LONG TOM
WATERSHED COUNCIL

Stream Health & Water Quality in the Long Tom Watershed

1999 – 2006

This page intentionally left blank

Stream Health and Water Quality in the Long Tom Watershed: 1999 – 2006

Prepared by

Cindy Thieman, Monitoring Coordinator
Long Tom Watershed Council
751 S. Danebo Ave.
Eugene, OR 97402
www.longtom.org

with support from

Oregon Watershed Enhancement Board
Oregon Department of Environmental Quality
Long Tom Watershed Council contributors

April 2007

Citation

Bibliography
Thieman, C. 2007. Stream Health and Water Quality in the Long Tom Watershed, 1999–2006. Eugene (OR): Long Tom Watershed Council. Technical Report No. 2007-M-01. 2007. 36 p.

In Text:
(Thieman 2007)

This page intentionally left blank

Table of Contents

Acknowledgements

This study was funded by grants from the Oregon Watershed Enhancement Board and the Department of Environmental Quality as well as support from Long Tom Watershed Council contributors. It was also made possible by hundreds of volunteer hours. The Long Tom Watershed Council and Monitoring Coordinator wish to thank the funding agencies that made this study possible and the dedicated volunteers and interns listed below.

Rolf Anderson
Stephanie Astorino
Paul Atkinson
Nancy Blum
Cathy Boucher
Jonathan Brown
Jack Detweiler
John Dillard
Carl DiPaolo
Barbara Dumesnil
Jackie Fern
Adam Fleenor
Lita Furby
Jenny Getty
Len Gillette
Andy Gilmore
Cathy Glaudin
Jules Gordon
Brian Greene
Nancy Hafner
Bob Hager
Earl Hain
Brian Issa
Michael James
Lafona Jensen
Andy Lanier
Dawn Lesley
Bart Melton
Lane-Metro Youth Corps
Lucy Murr
Liz Myers
Allison Nabours
Eric Osborn
Chris Pendergrass
Jim Pendergrass
Will Peters
Sharmila Premdas
Lori Quillen
Paul Reed
Brad Schallert
Michele Stowe
Andy Strickland

A number of scientists significantly improved the scope, quality, statistical validity, and data analyses for this study. We wish to thank the following individuals for lending us their technical expertise and for their commitment to citizen-based monitoring.

Phil Kaufman, Environmental Protection Agency, Western Ecology Division
Phil Larsen, Environmental Protection Agency, Western Ecology Division
Tony Olsen, Environmental Protection Agency, Western Ecology Division
Dave Peck, Environmental Protection Agency, Western Ecology Division
Tom Mendes, Environmental Data Analyst, City of Eugene
Karen Font-Williams, Department of Environmental Quality
Rick Hafele, Department of Environmental Quality
Steve Hanson, Department of Environmental Quality
Shannon Hubler, Department of Environmental Quality
Dave Huff, Department of Environmental Quality

The author would also like to thank Dana Erickson, Phil Larsen, Phil Kaufman, Tom Mendes, Gary Nolan, Jim Pendergrass, and Mary Rae Thomson for reviewing a draft of this report; Jenna Garmon for assistance with document preparation; and Brian Issa for creating the water quality maps.

This page intentionally left blank

Summary of Major Issues and Findings

Water temperature and dissolved oxygen in most mid-elevation and lowland stream reaches prevent cutthroat trout and other sensitive native species from inhabiting them in the summer. (p. 16)

- Many lowland streams in the Long Tom Watershed reach lethal temperatures (22° C/72° F) for cutthroat trout during the warmest days of summer.
- Suitable temperatures and dissolved oxygen levels in the summer were found primarily in headwater streams.
- Restoring riparian areas to their natural potential could decrease instream temperatures by as much as 5° C.
- Stream gauge data show that summer flow in Coyote Creek decreased significantly between the 1930s and 1980s as surface water rights increased.
- Stream temperature models indicate that increasing stream flow could significantly reduce summer water temperatures in some parts of the watershed.
- Instream ponds have been documented to increase water temperature by as much as 8° C.

Bacteria concentrations do not meet state standards for the protection of human health in several parts of the Watershed (p. 20).

- High concentrations of *E. coli* were found in upper Amazon Creek in Eugene, Ferguson Creek, and Bear Creek
- Moderate concentrations of *E. coli* were found in Poodle Creek, Fern Ridge Reservoir, and lower Amazon Creek.

Nutrient concentrations are highest in urban and agricultural stream segments (p. 24)

- Seasonal average concentrations of total phosphorus were 1.5 to 4.5 times greater in lower Amazon Creek, which drains irrigated agricultural and urban land, than Coyote Creek, which drains forest and rural residential land.
- Seasonal average concentrations of nitrate during winter and spring were as much as 11 times greater in lower Amazon Creek than Coyote Creek.
- Nitrate levels are increasing at sites in Bear Creek, Ferguson Creek, lower Amazon Creek, and the lower Long Tom River.

Diversity and abundance of aquatic macroinvertebrates varied with riparian vegetation density and instream wood (p. 28)

- 58% of stream miles in the Long Tom Watershed are in poor condition, 17% are in fair condition, and 25% are in good condition based on macroinvertebrate indices.
- Sites with dense, native riparian vegetation and good shade had higher macroinvertebrate scores.
- Sites with more instream wood had somewhat higher macroinvertebrate scores.

This page intentionally left blank

Introduction

The water quality of streams and lakes is a significant concern to citizens both locally and nationwide, and efforts to assess instream conditions have been conducted by many organizations and public agencies. A recent study of wadeable streams conducted by the Environmental Protection Agency (EPA) was the first to establish nationwide, baseline conditions at a regional level (Stoddard et al., 2005). Researchers with the EPA found the best instream conditions in the West, where 45% of stream miles were in good condition based on macroinvertebrates. This compared to 29% in good condition for the Plains and Lowlands and 18% for the Eastern Highlands. Closer to home, the United States Geological Survey (USGS) investigated surface and ground water quality in the Willamette Basin between 1990 and 1995. USGS scientists found that nutrients and pesticides in streams are degrading water quality, and that habitat and fish communities were most degraded in urban and agricultural study units (Wentz et al., 1998).

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 cities, and monitoring streams across the state. Now, streams that do not meet water quality standards are placed on the 303(d) List of Water Quality Listed 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. Recently, DEQ developed TMDLs for temperature, bacteria, and mercury in the upper Willamette Basin as a result of many streams being listed for these attributes.

As our population grows in the Willamette Valley, water quality problems are likely to intensify as more land is converted from farms and forests to urban and rural residential landscapes. More people will potentially mean more pollutants entering our streams and rivers; yet our expectations for clean drinking water and healthy streams where people can fish, boat, and swim will not decrease. Protecting these water resources starts with having an accurate understanding of current conditions. This is what the Long Tom Watershed Council endeavored to do when it began its monitoring program in 1999. Based on earlier monitoring conducted by the DEQ (unpublished data), City of Eugene (unpublished data), Lane Council of Governments (1983), and USGS (Rinella and Janet, 1998), we suspected low dissolved oxygen and high water temperature, nutrient levels and bacteria to be problems in the watershed.

The findings of this 7-year study will enable the Council to target our watershed restoration and enhancement efforts in areas of the watershed that need the most improvement. This information will also allow us to promote better watershed stewardship by sharing the data directly with landowners and collaborating on solutions to identified water quality and stream health problems. Finally, results from the monitoring program have given us a comprehensive understanding of conditions in the Watershed that we can share with local residents and policy-makers alike.

Background on the Watershed

The Long Tom River Watershed drains 410 square miles of land at the southern end of the Willamette Valley. The headwaters of the Long Tom originate on the eastern side of the Coast Range and flow south through forested hills and small farms until reaching Noti where the river veers east near its confluence with Elk and Noti Creek. Coyote Creek, which drains the southern portion of the basin, and upper Amazon Creek, which drains the eastern portion, both merge with the upper Long Tom near what is now Fern Ridge Reservoir. The lower Long Tom starts at the spillway of the reservoir and flows north approximately 25 miles before its confluence with the Willamette River. Bear and Ferguson Creek, which drain from the Coast Range, and lower Amazon Creek are the major tributaries entering the lower Long Tom River.

Ecoregions

An ecoregion is defined by a unique combination of physical geography, geology, climate, soils, vegetation and land use (Omernik & Griffith 1991). Ecoregion designations are an important tool for interpreting existing watershed conditions and setting appropriate goals for instream habitat conditions, riparian zone conditions and water quality. The Long Tom Watershed contains four ecoregions: Valley Foothills, Mid-Coastal Sedimentary, Prairie Terraces and Willamette River and Tributaries Gallery Forest. The Valley Foothills and Mid-coastal Sedimentary Ecoregions are within the foothills of the Coast Range. Near headwaters, stream channels are confined within steep, narrow valleys, becoming more sinuous downstream where the valleys widen. The underlying geology is mostly sedimentary rock with some igneous rock. The combination of soft sedimentary rock and relatively high precipitation rates contributes to higher erosion rates. Native vegetation in these ecoregions includes western hemlock, western red cedar, Douglas fir, grand fir, big leaf maple, and red alder.

The Prairie Terraces Ecoregion covers most of the low gradient valley lands except for the Long Tom River north of Monroe, which is part of the Willamette River and Tributaries Gallery Forest Ecoregion. Historically, streams in these regions meandered across the valley floor and larger streams were deeply entrenched in the thick sedimentary clay soils deposited by the Missoula floods thousands of years ago. The native vegetation within the Prairie Terraces Ecoregion includes white oak, ash, and a variety of shrubs, grasses, sedges, rushes, and forbs. Vegetation of the Willamette River Gallery Forest includes cottonwood, alder, ash, bigleaf maple and Douglas fir.

Land Use

Forestry, agricultural, urban, rural residential, and industrial are the primary land uses in the watershed. **Table 1** shows the proportion of land uses in each sub-watershed and their total acreage.[1] Eighty-eight percent of the watershed is privately owned with parcels ranging from less than one to several thousand acres.

[1] Land use acreage was determined from state-wide zoning maps.

Table 1. Sub-watershed Land Use

Sub-basin	Agri-culture	Forestry	Urban	Rural Resident	Parks & Rec.	Rural Industry	Other	Total Acres
Upper Long Tom R.	8%	80%	<1%	10%	2%	<1%	0%	35,605
Elk Cr.	9%	88%	0%	1%	0%	1%	0%	27,709
Coyote Cr.	31%	64%	0%	4%	2%	0%	0%	45,185
Spencer Cr.	22%	49%	1%	27%	<1%	0%	0%	21,320
Upper Amazon Cr.	6%	6%	80%	7%	<1%	0%	0%	19,710
Lower Amazon Cr.	62%	0%	21%	6%	<1%	0%	11%	19,292
Fern Ridge	25%	20%	5%	20%	5%	0%	25%	32,209
Bear Cr.	33%	57%	0%	10%	<1%	0%	0%	17,701
Ferguson Cr.	40%	59%	0%	<1%	0%	0%	0%	16,357
Lower Long Tom R.	81%	7%	1%	8%	2%	0%	<1%	27,784
Watershed Total	**31%**	**46%**	**8%**	**9%**	**1%**	**1%**	**4%**	**262,872**

Precipitation

The majority of precipitation in this watershed comes as winter rain. Average annual precipitation ranges from 35 to 74 inches, with the highest levels falling in the Coast Range. Most of the precipitation falls from November through March and generally corresponds with increased stream flow. However, the largest storms tend to come in November and December, whereas peak stream flows come in December and January. This is because in early winter soils are not yet saturated and there is little if any overland flow. Later in the winter, as soils become saturated, increased amounts of overland flow lead to higher stream flows.

Water Use

Most of the water use in the watershed is from surface water, and a large percentage of this is stored in Fern Ridge Reservoir and other small, private reservoirs and ponds around the watershed. Approximately 98% of water rights are used for irrigation of crops and pastures, 1.5% is used for industrial purposes, and the remaining fraction goes to rural residential landowners.[2] Of the percentage of water rights used for irrigation, 67% is used in the lower Long Tom and lower Amazon sub-watersheds where farmers have access to water stored in Fern Ridge Reservoir. Monroe, Junction City, and Veneta acquire their drinking water from municipal wells, although the City of Monroe recently requested a permit to withdraw water from the Long Tom as a secondary drinking water source.

[2] These percentages do not include drinking water for the cities of Monroe, Junction City, or Veneta. Drinking water for Eugene residents comes from the McKenzie River.

There are no instream water rights in the Long Tom Watershed. This means that no minimum flow is required for the protection of fish and other aquatic organisms. Typically, this has not led to streams going completely dry in the summer, but water withdrawals appear to have had an increasingly significant impact on summer water levels. For example, **Figure 1** shows minimum flows for each water year and cumulative water rights in Coyote Creek between 1933 and 1987. Increasing ground water withdrawals and land use changes may also have contributed to the decrease in Coyote Creek's summer flow.

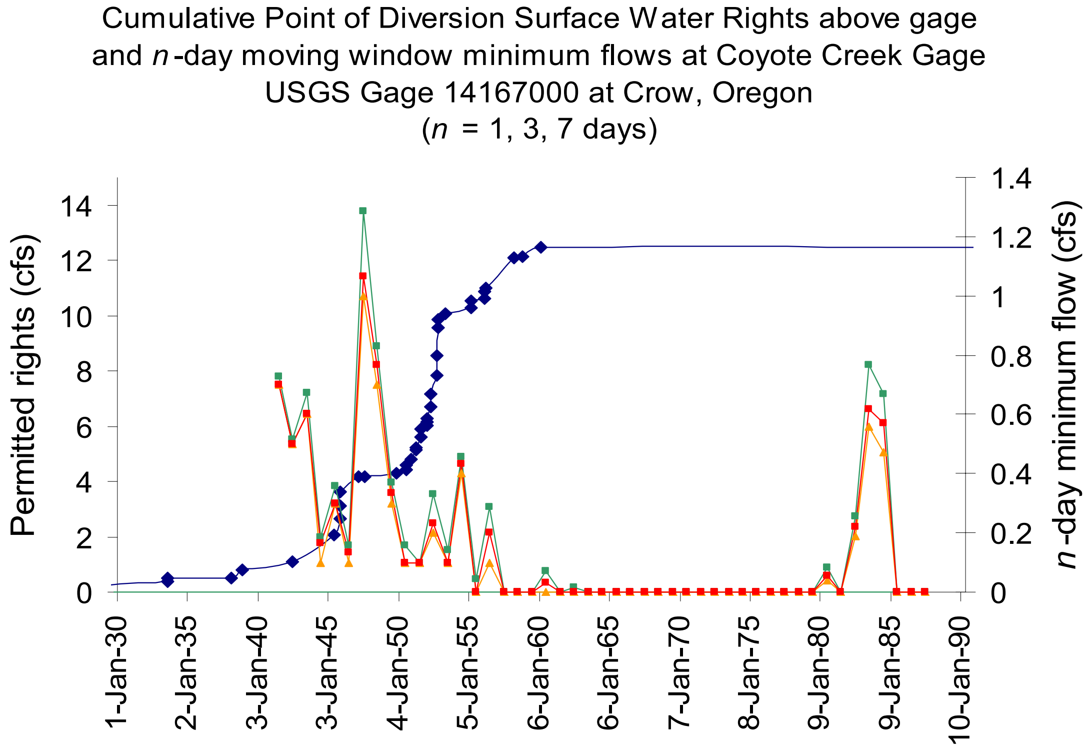
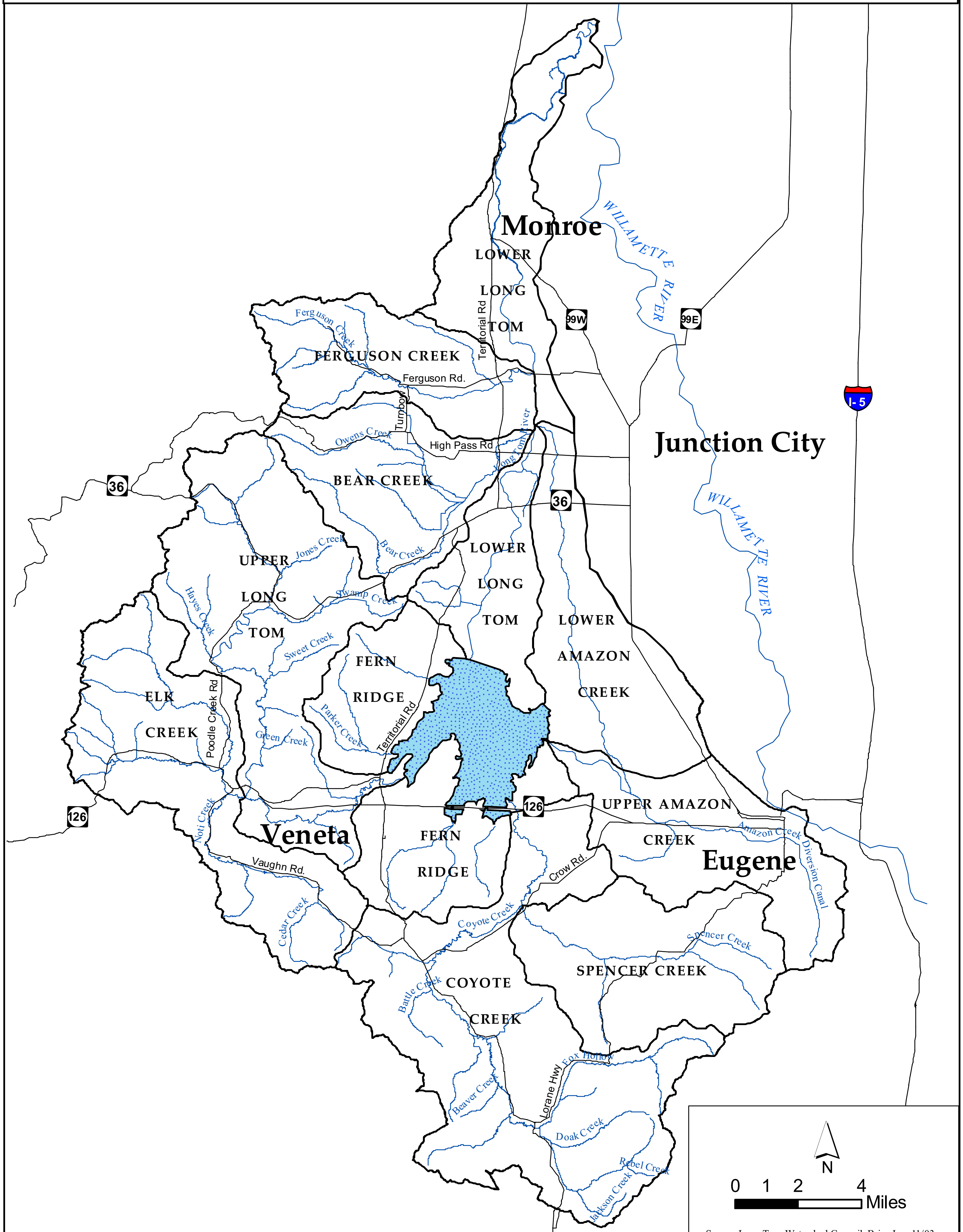


Figure 1. Cumulative water rights (left axis; blue line) and *n*-day minimum flows (right axis; red, orange, green lines) for Coyote Creek at Crow, Oregon. Minimum flow is the lowest value recorded for a consecutive *n*-day period anywhere within the water year. The 1, 3, and 7-day minimum flows are shown in orange, red, and green, respectively. **Graph courtesy of John Bauer, The Nature Conservancy**

Fish and Amphibians

The Long Tom Watershed is home to a variety of fish and wildlife that rely on its network of streams, lakes and wetlands. Some of these species are particularly sensitive to water quality conditions such as water temperature, dissolved oxygen, and sediment levels. Native fish sensitive to poor water quality include cutthroat trout, paiute, torrent and riffle sculpin, mountain whitefish, and Pacific lamprey. Currently, no fish species that spawn in the Long Tom Watershed are on the federal list of Threatened and Endangered Species. Historically, however, Oregon chub inhabited the watershed, and this species is currently listed. In addition, the Oregon Department of Fish and Wildlife (ODFW) considers the lower Long Tom River below Monroe as suitable and likely winter rearing habitat for juvenile Spring Chinook (Galovich, pers.comm.). Native amphibian species that are sensitive to poor water quality include red legged frog, southern seep salamander, and tailed frog.

Long Tom Watershed Ten Major Subbasins



Source: Long Tom Watershed Council. Brian Issa 11/03

Monitoring Questions and Study Design

In the initial phase of this study, from September 1999 to June 2003, our goals were to characterize water quality in each sub-watershed and investigate the relationship between water quality and land use. Our specific questions were: "Do streams in the Long Tom Watershed meet state water quality standards?," "Do they provide sufficient water quality for the most sensitive beneficial uses of surface waters?," and "How does water quality correlate with land use in the watershed?" To answer these questions we selected 18 monitoring sites around the watershed, which included the mouths of each sub-watershed, junctures between different land uses, and varying elevations and stream sizes in the watershed. Results from this first phase of monitoring are summarized in *Water Quality in the Long Tom River Watershed: 1999-2003* (Thieman, 2003), which can be found at www.longtom.org.

Phase 1 Monitoring Questions

Do streams in the Long Tom Watershed meet state water quality standards?

Do they provide sufficient water quality for the most sensitive beneficial uses of surface waters?

How does water quality correlate with land use in the watershed?

Towards the end of our Phase 1 study we began sharing water quality results at Council meetings and with small groups of landowners that had streams and wetlands on their property. At the same time, we began working with private landowners to enhance or restore streams and wetlands. Out of this, we realized a need for more spatially detailed water quality data and information on the biological condition of our streams.

Our goals in the second phase of monitoring were to characterize the biological health of our streams using benthic macroinvertebrates, narrow in on the spatial extent of water quality problems identified in Phase 1, begin to assess trends in water quality over time, and provide focus for our restoration and enhancement efforts. Our specific questions were: "What proportion of our streams are in poor, fair, and good biological condition compared to reference sites for the region?," "Where should we target our efforts at improving known water quality problems?," "What are the likely causes of poor biological condition?," and "What areas of the watershed have high water quality and biological integrity?" To answer these questions we expanded our network of water quality monitoring sites, collected macroinvertebrates at randomly selected locations, and measured physical habitat quality at a sub-set of the macroinvertebrate sites.

Phase 2 Monitoring Questions

What proportion of our streams are in poor, fair, and good biological condition compared to reference sites for the region?

Where should we target our efforts at improving known water quality problems?

What are the likely causes of poor biological condition?

What areas of the watershed have high water quality and biological integrity?

Physical and Chemical Water Quality Indicators

Table 2 summarizes the sampling frequency, data collector and general method for each indicator.

Table 2. Physical & Chemical Water Quality Indicators & Sampling Frequency

# of Sites	Indicator	General Sampling Frequency	Data collection responsibility	Comments
71	Continuous Temperature	Hourly: June – October	Monitoring coordinator	Some of these sites were monitored multiple summers and others were monitored only one summer.
19	Single Reading Temperature	Monthly	Volunteers	Monthly temperature, turbidity, conductivity, & dissolved oxygen were measured monthly for almost 7 years at 16 sites, and every month for 2 - 3 years at 3 additional sites. pH was measured once/month at 17 sites for 3 years. Starting in Fall of 2003, dissolved oxygen was not measured December through March.
19	Turbidity	Monthly	Volunteers	
19	pH	Monthly	Volunteers	
19	Dissolved Oxygen	Monthly	Volunteers	
19	Conductivity	Monthly	Volunteers	
29	E. coli	Monthly (9/99-6/03) Bi-monthly (11/03 – 12/06)	Monitoring coordinator	*E. coli* data were collected at 29 sites. From September 1999 to June 2003 an average of 18 sites were sampled once/month; from July 2003 to December 2006 29 sites were sampled once every two months. In addition, samples were collected 5 times each quarter within a 30-day period at 17 sites from April 2000 to May 2001, allowing us to evaluate these sites based on DEQ's 30-day average standard.
30	Total Phosphorus	Monthly (1999-2003) Bi-monthly (2003 – 2006)	Monitoring coordinator	
32	Nitrate	Monthly (1999-2003) Bi-monthly (2003 – 2006)	Monitoring coordinator	

Macroinvertebrate and Physical Stream Habitat Surveys

Benthic macroinvertebrates are organisms that lack backbones and are larger than ½ millimeter long. 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 organisms 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 that fish are susceptible to. 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 like 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. Finally, they help answer the question: "Does water quality support diverse and healthy populations of organisms?"

Our objective in selecting a macroinvertebrate study design was to quantify instream conditions at a watershed and sub-watershed level. We used a statistically valid, probability-based design stratified by sub-watershed, which enabled us to assess the percentage of stream miles in each sub-watershed that were in good, fair, or poor condition compared to reference site conditions. To detect potential differences among the 10 sub-watersheds in the Long Tom, we needed approximately 10 sites on average in each sub-watershed. The USEPA's research division in Corvallis, OR designed the survey by selecting a spatially balanced random set of sites in each of the sub-watersheds. The set of sites consisted of 100 base sites and an additional 200 as back up to be used when one of the original 100 sites could not be sampled. Descriptions of the design process can be found at www.epa.gov/nheerl/arm.

We collected physical habitat measurements for a number of riparian and instream characteristics that can affect macroinvertebrates directly or indirectly. Shade was selected due to its influence on stream temperature. Presence of trees and density of understory and ground cover relate to the amount of leafy material available for consumption by macroinvertebrates and the relative amount of human disturbance. Streambed material can also influence the type of macroinvertebrates present because of feeding and attachment methods. Thalweg depth, a measurement of the deepest point in the stream taken every 1 meter or so, indicates the diversity of stream habitat types (e.g., pools, riffles) and the total amount of aquatic habitat at a site. The amount and size of instream wood also influences stream habitat types and the stream's resistance to flow (hydraulic roughness). This last point is significant, because high velocities can scour the streambed to the point that macroinvertebrates and smaller bed material, such as sand and gravel, get washed downstream.

Methods

Physical and Chemical Water Quality Measurements

Measurements of stream temperature, pH, turbidity, conductivity and dissolved oxygen were conducted using the standard protocols described in the Oregon Plan for Salmon and Watersheds Water Quality Monitoring Technical Guidebook (1999). **Appendix A** includes specific instructions given to volunteers for conducting each measurement. **Table 3** lists equipment specifications and analytical methods for both field and laboratory measurements.

Volunteers measured and recorded water temperature, pH, conductivity, dissolved oxygen, and turbidity in the field on a monthly basis. One exception to this is that beginning in August 2001 pH measurements were made at the Council office. Volunteers collected water samples in dark bottles, placed them in a cooler on ice, and took them back to the Council office. The monitoring coordinator then measured the pH within 24 hours. We made this change because of poor accuracy and precision levels when using the pH meters out in the field.

Surface water samples for *E. coli* and nutrients were collected either directly from the stream or by drawing a bucket of water from a bridge above the stream. The former method was used when streams were wadeable in the summer; the latter when stream flows were high in the winter. We placed samples inside a cooler with ice and delivered them to a local laboratory

Table 3. Specifications for Monitoring Equipment and Analytical Methods

Indicator	Equipment/Method	Container	Preservation	Holding Time
Water Temperature: Single Reading	NIST Traceable Thermometer on Conductivity Meter	Instream or bucket	N/A	immediately
Water Temperature: Continuous	Vemco data logger	Instream	N/A	N/A
Dissolved Oxygen	HACH OX-DT Kit	300 ml BOD btl	Winkler Titration	8 hr.
Conductivity	YSI Model 30 Meter	Instream or sampling bucket	none	immediately
Turbidity	HACH 2100P Meter	Screw top bottle	none	immediately
Total Phosphorus-P	EPA 365.3	125 mL plastic bottle	Acidified to pH <2; stored < 4° C	28 days
Nitrate-Nitrite-N	EPA 353.3	125 mL plastic bottle	Acidified to pH <2; stored < 4° C	28 days
E. coli	Colilert QT (IDEXX laboratories)	120 mL plastic bottle	none	24 hours

within 24 hours of collection. Each sample was marked with the sample ID number, time, and date of collection.

Continuous temperature loggers were checked for accuracy before and after field deployment according to the procedures outlined in Chapter 6 of the Water Quality Monitoring Technical Guidebook. Loggers 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 and Physical Stream Habitat Surveys

Macroinvertebrates were collected according to protocols developed by the DEQ (see **Appendix B**). This included collecting macroinvertebrates using a 350-micron D-frame kicknet at 8 one-square foot plots in one or more riffles throughout the sample reach. At sites where no riffles existed, we collected samples in fast moving sections no more than 1.5 to 2 feet deep. Samples from all 8 plots were combined in a 5-gallon bucket and the material was drained of all water using a 350-micron sieve, placed in one-liter Nalgene containers, and immediately preserved with alcohol. Samples were delivered to ABR in Forest Grove for sorting and identification. See **Appendix C** for a complete description of ABR's laboratory methods.

We developed our physical habitat survey by adapting protocols developed by the EPA for their Western Region Wadeable Streams Assessment (Peck et al., 2006). Like the EPA protocol, we determined survey length by multiplying the average wetted width by 40 or sampling 150 meters, whichever length was greatest. We measured streambed particle size using a Wolman Pebble Count and thalweg depth using the EPA protocol. Surveyors also assessed the relative degree of human impact on a site using the Human Disturbance Index developed by DEQ. The remaining habitat measures we developed independently to enable the survey and macroinvertebrate sampling to be conducted in a half day by volunteers. This included a visual density estimate of shade, riparian understory and ground cover, documentation of tree presence and non-native plant species in the riparian area, and tally of instream wood larger than 1' diameter (see **Table 4**).

Table 4. Summary of Physical Habitat Measurements

Indicator	Method
Riparian	
Shade	Visual Density Estimate (<40%, 40-70%, >70%)
Trees	Presence/Absence
Understory Density	Visual Density Estimate (None, Sparse, Moderate, Dense)
Ground Cover Density	Visual Density Estimate (None, Sparse, Moderate, Dense)
Stream Bed Substrate	Wolman Pebble Count (5 measurements at 21 transects)
Thalweg Depth	100 – 150 measurements
Large Wood	# Pieces 1' – 2' diameter; # Pieces > 2' diameter
Invasive Plant Species	Presence/Absence

Because these protocols vary significantly from those used by EPA, our riparian, shade, and large wood results cannot be directly compared with their studies. See **Appendix D** for the Council's protocol overview, physical habitat data sheet, and DEQ Human Disturbance Index.

Quality Assurance

Training

A DEQ led training session on water quality measurement methods and equipment was held in August of 1999. Attendees were given hands-on experience in collecting and analyzing samples for dissolved oxygen, pH, conductivity, turbidity, and water temperature. The monitoring coordinator conducted subsequent training sessions for all new volunteers. In addition, participants continued to receive feedback on results and technical support from the monitoring coordinator throughout the program. The monitoring coordinator conducted a ½ day volunteer training for macroinvertebrate sampling and stream habitat measurements after being trained by EPA staff. The coordinator or monitoring assistant also assisted volunteers at their first site to ensure they fully understood the methods.

Precision and Accuracy Levels

Methods for quality assurance and control for water quality measurements included: 1) DEQ approved equipment, 2) regular calibration and accuracy checks of field equipment, 3) field checks by the monitoring coordinator, 4) duplicate sampling at 2 out of the 17-18 sites for each round of sample collection, and 5) pre and post-deployment accuracy checks and field audits of continuous temperature loggers using a NIST certified thermometer. For more details see the Quality Assurance Project Plan for the Long Tom Water Quality Monitoring Program (**www.longtom.org**).

Most of the water quality data collected were rated A or B level based on accuracy and precision. Accuracy evaluates whether equipment is calibrated correctly and/or whether that equipment measures a known standard within an acceptable range. Precision reflects the degree of repeatability between measurements.

A variety of steps have been implemented over the past several years to improve accuracy and precision levels. The turbidity and pH meters lose their accuracy and precision when the machines are cold. The coordinator reminded volunteers to keep equipment indoors overnight and, if possible, use the equipment in their car on cold days. In August 2001, we changed our pH sampling protocol by having volunteers bring in samples to be analyzed for pH in the office. This step dramatically improved our accuracy and precision levels and allowed us to determine that pH was in fact not a problem in the watershed. Another step we took to improve accuracy was to tape the acceptable ranges for turbidity and conductivity to the machine so the user could immediately see whether the machines were in range during accuracy checks. The coordinator also visited each volunteer every 3 to 4 months during sampling to observe their technique and make suggestions when necessary. We also conducted split sampling with the DEQ volunteer monitoring coordinator twice in the past 4 years. There was a high level of agreement between the DEQ coordinator's results and Council monitoring volunteers' results.

Water Quality Results

Temperature and Dissolved Oxygen

The biologically-based numeric temperature criterion applicable to streams and tributaries within the Long Tom Watershed is 18° C (64.4° F) for the protection of trout rearing and migration from May 16 through October 14; the lower reach of the Long Tom River extending from Fern Ridge Reservoir to the Willamette River is unassigned. This standard is based on a 7-day moving average of daily maximum temperatures. Water temperatures above this can weaken or kill fish, especially trout and salmon. High temperatures 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. Many sculpin, another type of native fish in the Long Tom Watershed, are also sensitive to temperature (Thieman 2000). The primary causes of high stream temperature include air temperature, direct solar radiation, and low stream flow.

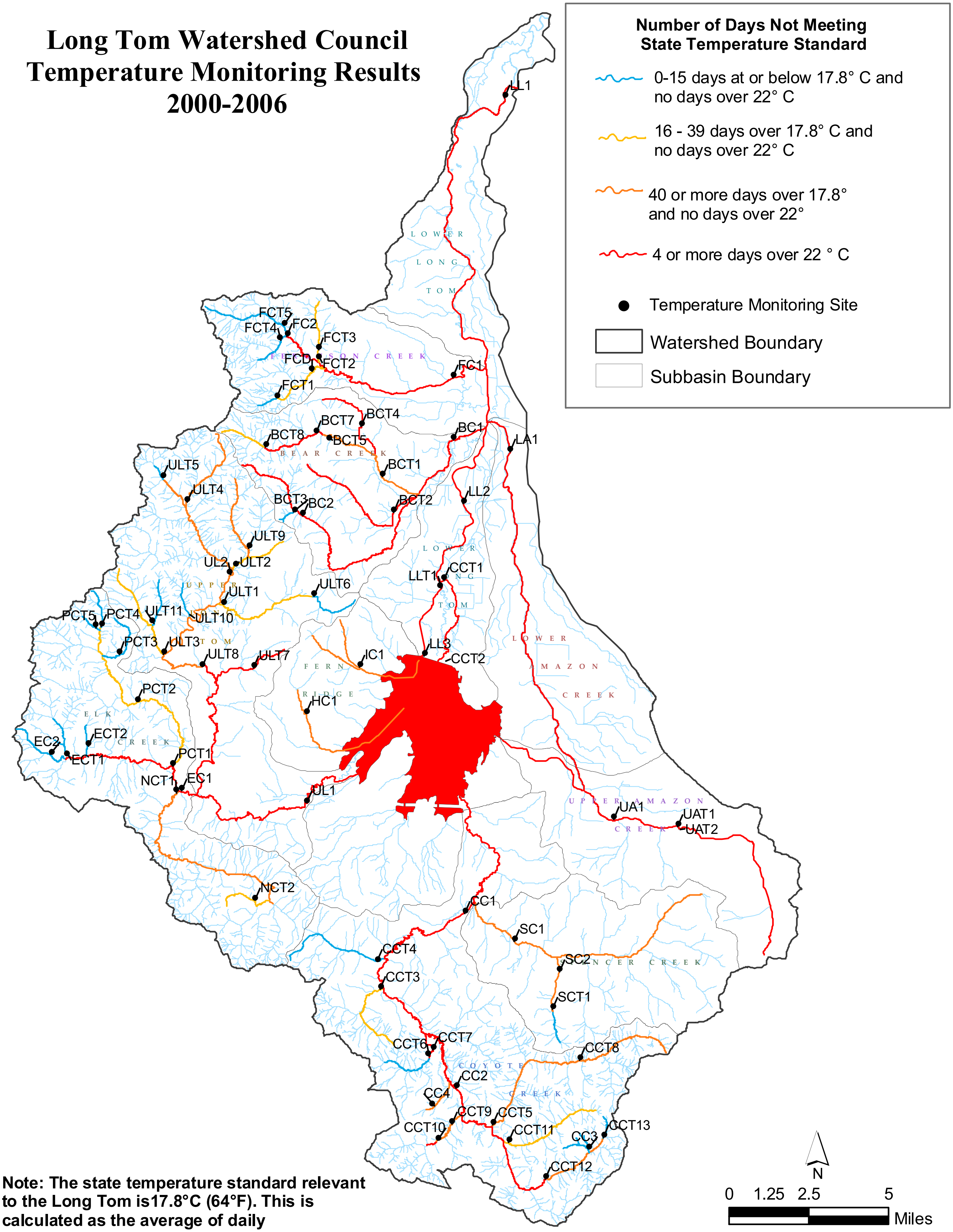
The state dissolved oxygen standard requires that oxygen levels be at or above 8 mg/L to protect cool-water aquatic life. One factor affecting the amount of dissolved oxygen in water is temperature. The higher the temperature, the less oxygen water can hold. Another factor is the amount of biological activity. If a lake or stream has high nutrient concentrations it stimulates the growth of algae. This can lead to high dissolved oxygen levels on sunny days but low levels at night when algae are respiring but not photosynthesizing. In addition, bacteria consume dead algae and other organic matter, which further depletes dissolved oxygen. Low levels and large diurnal fluctuations of dissolved oxygen are stressful and sometimes deadly to fish.

Water temperatures in the Long Tom Watershed do not meet state standards at many of our monitoring sites during the summer. The **map on page 17** shows that all of the lowland reaches and many at mid-elevation do not meet the state standard for 16 or more days during the summer. The dark red lines indicate stream segments that had four or more days above 22° C (72° F), which is the lethal temperature for cutthroat trout based on laboratory studies conducted at Oregon State University (Armantrout pers. comm. 1999). Orange lines indicate 40 or more days above 17.8° C (64° F); yellow lines indicate 16 – 39 days over 17.8° C; and blue lines indicate less than 16 days above 17.8°.[3] The warmest water temperature days are typically in August and early September when air temperatures are still high and flow is the lowest.

Streams closer to the headwaters that are well shaded generally show water temperatures that remain cool and meet the state temperature standard despite very high air temperatures. Stream temperature models show that if we established maximum potential shade on the mid to lower reaches of all our streams, we could decrease average summer water temperatures by as much as 5° C. For the Long Tom River below Fern Ridge Reservoir, temperatures could decrease 1.5° to 2° C (Department of Environmental Quality, 2006). This would mean cutthroat trout could inhabit mid-elevation and some lowland stream sections throughout the summer.

[3] The new state temperature standard is 18° C (64.4° F). Our results were calculated using the old standard of 17.8 C because we were not aware of the new standard at the time of analysis. For most sites, the difference between the old and new standard would not change its status.

Long Tom Watershed Council Temperature Monitoring Results 2000-2006



Note: The state temperature standard relevant to the Long Tom is17.8°C (64°F). This is calculated as the average of daily maximum temperature for 7 consecutive days.

Another significant factor affecting stream temperature is the amount of flow during the summer. Streams with lower flow heat more quickly than those with higher flow. As noted in **Figure 1** on page 8, withdrawals during the summer for irrigation (as indicated by cumulative water rights) were associated with decreasing minimum stream flows in Coyote Creek.

Instream ponds or impoundments can also affect stream temperature. This can be seen at sampling sites LL3, CCT7, CCT10, ULT4, CC4, EC1, and NCT1. Each of these sites has an impoundment upstream of it. CCT7, which is located just below an impoundment on a small Coyote Creek tributary, provides a particularly striking example. At this site, we were able to place a probe immediately upstream of the impoundment's backwater (CCT6) as well as below the impoundment (CCT7). Temperatures above the impoundment met the state standard all summer and were an average of 8° C cooler than below the impoundment.

Figure 2 shows the percentage of measurements from 2000 - 2006 that did not meet the state dissolved oxygen standard. These were monthly measurements taken April through November between 8 and 11 a.m. at all sites. Sites with a high percentage of low dissolved oxygen measurements correspond with high temperature levels. However, some sites have lower dissolved oxygen levels than temperature alone predicts. This is due to high biological oxygen demand caused by excessive nutrients that fuel algal growth.

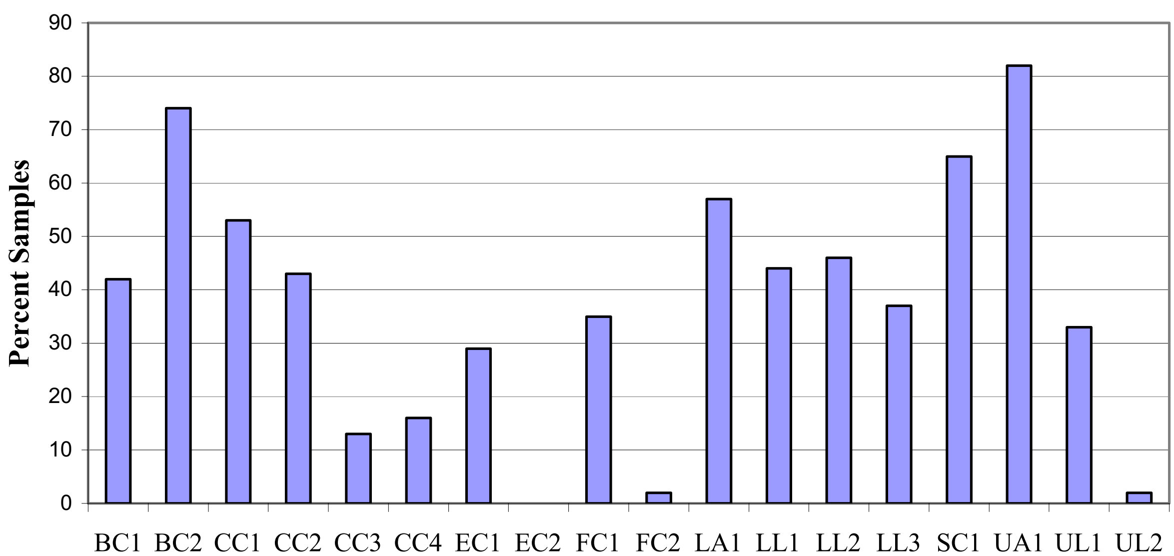


Figure 2. Percent dissolved oxygen samples not meeting the state standard. These results are for monthly measurements made April through November, 2000 – 2006. Site locations can be found on the maps on pages 16, 19, 22, and 23. Site descriptions can be found in **Appendix A**.

Several sites show a decreasing trend in dissolved oxygen levels, including upper Ferguson Creek (FC2), lower Amazon Creek (LA1), and the lower Long Tom River (LL1, LL2). In the case of lower Amazon Creek and the Long Tom River we also see an increasing trend in nitrate levels. **Figures 3 and 4** show trends for dissolved oxygen and nitrate between 2000 and 2006 for lower Amazon Creek. **Appendix E** lists additional trend results for the watershed and describes the Seasonal Kendall Test statistic.

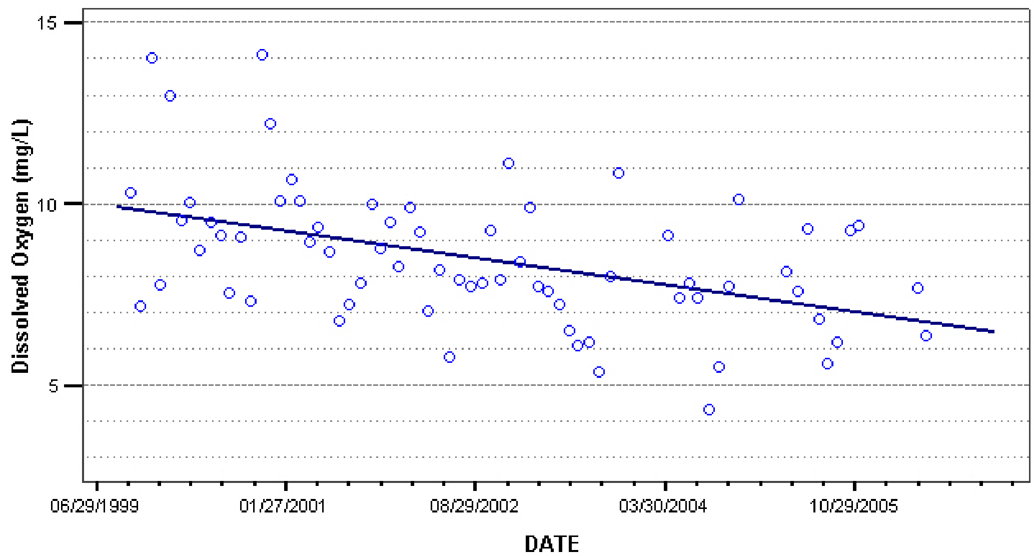


Figure 3. Trend for dissolved oxygen at monitoring station LA1 derived from Seasonal Kendall Test. **Analysis and graph courtesy of Tom Mendes, City of Eugene**.

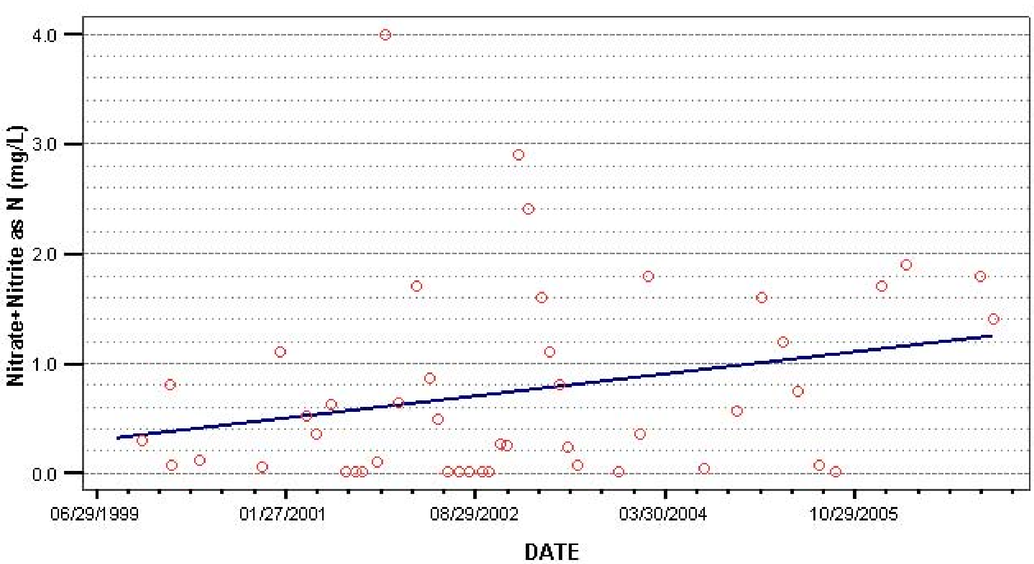


Figure 4. Trend for nitrate at monitoring station LA1 derived from Seasonal Kendall Test. **Analysis and graph courtesy of Tom Mendes, City of Eugene.**

Bacteria

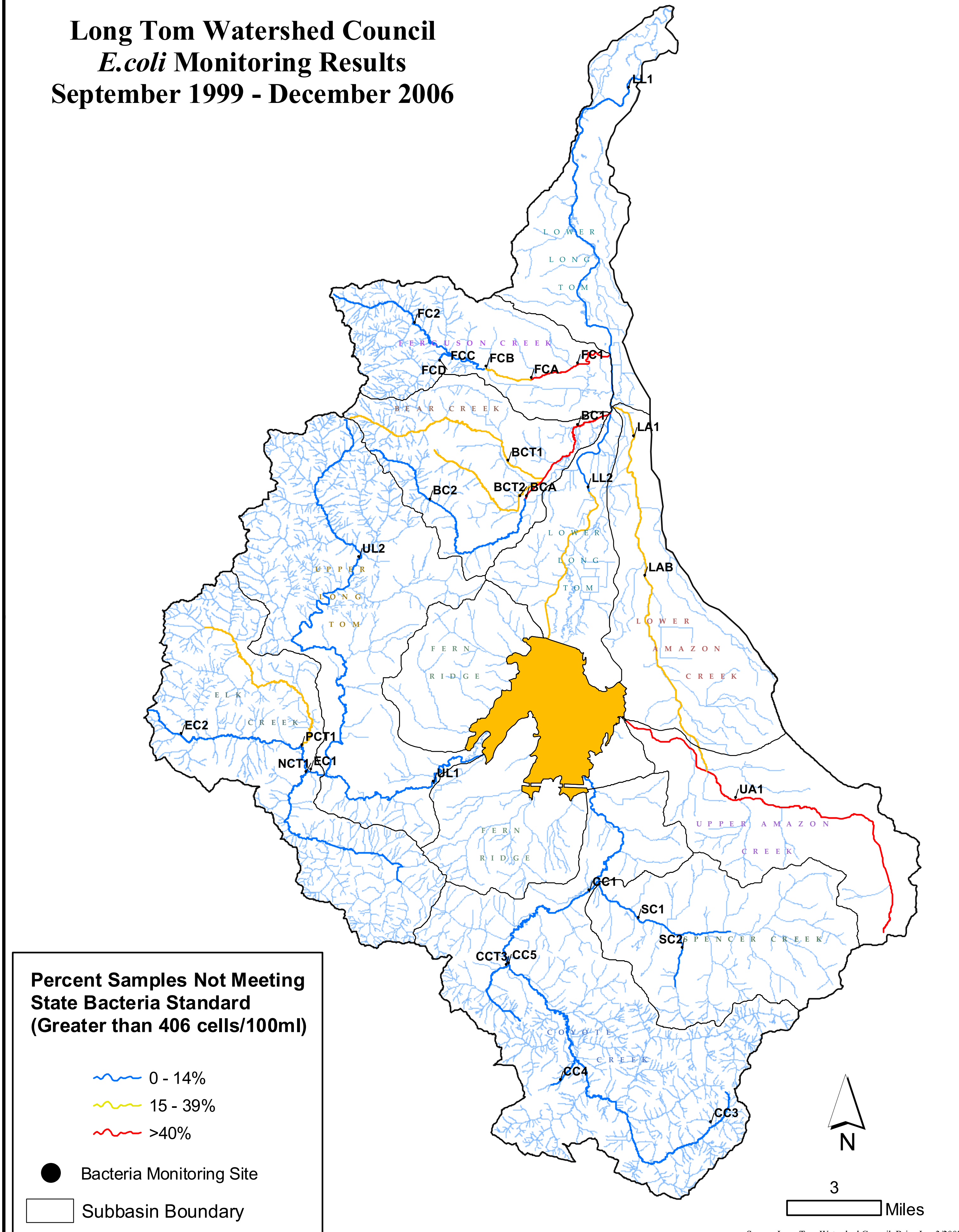
E. coli originates from fecal matter and is an easily measured indicator of fecal contamination of surface waters. Two state standards, based on *E. coli* concentrations, have been developed to protect humans from pathogenic bacteria associated with fecal matter. One standard applies to single samples and the other applies to the average of five samples taken within a 30-day period. The single sample standard is 406-organisms/100 mL of water. The 5-sample average standard is 126 organisms/100 mL. Streams that have average levels above 126 organisms/100 mL indicate chronic *E. coli* problems.

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. Most of the drainages in the Long Tom meet both the single-sample and 5-sample standard the majority of the time (see **Appendix F).** The **map on page 21** shows stream segment ratings according to the single-sample standard. Sections in red did not meet the standard for 40% or more of samples. Yellow segments indicate 15 – 39% of samples did not meet the standard, and blue indicates that 15% or less did not meet the standard.

The highest concentrations of *E. coli* are found at upper Amazon Creek (UA1), Bear Creek (BC1), Owens Creek (BCT1), Jones Creek (BCT2), and Ferguson Creek (FC1, FCA). In the case of upper Amazon Creek, with an average *E. coli* concentration of 786 cells/100 mL, bacteria comes from a variety of urban sources, including illicit discharges, pet waste, ducks, geese and nutria. Contrary to the trends in Bear and Ferguson Creek, *E. coli* levels are lower at the downstream site (see **Figure 5**). Here the average concentration is 350 cells/100 mL and the creek flows through irrigated agricultural land. It is likely that much of the *E. coli* at this site is coming from upstream in the City of Eugene.

In Bear Creek, *E. coli* levels rise somewhat consistently the further you move downstream. The upstream site drains primarily forestland, whereas the middle and downstream sites drain rural residential and pasture land. In Ferguson Creek, land use follows a similar pattern. However in this sub-watershed there is a distinct spike in *E. coli* concentrations downstream of Turnbow Rd. (FCB). Livestock have access to the creek both upstream and downstream of here, but grazing management practices differ significantly at one downstream site compared to the upstream livestock operations. In both the Bear and Ferguson Creek sub-watersheds, the likeliest source of *E. coli* appears to be runoff from pastures.

Long Tom Watershed Council
E.coli Monitoring Results
September 1999 - December 2006



Source: Long Tom Watershed Council. Brian Issa 3/2007

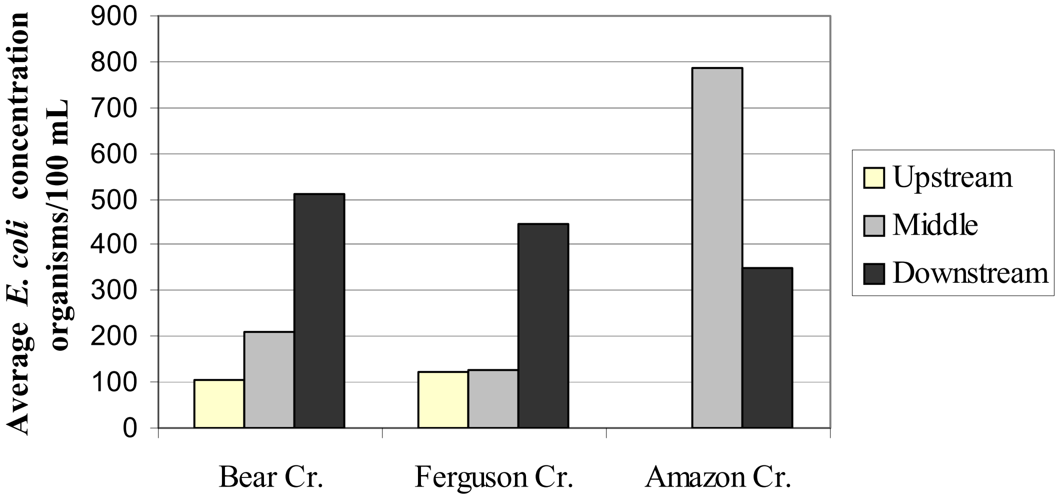


Figure 5. Upstream-downstream average *E. coli* levels for sites on Bear Creek, Ferguson Creek, and Amazon Creek. Downstream levels are higher at Ferguson and Bear Creek, but lower on Amazon Creek.

Conductivity and pH

Conductivity is related to the total dissolved solids (typically salts) concentration in water and can be used as an indicator of pollution levels in freshwater. We collected monthly data on conductivity at 17 – 19 sites between 1999 and 2006. High conductivity levels did positively correlate with sites that showed impairment from other attributes such as nitrates and total phosphorus. For our study, conductivity was not as useful a measure of water quality compared to the other attributes we measured.

The acceptable range for pH according to the state standard is 6.5 – 8.5. This measurement reflects the relative acidity of a liquid, and is measured on a scale of 1 to 14 (1 = highly acidic, 7 = neutral, 14 = highly alkaline). The pH of rainwater in the Pacific Northwest is between pH 5 and 6. As water hits the ground and intercepts soil particles and other substances its pH generally increases. The pH in a river or lake can be influenced by human activity (e.g., industry, automobile exhaust), the soil and rock types in the watershed, and the amount of algae in the water. Large concentrations of algae or aquatic plants can effect pH changes through photosynthesis. During the day pH levels are higher because photosynthesis is occurring, whereas at night pH levels are lower (i.e., more acidic) because no photosynthesis is occurring. The Council monitored pH at its original 17 baseline sites from September 1999 through June 2003. During this time, all samples met the state standard for pH.

Turbidity

Conditions for fish and other aquatic life become impaired when suspended sediment levels exceed natural background levels. Turbidity, which is measured by the amount of light that can pass through a water sample, is often used as an indicator of suspended sediment concentrations because it is inexpensive and easy to measure. High turbidity levels indicate suspended sediment concentrations that may interfere with visual feeding by fish, smother eggs, and impair gill respiration. Typically turbidity levels increase substantially when there is a heavy rain event.

Significant sources of sediment to streams include landslides caused by road failures or clear cuts on steep ground, exposed soil along ditches and road surfaces, stream bank erosion, and construction sites in urban areas.

The state standard for turbidity requires that a source not increase turbidity levels by more than 10% of upstream levels. Our data show upstream-downstream differences of greater than 10% at several sites in the watershed, as illustrated in **Figure 6**. The highest average turbidity levels are downstream of Fern Ridge Reservoir. Average turbidity on Coyote Creek near its outlet into Fern Ridge Reservoir (CC1) is 10 NTU, compared to 34 NTU in the lower Long Tom below Fern Ridge (LL2). This is due to the reservoir's shallow depth and heavy wave action that stirs up bottom sediment. The downstream sites on Bear Creek, Ferguson Creek, and Elk Creek also show significant increases in average turbidity compared to their upstream counterparts. Amazon Creek at Danebo Ave. in Eugene (UA1) shows higher average turbidity than downstream at High Pass Rd. (LA1). The same is true for Coyote Creek at Powell Rd. (CC2), which has an average turbidity of 29 NTU compared to 24 NTU downstream at Petzold Rd. (CC1). These comparisons differ from the first four in that CC2 and UA1 are mid-basin sites and obviously have significant sources of upstream erosion.

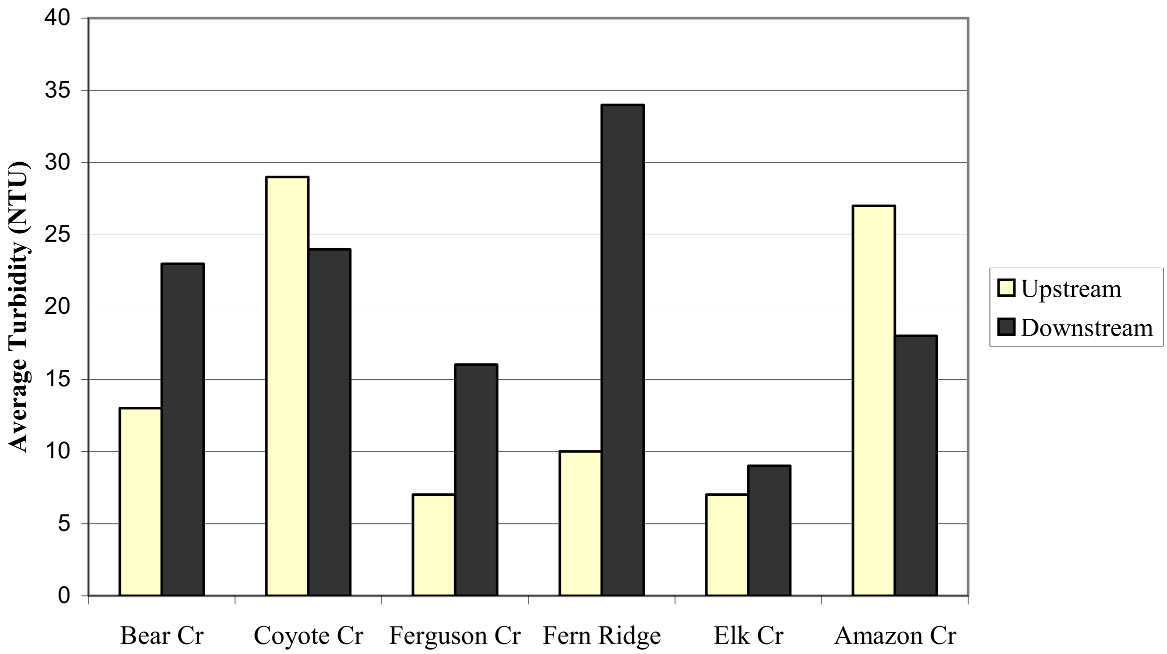


Figure 6. Average turbidity levels at several upstream-downstream sub-watershed sites. Four of the sub-watersheds show an increase in turbidity of greater 10% compared to upstream levels. Amazon and Coyote Creek show higher average turbidity levels at their mid-basin sites than downstream sites.

Nutrients

No state standards exist to protect freshwater aquatic life from excessive nitrogen or phosphorus concentrations. This is due to the natural variability of nutrient concentrations in streams and lakes, which is influenced by watershed geology and plant communities. Although relative concentrations of nitrogen and phosphorus vary in their impact on local water quality and stream health, numerous studies have shown that water quality and instream habitat deteriorate when nutrient concentrations increase over background levels (Horne & Goldman, 1994). Often, this is associated with human impacts, such as an increasing number of septic systems adjacent to a river or lake, impervious surfaces in urban areas, and fertilizer use on urban and agricultural land.

For the purposes of this study, we have selected 0.1 mg/L of total phosphorus and 0.3 mg/L of nitrate as indicators of poor water quality[4]. In the Long Tom Watershed, phosphorus and nitrate concentrations above this are associated with dense blooms of algae in the summer, increased turbidity, and low dissolved oxygen levels. The **maps on pages 26 and 27** show the distribution of nitrate and total phosphorus concentrations in relation to 0.1 mg/L for phosphorus and 0.3 mg/L for nitrate. Stream reaches in which more than 40% of samples were above these levels are red. Sections with 15% - 39% of samples above are yellow and 0% - 14% are blue.

Phosphorus levels are the highest in upper and lower Amazon Creek (UA1, LA1, LAA, LAB, LAC), Fern Ridge Reservoir (LL3), and upper Spencer Creek (SCA). The lower Long Tom R, Ferguson Cr., Bear Cr., and Coyote Cr. have moderate levels of phosphorus in their lower reaches, and the rest of the Watershed has relatively low levels of phosphorus. The distribution of nitrate concentrations is somewhat different than phosphorus, although lower and upper Amazon Creek again show very high levels. EC2, the most pristine sampling site in the Watershed also shows high levels of nitrate. There are no residences, farms, or recent logging operations upstream of this site, which suggests that a higher background level may exist in this sub-watershed.

Without extensive historical data, distinguishing between natural levels and human contribution can be difficult. But in the Amazon Creek basin the data provide strong evidence that human contribution is significant. **Figures 7 and 8** compare seasonal average concentrations of total phosphorus and nitrate for lower Amazon Creek, upper Amazon Creek, and the mouth of Coyote Creek. Upper Amazon Creek (UA1) drains urban land. The lower segment of Amazon Creek (LA1) runs through irrigated agricultural land and receives input from industrial land to the east of Highway 99. Coyote Creek (CC1) drains forest and rural residential land.

Average total phosphorus levels are 1.5 to 4.5 times higher in lower Amazon Creek than Coyote Creek. The highest levels in lower Amazon Cr. occur in summer (May – July), whereas Coyote Creek levels peak in the winter (November – January). Average nitrate levels are up to 11 times greater in lower Amazon Creek than Coyote Creek between November and April, and then drop below Coyote Creek levels July to October. These results are consistent with the USGS study of the Willamette River showing the highest concentrations of nutrients in streams draining urban and agricultural land (Wentz et al. 1998).

[4] Nitrate is measured as nitrate-nitrite nitrogen.

Nitrate levels show an increasing trend at several watershed sites, including the mouths of Bear Creek (BC1), Ferguson Creek (FC1), Amazon Creek (LA1), and the Long Tom River (LL1). Sites on the Long Tom River near Cheshire (LL2), Veneta (UL1), and Alderwood State Park (UL2) are also increasing in nitrate concentrations. Only one site in the Watershed showed a change in total phosphorus levels, which was a decreasing trend on the upper Long Tom River near Veneta (UL1). See **Appendix E** for a description of the statistical test used to calculate nutrient trends and other trend results for the Watershed.

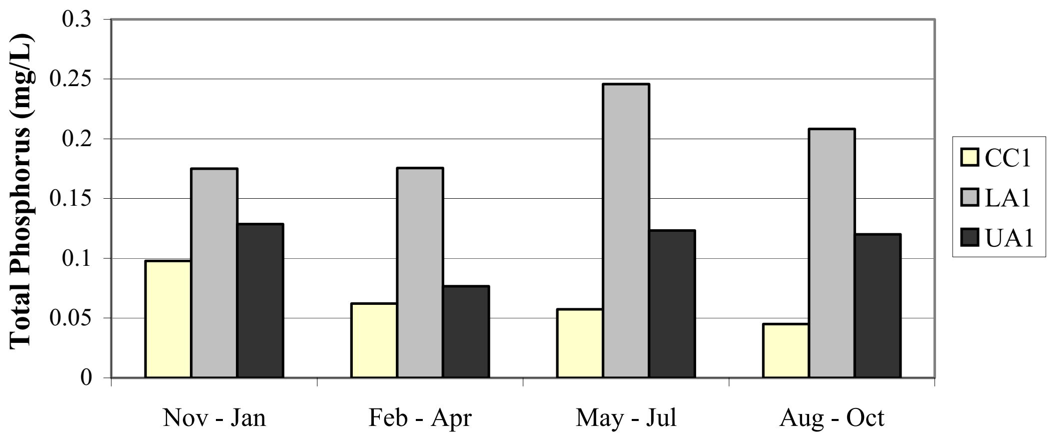


Figure 7. Average seasonal concentrations of total phosphorus for Coyote Cr. at Petzold Rd. (CC1), lower Amazon Cr. at High Pass Rd. (LA1), and upper Amazon Cr. at Danebo Ave. (UA1). Differences in year round averages are statistically significant for all sites.

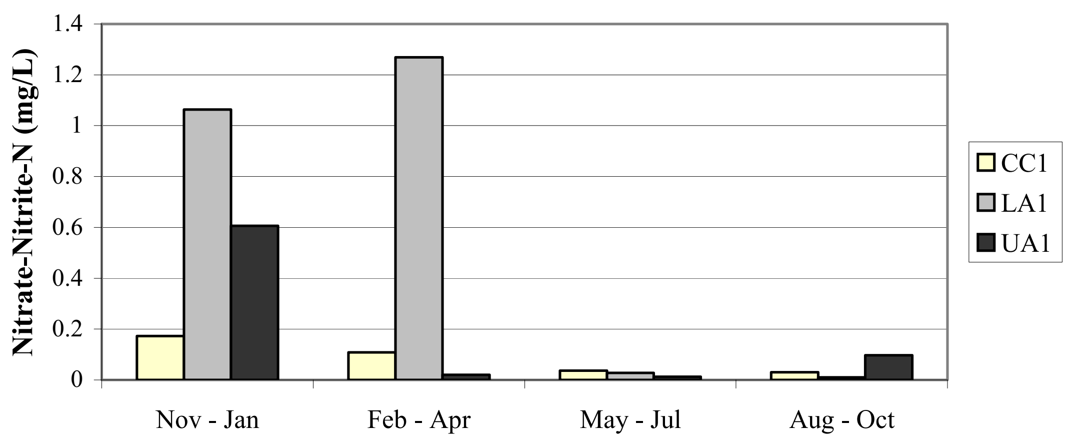
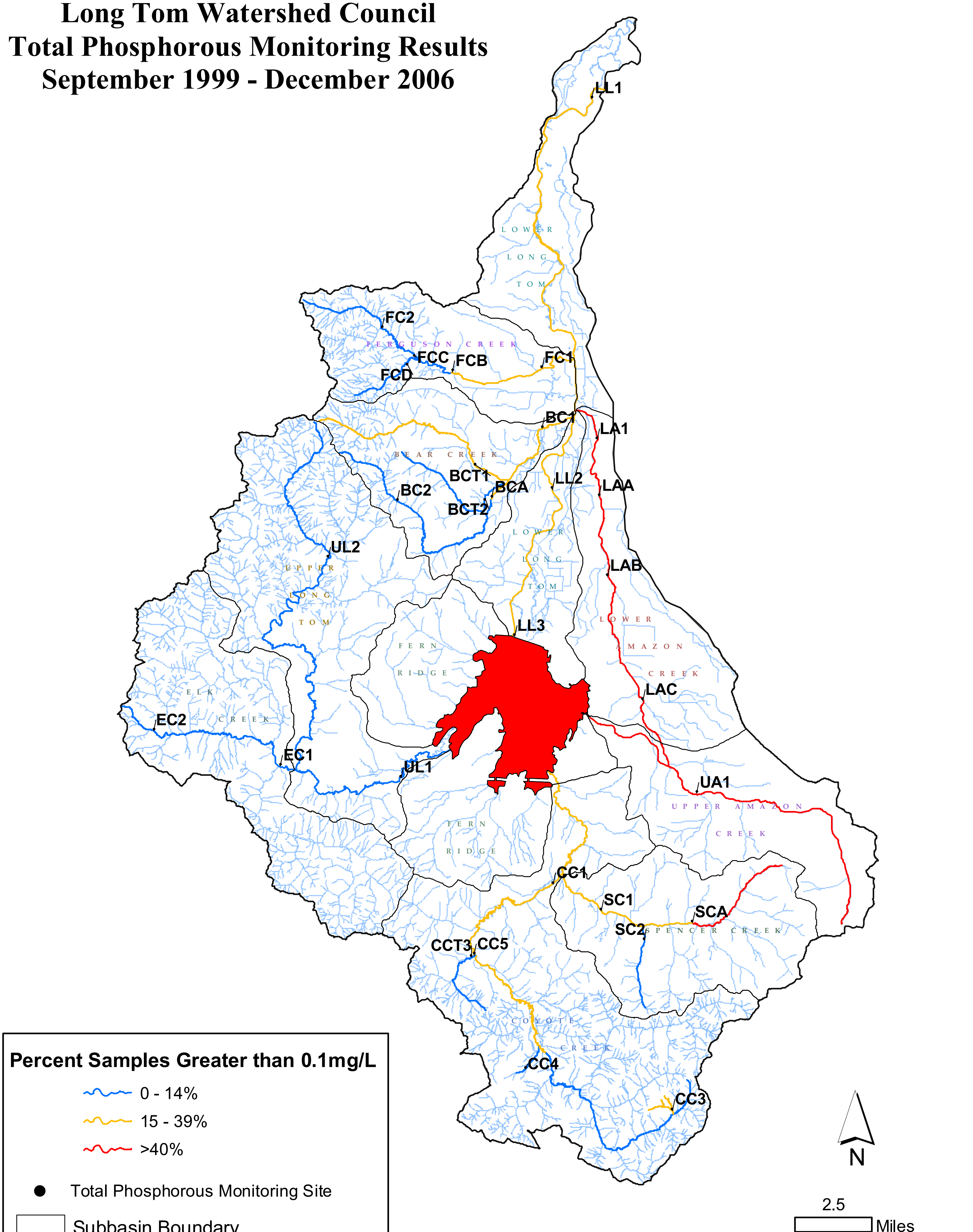


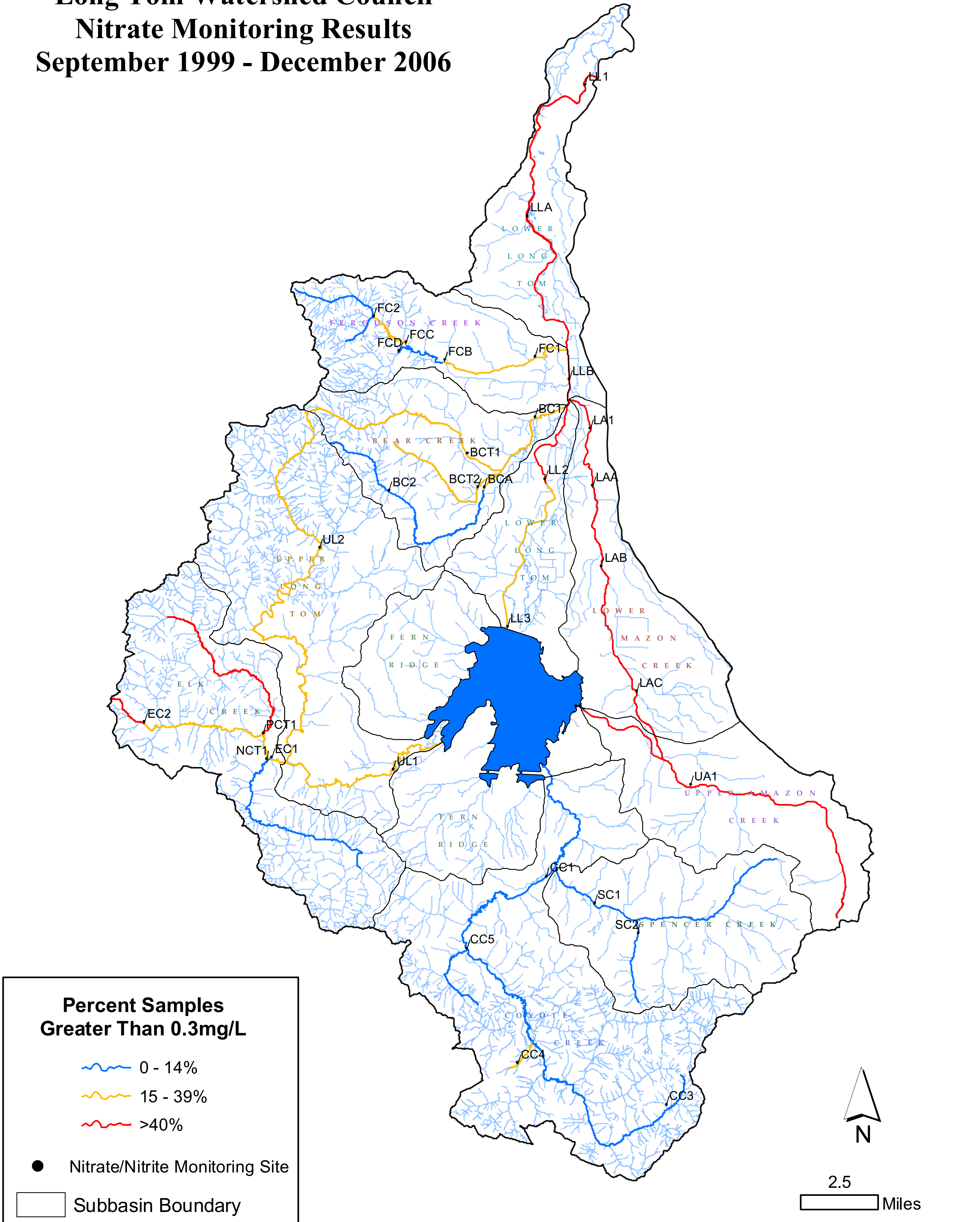
Figure 8. Average seasonal concentrations of nitrate for Coyote Cr. at Petzold Rd. (CC1), lower Amazon Cr. at High Pass Rd. (LA1), and upper Amazon Cr. at Danebo Ave. (UA1). Differences in year round averages are statistically significant for CC1 compared to LA1 and CC1 compared to UA1, but not LA1 compared to UA1.

Long Tom Watershed Council
Total Phosphorous Monitoring Results
September 1999 - December 2006



Source: Long Tom Watershed Council. Brian Issa 3/2007

Long Tom Watershed Council
Nitrate Monitoring Results
September 1999 - December 2006



Source: Long Tom Watershed Council. Brian Issa 3/2007

Macroinvertebrate and Physical Habitat Survey Results

Macroinvertebrate samples were collected at 90 random sites and 2 non-random sites across the watershed. The majority of these sites were on private land. **Figure 9** shows the proportion of sampled sites in public and private ownership and the dominant land use. Land use for each site was determined in the field and varied somewhat from land use identified by zoning. For example, a site zoned as farm/forest but whose upstream and surrounding influence was predominately rural residential was classified as rural residential for our study. Sites that we classified as forest have no upstream influence from residences or agriculture.

We analyzed our macroinvertebrate data using two different models. Both models generate a score for each site by comparing the actual results with results that would be expected from applicable reference sites in the region. These reference sites are characterized by having the least amount of human disturbance and good water quality and habitat conditions. This is a significant point, because we are comparing our macroinvertebrate results with what could be reasonably expected in the present day as opposed to pre-settlement conditions. However, one problem with both of these models is that they tend to give lowland sites poorer scores. This is because there are so few lowland reference sites available due to development patterns on the landscape. Thus lowland sites are scored against predominately upland reference sites, which may not be a reasonable comparison. (See **Appendix C** for a detailed description of each model and a comparison of model results.)

The Oregon Marine Western Coastal Forests Predictive Model classifies streams as poor, fair, or good condition. In the Long Tom Watershed, 58% of stream miles were rated in poor condition, 17% in fair condition, and 25% in good condition. Similarly, the Western Oregon Multimetric Index rated 61% of stream miles as moderately to severely impaired, 30% as slightly impaired, and 9% as no impairment (see **Figure 10**). Generally, downstream sites had poorer scores than upstream sites, and those in the urban and agricultural parts of the Watershed were all rated as poor or moderately to severely impaired. When the lower Amazon, upper Amazon, and Fern

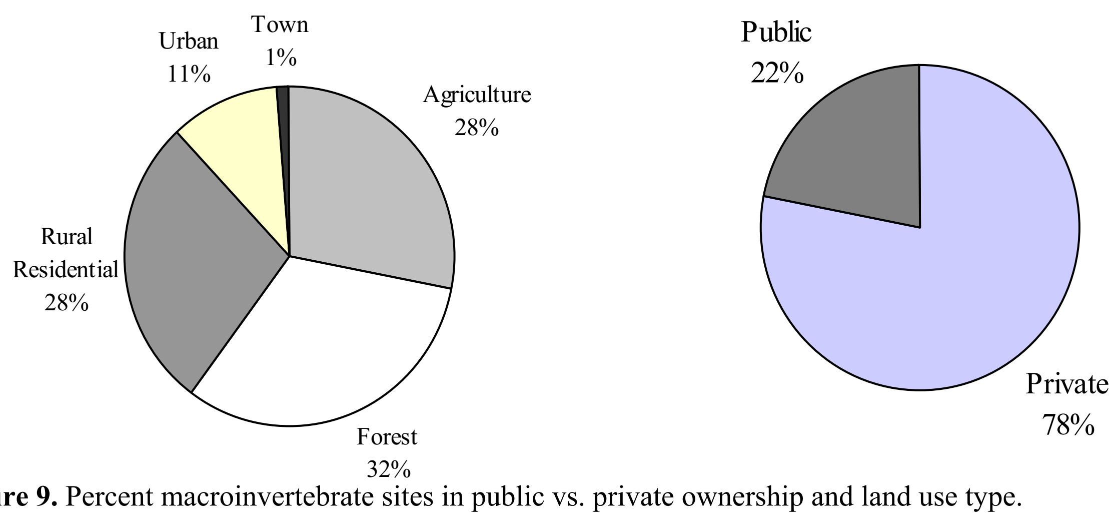


Figure 9. Percent macroinvertebrate sites in public vs. private ownership and land use type.

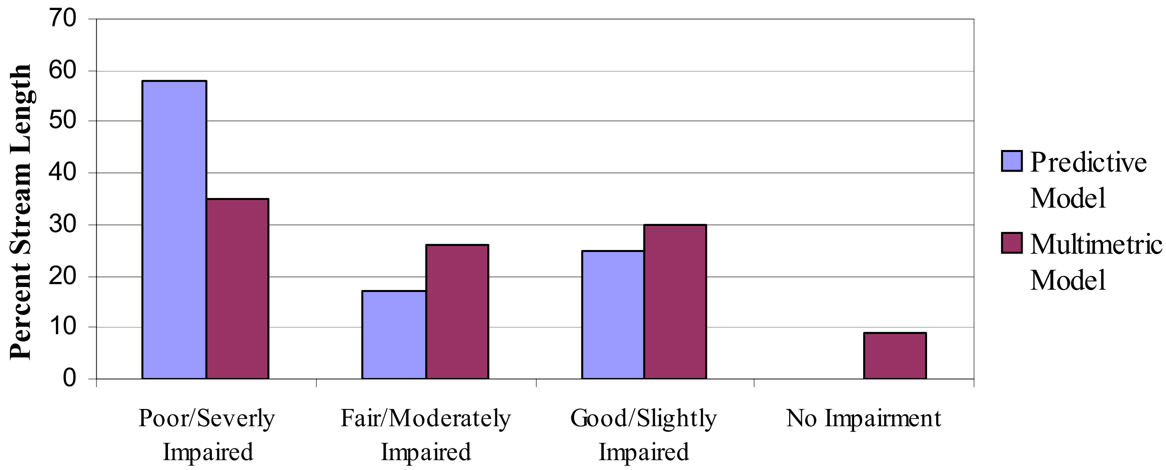


Figure 10. Percentage of sites in Long Tom Watershed that scored poor, fair, or good according to the Oregon Marine Western Coastal Forests Predictive Model or severely impaired, moderately impaired, slightly impaired, or no impairment according to the Western Oregon Multimetric Index.

Ridge sub-watersheds (all exclusively lowland sites) are excluded from the watershed evaluation, the total number of stream miles in good condition increases to 32%, fair to 20%, and poor decreases to 48%. Similarly, for the Multimetric Index 12% of stream miles show no impairment, 38% show slight impairment, and 50% indicate severe to moderate impairment when the lower Amazon, upper Amazon, and Fern Ridge sub-watersheds are excluded.

Figures 11 and 12 show the average macroinvertebrate scores and 95% confidence intervals for each sub-watershed based on the Predictive Model and Multimetric Index. These confidence intervals show the uncertainty in the estimated average for each sub-watershed and illustrate whether one set of results is statistically different from another. The Predictive Model results show that Ferguson and Elk Creek have higher average scores than Coyote, Spencer, Fern Ridge, Lower Amazon and Upper Amazon but they cannot be distinguished from Bear Creek and Upper Long Tom. Conversely, Upper and Lower Amazon Creek have lower average scores than all of the other sub-watersheds.[5]

The Multimetric Index results also place Lower and Upper Amazon below most of the other sub-watersheds, but it does not distinguish between the remaining drainages. Interestingly, the Multimetric Index placed Spencer Creek among the highest scoring sub-watersheds, in contrast to the Predictive Model which placed it with Fern Ridge and Coyote Cr. A possible explanation is that most of the sites in Spencer Creek were sampled in late May/early June before the streams in the area dried up. The sites for the rest of the Watershed were sampled July through September. Cooler water temperatures in May/June could have contributed to more diverse or pollution sensitive species being present in the Spencer Creek samples.

[5] Only one randomly selected site was sampled on the lower Long Tom due to unwadeable depths along most of the river. Consequently we cannot quantify stream conditions based on macroinvertebrates for this sub-watershed.

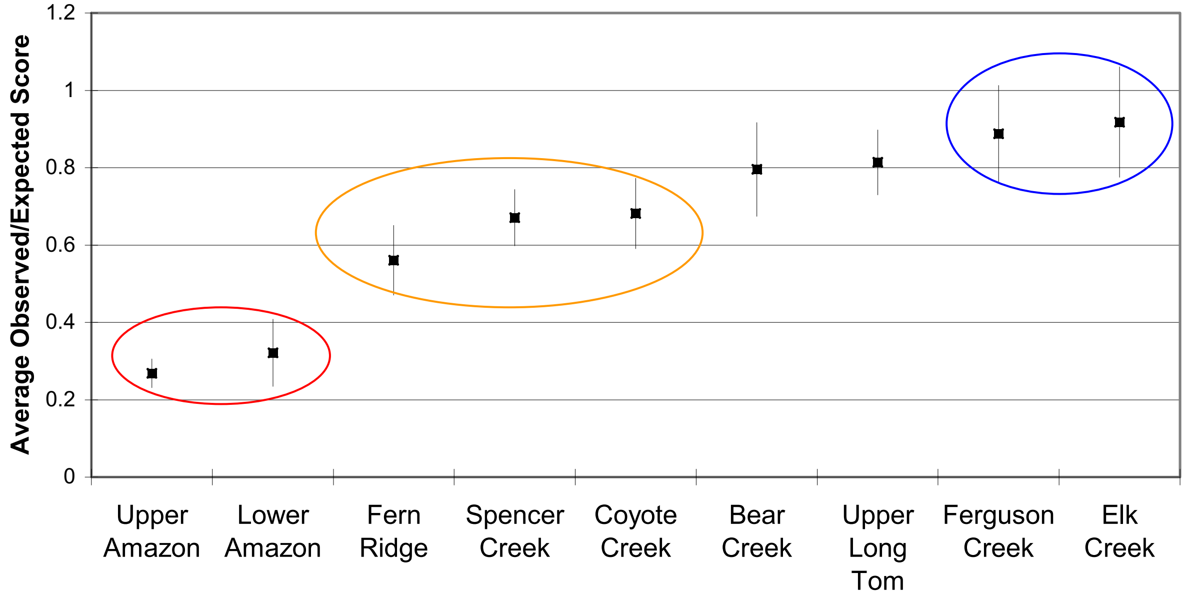


Figure 11. Average macroinvertebrate scores for each sub-watershed using the Oregon Marine Western Coastal Forests Predictive Model (O/E Score). The vertical line extending from each average value represents the 95% confidence interval. Sub-watersheds that have overlapping confidence intervals are not, on average, statistically different from each other.

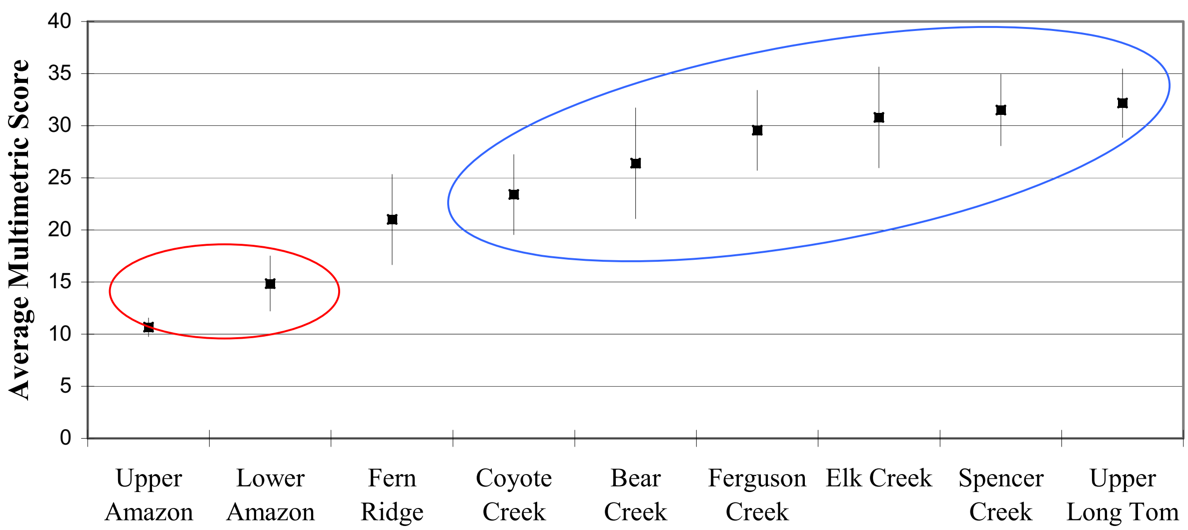


Figure 12. Average macroinvertebrate scores for each sub-watershed using the Western Oregon Multimetric Index.

We collected physical habitat measurements at 61 of the 90 randomly selected macroinvertebrate sites. The remaining 29 sites were either too deep to wade for most of their length or too difficult to walk upstream due to blackberry or logging slash. Habitat measurements included an assessment of riparian conditions, stream bottom composition, and instream large wood.

A riparian condition score was calculated by summing the scores for shade, tree presence/absence, understory density, and groundcover density. Each element was weighted equally. Of the physical habitat measurements we made, riparian condition appears to be the best predictor of macroinvertebrate score for both the Multimetric Index (see **Figure 13**) and the Predictive Model.[6] This likely relates to the increased shade, correspondingly cooler water temperatures, and greater volume of leaf litter and small wood associated with healthy riparian areas. Sites with high scores for riparian zone conditions also tended to have fewer immediate impacts from humans, such as livestock, cropland, buildings, or roads. However, many environmental variables influence macroinvertebrate assemblage, as we see for the sites with low macroinvertebrate scores, but fair to good riparian scores. In these cases, some other environmental variable, such as temperature, nutrient levels, or stream bottom condition, may better explain the macroinvertebrate results.

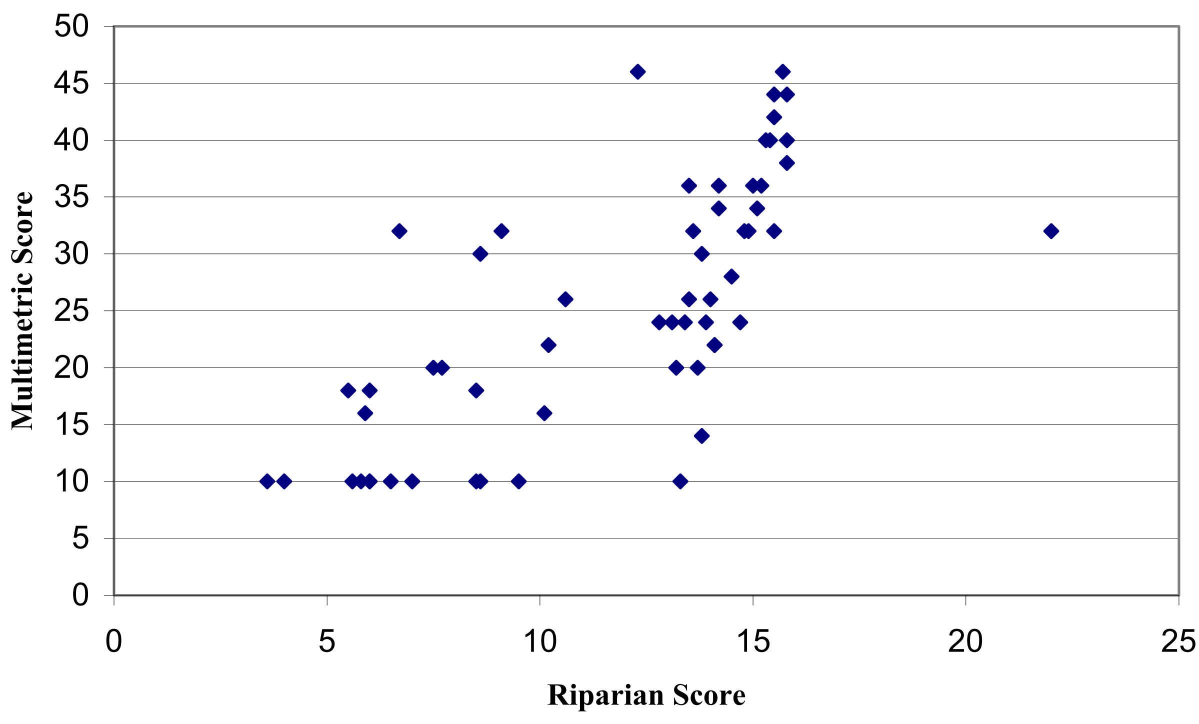


Figure 13. Multimetric scores in relation to riparian zone conditions. Macroinvertebrate scores are higher for sites with more developed riparian areas.

[6] R^2 values for the riparian, substrate, and large wood regressions were not available for this report, but will be calculated and provided in an addendum on macroinvertebrate and physical habitat results later this year.

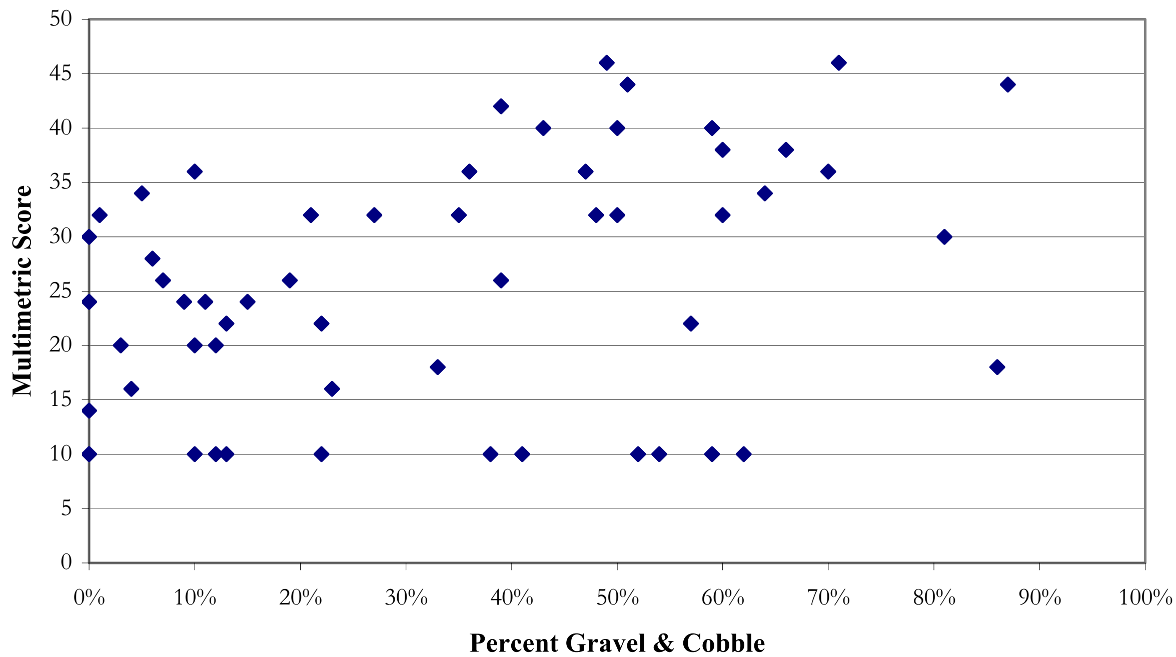


Figure 14. Multimetric scores in relation to percent stream bottom composed of gravel and cobble. No trend is evident.

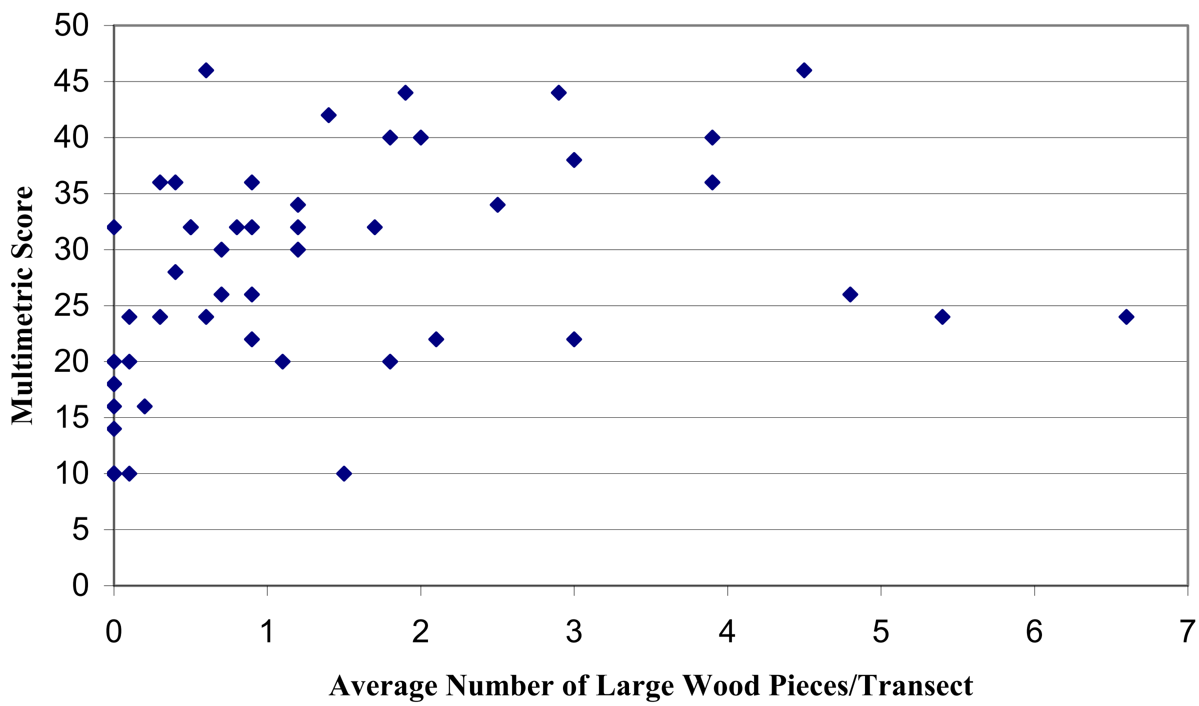


Figure 15. Multimetric scores in relation to instream large wood density. Scores indicate a possible increasing trend as number of wood pieces greater than 1' diameter increase.

Stream bottom composition does not appear to predict macroinvertebrate scores well using either the Predictive Model or the Multimetric Index. **Figure 14** shows Multimetric macroinvertebrate scores over percent cobble and gravel. The pattern was similar for macroinvertebrate scores over percentage of fine sediment. These results differ from studies in the Oregon Coast Range that show mean substrate diameter and relative bed stability to be the best instream predictors of both macroinvertebrates (Kaufman, unpublished data) and aquatic vertebrate community health (Kaufman and Hughes, 2006).

Relative amount of large wood appeared to be moderately predictive of macroinvertebrate scores (see **Figure 15**). This suggests that wood does have a positive influence on instream habitat for macroinvertebrates, but that other attributes, such as water quality and riparian conditions, have a larger influence.

Conclusions

The Long Tom Watershed encompasses a diverse landscape, is home to many species of fish and wildlife, and supports its human residents with rich forests and farmland. Given the rapid growth and changing environment we are beginning to experience, there are many aspects of our natural resources that we need to monitor and protect, be it farmable land, clean drinking water, or habitat for our native fish and wildlife. Water quality and biological indicators, such as macroinvertebrates, are important elements of our environment to monitor, since they integrate and respond to many impacts and changes to our watershed.

Seven years of monitoring have provided the Council and its partners a solid foundation for understanding aquatic conditions in the Long Tom Watershed. The macroinvertebrate and physical habitat data we collected over the past three years provided an important addition to the data on water chemistry and temperature. The results showed that a majority of our stream length is impaired for biological condition, which is consistent with the water quality data we have collected over the past seven years.

Water temperature and dissolved oxygen limit seasonal distribution of cutthroat trout and are a likely source of poor macroinvertebrate scores in the lowland parts of the watershed. Although we do not have historical data on temperature or dissolved oxygen, we do know that riparian vegetation has been reduced and significantly altered over the past 150 years (Thieman, 2000), which has led to less shade and undoubtedly higher water temperatures. We also know that surface water withdrawals contribute to lower summertime stream flows, which contributes to increased stream temperatures as well. Finally, instream ponds or impoundments can significantly elevate downstream water temperatures by increasing the residence time of water and often exposing it too more solar radiation. To varying extents these impacts can be reversed or at least attenuated. Landowners with senior water rights may be in a position to donate part or all of their rights for instream flow. Others may be able to remove small dams or replace summer stream withdrawals with an off-channel pond. And most landowners with streams running through their property, if they are willing and given financial or technical assistance, could restore riparian vegetation and shade.

High nutrient and bacteria levels in some streams are also likely related to human impacts. This is supported by data from lower and upper Amazon Creek, which show the poorest macroinvertebrate scores and the worst overall water quality in the parts of the watershed with the most intensive land use. In general, as one moves downstream through progressively more intensive land use, we see increasingly poor water quality. At some sites, nitrate levels are increasing. This may indicate changing management practices such as removal of riparian vegetation, higher stocking rates in streamside pastures, and more fertilizer being used in urban and rural areas. It may also reflect the increasing amount of development in the watershed, which leads to more impervious surface, sewer connections, and septic systems.

Many human impacts to streams and rivers could be lessened by restoring and protecting riparian areas. Stream temperature models suggest significant cooling could occur with the addition of shade, which would allow cutthroat trout to occupy a larger portion of the stream network in the summer. In addition, restoring riparian areas would buffer streams from adjacent land use practices that may be contributing nutrients and sediment. Dense, native riparian vegetation also reduces bank erosion and provides wood to the stream.

In urban and agricultural areas, additional strategies need to be implemented to improve water quality. This is because the intensity of the land use generates more pollutants than a riparian zone can filter out. In urban areas, individual residents can make choices about yard care, where to wash their cars, what they do with pet waste, and how much impervious surface they create. On agricultural land, farmers can employ precision agriculture techniques, plant cover crops, and utilize no-till practices.

Looking ahead, long term monitoring is an important action the Watershed Council can take to help improve and protect water quality and habitat. Setting goals for water quality and habitat, and monitoring our progress every 5 years, will enable us to focus on the most pressing problems, assess our effectiveness, and adapt our strategies. Future monitoring data will also help keep the public informed about conditions in their environment and the importance of protecting water quality and aquatic habitat.

References

Armantrout, Neil. 1999. Personal Communication. Fisheries biologist, Bureau of Land Management.

Department of Environmental Quality. 2006. Willamette Basin Total Maximum Daily Load. Chapter 10-Upper Willamette Sub-basin Total Maximum Daily Load and Chapter 4-Mainstem Temperature Total Maximum Daily Load.

Galovich, Gary. 2001. Personal Communication. Fisheries biologist, Oregon Department of Fish & Wildlife.

Horne, Alexander J. and Charles R. Goldman. 1994. Limnology, 2nd ed. McGraw-Hill Inc. pp. 470 – 472.

Kaufman, Philip R. and Robert M. Hughes. 2006. Geomorphic and Anthropogenic Influences on Fish and Amphibians in Pacific Northwest Coastal Streams. American Fisheries Society Symposium 48: 429-455.

Lane Council of Governments. 1983. Fern Ridge Clean Lakes Study.

Omernik, James M. and Glenn Griffith. 1991. Ecological regions versus hydrologic units: Frameworks for managing water quality. Journal of Soil and Water Conservation, 46(5).

Oregon Plan for Salmon and Watersheds. 1999. Water Quality Monitoring Technical Guidebook.

Peck, D. V., A. T. Herlihy, B. H. Hill, R. M. Hughes, P. R. Kaufman, D. Klemm, J. M. Lazorchak, F. H. McCormick, S. A. Peterson, P. L. Ringold, T. Magee, and M. Cappaert. Environmental Monitoring and Assessment Program-Surface Waters Western Pilot Study: Field Operations Manual for Wadeable Streams. U.S. Environmental Protection Agency, Washington, DC, EPA/620/R-06/003, 2006.

Rinella, Frank and Mary Janet. 1998 Seasonal and spatial variability of nutrients and pesticides in streams of the Willamette Basin, Oregon, 1993-95. U.S. Geological Survey Water-Resources Investigations Report 97-4082-C.

Stoddard, J. L., D. V. Peck, S. G. Paulsen, J. Van Sickle, C. P. Hawkins, A. T. Herlihy, R. M. Hughes, P. R. Kaufman, D. P. Larsen, G. Lomnicky, A. R. Olsen, S. A. Peterson, P. L. Ringold, and T. R. Whittier. 2005. An Ecological Assessment of Western Streams and Rivers. EPA 620/R-05/005, U.S. Environmental Protection Agency, Washington, D.C.

Thieman, Cindy. 2000. Long Tom Watershed Assessment. Long Tom Watershed Council unpublished document.

Thieman, Cindy. 2003. Water Quality in the Long Tom River Watershed: 1999-2003. Long Tom Watershed Council unpublished report.

Wentz, Dennis A., Bernadine A. Bonn, Kurt D. Carpenter, Stephen R. Hinkle, Mary L. Janet, Frank A. Rinella, Mark A. Uhrich, Ian R. Waite, Antonius Laenen, and Kenneth E. Bencala. 1998. Water Quality in the Willamette Basin, Oregon, 1991-95. U.S. Geological Survey Circular 1161.