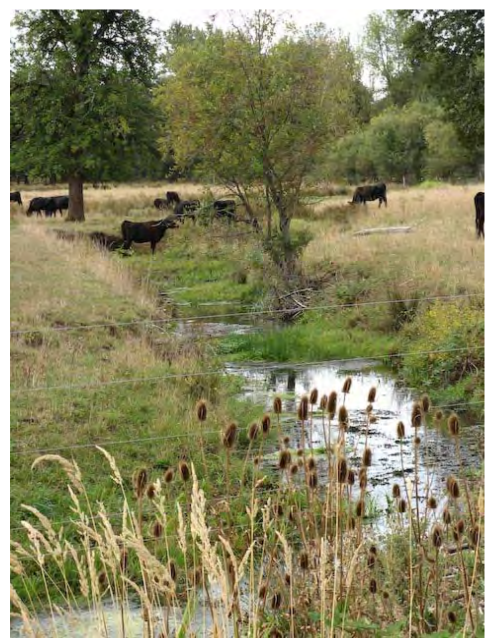
Water Quality Results for the Middle and Coast Fork Willamette Watersheds and Eight Small Cities in the Upper Willamette Sub-basin: 2008- 2010



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Oregon Department of Environmental Quality
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Executive Summary

The Middle Fork Willamette, Coast Fork Willamette and Long Tom Watersheds encompass a large and diverse landscape in the southern Willamette Valley. These watersheds are home to fish, wildlife and people who rely on a supply of clean water for multiple uses. Responsible management of our landscape helps protect and preserve this resource. Understanding current water quality conditions surrounding towns and rural areas supports our ability to identify steps to protect the resource in the long run.

Several watersheds in the upper Willamette region are listed on the 303(d) list under the Clean Water Act with a number of stream segments that do not meet State Standards for temperature, bacteria and mercury. In addition to these listings, it was suspected that there might be nutrient, bacteria and dissolved oxygen problems in rural and residential sub-watersheds that had no previous monitoring data. Eight small cities in the Upper Willamette in Lane County were designated as Management Agencies (DMAs) for the purpose of implementing the 2006 Upper Willamette Total Maximum Daily Load (TMDL) allocations for temperature, bacteria, and mercury. All DMAs were required to develop implementation plans to reduce their contributions to the three parameters in the TMDL. A significant limitation in implementing these plans is the lack of data identifying DMA contributions to water quality issues.

This study was created to develop baseline water quality data for certain rural areas of the Middle Fork and Coast Fork Willamette Watersheds. In this study, monthly water quality samples were taken both upstream and downstream of eight small city DMAs in Lane County. A total of 40 sites were monitored for dissolved oxygen, water temperature, conductivity, turbidity, total suspended solids, nitrogen, phosphorus, and *E. coli*. A subset of these sites was also monitored for macroinvertebrates. In addition, the Springfield Utility Board (SUB) was interested in determining concentrations of volatile organic chemicals (VOC), synthetic organic chemicals (SOC), inorganic chemicals, and secondary contaminants in surface waters because of their impact on drinking water quality. Four sites on the Middle Fork Willamette River were sampled for these parameters. Detailed location information for all of the sampling sites included in this project is found in Appendix A.

This study encompassed two years of sample collection and is intended to provide a baseline for future work.

Upper Middle Fork Willamette Watershed

- The North Fork of the Middle Fork where it flows through Westfir did not meet State Standards for temperature and dissolved oxygen and the DEQ benchmark for total suspended solids. However, turbidity levels were significantly higher at the upstream site than at the downstream site.
- McLean Creek did not meet State Standards or benchmarks for dissolved oxygen, *E. coli,* conductivity, turbidity, total suspended solids, total phosphorus, and nitrate.
- The Middle Fork Willamette River in Oakridge did not meet the State Standard for dissolved oxygen nor the DEQ benchmarks for conductivity, turbidity and total suspended solids
- Salt Creek and Salmon Creek, which are tributaries to the Middle Fork in Oakridge did not meet the State Standard for dissolved oxygen nor the DEQ benchmarks for conductivity, total suspended solids, and total phosphorous. Salt Creek did not meet the benchmark for turbidity.

Lower Middle Fork Willamette Watershed

- The small ephemeral stream that runs through Lowell did not met State Standards for dissolved oxygen and *E. coli* but did meet the standard for temperature.
- Results from the stretch of the Middle Fork Willamette River between Dexter Dam and the Springfield Drinking Water Treatment Plant in Springfield did not meet State Standards for temperature or dissolved oxygen but did for *E. coli.*
- Wallace Creek, a small tributary that enters the Middle Fork Willamette River downstream of Dexter Dam and which dries up in the summer, always met the State Standard for temperature but did not for dissolved oxygen and *E. coli.*
- Hills Creek, also a small tributary to the Middle Fork Willamette River downstream of Dexter Dam, did not meet State Standards for temperature, *E. coli* or dissolved oxygen. DEQ benchmarks for turbidity and total inorganic nitrogen were also not met.
- Fall Creek, a large tributary to the Middle Fork Willamette River, did not meet State Standards for temperature or dissolved oxygen. The DEQ benchmark for turbidity was not met 33% of the time.
- Results from Lost Creek, a large tributary of the Middle Fork Willamette River that enters downstream of Dexter Dam, did not meet State Standards for dissolved oxygen or temperature at both up and downstream sites and for *E. coli* at the downstream site only.
- Results from Little Fall Creek, another large tributary of the Middle Fork Willamette River that enters downstream of Dexter Dam, did not meet State Standards for temperature or dissolved oxygen.

Coast Fork Willamette Watershed

- The results from the Coast Fork Willamette River in the stretch that flows through Cottage Grove did not meet State Standards for dissolved oxygen and *E. coli* at both up and downstream sites. The standard for temperature was not met at the downstream site. DEQ benchmarks for turbidity and total suspended solids were not met at both sites. Total phosphorous and total inorganic nitrogen were not met at the downstream site.
- Silk Creek, which flows through Cottage Grove, did not meet State Standards for dissolved oxygen and *E. coli*. The DEQ benchmark for conductivity was not met 83% of the time at both up and downstream sites and turbidity was not met 83% at the upstream site and 50% at the downstream site.
- The section of Silk Creek that is upstream of Cottage Grove did not meet any of the State Standards for the parameters that were measured. Also the DEQ benchmarks for conductivity and turbidity were not met.
- The results for Mosby Creek exceeded State Standards for temperature and dissolved oxygen.
- Gettings Creek did not meet State Standards for temperature, dissolved oxygen or *E. coli,* with the downstream sampling site not meeting the *E. coli* standard 54% of the time. Also, the DEQ benchmark for conductivity was not met at either the upstream or downstream sites and the benchmarks for turbidity, total suspended solids, and total inorganic nitrogen were not met at the downstream site.
- The results for Hill Creek, which runs through a series of ponds in Creswell, did not meet the State Standard for dissolved oxygen at both upstream and downstream sites, as well as the standard for *E. coli* at the downstream site. The results for the unnamed creek that drains stormwater from the western side of Creswell did not meet State Standards for dissolved oxygen and *E. coli*.

Long Tom Watershed

- Tributary 1 which flows through Junction City did not meet State Standards for temperature but did for *E. coli* and dissolved oxygen.
- Tributary 2 which flows through Junction City did not meet State Standards for temperature at the downstream site and dissolved oxygen at the upstream site.
- Results for the small ephemeral waterway that flows through Veneta exceeded State Standards for *E. coli* and dissolved oxygen but not temperature

This study was not conducted for regulatory purposes. Monitoring results of the basic water quality parameters measured in this study will be shared with city councils and citizens in the region to highlight how small cities and rural residents can protect waterways and riparian areas to attain high water quality. Results from targeted monitoring in the future can play a role in determining the location, type, and prioritization of restoration activities undertaken by watershed councils and best management practices by DMAs.

Introduction

Stream health is important to the well-being of inhabitants of the Willamette River Watershed. The Upper Willamette Valley is one of the most densely populated areas in the State of Oregon, encompassing about 2 million acres. It includes the McKenzie, Middle Fork Willamette, Coast Fork Willamette, and Long Tom watersheds. The Upper Willamette River Basin has about 225,680 people or about 6% of Oregon's population (LCOG 2008b). As our population grows, water quality problems may intensify as more land is converted from farms and forests to urban and rural residential landscapes. Yet, expectations by the public for clean drinking water and healthy streams for fishing, boating, and swimming will not decrease. Protecting water quality starts with having an understanding of current conditions.

The Oregon Department of Environmental Quality (DEQ) has been regulating and monitoring water quality in the state since 1938 (www.oregon.gov/DEQ). Initially, its mission was to improve conditions in the Willamette that had been degraded by the discharge of untreated sewage into the river. Over time, the agency began regulating all point sources, requiring storm water management plans for large cities, and monitoring streams across the state. Now, streams known to not meet water quality standards are placed on the 303(d) List of Water Quality Limited Streams and the DEQ develops Total Maximum Daily Loads (TMDLs) for each listed water quality attribute. These load limits are enforced through city storm water and industrial discharge permits and water quality management plans implemented by the Oregon Departments of Agriculture and Forestry. In 2006, DEQ developed TMDLs for temperature, bacteria, and mercury for the upper Willamette Basin. In addition to the listed stream segments, it was suspected that there might be temperature, nutrient, bacteria and dissolved oxygen problems in rural and residential sub-watersheds that had no previous monitoring data.

Eight small cities in the Upper Willamette in Lane County were selected by DEQ as Designated Management Agencies (DMAs) for the purpose of implementing the 2006 TMDL allocations for temperature, bacteria, and mercury. All DMAs were required to develop implementation plans to reduce contributions of the three parameters addressed in the Upper Willamette TMDL. In 2007, the DMAs worked with watershed councils to develop implementation plans that describe management practices that they will use to reduce contributions to stream temperature, *E. coli*, and mercury levels (http://www.lcog.org/tmdl/). However, a limitation in understanding the effectiveness of these plans is the lack of background data to evaluate DMA contributions to water quality issues.

This two-year study was initiated to develop baseline water quality data for the rural areas of the Middle Fork and Coast Fork Willamette Watersheds and evaluate water quality impacts of the eight small-city DMAs located in or near the Middle Fork Willamette, Coast Fork Willamette, and Long Tom Watersheds. Results from this study and future studies can be used to determine location, type and priority of voluntary restoration activities and best management practices to protect and improve water quality and to assess progress towards water quality goals.

Together with the Coast Fork and Long Tom Watershed Councils, the Middle Fork Willamette Watershed Council (MFWWC) received funding from DEQ and Springfield Utility Board (SUB) to implement this water quality monitoring project in the upper Willamette basin. Project partners included the Cities of Oakridge, Westfir, Lowell, Creswell, Cottage Grove, Veneta, Junction City and Coburg, SUB, DEQ, United States Forest Service, United States Army Corps of Engineers and Oregon Department of Fish and Wildlife.

Chapter 1:

Monitoring Goals and Study Design

This study was designed to establish baseline water quality monitoring data in the Coast and Middle Fork Willamette watersheds and identify impacts from DMAs in the Coast Fork, Middle Fork and Long Tom watersheds. The project goals and monitoring questions listed below provide the framework for this study.

Project Goals

- Provide water quality data that each DMA can use to evaluate their relative impacts on the water quality of streams flowing through their zone of influence;
- Support the implementation of management practices that target water quality impacts identified during the monitoring phase. This may include adding management practices to the DMAs' TMDL Implementation Plans;
- Establish baseline water quality information that may later be used to evaluate long-term trends and effectiveness of management practices implemented by each DMA and councils;
- Evaluate bacteria, total suspended solids, turbidity, dissolved oxygen, temperature, and nutrient concentrations in rural residential sub-watersheds of the Coast and Middle Fork Willamette that did not yet have data
- Provide relevant, locally generated, and site specific monitoring results that support outreach and education efforts to local residents and decision makers; and
- Prioritize enhancement and restoration actions that address identified water quality problems within the DMAs and the surrounding rural areas within the Middle and Coast Fork Willamette and Long Tom watersheds.

Monitoring Questions

- Is there a statistically significant difference in water temperature, *E. coli*, total inorganic nitrogen, total phosphorus, total suspended solids, turbidity, dissolved oxygen and biological indices (macroinvertebrate metrics) between upstream and downstream sampling sites bracketing the DMAs (small cities)?
- Do *E. coli*, dissolved oxygen, and temperature conditions in the monitored urban and rural waterways meet State Standards?
- Do total suspended solids, conductivity, total phosphorus, total inorganic nitrogen meet State benchmarks?
- Are there detectable amounts of Volatile Organic Chemicals or Synthetic Organic Chemicals present during fall (first flush) runoff or subsequent storm-related runoff events that would impact drinking water treatment or other environmentally sensitive processes?

We conducted monthly monitoring over a two year period at 40 sites (Figure 1), 24 of which were on perennial streams and the remaining 16 on intermittent streams (Appendix A). The site locations for this study were based on the type of information needed to make key decisions regarding management practices and restoration goals of the watershed councils and small cities. Twenty four of the sites were located above and below the DMAs in an effort to determine their impact on adjacent waterways. Sixteen other sites were chosen in rural parts of the Middle Fork and Coast Fork Willamette sub-watersheds to gather baseline data on non-point sources of pollution. All but three of the sites were paired in upstream/downstream combinations in an attempt to detect the impact of those areas/land uses on water quality. The other three sites were included to assess the water quality of three major tributaries just upstream of their confluence with the Middle Fork Willamette and thereby gain information on their potential impact on overall water quality in the watershed.

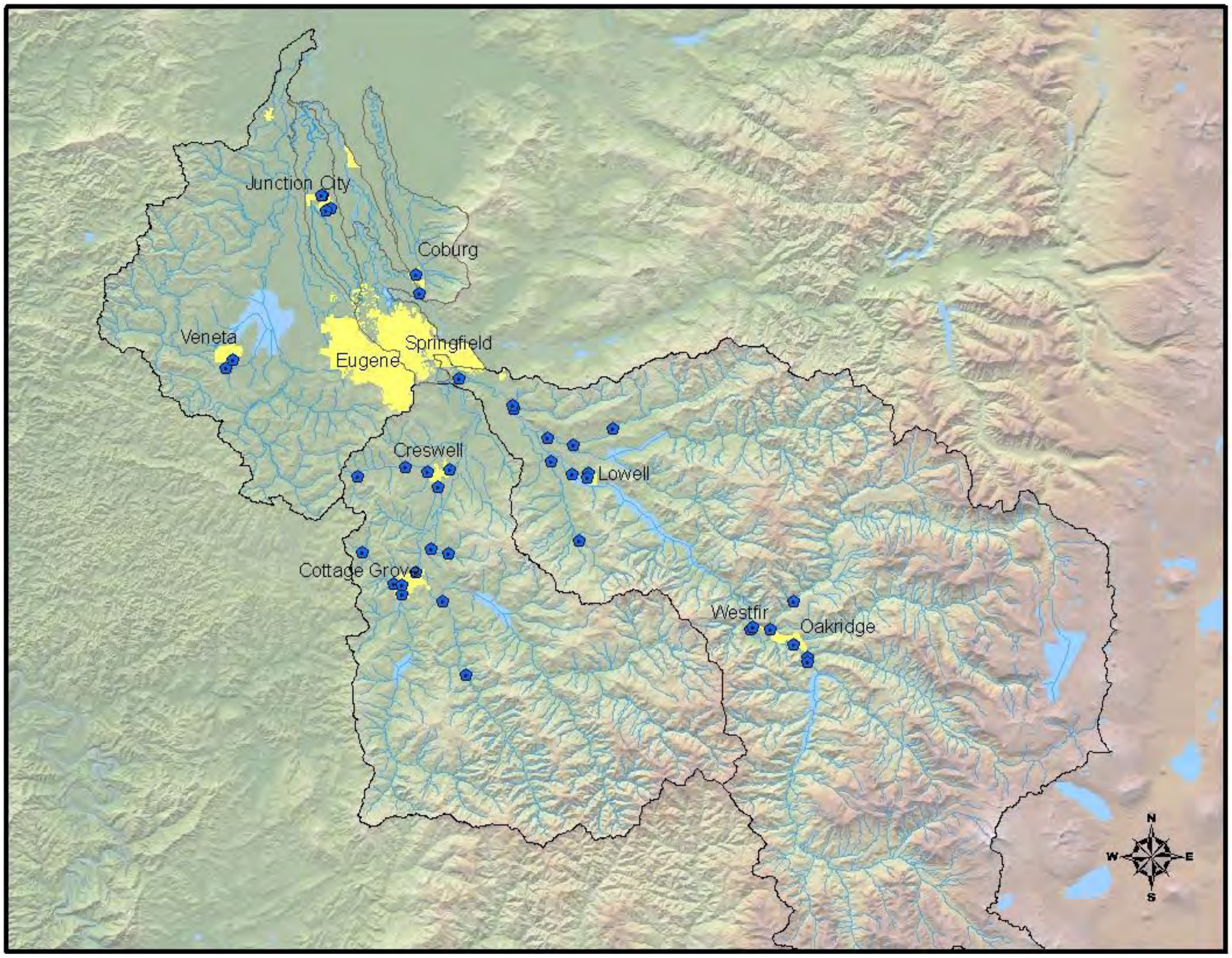

Figure 1. Monitoring sites in the Middle Fork Willamette, Coast Fork Willamette and Long Tom watersheds.

Sampling Methods and Parameter Descriptions

Monthly Sampling

Sampling began in October of 2008 and was completed in September of 2010. Monthly field samples were collected at 24 sites and once during every month there was flowing water at the remaining 16. Monthly water quality parameters included single-reading temperature, dissolved oxygen, *E. coli*, turbidity, conductivity, total suspended solids, total inorganic nitrogen and total phosphorous as described in Appendix B and the Quality Assurance Project Plan. These outline the protocols used in this study. Volunteers measured and recorded water temperature, conductivity, dissolved oxygen, and turbidity in the field and collected surface water samples for *E. coli* and nutrients that were later analyzed by a water quality testing laboratory.

Temperature: The biologically-based numeric temperature criterion applicable to streams and tributaries varied between the subwatersheds being sampled. The specifics of the requirements for each site are included in Appendix F. The State Standard for temperature is based on a 7-day moving average of daily maximum temperatures. Water temperatures above the standards can affect fish, especially trout and salmon. High temperatures can make them more susceptible to disease, elevate their metabolism so they require more food to survive, and render them less able to compete with introduced warm water game fish. Primary determinants of stream temperature include air temperature, direct solar radiation, and stream flow.

Dissolved oxygen (DO): The state dissolved oxygen standard is 8 mg/L for cool water aquatic life and 11 mg/L for cold water aquatic life, depending on the time of year. Details on the requirements for each of our collection sites are included at the top of the chart for each site in Appendix E. One factor affecting the amount of dissolved oxygen in water is water temperature. The higher the temperature the less oxygen water can hold. Another factor is the amount of biological activity. If a lake or stream has high nutrient concentrations it stimulates the growth of algae. This can lead to high dissolved oxygen levels during the day as algae are photosynthezing but low levels at night when bacteria that break down organic matter are respiring but the algae are not adding oxygen to the water through photosynthesis. Low levels of dissolved oxygen can be stressful to fish.

Bacteria: *E. coli* originates from fecal matter and can be an indicator of fecal contamination of surface waters. Bacteria levels vary greatly over the course of a year and tend to be highest just after soils become saturated in the fall. Common sources include runoff carrying livestock manure, fecal matter from wildlife or domestic pets, and human sewage from leaking septic systems or sewer connections.

Conductivity: Conductivity is related to the total dissolved solids (typically salts) concentration in water and in some cases can be an indicator of pollution.

Turbidity & Total Suspended Solids: Turbidity, which is measured by the amount of light that can pass through a water sample, is often used as a surigate for measuring the suspended sediment concentration because it is inexpensive and easy to measure. High turbidity and suspended sediment levels may interfere with visual feeding by fish, smother eggs, and impair gill respiration. Typically, turbidity levels increase during periods of rainfall. Sources of sediment to streams include stormwater that flows off impervious surfaces, landslides next to streams, streambank erosion, and runoff from roads and construction sites.

Total inorganic nitrogen/Total phosphorus: Water quality and associated instream habitat can deteriorate when nutrient concentrations increase (Horne & Goldman, 1994). An increase in nitrogen and phosphorus can increase a stream's algal or plant productivity which can then lead to low dissolved oxygen levels. Sources of increased nutrient levels can include septic systems adjacent to a river or lake, discharge from wastewater treatment plants, industrial discharges, runoff from impervious surfaces, and leaching of fertilizer that is used on both urban and agricultural land.

Storm Monitoring

Samples were collected at all DMA sites for turbidity, total suspended solids, *E. coli,* total phosphorus and total inorganic nitrogen during the first major storm event for each site in both 2009 and 2010. The rationale for this was to capture the effect that storm runoff has on water quality exiting a particular DMA. Criteria for sample collection was determined primarily by the amount of significant rainfall preceded by at least a week of no rain, as well as how much of the storm collection system of the particular municipality was comprised of grassy ditches, paved roadways with storm grates or some mixture of the two.

Continuous Temperature Monitoring

The Water Quality Technician deployed continuous temperature probes during the summer in both 2009 and 2010 in accordance with the procedures outlined in Chapter 6 of the OWEB Water Quality Monitoring Guidebook (also found in the QAPP). Continuous temperature loggers were checked for accuracy before and after field deployment and were set to record a data point once an hour. The monitoring coordinator conducted independent field audits at each site using a National Institute of Standards and Technology (NIST) traceable thermometer at the time of deployment and retrieval.

Macroinvertebrate Monitoring

Benthic macroinvertebrates are organisms that lack backbones. They are aquatic for part or all of their life cycle, and can be found on rocks, wood, algae, or other surfaces within a stream. Examples are crayfish, clams, snails, aquatic worms, and the larval stage of dragonfly and caddisfly. We selected this group of organism (instead of fish) as an indicator of the biological health of streams for several reasons. First, macroinvertebrates exist in all types of streams and are not affected by the physical barriers to which fish are susceptible. Also unlike fish, they cannot leave a stream when conditions are poor and return when they are better. Second, they possess a range of sensitivities to pollutants and other stressors in the environment, such as water temperature, riparian conditions, and stream bottom characteristics. Third, they are relatively sedentary and live in a stream over a long period of time, so they reflect conditions in the water that might not be detected by water quality samples that are collected at discrete points in time

For this study, we collected macroinvertebrate samples at 11 of the 24 DMA sites in the summers of 2009 and 2010. The remaining 13 DMA sites were not suitable for macroinvertebrate collection due to depth, lack of velocity, or dangerous sampling conditions. Samples were collected following the Oregon DEQ Benthic Macroinvertebrate Protocol for Wadeable Rivers and Streams as described in the QAPP for this project. Samples were sent to ABR, Inc Environmental Research & Services in Forest Grove, OR for analysis. Specific methods and results are described in Appendix G.

SOC/VOC Monitoring

A water quality concern for treating drinking water relates to concentrations of volatile organic chemicals (VOC), synthetic organic chemicals (SOC), inorganic chemicals, and secondary contaminants in the raw water used for processing. Springfield Utility Board (SUB), a stakeholder for this project, was interested in these contaminants because of the potential impact of these compounds on the quality of drinking water. SUB is required to provide treatment to reduce any of these parameters that might exceed one half of the Maximum Contaminant Level (MCL). In addition to the health risks associated with most of these parameters, some chemicals pose a problem for the treatment processes that they employ. The VOC and SOC contaminants are a particular risk for SUBs current treatment processes because SUB currently uses a slow sand filtration process in combination with ultraviolet light and chlorine. It does an excellent job of treating *E-coli*, Giardia, Cryptosporidium, and other biologic contaminants but does little to treat greases, oils, gasoline, or other VOCs. It also does not remove herbicides or pesticides. SUB is being proactive in the Middle Fork Willamette watershed monitoring program in order to identify the need for treatment processes in advance of a recognized health risk to the community, and more importantly, to identify problems early so that protective measures and actions can be taken to reduce or eliminate contamination at the source.

SOC/VOC collection occurred at four sites, two times each year in the Middle Fork Willamette watershed. Collection occurred during the first measureable storm in fall of 2008 and 2009 and once a year during a dry period in June and July of 2009 and 2010. Determination of a measureable storm was based on a 24-hour period of heaviest rain after a 24-48 hour period of light rain. Also, information on the peak discharge from the US Army Corps of Engineers' dams was considered, since all collection sites for these parameters are below the flood control dams on the Middle Fork Willamette River.

Analytical Methods

Comparison to State Standards or Benchmarks

State Water Quality Standards exist for *E. coli,* continuous temperature, and dissolved oxygen (Appendix C). Two State Standards for *E. coli* have been developed and are used as an indicator of pathogenic bacteria associated with fecal matter. The standard used in this project applies to single samples and the allowable maximum is 406-organisms/100 mL of water. The state temperature standard that applies to continuous temperature data varies according to stream location and designated fish use (Appendix F). If a particular stream has no fish use designation, then the DEQ regular definition of summer as June 1 through September 30 is applied. The continuous temperature data was summarized as 7-day moving averages and is the basis for comparisons to the temperature standard. The state dissolved oxygen standard is based on fish life history needs. Dissolved oxygen concentrations below 8.0 mg/L or 90% of saturation in most waters, or 11.0 mg/L or 95% of saturation in bull trout spawning habitat (upper McKenzie and upper Middle Fork Willamette) do not meet the State Standard. Turbidity, TSS, TOTAL INORGANIC NITROGEN, total P, and conductivity were assessed against benchmarks presented in *Willamette Basin Rivers and Streams Assessment,* a DEQ report written in December 2009 (Appendix D). These benchmarks were created by surveying 451 randomly selected and 238 hand-selected reference sites between 1994 and 2007 for the period from late June to late September. As the benchmarks were created using data collected during the summer months, they are not comparable to data collected during the winter months of our study.

Statistical Tests

The data collected from the sites associated with the DMAs were compared in upstream and downstream pairs using a non-parametric method called the Wilcoxon Signed-Ranks Test[1] for the larger datasets. For smaller data sets (< 11) and when comparing different streams to each other, the Mann-Whitney Test[2] was utilized. Data was analyzed for statistical significance of the difference between pairs for all eight parameters.

Macroinvertebrates

ABR, Inc Environmental Research & Services analyzed the results for the macroinvertebrate sampling. They analyzed the data using two models. Both models generate a score for each site by comparing the number of taxa indentified in the samples with the number of taxa that would be expected from reference sites in the region. Reference sites are characterized by having the least amount of human disturbance and good water quality and habitat conditions. The Oregon Marine Western Coastal Forests Predictive Model classifies streams as poor, fair, or good condition. The Western Oregon Multimetric Index (PREDATOR) classifies streams as severely impaired, moderately impaired, slightly impaired, or not impaired. See Appendix G for further description.

The PREDATOR model compares the number of taxa observed (O) at the sampling location to the number of taxa expected (E) at a minimally disturbed reference site. In some cases, the

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[1] Wilcoxon Signed-Ranks Test. Nonparametric test for the significance of the difference between the distributions of two non-independent samples involving repeated measures or matched pairs. This program evaluates a set of n paired values of X_a and X_b, and performs the necessary rank- ordering and then produces results including P values for statistical significance. Minimum N of 11 pairs. http://faculty.vassar.edu/lowry/VassarStats.html

[2] Mann-Whitney Test. Nonparametric test for the significance of the difference between the distributions of two independent samples, A and B, of sizes n_a and n_b, respectively. The samples can be s same or different sizes with a minimum of n = 5. http://faculty.vassar.edu/lowry/VassarStats.html

reference sites may not be appropriate references for sites that are being assessed. The MFWW and the CFW encompass two separate predictive model "zones", so some of the sample sites may not be well represented by reference conditions used in the model (*see page 12 of http://www.deq.state.or.us/lab/techrpts/docs/10-lab-004.pdf*). Another limitation with the PREDATOR model is that for sample sites with scores in the 10th to 25th percentiles of reference distributions, there is lower confidence that the O/E score is outside of the reference distribution, and additional samples are warranted (Hubler 2008).

SOC/VOCs

Analytical Lab, Eugene, OR analyzed the data from the SOC/VOC sampling. See QAAP for more information on methodology. No further analysis was conducted for these results because the lab found no detections.

Chapter 2: Middle Fork Willamette Watershed

The Middle Fork Willamette watershed (MFWW) is a 1355 square mile (867,110 acre) watershed (Hydrologic Unit Code 17090001) located in the southeastern portion of the Willamette Valley. It is located mostly within Lane County with a small portion in Douglas County; and includes the cities of Lowell, Westfir, Oakridge, Pleasant Hill, and southern Springfield. Eleven 5th field sub-watersheds are identified for the basin:

- Fall Creek
- Hills Creek
- Hills Creek Reservoir
- Little Fall Creek
- Lost Creek
- Lower Middle Fork Willamette
- Middle Fork Willamette / Lookout Point
- North Fork of Middle Fork Willamette
- Salmon Creek
- Salt Creek
- Upper Middle Fork Willamette

The watershed is dominated by public and private forest with some agriculture and residential land use in the lower watershed (Figure 2). Ownership is approximately 75% public, most of which is managed by the United States Forest Service (USFS) and the Bureau of Land Management (BLM). Small, private landholders and industrial timber companies comprise the remainder of the watershed.

The Middle Fork Willamette River (MFWR) conveys rain and snowmelt from the western Cascade Range and joins the Coast Fork River to form the Willamette River. Waldo Lake is in the headwaters and is a large natural lake with some of the purest water in the world. MFWW has more flow-control reservoirs than any other watershed in the Willamette basin. There are four reservoirs in the watershed, three on the mainstem river: Dexter, Lookout Point, and Hills Creek; and one on a tributary: Fall Creek. Six active USGS flow monitoring stations are located in the watershed – four on the mainstem (above Salt Creek, below North Fork Middle Fork, Dexter, Jasper), one on Fall Creek and one on Winberry Creek. The MFWR provides habitat to bull trout, Oregon chub, spring Chinook, summer and winter steelhead. The river also provides water to farms and communities and the lakes, reservoirs, and rivers are used for boating and fishing.

Monitoring sites in the MFWW include three DMAs (Lowell, Oakridge and Westfir), two large tributaries downstream of the dams (Lost Creek and Little Fall Creek), and five additional sampling sites on the mainstem river below Dexter Dam. Lost Creek and Little Fall Creek have areas of rural residential development in their lower reaches. Paired upstream and downstream sampling sites in these sub-watersheds were included in this study due to their high-priority status with the watershed council. Of the five additional sampling sites, two are located directly along the Middle Fork Willamette River just below Dexter Dam and at the Springfield Treatment Plant intake in Springfield. Three more sites are located at the confluences of Wallace, Hills and Fall Creeks with the Middle Fork.

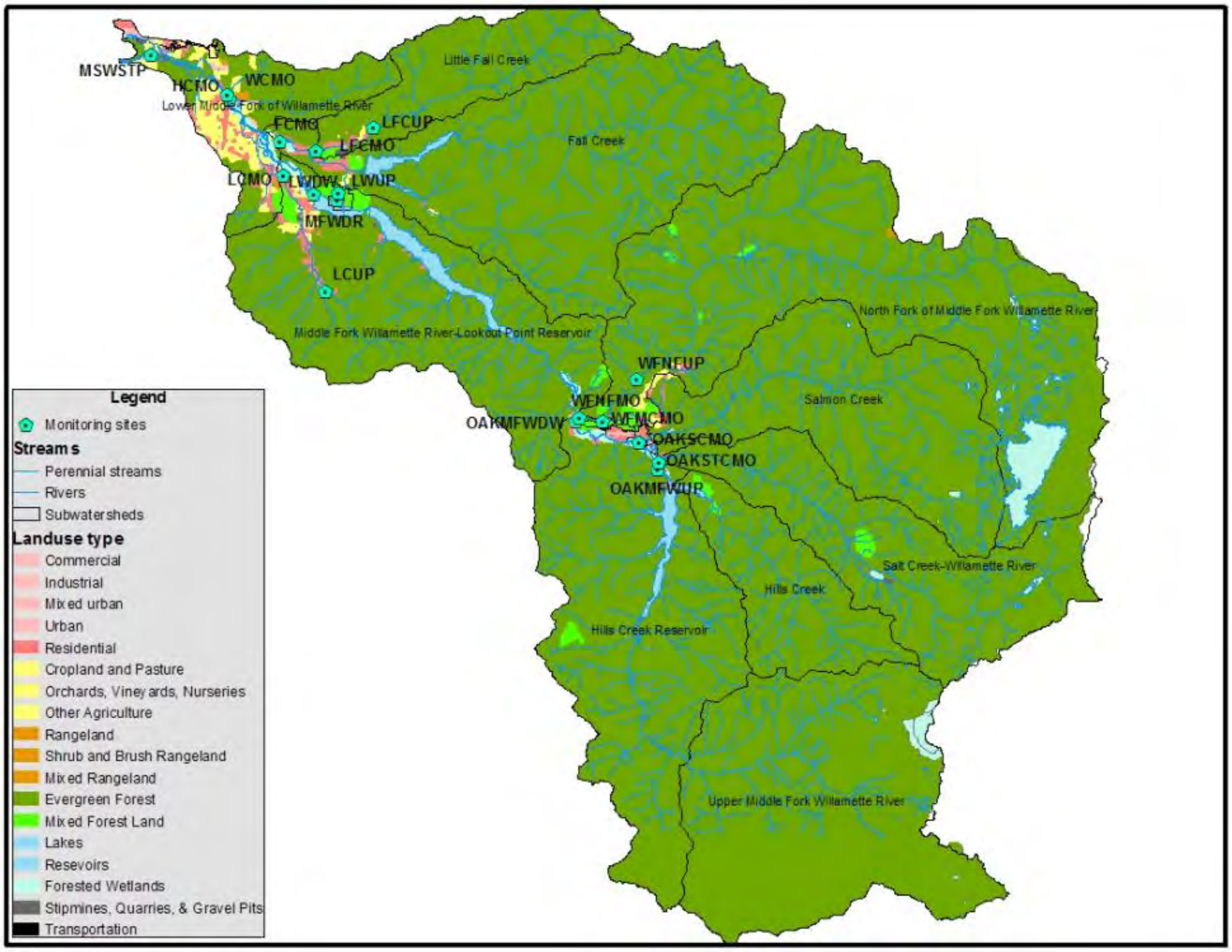


Figure 2. Middle Fork Willamette Watershed Monitoring Sites and Land Use.

Middle Fork Willamette Watershed Designated Management Areas

Middle Fork Willamette River - City of Oakridge, Salmon Creek and Salt Creek

The City of Oakridge is located east of the confluence of the North Fork Middle Fork and Middle Fork Willamette River and southwest of Hills Creek Reservoir and is surrounded mostly by forest land.

Geography: Oakridge's population in 2009 was estimated to be 3221 people. In the year 2000, nearly 22% of the land inside Oakridge's Urban Growth boundary was outside the city limits. Fifty-four percent of land in Oakridge is zoned for residential use, 32.1% is zoned for commercial, industrial, or mixed-use, the remaining land is zoned for parks/open space, public use, and aggregate extraction.

Current water quality policies: Oakridge does not have stormwater detention facilities or programs to detect and eliminate illegal discharges. The City performs a comprehensive stormwater maintenance program through the Public Works Department and trains employees in proper maintenance procedures. The City has implemented a Critical Drainage Area Ordinance, which requires a vegetation removal permit for activity on steep slopes.

Monitoring sites: We sampled four sites in Oakridge, two on the Middle Fork Willamette (OakMFWUP and OakMFWDW) up and downstream of potential influences of Oakridge, and one each at the mouths of Salt Creek (OakSTCMO) and Salmon Creek (OakSCMO) (Figure 3). Salt Creek and Salmon Creek empty into the Middle Fork Willamette midway between the upstream and downstream sampling sites that bracket the City of Oakridge.

Oakridge Middle Fork Willamette (OakMFWUP and OakMFWDW): Results from monthly samples upstream and downstream of Oakridge on the Middle Fork indicate generally good water quality that does not diminish as it passes through the city (Table 1). State Standards for *E. coli*, were consistently met (Figure 4, Appendix E). Although the monitoring site downstream from Oakridge (OakMFDW) had statistically higher values for conductivity and *E. coli*, the levels for *E. coli* were low. Additionally, storm sampling at the two Middle Fork sites indicated higher *E. coli* in the winter of 2008 – 2009 than the winter of 2009 – 2010 although the State Standard for *E. coli* was never exceeded for either of the sites in either year.

Some indications of poorer water quality did arise through the sampling period (Table 1). DO only met State Standards 50% of the time at the upstream site and 56% of the time at the downstream site (Figure 5). DO levels were statistically lower at the upstream site than at the downstream site, especially in late spring and fall (Appendices E). Summer results indicate high turbidity and TSS at both monitoring sites, resulting in fair to poor water quality during July through early September (Figure 6). Turbidity levels exceeded the reference conditions 100% of the time in the summer months for both up and downstream collection sites, with the upstream site having the statistically significantly higher values. Much of this elevated turbidity likely originates at Hills Creek Reservoir. Authors of a 1971 investigation of turbid water exiting the Hills Creek Reservoir attributed the high turbidity to smectite clay minerals in the soils (http://ir.library.oregonstate.edu/xmlui/handle/1957/297). The clay is common in the watershed and is delivered to the reservoir by streams and then is kept in suspension by wave lap along the edge of the reservoir.

TSS levels exceeded the DEQ benchmarks 33% of the time for the upstream site and 17% for the downstream site on the Middle Fork (Table 1).

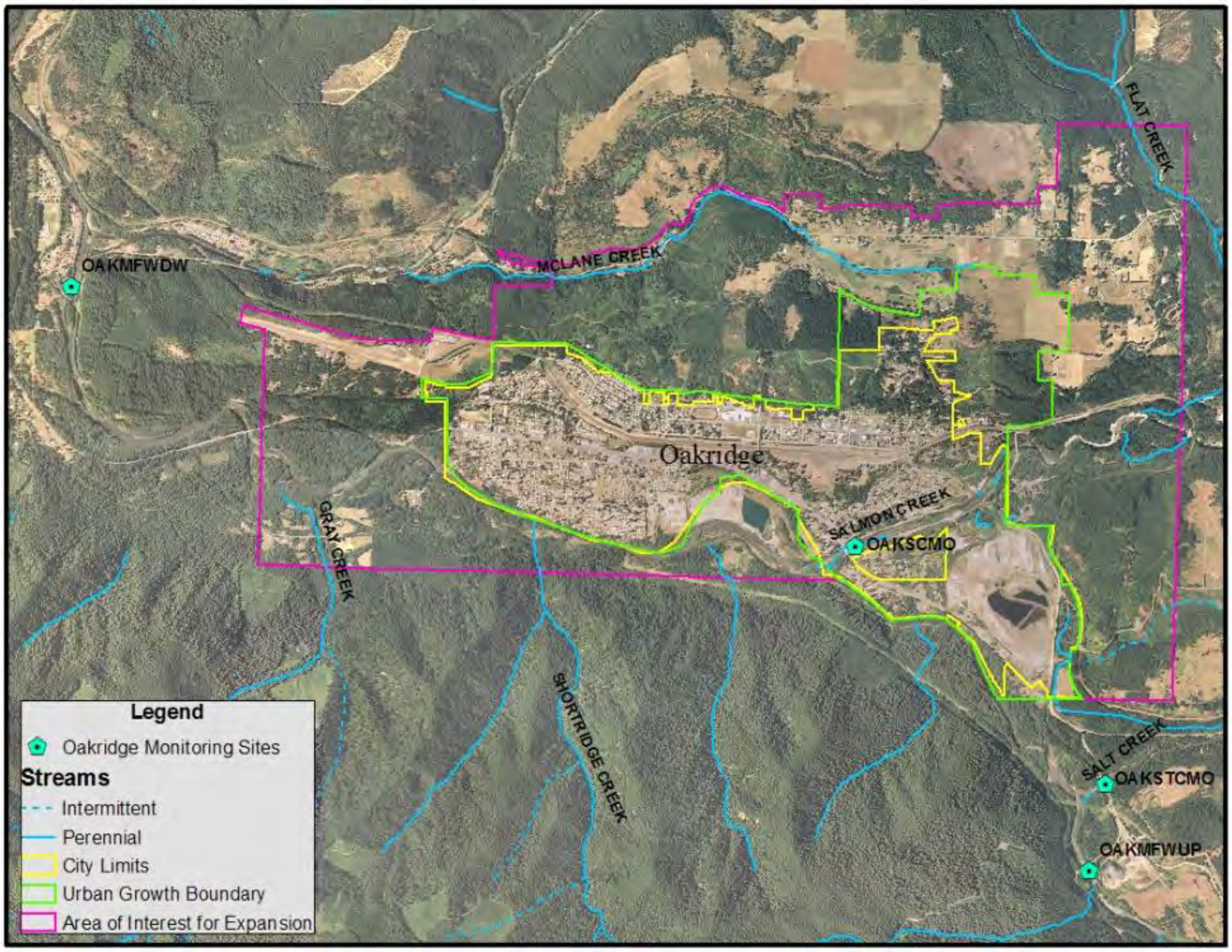


Figure 3. Oakridge monitoring sites, city limits, urban growth boundary, and expansion interest area.

Macroinvertebrate sampling was conducted at both sites in 2010. Results from the western Oregon multimetric index show that the upstream site has "Moderate Impairment" and the downstream site has "None". The predictive model scores showed that the upstream site is categorized as "Most Disturbed" and the downstream site is listed as "Least Disturbed" (Appendix G).

Table 1. Comparison of the Middle Fork Willamette River in Oakridge, Salt Creek and Salmon Creek water quality results with State Standards or benchmarks, from the upper most to the lower most monitoring site. A complete summary of results can be found in Appendix E.

	Oakridge MF upstream (OakMFWUP)	**Salt Creek (OakSTCMO)**	**Salmon Creek (OakSCMO)**	**Oakridge MF downstream (OakMFWDW)**
Temperature Standard	No continuous data	No continuous data	No continuous data	No continuous data
DO Standard*	Failed 50%	Failed 44%	Failed 56%	Failed 44%
E. coli Standard*	Good	Good	Good	Good
TSS (summer	Good/Fair	Fair	Good	Good

benchmark)				
Turbidity* (summer benchmark)	Poor	Good	Good	Poor/Fair
Conductivity* (summer benchmark)	Good	Fair	Fair	Good/Fair
Storm Sampling	Good	Good	Good	Good
TP (summer)	Good	Good	Good	Good
N (summer)	Good	Good	Good	Good
Oregon multimetric index	Moderate impairment	No impairment	No impairment	No impairment
Predictive model shore	Most disturbed	Least disturbed	Least disturbed	Least disturbed

*Statistically significant difference between upstream of Oakridge and downstream..

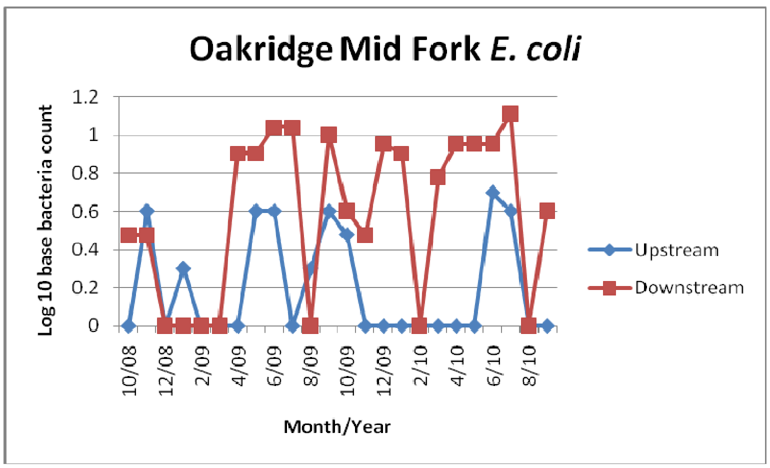


Figure 4. E. Coli results for Middle Fork Willamette River at Oakridge.

Oakridge Salt Creek (OakSTCMO) and Oakridge Salmon Creek (OakSCMO): Contributions from Salt and Salmon Creeks to the mainstem Middle Fork Willamette were generally consistent with each other and do not appear to be making large negative contributions to water quality in the mainstem (Table 1). For both tributaries, State Standards for *E. coli* were met during monthly sampling. Additionally, the State Standard for *E. coli* was never exceeded during storm sampling for either Salt Creek or Salmon Creek (Appendix E). The standard for DO, however, was not met 7 out of 16 months for Salt Creek and 9 out of 16 months for Salmon Creek, primarily in late spring and fall (Figure 7). Nevertheless, these differences were small for most deviations from the State Standard. For Salt Creek, total suspended solids (TSS) fell into the "fair" water quality category for water quality 4 out of 6 months (Figure 8), all 6 months for conductivity, and 1 out of 6 months for turbidity during the 2009 and 2010 summer months. Data for Salmon Creek indicate conductivity fell into the "fair" benchmark category all six of 2009/2010 summer months, but ranked "good" 5 out of 6 months for TSS and all 6 months for turbidity during the 2009/2010 summer months. Both Salt Creek and Salmon Creek ranked fair 1 out of 6 of the 2009/2010 summer months for TP.

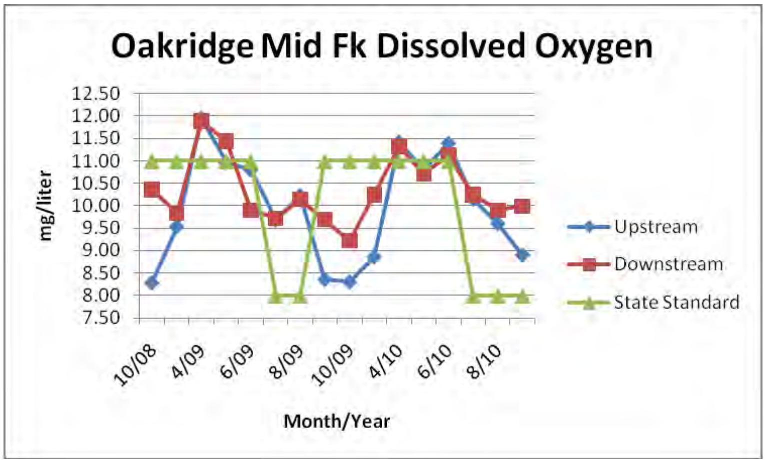


Figure 5. Oakridge DO results.

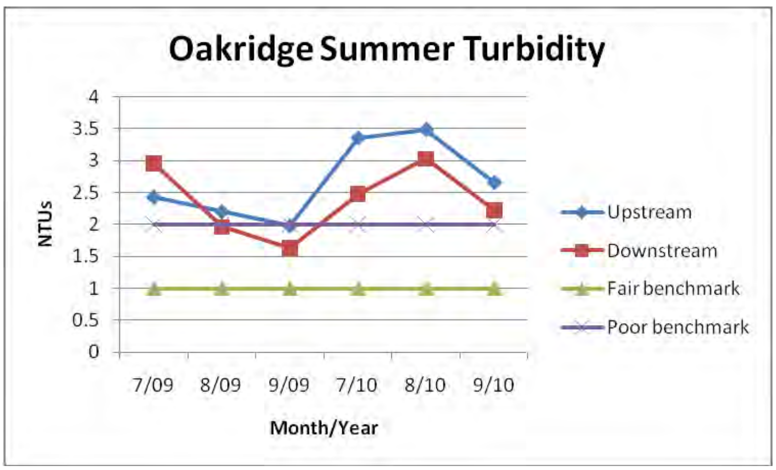
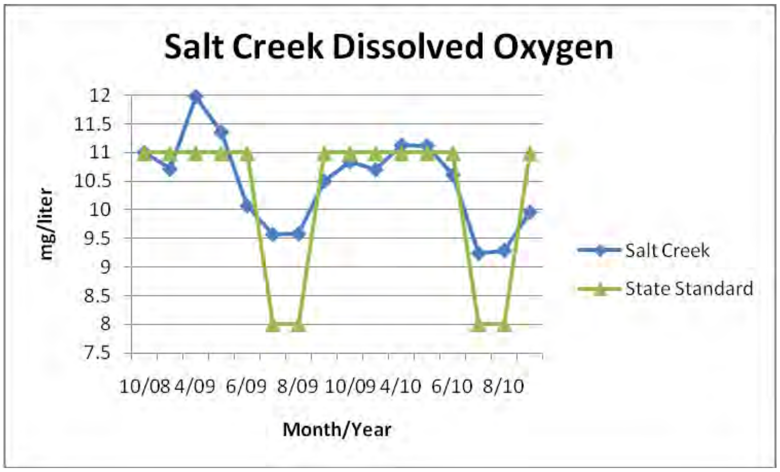


Figure 6. Oakridge Middle Fork summer turbidity.

Macroinvertebrate sampling was conducted in 2010. Results from the western Oregon multimetric index show that both Salt and Salmon Creek had “No Impairment”. The predictive model scores showed that the Salt and Salmon Creeks are categorized as “Least Disturbed” (Appendix G).

Oakridge Area Summary: Water quality in the Oakridge area is generally good. Preliminary results suggest sediment related pollutants present from upstream of Oakridge may settle out or are diluted by water entering within or downstream of Oakridge. A comparison of available USGS discharge data indicates summer low flow from Salmon equals about 10% the summer low flow of Middle Fork near Dexter and Salt Creek has similar flow.



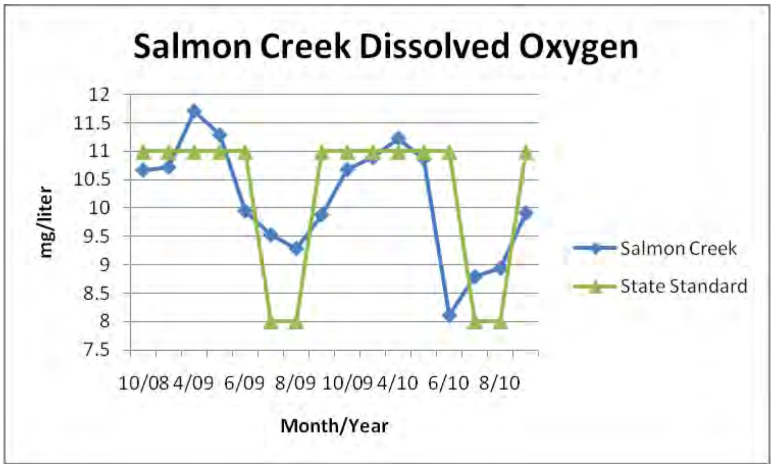


Figure 7. a) Salt Creek and b) Salmon Creek DO results.

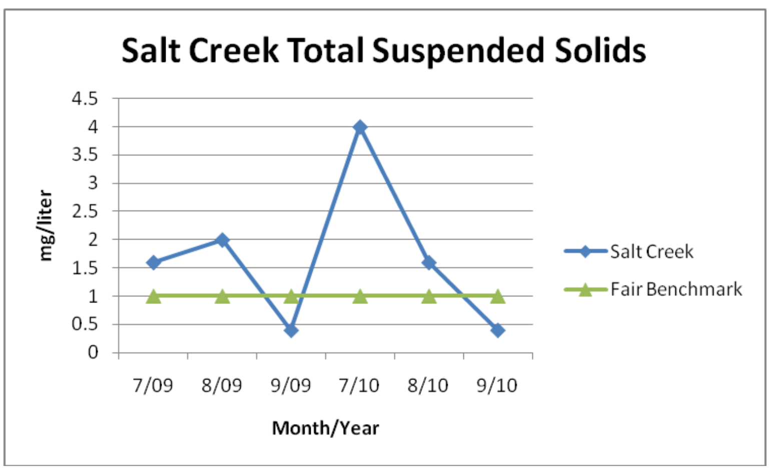


Figure 8. Salt Creek summer TSS results.

Westfir

Westfir is two miles northwest of Oakridge on the North Fork of the Middle Fork Willamette River immediately upstream of its confluence with the Middle Fork.

Geography: Westfir encompasses approximately 180 acres and has a population of approximately 300 residents. Nearly 50% of land inside the Westfir Urban Growth Boundary is undeveloped and mostly on the 60-acre Westfir Lumber Mill site. The old mill site has been cleaned up and re-zoned, primarily for residential use, but has yet to be developed. Currently, 40% of Westfir is zoned for residential use, 23% for industrial/mixed commercial use, and 26% for parks and open space, including a riparian corridor along the river within the old mill site property.

Current water quality policies: According to the Westfir Comprehensive Plan, over half of the homes in the City use septic systems. Only the Hemlock neighborhood (the 64 homes north of the river) is serviced by a sewer system. The City is already working to educate their citizens about proper septic maintenance. Lane County Public Works maintains the City's stormwater system, some of which drains into the North Fork. The City replaced the wastewater treatment plant in 2006 with a POD system. The City's Comprehensive Plan contains language directing the City to protect steep slopes from erosion from improper development. The Comprehensive Plan also identifies the protection and enhancement of the river corridor as a goal.

Monitoring sites: We sampled three sites associated with this DMA, a site upstream (WFNFUP) and downstream (WFMFMO) of Westfir along the North Fork of the Middle Fork Willamette and one near the mouth of McLean Creek (WFMCMO) (Figure 9). McLean Creek, a small, perennial side tributary of the North Fork of the Middle Fork Willamette is located between the two samples sites along the North Fork in Westfir. McLean Creek enters the North Fork in the center of Westfir and was selected for sampling due to the potential influence on water quality as the North Fork passes through Westfir.

Westfir North Fork of the Middle Fork Willamette (WFNFUP and WFNFMO): Monthly sampling upstream and downstream of Westfir showed that water quality standards in the North Fork of the Middle Fork were generally good as the river passed through the city. Standards for *E. coli* were always met (Table 2).

Standards for DO were met 8 out of 16 monthly samples at both the up and downstream sites (Figure 11). Failure to meet State Standards generally occurred in June, September, October and November. Though generally good, there were a couple of months were TSS indicated "fair" water quality – August 2009 for both sites and Sept 2009 at the downstream site (Figure 12). Turbidity was good at both sites and statistically higher at the upstream site.

Macroinvertebrate sampling was conducted at both sites in 2010. Results from the western Oregon multimetric index indicate that the upstream site has "Slight Impairment" and the downstream site has "None". The predictive model scores indicate that both the upstream and downstream sites are categorized as "Least Disturbed" (Appendix G).

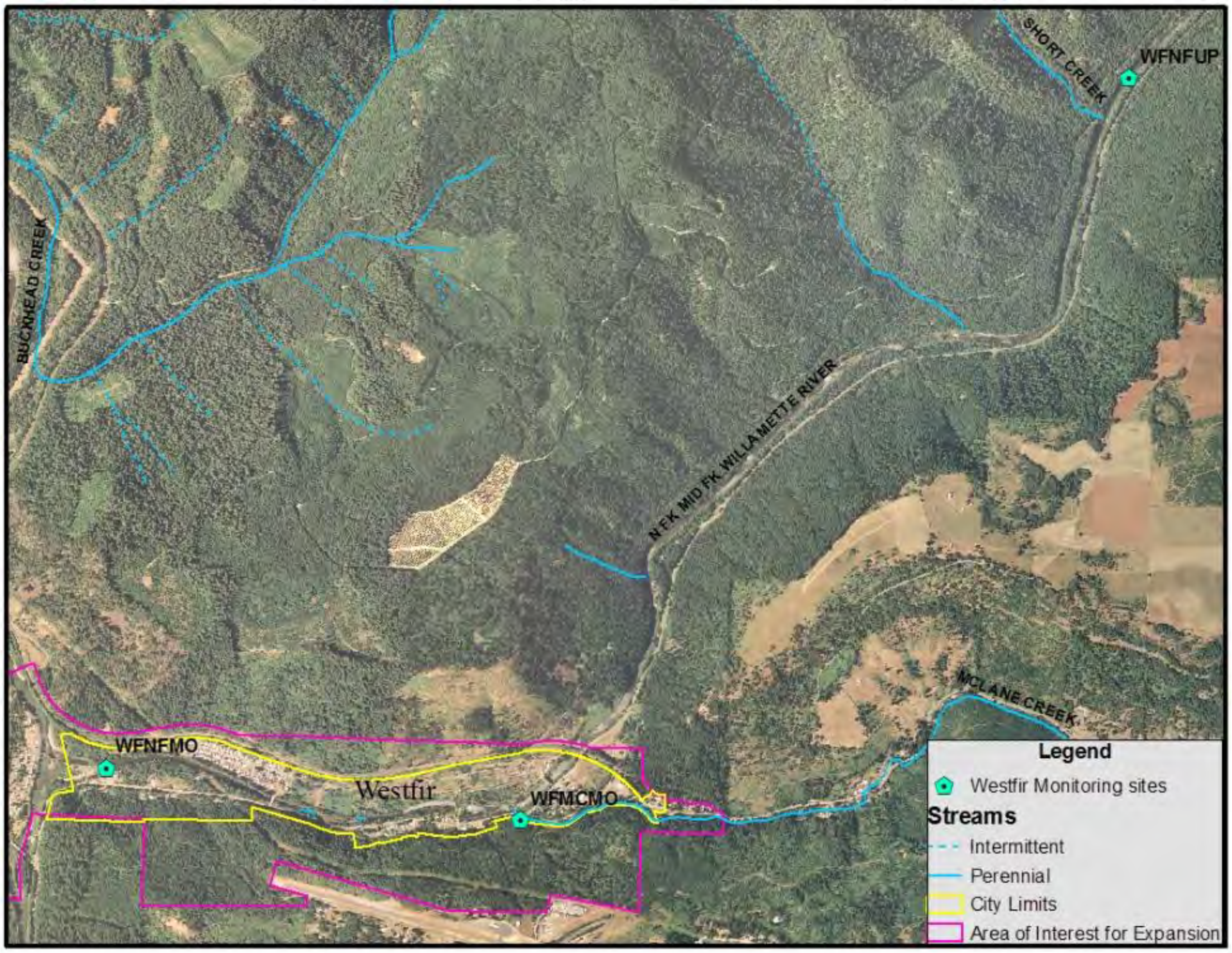


Figure 9.Westfir monitoring sites, city limits, urban growth boundary, and expansion interest area.

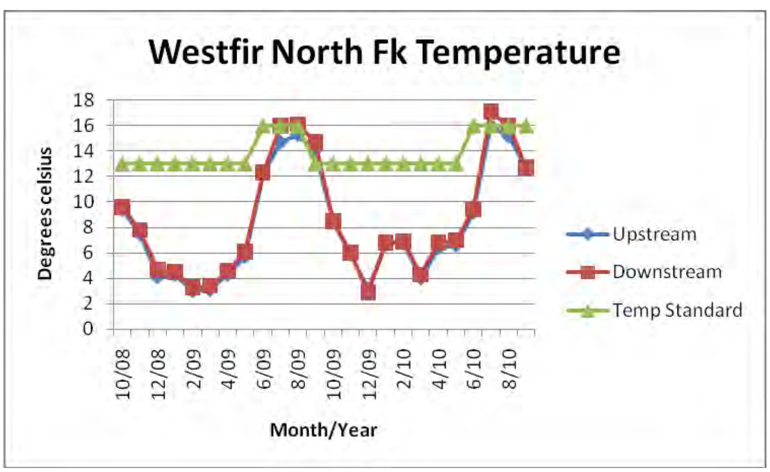


Figure 10. Westfir North Fork Temperature Results

Table 2. Comparison of the North Fork of the Middle Fork Willamette River in Westfir and McLean Creek water quality results with State Standards or benchmarks, from the upper most to the lower most monitoring site. A complete summary of results can be found in Appendix E.

	Westfir North Fork Upstream (WFNFUP)	**McLean Creek (WFMCMO)**	**Westfir North Fork Downstream (WFNFMO)**
Temperature Standard	No continuous data	No continuous data	No continuous data
DO Standard	Failed 50%	Failed 81%	Failed 50%
E. coli Standard	Good	Failed 17%	Good
TSS (summer benchmark)	Good	Fair	Fair
Turbidity* (summer benchmark)	Good	Poor	Good
Conductivity* (summer benchmark)	Good	Poor	Good
Storm Sampling	Good	*E. coli* failed	Good
TP (summer)	Good	Good	Good
N (summer)	Good	Good	Good
Oregon multimetric index	Slight Impairment	No Impairment	None
Predictive model shore	Least Disturbed	Most Disturbed	Least Disturbed

*Statistically significant difference between upstream and downstream of Westfir.

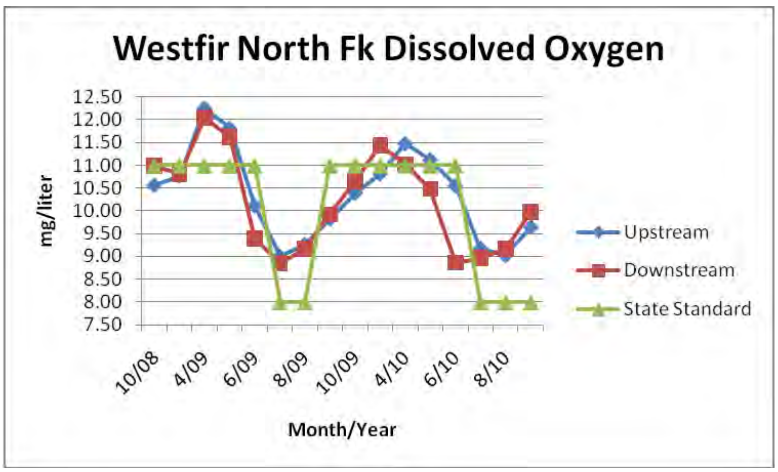


Figure 11. Westfir North Fork Dissolved Oxygen Results

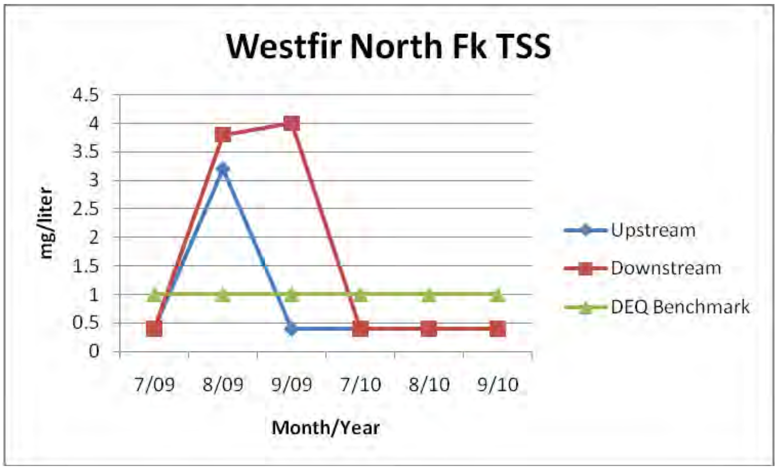
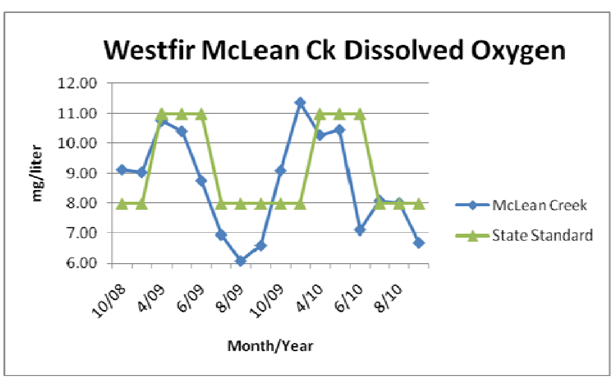


Figure 12. Westfir North Fork TSS Results

Westfir McLean Creek (WFMCMO): Though monthly grab sample data do not suggest problems with nutrients, several State Standards and DEQ benchmarks were not met in McLean Creek (Table 2). *E. coli* failed the State Standard in October and November of both 2008 and 2009, and during the August 2009 and September 2010 storm sampling (Figure 13, Appendix E). Dissolved oxygen failed most of the months sampled, except during the fall (Figure 13, Appendix E). Turbidity and conductivity were "poor" during summer monthly sampling in both 2009 and 2010, and TSS was "fair", mainly in 2009 (Figure 14, Appendix E). Though generally good, TP was found to be "fair" 1 out of 6 months and N "poor" 1 out of 6 months during the 2009/2010 summer monthly samples.

Macroinvertebrate sampling was conducted at this site in 2010. Results from the western Oregon multimetric index indicate that the McLean Creek site has "No Impairment". Conversely, the predictive model scores indicated that the McLean Creek site is categorized as "Most Disturbed" (Appendix G).



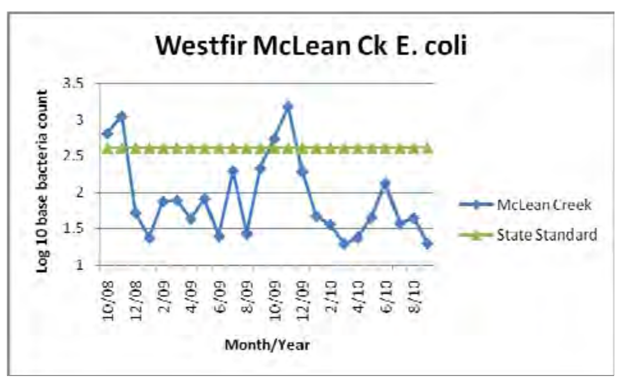


Figure 13. McLean Creek dissolved oxygen and E. coli.

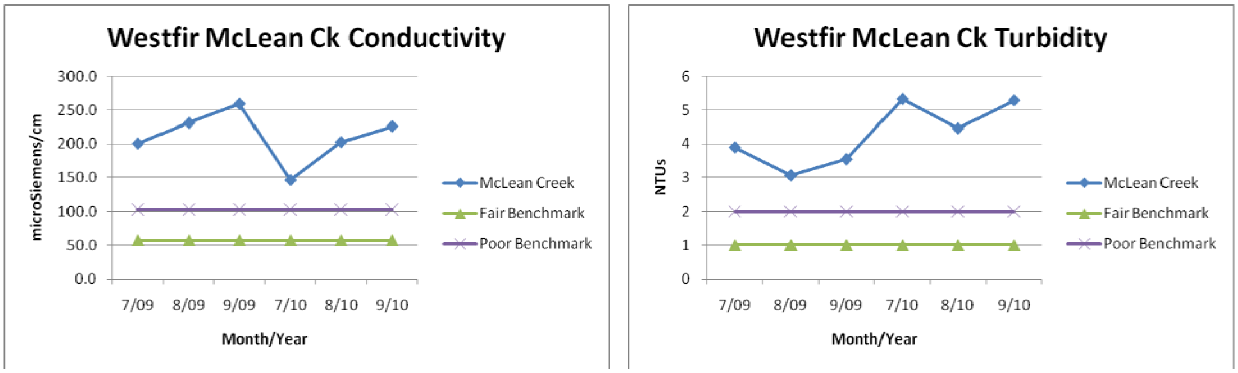


Figure 14. McLean Creek conductivity and turbidity.

Westfir Area Summary: Water quality in the mainstem North Fork Middle Fork Willamette is generally good as it passes through Westfir. Tubidity levels actually drop from upstream to downstream, but otherwise water quality remains unchanged as it flows through town. The discharge of McLean Creek is small relative to the Middle Fork and so any water quality impairment within McLean Creek does not appreciably affect the Middle Fork. McLean Creek generally had significantly larger values for *E. coli* than either of the North Fork sites and higher TSS than the downstream North Fork site. Although we did not monitor continuous stream temperature in the North Fork, previous studies have shown that maximum temperatures are sometimes higher than the State Standard and so DEQ has put the North Fork Middle Fork Willamette River on the 303(d) list.

City of Lowell

The City of Lowell is located on the shores of Dexter Reservoir about 20 miles southeast of Eugene.

Geography: Lowell's population was estimated to be about 1000 in 2010. About 71% of the land in Lowell is zoned as low-density residential. Commercial and manufacturing uses are zoned for 5% of the land within Lowell's Urban Growth Boundary and public lands or open lands comprise 22%. The town is adjacent to an Army Corps of Engineers controlled reservoir and dam. The city has little control over the operation of the reservoir or the use of land directly adjacent to the reservoir. The Corps of Engineers owns and controls much of the land along the reservoir shore, although houses line some of the north shoreline of Dexter Reservoir and Highway 58 is close to the south shoreline. There are no permanent waterways that flow through the City, only ephemeral drainages that the City uses for stormwater conveyance.

Current water quality policies: Lowell recently switched the source of their drinking water from wells to surface water (Dexter Reservoir) and installed a new drinking water treatment facility in 2001. The City has erosion and sediment control standards for public improvement projects and a hillside development ordinance for activity on slopes over 15%. Currently, the City's stormwater runoff flows directly into Dexter reservoir. In the implementation of TMDLs, Lowell is focusing on stormwater management and landowner education.

Monitoring sites: An unnamed intermittent stream that collects stormwater as it flows through the west side of Lowell is the waterway along which the two sampling sites (LWUP and LWDW) for the DMA were located (Figure 15). We collected data only 12 months out of 24 due to lack of water in the summer months.

***Lowell Unnamed Stream (LWUP and LWDW)*:** Since the stream dries up in the summer, the main interest was whether or not the stream met State Standards for *E. coli* and DO during the non-summer months. *E. coli* standards were not met 4 out of 12 times at the upstream site and 5 out of 12 times at the downstream site (Table 3, Figure 16, Appendix E). During August 2009 the downstream site and September 2010 both sites failed to meet *E. coli* standards (Appendix E). Winter DO levels fell below the winter standards April through June at both the up and downstream sites (Figure 16). Additionally, winter monthly samples for conductivity, turbidity and total suspended solids were statistically higher at the downstream site over the upstream site, though no benchmarks exist to evaluate their relative state of water quality (Appendix E).

Table 3. Comparison of the water quality results with State Standards at the upstream and downstream sites on an unnamed stream in Lowell. A complete summary of results can be found in Appendix E.

	Lowell Unnamed Stream (LWUP)	**Lowell Unnamed Stream (LWDW)**
Temperature Standard	No continuous data	No continuous data
DO Standard	Failed 83%	Failed 83%
E. coli Standard	Failed 33%	Failed 42%
Storm Sampling	*E. coli* failed	*E. coli* failed

<u>Lowell Area Summary</u>: Water quality assessment was limited by the sampling season due to the stream having no flow during the summer. DEQ benchmarks could not be assessed. State Standards for DO and *E. coli* were frequently not met, with the upstream having lower DO and the downstream often having higher levels of *E. coli,* although results were not statistically different.

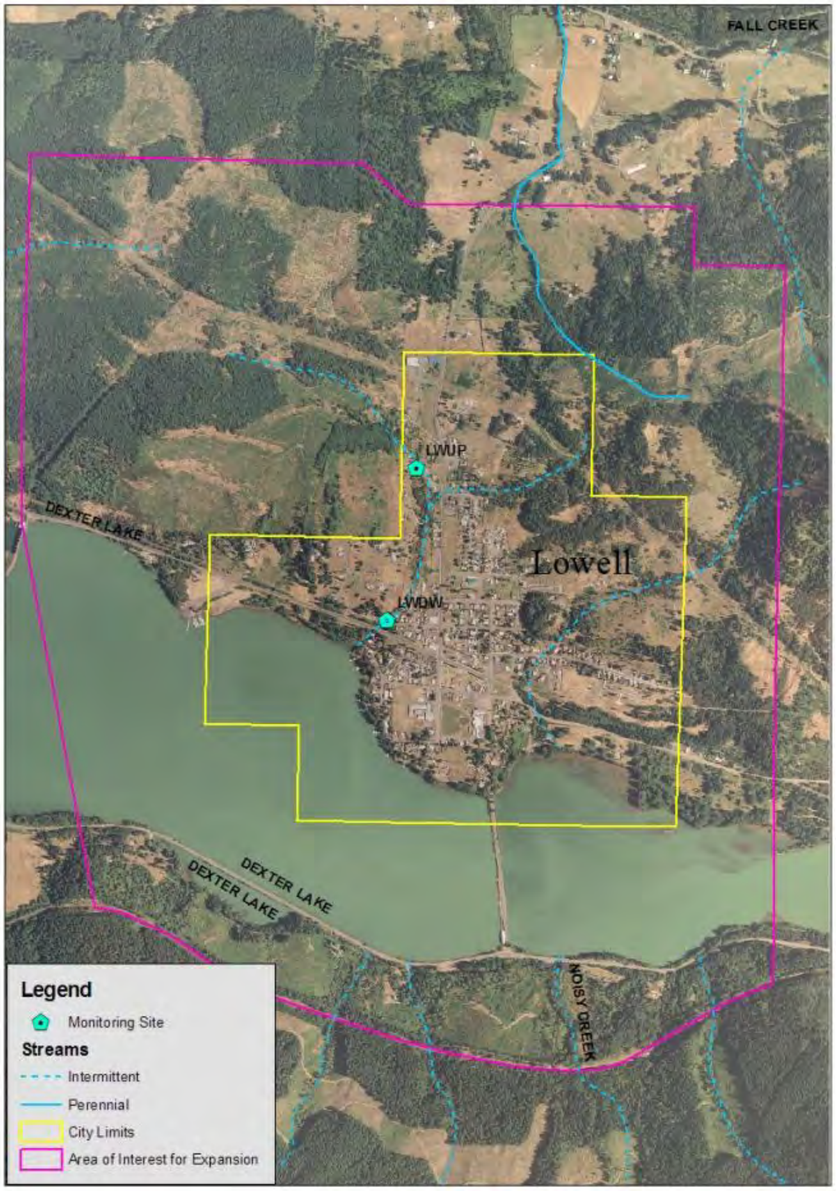


Figure 15. Location of the two monitoring sites on the west side of Lowell.

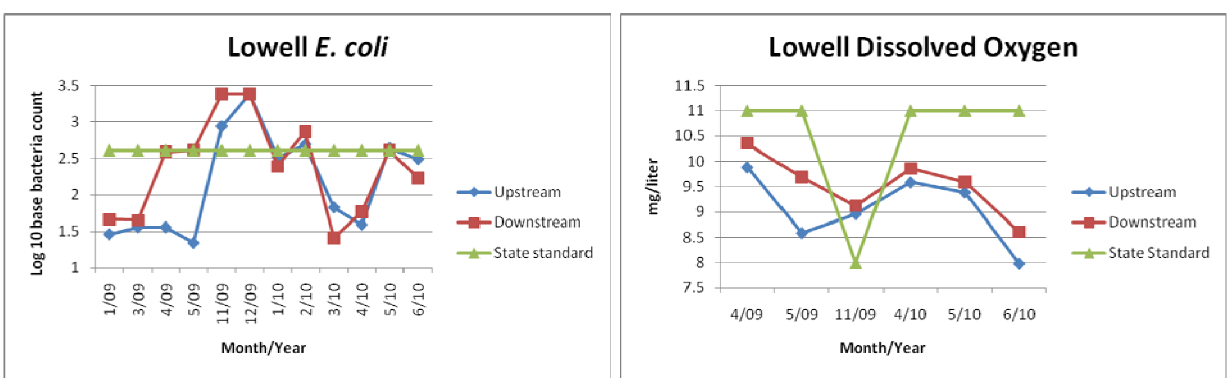


Figure 16. State Standards for *E. coli* and DO upstream and downstream sites.

Middle Fork Willamette River and Tributaries

Nine additional sites were sampled in the Middle Fork Willamette watershed. They were not associated with DMAs but located along the Middle Fork Willamette River or tributaries with rural residential development. Our purpose in monitoring these sites was to characterize water quality of the Middle Fork and tributaries that overlap areas of rural residential development.

Current water quality policies: Springfield Utility Board continuously monitors temperature and turbidity at its plant for its drinking water treatment processes. They also monitor dissolved oxygen at regular intervals.

Monitoring sites: We monitored five sites on the mainstem Middle Fork or at the mouths of tributaries to the river (listed upstream to downstream): below Dexter Dam (MFWDR), Fall Creek (FCMO), Hills Creek (HCMO), Wallace Creek (WCMO), and at the Springfield Treatment Plant (MFWSTP) (Figure 17). MFWDR and MFWSTP were paired to assess the quality of water between Dexter Dam and just upstream of the confluence with the Coast Fork Willamette outside of Springfield. Fall Creek is dammed approximately 6 miles upstream of the monitoring site.

Two upstream/downstream pairs were sampled along a tributary to the Middle Fork - Lost Creek (LCUP and LCMO) and a tributary to Fall Creek - Little Fall Creek (LFCUP and LFCMO). Lost Creek Watershed includes several different types of land use, including forestry, agriculture, some livestock, and residential development. Little Fall Creek Watershed includes forestry, agriculture, and residential development.

Middle Fork Willamette just below Dexter Dam (MFWDR) and at Springfield Treatment Plant (MFWSTP): Based on monthly water quality samples, water quality for the Middle Fork Willamette River is generally good, though State Standards for dissolved oxygen and temperature were not met some months (Table 4). Failure to meet DO standards occurred throughout the spring-fall sampling period for both sites (Figure 18). Data from the continuous temperature monitoring of the site below Dexter Dam show the State Standard not being met from September 1 through September 8, 2009, after which the temperature gage was removed (Figure 19). In 2010, when there were only 17 days of continuous temperature data taken (in July), there were 6 days when the 7-day moving average was above the limit. At the downstream site in 2009, the State Standard was not met throughout most of the sampling period (Figure 19). Only 3 days of temperature data were collected in 2010, but failed to meet the State Standard during each of those days (Appendix E).

Though benchmarks for turbidity, TSS, conductivity and *E. coli* were met for the Middle Fork Willamette River, all were statistically higher at the downstream site when compared to the upstream site (Figure 20). Dissolved oxygen frequently exceeded the State Standard at the downstream site and was statistically lower than the upstream site.

SOC/VOC grab samples collected four times over the two years showed no detection of any of the analyzed compounds for this site (Appendix H).

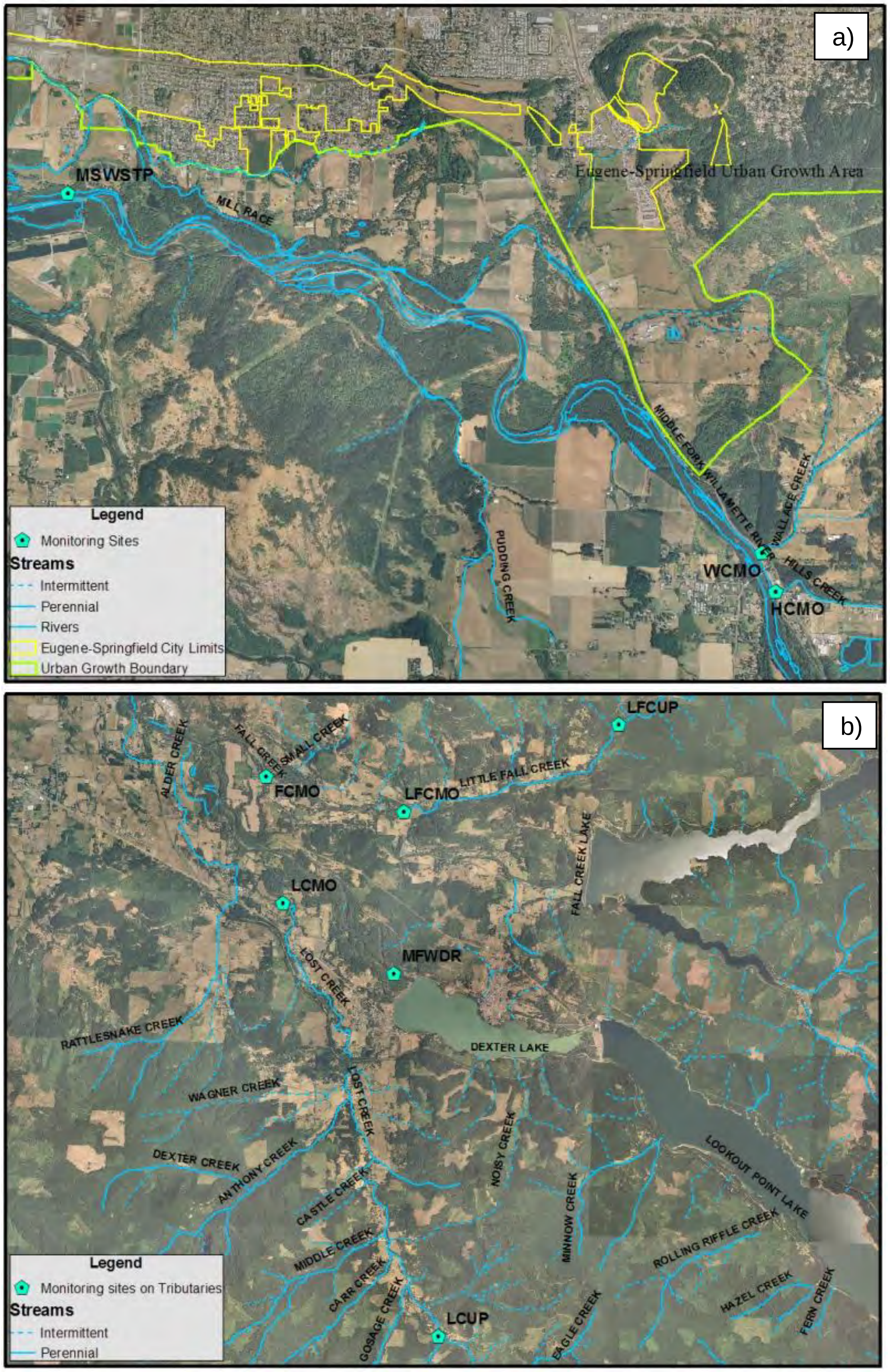


Figure 17. a) Lower MF and b) Upper MF. The sequence of photos show sampling sites located along the Middle Fork Willamette River and tributaries. Major tributaries: Little Fall Creek, Fall Creek, Lost Creek, Hills Creek and Wallace Creek.

Table 4. Comparison of the Middle Fork Willamette River below Dexter Dam water quality results with State Standards or benchmarks, from the upper most to the lower most monitoring site. A complete summary of results can be found in Appendix E. Macroinvertebrates were not sampled.

	MF below Dexter Dam (MFWDR)	**Fall Creek (FCMO)**	**Hills Creek (HCMO)**	**Wallace Creek (WCMO)**	**MF Springfield Trt Plant (MFWSTP)**
Temperature Standard	Failed	Not enough data	Failed	No Data	Failed
DO Standard*	Failed 50%	Failed 69%	Failed 38%	Failed 67%	Failed 80%
E. coli Standard*	Good	Good	Failed 38%	Failed 41%	Good
TSS (summer benchmark)*	Good	Good	Good	Good (1 sample)	Good
Turbidity* (summer benchmark)	Good	Fair	Good	Good (1 sample)	Good
Conductivity* (summer benchmark)	Good	Good	Good	Good (1 sample)	Good
TP (summer)	Good	Good	Good	Good (1 sample)	Good
N (summer)	Good	Good	Good	Good (1 sample)	Good

* Indicates statistically significant differences between upstream and downstream mainstem MF.

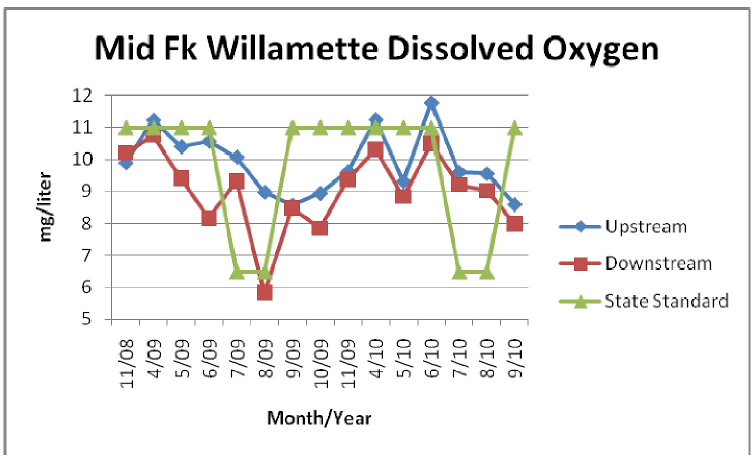


Figure 18. Dissolved oxygen for upstream and downstream collection sites located on the Middle Fork Willamette between Dexter Dam and the Springfield Treatment Plant.

Wallace Creek (WCMO): Results from monthly sampling show *E. coli* exceeded State Standards several times throughout the fall through spring sampling and DO did not meet State Standards April through June (Figure 21, Table 4, Appendix E).

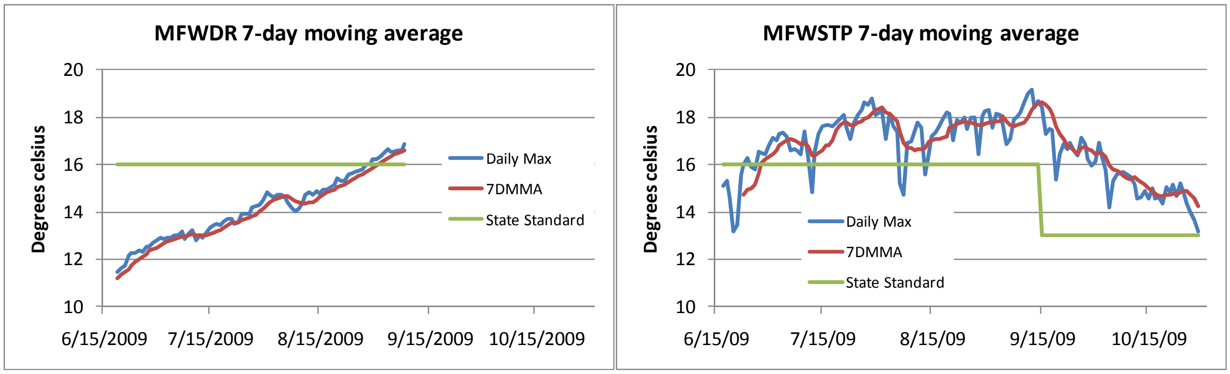


Figure 19. The 7-day moving average at the upstream (MFWDR) and downstream (MFWSTP) sampling sites on the Middle Fork during the summer of 2009.

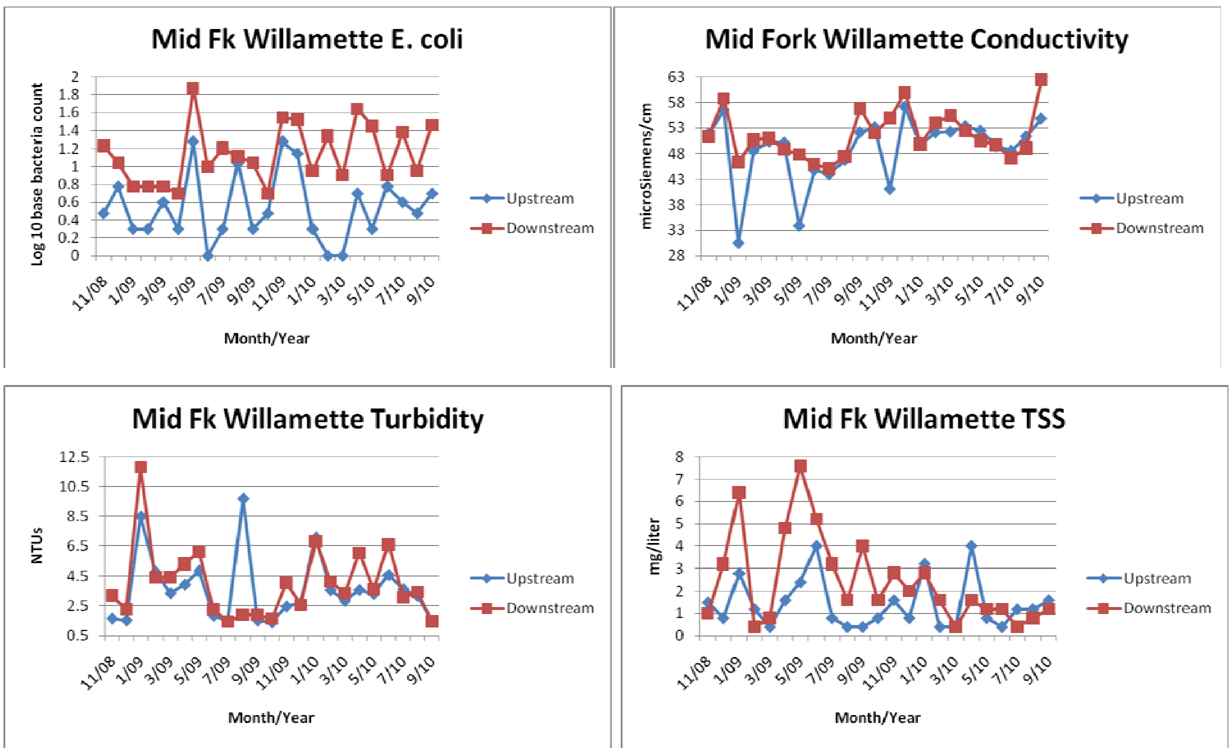


Figure 20. Upstream and downstream results for the Middle Fork between Dexter Dam and the Springfield Treatment Plant for E. coli, conductivity, turbidity, and total suspended solids.

Hills Creek (HCMO): Samples taken at the mouth of Hills Creek occasionally failed to meet the State Standard for *E. coli* and DO (Table 4, Figure 22). *E. coli* did not meet standards 9 out of 24 sampling months, with violations during all seasons (Appendix E). Failure to meet DO standards mainly occurred in spring and summer. Additionally, continuous temperature was measured and failed to meet the State Standard during the summer months (Figure 23, Appendix E). Furthermore, monthly sampling in summer resulted in one violation of each of the benchmarks for turbidity and nitrate (Appendix E).

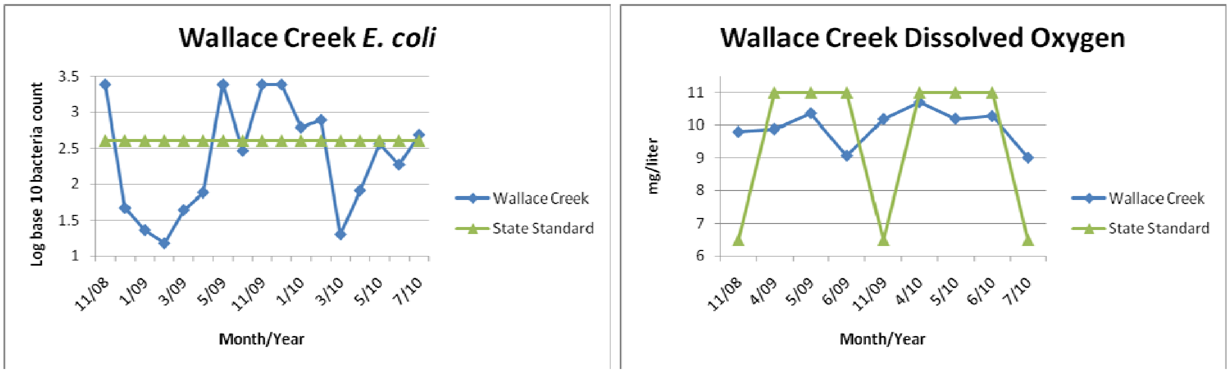


Figure 21. Water quality in Wallace Creek for *E. coli* and DO

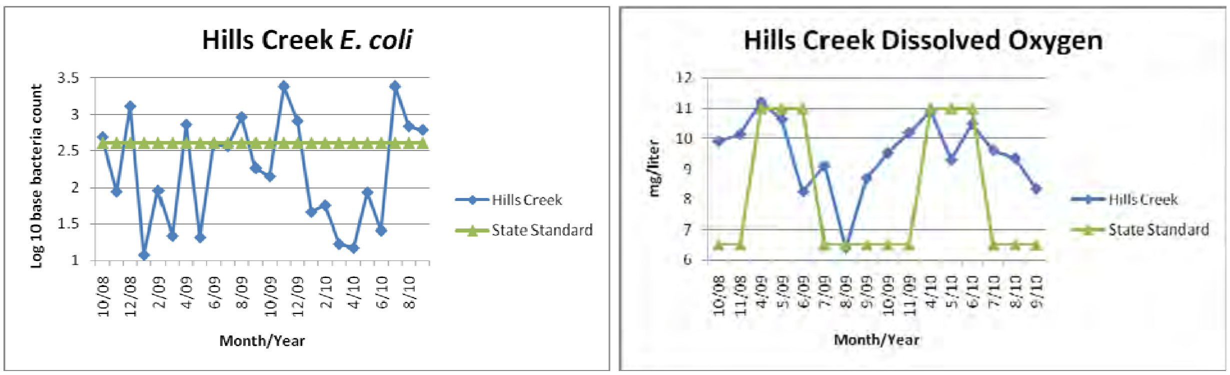


Figure 22: State Standards for *E. coli* and DO in Hills Creek.

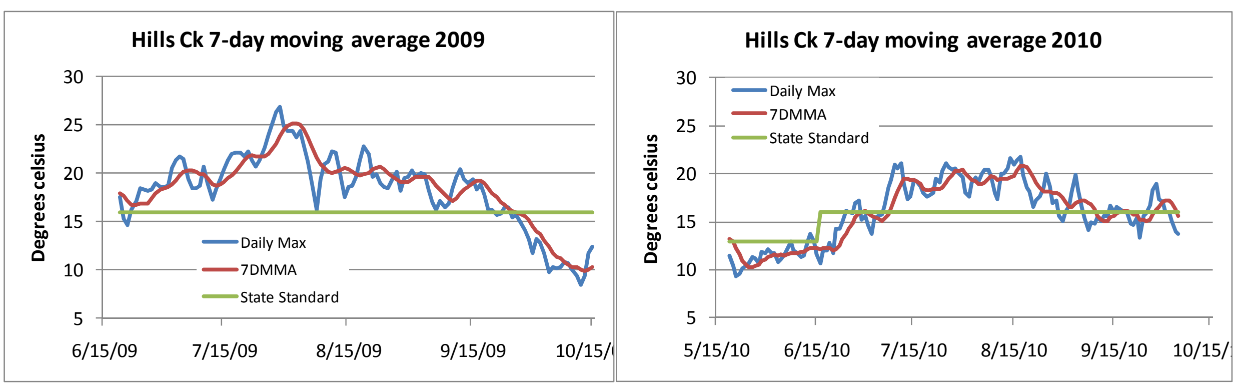


Figure 23. Hills Creek water temperature data from 2009 and 2010.

Fall Creek (FCMO): Monthly water quality sampling suggested relatively good water quality for Fall Creek, with the exception of DO and turbidity. Through limited continuous temperature sampling in 2010 (17 days in July) combined with monthly temperature samples, there was some indication that temperature may exceed State Standards (Figure 25, Appendix E). Dissolved oxygen was frequently below the State Standard, especially in spring and fall (Table 4, Figure 25, Appendix E). Summer monthly samples of turbidity resulted in fair water quality during summer 2009 (Figure 26).

SOC/VOC samples collected four times over the two years for SOC/VOC testing showed no detection of any of the compounds (Appendix H).

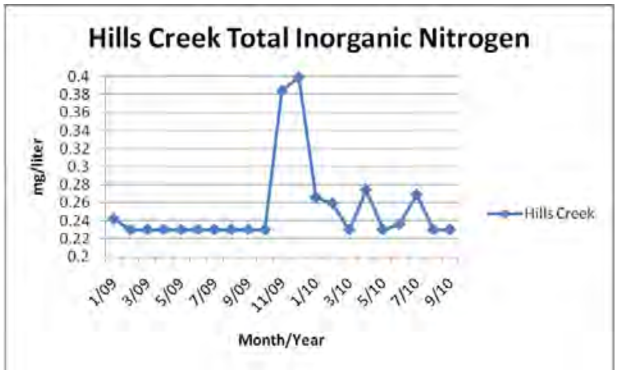


Figure 24: Total inorganic nitrogen for Hills Creek.

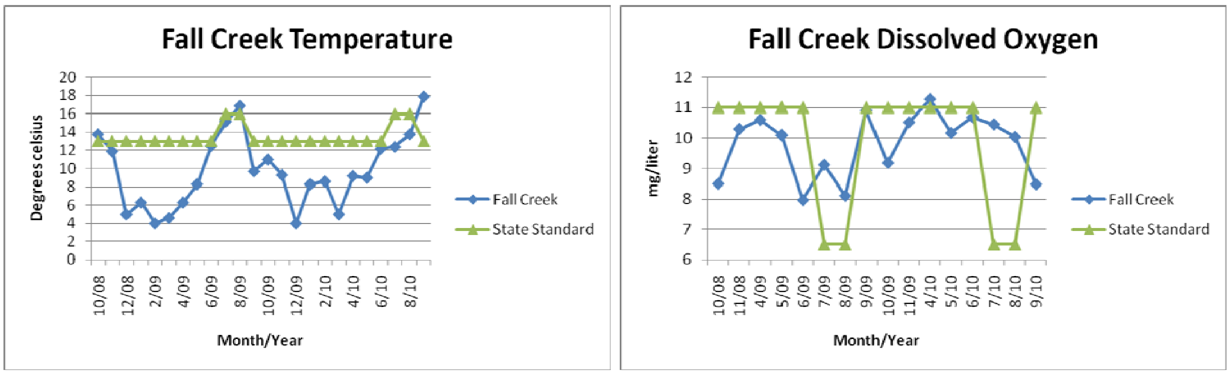


Figure 25: Water temperature and dissolved oxygen for Fall Creek.

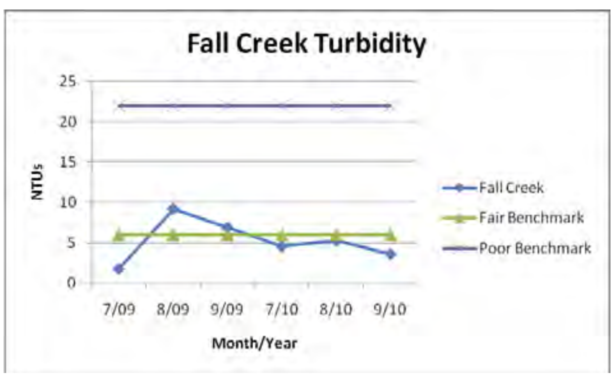


Figure 26: Summer turbidity for Fall Creek.

Lower Middle Fork Willamette Area Summary: Water quality along the mainstem Willamette River is generally good, although water temperature and dissolved oxygen occasionally did not meet State Standards.. The three reservoirs immediately upstream of this segment of the Middle Fork Willamette River influence water quality parameters. Most notably, the dams release water that is typically cooler in the summer and warmer in the fall when compared to conditions prior to dam construction.

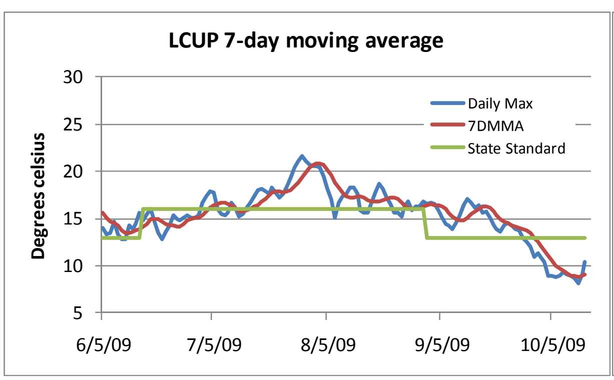
On the tributaries with rural residential development, temperature and DO standards were frequently exceeded and *E. coli* counts exceeded State Standards in Wallace and Hills Creek. Though the continuous temperature sampling period was limited, monthly samples and previously collected DEQ data suggest that temperatures may exceed State Standards.

Lost Creek upstream (LCUP) and downstream at the confluence (LCMO):
Continuous temperature results show that the State Standard was frequently exceeded from June through October in 2009 (Figure 27, Table 5, Appendix E). At the upstream site, temperature exceedances occurred primarily during July and August. State Standards were exceeded June through early October at the downstream site, often by 2-3° C. For the 17 days of July in 2010, the daily maximum temperature exceeded the limit at the upstream site for 10 of those days, while the 7-day moving average exceeded it 3 days. Over the same time period for the lower collection site, all daily maximums as well as 7-day moving averages exceeded the limit by at least 3° C and up to 5° C or more. DO State Standards were exceeded during both spring and fall at both the upstream and downstream sites, with the downstream site statistically lower than the upstream site (Table 5, Figure 28, Appendix E).

Table 5. Comparison of Lost Creek and Little Fall Creek water quality results with State Standards or benchmarks, from the upper most to the lower most monitoring site. A complete summary of results can be found in Appendix E.

	Lost Creek upstream (LCUP)	**Lost Creek downstream (LCMO)**	**Little Fall Creek upstream (LFUP)**	**Little Fall Creek downstream (LFCMO)**
Temperature Standard	Failed	Failed	Failed	Failed
DO Standard*^	Failed 56%	Failed 53%	Failed 60%	Failed 56%
E. coli Standard*^	Good	Failed 13%	Good	Good
TSS (summer benchmark)	Good	Good	Good	Good
Turbidity (summer benchmark)*	Good	Good	Good	Good
Conductivity (summer benchmark)^	Good	Good	Good	Good
TP (summer)	Good	Good	Good	Good
N (summer)	Good	Good	Good	Good
Oregon multimetric index	No impairment	Slightly impaired	No data	No data
Predictive model shore	Moderately disturbed	Most disturbed	No data	No data

* Statistically significant differences between upstream and downstream sampling sites for Lost Creek.
^ Statistically significant differences between upstream and downstream sampling sites for Little Fall Creek.



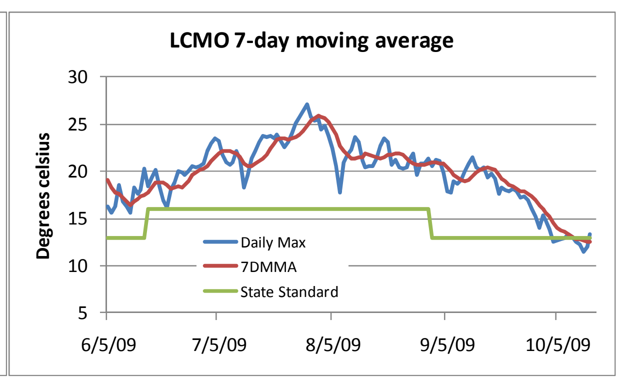


Figure 27. Lost Creek upstream (LCUP) and downstream (LCMO) 7-day moving average continuous temperature data in 2009.

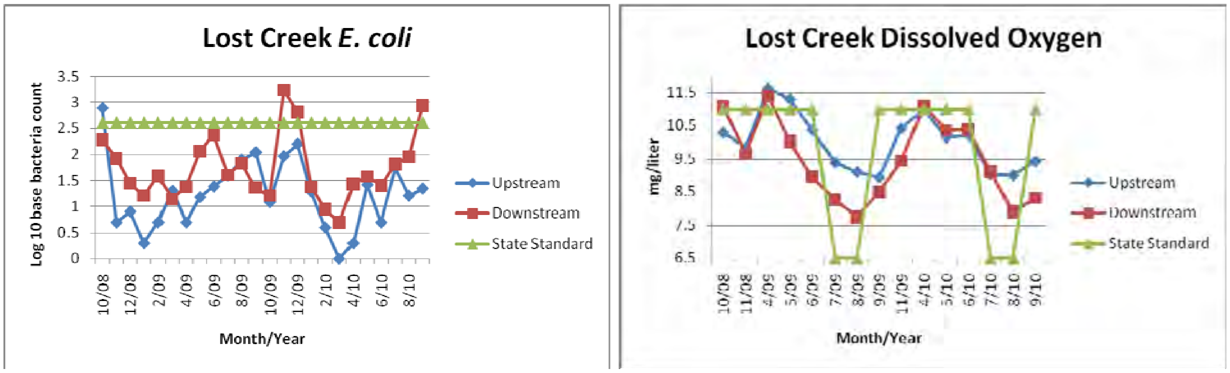


Figure 28: E. Coli and dissolved oxygen for Lost Creek.

E. coli concentrations did not exceed the State Standard at the upstream site and rarely at the downstream site. Nevertheless, sampling indicated that values at the downstream site were statistically higher at the downstream site (Appendices E & J). Though monthly sampling was not designed to test the effects of storms, the three occurrences where *E. coli* exceeded State Standards happened after large rainfall events. The highest *E. coli* reading occurred after 3.5 inches of rain fell over a 12 day period, with 0.84 inches falling within the 24 hours prior to sampling. The second highest value occurred after 0.75 inches of rain fell in the 24 hours previous to the sampling. The third highest value occurred after a little over 1 inch of rain fell within the four days previous to the sampling with 0.76 inches falling in the 24 hours previous to the sampling[3]. Turbidity did not exceed summer benchmarks, but was statistically higher at the downstream site when compared to the upstream site (Figure 29).

Results from the macroinvertebrate sampling conducted in 2009 show that the upstream site had “No Impairment” according to the western Oregon multimetrics analysis but was “Moderately Disturbed” according to the Predator Model O/E score (Appendix G). The downstream collection site was listed as “Slightly Impaired” according to the Multimetrics analysis and “Most Disturbed” according to the Predator Model O/E score.
SOC/VOC samples collected four times over the two years at the downstream site showed no detection of any of these compounds (Appendix H).

[3] http://www.cocorahs.org/ViewData/ListDailyPrecipReports.aspx (citing info from the two Dexter collection sites)

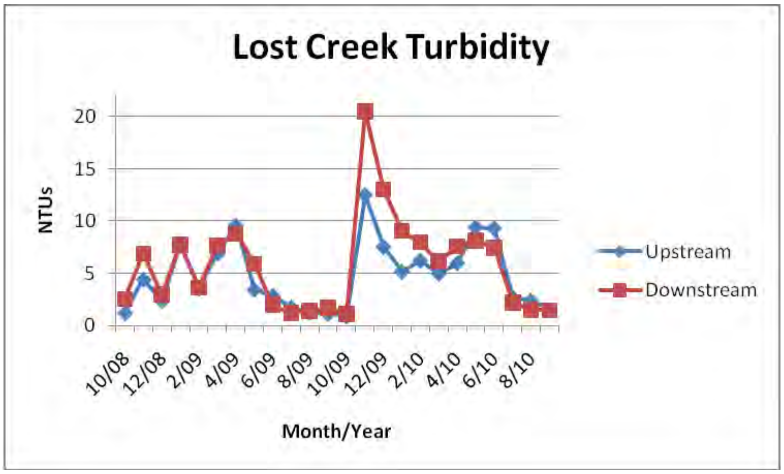


Figure 29: Lost Creek up and downstream turbidity.

Lost Creek Area Summary: Some impairment of water quality occurs from the upstream site to the downstream sampling site along Lost Creek. At the downstream site E. coli concentrations are higher, dissolved oxygen is lower, and macroinvertebrate indices score lower.

Little Fall Creek upstream (LFCUP) and at the confluence (LFCMO): Overall, water quality in Little Fall Creek is good, though water quality failed to meet State Standards for temperature and DO (Table 5). Continuous temperature results show the 7-day moving average State Standard was exceeded, often by 2 - 3+ ^{0}C, every day from mid-June to mid-September at the upstream site and to early October for the downstream site in 2009 (Figure 30, Appendix E). For the 3 days of data collected in July 2010, the daily maximum temperature exceeded the limit at both sites. DO did not meet State Standards at both sites in spring and fall, though DO was statistically lower at the downstream site (Figure 31, Appendix E). There was only one indication that nitrate violated the benchmark at the upstream site, otherwise all benchmarks were met at both sites (Appendix E). Some indication of a degradation of water quality from upstream to downstream is suggested by the statistically higher DO, conductivity, and *E. coli*; however, none of those standards or benchmarks were exceeded (Figure 32).

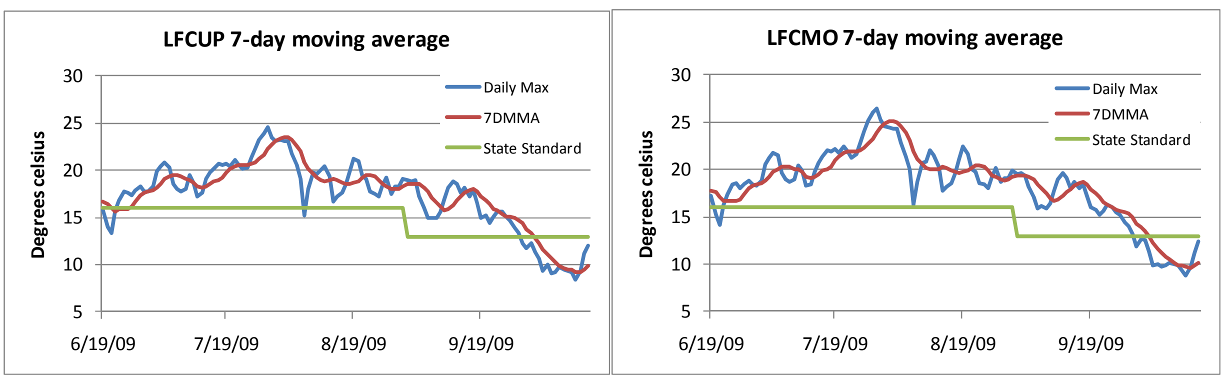


Figure 30. Little Fall Creek upstream (LFCUP) and downstream (LFCMO) 7-day moving average continuous temperature data in 2009.

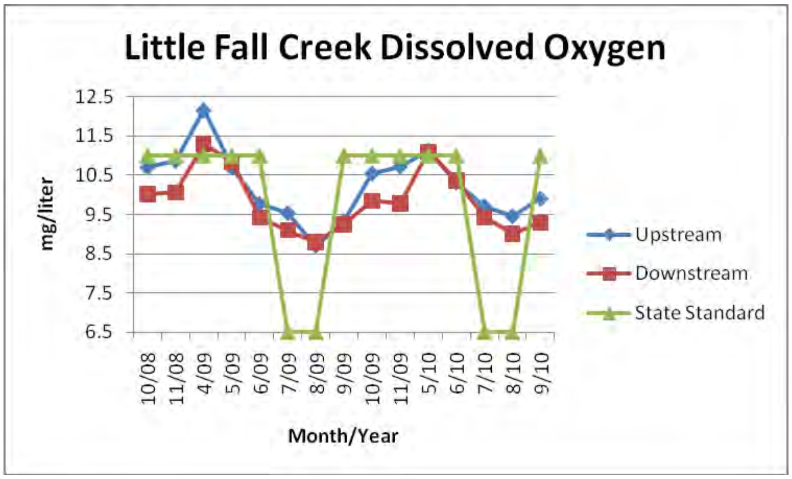


Figure 31. Dissolved oxygen for Little Fall Creek.

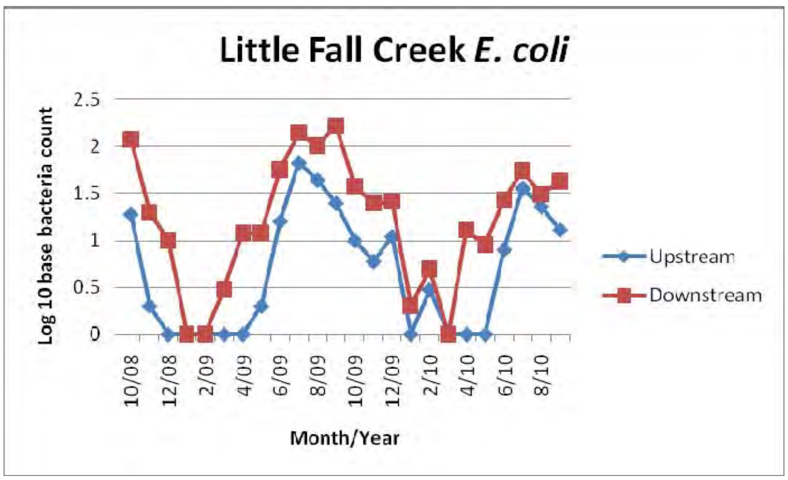


Figure 32. E. coli for Little Fall Creek.

Chapter 3: Coast Fork Willamette Watershed

The Coast Fork Willamette is located in the most southern portion of the Willamette Basin. The Coast Fork flows into the Willamette River at the confluence of the Middle Fork Willamette River. The watershed's 666 mi^2 include five watersheds, of which we monitored the following three:

- Lower Coast Fork Willamette (Hill Creek, unnamed stream in Creswell, Gettings Creek, and Camas Swale
- Upper Coast Fork Willamette (Silk Creek, Coast Fork Willamette, and the City of Cottage Grove)
- Mosby Creek

The basin is located within portions of Lane and Douglas Counties, and includes the cities of Cottage Grove and Creswell (Figure 33). BLM and USFS administer much of the upland area, but most of the land in the watershed is privately owned. The land use is primarily forestry, with agriculture and urban land uses near the main stem Coast Fork Willamette River. The Coast Fork Willamette River and the Row River are a source of drinking water for the cities of Creswell and Cottage Grove, respectively.

Trend monitoring data collected in the Coast Fork Willamette Watershed over the past 40 years by the DEQ and US Forest Service indicate that water quality is impacted by high levels of fecal coliform, biochemical oxygen demand, and total phosphorus. In addition, water temperature and mercury have been identified as being higher than State Standards. These were greatest during summer low flows and during heavy precipitation at other times of the year. Basinwide trends indicate that water quality improves in a downstream direction during the summer months signifying fewer sources of pollution towards the mouth of the river.

Building off of these past monitoring results, we selected monitoring sites up and downstream of Creswell and Cottage Grove as well as rural tributaries that had no prior monitoring data. The latter included Gettings Creek, Silk Creek, the lower reach of Mosby Creek, and Camas Swale Creek.

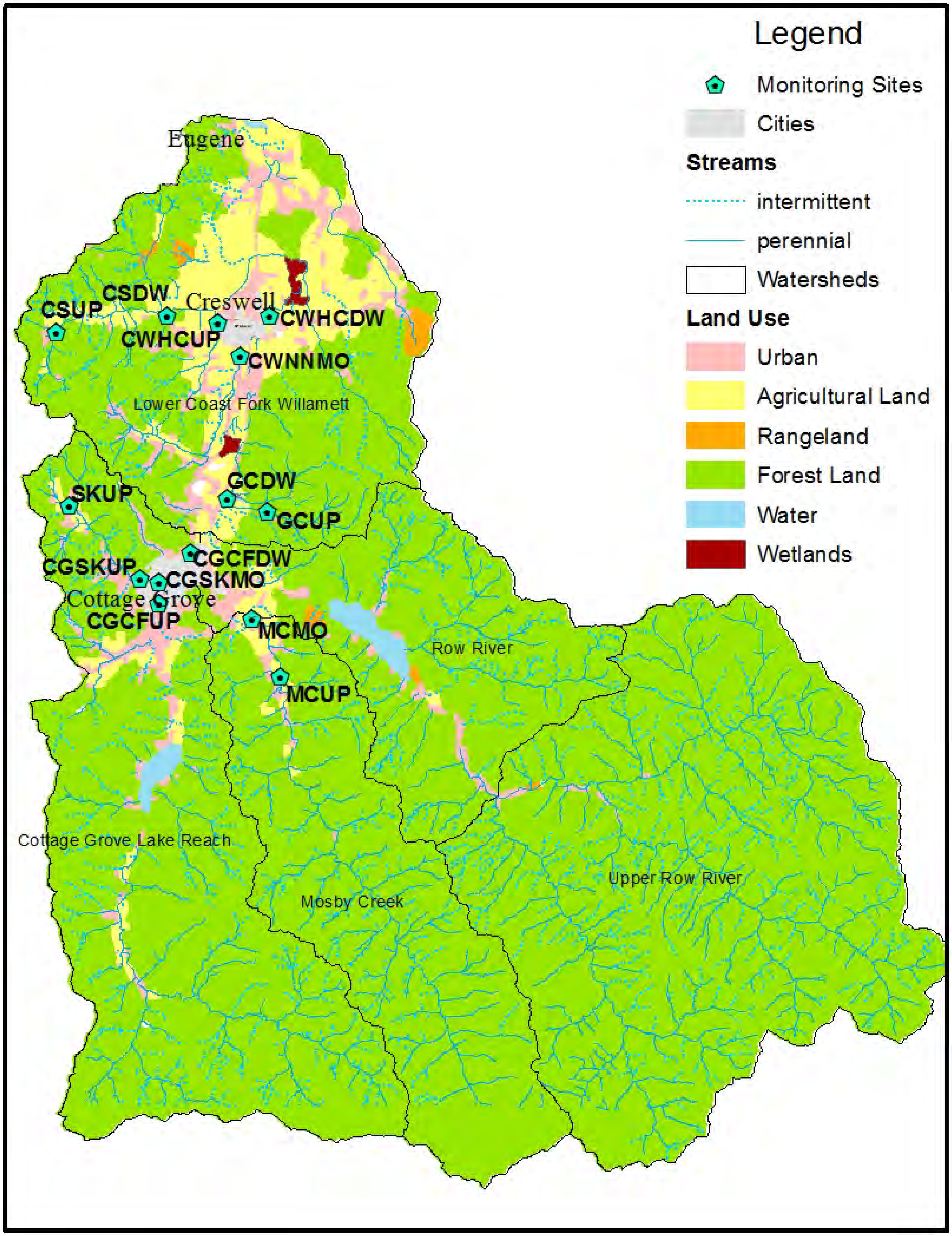


Figure 33: Coast Fork Willamette Monitoring Sites and Land Use

Coast Fork Willamette Watershed Designated Management Areas

Coast Fork Willamette – City of Cottage Grove and Silk Creek

The City of Cottage Grove is located on the Coast Fork Willamette River just above the confluence with the Row River.

Geography: The population of 9,495 makes it the largest city in the Coast Fork Willamette basin. About 63% of the land within the Cottage Grove Urban Growth Boundary is zoned as general, medium-density, or high-density residential, 19% is zoned for commercial use, 8% for controlled industrial use, and the remaining 10% for public land, parks, and professional uses (LCOG, 2008).

Current water quality policies: Cottage Grove has taken substantial steps to protect water quality in the Row River watershed since it is a source of drinking water for the City. A Willamette Greenway overlay zone and a riparian protection ordinance for the Row River have also been implemented (LCOG, 2008). The stormwater network in Cottage Grove drains to the Row River, Silk Creek, and the Coast Fork. The Public Works department performs leaf and branch pick-up in the fall which helps to reduce organic matter in runoff. Although the City has implemented a pet waste pick-up ordinance, there is limited enforcement.

Monitoring sites: We sampled five sites in and around Cottage Grove (Figure 34). Two sites were on the Coast Fork Willamette River upstream (CGCFUP) and downstream (CGCFDN) of Cottage Grove. The upper site is by the bridge on Hwy 99 near the high school, and the lower site is just below the Wastewater Treatment Facility outfall.

We sampled three sites on Silk Creek. One was high in the watershed (SKUP) a few miles NW of Cottage Grove. The other two sites are at the upstream city limit (CGSKU) and at the mouth of Silk Creek (CGSKMO) to estimate potential impacts the urban area has on the water quality. Silk Creek, a tributary of the Coast Fork of the Willamette River, is a small perennial stream that empties into the Coast Fork within the city limits of Cottage Grove. The watershed area is 16 square miles - 3% urban, 11% agriculture and 96% private forest.

Cottage Grove Coast Fork: For this study, continuous temperature data were not collected at either site. The US Forest Service has collected continuous temperature data in previous years that documented summer water temperatures not meeting the state standard. Our single reading temperature measurements were usually below 16° C, but were collected in the cool morning hours and we expect temperatures were much higher in the afternoon. *E. coli* standards were not met 4 times (17%) at the upstream site and 7 times (29%) at the downstream site (Figure 35, Appendix E). Storm runoff monitoring data for 2008 indicate *E. coli* standards were not met on the Coast Fork just downstream of Cottage Grove (CGCFDW). In 2009 *E. coli* standards were not met at either the upstream or downstream site. Dissolved oxygen standards were not met 3 times (19%) at the upstream site and 2 times (14%) at the downstream site.

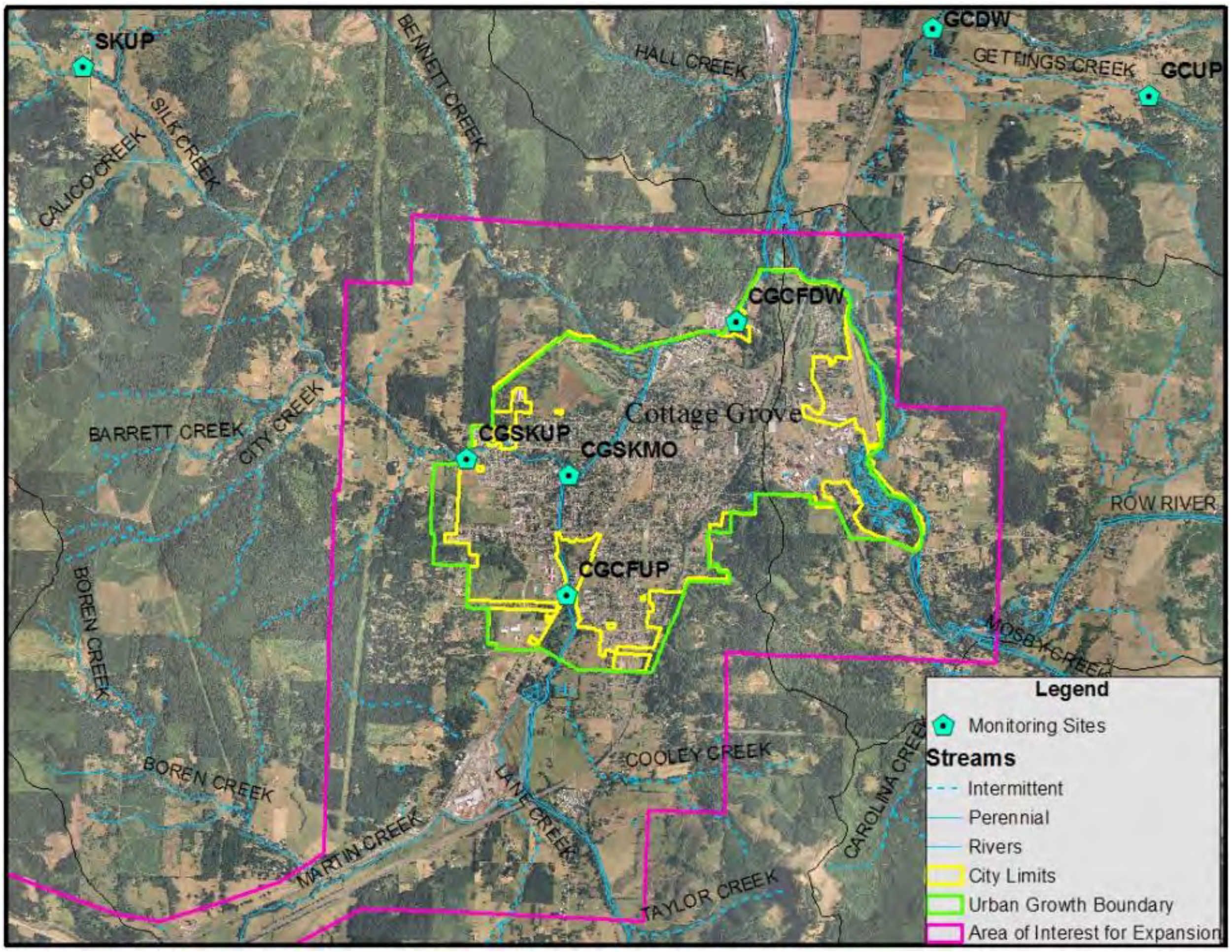


Figure 34. Sampling sites for the Coast Fork and Silk Creek in the Cottage Grove DMA as well as the upper Silk Creek site and the two Gettings Creek sites. Map includes Cottage Grove urban growth boundary and interest area for urban expansion. SKUP is above most rural residential land use and CGSKUP is just upstream of Cottage Grove.

DEQ benchmarks (Appendix D) for turbidity, total suspended solids (TSS), total inorganic nitrogen, and total phosphorus (TP) were developed for summer baseflow (i.e. not surface runoff) in nearby streams relatively undisturbed by human activity (Mulvey, et.al., 2010). The benchmark for TSS was met for all months but one at both the upstream and downstream sites. The turbidity benchmark was met for all months but one at the upstream site and twice at the downstream site (Figure 37), Table 6, Appendix E). Summer benchmarks for TP and total inorganic nitrogen were met at the upstream site for all months but were not met three times (TP) and four times (total inorganic nitrogen), respectively, for the downstream site (Figure 36).

Macroinvertebrate sampling (western Oregon Multimetric) results showed “Moderate Impairment” of stream quality and the Predator Model assigned a “Most Disturbed” designation for both sites along the Coast Fork (Appendix G).

Table 6. Comparison of Coast Fork and Silk Creek water quality results with State Standards or benchmarks. A complete summary of results can be found in Appendix E.

	Coast Fork Upstream CG (CGCFUP)	Coast Fork Downstream CG (CGCFDW)	Uppermost Silk Creek (SKUP)	Silk Creek Upstream CG (CGSKUP)	Silk Creek at Mouth (CGSKMO)
Temperature Standard	No continuous data	No continuous data	Failed	No continuous data	No continuous data
DO Standard	Failed 19%	Failed 14%	Failed 31%	Failed 31%	Failed 19%
E. coli Standard*^	Failed 17%	Failed 30%	Failed 17%	Failed 29%	Failed 29%
TSS (summer benchmark)^	Good/Fair	Good/Fair	Good	Fair	Good
Turbidity (summer benchmark)*	Good/Fair	Good/Fair	Fair	Fair	Fair
Conductivity (summer benchmark)*^	Good	Good	Fair	Fair/Poor	Fair/Poor
Storm Sampling	No data	No data	No data	*E.coli* failed	*E.coli* failed
TP (summer)*	Good	Fair/Good	Good	Good	Good
N (summer)*	Good	Fair/Poor	Good	Good	Good/Poor
Oregon multimetric index	Moderate Impairment	Moderate Impairment	No data	Severe Impairment	Moderate Impairment
Predictive model	Most Disturbed	Most Disturbed	No data	Most Disturbed	Most Disturbed

* Statistically higher values downstream than upstream for the Coast Fork sites.
^ Statistically higher values at the CGSKUP site over the SKUP site.

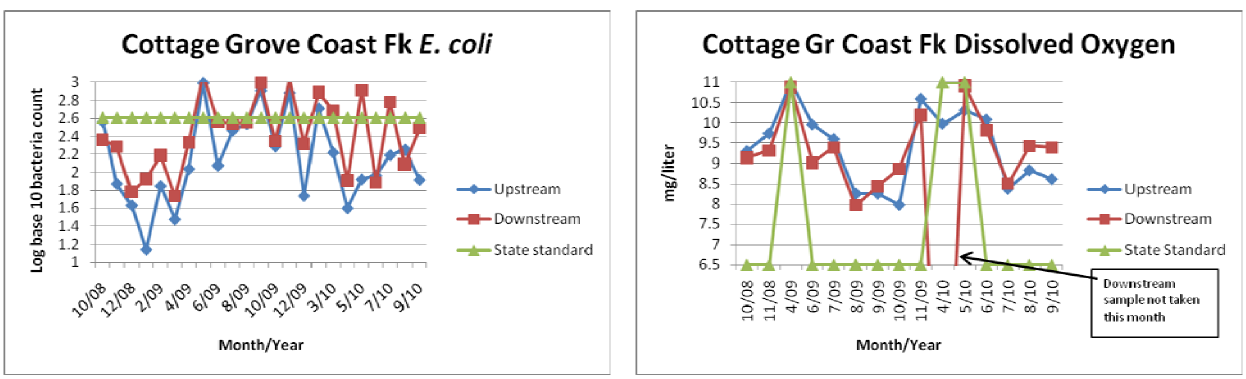


Figure 35. *E. coli* and DO results for Coast Fork Willamette River up and downstream of Cottage Grove .

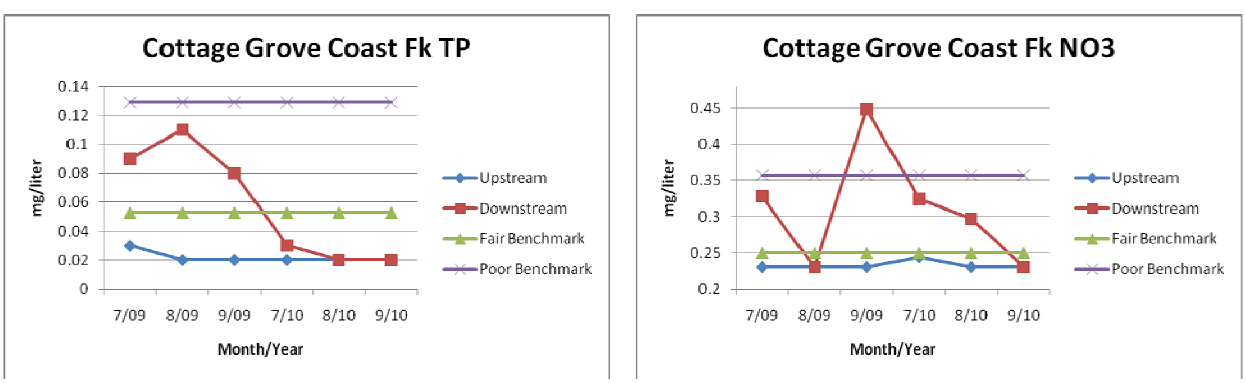


Figure 36. Coast Fork total phosphorous and inorganic nitrogen

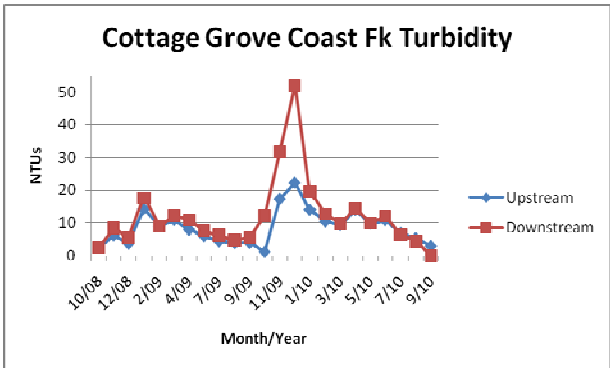


Figure 37. Coast Fork turbidity upstream and downstream of Cottage Grove.

Silk Creek upstream (SKUP), upstream of Cottage Grove (CGSKUP), and at the mouth (CGSKMO): Continuous temperature data at the site on Silk Creek furthest upstream of the city boundary (SKUP) indicated that the 7-day moving average was higher than the State Standard for 28 days in the summer of 2009 (Figure 38). In July 2010, temperature was monitored for 17 days and of those, 6 daily maximum temperatures exceeded 18 ^{O} C. Continuous temperature was not measured at the downstream site (CGSKMO).

Values for dissolved oxygen were below (but only slightly less) than the State Standard at the site urban boundary 3 out of 16 times (31%) and 5 out of 16 times at the mouth of the stream (Figure 39). *E. coli* standards were not met 29% of the time (7 out of 24 times) both upstream and downstream of Cottage Grove and were statistically significantly higher at the site just upstream of Cottage Grove (CGSKUP) (Figure 39). State standards for *E. coli* were not met 17% of the time at the uppermost site (SKUP). The *E. coli* standard was not met during 2009 or 2010 storm sampling at the Silk Creek site upstream of Cottage Grove (CGSKUP) or at the mouth (CGSKMO).

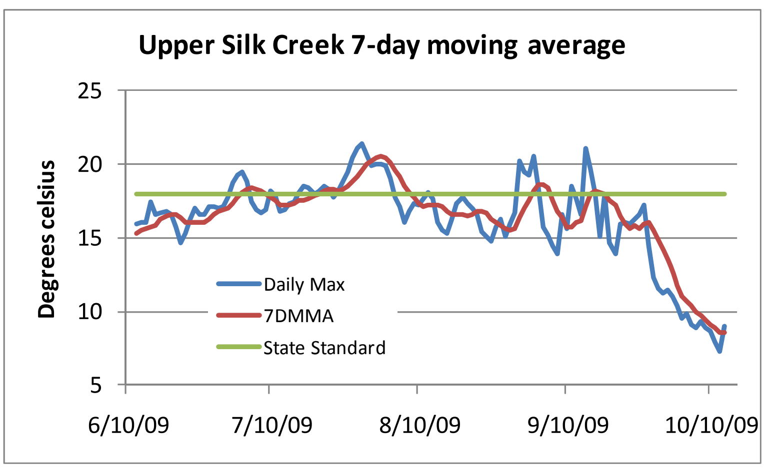


Figure 38. Continuous temperature data from the uppermost collection site on Silk Creek.

From looking at the number of times exceeding the summer benchmark – turbidity and TSS are poorer upstream than downstream of Cottage Grove, whereas total inorganic nitrogen is poorer downstream (Table 6, Figure 40, Appendix E). The turbidity benchmark was exceeded 100% of the time at the Silk Creek uppermost site (SKUP) and 83% of the time upstream of Cottage Grove (CGSKUP) and 50% of the time at the mouth (CGSKMO). The conductivity benchmark was exceeded 4 out of 6 times at the uppermost site (SKUP) and 5 out of 6 times upstream and downstream of Cottage Grove (Figure 40). A comparison of the two upper sites on Silk

Creek (CKUP and CGSKUP) indicates statistically higher values for summer baseflow conductivity and TSS at the downstream site (CGSKUP) (Figure 40). Total inorganic nitrogen levels met the DEQ benchmark except once at the downstream site (Appendix E).

Macroinvertebrate sampling results from the western Oregon Multimetric index indicate “Moderate Impairment” of stream quality and the Predator Model O/E a “Most Disturbed” designation for the downstream collection site along Silk Creek (CGSKMO), but “Severe Impairment” and a “Most Disturbed” designation for the site upstream of Cottage Grove (CGSKUP) on Silk Creek (Appendix G).

Cottage Grove Area Summary: The monitoring results indicate that water quality in the Coast Fork Willamette River is poorer downstream than upstream of Cottage Grove and analysis suggests the difference is statistically significant for temperature, *E.coli,* conductivity, turbidity, total phosphorous, and inorganic nitrogen. Water quality in Silk Creek, on the other hand, generally improved as it left the rural area upstream of Cottage Grove and flowed through the city. The one exception was summertime water temperature, which increased as it flowed through the city.

Since flow of Silk Creek is only about 1% of the flow of the Coast Fork Willamette River at their junction, it is too small to have a measurable influence on the Coast Fork Willamette water quality for the parameters in this study.

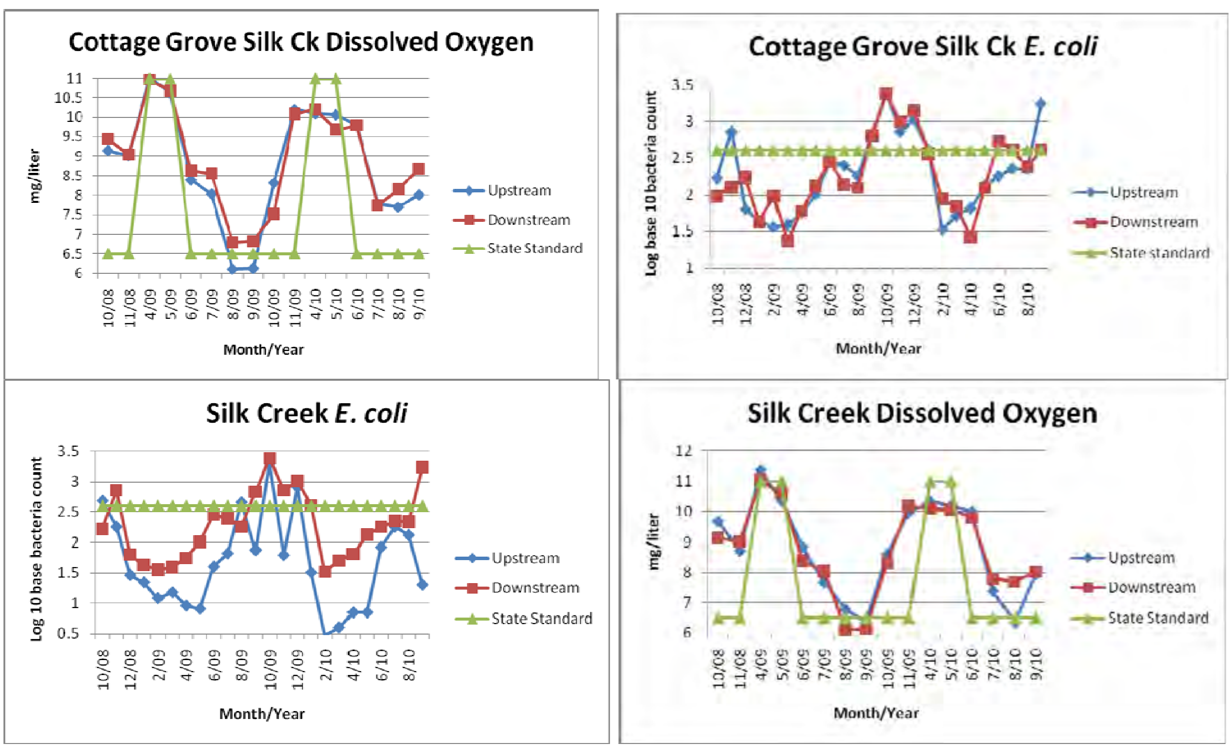


Figure 39. State Standards for DO and *E. coli* were not met at any of the sites for Silk Creek. First row of plots – CGSKUP is upstream and CGSKMO is downstream. Second row of plots – SKUP is upstream and CGSKUP is downstream.

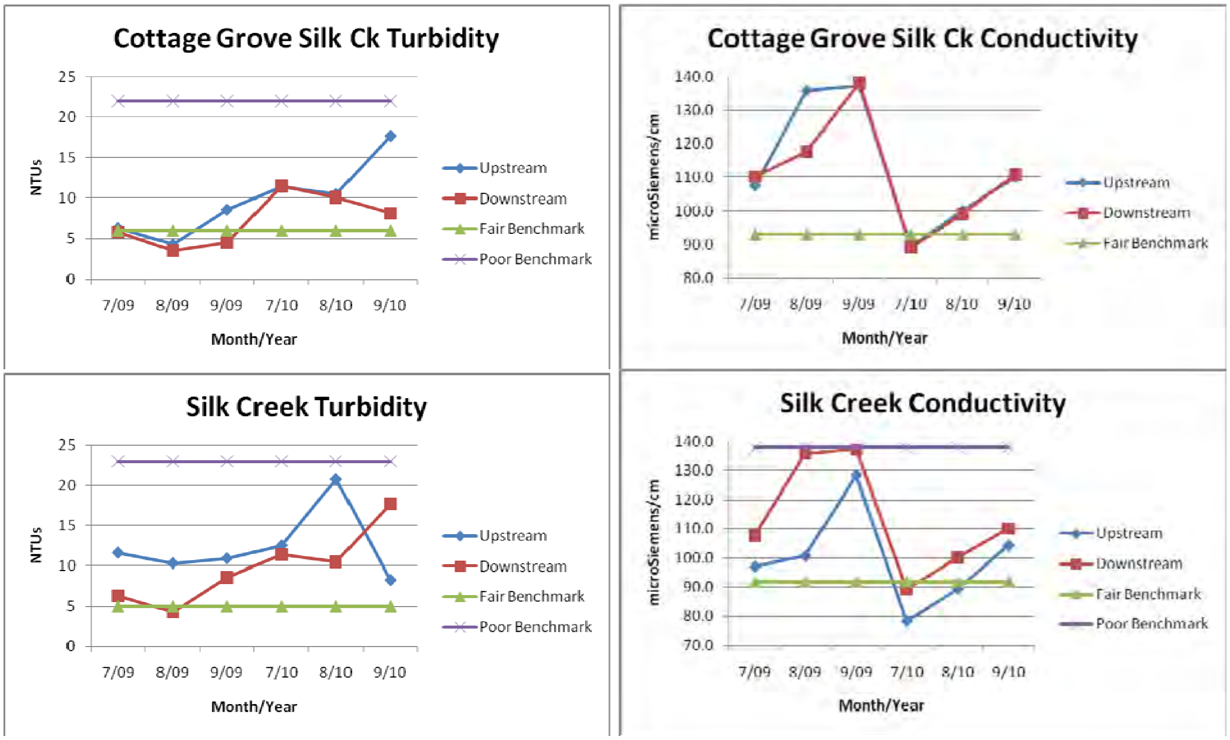


Figure 40. Turbidity and conductivity results for Silk Creek in relation to DEQ summer benchmarks. First row of plots – CGSKUP is upstream and CGSKMO is downstream. Second row of plots – SKUP is upstream and CGSKUP is downstream.

Overall, Silk Creek at the upper city limit of Cottage Grove had the poorest water quality for all parameters, especially those related to sediments, DO and bacteria. The macroinvertebrate data indicated severe impairment. Silk Creek had some of the highest bacteria levels in the study. *E. coli* in the uppermost, forested reach of Silk Creek was generally low, but peaked in the reach at the upstream boundary of Cottage Grove. *E. coli* levels decreased as Silk Creek flowed through the City of Cottage Grove and into the Coast Fork Willamette. The highest pulses of *E.coli* were upstream of Cottage Grove in the fall–early winter months (10/03, 10/09, 11/09, 12/09 and 9/10). The timing suggests the source of bacteria may be from surface runoff during the fall flush

On the Coast Fork Willamette River levels of *E.coli*, were much higher downstream of Cottage Grove than upstream suggesting the city does have an input of bacteria into the Coast Fork Willamette. The sites above and below Cottage Grove had a spike in June 2009 and readings were relatively high on the Coast Fork downstream of Cottage Grove throughout the summer suggesting a potential urban summer source of bacteria. Stream flow and high concentrations of bacteria were concurrent in many cases with the bacteria spike lagging behind the initial runoff by a couple of weeks.

DO in Silk Creek was lowest (poorest) in August and September 2009. Silk Creek upstream of Cottage Grove (GCSKUP) and Silk Creek upper most reach (SKUP) had the poorest DO. After leaving the agricultural and rural residential area and flowing through Cottage Grove (CGSKMO), DO improved.

Results suggest there may be nutrient concerns in the Coast Fork Willamette River and Silk Creek from the urban area, but not in the rural areas. Total P and total inorganic nitrogen were unusually high on the Coast Fork downstream of Cottage Grove and P was high at the mouth of Silk Creek.

At all three Silk Creek sites values were elevated for turbidity, *E. coli,* TSS, TP, and total inorganic nitrogen during the months of November and December 2009 and January and February 2010. These values increased with distance downstream from the uppermost sampling point, with the highest readings occurring at the site located at the confluence with the Coast Fork Willamette River.

City of Creswell

The City of Creswell is located just to the west of the Coast Fork Willamette River.

Geography: In 2004, the population was estimated at 4,120. About 51% of land in the Creswell urban growth boundary is zone for residential purposes, 25% for commercial, 14% for industrial, and the remaining 10% for parks or public facilities. Situated 18 miles south of Eugene-Springfield, Creswell has grown rapidly and to continue. According to preliminary estimates, Creswell's population is expected to quintuple over the next 50 years to over 20,000 residents. To accommodate this growth the existing urban growth boundary may be expanded by nearly 2,000 acres by 2055, including an additional 400 acres of associated development (mostly residential) occurring within the 100-year floodplain of the Coast Fork Willamette River. As a percentage, this is the largest estimated increase of any of the small cities in Lane County.

Current water quality policies: There are a number of water quality efforts underway in Creswell. Creswell's Development Code includes erosion control standards for new development and an ordinance encouraging the retention of natural vegetation on construction sites. The City has also adopted a pet waste pick-up ordinance. The City is now diverting some wastewater effluent to irrigate 118 acres of property owned by the city. Monitoring wells around the site continuously monitor application rates to avoid any surface runoff. As a DMA, Creswell emphasizes strategies to reduce heat loading to tributaries of the Coast Fork. Creswell has selected a package of strategies to meet the following objectives: reduce heat loads to less than 0.05º C, meet a planning target of 80-94% reduction in bacteria loading, and minimize mercury contributions (TMDL Implementation Plan).

Monitoring sites: The two streams sampled in Creswell are intermittent. We sampled two sites on Hill Creek up and downstream of Creswell (CWHCUP and CWHCDW), and one site (CWNNCMO) on an unnamed stream that drains stormwater from western Creswell into Camas Swale near the wastewater treatment plant (Figure 41).

The Hill Creek sub-watershed makes up 17% of the land area of the Lower Coast Fork Watershed. It is dominated by rural residential development, small-scale agriculture and livestock production (87%) with uplands in industrial timber (8%) and BLM lands (5%). An irrigation system, a Corps of Engineers diversion dam, and an excavated stream course strongly influence the water quality at the lower elevations. The result of stream alterations is that Hill Creek is largely a series of ponds within the Creswell city limits. The water at the upstream collection sites (CWHCUP) was stagnant during summer months limiting data collection to periods of flowing water.

Camas Swale is a perennial stream with a sub-watershed covering 27,776 acres (43.4 square miles) and makes up 30% of the Lower Coast Fork Watershed. The dominant land uses are rural residential and livestock-based agriculture with some commercial forestry, recreation, and public services. It flows west-northwest, draining foothills on the south side of the southernmost ridge within the Eugene City Limits. Camas Swale is a low gradient stream dominated by hydric soils in the lower reaches but influenced by numerous higher gradient tributaries. Ownership is small private (80%), industrial timber (11%), BLM (6%), and other public—Short Mountain/Quamash Prairie, Spencer's Butte (5 %) (Jones, 2005). The lower site (CSDW) is about 4.25 miles downstream of the upper site (CSUP).

Creswell Hill Creek upstream (CWHCUP) and downstream (CWHCDW): Water quality at the two sites on Hill Creek (CWHCUP & CWHCDW) failed to meet State Standards once for *E. coli*, but frequently failed to meet DO standards (Table 7). DO levels were below State Standards three out of five times at CWHCUP and four of five times at CWHCDW, with the values at the site downstream of Creswell always poorer than the upstream site (Figure 42). *E. coli* levels exceeded State Standards once at the upstream site, but never at the downstream site, and were significantly lower at the downstream site (Figure 43, Appendices E and F). Furthermore, storm samples from Hill Creek exceeded *E. coli* standards for both years at the upper collection site but not the downstream site, suggesting that during these events Creswell did not substantially increase bacteria concentrations in Hill Creek (Appendix E). Results also indicated the downstream site had significantly lower levels of turbidity (Figure 43).

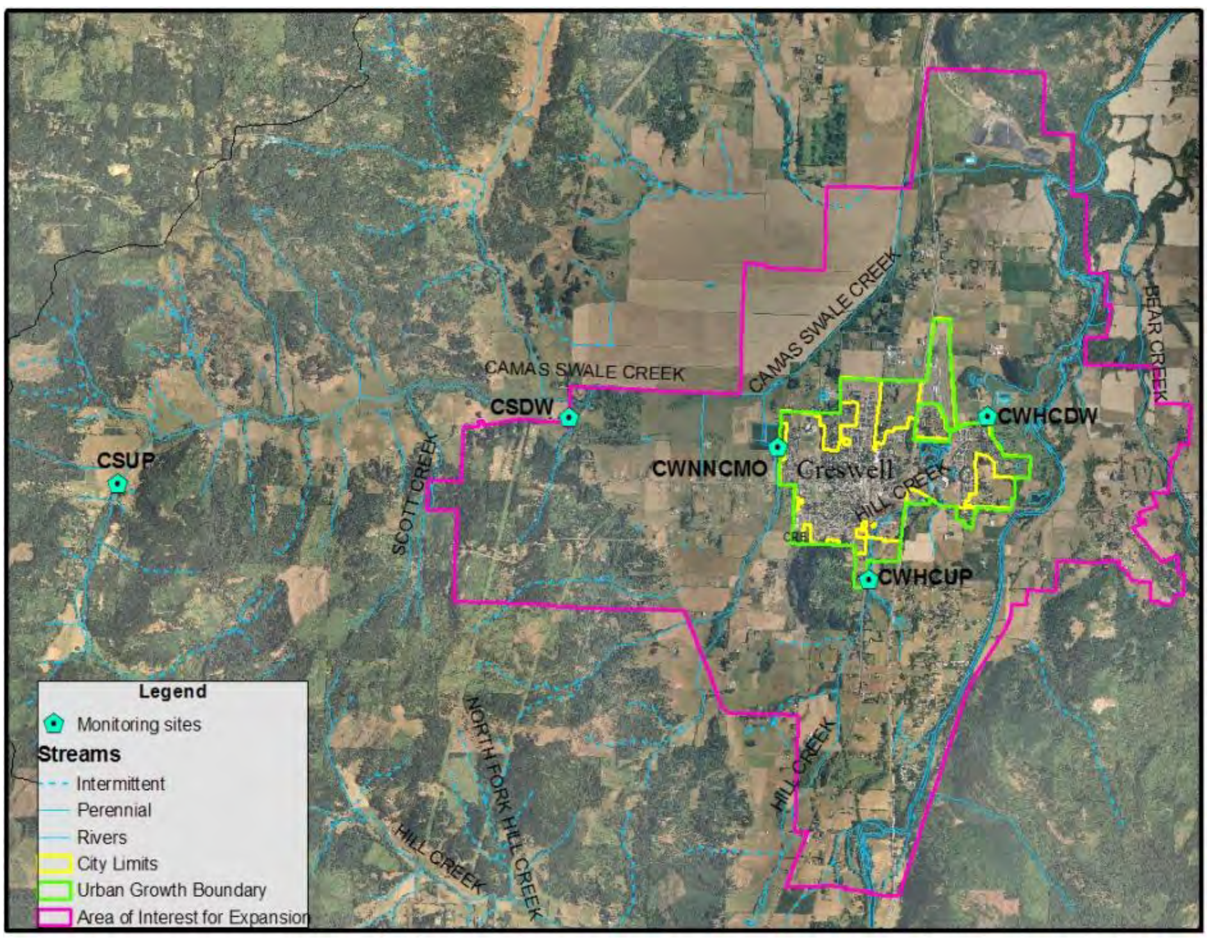


Figure 41. Creswell and surrounding streams, including, Hill Creek, Camas Swale and an unnamed creek on the western city limit.

Table 7. Comparison water quality results with State Standards at monitoring sites in the Creswell area. A complete summary of results can be found in Appendix E.

	Hill Creek Upstream Creswell (CWHCUP)	**Hill Creek Downstream Creswell (CWHCDW)**	**No-name Creek Downstream Creswell (CWNNCMO)**	**Camas Swale Upstream Rural (CSUP)**	**Camas Swale Downstream Rural (CSDW)**
Temperature Standard	No continuous data	No continuous data	No continuous data	Failed	Failed
DO Standard	Failed 60%	Failed 80%	Failed 50%	Failed 40%	Failed 40%
E. coli Standard*^	Failed 8%	Good	Failed 40%	Failed 7%	Failed 20%
Storm Sampling	*E. coli* failed	Good	Good	No data	No data

* Statistically higher values upstream than downstream for the Hill Creek/Creswell sites.
^ Statistically higher values downstream than upstream for the Camas Swale sites.

Creswell Unnamed Creek (CWNNCMO): This unnamed creek, technically a tributary to Camas Swale, is intermittent and generally flows only when rain creates stormwater runoff from the western side of Creswell. Results from this site describe the condition of the water as it leaves Creswell and joins with Camas Swale. Due to insufficient stormwater runoff during much of our sampling period, this site was sampled 5 times over 2 years. *E. coli* standards were not met in 2 of the 5 samples (Figure 44) and once in the two times it was tested for DO (Table 7). Storm samples taken in 2009 did not exceed the state standard for *E. coli*.

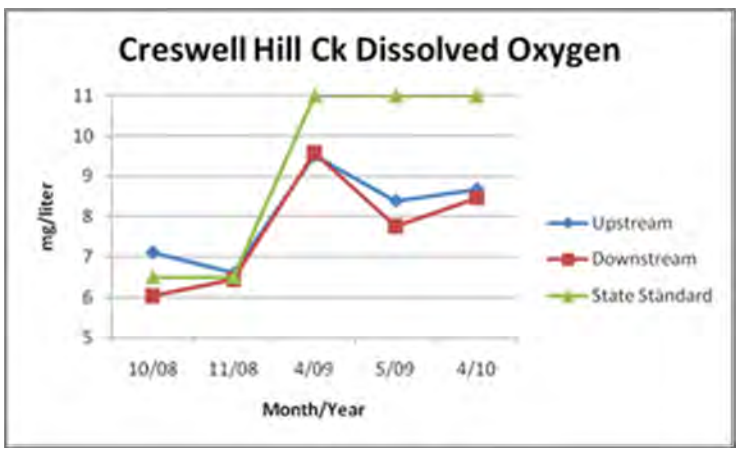
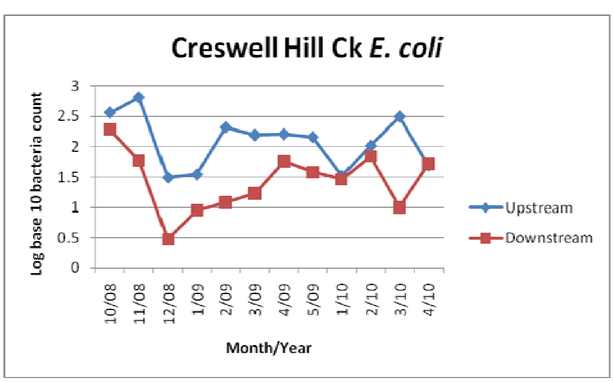


Figure 42. Dissolved oxygen for Creswell Hill Creek.



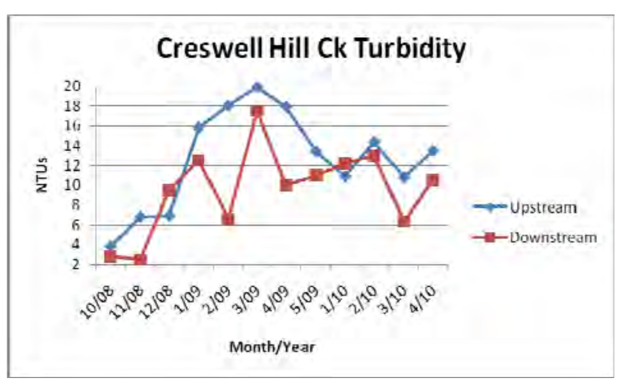


Figure 43. *E. coli* and turbidity for Creswell Hill Creek.

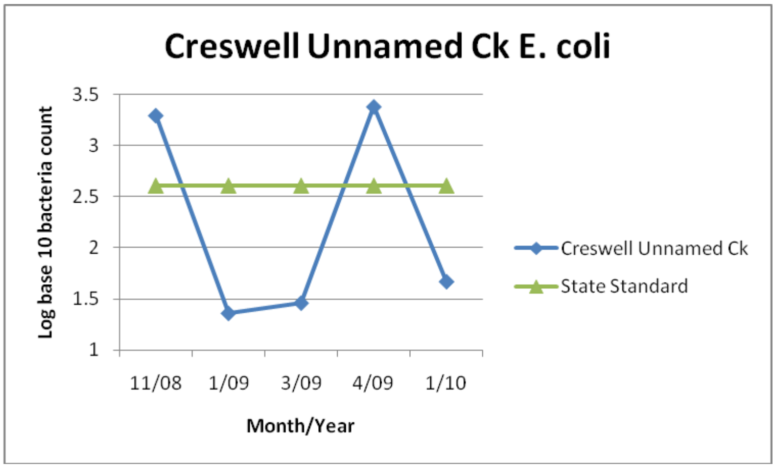


Figure 44. *E. coli* values for the unnamed stream in Creswell.

Camas Swale upstream (CSUP) and downstream (CSDW): Temperature, *E. coli* and DO exceeded State Standards in Camas Swale (Table 7). The upstream continuous temperature monitoring site did not meet state standards at any time July 20-August 15, 2009 by an average 1.5º C (Figure 45). In 2010, the standard was exceeded 4 days out of 11. The downstream continuous temperature monitoring site did not meet standards June 5 -October 1, 2009 by an average 2.5º C and the 2010 temperatures exceeded the 7-day moving average standard 17 of the 17 days for which we collected data (Appendix E). Lower Camas Swale met the *E. coli* standard 80% of the time but had significantly higher levels of *E. coli* than upper Camas Swale, which met the standards except at one sampling event (Figure 46, Appendix E). At both monitoring sites, 43% of the samples did not meet the DO standard (Figure 46). We found statistically significant differences between upstream and downstream sites for conductivity, turbidity, and total suspended solids that suggested poorer water quality at the downstream site.

Although summer sampling of total phosphorous did not occur, therefore we were unable to compare to benchmarks, many samples taken at other times of the year were considerably higher at Camas Swale than those seen at other sites in this project (Figure 47, Appendix E).

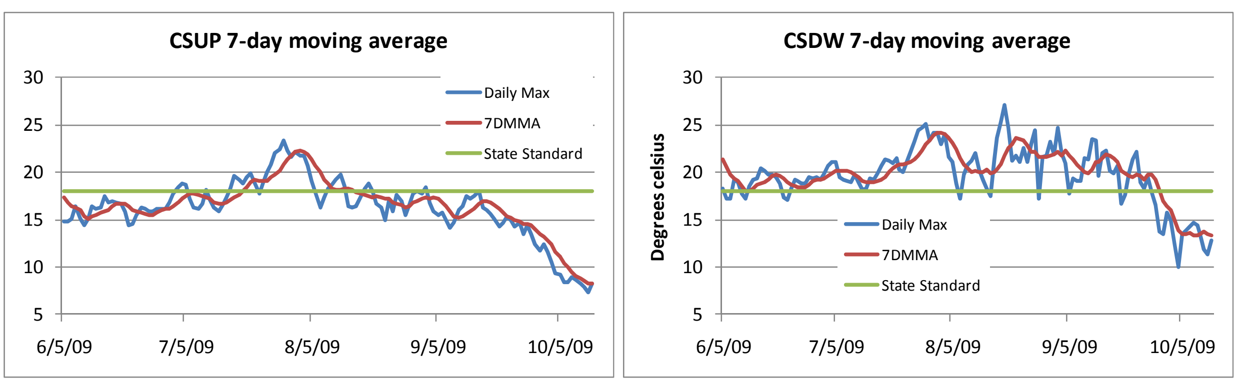


Figure 45. Continuous temperature results for both the upstream (left) and downstream (right) sites on Camas Swale in 2009.

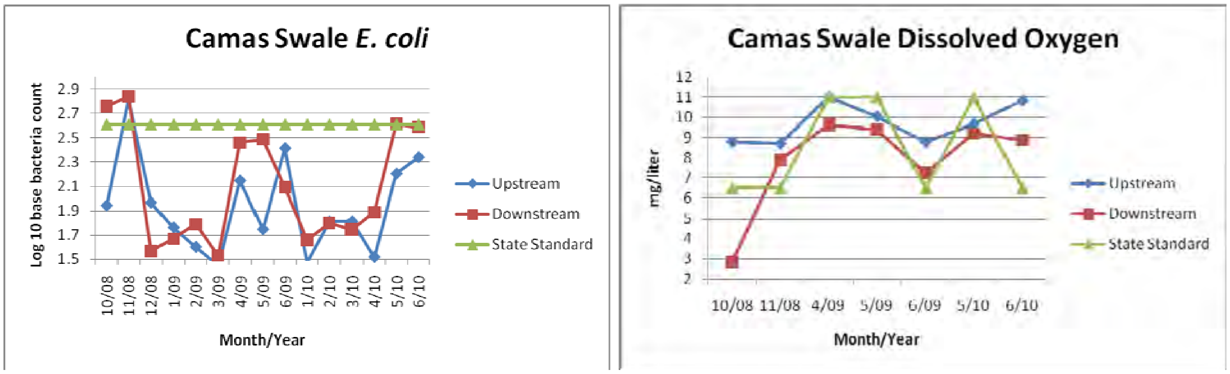


Figure 46. *E. coli* values for upstream and downstream sampling sites on Camas Swale.

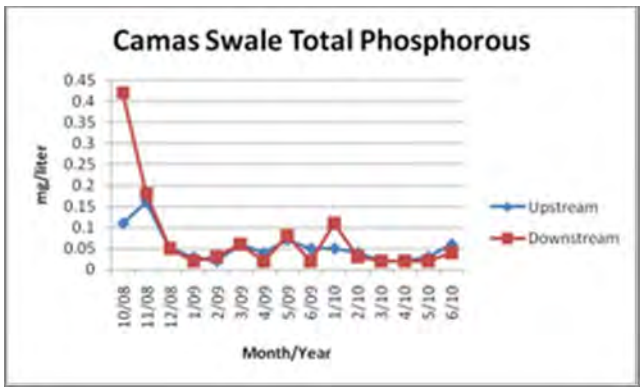


Figure 47. Total phosphorous for Camas Swale.

<u>Creswell Area Summary</u>: The City of Creswell has numerous wetlands that can isolate nutrients and sediment and therefore improve water quality to some extent. Hill Creek—is a series of ponds due to extensive stream alteration—had higher temperatures and conductivity, but lower *E. coli,* turbidity, and total suspended solids. We presume that water warms as it travels through the series of ponds but suspended sediment settles out as it flows through them within Creswell. The downstream site tended to have higher flow levels than the upstream site and this provides some level of dilution.

Camas Swale exceeded water quality standards for temperature, DO and *E.coli*. Temperatures, especially in Lower Camas Swal,e were well above the standard for several weeks in the summer.

Coast Fork Willamette Tributaries

Two tributaries to the Coast Fork Willamette were also included in this study because the tributary watersheds are in areas of rural residential development.

<u>Gettings Creek</u> is a small, perennial stream draining a sub-watershed that makes up 12% of the Lower Coast Fork Willamette River watershed. Land use is largely rural residential, agriculture, and forestry. Livestock are common and little riparian fencing or vegetative buffer occurs along the stream. About 48% is private industrial timber in the uplands, and 51% (5,420 acres) is rural residential/agriculture. Two sampling sites were located along this stream. The lower Gettings Creek monitoring site (GCDW) is about 2 miles upstream of where it joins the Coast Fork

Willamette (Figure 34). The upstream site (GCUP) is above most of the rural residential, agricultural and livestock use along Gettings Creek. The distance between the two sites is about 1.6 miles.

Mosby Creek, a tributary to the Row River, is a large perennial stream that drains 97 square miles. The upper two-thirds of Mosby Creek is primarily industrial and federal timberland, with the lower third being rural residential and small scale agriculture. Two sampling sites were located along the lower section of this creek, one about a half mile upstream of the mouth (MCMO) adjacent to a BLM park and the other about 2.5 miles further upstream, which is above most of the rural residential development along Mosby Creek Rd (Figure 48).

Limiting factors for Mosby Creek were identified during the 2008 ODFW Mosby Creek Aquatic Inventory (ODFW 2008). These include: lack of in-stream structure, young riparian condition (most riparian zones 40-80 years old), and a bedrock-dominated stream channel that is 30 meters wide in some areas. Streamflow was described as extremely flashy. Temperature impairment is the single major water quality problem in this watershed (Coast Fork staff as per communication 2011).

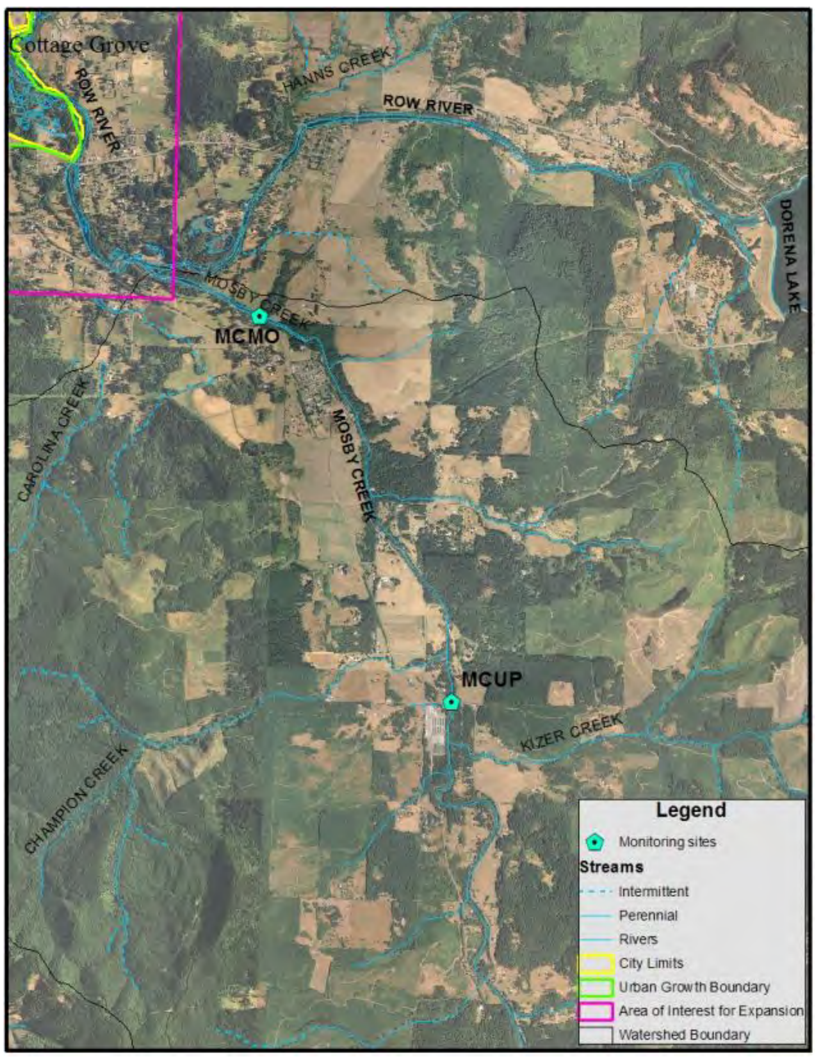


Figure 48. Monitoring locations for Mosby Creek.

Gettings Creek upstream (GCUP) and downstream (GCDW): Samples from Gettings Creek did not meet State Standards for temperature, *E. coli,* and DO (Table 8). At the upstream site (GCUP) continuous monitoring data indicated that between July 3 and September 21, 2009, the 7-day moving average exceeded the temperature standard by an average of 1.5º C (Figure 49). In 2010, the standard was exceeded 5 out of 17 days by about 0.5º C. At the downstream site (GCDW) all of the 7-day moving averages between June 12 and October 3, 2009, were above the State Standard by 6º C or more. In 2010, all 17 days between July 16 and July 26 exceeded the standard (Appendix E). The E*. coli* water quality standard was met at the upstream site but was significantly higher at the downstream site, failing to meet the State Standard for 13 of 24 monthly samples (54%) (Figure 50) The DO State Standard was not met for 13% samples at the upstream and 19% at the downstream site. Values were significantly lower at the downstream site.

Water quality samples from Gettings Creek generally met benchmarks for conductivity, turbidity, TSS, total P, and total inorganic nitrogen (Table 8). Conductivity levels did not meet the summer benchmark for 83% of the samples at the upstream site and 100% of the samples at the downstream site. The turbidity levels met summer benchmarks at the upstream site but did not meet them twice at the downstream site (Figure 51). Conductivity, turbidity and TSS were significantly higher at the downstream site .

Total inorganic nitrogen levels exceeded the benchmarks once at the upstream site and many readings were considerably higher than those seen at other sites involved in this project. Though upstream and downstream values were relatively similar, there were three incidents where the upstream site had higher levels than the downstream site (Figure 52).

Table 8. Comparison water quality results with State Standards or benchmarks at monitoring sites at Gettings Creek and Mosby Creek. A complete summary of results can be found in Appendix E.

	Gettings Creek Upstream (GCUP)	**Gettings Creek Downstream (GCDW)**	**Mosby Creek Upstream (MCUP)**	**Mosby Creek Downstream (MCMO)**
Temperature Standard	Failed	Failed	Failed	Failed
DO Standard*^	Failed 12%	Failed 19%	Failed 19%	Failed 19%
E. coli Standard*	Failed 8%	Failed 54%	Good	Good
TSS (summer benchmark)*	Good	Good	Good	Good
Turbidity*^ (summer benchmark)	Good	Fair/Good	Good	Good
Conductivity*^ (summer benchmark)	Fair	Fair	Good	Good
TP (summer)	Good	Good	Good	Good
N (summer)	Good	Good	Good	Good
Oregon multimetric index	No data	No data	Slight Impairment	Slight Impairment
Predictive model shore	No data	No data	Most Disturbed	Most Disturbed

* Statistically higher/lower values for the downstream over the upstream site at Gettings Creek.
^ Statistically higher/lower values for the downstream over the upstream site at Mosby Creek.

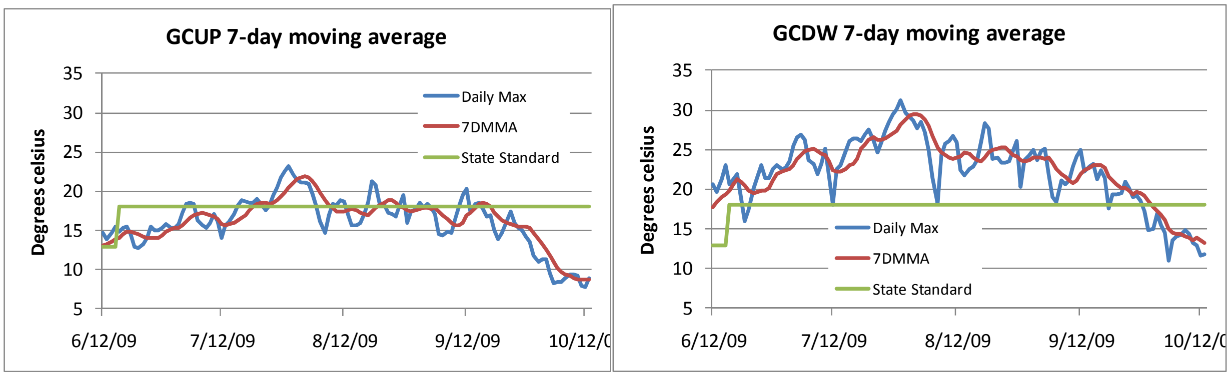


Figure 49. 2009 Continuous temperature results for both up and downstream sites on Gettings Creek. The State Standard was not met at either of these sites.

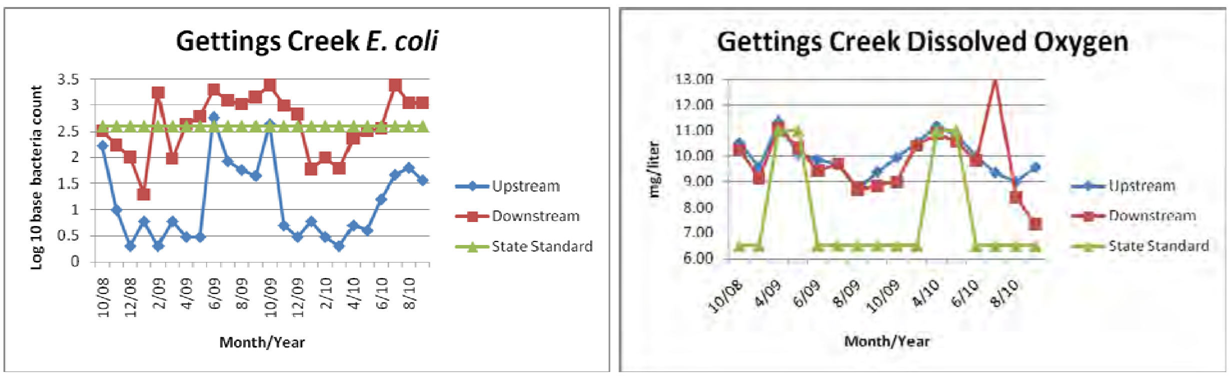


Figure 50. The State Standard for *E. coli* was not met at the downstream site and the one for dissolved oxygen was not met at either the up or downstream collection site.

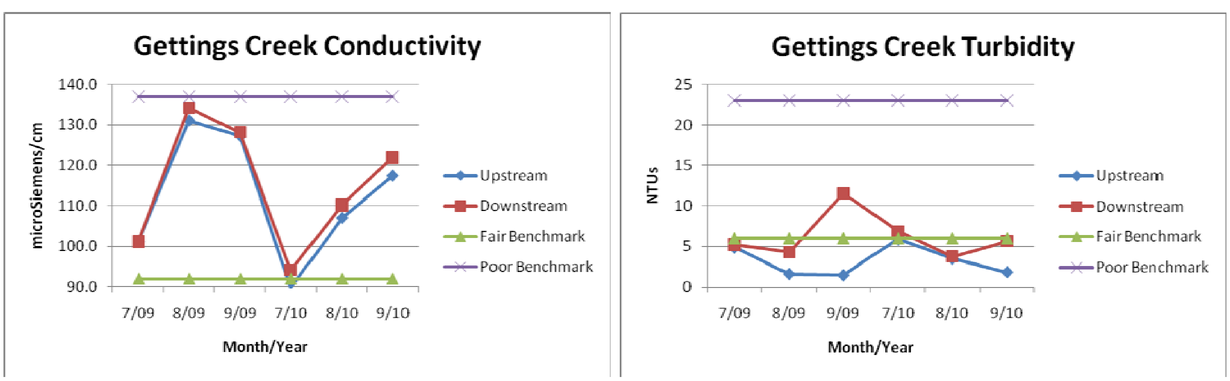


Figure 51. The DEQ benchmark for conductivity was not met most of the time and the benchmark for turbidity was not met twice but only at the downstream site.

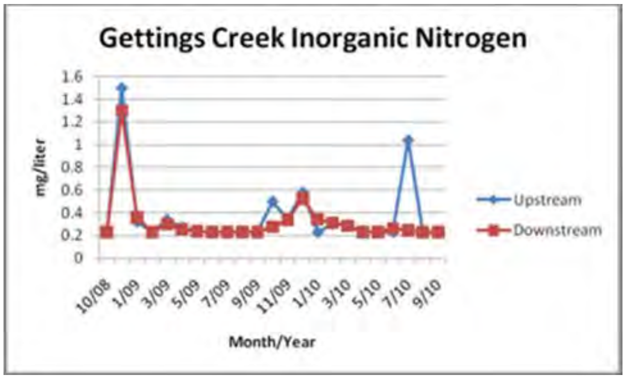


Figure 52. Total inorganic nitrogen levels were actually higher at the upstream site on several occasions.

Mosby Creek upstream (MCUP) and downstream (MCMO): Temperature at both the upstream and downstream sites exceeded State Standards in the summer (Table 8). At the upstream site, 7-day moving averages between June 12th and September 30th 2009 were above the allowable limit by an average of 5º C (Figure 53). In 2010, only 17 days of data was collected at the upstream site but the 7-day moving average during the entire time was 4 - 5º C higher than the State Standard (Figure 54). At the downstream site, no temperature data is available from 2009 and in 2010 only 17 days of data was collected. The 7-day moving average in 2010 was 5 - 6º C higher than the State Standard.

DO was below the State Standard for 19% of our samples at the upstream and downstream sites and all were during the spring. Levels were significantly lower at the downstream site (Table 8, Figure 55, Appendices E and F). *E. coli* levels in Mosby Creek peaked in the summer or fall on three occasions over the course of the study (Oct 2008, Oct 2009, and July 2010) after periods of no rain in the summer. However, the *E. coli* State Standard was not exceeded (Figure 55). All baseline, summer flow nutrient and sediment related benchmarks were met. The data indicate statistically higher levels of conductivity and turbidity at the downstream site.

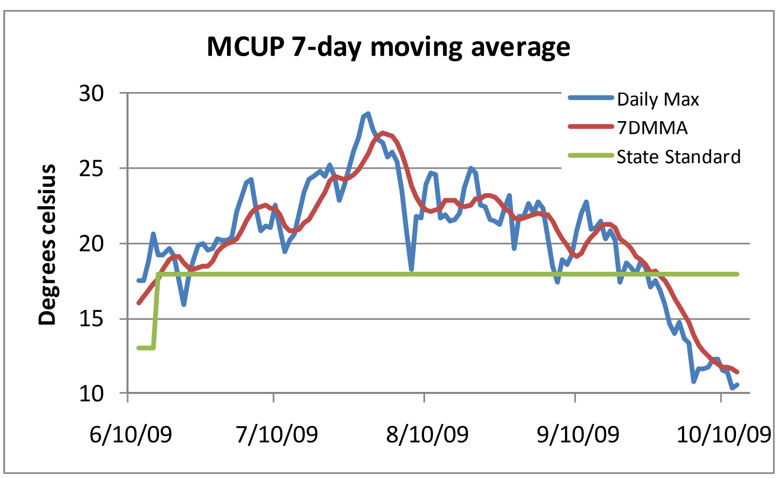


Figure 53. Continuous temperature results for the upstream Mosby Creek site in 2009

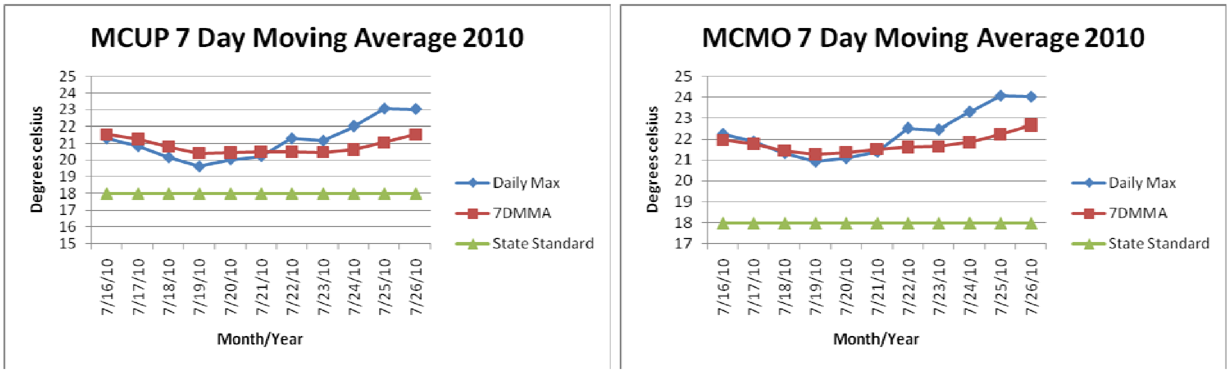


Figure 54. Temperature for the upstream (left) and downstream (right) sites in Mosely Creek for 2010.

Macroinvertebrate sampling was conducted in the summer of 2010. The sampling results from the western Oregon Multimetric index showed “Slight Impairment” of stream quality and the Predator Model O/E results showed a “Most Disturbed” designation for both the upstream and downstream collection sites (Appendix G).

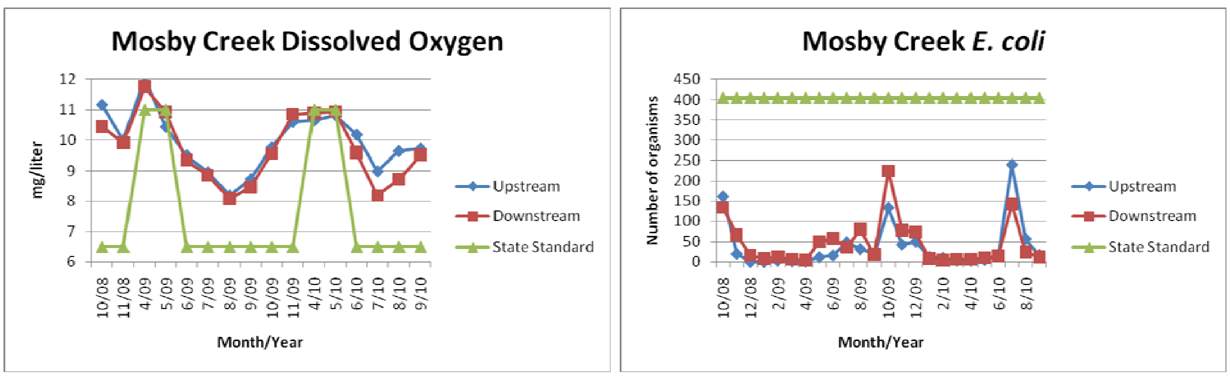


Figure 55. Dissolved oxygen and *E. coli* for Mosby Creek.

<u>Coast Fork Willamette Tributary Summary</u>: Gettings Creek had impaired water quality compared to other streams in the study. Temperatures were well above the standard throughout the summer, especially at the lower site. The *E.coli* State Standard was met at the upstream site but not at the downstream site. We commonly viewed cows in the stream while collecting samples. Downstream conditions tended to be worse, as indicated by statistically significant differences in *E. coli,* DO, summer conductivity, turbidity, and TSS.

Water temperature was high in Mosby Creek. Temperatures were 5º C above the State Standard from June through September. The watershed is significant to fish because this is the only undammed large stream in the Coast Fork basin and salmonids require water that is cool enough to rear. *E. coli* levels in Mosby Creek were highest in the summer and fall after periods of now rain in the summer, although the *E. coli* State Standard was not exceeded. All baseline, summer flow nutrient and sediment related state benchmarks were met. Downstream water quality declined as indicated by statistically significant differences of DO, conductivity and turbidity.

Chapter 4: Upper Willamette/Long Tom Watershed

The Upper Willamette Watershed (Hydrologic Unit Code 17090003) is located in the southwest portion of the Willamette Basin with tributaries that flow to the Willamette River. The watershed's 1,861 square miles (1,190,770 acres) extend from the foothills of the Cascade Mountains on the east to the Coast Range foothills on the west (Figure 56). Six major watersheds comprise the Upper Willamette, including the Long Tom, Calapooia, Luckiamute, Marys, Muddy Creek, and Oak Creek . Because this study was focused on watersheds in Lane County within the Willamette Valley, it included the Long Tom Watershed but not the five other watersheds in the Upper Willamette. A comprehensive study of water quality in the Long Tom Watershed was completed in 2007 (Thieman). Thus we limited our scope for this study to include the two small-city DMAs in the Long Tom Watershed (i.e., Veneta and Junction City) and one small city that drains directly into the Willamette (i.e., Coburg).

Long Tom Watershed

The Long Tom Watershed accounts for 410 square miles (262,000 acres) originating on the eastern side of the Coast Range at the southwestern end of the Willamette Valley (Thieman 2000). Land use in the watershed includes a mixture of forest land, farms and small and large cities. Agriculture, rural residences, and cities dominate the valley lowlands while forestlands cover the foothills and headwaters. The upper and lower Long Tom subwatersheds are divided by Fern Ridge Reservoir, which is managed by the Corps of Engineers for flood control and irrigation. The watershed's political jurisdiction includes portions of Lane and Benton County. The watershed is owned almost entirely by private land owners, with a small amount being managed by the Bureau of Land Management (BLM) and the State of Oregon.

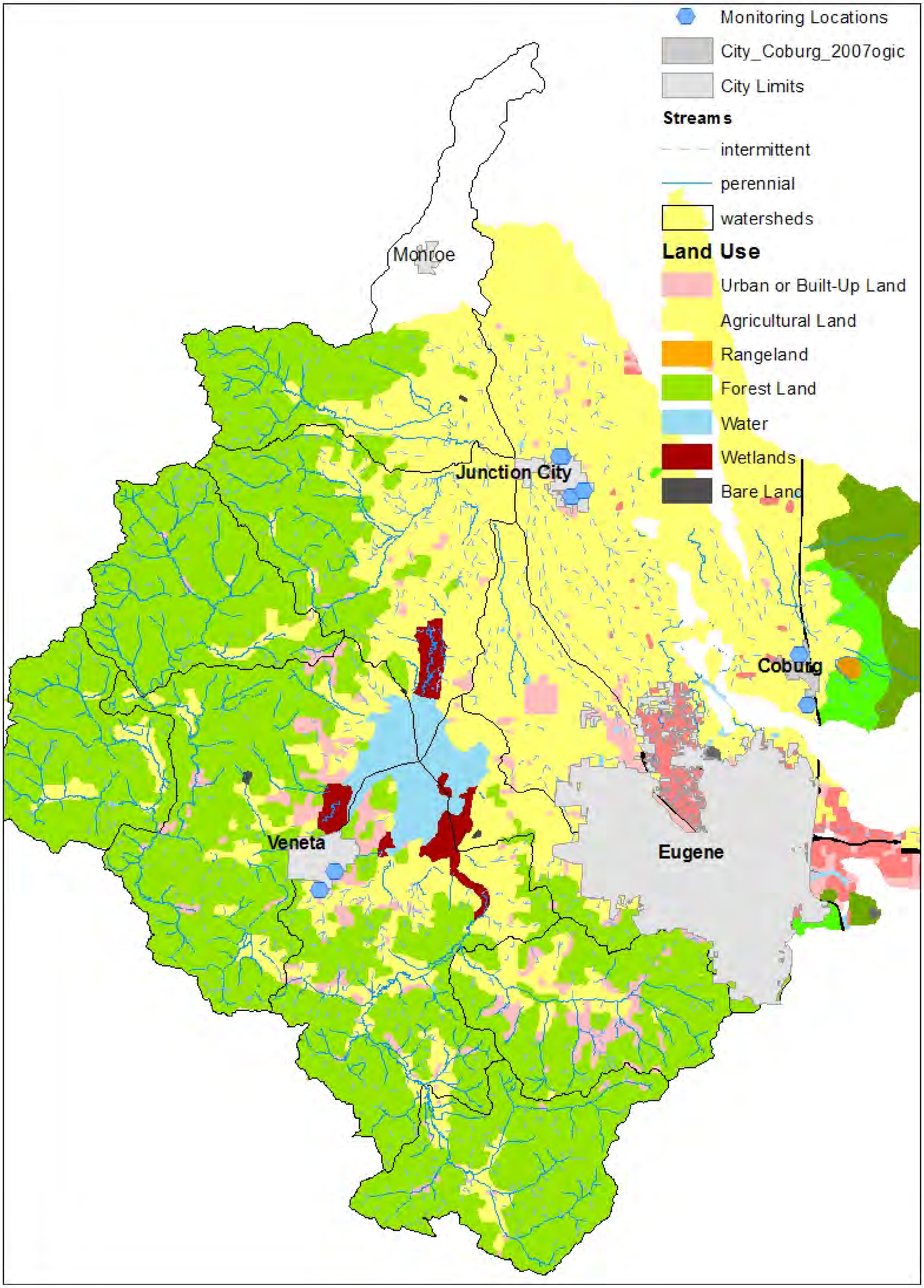


Figure 56. Long Tom and mainstem Willamette land use and monitoring points

Upper Willamette Designated Management Areas

Junction City

Junction City is located in the Upper Willamette watershed between the Willamette River and the Long Tom River.

Geography: The population is approximately 5340 and growing steadily (PSU Population Research Center).

Current water quality policies: Junction City's stormwater system carries runoff into Flat Creek, an overflow channel of the Willamette River, and Crow Creek, an intermittent channel that flows northwest to the Long Tom River. The City relies on groundwater as their drinking water source and was one of the first municipalities in Oregon to develop a Drinking Water Protection Plan. The City has also implemented an overlay zone that establishes a 50-foot riparian corridor along perennial streams. All public works projects must follow design standards that include erosion control and the City trains mechanics in proper hazardous waste disposal methods.

Monitoring sites: There are four collection sites associated with the Junction City DMA (Figure 57). Two of these sites are located along a small stormwater collection ditch that runs through the eastern side of Junction City and eventually joins with Flat Creek north of town. The upstream site (JCTR1UP) is located just south of E 1st Ave and the downstream site (JCTR1DW) is located just north of town along W. 18th Avenue. The other two sites are located along a creek that appears to be a branch of Flat Creek that also collects stormwater as it travels through the central and more westerly portion of Junction City. The upstream site (JCTR2UP) is located just south of town at a small footbridge to the east of Hwy 99 and south of an RV dealership and the downstream site (JCTR2DW) is located at a culvert on W. 18th just north of town. The seasonality of flow allowed for only 5-6 sampling monthly events during the two year study.

Junction City Tributary 1 upstream (JCUPTR1) and downstream (JCDWTR1): Water quality State Standards were met for all parameters except *E. coli* storm sampling in September 2010 (Table 9).. We only sampled DO a few times due to seasonality of the stream, but the values were extremely high. This may be due to the time of sampling and the abundance of vegetation in this small waterway. Consequently, we considered the results for DO unreliable. Turbidity and TSS were significantly higher at the upstream site than the downstream site, though the sample size is small (Figure 58, Appendices E and F).

Junction City Tributary 2 (JCUPTR2) and downstream (JCDWTR2): Water quality standards were met for *E. coli* during monthly samples, but failed DO during the one sampling occurrence at the upstream site (Table 9, Appendix E). *E. coli* levels failed to meet State Standards during storm sampling in September 2010 (Appendix E). DO at the downstream site was abnormally high, most likely due to the time of day and the abundance of vegetation in this small waterway, so was removed from this comparison. Significantly higher values of turbidity and somewhat higher values of TSS occurred (Figure 59).

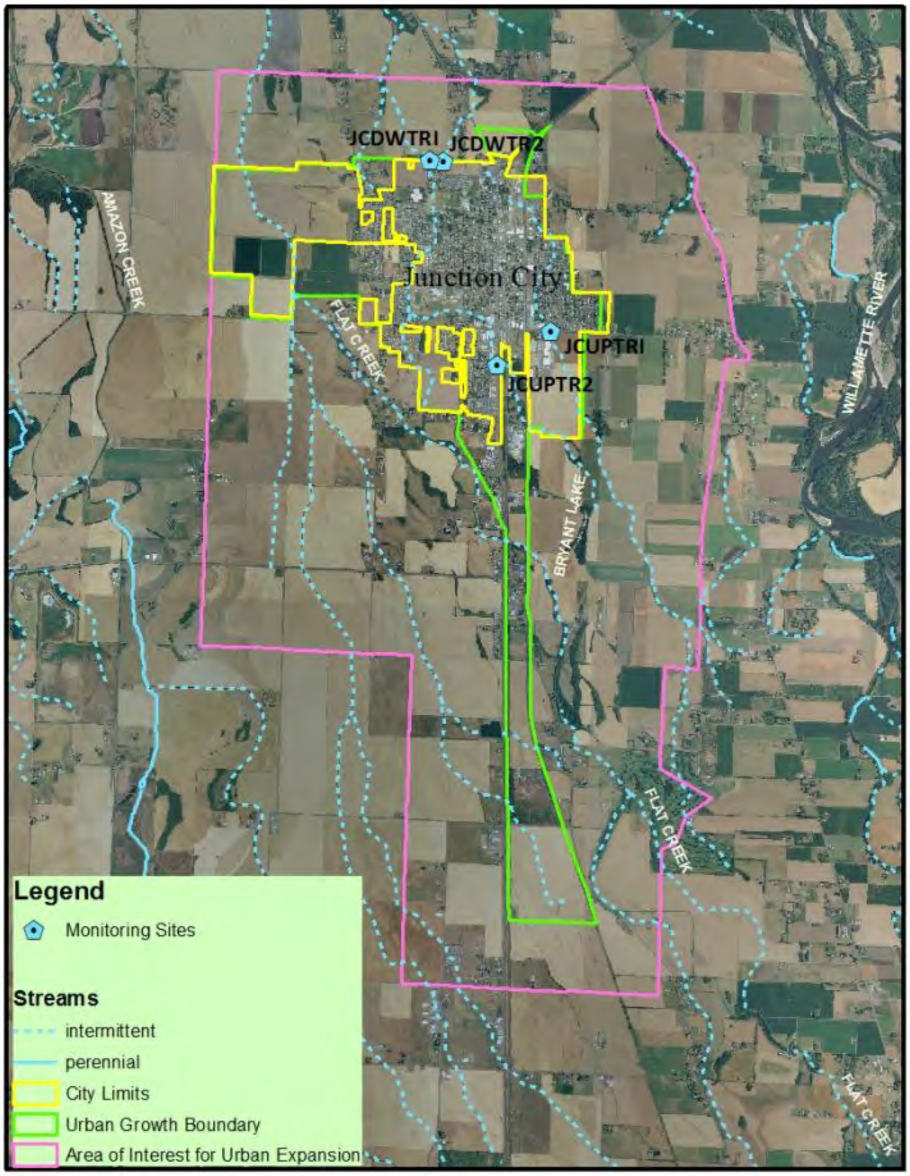


Figure 57. Location of the four sampling sites for the Junction City DMA.

Table 9. Comparison water quality results with State Standards at monitoring sites in the Junction City area. A complete summary of results can be found in Appendix E.

	Trib 1 Upstream Junction City (JCUPTR1)	**Trib 1 Downstream Junction City (JCDWTR1)**	**Trib 2 Upstream Junction City (JCUPTR2)**	**Trib 2 Downstream Junction City (JCDWTR2)**
Temperature Standard	No continuous data	No continuous data	No continuous data	No continuous data
DO Standard	Good	Good	Failed 100%	Good
E. coli Standard	Good	Good	Good	Good
Storm Sampling	Failed *E. coli*	Failed *E. coli*	Failed *E. coli*	Failed *E. coli*

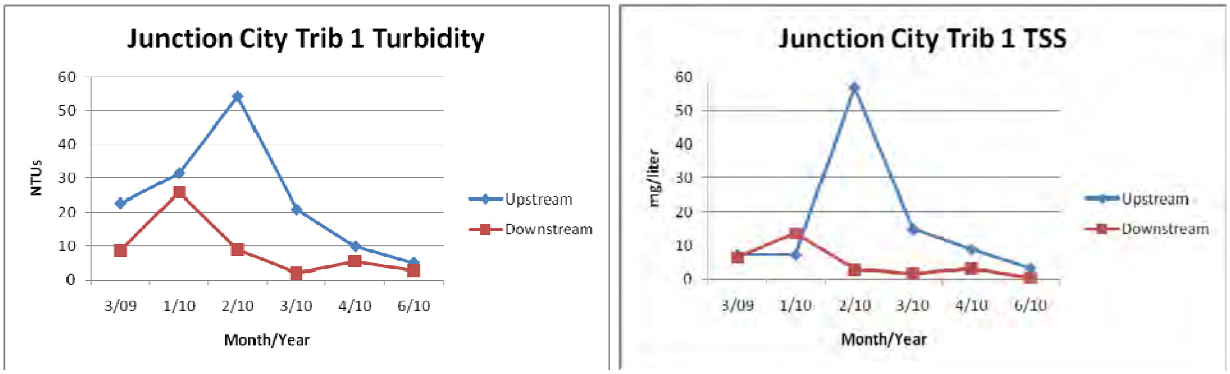


Figure 58. Turbidity and total suspended solids for Tributary 1.

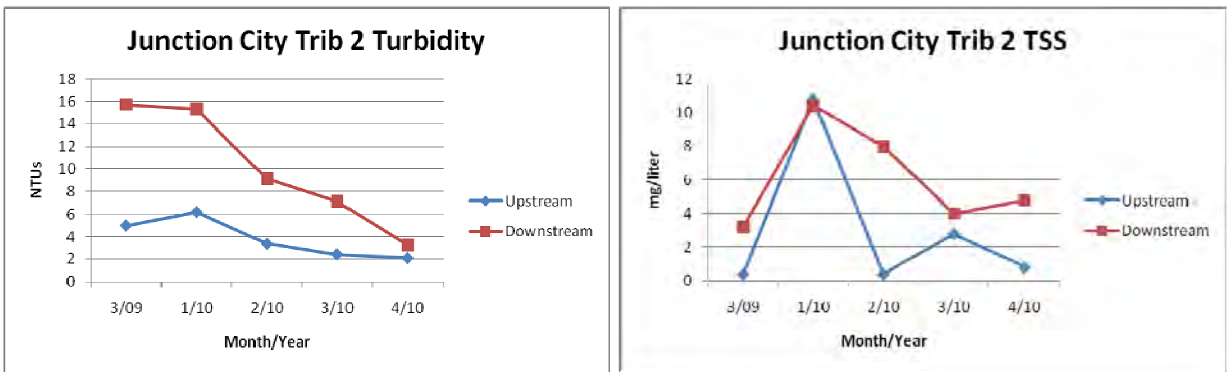


Figure 59. Turbidity and total suspended solids for Tributary 2.

Veneta

The City of Veneta is located in the Upper Willamette watershed, 13 miles west of Eugene. The City is in the foothills of the Coast range.

Geography: The population has been growing steadily over the past five years going from 2,762 in 2000 to 5,035 in 2010. Averaging 5% population growth a year from 2003 to 2010, the City is planning and constructing infrastructure to meet the growing demand for services. Veneta is bordered by Coyote Creek (approximately 6 miles to the east), the Long Tom River (immediately northwest of the Urban Growth Boundary), and Fern Ridge Reservoir (to the north and east).

Current water quality policies: Jurisdictions in the Upper Willamette watershed are facing unique problems related to the high levels of bacteria in the waterways.

Monitoring sites: A small ephemeral stream that runs through Veneta collecting storm water as it travels north. There were two sampling sites along this waterway, one is upstream near the junction of Strawberry Lane and Territorial Road just outside of Veneta City limits (VNUP) and the other is downstream at a culvert on E. Bolton Rd (VNDW) (Figure 60). Samples were only collected 10 times in a two year period at this DMA's sites due to lack of flowing water.

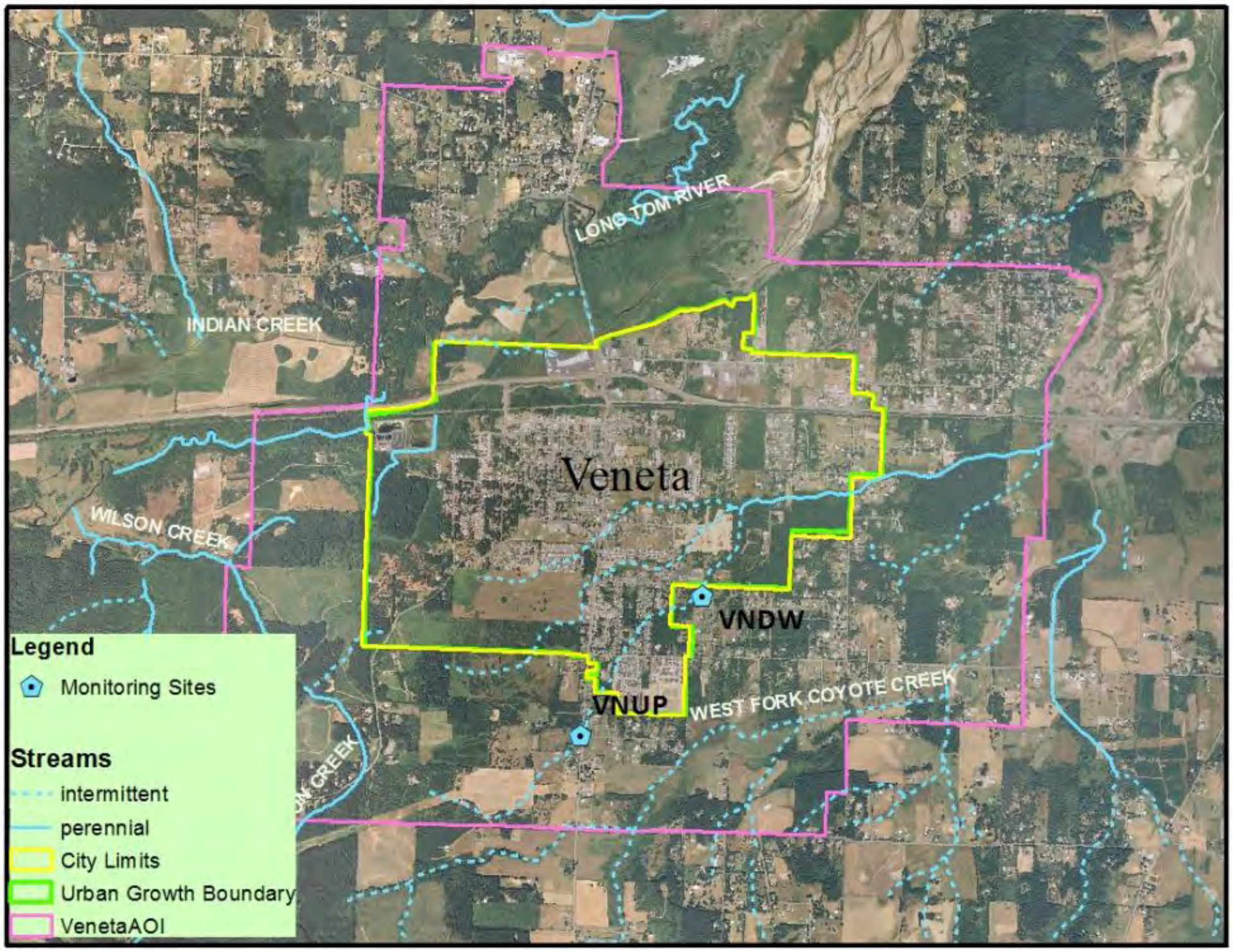


Figure 60. Sampling sites in Veneta

The State Standard for *E. coli* was met for 80% of the samples at the upstream site and 70% at the downstream site, with the downstream site having significantly higher levels (Table 10, Figure 61). Additionally, *E. coli* exceeded State Standards during storm sampling in 2009 and 2010 (Appendix E). DO was low and did not meet standards 100% of the time at the upstream site and 50% at the downstream site (Figure 61). There is not a clear indication of the change in water quality as water passes through Veneta. The downstream site has significantly higher conductivity than the upstream site but the upstream site has significantly higher TSS (Figure 62, Appendices E). Storm sampling also had a mixture of results, with turbidity and TSS higher downstream for both sampling years and *E. coli* and total inorganic nitrogen higher downstream in 2009 and higher upstream in 2010 (Appendix E).

Table 10. Comparison water quality results with State Standards at monitoring sites in the Veneta area. A complete summary of results can be found in Appendix E.

	Veneta Upstream (VNUP)	**Veneta Downstream (VNDW)**
Temperature Standard	No continuous data	No continuous data
DO Standard	Failed 100%	Failed 50%

E. coli Standard	Failed 20%	Failed 30%
Storm Sampling	Failed *E. coli*	Failed *E. coli*

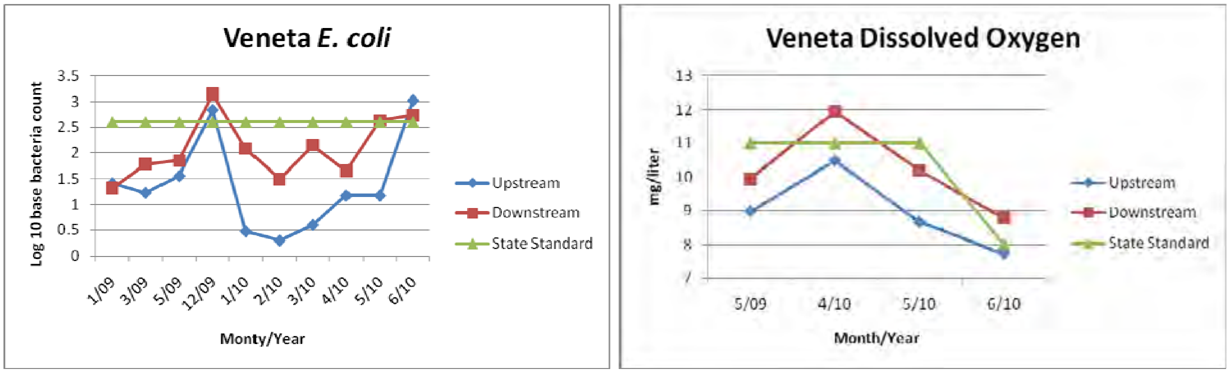


Figure 61. *E. coli* and for dissolved oxygen for the waterway in Veneta.

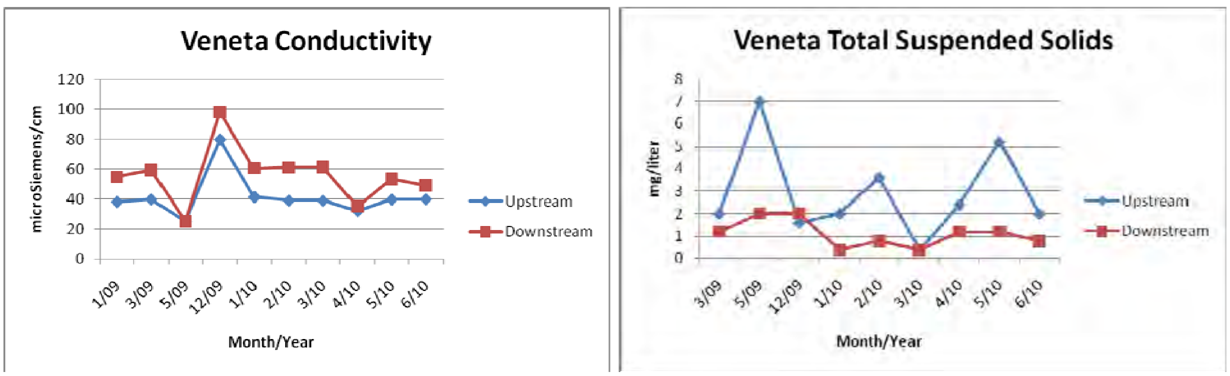


Figure 62. Conductivity and total suspended solids for the waterway in Veneta.

Coburg

Coburg is situated at the foot of the Coburg Hills west of the Cascade Range and about 2.5 miles northeast of the confluence of the McKenzie and Willamette Rivers.

Geography: There are 531 acres of the land within the Urban Growth Boundary (UGB). Thirty-one percent of this land is zoned for commercial or industrial use and 16% is zoned residential. Nearly 34% of the land in the UGB is undeveloped. The City has designated 40% of the land in the UGB as residential and 39% as light industrial.

Current water quality policies: Coburg relies on groundwater for drinking water and was one of the first municipalities in Oregon to prepare and implement a state-certified Drinking Water Protection Plan. This plan includes suggested management strategies to minimize non-point source pollution. The City is currently in the process of securing funds to connect buildings in Coburg to a municipal wastewater treatment system. In the future dry wells will be abandoned. At the present time, all of Coburg relies on on-site systems to treat wastewater, including the large industrial park west of Interstate 5. Developing a wastewater treatment plant is currently the top priority for the City. Muddy Creek and Mill Slough are the main stormwater channels for the city, but dry wells are used throughout the City with a network of roadside ditches that allow infiltration. The topography in Coburg is flat and most of the area has porous soils. Both Muddy Creek and Mill Slough are currently in compliance. In 1999, a Storm Drainage Master Plan was completed for the City to help guide system development. As part of their stormwater system the City has constructed and maintains two bioswales and one sandfilter catch basin.

<u>Monitoring sites</u>: Coburg is located near the McKenzie River and the mainstem Willamette downstream of Eugene. We sampled a tributary of Muddy Creek which is watered only by a seasonal irrigation inflow valve on the McKenzie River that is opened during the summer months when there is a demand for irrigation water by the local farmers. The data that was taken in the first several months which were in fall and winter may have been ponded water remaining from the previous summer. The upstream sampling site (CBUP) was located at a culvert crossing on the road into the Veterans Cemetery just off of Coburg Road which is south of Coburg (Figure 63). The downstream sampling site (CBDW) was located at a culvert at the west end of a large parking lot at Monaco Coach plant north of Coburg.

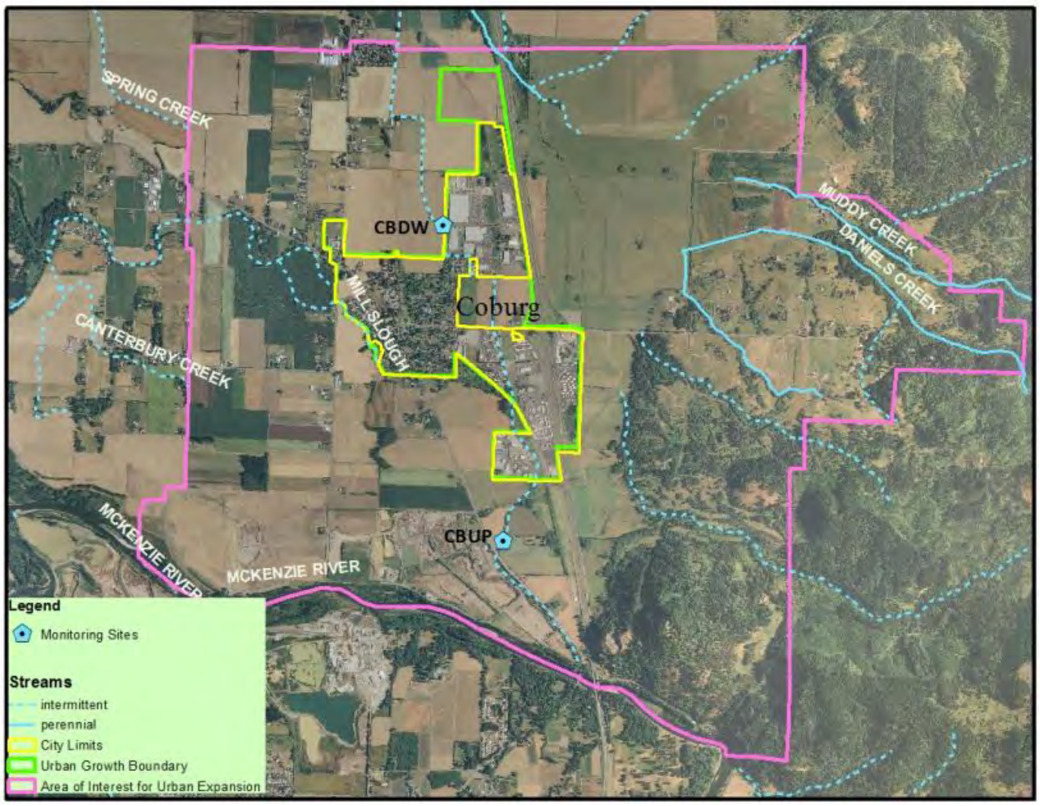


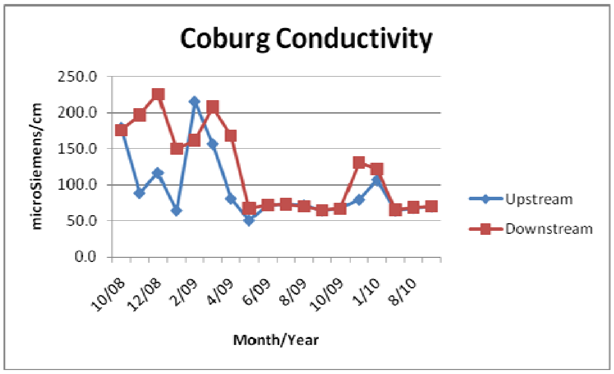
Figure 63. Location of the two sampling site associated with the Coburg DMA.

Water quality standards for *E. coli* and DO were consistently met (Table 11). However, in 2009 and 2010 the *E.coli* standard was exceeded at the downstream site (Appendix E). The summer benchmark for total phosphorous was met except once at the downstream site (Appendix E). The results from the comparative pairing indicate that conductivity was statistically higher at the downstream site.

Table 11. Comparison water quality results with State Standards or benchmarks at monitoring sites in Coburg. A complete summary of results can be found in Appendix E.

	Coburg Upstream (CBUP)	**Coburg Downstream (CBDW)**
Temperature Standard	No continuous data	No continuous data
DO Standard	Failed 8%	Failed 8%

E. coli Standard	Good	Good
TSS (summer benchmark)	Good	Good
Turbidity (summer benchmark)	Good	Good
Conductivity (summer benchmark)	Good	Good
Storm Sampling	Good	Failed *E. coli*
TP (summer)	Good	Good
N (summer)	Good	Good



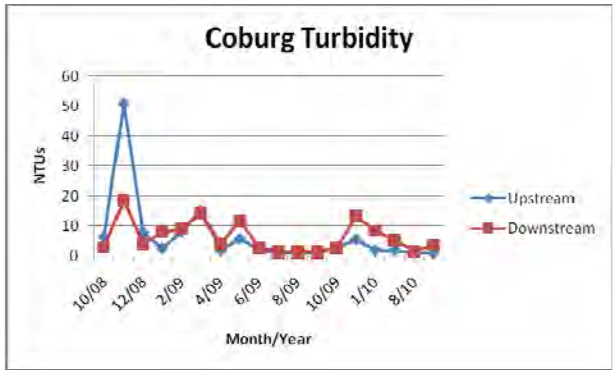


Figure 64. Conductivity and turbidity for the Coburg site.

Conclusions and Recommendations

The Middle Fork Willamette, Coast Fork Willamette and Long Tom Watersheds encompass a large and diverse landscape in the southern Willamette Valley. These watersheds are home to fish, wildlife and people who rely on a supply of clean water for many uses. Responsible management of our forests, farmland and urban areas helps protect and preserve these resources.

The monitoring that occurred in this two-year-long project provides baseline data that will help land managers understand current and potential future problems they face in managing water quality.

Overall, results showed that all of the DMAs had at least one parameter that indicated statistically significant and impairment in water quality for monitored waterways that flowed through the DMA. On average, 2.5 of negative changes occur for the DMAs. If the seven pairs of rural residential streams are included in this comparison, the average goes up to 3.4. The number of parameters that indicated statistically significant negative impacts at the downstream sites of the rural residential stream pairs alone averages even higher (4.4). This study focused on the effects of the DMA's on local water quality, but water quality issues have also been detected in the areas of rural residential development.

The Middle Fork Willamette Watershed which has many headwater and/or higher gradient streams and generally less developed land did not have as many issues with nutrient and bacterial contamination of water as the lowland streams of the Coast Fork Willamette and the Long Tom. One exception was Mosby Creek which is higher gradient and had issues similar to those of the higher gradient streams of the Middle Fork. The issues for these higher gradient streams have to do with turbidity and total suspended solids. In general, the results of this study suggest that small streams have less desirable water quality than larger streams and rivers, possibly due to their greater flow and ability to dilute and assimilate pollutants.

Twenty out of the 40 sites samples in this study exceeded the State Standard for temperature and 16 out of the 40 sites exceeded the State Standard for dissolved oxygen, although not necessarily at the same site during the same times. Nevertheless, most of these excursions from the State Standards occurred during the summer.

This type of baseline monitoring can only identify a sampled stream that has not met state water quality standards or benchmarks. The cause associated with the departures from standards and benchmarks requires a different type of study. Cause and effect must take into account natural processes of water quality transformation as a stream gains flow as it moves downstream and travels through different types of geology, topography, and natural streamside vegetation. Also, such a study must consider between-sample variability (due to natural processes, collection laboratory error) and the location of potential sources of pollution. Finally, the processes by which water quality constituents or characteristics are conserved, consumed, or released to the air should be incorporated into the study. Dilution of pollutants simply due to the large flow of a receiving stream is also basic to a study of how land use affects water quality and the ability of that water to provide desirable habitat for fish and safe water for recreation and consumption.

Until those cause and effect studies are conducted, it is our recommendation that remediation and restoration efforts such as those already started by local watershed councils and the DMAs continue. Included in these activities are tree planting for reducing stream temperature and erosion control and education in the local schools. We also recommend disseminating information on activities such as the use of impervious paving, properly placed and maintained septic systems, progressive ways of routing and treating stormwater, proper use of herbicides, washing cars in a location that does not drain into the stream, and proper disposal of dog waste. Information about how to curb activities that degrade water quality can lead people to become invested in making their watershed a more habitable place to live.

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