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Dobbs Creek Water Quality Monitoring for Fecal Coliform Bacteria

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Dobbs Creek
Water Quality Monitoring
for Fecal Coliform Bacteria

By
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Fecal Coliform Bacteria

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Abstract

Washington State Department of Ecology (Ecology) conducted water quality monitoring for fecal coliform (FC) bacteria in the Dobbs Creek watershed between November 2007 and April 2008. The objectives of the study were to assess compliance with Washington State's Extraordinary Primary Contact water quality criteria for FC bacteria and to identify potential sources of FC bacteria. Water quality in mainstem Dobbs Creek did not meet the state designated water quality standard for Extraordinary Primary Contact Recreation in freshwater. Bacteria concentration and loading increase in the mainstem when at least 0.2 inches of rain fall in the previous 24 hours. Source areas were identified for FC bacteria. Areas are also identified that need additional sampling and investigation of FC bacteria sources.

Origins for the fecal coliform bacteria in the watershed include failing or non-existent on-site septic systems, domesticated animals (e.g., horses, dogs, and cattle), wildlife, storm water runoff, and re-suspension of bacteria from in-stream sediments. Additional source monitoring and discussions with landowners will be necessary to further refine and control FC bacteria sources.

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Introduction

Dobbs Creek is located in northeast Thurston County. It flows approximately 1.5 miles before discharging into marine waters of Henderson Inlet (Figures 1 and 2). The creek supports a variety of aquatic life and habitat; it has a history of supporting coho (*Oncorhynchus kisutch*) and chum *(O. keta)* salmon. The primary land uses in the Dobbs Creek watershed are rural residential and agricultural. The agricultural activities dominate the upper area of the watershed. Land use transitions to residential about a mile before entering Henderson Inlet. Henderson Inlet supports marine life including shellfish; there are commercial and recreational shellfish areas. Potential sources for fecal coliform (FC) bacterial pollution in the Dobbs Creek watershed include failing on-site septic systems, domesticated animals (e.g., horses, dogs, and cattle), wildlife, stormwater runoff, and re-suspension of bacteria from in-stream sediments.

The project goal for Washington Department of Ecology's (Ecology) water quality monitoring in Dobbs Creek:

- Identify sources of FC bacteria in the watershed during the wet season.

Project objectives for Dobbs Creek water quality monitoring:

- Collect and analyze water quality samples for FC bacteria during the wet season.
- Assess compliance with State Extraordinary Primary Contact Recreational water quality standards for FC bacteria.
- Document current bacterial water quality conditions in Dobbs Creek that may be contributing to FC bacteria concentrations and impacts to shellfish beds in Henderson Inlet.
- Provide the Henderson Inlet Technical Advisory Group with additional FC bacteria data to assist with prioritizing implementation activities needed to improve water quality.

Background

Under the federal Clean Water Act of 1972, a TMDL must be performed on all water bodies on the 303(d) list. A TMDL is the calculation of the maximum amount of pollutants that a water body can assimilate and still meet Washington State's Water Quality Standards, Chapter 173-201A of the Washington Administrative Code (Washington State Department of Ecology, 2006). The TMDL analysis determines the best ways to bring water bodies back into compliance with water quality standards. The TMDL developed for the Henderson Inlet Watershed included monitoring in Dobbs Creek (Sargeant et.al. 2006). The United States Environmental Protection Agency (EPA) approved the TMDL on January 8, 2007. Dobbs Creek is categorized as 4a in Ecology's Water Quality Assessment (Appendix A) for FC bacteria.

This 2007/2008 monitoring study was the result of recommendations made in the 2006 Henderson Inlet Watershed TMDL technical report (Sargeant, op. cit.) and the subsequent Water Quality Implementation Plan (Hempleman, 2008). Dobbs Creek had the highest storm-event bacterial loading to Henderson Inlet of all creeks sampled in that project. A request was made by

Ecology's South Puget Sound TMDL coordinator to conduct additional source monitoring for FC bacteria in the Dobbs Creek watershed.

FC bacteria are found in the intestinal tract of warm-blooded animals and are transmitted to water and soil by human and animal feces. Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. Fecal coliform in water "indicates" the presence of waste from humans and other warm-blooded animals and may result in unhealthy conditions for primary contact. Elevated concentrations may result from rain washing waste material from surfaces into water bodies or can result from direct inputs to the water. Identifying bacteria sources, followed by cleanup of the bacterial pollution, helps protect beneficial uses such as recreational activities and shellfish harvesting.

Current state water quality standards classify Dobbs Creek as Extraordinary Primary Contact Recreational water (Appendix B). The standard for this classification requires that:

> "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/ 100 mL."

This water quality project is designed to further investigate FC bacteria levels in Dobbs Creek and to identify reaches with contamination problems (site locations are described in Table 1). By meeting bacteria water quality standards in Dobbs Creek, it is likely that water quality will also improve in Henderson Inlet.

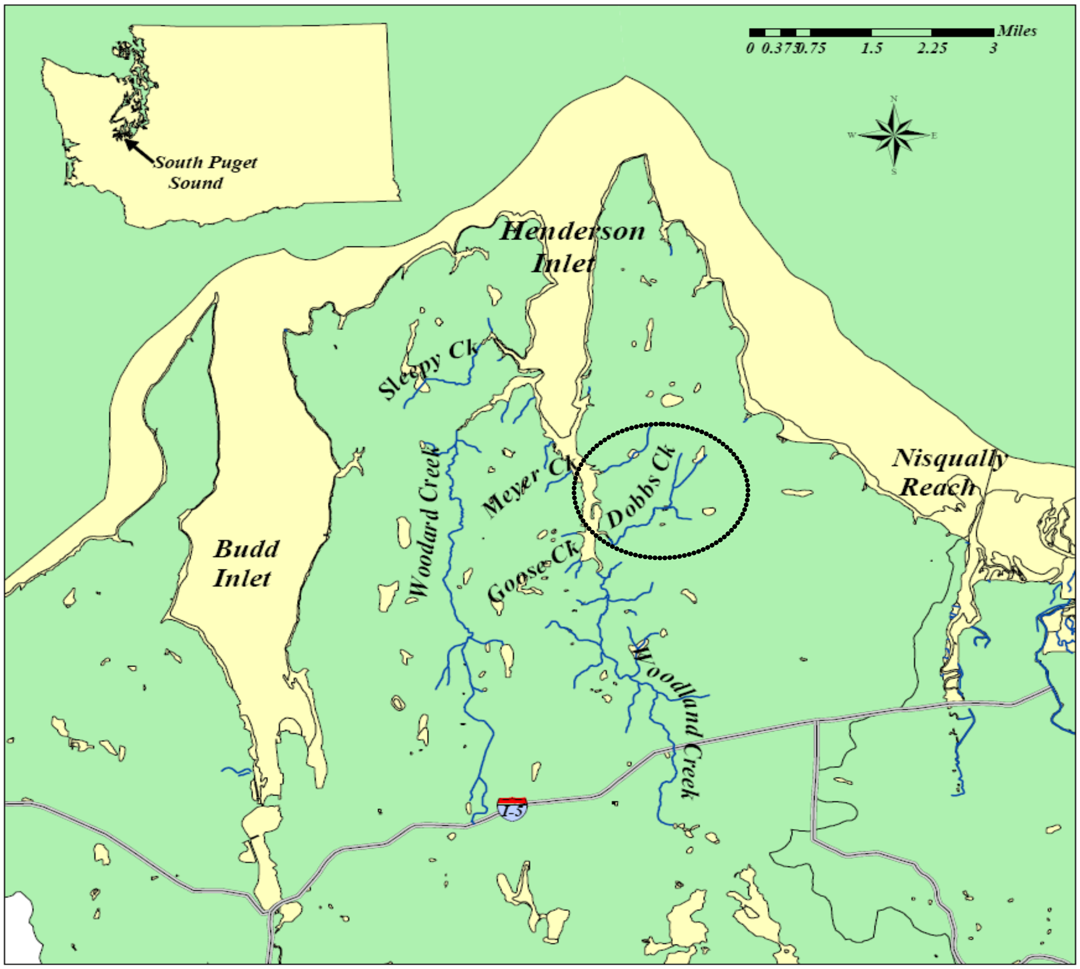

Figure 1. Map of Dobbs Creek and Surrounding Area

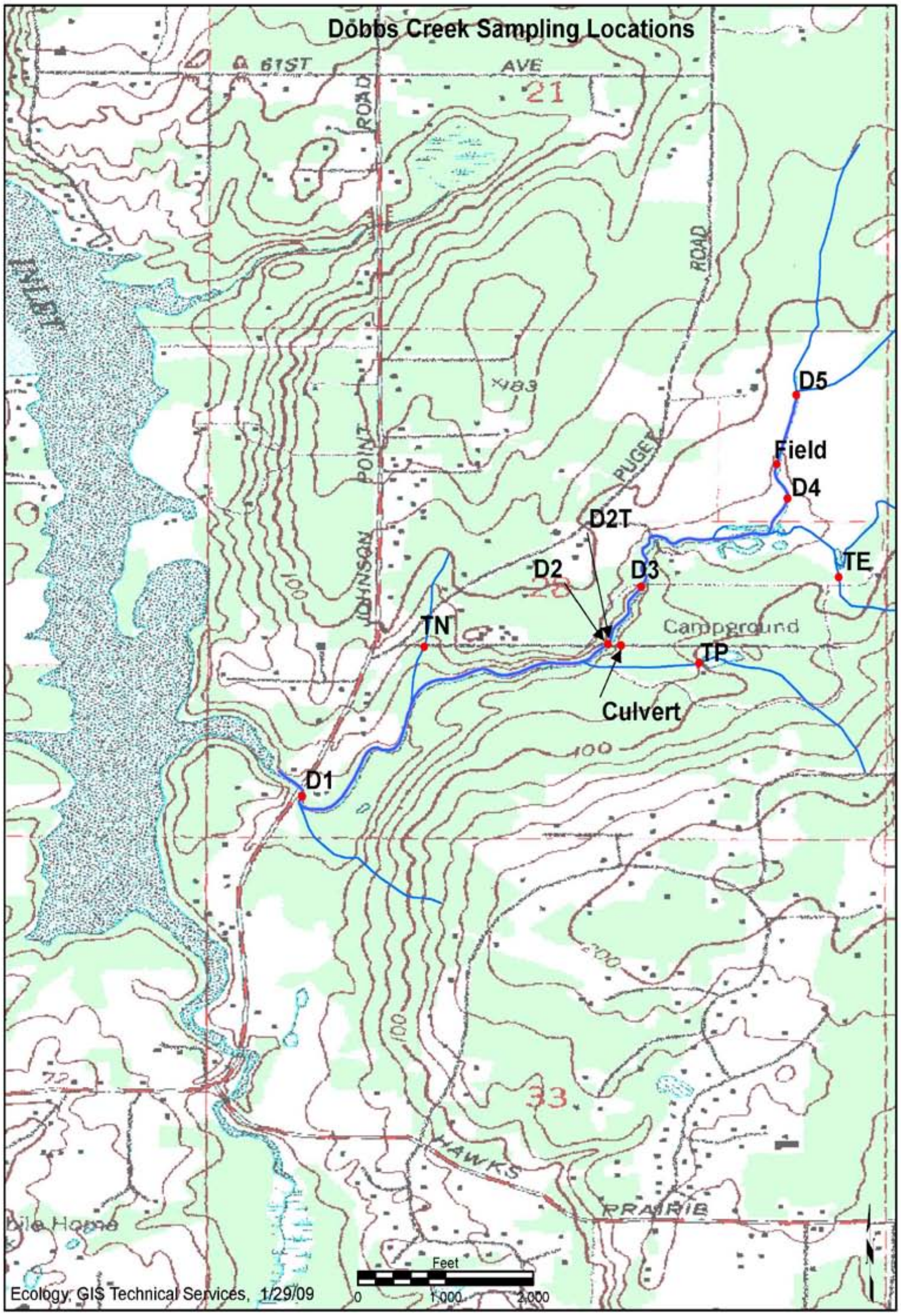

Figure 2. Map of Dobbs Creek Watershed Sampling Locations

Table 1. Description of Sample Site Locations

Site Name	River Mile		Site Description	Latitude	Longitude
	Mainstem (MS)	Tributary Intersects MS			
D1	0.06		Dobbs Creek (mainstem) where creek crosses Johnson Point Road near the estuary. Site is tidally influenced.	N47° 05" 55.5'	W123° 49" 13.1
TN		0.39	First tributary coming in on right bank nearest mouth before you enter the Pleasant Forest Campground/RV park (PFC).	N47° 06" 11.2'	W122° 48" 57.5'
TP		0.68	Taken in the tributary downstream of the pond.	N47° 06" 10'	W122° 48" 29'
Culvert		0.73	Enters Dobbs from left bank downstream side of road and downstream of sampling location for D2.	N47° 06" 12'	W122° 48" 38'
D2	0.731		First large bridge crossing the mainstem after passing through PFC main gate; at base of hill. Just upstream of culverts.	N47° 06" 11.7'	W122° 48" 38.2'
D2T		0.7311	Tributary entering in from left bank just upstream of D2 sampling location.	N47° 06" 12'	W122° 48" 38'
D3	0.86		Bridge over mainstem on the Elm Road. Upstream of the PFC.	N47° 06" 17.8'	W122° 48" 34'
TE		1.16	Tributary east of D3.	N47° 06" 17.8'	W122° 48"15'
D4	1.23		Upstream of concentrated residential and downstream of agriculture.	N47° 06" 26.9'	W122° 48" 18.5'
TFIELD		1.3	Runoff channel from the field entering on the right bank above the location for D4.	N47° 06" 32'	W122° 48" 19'
D5	1.44		Collected from downstream side of wooden bridge on the upper area of Dobbs Creek Farm.	N47° 06" 38'	W122° 48" 17'

Methods

Standard protocols were used for sample collection (Mathieu, 2007; MEL, 2008). Sampling locations were selected to identify potential sources of fecal coliform bacteria. Accessibility, permission to access the property, and the previous locations used in the Henderson TMDL were key factors in selection. Site locations are described in Table 1 and mapped in Figure 2. The Quality Assurance Project Plan (QAPP) (Dickes, 2008) for this study can be reviewed for more details. http://www.ecy.wa.gov/pubs/0810009.pdf

Water sampling occurred approximately twice a month during the wet season from November 2007 through April 2008. Grab samples were collected directly into pre-cleaned polyethylene containers supplied by Ecology's Manchester Environmental Laboratory (MEL) and described in their User's Manual (MEL, 2008). Sample collection was conducted in a manner to minimize sediment disturbance. The sample was taken from mid-channel in the area of predominate flow. Samples were also collected in a manner to avoid material on the water's surface.

Each sample was labeled with project and site name, date, laboratory identification number and time. Samples were immediately placed in a dark thermal cooler with ice and kept in conditions between 0°C and 10 °C until the samples were processed by the laboratory. Samples were received at the Manchester Laboratory within the 24 hour holding time.

Appendix C provides a summary of sampling and analysis procedures for field and laboratory procedures and quality assurance expectations. Replicate FC bacteria samples were taken at 20 percent of the sample locations per event to assess variability and precision. A replicate flow measurement was taken at one sample location per event.

The methods for determining river mile and mapping locations had inherent variability. Therefore these designators should be used as relative positioning guides rather than exact locations. The stream sampling locations were mapped using field Global Positioning System (GPS) data. The GPS readings were accurate within 20 feet. Map source data was obtained using Washington Hydrography Framework 1:24,000 scale stream layer, USGS 7.5 minute, and1:24,000 scale quad map image. The accuracy of that system is within 40 feet.

Data analysis

Field and laboratory data were compiled and managed using Microsoft Excel® software. The average of field replicate pairs was used in data analyses. Duplicate samples taken in the Laboratory were used to provide laboratory quality assurance information; the data were not used in analyses.

Mass loading was calculated for the mainstem sites. This was determined by taking the measured stream flow (cfs), multiplied by the FC bacteria concentration (cfu/100 mL), and then multiplied by a conversion factor of 0.0245 to obtain billions (10^9) of fecal coliforms per day. Hourly rainfall data from the Olympia Airport was used to estimate total amount of rain in inches for the previous 24 hours. The mouth site, site D1, site was used as the temporal reference for setting the 24 hour period.

Quality assurance

Field and laboratory quality assurance results are available for review in Appendix D.

Laboratory

The laboratory's data quality objectives and quality control procedures are documented in the MEL Lab Users Manual (MEL, 2008) and the MEL Quality Assurance Manual (MEL, 2006).

Laboratory duplicates for bacteria are analyzed in the laboratory by taking a sub-sample of a field sample. The sub-samples are analyzed to determine variability within the laboratory procedures. There were two laboratory duplicates which exceeded the quality assurance limits of 40 percent relative percent difference (RPD):

- The laboratory duplicates for site TN (collected 4/7/08), were 21 cfu/100 mL and 35 cfu/100 mL resulting in a RPD of 50 percent. The data were qualified as estimates and the qualified field data used in analyses.
- The laboratory duplicates for site Culvert (collected on 4/21/08), were 40 cfu/100 mL and 14 cfu/100 mL resulting in a RPD of 96 percent. The data were qualified as estimates and the qualified field data used in analyses.

Field data

Fecal coliform bacteria tend to be highly variable in the environment. Field replicates are two samples taken at the same location and as close as possible in time and space. Data from these samples represents total variability, that is, the sum of variability from both field and laboratory methods.

The data quality objective for field replicate samples (with a mean greater than 20 cfu/100 mL) is to have 50 percent of the replicates below a 20 percent relative standard deviation (RSD) and 90 percent of the samples below a RSD of 50 percent (Mathieu, 2006). The field replicate pairs met both quality assurance criteria. Fifty percent of the 21 replicate pairs had a RSD of 17 and 90 percent of the pairs had a RSD below 40.

Some of the replicate discharge measurements did not all meet the 0.1 ft/sec data quality objective. However, replicates were all within 0.15 ft/sec. The discharge data were considered acceptable to provide a general idea of bacterial loading and source areas to the mainstem Dobbs Creek system.

Results and Discussion

A data summary of field fecal coliform bacteria concentrations are provided in Table 2. Field and laboratory data are provided in Appendix D.

The mainstem of Dobbs Creek did not meet water quality standards for Extraordinary Primary Contact Recreation during this study period. All routine (those sampled 10 or more times) sampling sites on the mainstem exceeded both the geometric mean criterion of 50 cfu/100 mL and all had more than 10 percent of their sample results exceed 100 cfu/100 mL. Bacteria concentrations increase in the mainstem in response to storm events (defined in this study as at least 0.2 inches of rainfall in the previous 24 hours).

Table 2. Fecal coliform bacteria summary concentrations in the Dobbs Creek watershed, 2007/2008.
The bolded values and shaded columns represent sites on Dobbs Creek mainstem.

← flow direction ←											
	Fecal Coliform Bacteria Concentrations (cfu/100 mL)										
DATE	Station Name										
	D1	TN	TP	culvert	**D2**	D2T	**D3**	TE	**D4**	TFIELD	**D5**
11/5/2007	**19**	x*	x	x	**x**	x	**x**	x	**x**	x	x
11/19/2007	**x**	70	x	x	**92**	x	**87**	x	**140**	x	x
12/10/2007	**125**	84	3	x	**43**	x	**35**	3	**nd**	x	x
1/7/2008	**104**	36	1	360	**200**	x	**160**	2	**78**	x	x
1/14/2008	**230**	31	1	700	**110**	x	**150**	21	**210**	x	x
1/30/2008	**2900**	55	1	295	**5300**	x	**4900**	83	**3900**	x	x
2/11/2008	**105**	43	1	17	**120**	x	**115**	8	**150**	x	x
2/25/2008	**33**	11	x	7	**40**	x	**49**	x	**870**	x	x
3/10/2008	**26**	24	1	96	**31**	x	**47**	x	**5400**	x	x
3/24/2008	**335**	60	x	160	**450**	x	**480**	19	**310**	520	62
4/7/2008	**310**	21	x	260	**120**	2400	**210**	1	**1250**	69	10
4/21/2008	**40**	2	x	40	**37**	370	**3**	x	**190**	x	x
Geometric mean	**118**	29	1	104	**127**	942	**110**	8	**464**	189	**25**
# of samples over 100 cfu/100 mL	**7 of 11**	0 of 11	0 of 6	5 of 9	**6 of 11**	2 of 2	**6 of 11**	0 of 7	**9 of 10**	1 of 2	**0 of 2**

*x = no data collected

Four storm events were sampled during this study: 1/14/08, 1/30/08, 3/24/08, and 4/7/08. Potential sources for FC bacteria include failing or non-existent on-site septic systems, waste from domesticated animals (e.g., horses, dogs, and cattle) and wildlife, storm water runoff, and re-suspension of bacteria from in-stream sediments.

Summaries for each sampling location are provided below. The descriptions start at the upstream site location and continue downstream. Storm events are discussed at the end of this section.

Mainstem Site D5 (RM 1.44)

Site D5 (RM 1.44), above most activities on Dobbs Creek Farm, was sampled twice. Sampling at this site started late in the study; the sample size is too small for meaningful comparison with water quality standards. However, concentrations were relatively low even though taken during storm events. The water sample taken on 3/24/08 had 62 cfu/100 mL and on 4/7/08, the concentration was 10 cfu/100 mL. Bacteria concentrations increased downstream as documented at Site D4 which had FC concentrations of 310 cfu/100 mL, and 1250 cfu/100 mL respectively, on those days.

Site TFIELD (RM 1.3)

Site TFIELD (RM 1.3) was a relatively small runoff depression flowing intermittently west to east across the Dobbs Creek farm. It enters Dobbs Creek from the right bank between site D5 and site D4. Two samples were collected during the study period, both during storm events. The sample size is too small for meaningful comparison with water quality standards or source identification, but, the concentration variability is notable. On 3/24/08, the sample result of 520 cfu/100 mL while on 4/7/08 the concentration was 69 cfu/100 mL. Cattle are removed from the fields during the winter months, but, the manure piles could continue to be a bacteria source. Birds and other wildlife may also be a source. Discharge measurements could not be taken here since the water was shallow and not confined to a channel.

Mainstem Site D4 (RM 1.23)

Site D4 (RM1.23) was a routine sampling location in the upper watershed. This site is located at the lower end of the Dobbs Creek farm property. The water at this site did not meet the water quality criterion for Extraordinary Primary Contact. Bacteria concentrations at this location ranged from 78 cfu/100 mL (1/7/08) to 5400 cfu/100 mL (the highest bacteria concentration found during the study collected on 3/10/08). The geometric mean of ten samples was 464 cfu/100 mL - the highest geometric mean for sites in the mainstem. Additionally, nine out of ten samples had concentrations over 100 cfu/100 mL. Concentrations at this site were often higher than downstream concentrations during non-storm event conditions. This would suggest that there is a source of bacteria entering the creek upstream of site D4, but below site D5.

Site TE (RM 1.16)

Site TE is located in an intermittent runoff channel. The 7 samples collected met the water quality criterion for Extraordinary Primary Contact with a geometric mean of 8 cfu/100 mL and all samples below 100 cfu/100 mL. FC bacteria were elevated during the 1/30/08 storm event with a concentration of 83 cfu/100 mL.

Mainstem Site D3 (RM 0.86)

Site D3 (RM 0.86), at the upper end of the Pacific Forest RV campground facility, did not meet the FC bacteria water quality criterion for Extraordinary Primary Contact. The geometric mean was 110 cfu/100 mL and six out of the 11 samples were over 100 cfu/100 mL. Concentrations ranged from 3 cfu/100mL on 4/21/08 to 4900 cfu/100mL, collected during the 1/30/08 storm event. Land use here includes the Dobbs Creek farm, rural residential, horse pastures, and the runoff channel identified as site TE in this study.

There was a hose coming from the residential upland area that entered the creek at site D3. No water was observed being discharged or removed via this hose. The purpose of the hose is not clear and was not investigated during this study.

Site D2T (RM 0.7311)

A small tributary (site D2T at RM 0.7311) enters just upstream of site D2 from the left bank. Two samples were collected during the study period. The sample size is too small for meaningful comparison with water quality standards or source identification. This tributary was not identified until a turbid plume was seen flowing from it while sampling at site D2 during a storm event on 4/7/08. The sample taken at site D2T, near the mouth before entering the mainstem had a concentration of 2400 cfu/ 100 mL. The turbid water appeared to be running off from the roadway.

Mainstem Site D2 (RM 0.731)

Site D2 (RM 0.731) is in the lower area of the Pacific Forest RV campground. It was sampled above the culvert that goes under the main access road for the campground. Water here did not meet the FC bacteria water quality criterion for Extraordinary Primary Contact with a geometric mean of 127 cfu/100mL and 6 of the eleven samples over 100 cfu/100 mL. The concentrations ranged from 31 cfu/100mL (3/10/08) to 5300 cfu/100mL (1/30/08).

Usually the amount of water entering from the tributary at site D2T is minimal. However, it is important to note that water samples collected at site D2 did *not* include water from the tributary. The discharge measurements for site D2 *would* include the discharge from that tributary. Sampling during the TMDL did not take this tributary into account (D. Sargeant, personal communication).

Site Culvert (RM 0.73)

The road side ditch (site Culvert, RM 0.73) was sampled about 5 meters upstream from where it discharges into Dobbs Creek. This site did not meet the Extraordinary Primary Contact water quality criterion for FC bacteria. The nine samples resulted in a geometric mean of 109 cfu/100mL with five samples above 100 cfu/100mL. The roadside culvert carries water from the roadway and residential properties. It discharges into the creek from the left bank on the downstream side of the road from mainstem site D2.

Site TP (RM 0.68)

Site TP (RM 0.68) characterized water exiting a community park pond. Water quality at this site met the FC bacteria water quality criterion for Extraordinary Primary Contact. Ducks were usually seen on the pond yet the FC bacteria levels were low, averaging 1 cfu/100 mL. Water levels were often too low to obtain a sample or take a discharge measurement at the discharge area. The concentrations at this site do not reflect potential bacterial contributions that may occur from human or wildlife impacts as the water flows through the rest of the campground before discharging into the mainstem.

There are sanicans located on the bank near the lake discharge point. They did not appear to be a source of bacteria during this study. However, if they are being used they pose a potential threat for a sewage spill.

Site TN (RM 0.39)

Water quality at this site met the FC bacteria water quality criterion for Extraordinary Primary Contact. The 11 samples collected resulted in a geometric mean of 29 cfu/100 mL. Concentrations varied during the study from 2 cfu/100 mL to 84 cfu/100 mL, but all bacteria samples were less than 100 cfu/100 mL.

Mainstem Site D1 (RM 0.06)

Site D1 (RM 0.06) did not meet the FC bacteria water quality criterion for Extraordinary Primary Contact. The geometric mean value was 118 cfu/100 mL. Seven of the eleven samples had concentrations over 100 cfu/100 mL. The concentrations ranged from 19 cfu/100 mL (11/5/07) to 2900 cfu/100 mL (1/30/08).

Storm events

Storm events for this study were defined as sample events when at least 0.2 inches of rain fell in the previous 24 hours. Site D1 near the mouth of Dobbs Creek was used as the reference (Table E-1). Rainfall was estimated using hourly precipitation data from the Olympia airport. Based on these criteria there were four storm events: 1/14/08, 1/30/08, 3/24/08, and 4/7/08. The bacteria concentrations in the watershed responded to precipitation events, but they were noticeably elevated when 0.4 inches of rain fell during the 1/30/08 storm.

Loading of fecal coliform bacteria in Dobbs Creek was typically greater during storm events (Table F-1). The loading pattern varied within each storm event. The greatest bacterial loading occurred between sites D4 and D3 during the 1/30/08 and 3/24/08 storm events. The average load increased steadily as you move downstream to the mouth at site D1 (Figure F-1).

Bacterial loading increased between Site D2 and Site D1 eight out of ten sampling events.

During two of the storm events, 1/14/08 and 4/7/08, the FC load more than tripled between these sites. These two storm events had elevated precipitation in the previous 12 hour period. This suggests that there may be sources that get mobilized early in the storm event.

Conclusions

There are sources of FC bacteria entering Dobbs Creek. Water quality analyses identified concentrations of bacteria in the watershed that did not meet the FC bacteria water quality standard for Extraordinary Primary Contact. The four routine mainstem sites exceeded both parts of the FC bacteria criterion. Further investigation is necessary to identify the original source for the pollution. Potential sources could be failing, or non-existent, on-site septic systems, domesticated animals (e.g., horses, dogs, and cattle), wildlife, stormwater runoff, and re-suspension of bacteria from in-stream sediments.

FC bacteria concentration and loading elevate in response to precipitation and stormwater runoff.

There is a variable concentration pattern in the Dobbs Creek system as the water flows from the upstream to downstream sites.

During low-flow conditions bacteria concentrations are often higher upstream and decrease downstream at the mouth. However, loading is often higher at the mouth during this time.

FC bacteria are entering the reach of Dobbs Creek between sites D5 and D4. One of the sources identified in this study was the small drainage flowing from the western fields, site TFIELD. There was also a larger channel entering Dobbs Creek from the east (left bank) between sites D5 and D4. It appears that the water comes from runoff from the Dobbs Creek farm pastures as well as adjacent property from the northeast. It is notable that the average FC load at site D4 accounted for a relatively high percentage of the average load seen at the mouth.

The FC concentration and loading increased between sites D4 and D3during the storm event on 1/30/08. Impacts to this reach could be from improperly managed manure from horses and cattle, septic systems, wildlife, and road runoff.

Waterfowl were usually seen on the RV campground pond (TP), yet the FC bacteria levels there were usually low, near 1 cfu/100 mL.

The FC concentration and loading increased between sites D3 and D2 during the storm event on 1/30/08. Sources of bacteria in this reach would be those coming primarily from the RV campground.

It appears that polluted water is entering Dobbs Creek between sites D2 and D1, especially as seen during the 1/14/08 and 4/7/08 storm events. Sources of water into this area need further investigation and characterization, especially those not characterized in this study.

Recommendations

- Review County Health Department records to verify all residences and farms in the Dobbs Creek watershed have sanitary facilities.
- Inspect on-site sewage systems in the watershed on a regular basis. Priority for the operation and maintenance inspections should be given to those systems and residences located along waterways and on the near shore areas.
- Review farm plans to determine if they continue to be adequate for current land use. Encourage full implementation of water quality and manure management elements.
- Develop effective farm plans for agricultural properties that currently are not covered by a management plan. Include manure management and water quality protection elements.
- Identify and eliminate illicit discharges entering the creek.
- Relocate the sanicans at the campground pond further away from the lake shore and lake out-fall. The location should be far enough away to protect the pond and creek from a possible waste spill. Maintenance of the sanicans should be completed away from the water as well.
- Reroute stormwater from dirt roads away from waterways.
- Future sampling efforts should include the addition of the following four sites:
    - Unnamed left bank tributary just above site D4
    - Site D2T
    - Confluence of the tributary (that originates at the pond) with Dobbs Creek
    - Unnamed left bank tributary that drains Fox Hollow residential community
- Investigate the origin of water entering the roadside ditch reflected at RM 0.73, site Culvert.
- Identify and eliminate bacteria sources that are entering into the mainstem between sites D2 and D1.
- Investigate sources of bacteria in the Fox Hollow residential community and the potential for contaminating water discharging to Dobbs Creek between sites D2 and D1.
- Focus sampling during storm events with greater or equal to 0.2 inches of rain in the previous 24 hours. Include discharge measurements.
- Focus education and outreach for watershed residents on effective waste management options for humans, agricultural impacts, and pet waste (including horses). Provide technical assistance for site specific issues.

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Appendices

Appendix A
Federal Clean Water Act Requirements Water Quality Assessment

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, each state is required to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of designated uses for protection, such as cold water biota and drinking water supply, as well as criteria, usually numeric criteria, to achieve those uses.

Every two years, states are required to prepare a list of waterbodies – 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, Ecology compiles its own water quality data along with data submitted by 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 waterbodies 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 plan in place that should solve the problem
- 4c. – Is impaired by a non-pollutant such as low water flow, dams, culverts.

Category 5 – Polluted waters that make up the 303(d) list and require a TMDL.

TMDL process overview

The Clean Water Act requires that a Total Maximum Daily Load be developed for each of the waterbodies on the 303(d) list. A TMDL identifies how much pollution needs to be reduced or eliminated and still meet Washington State's Water Quality Standards, Chapter 173-201A of the Washington Administrative Code. Then Ecology works with the local community to develop (1) a strategy to control the pollution and (2) a monitoring plan to assess effectiveness of the water quality improvement activities.

Elements required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources.

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) source such as general urban, residential, or farm run-off, the cumulative share is called a *load allocation*.

The TMDL must also consider seasonal variations and 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. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

TMDL = Loading Capacity = sum of all wasteload allocations + sum of all load allocations + margin of safety.

Total Maximum Daily Load analyses: Loading capacity

Identification of the contaminant loading capacity for a waterbody is an important step in developing a TMDL. The Environmental Protection Agency (EPA) defines the loading capacity as "the greatest amount of loading that a waterbody 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 waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

Appendix B
Water Quality Criteria for Fecal Coliform Bacteria

Table B1. Water Contact Recreation Bacteria Criteria in Freshwater

Water Contact Recreation Bacteria Criteria in Freshwater	
Category	Bacteria Indicator
Extraordinary Primary Contact Recreation	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 10 sample points exist) obtained for calculating the geometric mean value exceeding 100 colonies/100 mL.
Primary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies /100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for Calculating the geometric mean value exceeding 200 colonies /100 mL.
Secondary Contact Recreation	Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 400 colonies /100 mL.

Bacteria, fresh waters

Bacteria criteria are set to protect people who work and play in and on the water from waterborne illnesses. In the Washington State water quality standards, fecal coliform is used 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 have been shown to maintain low rates of serious intestinal illness (gastroenteritis) in people.

Use categories

There are three use categories related to the freshwater bacteria criteria in Washington:

(1) 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." 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 10 sample points exist) obtained for calculating the geometric mean value exceeding 100/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

(2) The *Primary Contact* use is intended for waters "where a person would have direct contact with water to the point of complete submergence including, but not limited to, skin diving, swimming, and waterskiing." More to the point, however, the use is to be designated to any waters where human exposure is likely to include exposure of the eyes, ears, nose, and throat. Since children are also the most sensitive group for many of the waterborne pathogens of concern, even shallow waters may warrant primary contact protection. To protect this use category: "Fecal coliform organism levels must not exceed a geometric mean value of 100 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 200/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

(3**)** The *Secondary Contact* use is intended for waters "where a person's water contact would be limited (e.g., wading or fishing) to the extent that bacterial infections of the eyes, ears, respiratory or digestive systems, or urogenital areas would be normally avoided." To protect this use category: "Fecal coliform organism levels must not exceed a geometric mean value of 200 colonies/100 mL, with not more than 10 percent of all samples (or any single sample when less than 10 sample points exist) obtained for calculating the geometric mean value exceeding 400/colonies mL" [WAC 173-201A-200(2)(b), 2003 edition].

Compliance is based on meeting both the geometric mean criterion and the 10% of samples (or single sample if less than 10 total samples) limit. These two measures used in combination ensure that bacterial pollution in a waterbody will be maintained at levels that will not cause a greater risk to human health than intended. While some discretion exists for selecting sample averaging periods, compliance will be evaluated for both monthly (if five or more samples exist) and seasonal (summer versus winter) data sets.

Appendix C
Analyses and Quality Assurance

Table C-1. Summary of Sampling and Analysis Procedures for Field and Laboratory Procedures

Analysis	Method or Equipment	Estimated Range	Lower Reporting Limit	Holding Time	Preservation	Container	Estimated Samples
Fecal Coliform Bacteria	**<u>Standard Methods,</u> Membrane Filter 9222D**	**0 - 1000 cfu/100mL**	**1cfu/100 mL**	**24 hours**	**Cool to 4ºC**	**250 ml autoclaved poly-bottle**	**9**
Water Velocity	**Marsh-McBirney Flo-mate 2000**	**0-30 ft/s**	**0.05 ft/s**	**N/A**	**N/A**	**N/A**	**9**

Table C-2. Measurement Quality Objectives for Field and Laboratory

Analysis	**Accuracy** percent deviation from true value	**Precision** Relative Standard Deviation (RSD)	**Bias** deviation from true value due to systematic error	Lower reporting Limits
Fecal Coliform Bacteria	**N/A**	**20 - 50% RSD***	**N/A**	**1 cfu/ 100mL**
Water Velocity	**±2% of reading +0.05 ft/s**	**0.1 ft/s**	**N/A**	**0.01 ft/s**

*Replicate results with a mean greater than 20cfu/100 mL.

Appendix D

Table D-1. Laboratory and field data for FC bacteria samples collected in Dobbs Creek watershed.
Blank fields represent no data collected.

Site Name	Sample Date	Sample Time	FC Bacteria Result (cfu/100mL)		FC Bacteria Field Replicate (cfu/100mL)		FC Bacteria Laboratory Duplicate (cfu/100mL)		Discharge (cfs)	Discharge Field Replicate (cfs)
D1	11/5/07	12:41	19		19		13		nd	
	12/10/07	10:13	110		140				3.40	
	1/7/08	11:00	88	J	120	J			9.82	
	1/14/08	15:28	200		260				11.91	
	1/30/08	15:35	3000	J	2800	J			5.25	
	2/11/08	14:40	140		69				8.69	
	2/25/08	14:44	40		26				1.97	1.75
	3/10/08	13:52	21		30				1.52	1.65
	3/24/08	13:03	350		320		380		5.85	
	4/7/08	12:58	280		340				2.14	2.17
	4/21/08	12:12	31		49				1.46	1.55
D2	11/19/07	11:55	100		84				0.73	
	12/10/07	11:35	43		43				1.86	1.91
	1/7/08	11:43	200	J					6.64	
	1/14/08	12:08	110						6.44	
	1/30/08	11:15	5300	J					2.89	
	2/11/08	11:30	120	J					6.26	
	2/25/08	13:32	40						0.53	
	3/10/08	11:25	31						0.35	
	3/24/08	11:25	450						4.13	
	4/7/08	11:12	120						1.09	
	4/21/08	10:33	37						0.15	
D2T	4/7/08	11:08	2400	J						
	4/21/08	10:34	370							
D3	11/19/07	12:45	87						0.78	
	12/10/07	12:08	35						1.68	
	1/7/08	12:28	160						5.97	
	1/14/08	12:53	150						6.04	
	1/30/08	12:10	4900	J					2.48	2.59
	2/11/08	12:20	120		110				5.72	
	2/25/08	11:23	46		51				0.48	
	3/10/08	12:06	61		33				0.23	
	3/24/08	11:59	480						3.96	
	4/7/08	11:51	210						0.58	
	4/21/08	11:12	3	U					0.19	

J - Organism positively identified, but numerical result is an estimate.
U - Organism not detected at or above the reported result.

Table D-1. *(continued)*

Site Name	Sample Date	Sample Time	FC Bacteria Result (cfu/100mL)		FC Bacteria Field Replicate (cfu/100mL)		FC Bacteria Laboratory Duplicate (cfu/100mL)		Discharge (cfs)	Discharge Field Replicate (cfs)
D4	11/19/07	13:50	140	J					0.28	
	1/7/08	14:37	63		92				6.13	6.60
	1/14/08	13:35	210						5.54	5.95
	1/30/08	14:50	3900	J					2.09	
	2/11/08	13:43	150						4.99	4.62
	2/25/08	11:54	870						0.30	
	3/10/08	13:15	5400	J					0.16	
	3/24/08	14:05	370		250				2.66	2.79
	4/7/08	13:49	1200		1300				0.46	
	4/21/08	13:02	210		170				0.09	
D5	3/24/08	14:12	62							
	4/7/08	14:00	10							
TFIELD	3/24/08	13:31	520							
	4/7/08	13:55	69							
TN	11/19/07	13:10	70				87		0.02	
	12/10/07	10:38	84				110		0.05	
	1/7/08	11:17	36	J					0.30	
	1/14/08	11:30	31				36		0.28	
	1/30/08	10:25	55						0.14	
	2/11/08	11:07	43						0.21	
	2/25/08	10:30	11				9		0.02	
	3/10/08	10:55	24						0.01	
	3/24/08	10:48	60						0.15	
	4/7/08	10:31	21	J			35	J	0.00	
	4/21/08	10:00	2							
TP	12/10/07	11:40	3							
	1/7/08	12:05	1	J			1	UJ		
	1/14/08	12:30	1	U						
	1/30/08	11:27	1	U					0.04	
	2/11/08	11:57	1	U			1	U	0.06	
	3/10/08	11:38	1	U			1	U		
CULVERT	1/7/08	11:57	360	J						
	1/14/08	11:56	700	J						
	1/30/08	10:35	300		290					
	2/11/08	11:26	17							
	2/25/08	12:14	7							
	3/10/08	11:04	96						0.01	
	3/24/08	11:05	160						0.06	
	4/7/08	10:45	260						0.02	
	4/21/08	10:12	40	J			14	J		

J - Organism positively identified, but numerical result is an estimate.
U - Organism not detected at or above the reported result.

Table D-1 *(continued).*

Site Name	Sample Date	Sample Time	FC Bacteria Result (cfu/100mL)		FC Bacteria Field Replicate (cfu/100mL)		FC Bacteria Laboratory Duplicate (cfu/100mL)		Discharge (cfs)	Discharge Field Replicate (cfs)
TE	12/10/07	12:20	3							
	1/7/08	14:18	2							
	1/14/08	13:20	21							
	1/30/08	14:30	83				91			
	2/11/08	13:23	8							
	3/24/08	13:15	19							
	4/7/08	13:15	1							

J - Organism positively identified, but numerical result is an estimate.
U - Organism not detected at or above the reported result.

Appendix E
Precipitation

Table E-1. Rainfall for Dobbs Creek for the 12 and 24 hour periods prior to sampling time at RM 0.1 (site D1). Highlighted cells indicate sampling events that met storm event criteria: at least 0.2 inches of rain in the previous 24 hours.

Sample Date	RM 0.1 Sampling Time	12 hour Rain (inches)	24 hour Rain (inches)
11/19/2007	12:41	0.03	0.04
12/10/2007	10:13	0	0.05
1/7/2008	11:00	0	0.05
1/14/2008	15:28	0.28	**0.28**
1/30/2008	15:35	0.14	**0.42**
2/11/2008	14:40	0	0.01
2/25/2008	14:44	0.02	0.02
3/10/2008	13:52	0.1	0.1
3/24/2008	13:03	0	**0.22**
4/7/2008	12:58	0.3	**0.36**
4/21/2008	12:12	0	0.16

Appendix F
Loading

Table F-1. Dobbs Creek loading analyses data (billions of FC/day). *Rain events are bolded.*

Date	Site (Flow direction ⇒)			
	D4	D3	D2	D1
11/19/2007	0.95	1.66	1.65	x
12/10/2007	x	1.44	1.96	10.41
1/7/2008	11.64	23.41	32.56	25.02
1/14/2008	**28.5**	**22.19**	**17.37**	**67.13**
1/30/2008	**200.08**	**298.08**	**375.14**	**373.3**
2/11/2008	18.33	16.12	18.4	22.25
2/25/2008	6.46	0.57	0.52	1.6
3/10/2008	21.7	0.27	0.27	0.95
3/24/2008	**20.17**	**46.53**	**45.54**	**48.02**
4/7/2008	**14.21**	**2.99**	**3.2**	**16.28**
4/21/2008	0.4	0.01	0.13	1.43

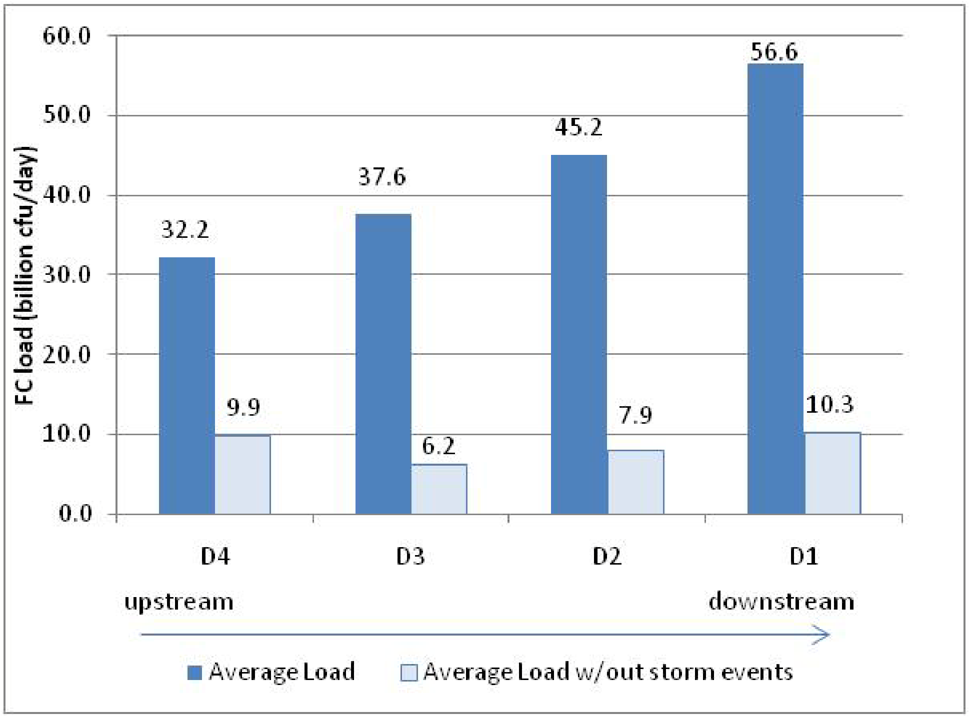

Figure F-1. Average fecal coliform loading in mainstem Dobbs Creek. *The average is shown with and without the influence of storm events.*