of six people to help prep and plant the site. This made it much less daunting for the homeowner, and they were able to enjoy the restoration experience versus getting stressed by the amount of work expected of them. Overall the private restoration that did get completed was incredible real success in getting more native plants installed on the Cottage Lake shoreline and increasing habitat diversity.

Monitoring water quality was a form of evaluating the success of this project. Decreasing phosphorus levels in the lake was the overarching goal and while the project did not do that, there is evidence that it is happening in Daniels Creek, which was the inlet called out in the 1996 Lake Management Plan as a major source of phosphorus to the lake.

7.2 Possible Future Actions

The post survey illuminated a few topics that would be worth addressing in future efforts on education and getting people involved. The post survey showed that Cottage Lake Park was the most heavily utilized part of the lake and visiting it was the most popular activity for watershed

residents. This means that future work being done to improve the lake will be most visible at the park. That could be done through educational material begin posted at the kiosk by the public dock, having educational fairs at the park, or finding ways to keep restoration going at the park.

Residents continue to be very interested in including native plants to their gardens and how to landscape using natives as buffers. It would benefit the community to bring Natural Yard Care, or something similar, back as a workshop again. It seems that residents are always open to information about how to create beautiful landscapes, while making environmentally responsible choices. In conjunction with that there is still very little known in the community about how to recognize and remove noxious weeds. It would be worth bringing in an organization such as the King County Noxious Weed Program to hold workshops centered around the common noxious weeds found in local gardens and lakes. Residents may respond well to learning more about alien plants as they focus on planting more natives in their yards.

Workshops were fairly well attended, but the best education efforts were done more passively, like the Welcome to the Lake Book. If more education is to be done, it is recommended that educational materials be provided through the mail, posted at the library or signs at the park kiosk.

It was identified in the Cottage Lake Management Plan that internal cycling was a large contributor to the phosphorus loading in the lake at 29% of the total annual budget. It is a possibility that as inputs of phosphorus are controlled through landscape changes, statewide phosphorus bans on dish detergents and lawn fertilizers, as well as behavioral changes from the residents, the amount of phosphorus entering the lake will decrease. Certainly, Daniels Creek as the single largest contributor, seems already to be responding to changes on the landscape. Under that scenario, a chemical treatment of the lake to sequester phosphorus, known as an aluminum sulfate or “alum” treatment, may be an appropriate way to bring Cottage Lake into compliance with the TMDL. However, alum treatments are in general very expensive and may be cost prohibitive on a lake such as Cottage Lake. Until it is clear that external nutrient inputs are much reduced and no longer exacerbating the situation in the lake, alum could only be a temporary fix. Once external inputs are controlled, alum treatment would be a good way to increase water quality quickly by immediately limiting the amount of internal cycling of phosphorus from the sediments. Otherwise, natural recovery could take a very long time.

This effort has also provided a long-term data set of water quality for Cottage Lake and its streams, with one decreasing trend validated over the life of the grant. It is likely that continued beneficial behavior changes in the watershed will be reflected in water quality parameters over time. Returning to the watershed to repeat the monitoring effort in a few years would be helpful to understanding the story of phosphorus reduction in Cottage Lake.

8.0 References

King County (1996). Cottage Lake Management Plan. KCM, Inc. Seattle, WA.

Latterell, Josh. (2010). Personal communication. Seattle, WA.

Richter, Klaus. (2010). Personal communication. Seattle, WA.

Saldi-Caromile, K., K. Bates, P. Skidmore, J. Barenti, D. Pineo. 2004. Stream Habitat Restoration Guidelines: Final Draft. Co-published by the Washington Departments of Fish and Wildlife and Ecology and the U.S. Fish and Wildlife Service. Olympia, Washington.

University of New Hampshire Cooperative Extension. 2007. Landscaping at the Water's Edge: an ecological approach. Concord, New Hampshire.

Washington Department of Ecology. (2004). Cottage Lake Total Phosphorus Total Maximum Daily Load Analysis. Olympia, Washington: Prepared by A.J.Whiley, Washington State Department of Ecology, Water Quality Program.

Washington Department of Ecology. (2006). Cottage Lake Total Phosphorus Total Maximum Daily Load Water Quality Implementation Plan. Bellevue, Washington: Prepared by Tricia Shoblom, Washington State Department of Ecology Northwest Regional Office, Water quality Program.