Fauntleroy Creek
Fecal Coliform
Total Maximum Daily Load

Water Quality Improvement Report

June 2007

Publication No. 07-10-037

WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Publication Information

This report is available on the Department of Ecology's website at
www.ecy.wa.gov/biblio/0710037.html

For more information contact:

Publications Coordinator
Water Quality Program
P.O. Box 47600
Olympia, WA 98504-7600

E-mail: jlet461@ecy.wa.gov
Phone: 360-407-6764

Washington State Department of Ecology - www.ecy.wa.gov/

- Headquarters, Lacey 360-407-6000
- Northwest Regional Office, Bellevue 425-649-7000
- Southwest Regional Office, Lacey 360-407-6300
- Central Regional Office, Yakima 509-575-2490
- Eastern Regional Office, Spokane 509-329-3400

Data for this project are available at Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, Faun09FC.

Ecology's Study Tracker Code for this study is Faun09FC.

Fauntleroy Creek
Fecal Coliform
Total Maximum Daily Load

Water Quality Improvement Report

by

Sinang H. Lee
Water Quality Program
Northwest Regional Office
Washington State Department of Ecology
Bellevue, Washington 98008

Waterbody Number: WA-09-1005

This page intentionally left blank – because of page numbering

Table of Contents

List of Figures and Tables

Page

Figures

Tables

Abstract

Fauntleroy Creek flows from its headwaters in a Seattle park about one mile through a residential neighborhood and steep-sided ravine before reaching Fauntleroy Cove in Puget Sound. Under the **Clean Water Act's Section 303(d)**, the Washington State Department of Ecology (Ecology) listed Fauntleroy Creek in 1998 as impaired for fecal coliform bacteria.

Water quality has improved since the early years of monitoring in the creek. However, recent data indicate the creek still does not meet standards for recreational contact during all seasons, especially during the drier months of May through September.

To address this problem, Ecology established a **total maximum daily load (TMDL)** for bacteria and developed a strategy with key partners to reduce the total current amount of bacteria ('loadings') to the creek to meet its estimated total **loading capacity**.

In this Water Quality Improvement Report, Ecology defined the present-day Fauntleroy Creek drainage basin as the study area to develop the TMDL. The implementation strategy will incorporate the larger, historical drainage basin to the creek. This larger area is defined as the implementation area.

Between 2004 and 2006, the creek had an average annual bacteria concentration of 99 colony forming units per 100 milliliters of water (cfu/100 mL). To reach standards, it will take an 80 percent reduction in current bacteria loadings from all sources to the creek. To reduce current pollutant loadings to the creek, while fully supporting all beneficial uses, the TMDL establishes a **wasteload allocation** of 69 percent of the total annual bacteria loading capacity in Fauntleroy Creek to Seattle stormwater point sources, 21 percent to **nonpoint** sources, and 10 percent for a **margin of safety**.

Implementing the Fauntleroy Creek TMDL has the potential to improve water quality in Fauntleroy Cove as well. In 2004, Ecology listed Fauntleroy Cove as impaired for fecal coliform bacteria. In recent years, the cove has been closer to meeting water quality standards for bacteria, and past studies indicate that Fauntleroy Creek is contributing to the bacteria problem in Fauntleroy Cove. Thus, improvements in creek bacteria levels may help Fauntleroy Cove meet water quality standards for bacteria. After implementation has taken effect, Ecology recommends future monitoring of Fauntleroy Cove for bacteria.

(**Bold** text is defined in the Glossary, Appendix A)

Acknowledgements

Many individuals contributed valuable input to the development of the *Fauntleroy Creek Fecal Coliform TMDL Water Quality Improvement Report*. Thanks are due, first, to the city of Seattle staff – Ingrid Wertz, Kathy Minsch, Cheryl Eastberg, and Darla Inglis – who provided significant insight and critiques that improved our understanding of the Fauntleroy Creek basin. Laurie Mann (U.S. Environmental Protection Agency), Jonathan Olds (Washington State Ferries), and Stuart Glasoe (Puget Sound Partnership) shared their early thoughts and interest in supporting the water quality improvement efforts in the Fauntleroy Creek basin. Thanks, too, are due to Scott Mickelson of King County who provided long-term water quality data on Fauntleroy Creek which gave a historical picture of the bacteria conditions in the creek.

Many Ecology staff also contributed to this report. Mike Woodall helped the author create watershed maps to support both the technical analysis and visual aids for this report. Discussions with Joe Joy of Environmental Assessment Program strengthened the report's technical analysis. Helen Bresler, Diane Dent, and Ron McBride ensured that the report was consistent with state policies. Public Outreach Specialist DouGlas Palenshus helped improve the readability of the report for the general public. Rachel McCrea provided assistance during the public meeting. A special thanks to Craig Homan for collecting additional water samples and recent flow measurements that added to the technical analysis. Sincere thanks go out to Dave Garland and Ralph Svrjcek for providing immeasurable guidance and feedback throughout the evolution of this report.

Finally, the author wants to express a special gratitude to Judy Pickens and the Fauntleroy Watershed Council who shared with us their local knowledge about the basin and helped publicized to the community about this effort. And special thanks to the residents of Fauntleroy Creek watershed who love their creek and are working diligently to protect and restore this beautiful watershed.

Executive Summary

The federal **Clean Water Act (CWA)** requires states to place the names of water bodies that exceed state pollution standards (are '**impaired**') on a list known as the "**303(d) list.**" The CWA then requires a **total maximum daily load (TMDL)** study for these impaired water bodies to identify the pollution problems and specify how much pollution needs to be reduced to achieve clean water. A TMDL is an estimated amount of a pollutant a water body can handle without exceeding the **state water quality standards**. The Washington State Department of Ecology (Ecology) then works with the local community to develop an overall approach to control the pollution, called the implementation strategy.

The *Fauntleroy Creek Fecal Coliform Total Maximum Daily Load Water Quality Improvement Report* is Ecology's most recent effort to address potential bacteria pollution sources to the creek. This report documents the amount of bacteria Fauntleroy Creek can receive without exceeding water quality standards, the relative allocations of bacteria to the pollution sources, and an implementation strategy describing actions needed to improve the water quality of the creek.

Ecology determined Fauntleroy Creek has **fecal coliform** bacteria levels beyond what the state allows in our freshwaters. Long-term data indicate water quality has improved since the early years of monitoring in the creek. However, recent data show the creek still does not meet state water quality standards for recreational contact during all seasons, especially during the drier months of May through September.

Ecology has a longstanding interest in improving water quality in urban creeks such as Fauntleroy Creek. After collecting two years of recent surface water monitoring data in Fauntleroy Creek, Ecology initiated a bacteria TMDL study for Fauntleroy Creek. The city of Seattle and Fauntleroy Watershed Council have been active partners in restoring Fauntleroy Creek for years and assisted in the development of this report. This effort will build upon their accomplishments to provide steps by which Fauntleroy Creek can approach meeting water quality standards for bacteria.

Fauntleroy Creek begins in a Seattle park and flows about one mile through a residential neighborhood on the West Seattle peninsula before reaching Fauntleroy Cove in Puget Sound. As a result of Seattle's stormwater infrastructure, the drainage area into Fauntleroy Creek dramatically decreased to one third its historical size. Ecology defined this present-day Fauntleroy Creek drainage basin as the study area to develop the TMDL. The implementation strategy will incorporate the larger, historical drainage basin to Fauntleroy Creek. This larger area is defined as the implementation area. In this urban watershed, land use consists primarily of single-family homes and local roads, some commercial and public buildings, and a city park.

Ecology established the following numerical TMDL values for Fauntleroy Creek:

- Since long-term flow data did not exist for Fauntleroy Creek, Ecology roughly estimated the average annual streamflow in Fauntleroy Creek using Walker Creek as a reference urban stream. Based on the estimated average annual flow and the state's **geometric mean** standard of 50 cfu/100 mL for fecal coliform bacteria, Fauntleroy Creek can receive about 179 billion bacteria colonies per year (489 million bacteria colonies per day) and still meet water quality standards. This is the estimated '**loading capacity**'.

- Using recent data, Ecology estimated how many bacteria colonies enter the creek on an annual and daily basis. Between 2004 and 2006, the creek had an average annual bacteria concentration of 99 cfu/100 mL. So it received about 354 billion bacteria colonies per year from all sources, exceeding its estimated total loading capacity. To bring Fauntleroy Creek into compliance with state water quality standards, it will take an 80 percent reduction in current bacteria loadings from all sources to the creek. This is the 'target percent reduction.'

- The responsibility for reducing bacteria levels is distributed among pollution sources on an annual basis. To reduce current pollutant loadings to the creek, while fully supporting all beneficial uses, this TMDL established a **wasteload allocation** of 69 percent of the total annual bacteria loading capacity in Fauntleroy Creek to Seattle stormwater **point sources**, 21 percent to **nonpoint sources**, and 10 percent for a **margin of safety**.

With key partners, Ecology will develop a water quality implementation plan to reduce bacteria loadings to Fauntleroy Creek. The plan will detail water quality improvement activities and will include a monitoring plan to assess their effectiveness. As actions are accomplished, Ecology expects Fauntleroy Creek to comply with state water quality standards for recreational contact (for extraordinary primary contact recreation) by June 2013.

In the implementation area, potential sources of fecal coliform bacteria include domestic wastewater, sewage, domestic pet waste, wildlife (including avian) waste, and decaying organic matter. The anticipated implementation actions needed to return the creek to good health include: tracking and controlling pollution sources, increasing public awareness, and monitoring water quality.

Organizations that will help improve water quality in the creek include the city of Seattle, Fauntleroy Watershed Council, and Washington State Ferries. Most importantly, the help of watershed residents, local businesses, and public citizens will be needed.

Some of the actions needed are required as part of the current **National Pollutant Discharge Elimination System (NPDES)** municipal stormwater permits. This TMDL provides recommended activities in the implementation strategy and does not establish new state regulations and requirements. Where funding is not currently available, Ecology will assist in seeking appropriate funding sources.

Implementing the Fauntleroy Creek TMDL has the potential to improve water quality in Fauntleroy Cove as well. In 2004, Ecology listed Fauntleroy Cove as impaired for fecal coliform bacteria. In recent years, the cove has been closer to meeting water quality standards for bacteria. Past studies indicate that Fauntleroy Creek is contributing to the bacteria problem in Fauntleroy Cove. Thus, improvements in creek bacteria levels may help Fauntleroy Cove meet water quality standards for bacteria. After implementation has taken effect, Ecology recommends future monitoring of Fauntleroy Cove for bacteria.

The efforts of concerned citizens and organizations to ensure clean, cold, healthy water throughout the Fauntleroy Creek watershed are important contributions to a better environment for us all. Thank you.

Recommendations

The goal of this TMDL is to establish the bacteria loading capacity in Fauntleroy Creek, initiate, and guide the development of an implementation strategy to reduce current bacteria loadings. During implementation, the overall goal is to achieve state water quality standards for bacteria in the impaired creek. As defined in this report, the implementation area is the historical drainage basin to Fauntleroy Creek.

Ecology recommends the following actions to reduce the current bacteria loadings to the creek, while fully supporting all beneficial uses.

- Source Tracking
    - Increase understanding of implementation area basin.
    - Investigation and repair of possible sewer leaks.
    - Identification and elimination of possible illicit connections to the stormwater drainage system.
    - Bacteria source detection monitoring to identify specific sources of bacteria pollution.

- Source Controls
    - Implement structural (as appropriate) and non-structural stormwater source control best management practices (BMPs).
    - Riparian re-vegetation projects to filter out pollutants.

- Increasing Public Awareness
    - Public outreach on local bacteria pollution issues.
    - Watershed stewardship education to provide opportunities to learn about how to protect Fauntleroy Creek from water quality degradation.

- Monitoring
    - Effectiveness (ambient and compliance) monitoring to evaluate the effectiveness of Water Quality Implementation Plan in reducing bacteria levels.
    - Flow monitoring to assess seasonal stream flow patterns and bacteria loadings in the creek.

Due to the potential for the Fauntleroy Creek TMDL to improve bacteria levels in Fauntleroy Cove, Ecology also recommends conducting bacteria monitoring in Fauntleroy Cove after implementation of the Fauntleroy Creek TMDL has taken effect.

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act requirements

The Clean Water Act established a process to identify and clean up polluted waters. It requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Washington State Water Quality Standards (Chapter 173-201a WAC) establish (1) designated uses for protection, such as cold water biota and drinking water supply, and (2) criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of water bodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, the Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before the data are used to develop the 303(d) list. The 303(d) list is part of the larger Water Quality Assessment.

The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides water bodies into one of five categories:

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data available.

Category 4 – Polluted waters that do not require a TMDL because:

- 4a. – Has a TMDL approved and it's being implemented.
- 4b. – Has a pollution control program in place that should solve the problem.
- 4c. – Is impaired by a non-pollutant such as low water flow, dams, and culverts.

Category 5 – Polluted waters that require a TMDL – the 303d list.

TMDL process overview

The Clean Water Act requires that a TMDL be developed for each of the water bodies on the 303(d) list. The TMDL begins with a study that identifies pollution problems in the watershed and then specifies how much that pollution must be reduced or eliminated to achieve clean water. Ecology shares this information with the local community to set goals for restoring the impaired water body to good health. This Water Quality Improvement Report documents the findings from the TMDL study, the recommendations for actions, and the work with the community. Once U.S. Environmental Protection Agency (EPA) approves the Report, a Water Quality Implementation Plan must be developed within one year. The plan identifies specific tasks, responsible parties, and timelines for achieving clean water.

What part of the process are we in?

In this report, Ecology has determined the amount of fecal coliform bacteria that Fauntleroy Creek can receive without exceeding water quality standards, assigned load allocations for pollution sources, and developed an implementation strategy of actions needed to improve water quality.

This report documents the numerical TMDL values, recommended actions needed to improve the quality of the polluted waters, and how the community was included in the decision-making process (Appendix B).

Elements required in a TMDL

The goal of this report is to establish the bacteria loading for Fauntleroy Creek and begin working with the local community to restore it to good health. It includes a written, quantitative assessment of pollutant sources that are causing the pollution problem and water quality problems using the best available information. The study determines the amount of a given pollutant that can be discharged to the water body and still meet state water quality standards (loading capacity), and allocates that load among the various sources.

Identifying the pollutant loading capacity for a water body is an important step in developing a TMDL. EPA defines the loading capacity as “the greatest amount of loading that a water body can receive without violating water quality standards” (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

The portion of the receiving water’s loading capacity assigned to a particular source is a load or wasteload allocation (WLA). If the pollutant comes from a discrete (point) source, such as a municipal or industrial facility’s discharge pipe, that facility’s share of the loading capacity is called a wasteload allocation. If the pollutant comes from a set of diffuse (nonpoint) sources such as general urban, residential, or farm runoff, the cumulative share is called a load allocation (LA).

The TMDL study must also consider seasonal variations, and, when appropriate, include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included as well. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity. The sum of the wasteload and load allocations, the margin of safety (MOS), and any reserve capacity must be equal to or less than the loading capacity.

TMDL (Loading Capacity) = sum of all WLAs + sum of all LAs + MOS

Why is Ecology Conducting a TMDL Study in this Watershed?

Overview

Fauntleroy Creek is impaired for fecal coliform bacteria and action must be taken to improve water quality. To address the bacteria problem, Ecology conducted a TMDL study and developed a strategy with key partners to decrease bacteria concentrations in the creek. In this report, Ecology defined the present-day Fauntleroy Creek drainage basin as the study area to develop the TMDL and set pollutant load allocations (Figure 1). The implementation strategy incorporates the larger historical drainage basin to Fauntleroy Creek. This larger area is defined as the implementation area.

Implementing the Fauntleroy Creek TMDL has the potential to improve water quality in Fauntleroy Cove as well. In 2004, Ecology listed Fauntleroy Cove as impaired for fecal coliform bacteria. In recent years, the cove has been closer to meeting state water quality standards for bacteria, and past studies indicate that Fauntleroy Creek is contributing to the bacteria problem in Fauntleroy Cove. Thus, improvements in creek bacteria levels may help Fauntleroy Cove meet state water quality standards for bacteria. After implementation has taken effect, Ecology recommends future monitoring of Fauntleroy Cove for bacteria.

Study area

Fauntleroy Creek is an urban creek located four miles south of Alki Point on the West Seattle peninsula within Water Resource Inventory Area (WRIA) 09. Fed by runoff and springs, the creek flows in a northwest direction through Fauntleroy Park, then through alternating culverts and open reaches before entering Fauntleroy Cove in Puget Sound through private property.

The study area for this TMDL is the present-day drainage basin of Fauntleroy Creek, comprised primarily of residential homes and local roads, some commercial businesses and public buildings, and a coniferous/deciduous forest city park (Figure 1). From 1920 to 1979, the city of Seattle installed an extensive network of drains to divert road and roof runoff into the public stormwater system (Seattle, 2004). As a result of Seattle's storm water infrastructure, the drainage area into Fauntleroy Creek decreased to one third its historical size, to about 149 acres.

Implementation area

The implementation area extends beyond the study area into the larger historical creek drainage basin, so certain improvement actions can be applied to the larger Fauntleroy community (Figure 1). Due to the local use of Fauntleroy Park and parts of the creek by those living outside the present-day creek drainage area, some outreach strategies are appropriate for the entire implementation area. Other strategies (e.g., illicit discharge detection) would benefit the creek when conducted within the present-day creek drainage area. The overall goal for implementation is to achieve water quality standards for bacteria in Fauntleroy Creek.

Figure 1. Map of present-day Fauntleroy Creek drainage basin (study area) and historical creek drainage basin (implementation area).

Pollutant addressed by this TMDL

This TMDL study addresses fecal coliform bacteria in Fauntleroy Creek. These organisms may enter the aquatic environment directly from humans and animals, agricultural and stormwater runoff, and wastewater. Although fecal coliform are usually not pathogenic, they occur in association with disease-causing bacteria and viruses (i.e., pathogens) and thereby serve as indicators of the potential for pathogens in the water. Generally, a high fecal coliform count indicates a greater probability for pathogens to be present. Fecal coliform are typically found in higher numbers than pathogens and are easier to analyze in the laboratory.

Impaired beneficial uses and water bodies on Ecology's 303(d) list of impaired waters

Water quality monitoring indicates that Fauntleroy Creek is impaired for fecal coliform bacteria, as measured as counts in the water (colony forming units per 100 mL) (Table 1). Based on multiple excursions beyond the 90^{th} percentile water quality criterion in 1988, Ecology placed Fauntleroy Creek on the 1998 303(d) list of impaired freshwaters that require a TMDL (Kendra, 1989). In 2004, Ecology placed Fauntleroy Cove on the 2004 303(d) list based on 2003 King County data showing 2 of 11 samples (18.2%) in Fauntleroy Cove exceeded standards (King County, 2004a). This TMDL addresses the water quality impairment of Fauntleroy Creek.

Table 1. Water bodies on the 2004 303(d) list for fecal coliform.

Water body	Medium	Listing ID	Township	Range	Section
Fauntleroy Creek	Water	6656	24N	03E	35
Fauntleroy Cove	Water	42494	--	--	--

Ecology assigned Fauntleroy Creek to be protected for "extraordinary primary contact recreation" use because it is a tributary to the "extraordinary quality marine waters" of Puget Sound. Puget Sound from Admiralty Inlet to South Puget Sound has been assigned "extraordinary quality" for aquatic life uses, which include shellfish rearing and spawning [WAC 173-201A-600(1)(a)(iv), WAC 173-210A-610, Table 610, and WAC 173-201A-612 Table 612]. Fauntleroy Creek discharges into Puget Sound at Fauntleroy Cove, an area historically used for shellfish harvesting.

Recreational activities that can put people in contact with fecal coliform bacteria in the creek include children playing in the creek or people walking in the waters. Fauntleroy Creek appears to have some public use or exposure potential. People can access the creek through Fauntleroy Park where walking trails exist. In contrast, private property adjacent to much of the lower reach limits public access to nearby residents. Near the creek mouth, the tidelines of Fauntleroy Cove and ferry dock are, for the most part, privately owned.

Why are we doing this TMDL now?

Ecology has a longstanding interest in improving water quality in urban creeks, such as Fauntleroy Creek. After collecting two years of recent ambient monitoring data in Fauntleroy Creek, Ecology initiated a TMDL study for Fauntleroy Creek.

The city of Seattle and Fauntleroy Watershed Council have been active partners in restoring Fauntleroy Creek for years and assisted in the development of this report. They have collaborated on Reach to the Beach project, funded by the city of Seattle's Aquatic Habitat Matching Grant Program, King County and National Fish and Wildlife Foundation's Community Salmon Fund, and Ecology's Coastal Resource Protection Fund. The project goals are to help fish passage and habitat and help mitigate adverse impacts to the lower creek reach environment caused by urbanization and the historic use of Fauntleroy Creek as a receiving water body for stormwater. Recommended actions for implementation will build upon the accomplishments already achieved or in progress to provide steps by which Fauntleroy Creek can approach meeting state water quality standards for bacteria.

Implementing the Fauntleroy Creek TMDL has the potential to improve water quality in Fauntleroy Cove as well. In 2004, Ecology listed Fauntleroy Cove as impaired for fecal coliform bacteria. In recent years, the cove has been closer to meeting water quality standards for bacteria, and past studies indicate that Fauntleroy Creek is contributing to the bacteria problem in Fauntleroy Cove. Thus, improvements in creek bacteria levels may help Fauntleroy Cove meet state water quality standards for bacteria. After implementation has taken effect, Ecology recommends future monitoring of Fauntleroy Cove for bacteria

Water Quality Standards and Beneficial Uses

Criteria for bacteria water quality standards in freshwater are set to protect people who work and play in and on the water from waterborne illnesses. In Washington State, Ecology's water quality standards use fecal coliform as an "indicator bacteria" for the state's freshwaters (e.g., lakes and streams). Fecal coliform in water "indicates" the presence of waste from humans and other warm-blooded animals. Waste from warm-blooded animals is more likely to contain pathogens that will cause illness in humans than waste from cold-blooded animals. The fecal coliform criteria are set at levels that are shown to minimize rates of serious intestinal illness (gastroenteritis) in people.

Fauntleroy Creek is protected for the use of "extraordinary primary contact recreation" because it is a tributary to the "extraordinary quality marine waters" of Puget Sound. Puget Sound from Admiralty Inlet to South Puget Sound has been assigned "extraordinary quality" for aquatic life uses, which include shellfish rearing and spawning [WAC 173-201A-600(1)(a)(iv), WAC 173-210A-610, Table 610, and WAC 173-201A-612 Table 612]. Fauntleroy Creek discharges into Puget Sound at Fauntleroy Cove, an area historically used for shellfish harvesting

The Extraordinary Primary Contact use is intended for waters capable of "providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality marine waters." To protect this use category: "Fecal coliform organism levels must not exceed a geometric mean value of 50 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 100/colonies mL." [WAC 173-201A-200(2)(b), 2003 ed.]

Compliance with bacteria water quality standards is based on meeting both the geometric mean criterion and the 10 percent of samples (or single sample if less than ten total samples) limit. These two measures used in combination ensure that bacterial pollution in a water body will be minimized so as to avoid significant risk to human health. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both annual and seasonal (summer versus winter) data sets.

The criteria for fecal coliform are based on allowing no more than the pre-determined acceptable risk of illness to humans that work or recreate in a water body. The criteria used in the state standards are designed to allow seven or fewer illnesses out of every 1,000 people engaged in primary contact activities. Once the concentration of fecal coliform in the water reaches the numeric criterion, human activities that would increase concentrations above the criteria are not allowed. If the criterion is exceeded, the state will require that human activities be conducted in a manner that will bring bacteria concentrations back into compliance with the standard.

If natural levels of fecal coliform cause criteria to be exceeded, no allowance exists for human activities to measurably increase bacteria pollution. While the specific level of illness rates caused by animal versus human sources has not been quantitatively determined, all warm-blooded animals are a common source of serious waterborne illness for humans.

Watershed Description

Geographic setting

As defined in this report, the study area is the current drainage basin to Fauntleroy Creek and the implementation area is the historical drainage basin to Fauntleroy Creek (Figure 1). The study area covers approximately 149 acres and the implementation area covers about 516 acres. Both the study area and implementation area consist primarily of single-family homes and local roads. Ecology is developing the TMDL and setting pollutant load allocations for the study area, specifically at Fauntleroy Creek near the mouth. The implementation strategy applies to the implementation area.

In this urban watershed on the West Seattle peninsula, Fauntleroy Creek flows about one mile through a residential neighborhood and steep-sided ravine before reaching Puget Sound. Two major and several minor tributaries constitute the headwaters. They converge into a mainstem in Fauntleroy Park. The city of Seattle owns and maintains the park and its trail network as a natural preserve. The creek drops 300 feet in elevation before draining into Fauntleroy Cove about 50 feet south of the Fauntleroy Ferry dock. Williams and Brace Points bound the cove and ferry dock.

Creek drainage basin

Growing human settlement in the watershed resulted in the diversion of much of the natural flow away from Fauntleroy Creek and through stormwater infrastructure to Fauntleroy Cove (Fauntleroy Watershed Action Plan, 2002). Early settlers in Fauntleroy Creek basin bridged the creek and dammed its flow to pipe water to livestock. Following World War II, more people moved into the neighborhood and homebuilding expanded into the hillsides above Fauntleroy Cove (Richardson, 2002). The city of Seattle, along with developers and individual homeowners, installed culverts and landscaping features adjacent to the creek that impact creek flow, fish passage, and water quality.

From 1920 to 1979, the city installed an extensive network of drains to divert road and roof runoff into the public stormwater system (Seattle, 2004). As a result of Seattle's stormwater infrastructure, the area that drains into Fauntleroy Creek dramatically decreased from about 516 acres to 149 acres (Figure 2). This TMDL study focuses on this present-day creek drainage basin (study area) for setting load and wasteload allocations.

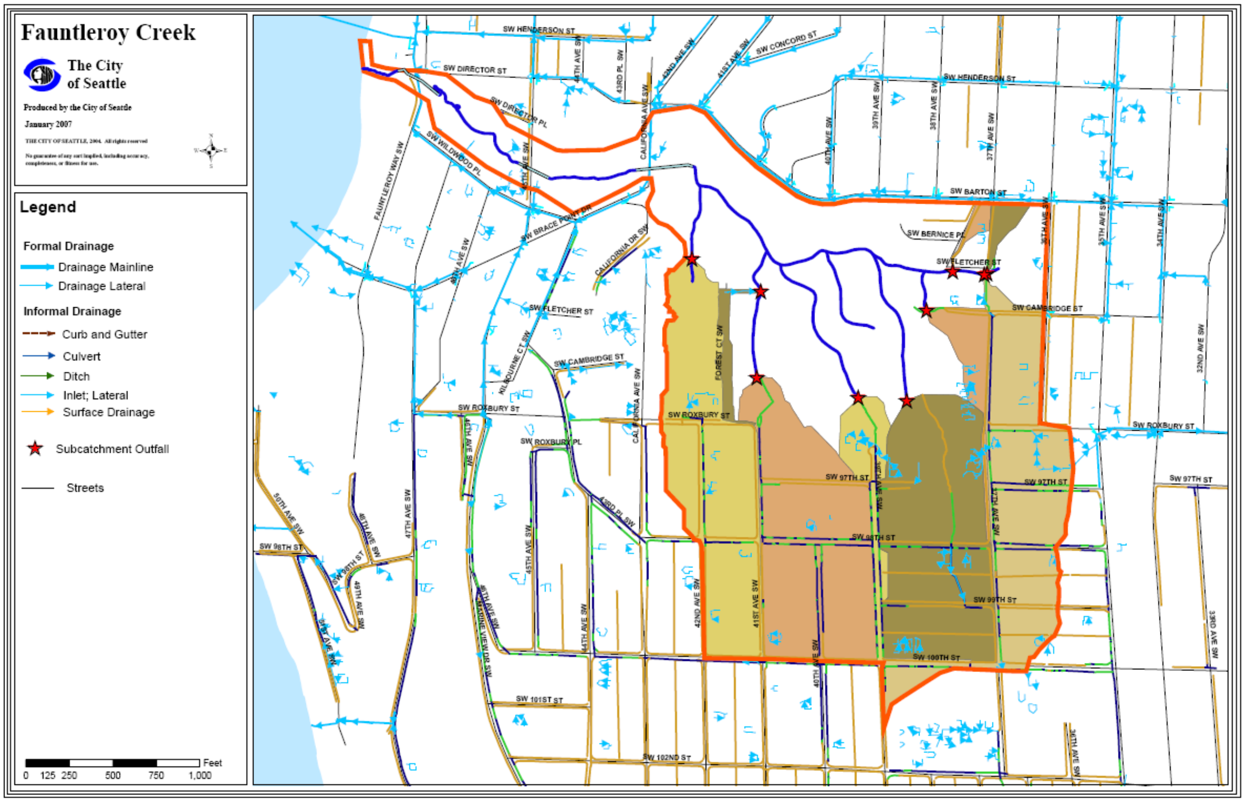

Figure 2. City of Seattle drainage system in Fauntleroy Creek study area (SPU, 2007).

Land use

In the present-day creek drainage basin (study area), land use consists of primarily single-family homes, local roads, some commercial and public buildings, and a city park (Figure 3). The creek's upper mainstem lies within Fauntleroy Park, in a dense stand of mixed coniferous and deciduous forest. These 33 acres preserve the headwaters of the creek and many native plant species. Residential homes dot the steep ravine edges and some residential stormwater is discharged into the creek ravine (Figure 2). In the lower reach near the creek mouth, homes encroach closer to the creek. Much work has been done to restore the stream riparian habitat to create a natural buffer for the creek.

A culvert channels the creek underneath the parking lot for Fauntleroy United Church of Christ, YMCA, and school located on California Avenue SW. A small business district evolved at the intersection of 45th Avenue and Wildwood (Richardson, 2002). Land use in the historic creek drainage basin (implementation area) is similar to that in the study area. In the 1920s, the Kitsap County Transportation Company began the Fauntleroy-Vashon-Harper ferry run near the mouth of the creek. Today the Washington State Ferries (WSF) system runs these services as the Fauntleroy-Vashon-Southworth ferry route.

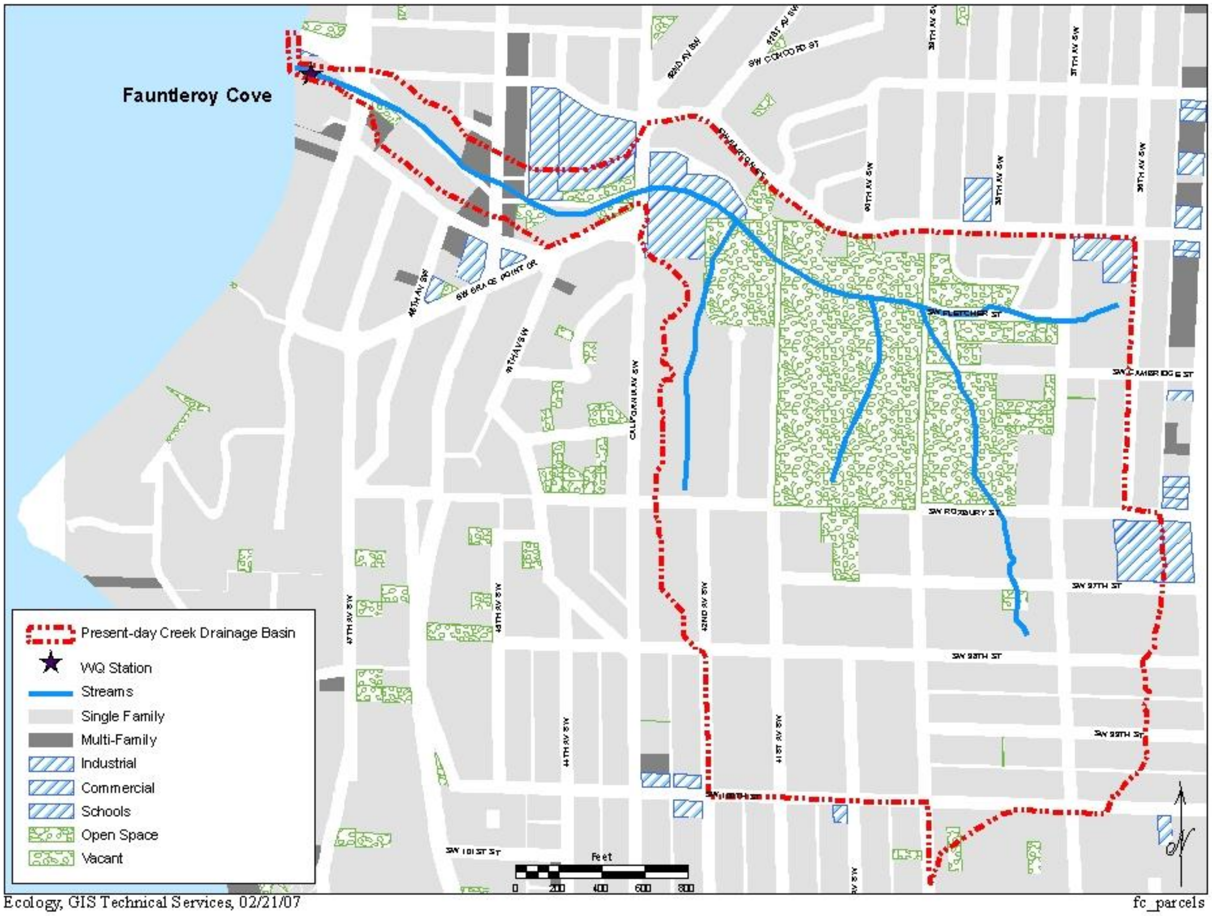

Figure 3. Land uses in Fauntleroy Creek study area.

Basin characteristics

Geology

Fauntleroy Creek is typical of Puget Sound lowland watersheds. As prehistoric glaciers flowed into the Puget Lowland and retreated across Seattle, various glacial sediments were deposited across the landscape. In the historic Fauntleroy Creek basin, layered sequences of glacial sediments control the flow and availability of groundwater and determined the susceptibility of the slopes to landslide. In the upper historic Fauntleroy Creek basin, fine material was deposited over less permeable silt/clay layers which are exposed on steep slopes. This created an unstable slide in the headwaters which has added sediment to the stream channel system (Waldron et al., 1961). The creek has a sandy streambed with an abundance of instream wood which adds to channel complexity. The stream channel structure is dynamic (changes visibly over time) and complex, where it has been allowed to develop with regular step-pools and pool-riffle sequences (Reidy, 2004).

Seasonal periods

Weather can play an important role in the quality of our local streams. For that reason, the Clean Water Act Section 303(d)(1)(C) requires that TMDLs "…be established at a level necessary to implement the applicable water quality standards with seasonal variations…." The regulation also states that "TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters" [40 CFR 130.7(c)(1)].

Ecology determined the seasonal period in Fauntleroy Creek streamflows using precipitation data from the Western Regional Climate Center (WRCC, 2006). The closest long-term weather station is at Seattle-Tacoma International (Sea-Tac) Airport, which has precipitation records from 1936 to present. Rain events of 0.3 inches or more occur at a higher probability during the months October through April (Figure 4). October 1 through April 30 defines the wet season. The average precipitation for the seven month wet season is 31 inches. Conversely, rain events are less likely to occur the rest of the year, so the dry season is defined as May 1 through September 30. The average precipitation during those five months is six inches. Annually, the region receives a total average of 37 inches of rain.

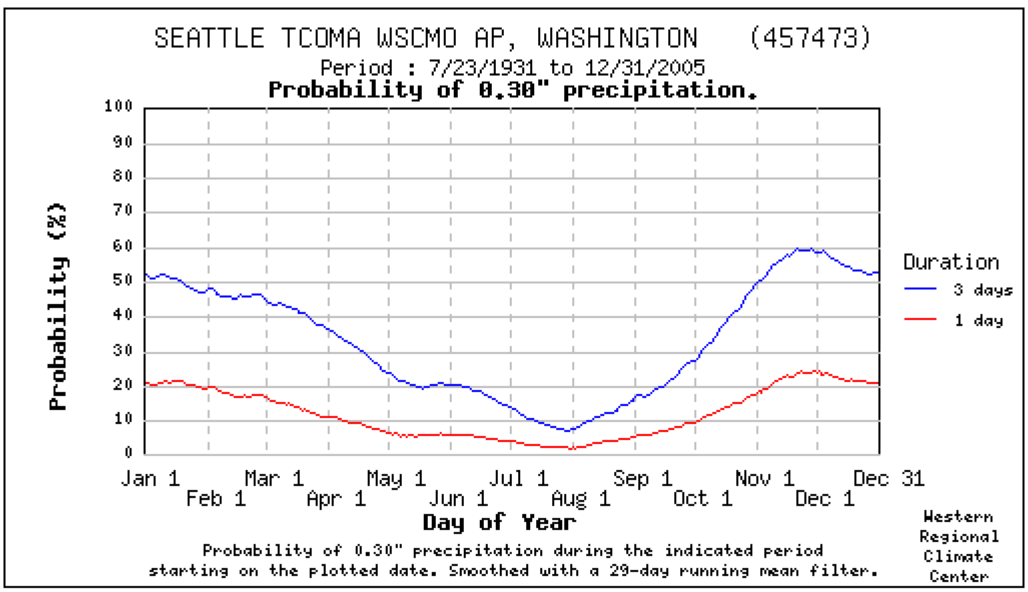

Figure 4. Long-term average rainfall patterns near Fauntleroy Creek.

Streamflow patterns

Groundwater seeping from a deep aquifer east of the park and surface runoff during rains feed Fauntleroy Creek. No long-term flow data exist for Fauntleroy Creek; however, limited past discrete measurements indicate flows between 0.3 to 0.5 cubic feet per second (cfs) at downstream segments of Fauntleroy Creek. The few measurements taken in dry months ranged from 0.3 to 0.42 (Kendra, 1989; Reidy, 2004). Measurements taken in wet months ranged from 0.4 to 0.5 cfs (Fauntleroy Watershed Action Plan, 2002). Recently, Ecology made discrete measurements of 0.43 cfs for winter flows in February and March 2007. Current flow in Fauntleroy Creek is likely lower than historic flow due partly to the diversion of much of the natural flow away from the creek and into stormwater drainage ditches and pipes (Figure 2).

To estimate average streamflow in Fauntleroy Creek, Ecology used Walker Creek as a reference urban stream. Walker Creek is located just west of the Sea-Tac Airport in WRIA 09. It flows for roughly two miles through city of SeaTac, city of Burien, and Normandy Park. Walker Creek joins Miller Creek before reaching Puget Sound. The Miller and Walker Creeks Basin encompasses approximately eight square miles of land and is home to about 30,000 people. Residential neighborhoods (mostly single family homes) comprise about 74 percent of its total land area. Development in the Walker Creek Basin has been generally less intense than Miller Creek Basin and no stormwater flow control facilities have been constructed on Walker Creek (Miller and Walker Creeks Basin Plan, 2006).

The stream gauge is located at King County's site 42e in Walker Creek at 13th SW in Normandy Park. Residential neighborhoods, mostly of single family homes, and commercial areas characterize the land uses in the basin (King County, 2007a). Comparable to Fauntleroy Creek, surface drainage from the upland area flows into a network of steep-sided ravines down to sea level. Relatively undisturbed riparian zones and wide greenbelts are adjacent to the channels through much of this ravine section. In general, Walker Creek watershed has problems with water quality and peak flows associated with urban development (King County, 2007c).

King County recorded daily mean flow rates (cfs) at site 42e in Walker Creek from 1993 to 1996 and 2000 to present (King County, 2007a). Ecology calculated the percent differences in the flows between Walker Creek and Fauntleroy Creek taken on February 1, 2007 and March 1, 2007. Based on the average of these percent differences, Ecology estimated that Fauntleroy Creek has about 16 percent of flow in Walker Creek. (See Appendix E for details on the estimation of flows in Fauntleroy Creek.)

Extrapolating from Walker Creek's annual average of 2.58 cfs, Fauntleroy Creek has an estimated annual flow average of 0.40 cfs. Based on Walker Creek's seasonal flow averages, Fauntleroy Creek has an estimated wet seasonal flow average of 0.50 cfs and dry seasonal flow average of 0.26 cfs (Appendix E).

Ecology assumes Fauntleroy Creek exhibits similar flow patterns typical of a comparable urban stream such as Walker Creek. During storm events, impervious surfaces direct much of the runoff quickly into streams which lead to flashy peak flows. Stream flows are typically lower during the dry season due to less precipitation. In Figure 5, the estimated mean monthly flows in Fauntleroy Creek (based on extrapolation from Walker Creek mean monthly flows) follow a pattern comparable to the local monthly precipitation pattern.

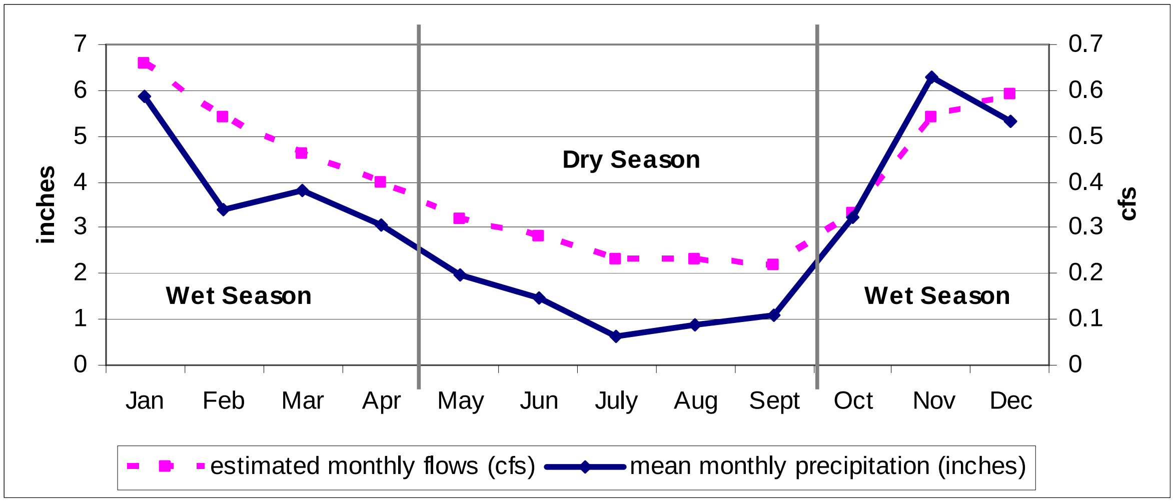

Figure 5. Comparison of mean monthly precipitation and estimated mean monthly flows in Fauntleroy Creek.

Potential pollution sources

In the implementation area, there are several potential sources of fecal coliform bacteria including domestic wastewater, sewage, domestic pet waste, wildlife (including avian) waste, and decaying organic matter (Table 2).

Table 2. Potential sources of bacteria pollution in the implementation area.

Source	Explanation
Domestic wastewater/sewage	Potential leakage from municipal sanitary sewer lines and side sewers. Illicit cross-connections to stormwater drainage system.
Domestic pet wastes	Runoff and drainage from dog walks and animal play areas. Improper waste management and/or storage practices of domestic pet waste.
Wildlife	Excrement from wildlife in the watershed such as otters, gray squirrels, and raccoons.
Avian	Excrement from avian sources in the watershed such as gulls, crows, diving ducks and other marine waterfowl.
Decaying Organic Matter	Fecal coliform bacteria associated with organic materials.
Urban stormwater*	Conveys contaminated runoff from roads, parking lots, roofs, roadside ditches, yards, dumpsters and other areas. Sources of contamination are those listed in table above.

*Ecology does not consider stormwater as a pollutant in itself, but an efficient conveyor of pollutants from drainage surfaces.

Domestic wastewater/sewage

Wastewater from showers, toilets, and sinks is defined as “domestic wastewater.” Domestic wastewater can be generated in private residences or commercial businesses. In the implementation area, wastewater is conveyed to a King County wastewater treatment facility through a regional sewage conveyance system. A sanitary sewer collection line parallels the creek and borders the cove shoreline.

Centrally conveyed sewage could enter surface waters under several scenarios: sanitary sewer line breakages, or illicit cross-connections to stormwater sewers. These can be significant sources of fecal coliform contamination (with concentrations in the tens of thousands of bacteria colonies per 100 mL) and pose great human health risk to people in contact with the water.

There are several ways in which leaky sewer lines might contribute pollutants to local surface waters. The first is a leaky force main or gravity sewer in close proximity to surface water. For sewer systems that rely on gravity to ensure good flow, the favorable natural grade adjacent to a stream makes it a practical place to locate lines at an economical cost. Leaky joints due to shifting earth, line deterioration, or improper installation could lead to leakage to a local stream in these situations.

Sewer system breakdowns or illegal cross-connections are generally corrected as soon as they are detected. In winter of 2006, two pipe failures near Fauntleroy Cove resulted in sewer-line replacement between pump stations in the cove and at Lowman Beach to the north.

Domestic pet waste

In other urban watersheds, dogs have been found to be significant contributors of bacteria. Pet wastes generated at individual homes and public areas such as parks and playgrounds may likewise contribute fecal coliform to Fauntleroy Creek. Dog feces have been frequently observed along trails popular with dog walkers in Fauntleroy Park (Pickens, 2006). Seattle installed ‘Scoop Law’ signage at trail entrances to Fauntleroy Park. Pet waste from cats and other domestic pets could be sources of fecal coliform bacteria.

Wildlife and avian

Wildlife contributes bacteria to surface waters and at typically low levels in undisturbed watersheds this is not considered pollution. In those cases where man-caused alterations of the natural environment have increased wildlife levels, their contributions may be considered a source of pollution. Some practices such as unkempt dumpster areas, littered parking lots or grass lawns along shorelines can attract birds and other wildlife and cause excess bacteria loading.

River otters, Northern flying squirrels, mountain beavers, red foxes, and dozen kinds of birds, including raptors, woodpeckers, owls, wrens, gulls, ducks, and geese have been observed in the Fauntleroy Creek area (Fauntleroy Watershed Action Plan, 2002). These and other warm-blooded animals contribute bacteria loading directly and indirectly to streams. The mouth of the creek frequently has a fresh-water pool which attracts pigeons, crows, gulls, ducks, and shorebirds to bathe and loaf (Kendra, 1989).

Decaying organic matter

Large stocks of decaying organic matter can be a source of fecal coliform bacteria. Klebsiella is a genus that is most commonly associated with decaying organic matter although there are some pathogenic strains. A study of a large wood pile in Seattle showed elevated fecal coliform bacteria concentrations in runoff from the pile (> 60,000 cfu/mL). Approximately 80 percent of the fecal coliform bacteria in the runoff were Klebsiella, and the remaining 20 percent were E. coli. (Herrera, 2005; Zisette, R., Herrera Environmental Consultants, e-comm., 2007).

Urban stormwater

Ecology does not consider stormwater a pollutant source in itself, but an efficient conveyor of pollutants from drainage surfaces to local waters. Stormwater starts as rainwater and other precipitation and either infiltrates into the ground or accumulates and flows over impervious surfaces. Land uses and activities in urban areas, coupled with an increase in impervious surfaces and accumulation of contaminants, typically result in polluted stormwater. Heavy rainfall and runoff wash contaminants off impervious areas, including rooftops, driveways, sidewalks, parking lots, and roads into storm drains, or directly into streams. During typical storms, pollutants can reach stream systems quickly.

Some stormwater that enters streams is untreated and can contain toxic metals, organic compounds, and bacterial and viral pathogens. Stormwater can carry bacteria from sources such as pet waste and urban wildlife to Fauntleroy Creek. The specific water quality impact of stormwater on the creek is hard to quantify, partly because of the high variability of pollutant concentration in stormwater and creek water.

The majority of stormwater that is captured within the present-day Fauntleroy Creek drainage basin reaches the creek through a system of surface ditches and culverts. The city of Seattle owns and operates this system and Ecology regulates it as a point source under Ecology's National Pollutant Discharge Elimination (NPDES) Municipal Phase I Stormwater Management Program.

Goals and Objectives

The goal of this report is to establish the pollution loading for Fauntleroy Creek and begin working with the local community to restore it to good health. During implementation, the overall goal is to achieve state water quality standards for bacteria in Fauntleroy Creek. A monitoring strategy of the implementation measures will ensure that progress is made towards obtaining compliance with state water quality standards in the creek.

Objectives of Ecology's technical analysis in this report are as follows:

- Characterize long-term trends and current conditions of bacteria concentrations in Fauntleroy Creek.
- Estimate the total maximum annual and daily loads (loading capacity) and current loadings of bacteria in Fauntleroy Creek.
- Establish bacteria load allocations for nonpoint sources and wasteload allocations for point sources to protect all beneficial uses.

Appendix C describes the data sources and provides the raw data used in this technical analysis.

Results and Discussion

Long-term trends in Fauntleroy Creek

Looking over many years, Fauntleroy Creek had extreme peaks of bacteria in the early years of monitoring with general improving conditions since late 1989. Figure 6 shows a 12-sample moving geometric mean of bacteria concentrations in Fauntleroy Creek. In 1987, six samples or 22 percent of total samples had bacteria concentrations above 1,000 cfu/100 mL. Four of these high concentrations were collected during the dry months. From 1990 to 1996, data show more stable bacteria concentrations with five samples greater than 1,000 cfu/100mL. This historical sub-dataset is more representative of bacteria levels collected during recent monitoring in 2004 to 2006.

The reasons for the dramatic decline in bacteria in late 1980s are unknown. Around this time, Fauntleroy residents had started to complain about beach odor. In 1987, King County's wastewater treatment division (formally known as METRO) and other agencies investigated the potential sources for the odor, initially thought to be associated with sewage (METRO, 1987). Seattle King County Public Health checked private side-sewer cards for all homes that border Fauntleroy Creek and Fauntleroy Cove for proper connections and questionable hookups. Additionally, visual checks were made to find other sources of pollution in the creek, such as erosion due to poor drainage and illegal dumping of fill or garbage.

In 1990, rotting sea lettuce was determined to be the culprit of the beach odor and was hauled out from Fauntleroy Cove on two occasions (WSDOH, 1991). During the beach odor investigations, repair of sewer line leaks and correction of illicit connections may have contributed to the declining bacteria trend in Fauntleroy Creek. Furthermore, a heightened public awareness about sources of fecal contamination may have led to improved residential pet waste management.

While bacteria levels in Fauntleroy Creek have dramatically improved since the late 1980s, annual bacteria concentrations still violate both the geometric mean and 90th percentile water quality standard criteria for extraordinary primary contact (Figure 7). It is noteworthy that 2006 annual geometric mean was the lowest in recent years.

Despite an eight-year gap in monitoring Fauntleroy Creek, the historical sub-dataset (1990-1996) and recent data (2004-2006) follow a similar seasonal pattern in bacteria concentrations. Seasonal bacteria levels begin to decline in October, the start of the wet season, and rise in May, at the start of the dry season. These two comparable datasets were compiled and analyzed together to show seasonal bacteria patterns in Fauntleroy Creek. As shown in Figure 8, the greatest peak in bacteria concentrations typically occurs in August and the lowest concentrations occur in April.

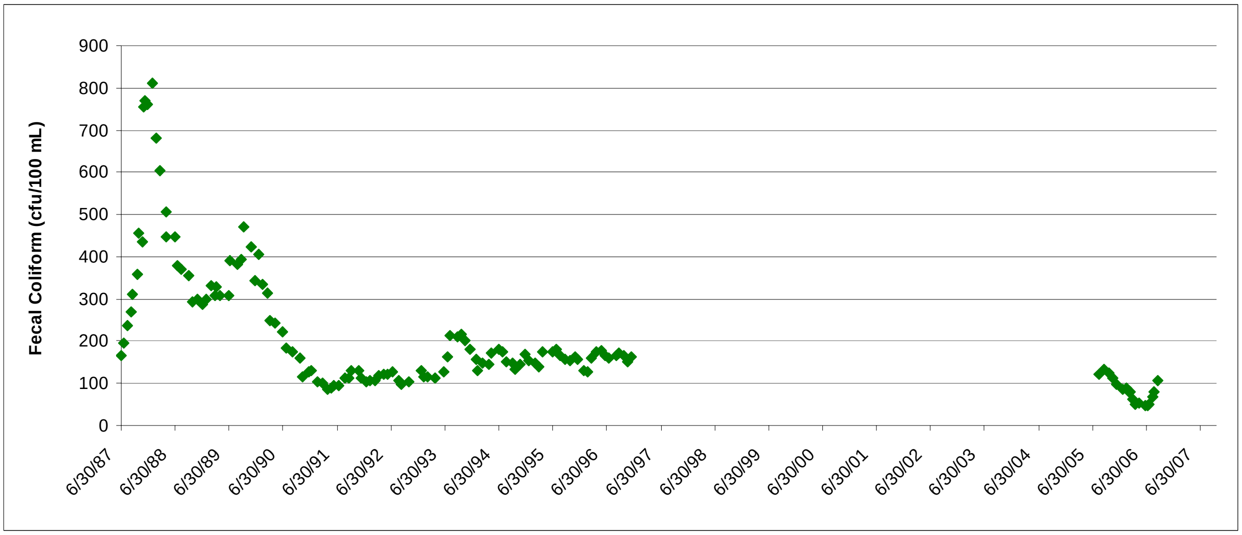

Figure 6. Long-term trend (12-sample moving geometric mean) of bacteria concentrations in Fauntleroy Creek (1987-1996; 2004-2006).

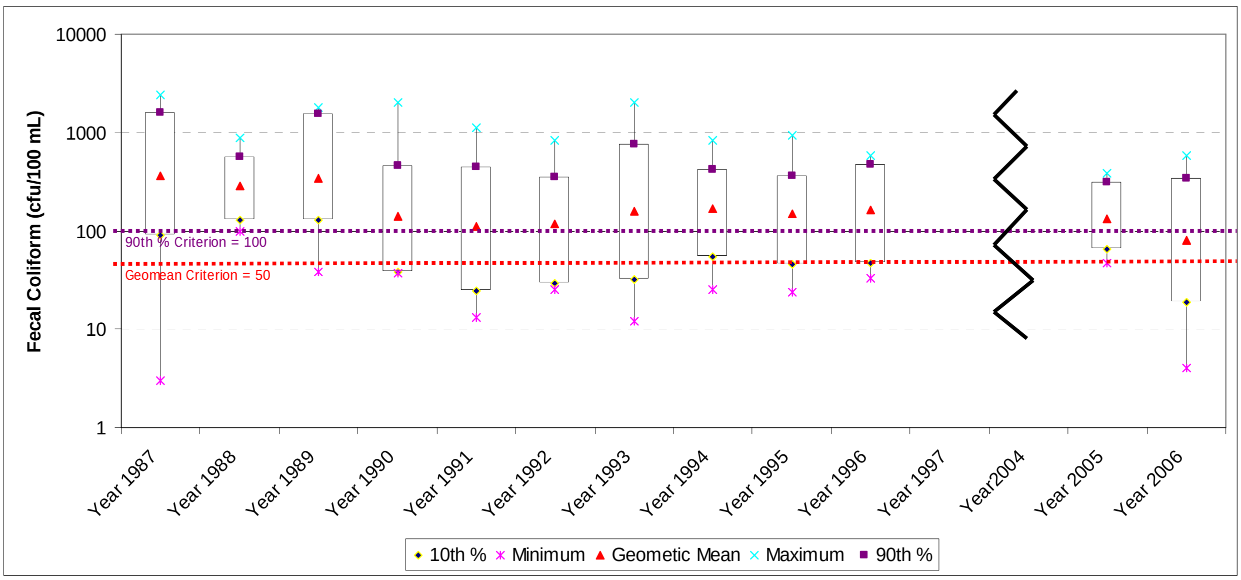

Figure 7. Annual bacteria trend in Fauntleroy Creek since 1987 (King County data 1987-1996 and Ecology data 2004-2006).

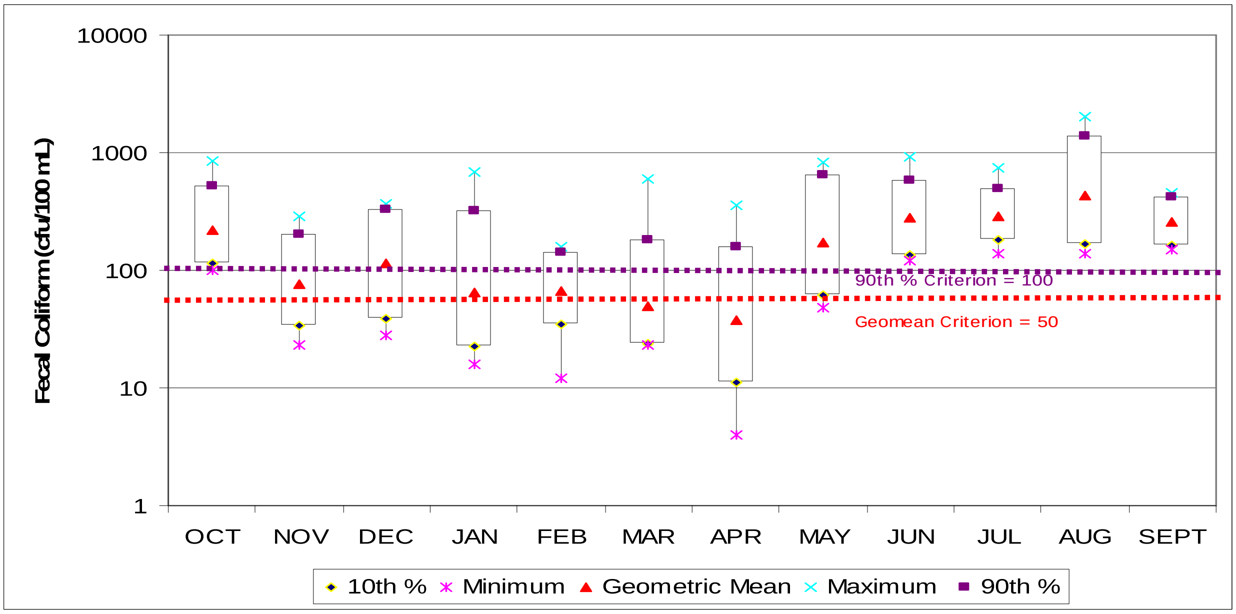

Figure 8. Seasonal pattern in monthly bacteria concentrations in Fauntleroy Creek (King County data 1990-1996 and Ecology data 2004-2006).

Current conditions, seasonal variation, and target reductions

Long-term data indicate water quality in Fauntleroy Creek has improved since the late 1980s. To assess the current bacteria conditions in the creek, Ecology compiled and analyzed recent data from 2004 to 2006.

Average yearly rainfall in the Fauntleroy area based on Sea-Tac weather record from 1987 to 2006 is 37 inches and the lowest rainfall period is between May and September (Figure 4). Figure 9 show general patterns in the relationship between water quality and estimated flow in Fauntleroy Creek. Bacteria conditions in Fauntleroy Creek show some seasonal variation:

- More than half the monthly samples collected from Fauntleroy Creek were over the 90th percentile criterion of 100 cfu/100mL. A majority of these excursions occurred during the dry season when concentrations of bacteria were highest. However, total loadings of bacteria would be expected to be greater in the wet season when there is a larger volume of stormwater runoff transporting bacteria into waterways.

- During the dry months when stream flows are usually low, bacteria levels greatly exceed both water quality standards criteria. During 2004 to 2006, the average dry season bacteria concentration was generally five times higher than in the average wet season. One potential explanation is that higher flows during the wet season are likely to be diluting bacteria concentrations. During the wet season, Fauntleroy Creek is close to meeting the geometric mean standard, but not close to meeting the 90th percentile criterion (Table 3).

Fauntleroy Creek consistently violates water quality standards during all seasons, especially during the drier months of May through September (Figure 10). On an annual basis, the bacteria levels in the creek exceed both parts of the water quality standards criteria (Table 3). Based on available water quality data, the critical period for this TMDL appears to be during the summer months when the exceedances are more frequent and recreational use in the creek basin is likely to increase (Table 3). This assessment is limited by the lack of specific storm event sampling and long-term flow data in the creek.

Seasonally and annually, meeting the 90^{th} percentile criterion is tougher, and therefore more restrictive, than meeting the geometric mean value criterion (Table 3). To meet standards during the critical period, it will take an 80 percent reduction in current bacteria loadings from all sources to the creek. Since best management practices are expected to be the same year round, the Fauntleroy Creek bacteria TMDL applies year round. The target percent reduction of 80 percent indicates the level of effort needed for the creek to meet water quality standards on an annual and seasonal basis.

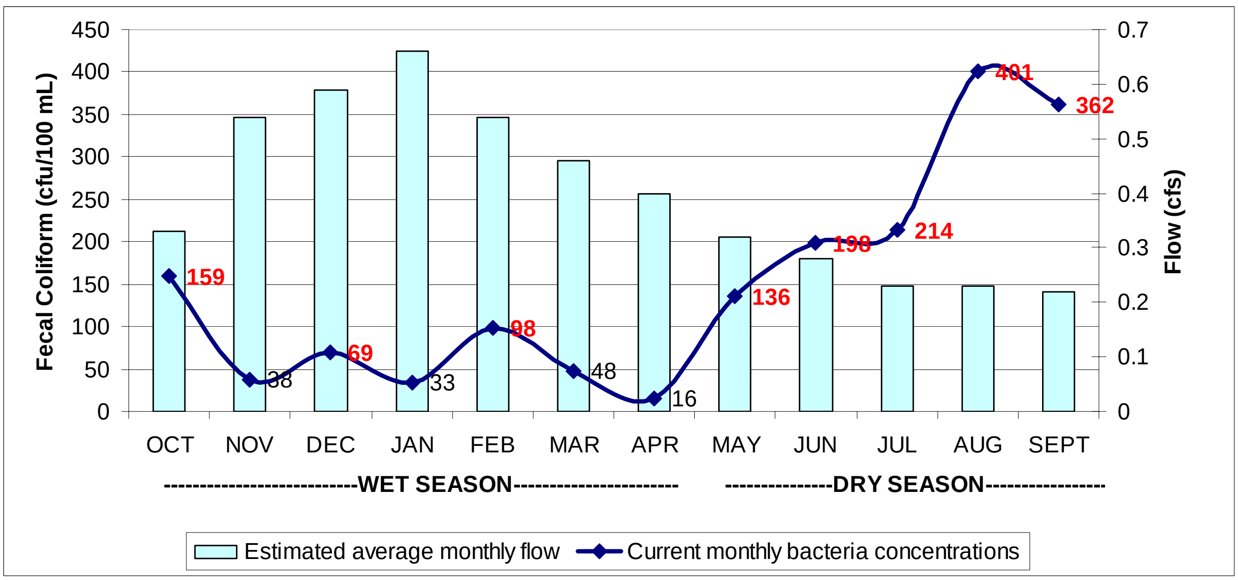

Figure 9. Comparison of the geometric means of current monthly bacteria concentrations and estimated average monthly flows in Fauntleroy Creek. Bold numbers indicate bacteria levels are above the water quality geometric mean standard of 50 cfu/100 mL.

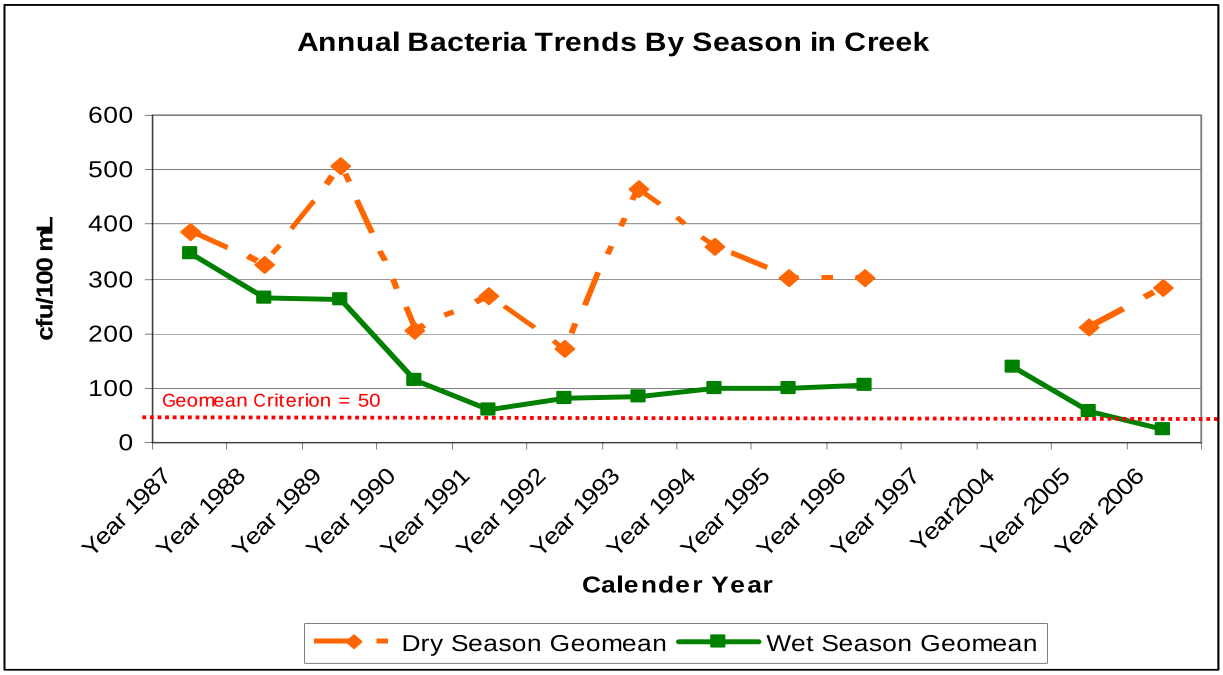

Figure 10. Annual bacteria trends by season in Fauntleroy Creek.

Table 3. Current water quality conditions and target bacteria reductions in Fauntleroy Creek. GMV is the geometric mean value of sample population. The 90th percentile is the threshold of the upper ten percent of the sample population. Bold numbers indicate violation in standards.

Fauntleroy Creek Near Mouth (Ecology Station 09K070)	Water Quality Standard		Current Conditions		Target Percent Reductions	
	GMV	90th %tile	GMV	90th %tile	GMV	90th %tile
Dry Season (May 1 – Sept. 30)	50	100	**250**	**497**	80%	80%
Wet Season (Oct 1 – April 30)	50	100	**52**	**192**	3.4%	48%
Annual	50	100	**99**	**437**	50%	77%

* Target Percent Reduction = [Current Conditions – Water Quality Standard] ÷ Current Conditions

TMDL Analysis

The purpose of the TMDL analysis is to establish bacteria discharge limits for sources in the present-day drainage basin to Fauntleroy Creek (study area).

So far in this report, the study evaluated the current bacteria conditions in Fauntleroy Creek and determined an 80 percent reduction in bacteria loading will bring the creek to state water quality standards. The study also demonstrated a pattern of seasonal variation in bacteria levels in the creek.

The final steps in the analysis section of this report are to:

1. Determine how much bacteria pollution the creek can absorb and still meet standards. (Estimated Loading Capacity)
2. Estimate how much each source can contribute to the bacteria loading capacity. (Estimated Load and Wasteload Allocations)

The study determines the amount of a given pollutant that can be discharged to a water body and still meet water quality standards. The total amount of allowable pollutant is called the loading capacity, and TMDLs allocate that load among the various sources within the watershed. If the pollutant comes from a discrete (point) source, its share of the loading capacity is referred to as a wasteload allocation. If the pollutant comes from a diffuse (nonpoint) source, then its share of the loading capacity is referred to as a load allocation. All sources that receive coverage under a permit issued pursuant to the National Pollution Discharge Elimination System (NPDES) are by definition point sources.

Appendix F describes the analytical framework for the TMDL in greater detail.

TMDL analysis results

Land-use analysis

The present-day drainage basin to Fauntleroy Creek is primarily residential. Runoff from residential land use, including local roads, is estimated to contribute the most to total stormwater bacteria loadings in the creek. Highly concentrated stormwater bacteria loads and moderate amount of impervious cover characterize residential land use (Appendix F, Table 12). In this analysis, residential land use is the only category which contributes to both point and nonpoint sources of stormwater bacteria loads.

Estimated loading capacity

Table 4 summarizes the estimated current loading and total loading capacity of bacteria for Fauntleroy Creek on an annual basis. Based on an estimated annual flow average of 0.40 cfs and a geometric mean standard of 50 cfu/100 mL, Fauntleroy Creek can receive about 179 billion bacteria colonies per year (or 489 million bacteria colonies per day) and still meet state water quality standards. This is the *estimated loading capacity* for bacteria in Fauntleroy Creek.

Under current annual conditions (geometric mean of 99 cfu/100 mL), the creek receives about 354 billion bacteria colonies per year -- exceeding the annual loading capacity. To meet the more restrictive 90^{th} percentile criterion, the creek requires an 80 percent reduction in current annual bacteria loading from all sources (Table 3). Compliance with the TMDL is based on the state water quality geometric mean of 50 cfu/100 mL with no more than 10 percent of the samples exceeding 100 cfu/100 mL.

During the current dry season (estimated flow average of 0.26 cfs), the creek receives about 243 billion bacteria colonies per dry season. Whereas, during the wet season (estimated flow average of 0.50 cfs), the creek receives about 135 billion bacteria colonies per wet season.

Although current bacteria concentrations are higher during the critical dry season, the same sources present in the dry season can contribute to bacteria loadings in the creek year round. Potential sources include domestic wastewater/sewage, domestic pet waste, wildlife (including avian) waste, and decaying organic matter.

Estimated load and wasteload allocations

This study recommends general load allocations (LA) for nonpoint sources and specific wasteload allocations (WLA) for the municipal stormwater permit holder, the city of Seattle, based on the estimated annual loading capacity. Ecology established allocations by taking into account the water quality monitoring data, land use information, and precipitation data. Relative annual allocations (expressed as percentages and estimated loadings) were established for all identified sources of bacteria to Fauntleroy Creek (Table 4).

Ecology recognizes the difficulty of characterizing the highly variable frequency and duration of bacteria loads in stormwater. Numeric effluent limits for municipal stormwater discharges are not often feasible or appropriate when determining stormwater discharge effluent limits in NPDES permits that are consistent with TMDLs. Therefore, best management practices (BMPs) are considered the appropriate form of effluent limits in permits for control of pollutants in stormwater (Wayland and Hanlon, 2002).

Ecology also recognizes that the analysis in this report is based on limited existing flow data and represents a first step to estimate fecal coliform bacteria conditions in Fauntleroy Creek.

Ecology anticipates that if pollutant source control strategies prove unsuccessful, further data collection and analysis of loading and sources to Fauntleroy Creek may be necessary. That effort would provide additional information that could be used to improve on the accuracy of the load estimates if necessary.

Table 4. Estimated loadings of bacteria in Fauntleroy Creek

	Annual Bacteria Loads (cfu/year)	**Maximum Daily Bacteria Loads** (cfu/day)	**Relative Allocations** (%)
ESTIMATED TOTAL CURRENT LOADINGS	354 billion	--	--
ESTIMATED TOTAL LOADING CAPACITY	179 billion	489 million	--
Seattle Stormwater Point Sources (WLA)	124 billion	339 million	69%
Nonpoint Sources (LA)	37.1 billion	102 million	21%
Margin of Safety	17.9 billion	48.9 million	10%

Margin of safety

Ecology takes a very conservative approach to estimate bacteria loadings where reliable monitoring and accurate long-term flow data are not yet available. The lack of long-term flow data for Fauntleroy Creek and assumptions used in the allocation setting add uncertainty to the TMDL analyses. In addition, the simplifications in the Simple Method Model may lead to uncertainty in the estimates of relative allocations.

Bacteria concentrations in surface water conditions tend to show more variation than other water quality parameters. During storms, bacteria counts tend to be high. Because the TMDL is based on estimates of annual bacteria loads in billions per year, it is not able to capture some of the critical episodic events. Consequently, the Simple Method Model is best used to estimate the relative contribution of each source to stormwater bacteria loads.

TMDLs account for uncertainty using a margin of safety (MOS) to ensure that load and wasteload allocations remain protective of water quality. This TMDL provides an explicit MOS for the estimates used for Fauntleroy Creek by reserving 10 percent of the available bacteria loading capacity for the MOS during the year.

In the loading analysis, Ecology made a conservative assumption (worst-case scenario) that the bacteria flowing from upper reaches will not die-off before impact downstream segments. In other words, all bacteria entering the creek from tributaries or pollution sources will stay active and suspended in the water column to the mouth of the creek.

Implementation Strategy

Introduction

This implementation strategy summarizes potential actions to improve water quality. It describes the roles and authorities of cleanup partners (that is, those organizations with jurisdiction, authority, or direct responsibility for cleanup) and the programs or other means through which they will address these water quality issues.

After the U.S. Environmental Protection Agency (EPA) approves this report, interested and responsible parties will work together to develop a Water Quality Implementation Plan. The plan will describe and prioritize specific actions planned to improve water quality and achieve water quality standards.

As defined in this report, the implementation area for this TMDL is the historical drainage basin to Fauntleroy Creek (Figure 1). The recommended actions for this TMDL will apply within this implementation area.

For over a decade, Fauntleroy Creek watershed citizens worked with city of Seattle and other partners to accomplish many projects in watershed awareness, habitat restoration, salmon restoration, education, habitat advocacy, and water-quality monitoring. The following are examples of their collaborative efforts in preserving, enhancing, and maintaining the natural ecosystem of Fauntleroy Creek watershed:

- In 1998, the city completed a culvert/fishway project in time to welcome home an estimated 200 Coho.
- In 2001, the city installed signs for park hours and the "Scoop Law."
- In 2002, the city and EarthCorps improved existing trails and closed rogue trails to reduce direct runoff into the creek from trails.
- In 2003-2004, students of KapKa Cooperative Primary School investigated pet waste in Fauntleroy Park and created pet waste stations with bag dispensers made from upside-down milk jugs and filled with used plastic grocery bags.

The Water Quality Implementation Plan as outlined in this summary implementation strategy will build upon the existing efforts by the active partners.

What needs to be done?

Table 5 shows a summary of implementation actions and parties likely to play a critical role in correcting sources of fecal coliform bacteria in the implementation area. Ecology will discuss these and related activities with the key parties and will refine this list of implementation actions during the implementation planning process. Agreements or commitments to implement specific actions will be documented in the Water Quality Implementation Plan.

Table 5. Summary of actions and key parties in the implementation area

Recommended Actions	Key Parties	Possible Timeframe
Source Tracking		
Increase understanding of land uses in the implementation area	Ecology, Seattle, Fauntleroy Watershed Council	2007-2008
Investigation and repair of possible sewer leaks	Seattle, Public Health-Seattle and King County, Property owners	2007-2010
Illicit discharge identification and elimination	Property owners, Seattle	2007-2010
Bacteria source detection monitoring	Seattle, Ecology	2007-2010
Source Controls		
Stormwater source control BMPs	Property owners, Seattle	2007-2013
Riparian re-vegetation projects	Property owners, Seattle, Fauntleroy Watershed Council, volunteers	2007-2013
Increasing Public Awareness		
Public outreach	Seattle, Fauntleroy Watershed Council, Washington State Ferries, Public Health-Seattle and King County	2007-2013
Watershed stewardship education	Seattle, Fauntleroy Watershed Council	2007-2013
Monitoring		
In-stream water quality & flow monitoring	King County, Ecology	2007-2013

Source tracking

An increased understanding of the area and land use draining to the implementation area will help define other actions. Additional information to be gathered may include specific land use and business types within the implementation area.

Investigation and repair of possible sewer leaks involve responding immediately and appropriately to sewer leaks by responsible parties.

Illicit discharge identification and elimination to the stormwater drainage system. There are several methods available to detect and eliminate illicit discharges and connections including outfall surveys to help identify dry weather flows. Many elements in the NPDES Municipal Stormwater Permit increase the city of Seattle's responsibilities to detect and eliminate possible illicit discharges and connections.

Bacteria source detection monitoring is targeted water quality monitoring to identify specific sources of bacteria pollution. It allows partners to focus Best Management Practice (BMP) resources where they are needed most.

Source controls

Stormwater source control BMPs may include structural treatment practices, where feasible, and stormwater control programs that address urban bacteria source control and stormwater treatment.

Riparian re-vegetation can be considered a subset of stormwater source control BMPs. Restoration of native riparian vegetation using stream buffers enhances water quality and habitat. Adequately sized and healthy riparian buffers help filter out a variety of pollutants including fecal coliform bacteria.

Increasing public awareness

Public awareness programs are a non-structural subset of stormwater source control BMPs.

Public outreach involves developing and disseminating educational materials (such as pamphlets, mailers, and signage) about local water pollution problems and solutions. Information could promote proper management of domestic pet waste, restricting feeding waterfowls, and reducing illicit discharges into storm sewers.

Watershed stewardship education involves opportunities for citizens to learn about the values and benefits of protecting Fauntleroy Creek from water quality degradation. Activities could include targeting riparian neighbors with tailored information that emphasize erosion control and creek stewardship and targeting students to engage in scientific discovery of the watershed.

Monitoring

Monitoring is needed during all phases of the TMDL implementation to identify polluted areas, contributing sources, and to verify that corrective actions have been and remain appropriate in protecting local waters.

Bacteria source detection monitoring is described under "Source Tracking".

Effectiveness monitoring of the receiving water body indicates whether the implementation plan is effective in reducing bacteria levels. There are two types of effectiveness monitoring: ambient monitoring and compliance monitoring. *Ambient monitoring* is done prior to a water body meeting water quality standards. *Compliance monitoring* is done after a water body is believed to meet state water quality standards to ensure standards continue to be met. *Flow monitoring* in Fauntleroy Creek will also be needed to assess the seasonal streamflow pattern in the creek and determine bacteria loadings in the creek.

Who needs to participate?

The following government agencies, citizen groups, and tribes have regulatory authority influence, information, resources or other involvement in activities to protect and restore the health of Fauntleroy Creek.

Federal, tribal, state, and county entities

U.S. Environmental Protection Agency

The 1997 Memorandum of Agreement between the Environmental Protection Agency, Region 10 and Ecology requires that EPA and Ecology jointly evaluate the implementation of TMDLs in Washington. These evaluations will address whether interim targets are being met, whether implementation measures such as BMPs have been put into effect, and whether NPDES permits are consistent with TMDL wasteload allocations.

EPA provides technical assistance and funding to states and tribes to implement the Clean Water Act (CWA). For example, EPA's CWA Section 319 grants, combined with Ecology's grant and loan funds, are made available to stakeholders through Ecology's annual Water Quality Grant and Loan Process. On occasion, the EPA also has other grant monies available (104(b)(3)) to address storm water pollution problems.

Washington State Department of Ecology

Ecology has been delegated authority by the EPA to implement many aspects of the federal Clean Water Act. These include the National Pollution Discharge Elimination System (NPDES) permitting and the Total Maximum Daily Load (TMDL) program. The Green/Duwamish watershed (WRIA 9) is under the jurisdiction of Ecology's Northwest Regional Office (NWRO). To address the municipal permitting needs of this TMDL, the NWRO has one municipal stormwater engineer and one municipal stormwater specialist who provide technical assistance and auditing activities for the Phase I municipal stormwater permits across the region. Ecology's headquarters also has several staff that can help identify and distribute education and outreach materials to stormwater permit holders.

Ecology has a Water Quality Improvement Lead assigned to the implementation of the Fauntleroy Creek TMDL who will assist the stormwater permit holder and other environmental agencies and groups. The NWRO also has a water quality monitoring specialist who is available to provide assistance in the development of ambient monitoring and source identification monitoring projects. Ecology's Environmental Assessment Program will assist in effectiveness monitoring as the TMDL is implemented.

Ecology also helps local governments with funding for water quality facilities and activities through the Centennial Clean Water Fund, 319 Fund and State Revolving Loan Fund. The full range of Ecology funding opportunities is discussed under the section "Funding Opportunities." Ecology's Grant Specialists assist local government in the development of stream restoration and water quality improvement projects.

Ecology will be responsible for organizing meetings of stakeholders' workgroup no less than annually and will lead additional meetings as requested by the workgroup.

Washington State Ferries

The Washington State Ferries (WSF) system has operated the Fauntleroy Vashon Ferry Terminal since 1951. It was expanded in 1984 and underwent a major refurbishment in 2002. WSF's mission is to provide safe, secure, reliable, and environmentally sound marine transportation for people and goods. WSF currently possesses a comprehensive Safety Management System (SMS) that incorporates policies and procedures for the safety, security, emergency preparedness, and environmental protection programs. WSF is in the process of more fully integrating environmental management into their SMS.

The Fauntleroy Vashon Ferry Terminal is prominently located near the Fauntleroy Creek watershed. WSF will be a valuable partner in helping to increase public awareness about improving water quality in Fauntleroy Creek.

Puget Sound Action Team (Puget Sound Partnership)

The Puget Sound Action Team (Action Team) soon to become Puget Sound Partnership works to restore and protect the biological health and diversity of Puget Sound by protecting and enhancing Puget Sound's water and sediment quality; its fish and shellfish; and its wetlands and other habitats. The Action Team works with tribal and local governments, community groups, citizens and businesses, and state and federal agencies to develop and carry out two-year work plans that outline measurable actions, as well as expected results to improve the water quality and habitats for fish, marine animals and other aquatic life in Puget Sound.

The Action Team has a Public Information and Education program, which can provide funding to qualified local governments to educate the public on bacteria pollution problems in the implementation area and the Action Team has provided important leadership promoting Low Impact Development (LID), an innovative approach to new development and redevelopment to prevent and better manage stormwater runoff.

Effective July 1, 2007, Puget Sound Partnership will replace the Action Team to coordinate regional efforts to protect and restore Puget Sound. The structure of the Partnership includes a leadership council, ecosystem board, science panel, executive director and staff. The work of the new organization will include the development of a 2020 action agenda, outlining approaches, actions and targets addressing habitat protection, toxic contamination, pathogen and nutrient pollution, stormwater runoff, water supply, ecosystem biodiversity, species recovery, and capacity for action. The 2007-09 work plan will continue to be implemented as the new action agenda takes shape.

Muckleshoot Indian Tribe

The ancestors of the present day Muckleshoot Indian Tribe had usual and accustomed fishing places primarily at locations on the upper Puyallup, Carbon, Stuck, White, Green, Cedar, and Black Rivers, including tributaries. Drainage area to Fauntleroy Creek is part of the Green-Duwamish watershed, and thus the Tribe has an interest in the area. The Tribe consists of the descendents of the area’s original Coast Salish peoples. The Tribe has always regarded salmon, which were more abundant in area streams, with great reverence. Today the Muckleshoot Indian Tribe has an active resource protection staff and may assist in stream restoration and water quality improvement efforts.

King County

King County provides regional services throughout both incorporated and un-incorporated areas. These services include sewage treatment, land-use regulations, stormwater management, and water quality monitoring. King County has monitored water quality in local lakes, rivers, and streams for over 30 years and this investigation furthers King County's interests in maintaining and enhancing regional water quality. King County has also been actively monitoring the water quality in Fauntleroy Cove since 1997. The Water and Land Resources Division of King County's Department of Natural Resources and Parks is involved in watershed stewardship, stormwater compliance, and water quality monitoring throughout King County.

Cities and towns

City of Seattle

The city of Seattle has been very active in watershed protection, stream restoration, and water quality improvement. With the largest population in Washington State, the city of Seattle faces many of the challenges associated with urban stormwater runoff. The city of Seattle has expanded the level of stormwater management beyond flood control and human health risks, to embrace actions that aim to improve overall surface water quality and enhance aquatic habitats.

Seattle Public Utilities (SPU) is the designated lead department for managing stormwater, including meeting stormwater regulatory requirements, conducting water quality programs, and managing major drainage-related capital projects. SPU is the lead city department for development of the Fauntleroy TMDL and is coordinating the input of other city departments including Seattle Parks and Recreation (Parks), Seattle Department of Transportation, and Seattle Department of Planning and Development.

Nonprofit and volunteer organizations

Fauntleroy Watershed Council

Guided by the Fauntleroy Watershed Action Plan and in cooperation with agency partners, the Fauntleroy Watershed Council has since 2001 been providing a venue for citizens and agency staff to advance restoration and stewardship goals for Fauntleroy Park and the Fauntleroy Creek system.

Local Citizens

Local citizens play a critical role in improving the water quality of Fauntleroy Creek. Many citizens can have an immediate impact on local water quality by doing certain tasks differently. By properly disposing of pet wastes and avoiding the addition of grass clippings or any other foreign substance into neighboring creeks, the bacteria levels can be reduced. Local citizens can also get involved in stream rehabilitation, communicate their interest in the environment to local elected officials, and educate others on how to improve water quality in Fauntleroy Creek.

Property owners can take it upon themselves to minimize runoff of nonpoint sources of pollution from their yards, repair of leaky side-sewers, and enhance streamside riparian vegetation.

Local Businesses

Ecology plans on working with partners to help educate local businesses on actions they can take to prevent bacteria pollution their activities may generate. Local businesses in turn can be partners in increasing public awareness on the local water quality issues in Fauntleroy Creek.

What is the schedule for achieving water quality standards?

The progress of the Water Quality Implementation Plan will be measured by (1) assessing the pollution control activities underway or completed; and (2) direct measurement of water quality. The goal is for Fauntleroy Creek to consistently meet the Washington State Water Quality Standards for bacteria. Ecology anticipates that if state and local coordination proceed as expected, compliance with the extraordinary primary contact recreation standard for Fauntleroy Creek is anticipated by June 2013.

Reasonable assurance

When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint sources) in the water body. For Fauntleroy Creek fecal coliform bacteria TMDL, both point and nonpoint sources exist in the present-day creek drainage basin. Sources also exist in the larger historical drainage basin to Fauntleroy Creek and will be addressed in the Water Quality Implementation Plan. TMDLs (and related action plans) must show "reasonable assurance" that these sources will be reduced to their allocated amount. Education, outreach, technical and financial assistance, permit administration, and enforcement will all be used to ensure that the goals of the plan are met.

Ecology believes that the following activities already support this TMDL and add to the assurance that bacteria in Fauntleroy Creek will meet conditions provided by Washington State water quality standards. This assumes that the activities described below are continued and maintained.

The primary goal of the Fauntleroy Creek Water Quality Implementation Plan for fecal coliform bacteria is to help Fauntleroy Creek meet the state's water quality standards. There is considerable interest and local involvement toward resolving the water quality problems in Fauntleroy Creek. Numerous organizations and agencies are already engaged in stream restoration and source correction actions that will help resolve the bacteria problem. The following rationale helps provide reasonable assurance that Fauntleroy Creek TMDL goals will be met by 2013.

- Effective on February 16, 2007, city of Seattle was required to implement their new NPDES Phase I Municipal Stormwater Permit. Under the city's Stormwater Management Program, as approved by Ecology on July 24, 1997, Seattle is implementing programs such as the Drainage System Inspection Program, the Mutt Mitt Program (targeting pet waste), and Urban Creeks and Watershed Stewardship Program (public education).

- The city of Seattle has legal authority to control discharges to Seattle's storm drainage systems. The city of Seattle's Stormwater, Grading and Drainage Control Code (SMC 22.800) prohibits illicit discharges from being introduced into the city's municipal storm sewer system. As part of the city's Stormwater Business Inspection and Complaint Investigation Programs, Environmental Compliance Inspectors inspect

Seattle businesses to ensure that stormwater best management practices are being implemented and conduct investigation based on citizen complaints related to stormwater pollution.

- According to Seattle's 2004 Comprehensive Drainage Plan, Seattle Public Utilities (SPU) plans to expand water quality monitoring activities and continue to focus on controlling pollution at the source. Seattle also plans to have an increased focus on improving and protecting habitat conditions along creeks and affected shorelines and fostering awareness and stewardship of natural systems and aquatic habitats through outreach, education, and partnerships.

- Fauntleroy Watershed Council will continue to implement their Fauntleroy Watershed Action Plan (2002) that details activities involved in stewardship and education, vegetation management, upland and in-stream erosion, trails and signage, and maintenance and safety.

- With funding from Ecology's Coastal Zone Protection Fund, King County's Community Salmon Fund, and the city of Seattle's Aquatic Habitat Matching Grants program, the Fauntleroy Watershed Council and property owners are starting the Reach to the Beach Project (2005 - ongoing) to enhance the stream and riparian corridor in the lower 200 feet of Fauntleroy Creek near the mouth. An objective of the project is to improve water quality by eliminating the grass that extends up to the stream bank. This will reduce the feeding areas for shorebirds and keep their waste farther from the water. Furthermore, increasing plantings along the riparian area will help filter stormwater runoff. In addition, the project will utilize public exposure of the site to maximize general education and awareness of water and habitat stewardship in urban watersheds.

While Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards, it is the goal of all participants in the Fauntleroy Creek TMDL process to achieve clean water through voluntary control actions. Ecology will consider and issue notices of noncompliance, in accordance with the Regulatory Reform Act, in situations where the cause or contribution to the cause of noncompliance with load or wasteload allocations can be established.

Adaptive management

Compliance with state water quality standards should be achieved by 2013. The Water Quality Implementation Plan can identify interim targets. These targets will be described in terms of concentrations and/or loads, as well as in terms of implemented cleanup actions. Partners will work together to monitor progress towards these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the cleanup strategy as needed.

It is ultimately Ecology's responsibility to assure that cleanup is being actively pursued and state water quality standards are achieved.

The Water Quality Implementation Plan will use an adaptive management approach to ensure the progress and overall success of this plan. Opportunities for adaptive management of the plan include conducting special inspections in identified source areas, evaluating effectiveness of Best Management Practices (BMPs), modifying stream sampling frequency and/or locations, helping develop and fund water quality projects that address fecal coliform pollution, administering local educational initiatives, and other means of conforming management measures to current information on the bacteria problem.

As bacteria source control measures and activities from the Water Quality Implementation Plan are successfully completed, those activities will be documented along with expected improvements in water quality. If the planned activities are not effective, the implementation activities as set out in this plan will be reexamined and modified as part of the adaptive management process. The results of ambient water quality monitoring will play a key role in determining the effectiveness of the plan. If new fecal coliform sources are found that were not previously identified, they will be corrected through appropriate responsible parties.

Monitoring progress

In order to gauge the progress of this TMDL implementation, Ecology will convene a meeting of municipal stakeholders no less than annually to share information on the state of water quality in Fauntleroy Creek and status of implementation activities. Water quality data, trends (where applicable), regulatory changes, new and innovative concepts, and funding sources will be discussed to evaluate the overall status of the TMDL. Ecology will solicit input from the workgroup at this time to help direct the adaptive management of this TMDL. Ecology will track implementation no less than annually using a tracking table to be developed in the Water Quality Implementation Plan.

Ecology will continue to offer grant funding for water quality studies, stream restoration projects, BMP effectiveness evaluations, and for the development and implementation of monitoring programs through its annual Centennial Clean Water Fund.

The Water Quality Implementation Plan will describe the coordinated monitoring strategy. Compliance monitoring will be needed when water quality standards are believed to be achieved. Entities with enforcement authority are responsible for following up on any enforcement actions. Stormwater permit holders are responsible for meeting the requirements of their permits. Those conducting restoration projects or installing best management practices (BMPs) are responsible for monitoring plant survival rates and maintenance of improvements, structures and fencing.

Potential funding sources

Table 6 describes several possible funding sources that may be available to implement activities necessary to correct bacteria problems in Fauntleroy Creek. Ecology will work with stakeholders to prepare appropriate scopes of work, to assist with applying for grant opportunities as they arise, and to help in other ways to implement the TMDL.

Table 6. Possible funding sources to support implementation.

Sponsoring Entity	Funding Source	Uses to be Made of Funds
Department of Ecology, Water Quality Program	Clean Water Fund, Section 319, and State Revolving Fund http://www.ecy.wa.gov/programs/wq/funding	▪ Implementation, design, acquisition, construction, and improvement of water pollution control ▪ Facilities and water pollution control related activities ▪ Priorities include: implementing TMDL plans, keeping pollution out of streams and aquifers, modernizing aging wastewater treatment facilities, reclaiming and reusing waste water.
Department of Ecology, SEA Program	Coastal Zone Protection Fund	Discretionary monies made available to regional Ecology offices to support on-the-ground projects to perform environmental restoration and enhancement.
Puget Sound Action Team	Public Involvement and Education Grants http://www.psat.wa.gov/Programs/Funding.htm	Project priorities include: reduce harmful impacts from stormwater, prevent contamination from public/private sewer systems and other nonpoint sources.
King County	King County Grant Exchange, including six grant programs http://dnr.metrokc.gov/grants/	Restoration, water quality improvement, education projects

Summary of public involvement methods

Ecology communicated with the public in several ways. Beginning in November 2006, Ecology staff met with key parties to share information on the TMDL study and set goals for restoring Fauntleroy Creek to good health. A public comment period provided opportunities for reviewing the draft Water Quality Improvement Report and ran from May 11 to June 11, 2007. The public comment period allowed time to solicit public input and feedback on the proposed final draft report. A public meeting was held on May 22, 2007, from 6:30-7:45 p.m. at the Southwest Branch Public Library in the Fauntleroy community.

Appendix B records the public notice methods and Ecology's responses to public comments. The meeting announcement and focus sheet on Fauntleroy Creek TMDL are included.

Next steps

Once EPA approves the TMDL, a water quality implementation plan must be developed within one year. Ecology will work with local government, businesses, and the public to create this plan, choosing the combination of possible solutions they think will be most effective in the implementation area. Elements of this plan include:

- Who will commit to do what.
- How to determine if the implementation plan works.
- What to do if the implementation plan doesn't work.
- Potential funding sources.

Conclusions

Water quality in Fauntleroy Creek has improved since the early years of long-term monitoring. Despite the improved conditions, recent data indicate Fauntleroy Creek still violates freshwater standards during all seasons.

Based on 2004 to 2006 data, bacteria concentrations in Fauntleroy Creek exhibited seasonal variation. The bacteria concentrations in the dry season were about five times higher than in the wet season. Storm events (which primarily occur in the wet season) can contribute to temporarily high bacteria loadings. Since potential sources could be present year round, the TMDL for Fauntleroy Creek applies year round.

A TMDL is a tool to estimate the relative magnitude of various pollutant sources. The Simple Method Model estimated the magnitude of pollution loading from various land uses, and provided a starting point for management recommendations and more detailed information gathering.

Based on an estimated annual average flow of 0.40 cfs, Fauntleroy Creek can receive about 179 billion bacteria colonies per year (or 489 million bacteria colonies per day) and still meet standards. Under current conditions, the creek has an annual bacteria concentration of 99 cfu/100 mL. It receives about 354 billion bacteria colonies per year from all sources, which exceeds the estimated total loading capacity. To meet the more stringent 90^{th} percentile criterion, it will take an 80 percent reduction in current bacteria loadings from all sources to the creek. Compliance of the TMDL is based on the creek meeting the state water quality geometric mean of 50 cfu/100 mL with no more than 10 percent of the samples exceeding 100 cfu/100 mL.

To reduce current pollutant loadings to the creek and fully support all beneficial uses, this TMDL recommends a wasteload allocation of 69 percent of the total annual bacteria loading capacity in Fauntleroy Creek to Seattle stormwater point sources, 21 percent to nonpoint sources, and a 10 percent for margin of safety. Implementation of this TMDL will involve bacteria source tracking, source controls, increasing public awareness, and monitoring. Provided the elements of the implementation strategy are done on schedule, Fauntleroy Creek is expected to meet water quality standards for bacteria by 2013.

Implementing the Fauntleroy Creek TMDL has the potential to improve water quality in Fauntleroy Cove as well. In 2004, Ecology listed Fauntleroy Cove as impaired for fecal coliform bacteria. In recent years the cove has been closer to meeting water quality standards for bacteria, and past studies indicate that Fauntleroy Creek is contributing to the bacteria problem in Fauntleroy Cove (Appendix G). Thus, improvements in creek bacteria levels may help Fauntleroy Cove meet water quality standards for bacteria. After implementation has taken effect, Ecology recommends future monitoring of Fauntleroy Cove for bacteria.

References

APHA, AWWA, and WEF, 1998. Standard Methods for the Examination of Water and Wastewater 20th Edition. American Public Health Association, Washington, DC.

Cappiella, K. and K. Brown, 2000. Derivations of Impervious Cover for Suburban Land Uses in the Chesapeake Bay Watershed. Prepared for the U.S. EPA Chesapeake Bay Program. Center for Watershed Protection, Ellicott City, MD.

CWP (Center for Watershed Protection), 2001. The Watershed Treatment Model. Center for Watershed Protection, Ellicott City, MD.
http://www.cwp.org/PublicationStore/TechResearch.htm

Code of Federal Regulations, Title 40, 7/1/02 version. Protection of the Environment, Part 122. EPA Administered Programs: National Pollutant Discharge Elimination System.
http://www.gpoaccess.gov/cfr/index.html

EPA, 2001. Overview of Current Total Maximum Daily Load - TMDL - Program and Regulations. U.S. Environmental Protection Agency.
www.epa.gov/owow/tmdl/overviewfs.html

Fauntleroy Watershed Action Plan, 2002. Prepared by watershed citizens in cooperation with Seattle Public Utilities and Seattle Parks and Recreation. Seattle, WA.

Herrera, 2005. Woodland Park Stormwater Investigation Report: Green Lake 2004 Alum Treatment. Prepared for Seattle Department of Parks and Recreation by Herrera Environmental Consultants, Inc. October 11, 2005.

Kendra, W. 1989. Water Quality in Fauntleroy Creek and Cove During the Summer of 1988. Washington State Department of Ecology, Environmental Investigations and Laboratory Services Program, Olympia, Publication No. wa-09-1005, May 1989.

King County, 2004a. Electronic data request through Kimberle Stark, King County Water and Land Resources Division, April 15, 2004. 201 S. Jackson Street, Suite 600, Seattle, WA 98104.

King County, 2004b. Water Quality Status Report for Marine Waters. King County Dept. of Natural Resources and Parks, 201 South Jackson Street, Suite 0190, Seattle, WA 98104.
http://dnr.metrokc.gov/wlr/waterres/marine/reports/puget-sound-water-quality-report-2004.htm

King County, 2007a. Electronic data retrieval from the King County Water and Land Resources Division’s Hydrological Information Center website. 201 S. Jackson Street, Suite 600, Seattle, WA 98104. http://dnr.metrokc.gov/wlr/waterres/hydrology/

King County, 2007b. Electronic data request through Scott Mickelson, King County Water and Land Resources Division's Marine and Sediment Assessment Group, January 19, 2007. 201 S. Jackson Street, Suite 600, Seattle, WA 98104.

King County, 2007c. Miller/Walker and Salmon Creek Basin Planning Effort from the King County Natural Resources and Parks' Land Resources Division website. 201 S. Jackson Street, Suite 600, Seattle, WA 98104. http://dnr.metrokc.gov/wlr/watersheds/puget/miller-salmon/OverviewBasins.htm.

Joy, J., 2004. Stillaguamish River Watershed FC, DO, pH, As, and Hg Study. Washington State Department of Ecology, Environmental Assessment Program, Olympia, Publication No. 03-03-042, April 2004.

Manchester Environmental Laboratory, 1994. Lab User's Manual, Fourth Edition. Washington Department of Ecology, Environmental Investigations and Laboratory Services Program, Manchester, WA.

METRO (Municipality of Metropolitan Seattle), 1987. Water quality status report for marine waters. Technical Document and Research Center, King County Dept. of Natural Resources and Parks, 201 South Jackson Street, Suite 0190, Seattle, WA 98104.

Miller and Walker Creeks Basin Plan, 2006. Draft 1/19/2006 Miller and Walker Creeks Basin Plan. http://www.ci.burien.wa.us/publicworks/miller_walker%20creek%20basin%20plan.pdf

NSSP (National Shellfish Sanitation Program), 2003. Center for Food Safety and Applied Nutrition. 5100 Paint Branch Parkway, College Park, MD 20740-3835. http://www.cfsan.fda.gov/~ear/nss2-42g.html

Olds, J., 2007. Washington State Ferries, electronic communication received on April 20, 2007.

Pickens, J., 2006. "Poop Study" Engages Primary Students. Volunteer Monitor 18(1), winter 2006. http://www.epa.gov/owow/monitoring/volunteer/newsletter/volmon18no1.pdf

PSAT (Puget Sound Action Team), 2007. Ninth Report of the Puget Sound Assessment and Monitoring Group. Chapter 5: Nutrients and Pathogens. http://www.psat.wa.gov/Publications/update_07/update07.htm

Reidy, C.A., 2004. Variability of Hyporheic Zones in Puget Sound Lowland Streams. Master of Science Thesis, University of Washington, College of Forest Resources.

Richardson, R, 2002. Seattle Neighborhoods: Fauntleroy Thumbnail History. March 22, 2002. http://www.historylink.org/essays/output.cfm?file_id=3680

Rhodes, M.W. and H. Kator, 1989. Survival of *Escherichia coli* and *Salmonella* spp. in Estuarine Environments. Applied and Environmental Microbiology, 54(12): 2902-2907.

Schueler, T. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices. MWCOG. Washington, DC.

Seattle, 2004. Mainline Installation Dates – The city of Seattle. Map created on May 19, 2004.

SPU (Seattle Publics Utilities), 2007. Map of Seattle Drainage System in Fauntleroy Creek Watershed. Electronic data request through Ingrid Wertz, January 24, 2007. 700 Fifth Avenue, Suite 490, Seattle, WA 98124-4018.

Waldron, H.H., Leisch, B.A., and Mullineaux, D.R, 1961. Preliminary geologic map of Seattle and vicinity, Washington: U.S. Geological Survey, Open-File Report OF-61-168, scale 1:24000.

Washington Administrative Code (WAC) Chapter 173-201A, June 2003. Water Quality Standards of Surface Waters of the State of Washington. http://www1.leg.wa.gov/CodeReviser/.

Wayland, R.H. and J.A. Hanlon, 2002. *Establishing Total Maximum Daily Loads (TMDL) Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on those WLAs.* U.S. EPA, Office of Water, Memo to Water Directors EPA Regions 1-10, Washington, D.C., November 22, 2002, 6 pp.

WRCC (Western Regional Climate Center), 2006. Electronic data retrieval from the Western Washington Climate Center website. 2215 Raggio Parkway, Reno, NV, 89512. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wa7473

WSDOH (Washington State Department of Health), 1991. Fauntleroy Cove Odor Investigation – 1990 Report. Prepared by Environmental Health Programs Office of Toxic Substances, Mail Stop LD-11, Olympia, Washington, 98504.

Wymer LJ, KP Brenner, JW Martinson, et al., 2005. The EMPACT Beaches Project: Results from a Study on Microbiological Monitoring in Recreational Waters. EPA Document No. 600/R-04/023. U.S. Environmental Protection Agency Office of Research and Development, National Exposure Research Laboratory, Cincinnati, OH.

Zisette, R., 2007. Herrera Environmental Consultants, Inc. Electronic communication received on April 3, 2007.

Appendices

Appendix A. Glossary and Acronyms

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State to periodically prepare a list of all surface waters in the state for which beneficial uses of the water– such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality limited estuaries, lakes, and streams that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Best Management Practices (BMPs): Physical, structural, and/or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Clean Water Act (CWA): Federal Act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the CWA establishes the TMDL program.

Designated Uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the state of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Effective Shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Enterococci: A subgroup of the fecal streptococci that includes S. *faecalis, S. faecium* , *S. gallinarum* and *S. avium*. The enterococci are differentiated from other streptococci by their ability to grow in 6.5 percent sodium chloride, at pH 9.6, and at 10 degrees C and 45 degrees C.

Existing Uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Extraordinary primary contact: Waters providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas.

Fecal Coliform (FC): That portion of the coliform group of bacteria which is present in intestinal tracts and feces of warm-blooded animals as detected by the product of acid or gas from lactose in a suitable culture medium within twenty-four hours at 44.5 plus or minus 0.2 degrees Celsius. FC are "indicator" organisms that suggest the possible presence of disease-causing organisms. Concentrations are measured in colony forming units per 100 milliliters of water (cfu/100mL).

Geometric Mean: A mathematical expression of the central tendency (an average) of multiple sample values. A geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if a straight average (arithmetic mean) were calculated. This is helpful when analyzing bacteria concentrations, because levels may vary anywhere from 10 to 10,000 fold over a given period. The calculation is performed by either: 1) taking the nth root of a product of n factors, or 2) taking the antilogarithm of the arithmetic mean of the logarithms of the individual values.

Load Allocation (LA): The portion of a receiving waters' loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading Capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of Safety (MOS): Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal Separate Storm Sewer Systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (i) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, storm water, or other wastes and (ii) designed or used for collecting or conveying stormwater; (iii) which is not a combined sewer; and (iv) which is not part of a Publicly Owned Treatment Works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing, modifying, revoking and reissuing, terminating, monitoring and enforcing permits, and imposing and enforcing pretreatment requirements under the Clean Water Act. The NPDES program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Nonpoint Source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Pathogen: Disease-causing microorganisms such as bacteria, protozoa, viruses.

Phase I Stormwater Permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Phase II Stormwater Permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point Source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than 5 acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state, including change in temperature, taste, color, turbidity, or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state as will or is likely to create a nuisance or render such waters harmful, detrimental, or injurious to the public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or to livestock, wild animals, birds, fish, or other aquatic life.

Primary contact recreation: Activities where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and water skiing.

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and watercourses within the jurisdiction of Washington State.

Total Maximum Daily Load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: 1) individual wasteload allocations (WLAs) for point sources, 2) the load allocations (LAs) for nonpoint sources, 3) the contribution of natural sources, and 4) a Margin of Safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload Allocation (WLA): The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. WLAs constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

This page intentionally left blank – because of page numbering

Appendix B. Record of Public Participation

Introduction

Ecology communicated with the public in several ways. Beginning in November 2006, Ecology staff met with key stakeholders to share information on the TMDL study to set goals for restoring Fauntleroy Creek to good health. A public comment period provided opportunities for the public, including key stakeholders, to review the draft Water Quality Improvement Report and ran from May 11 to June 11, 2007. The public comment period allowed time to solicit public input and feedback on the proposed final draft report.

Summary of comments and responses

Ecology received the following summarized comments during the public comment period for the *Draft Fauntleroy Creek Fecal Coliform TMDL Water Quality Improvement Report*. Comments regarding factual inaccuracies, improved wording, or those that clarify policy positions by other government agencies have been directly incorporated into the text of the final report. All other comments are summarized or paraphrased below.

1. Comment: Provide rationale for the implementation area to include the historical drainage basin to the creek. The explanation would provide a basis for determining the appropriate area to apply the various implementation strategies. For example, some of the strategies (e.g., increasing public awareness) are appropriate for the larger implementation area as they are likely to benefit the creek although located outside the current drainage basin (i.e., study area) due to local use of Fauntleroy Park by those living outside the current creek drainage basin. However, other strategies to benefit the creek (e.g., illicit discharge detection) would only provide a benefit to the creek when conducted within the current drainage area to the creek.

Response: Without further information, Ecology usually delineates the watershed boundary based on the land topography. The city of Seattle's stormwater drainage system map provided a more accurate boundary of the actual current drainage area to the creek. This present-day drainage basin for Fauntleroy Creek was determined to be one-third the area of the historical or topographical drainage basin to the creek. Ecology included the historical drainage basin in the implementation area in order to apply outreach strategies, as deemed appropriate, to the larger Fauntleroy community, beyond the present-day drainage basin area. In response to this comment, Ecology added an explanation regarding implementation in the historical drainage basin under *Implementation area*.

2. **Comment:** Meeting bacteria water quality standards in heavily urbanized areas is a challenge nationwide due to the significant presence of non-human, mobile sources (i.e., pets, wildlife and birds) and the limited non-structural and structural BMPs/technologies available to address bacteria pollution. City of Seattle supports Ecology's goal of meeting bacteria water quality standards in Fauntleroy Creek and will work with Ecology to make significant progress towards this goal. However, given the challenges associated with

managing bacteria in an urban setting, it may be optimistic to expect compliance with standards by 2013.

Response: Ecology agrees that urban watersheds are very complex and acknowledges that finding and correcting bacterial pollution sources is challenging in these settings. Ecology considers sources influenced by humans, such as domestic pets, must still be reduced enough for the water to be safe for uses we enjoy. As part of EPA requirements for TMDLs, Ecology must set a target year for when the impaired water body is expected to be in compliance with state water quality standards. Ecology concurs with EPA that it is important to have a goal and has set year 2013 for reaching compliance in Fauntleroy Creek. If compliance is not achieved by 2013, Ecology will work with the city of Seattle and other stakeholders to adaptively manage the TMDL and examine additional BMPs or other actions that need to be taken. Ecology looks forward to increasing our understanding of urban bacteria sources and working with all interested parties to craft activities and solutions to reduce them.

3. **Comment:** Recommend clarifying how Ecology interprets assignment of use: "Fauntleroy Creek is protected by the use 'extraordinary primary contact recreation' because it is a tributary to an 'extraordinary quality marine water;' the creek would otherwise be assigned the use 'primary contact recreation.' Puget Sound has been assigned 'extraordinary quality' for aquatic life uses, which include shellfish rearing and spawning. (WAC 173-201A-610, Table 610). Because of the use that has been assigned to Puget sound, Ecology interprets the regulation to assign the creek the use of fresh water 'extraordinary primary contact' by operation of WAC 173-201A-600(1)(a)(iv)." If this text isn't used, recommend replacing "Fauntleroy Creek is a water body in Puget Sound" with "Fauntleroy Creek is located in Puget Sound" in the current text.

Response: The "Extraordinary Primary Contact" use is intended for waters capable of "providing extraordinary protection against waterborne disease or that serve as tributaries to extraordinary quality shellfish harvesting areas" (WAC 173-201A; 173-201A-020 Definitions). The use assigned to Fauntleroy Creek represents the level of use protection that has historically existed for the creek. It is deemed the highest level of protection afforded for a water body in Washington State. In response to this comment, Ecology added the clarifying statement: "Fauntleroy Creek discharges into Puget Sound at Fauntleroy Cove, an area historically used for shellfish harvesting".

4. **Comment:** It is appropriate for Seattle to be a key party for monitoring of Seattle's MS4 system which is managed by the city. However, receiving water bodies are considered "waters of the state" and are not under the control of local jurisdictions. Thus, Seattle expects that Ecology would be responsible for in-stream monitoring and assessment of current conditions and trends in receiving water bodies.

Response: Ecology believes long-term in-stream water quality monitoring is important to verify that corrective actions have been and remain appropriate in protecting local waters. Limited state resources make state monitoring of all impaired water bodies impossible. Ecology will need to rely on key parties or other interested parties to assist in gathering water quality data in order to assess the current conditions and trends in receiving water bodies. If necessary, Ecology will return to conduct compliance monitoring at or after 2013. In response to this comment, Ecology removed city of Seattle as a key party for in-stream water quality and flow monitoring in Fauntleroy Creek. Ecology will discuss all monitoring options with the city, interested citizens, and other government parties to explore possible alternative approaches to assist in collecting water quality data in the creek.

5. **Comment:** Provide additional information on the location, basin size, and land use of Walker Creek to allow reader to evaluate accuracy of comparison.

Response: In response to this comment, Ecology provided additional details on Walker Creek under *Streamflow Patterns.* For additional information, refer to the Draft Miller and Walker Creeks Basin Plan (1/19/2006) found at http://www.ci.burien.wa.us/publicworks/miller_walker%20creek%20basin%20plan.pdf.

6. **Comment:** The flow estimates for Fauntleroy Creek presented in this appendix are very rough as the comparison between the two creeks was based on only two measurements. The rough nature (and potential inaccuracy) of the estimated flows for Fauntleroy Creek is shown by comparing the estimated dry season flow (0.26 cfs, Table 11) to the limited dry season flow measurements available (0.3 – 0.42 cfs, page 20).

Response: Ecology acknowledges the estimates of flow in Fauntleroy Creek (annual and seasonal) are rough and subsequent characterizations of bacteria loadings and loading capacity warrant careful interpretation. Numeric effluent limits for municipal stormwater discharges are not often feasible or appropriate when determining stormwater discharge effluent limits in NPDES permits that are consistent with TMDLs. Therefore, best management practices (BMPs) are considered the appropriate form of effluent limits in permits for control of pollutants in stormwater (Wayland and Hanlon, 2002). Ecology anticipates that if pollutant source control strategies prove unsuccessful, further data collection and analysis of loading and sources to Fauntleroy Creek may be necessary. That effort would provide additional information that could be used to improve on the accuracy of the load estimates if necessary.

7. **Comment:** In looking at Table 3, it appears that a percent reduction of 80 percent is needed in order to meet water quality standards in the summer critical period.

Response: Ecology agrees, and in response to this comment, changed the target percent reduction for this TMDL from 77 percent to 80 percent in order to account for the greater difficulty of meeting standards during the summer critical period. Ecology uses the target percent reduction of 80 percent as an indication of the level of effort needed by all responsible parties to reduce the bacteria loadings to the creek so water quality standards will be met on an annual and seasonal basis.

8. **Comment:** Recommend Ecology expresses the loading allocation for nonpoint sources and wasteload allocation for point sources in units that are meaningful (loadings or concentration) and not just as relative percentages.

Response: In response to this comment, Ecology translated the relative percentages of the allocations into units of annual and maximum daily bacteria loadings in Table 4. Ecology added estimates for seasonal current loadings into the text under *Estimating Current Loadings and Loading Capacity*. As discussed in Comment 6, estimates of flow in Fauntleroy Creek (annual and seasonal) are rough and subsequent characterizations of bacteria loadings and loading capacity warrant careful interpretation.

List of public meetings

A public meeting was held on May 22, 2007, from 6:30-7:45pm at the Southwest Branch Public Library in the Fauntleroy community.

Outreach and announcements

- Published *Draft Fauntleroy Creek Fecal Coliform TMDL Water Quality Improvement Report* on Ecology's website (May 11).
- Posted public meeting announcements at the Southwest Branch Public Library, High Point Branch Public Library, Fauntleroy Creek viewpoint, Fauntleroy Church, Fauntleroy YMCA, Fauntleroy Children's Center, Cove Park, Lincoln Park, and The Original Bakery.
- Publicized the meeting and request for input in the Fauntleroy Community Association's May E-Newsletter and Seattle Daily Journal of Commerce (May 22).
- Made hard copies of the *Draft Fauntleroy Creek Fecal Coliform TMDL Water Quality Improvement Report* and *Focus on Bacteria in Fauntleroy Creek* available at the Southwest Branch Public Library (May 14 – June 11) and during the Fauntleroy Community Association's Food Fest/Annual Meeting (May 23).
- Presented to members of the Fauntleroy Watershed Council on May 10.
- Emailed members in Fauntleroy Watershed Council to request input on the *Draft Fauntleroy Creek Fecal Coliform TMDL Water Quality Improvement Report*.
- Interviewed with KOMO 4 News about the TMDL effort in Fauntleroy Creek (May 22).

WASHINGTON STATE DEPARTMENT OF ECOLOGY

Focus on **Bacteria in Fauntleroy Creek**

from Ecology's Water Quality Program

What's the problem with bacteria in Fauntleroy Creek?

The creek has too much fecal coliform bacteria. Measurements dating back to 1987 have shown continuing declines, but the creek still has bacteria levels beyond what Washington State allows in our freshwaters. We all need to work together to fix this.

Fecal coliform bacteria are a common water quality problem in our state. They belong to a mostly harmless group of bacteria commonly found in large numbers in the feces of people and warm-blooded animals such as pets and wildlife. However, they indicate that more serious disease-causing organisms – called pathogens, may be present in water. Stormwater runoff and other discharges can carry these small organisms into Fauntleroy Creek where they can infect humans through skin contact or ingestion of water.

What is a Water Quality Improvement Report (TMDL)?

When these kinds of water quality problems are found, federal law requires that a Total Maximum Daily Load (TMDL) be developed for water bodies that don't meet state water quality standards. The TMDL process includes an evaluation of the water quality conditions. This information is put into a document that also specifies how much the pollution needs to be reduced to achieve clean water and describes how the state plans to work with citizens, local governments, and organizations to control the pollution and improve conditions in the affected water body. This information is contained in the draft *Fauntleroy Creek Water Quality Improvement Report (*Report*)*.

Ecology has a longstanding interest in improving water quality in urban creeks such as Fauntleroy Creek. After collecting surface water monitoring data for two recent years, Ecology initiated a TMDL for Fauntleroy Creek. The City of Seattle and Fauntleroy Watershed Council have been active partners in restoring Fauntleroy Creek for years and are contributing to this TMDL effort.

Ecology requests your valuable input on the draft Report during the public comment period from May 11 through June 11, 2007. Ecology then intends to issue the final Report in June 2007. A detailed implementation plan will be developed by June 2008.

Public Meeting

Ecology will host a public meeting on recent studies and plans to improve bacteria pollution in Fauntleroy Creek:

May 22, 2007

6:30 – 7:45 p.m.

Southwest Branch Public Library

9013 35th Ave. SW

West Seattle, 98126

Contact Information

Sinang H. Lee
WA Dept. of Ecology
3190 160th Ave. SE
Bellevue, WA 98008

(425) 649-7110
sile461@ecy.wa.gov

Everyone is invited to this meeting to learn about how state and local governments are approaching this problem and what you can do to keep informed or, possibly to be directly involved.

May 2007 **07-10-041**

Original printed on recycled paper

Where is the pollution coming from?

Urban watersheds are very complex and contain many potential pollutants. This makes it hard for everyone to pinpoint all of the sources that contribute to the problems. In general, the most common potential bacteria sources in urban Puget Sound watersheds include:

- Domestic pets
- Human waste from leaking sanitary sewer lines or from sanitary sewer lines improperly connected to the stormwater drainage system.
- Wildlife, including birds such as gulls and crows, and mammals such as squirrels, rats, and raccoons.

Bacteria from these sources then accumulate on yards, driveways, roadside ditches, roads, parking lots, and other locations. Then when it rains or snows, the resulting stormwater runoff can easily enter into the creek.

What can you do?

"Fixing" fecal coliform contamination problems means each of us looking at what we do (or don't do) on our property to prevent pet waste and other bacteria sources from reaching public waters. To be a good steward of your watershed, here are some important things you can do:

- Use proper waste management for dogs and cats. Bag pet waste and put it in the garbage.
- Don't feed ducks and other waterfowl (their wastes contribute to bacteria problems).
- Protect or restore natural vegetation along streams and shorelines. Vegetation slows & filters pollutants from runoff and promotes natural wildlife balance.
- Prevent pollution in stormwater runoff – plant a rain garden, direct downspouts away from paved surfaces, keep storm drains clear of leaves.

Together, We Can Improve Water Quality in Fauntleroy Creek!

For a copy of the Draft Report (Publication No. 07-10-037):
http://www.ecy.wa.gov/biblio/0710037.html

Please consider reviewing the *Draft Fauntleroy Creek Water Quality Improvement Report*. If you have comments, by June 11, 2007 please write or call:

Sinang H. Lee

Water TMDL Lead for Fauntleroy Creek

3190 160th Ave SE

Bellevue, WA 98008-5452

Phone: (425) 649-7110; or email: sile461@ecy.wa.gov

If you need this publication in an alternate format, please call DouGlas Palenshus at 425-649-7041. Persons with hearing loss can call 711 for Washington Relay Service. Persons with a speech disability can call 877-833-6341.

PUBLIC MEETING

Together, We Can Improve Water Quality In Fauntleroy Creek

Like many other urban streams, Fauntleroy Creek has levels of fecal coliform bacteria beyond what Washington State allows in our freshwaters.

Learn about recent studies and plans to improve bacteria pollution in the creek.

Share your ideas.

May 22, 2007
6:30 - 7:45 pm

Southwest Branch Public Library
9010 35th Ave. SW
West Seattle, 98126

For more information or copy of the Draft Report, contact Sinang Lee at
(425) 649-7110
sile461@ecy.wa.gov
WA State Dept. of Ecology NWRO
3190 160th Ave. S.E., Bellevue, WA 98008

Ecology requests your input on the *Draft Fauntleroy Creek Fecal Coliform TMDL Water Quality Improvement Report* at http://www.ecy.wa.gov/biblio/ 0710037.html.

Comment at this meeting or send comments to Sinang Lee by June 11.

WASHINGTON STATE Department of Ecology

This page intentionally left blank – because of page numbering

Appendix C. Data sources

A combination of past studies and long-term water quality monitoring in Fauntleroy Creek (1987-1996; 2004-2006) and in Fauntleroy Cove (1997-2006) exist to assess the long-term trends, current conditions, the effect of the creek on the cove, and seasonal differences in potential sources in the creek.

Data from King County and Ecology were used to assess the Fauntleroy Creek water quality. Since the early 1970s, King County has been conducting routine monthly monitoring on streams and rivers throughout the county including Fauntleroy Creek.

To assess current water quality conditions, data from 2004 to 2006 were used.

King County

King County's Water and Land Resources Division supports a comprehensive long-term monitoring program to assess water quality in freshwater and marine bodies throughout and adjacent to the county.

- From 1987 to 1996, the Major Lake and Stream Monitoring Program monitored in Fauntleroy Creek at the freshwater station LSVW02 (King County, 2007b). The station is near the mouth of the creek about 50 feet south of the Fauntleroy Vashon Ferry Dock. Sampling schedules varied from sometimes twice a month (1987) to monthly (1988 to 1991; 1993 to 1996) to monthly (1987 and 1992).

- Since 1997, the Marine and Sediment Assessment Group monitored in Fauntleroy Cove at the beach station LSVW01 (King County, 2007b). The station is located just north of the Fauntleroy Ferry Dock on a sandy beach. Sampling schedules varied from monthly (1997 to 2005) to sometimes twice a month in 2006.

Monitoring programs typically collect samples on a monthly basis. Samples were collected at approximately knee-depth by inverting sample containers just above the water surface, then sinking the bottle down to approximately 12-inches below the water surface (King County, 2004b). The bottles were not filled completely in order to allow room for mixing. Fecal coliform were analyzed using membrane filtration methodology according to Standard Methods 9222D (APHA, 1998). All samples were analyzed within the recommended holding times and quality assurance/quality control procedures included the use of blanks, duplicates, and spikes when appropriate. King County reviewed all data prior to entry into their LIMS (Laboratory Information Management System) database.

Table 7. King County freshwater stream monitoring data on fecal coliform bacteria at Fauntleroy Creek (station LSVW02).

Date	cfu/100 mL	Date	cfu/100 mL	Date	cfu/100 mL
2/3/1987	200	7/25/1990	163	3/27/1995	24
2/23/1987	220	8/30/1990	460	4/24/1995	360
3/4/1987	372	10/24/1990	87	6/26/1995	930
3/18/1987	110	11/5/1990	38	7/24/1995	330
3/30/1987	130	12/17/1990	370	8/21/1995	180
4/15/1987	60	1/9/1991	59	9/25/1995	150
4/20/1987	570	2/20/1991	137	10/23/1995	160
5/7/1987	3	3/26/1991	23	11/27/1995	290
5/19/1987	290	4/29/1991	13	12/18/1995	89
6/8/1987	767	5/22/1991	48	1/22/1996	33
6/22/1987	87	6/4/1991	280	2/20/1996	45
6/30/1987	1,000	7/15/1991	210	3/18/1996	590
7/14/1987	1,300	8/26/1991	1,110	4/22/1996	70
8/11/1987	2,400	9/17/1991	450	5/22/1996	480
9/9/1987	1,633	10/2/1991	440	6/17/1996	430
9/14/1987	622	11/25/1991	41	7/15/1996	190
10/20/1987	700	12/9/1991	60	9/5/1996	300
10/28/1987	1,133	1/15/1992	25	9/16/1996	210
11/18/1987	320	2/4/1992	160	10/21/1996	100
11/30/1987	2,220	3/17/1992	30	11/18/1996	95
12/7/1987	360	4/7/1992	37	12/16/1996	240
12/22/1987	670	5/14/1992	74		
1/25/1988	191	6/3/1992	300		
2/23/1988	120	7/8/1992	300		
3/22/1988	310	8/18/1992	140		
4/26/1988	290	9/9/1992	167		
5/3/1988	380	10/29/1992	840		
6/27/1988	580	1/19/1993	690		
7/18/1988	100	2/8/1993	12		
8/9/1988	870	3/3/1993	32		
9/27/1988	190	4/21/1993	110		
10/26/1988	210	6/21/1993	120		
11/28/1988	470	7/14/1993	750		
12/27/1988	450	8/3/1993	2,000		
1/25/1989	290	9/22/1993	260		
2/28/1989	420	10/19/1993	380		
3/28/1989	130	11/9/1993	60		
4/4/1989	600	12/14/1993	43		
5/2/1989	170	1/24/1994	160		
6/27/1989	630	2/2/1994	82		
7/5/1989	1,630	3/9/1994	51		
8/23/1989	690	4/19/1994	25		
9/18/1989	280	5/11/1994	820		
10/10/1989	1,780	6/27/1994	250		
11/27/1989	130	7/26/1994	430		
12/20/1989	38	8/23/1994	340		
1/16/1990	2,030	9/28/1994	200		
2/13/1990	43	10/19/1994	130		
3/12/1990	62	11/16/1994	140		
4/3/1990	37	12/20/1994	310		
5/9/1990	120	1/17/1995	55		
6/25/1990	200	2/27/1995	46		

Table 8. King County intertidal salt water monitoring data on fecal coliform bacteria at Fauntleroy Cove (station LSVW01). Any value reported as zero was assigned a value of one in the geometric mean calculation.

Date	cfu/100 mL	Date	cfu/ 100 mL	Date	cfu/ 100 mL
1/27/1997	54	2/26/2001	14	2/23/2005	1
2/19/1997	375	3/22/2001	5	3/22/2005	1
3/13/1997	190	4/17/2001	200	4/26/2005	1
4/21/1997	4	5/8/2001	160	5/25/2005	4
5/19/1997	40	6/26/2001	26	6/27/2005	4
6/23/1997	3,100	7/16/2001	80	7/20/2005	9
7/22/1997	120	8/27/2001	148	8/24/2005	4
8/27/1997	580	9/19/2001	18	9/28/2005	10
10/20/1997	105	10/29/2001	130	10/26/2005	3
11/17/1997	265	11/26/2001	250	11/30/2005	4
12/22/1997	445	12/19/2001	1	12/20/2005	10
1/21/1998	52	1/23/2002	14	1/31/2006	3
2/23/1998	18	2/27/2002	3	3/1/2006	22
3/17/1998	215	3/25/2002	1	3/29/2006	9
4/20/1998	7	4/29/2002	19	4/26/2006	18
5/18/1998	200	5/20/2002	260	5/31/2006	62
6/15/1998	395	6/26/2002	230	6/28/2006	4
7/28/1998	135	7/29/2002	140	7/26/2006	72
8/17/1998	850	8/21/2002	3,000	8/23/2006	73
9/28/1998	11	9/30/2002	80	9/27/2006	1
10/19/1998	9	10/28/2002	47	10/24/2006	15
11/17/1998	49	11/20/2002	26	12/5/2006	1
12/16/1998	78	12/17/2002	9	12/27/2006	4
1/26/1999	58	1/28/2003	35		
2/16/1999	50	2/26/2003	13		
3/18/1999	4	3/24/2003	1		
4/7/1999	77	4/23/2003	7		
5/26/1999	200	5/19/2003	1		
6/29/1999	27	6/24/2003	33		
7/19/1999	15	7/22/2003	1		
8/24/1999	160	8/27/2003	15		
9/27/1999	250	9/23/2003	66		
10/18/1999	18	10/28/2003	100		
11/22/1999	150	11/18/2003	210		
12/15/1999	1,105	12/16/2003	6		
1/24/2000	8	1/26/2004	15		
2/16/2000	5	2/17/2004	1		
3/7/2000	1	3/15/2004	12		
4/19/2000	95	4/26/2004	1		
5/10/2000	165	5/27/2004	16		
6/5/2000	34	6/28/2004	4		
7/10/2000	116	7/26/2004	8		
8/15/2000	140	8/23/2004	145		
9/25/2000	1,300	9/28/2004	26		
10/16/2000	18	10/27/2004	6		
11/15/2000	98	11/29/2004	40		
12/4/2000	75	12/27/2004	10		
1/16/2001	65	1/19/2005	4		

Ecology's Ambient Water Quality Monitoring Program monitors 12 water quality parameters on a monthly basis at 24 long-term and 10 to 15 rotating river and stream sampling stations in Puget Sound. From October 2004 to September 2006, Ecology collected monthly freshwater samples in Fauntleroy Creek at the station 09K070. Both Ecology and King County stations in Fauntleroy Creek are near the mouth of the stream below Fauntleroy Way. Sampling parameters included temperature, dissolved oxygen, pH, conductivity, turbidity, and fecal coliform. Ecology's Water Quality Program collected five additional random samples at station 09K070 during the two-year monitoring period.

Standard Ecology protocols were used for sample collection, preservation, and shipping to the Manchester Environmental Laboratory (Manchester Environmental Laboratory, 1994).

Table 9. Ecology freshwater stream monitoring data on fecal coliform bacteria at Fauntleroy Creek (station 09K070). Bold numbers indicate additional samples collected by Water Quality Program at Northwest Regional Office.

Date	cfu/100 mL	Date	cfu/100 mL
10/4/2004	**120**	1/23/2006	16
10/18/2004	280	2/13/2006	110
11/15/2004	63	**3/6/2006**	**32**
12/13/2004	170	3/13/2006	44
1/24/2005	69	**4/3/2006**	**4**
2/14/2005	87	4/17/2006	22
3/28/2005	80	5/15/2006	220
4/18/2005	47	6/19/2006	140
5/23/2005	84	**7/12/2006**	**250**
6/13/2005	280	7/17/2006	280
7/18/2005	140	**8/15/2006**	**590**
8/15/2005	390	8/21/2006	280
9/19/2005	320	9/18/2006	410
10/17/2005	120		
11/14/2005	23		
12/12/2005	28		

Appendix D. Equations for TMDL analysis

Simple Method Formula

$$\mathbf{L = 1.03\ E\text{-}3 * R * C * A}$$

Where….

L = Seasonal load in billions of colonies
R = Seasonal runoff in inches
C = Bacteria concentration in #/100 mL
A = Area in acres
1.03 E-3 = unit conversion factor

$$R = P * Pj * Rv$$

P = Seasonal rainfall in inches

Pj = Fraction of annual rainfall events that produce runoff (assumed 85 percent)

Rv = Runoff coefficient

Rv = 0.05 + 0.9Ia

Deriving the 90th Percentile Value

The federal Food and Drug Administration developed a statistically-based formula to evaluate growing areas for shellfish sanitation. The National Shellfish Sanitation Program Model Ordinance (NSSP, 2003) states:

The estimated 90th percentile shall be calculated by:

(a) Calculation the arithmetic mean and standard deviation of the sample result logarithms (base 10);

(b) Multiplying the standard deviation in (a) by 1.28;

(c) Adding the product from (b) to arithmetic mean;

(d) Taking the antilog (base 10) of the results in (c) to get the estimated 90th percentile; and

(e) The most probable number (MPN) values that signify the upper or lower ranger of sensitivity of the MPN tests in the 90th percentile calculation shall be increased or decreased by one significant number.

The 90th percentile derived using this formula assumes a lognormal distribution of the fecal coliform data. The variability in the data is expressed by the standard deviation, and with some data sets it is possible to calculate a 90th percentile greater than any of the measured data.

Loading Capacity

There are several ways to estimate the number of bacteria in Fauntleroy Creek. For example, numbers of bacteria can be counted over a day, month, or year. Ecology used the following method to estimate the loading capacity and daily bacteria loads in Table 4:

$$\underset{(ft^3/second)}{\textit{Flow}} \times \underset{(cfu/100\ mL)}{\textit{Bacteria Concentration Level}} \times \underset{(2.447 \times 10^7)}{\textit{Conversion Factor}} = \textit{Number of Bacteria per day}$$

Appendix E. Estimation of flow using a reference stream

To estimate the flow in Fauntleroy Creek, Ecology used Walker Creek as a reference stream. (See *Streamflow Patterns* for information on Walker Creek). Ecology calculated the percent differences in the flows between Walker Creek and Fauntleroy Creek taken on February 1, 2007 and March 1, 2007. Based on the average of these percent differences, Ecology estimated that Fauntleroy Creek has about 16 percent of the flow in Walker Creek (Table 10).

$$1 - \frac{(\text{Walker} - \text{Fauntleroy})}{\text{Walker}} \times 100 = \text{Percent Difference}$$

Table 10. Percent differences in the flows between Walker Creek and Fauntleroy Creek.

Date	Measured Flow (cfs)		Percent Difference
	Walker Creek (King County data)	**Fauntleroy Creek (Ecology data)**	
2/1/2007	2.73	0.43	15.75 %
3/1/2007	2.79	0.43	15.41 %
		Average Percent Difference =	**15.58 %**

The long-term hydrological record for streamflows in Walker Creek provided the measured average annual and seasonal flows. Ecology used the average percent difference between the two creeks from the two flow measurement dates (about 16%) to estimate the annual and seasonal average flows in Fauntleroy Creek (Table 11).

Table 11. Estimated flows in Fauntleroy Creek.

	Walker Creek Measured Average Flow (cfs)	**Fauntleroy Creek Estimated Average Flow (cfs)**
Annual	2.58	0.40
Wet Season (Oct – April)	3.23	0.50
Dry Season (May – Sept.)	1.68	0.26

The flow estimates for Fauntleroy Creek provide a rough comparison between the two creeks based on two measurements. Ecology recognizes that this analysis is based on limited existing flow data for Fauntleroy Creek. Ecology realizes that if pollutant source control strategies prove unsuccessful, further data collection and analysis of loading and sources to Fauntleroy Creek may be necessary.

This page intentionally left blank – because of page numbering

Appendix F. TMDL analytical framework

Estimating the loading capacity

The total allowable number of bacteria in Fauntleroy Creek varies depending on how much water is present. When there is more water in the stream, there is more capacity for bacteria without violating water quality standards. When there is less water, fewer bacteria can be added before a water body will violate standards. Bacteria added to Fauntleroy Creek that result in concentrations above and beyond the state standards must be removed. This study looks at the estimated annual and daily loadings (total number of bacteria per period) and the concentration (number of bacteria per 100 mL) to understand pollutant levels.

Knowing the existing loading of bacteria to a stream provides an extra tool for understanding how bacteria are distributed in a watershed. It is also necessary to look at the bacteria concentration to determine compliance with state standards. Because the waters of Fauntleroy Creek should never exceed state criteria, concentration levels are sometimes used as a surrogate measure for the Estimated Loading Capacity.

Since no long-term flow data exist for Fauntleroy Creek, Ecology estimated the average annual flow based on data from the King County gauging station on the reference stream Walker Creek (see Appendix E). The estimated average annual flow in Fauntleroy Creek is 0.40 cfs. This flow was then multiplied by the geometric mean standard for fecal coliform bacteria to calculate the maximum bacteria loading capacity in Fauntleroy Creek.

Estimating the load and wasteload allocations

Urban watersheds are very complex and contain many potential pollutant sources making detailed quantifications of sources difficult. Although this study does not provide a high level of detail on the bacteria sources in the present-day drainage basin to Fauntleroy Creek, it broadly categorizes pollution into “point” and “nonpoint” sources.

- **Point sources** are locations where pollution can enter local streams by pipes or channels owned or operated by municipal government or businesses. Ecology regulates discharges from these outfalls through its NPDES permit program. The city of Seattle owns and operates the storm sewer system of ditches and culverts in the study area.

- **Nonpoint source** pollution enters a local stream from dispersed land-based or water-based activities. These could include improperly managed pet wastes, excessive concentrations of wildlife, and perhaps leaky sewer lines and illicit connections. These activities are very hard to count and add up because they occur in so many locations.

The amount of impervious cover strongly correlates with water quality; the more impervious cover, the higher the bacteria levels (PSAT, 2007). Impervious surfaces such as roads, roof tops, and parking lots accumulate contaminants and prevent water from infiltrating as would occur on vegetated grounds. Due to the rush of water off these surfaces, stormwater can carry much of the bacteria directly into a stream during the wet season. Stormwater is largely conveyed to surface waters through stormwater drainage systems (point source) but can also flow off the land as nonpoint sources.

In the dry season, stormwater drainage systems still contribute some pollution during summer storm events. In this study area, an estimated six inches of rainfall occur on average in a dry season. This is little compared to the stormwater generated during the wet season. Therefore, the main source of bacteria pollution in the dry season is likely from nonpoint sources.

Bacteria are a difficult subject for watershed modeling because of the episodic nature of bacteria standards violations, the importance of secondary sources to total loads, variability in monitoring data, and bacteria’s ability to survive and reproduce in storm drains and stream sediments (CWP, 2001). This study did not collect data to specifically characterize bacteria concentrations in stormwater.

Without extensive data, Ecology used a land-use-based approach, the Simple Method Model (Schueler, 1987), to estimate the relative contribution of point and nonpoint sources to bacteria loads in stormwater runoff in the study area. The model uses estimates of drainage area, impervious cover, stormwater runoff bacteria concentrations, and annual precipitation (Table 12). In this TMDL, the point source wasteload allocations are assigned to areas with residential and commercial/industrial land uses. Nonpoint source load allocations are assigned to areas with forest/field land use.

The following process was used to determine load and wasteload allocations:

1. Perform Geographic Information Systems (GIS) analysis on land use types in the study area.

2. For each land use, calculate relative stormwater bacteria loads from nonpoint and point sources with a 10 percent margin of safety using the Simple Method Model.

3. Based upon the proportional contributions to stormwater bacteria loads, assign load allocations (LA) for nonpoint sources and specific wasteload allocations (WLA) for the point source, city of Seattle stormwater.

Ecology used several sources of data and assumptions to estimate model inputs (Table 12):

- GIS data from King County Assessment Department identified eight different land uses in the study area. These were broadly categorized into: Forest/Field, Residential, Commercial/Industrial. Right-of-Way was equated to local roads and aggregated into the Residential category.
- Cappiella and Brown (2000) study provided estimates on impervious cover for various land uses. Residential is assumed to be '1/8th acre lot residential' and Forest/Field is assumed to be 'open urban land' as defined in Cappiella and Brown (2000).
- Stormwater generated off Forest/Field is assumed to be background and associated with only nonpoint sources. To account for the urban environment influence, stormwater discharges from this land cover are assumed to have a geometric mean of 100 cfu/100 mL (Joy, 2004).
- From regional and national databases, Joy (2004) summarized the estimated bacteria concentrations in stormwater associated with Residential and Commercial/Industrial land uses.
- Ecology performed a GIS analysis on parcels within a 300 feet buffer of the creek to estimate how much Residential land use in the study area contributes directly to the stream system as nonpoint bacteria loads. This assumes run-off from half of the parcels located within the 300 feet buffer contribute to nonpoint loadings. The analysis found about 16 percent of the total residential land use area, including local roads, in the present-day creek drainage basin contributes to the nonpoint loads.
- Stormwater generated off Commercial/Industrial is assumed to contribute entirely to point sources.

Table 12. Land use estimates used in Simple Method model to determine relative bacteria loadings by sources with a 10 percent margin of safety.

Land Use	City of Seattle (acres)	Percent of Total Study Area (%)	Estimated Impervious Cover (%) Cappiella & Brown (2000)	Estimated Mean Bacteria Concentrations (cfu/100mL) Joy (2004)
Open Space	32.76			
Vacant	2.29			
Forest & Field =	**35.05**	**23.46%**	**9%**	**100**
Single-Family	75.85			
Multi-Family	1.34			
Right-Of-Way	29.90			
Residential =	**107.08**	**71.66%**	**33%**	**2000**
Commercial	5.93			
Industrial	0.05			
Schools	1.32			
Commercial/Industrial =	**7.30**	**4.88%**	**72%**	**980**
TOTAL =	**149**	**100%**		

Appendix G. Assessment of water quality in Fauntleroy Cove

This assessment of water quality in Fauntleroy Cove provides additional context for the recommendation for future monitoring in the cove after the implementation of the Fauntleroy Creek TMDL. Using King County data, Ecology assessed the water quality in Fauntleroy Cove. The objectives are as follows:

- Characterize long-term trends and current conditions of bacteria concentrations in Fauntleroy Cove.

- Evaluate the impact of bacteria discharge from Fauntleroy Creek on water quality in Fauntleroy Cove.

Long-term trends in Fauntleroy Cove

Sampling results indicate the fecal coliform problem in Fauntleroy Cove has been improving since monitoring began in 1997. Figure 11 shows a 12-sample moving geometric mean of bacteria concentrations in Fauntleroy Cove. From 1997 to 2002, four samples had high bacteria levels ranging from 1,100 to 3,100 cfu per 100 mL. Three of these samples were collected during the dry season months. Since 2003, marine water quality appears relatively stable with no extreme exceedances as before. In 2004 and 2005, the cove met standards at both the geometric mean of 14 cfu/100 mL and 90th percentile criterion of 43 cfu/100 mL (Figure 12).

The reasons for the gradual decline in bacteria in Fauntleroy Cove since 1997 are unknown. King County found improving trends at many of their other beach stations around Puget Sound (King County, 2004b). They suggest the trend may be attributable to changes in annual rainfall patterns in the area. Improved water quality in Fauntleroy Creek which discharges directly to the cove may also be a factor. However, available data are not adequate to conclude that improvements in cove quality are completely explainable by changes in water quality in the creek.

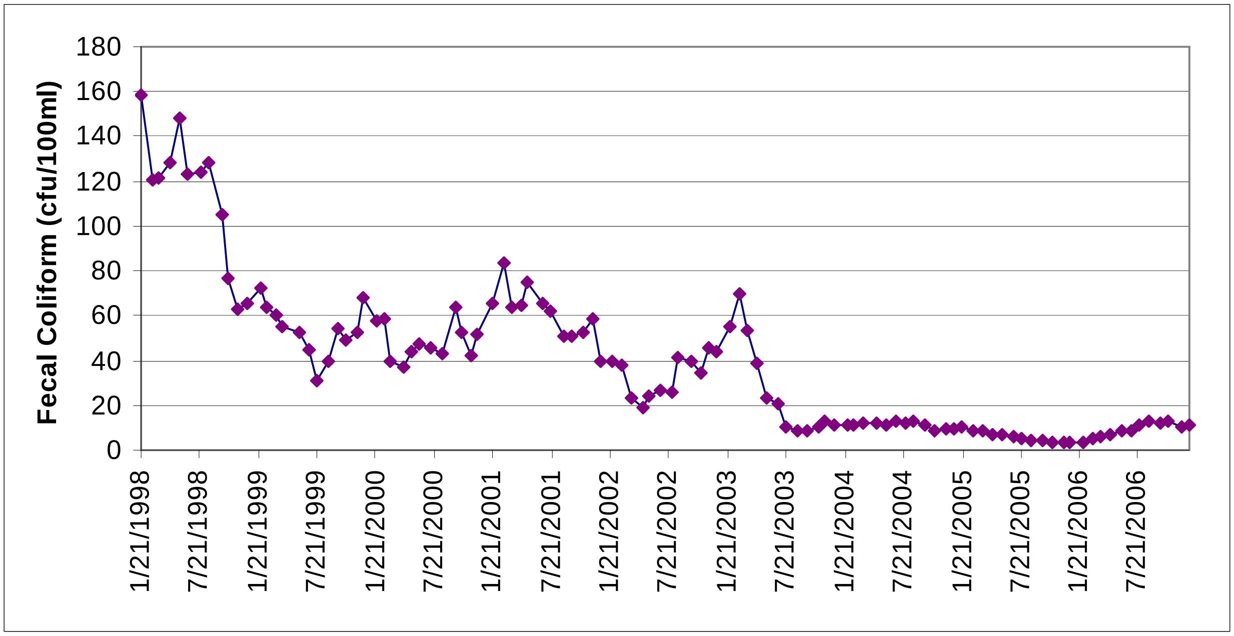

Figure 11. Long-term trend (12-sample moving geometric mean) of bacteria concentrations in Fauntleroy Cove (King County data 1997-2006).

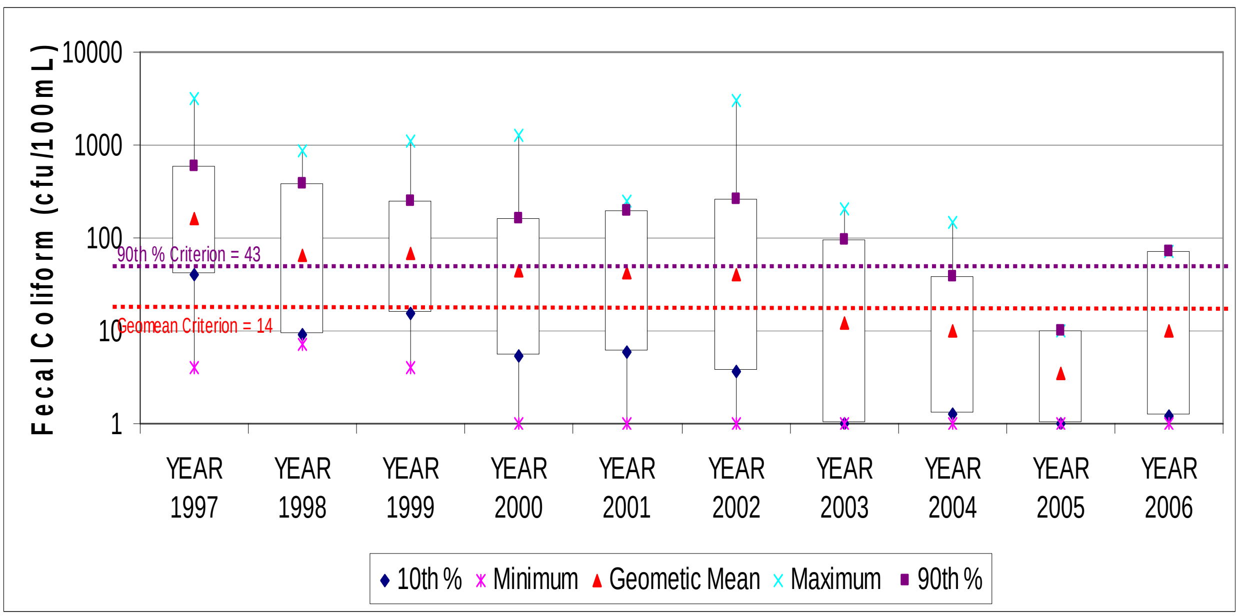

Figure 12. Annual bacteria trend in Fauntleroy Cove since 1997 using King County data.

Current conditions

Under current conditions, Fauntleroy Cove meets water quality standards on an annual basis. However, dry season bacteria levels in the cove exceeded the 90th percentile criterion (Table 13). Ecology expects reducing bacteria loadings in Fauntleroy Creek will contribute to improving water quality in the cove as well. After the implementation of the Fauntleroy Creek TMDL takes effect, Ecology recommends future monitoring in the cove.

Table 13. Current water quality conditions in Fauntleroy Cove. GMV is the geometric mean value of sample population. The 90th percentile is the threshold of the upper ten percent of the sample population. Bold numbers indicate violation in standards.

Fauntleroy Cove (King County Station LSVW01)	**Water Quality Standard**		**Current Conditions**	
	GMV	90th %tile	GMV	90th %tile
Dry Season (May 1 – Sept. 30)	14	43	12	**75**
Wet Season (Oct 1 – April 30)	14	43	5	22
Annual	14	43	7	40

Is Fauntleroy Creek impacting water quality in Fauntleroy Cove?

The greatest single determinant of fecal indicator level in marine waters is the distance between the shoreline bacteria sources and sampling point (Wymer et al., 2005). As mentioned earlier, the Fauntleroy Cove marine monitoring station is located just north of the mouth of Fauntleroy Creek, near the Fauntleroy Ferry Dock on a public sandy beach. The proximity of the cove sampling site to the creek discharge, and northerly drift currents make it likely that changes in creek water quality will be evident in cove sampling results.

Past studies suggest Fauntleroy Creek is likely a primary source of bacteria contamination in Fauntleroy Cove (Kendra, 1989; METRO, 1987). In 1988, Ecology surveyed the water quality along the creek and the cove on two summer days (Figure 13; Kendra, 1989). They found bacteria levels were consistently high throughout the creek in June, but highest near the mouth in August (Figure 14). Along the marine shoreline of Fauntleroy Cove, two sites nearest to the creek discharge had higher bacteria levels than other marine sampling sites and were generally higher in June than in August (Figure 15). This could mean the creek in June provided a continuous influx of bacteria into the marine waters. On both sampling days in the cove, results indicate bacteria levels decreased the further away the sampling site is from the creek discharge.

King County produced similar results in an earlier study: “Analysis of marine-water samples indicated that bacteria levels in the marine water in Fauntleroy Cove, collected just off of the mouth of Fauntleroy Creek, were higher than bacteria levels in marine water collected to the north or south of the creek mouth.” (METRO, 1987)

Looking at long-term data during stable periods of contamination, Fauntleroy Creek appears to influence the bacteria quality in Fauntleroy Cove. Figure 16 shows a comparison of monthly bacteria levels in the creek and the cove. From December through September, the monthly bacteria levels in the marine waters follow a similar pattern seen in the creek.

In late fall, the creek and cove exhibit contrasting trends in bacteria levels. From October to November, bacteria level dipped in the creek as it rose in the cove. This pattern could indicate fall storms had washed out the bacteria that accumulated in the creek during the dry months or disturbed bacteria in shoreline sediments. During this time, the initial influx of bacteria from the creek could contribute to the surge in bacteria levels seen in the cove.

A correlation study between marine bacteria counts and precipitation levels at three beach stations in Puget Sound supports the general observation that bacteria counts tend to be highest during or directly following rain events (King County, 2004b). The lower bacteria levels in marine water compared to the creek (Figure 16) is explainable in that once exposed to estuarine waters, bacteria have lower survival rates than in freshwaters (Rhodes and Kator, 1988). So for the rest of the wet season, the creek and cove exhibit a relatively stable period of low bacteria levels.

Findings from the review of past studies and assessment of long-term data suggest Fauntleroy Creek is strongly influencing the bacteria quality in Fauntleroy Cove.

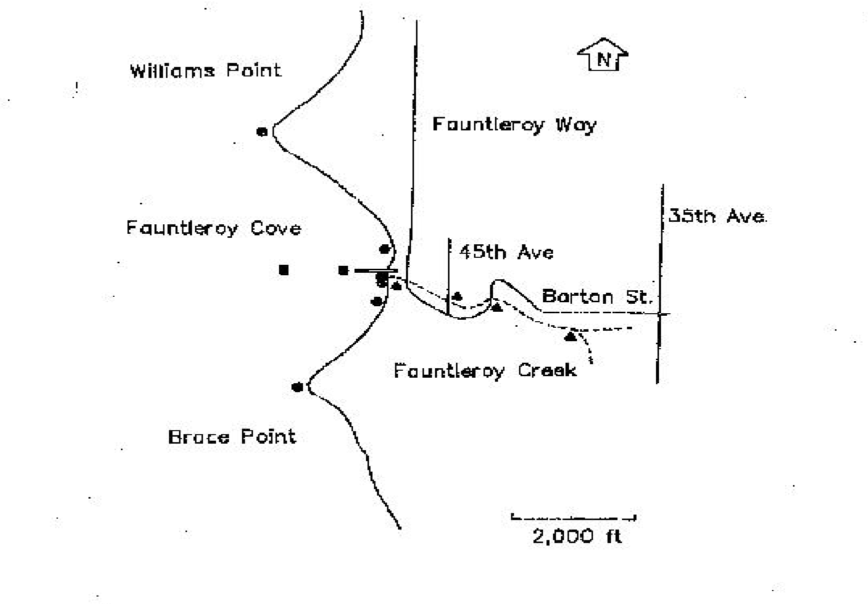

Figure 13. Map of study area from Kendra (1989) showing location of creek (triangles), nearshore cove (circles), and offshore cove (squares) sampling sites monitored on June 15 and August 29, 1988.

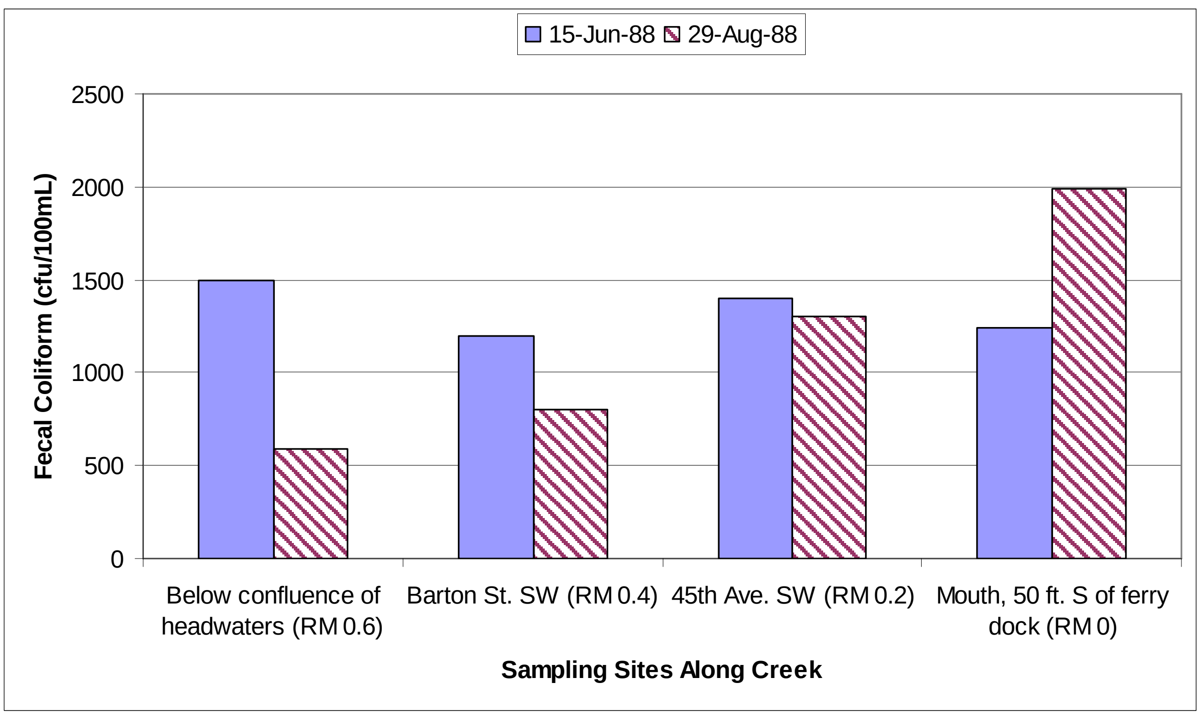

Figure 14. Bacteria levels at four sites along Fauntleroy Creek in June and August 1988.

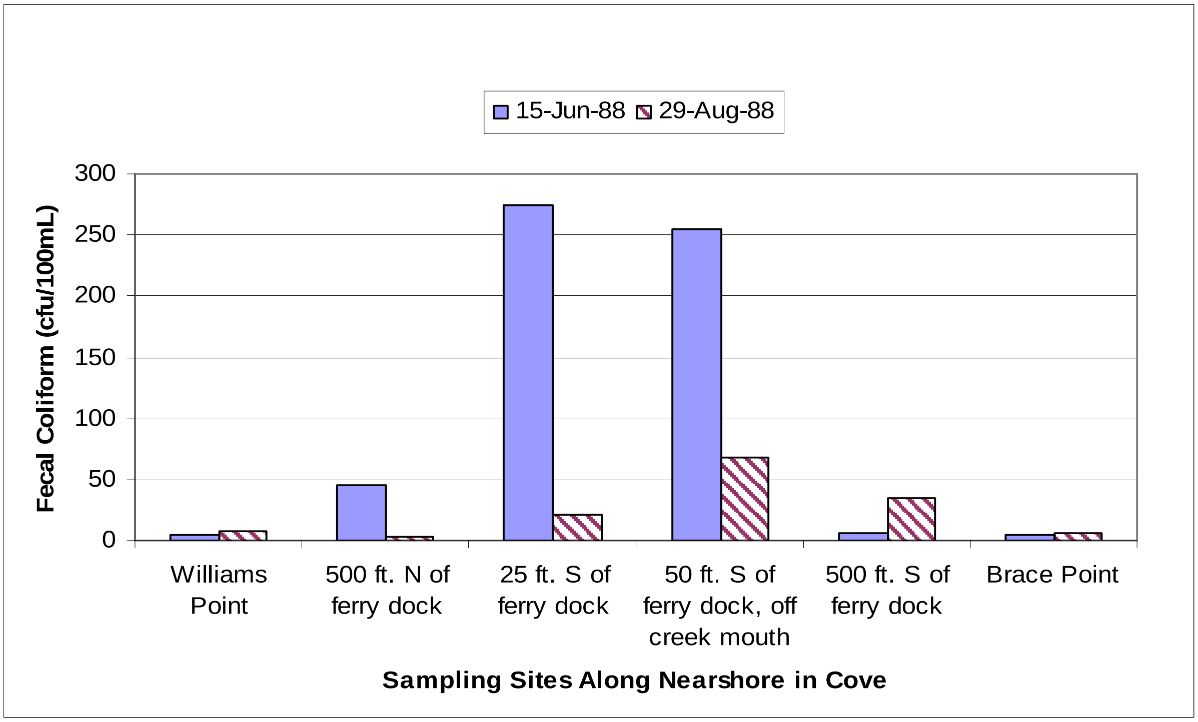

Figure 15. Bacteria levels at six nearshore sites in Fauntleroy Cove in June and August 1988.

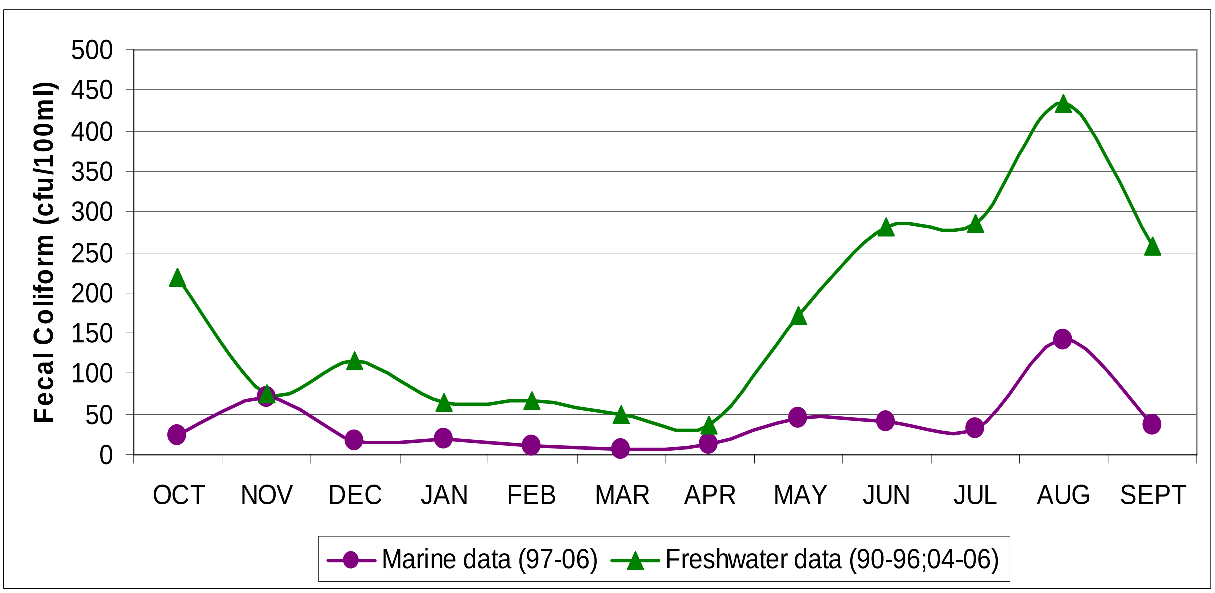

Figure 16. Comparison of monthly bacteria levels (geometric mean) in Fauntleroy Creek and Fauntleroy Cove.

END.