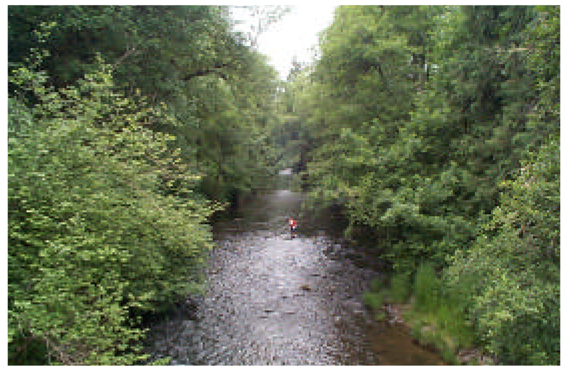
TUALATIN SUBBASIN

TOTAL MAXIMUM DAILY LOAD (TMDL)



Prepared by

Oregon Department of Environmental Quality

August 2001

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CHAPTER 1 - EXECUTIVE SUMMARY

1.1 WATER QUALITY SUMMARY

Section 303(d) of the Federal Clean Water Act (CWA) requires that a list be developed of all impaired or threatened waters within each state (303[d] list). This list is called the 303(d) list after the section of the CWA that requires it. In Oregon, the Oregon Department of Environmental Quality (ODEQ) is responsible for this work. Section 303(d) also requires that the state establish a Total Maximum Daily Load (TMDL) for any waterbody designated as water quality limited (with a few exceptions, such as in cases where violations are due to natural causes). TMDLs are written plans and analyses established to ensure that waterbodies will attain and maintain water quality standards.

The Tualatin River Subbasin has stream segments listed on the 1998 Oregon 303(d)[1] List for: temperature, bacteria, dissolved oxygen, chlorophyll a, toxics (arsenic, iron and manganese), biological criteria and low pH. TMDLs were established in 1988 for ammonia and phosphorus to address low dissolved oxygen and elevated pH and chlorophyll a in the mainstem. DEQ is proposing to revise the TMDLs for ammonia and phosphorus and establish new TMDLs for temperature, bacteria and tributary dissolved oxygen (DO).

There have been significant water quality improvements in the mainstem Tualatin due to the ammonia and phosphorus TMDLs that were developed and implemented since 1988. The dissolved oxygen and pH standards in the mainstem have been met most of the time in recent years. These improvements reflect reduced ammonia and phosphorus loadings from wastewater treatment plants, management of releases from Scoggins Reservoir for water quality purposes and implementation of non-point controls of agricultural, forestry and urban runoff.

In 1998, Tualatin Basin Policy Advisory Committee made recommendations to DEQ for modification to the Ammonia and Phosphorus TMDLs based on additional studies and information. DEQ is proposing to modify the TMDLs based on these recommendations and the analysis of other data and studies.

New TMDLs are proposed for temperature, bacteria and volatile solids (to address sediment oxygen demand [SOD] impacts on dissolved oxygen in the tributaries). The focus of the new TMDLs will be primarily in the tributaries of the Tualatin although they are applicable subbasin-wide.

Exceedance of arsenic, iron and manganese standards were identified as being due to the natural geo-chemical environment and regional groundwater hydrology, and thus most likely reflect natural background conditions. These water quality standards will be re-evaluated in future triennial standards reviews. Low pH values measured at selected sites were called into question. These waters are poorly buffered (low stream alkalinity) making pH measurements difficult. In addition, soils are acidic, rainwater is slightly acidic and there are no known anthropogenic (human influenced) sources in the watershed. TMDLs will not be established for these parameters. Habitat and flow modification concerns (identified under biological criteria standard exceedance) will be addressed in management plans to be developed by designated management agencies (DMAs). As they are not pollutants, TMDLs will not be developed for habitat and flow modification.

[1] The 303(d) list is a list of stream segments that do not meet water quality standards

1.2 TMDL SUMMARIES

Temperature: The temperature water quality standard uses numeric and qualitative triggers to invoke a condition that requires "no measurable surface water increase resulting from anthropogenic activities." The temperature TMDL targets anthropogenic sources of heat. The thermal pollutant is heat from human sources. There are two sources of pollutants: increased solar radiation heat loading and heat from point source warm water discharge. The loading capacity is the total allowable daily heat loading. Load allocations are developed for anthropogenic and background nonpoint sources of heat. Waste load allocations are developed for all fifteen point sources. There is no numeric margin of safety provided in the temperature TMDL.

Numeric and narrative triggers for the temperature standard apply to the Tualatin River Subbasin. Approximately 25% of the stream network currently experiences maximum daily temperatures below 64°F (17.8°C) in mid-summer. Threatened and endangered cold water salmonids reside in the subbasin. Dissolved oxygen violations occur throughout the subbasin. The stream temperature standard applies when one or more of these numeric and narrative triggers occur.

Results of temperature modeling that minimized human sources of heat found that 98% of the stream network would be below a 64°F (17.8°C) for maximum daily temperature threshold.

Percent effective shade is used as a surrogate measure for nonpoint source pollutant loading since it offers a straightforward parameter to monitor and measure. It is also easily translated into quantifiable water management objectives. Site specific effective shade surrogates can be used to assess TMDL nonpoint source allocation attainment. Attainment of surrogate measures ensures attainment of the nonpoint source allocations.

Bacteria: The analysis for the bacteria TMDL was broken into two broad categories: bacteria from runoff sources and bacteria from other sources. The allocations for runoff sources are based on a computer model that estimates the bacteria loadings coming off specific land uses during rain events. The reductions necessary to achieve the State's bacteria standard are derived from this modeling and are then used as the basis for allocations**.** Allocations for non-runoff periods are based on a straightforward analysis of instream bacteria levels and the percent reductions necessary to achieve standards.

Chlorophyll a and Phosphorus: An analysis of the original phosphorus TMDL work shows that the loadings of phosphorus from groundwater are higher than originally thought. This new information indicates that the natural in-stream levels of phosphorus in the Tualatin River Subbasin are also higher than originally thought. The allocations in the revised TMDL reflect this new understanding of the system with mainstem concentrations of 0.09 mg/L to 0.11 mg/L, and concentrations in the lower reaches of the tributaries ranging from 0.04 to 0.19 mg/l. They are based on the goal of achieving the natural levels of phosphorus in the mainstem Tualatin River. In recent years with good flow conditions, the Tualatin River has been predominately below the upper pH standard.

Dissolved Oxygen (Ammonia and Volatile Solids): Many of the Tualatin tributaries are listed as impaired due to insufficient concentrations of dissolved oxygen (DO). The mainstem has also experienced DO problems, which were originally addressed in 1988 through the ammonia TMDL. Though much progress has been made toward meeting the standard, modeling by the United States Geological Survey (USGS) has shown that both ammonia loads and other oxygen demands must be reduced further during the critical portions of the year. The same modeling has shown that ammonia loads may be increased during non-critical portions of the year with no adverse effects.

Water quality computer modeling performed by DEQ has indicated that the tributary dissolved oxygen problems may be addressed through a combination of temperature reductions and reductions in sediment oxygen demand (SOD). The temperature reductions will be addressed in the temperature TMDL. The SOD reductions (ranging from 20-50% reduction) for both the mainstem and tributaries will be addressed through allocations of volatile solids requiring controls on runoff.

Water Quality Management Plan (WQMP): To address these TMDLs, a WQMP has been developed focusing on the following areas:

- Protecting and planting trees along riparian areas;
- Urban storm water and agricultural/forestry runoff management;
- Temperature control of other permitted discharges;
- Ammonia, phosphorus, and temperature control of discharges from Wastewater Treatment Plants.

The Designated Management Agencies (DMAs) include: Unified Sewerage Agency of Washington County, Clackamas County, Washington County, Multnomah County, City of Lake Oswego, City of West Linn, City of Portland, Oregon Department of Agriculture, Oregon Department of Forestry, and the Oregon Department of Transportation. These agencies have developed water quality management plans to address phosphorus and ammonia loadings identified in the 1988 TMDLs and/or are operating under NPDES permits. These plans and permits will be updated to address the revised and new TMDLs within one year of the TMDL approval by the Environmental Protection Agency (EPA).

TMDL Report: This report presents the new and revised Tualatin TMDLs for public review. It addresses the elements of a TMDL required by the Environmental Protection Agency. These elements include:

- A description of the geographic area to which the TMDL applies;
- Specification of the applicable water quality standards;
- An assessment of the problem, including the extent of deviation of ambient conditions from water quality standards;
- The development of a loading capacity including those based on surrogate measures and including flow assumptions used in developing the TMDL;
- Identification of point sources and non-point sources; development of Waste Load Allocations for point sources and Load Allocations for non-point sources;
- Development of a margin of safety; and
- An evaluation of seasonal variation.

The report is organized as follows:

- The main text summarizes the seven elements listed above for each of the TMDL parameters: temperature, bacteria, phosphorus, ammonia and volatile solids;
- The appendices contain a more detailed description of the studies, computer modeling, references, and data analyses that were done to develop TMDLs or to address other parameters of concern (arsenic, manganese, iron, low pH, and biological criteria (habitat and flow modification). A Water Quality Management Plan is also presented in **Appendix I**;

These documents and several public summary documents are: available upon request, at locations within the Tualatin River Subbasin and can be found on the DEQ website: http://waterquality.deq.state.or.us/wq/

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CHAPTER 2 –OVERVIEW AND BACKGROUND

2.1 INTRODUCTION

The Tualatin River drains an area of 712 square miles and is situated in the northwest corner of Oregon. It is a subbasin of the Willamette River Basin. The headwaters are in the Coast Range and flow in a generally easterly direction to the confluence with the Willamette River. The subbasin lies almost entirely within Washington County. There are also small portions in Multnomah, Clackamas, and Yamhill counties. The Tualatin River is approximately 83 miles in length and has a very flat gradient for most of its length. There is a reservoir-like section between River Mile (RM) 24 and 3.4. Major tributaries to the Tualatin River include: Scoggins, Gales, Dairy (including East Fork, West Fork, and McKay Creeks), Rock (including Beaverton Creek), and Fanno Creeks. Summer flow is supplemented with releases of water from Scoggins Reservoir (Hagg Lake) on Scoggins Creek and from Barney Reservoir, located on the Trask River, which diverts water into the upper Tualatin River. Flow is also diverted from the Tualatin River to Oswego Lake in the lower portion of the river near river mile 6.7.

The subbasin supports a wide range of forest, agriculture and urban related activities. The urban area is apidly growing and includes the cities of Banks, Beaverton, Cornelius, Durham, Forest Grove, Gaston, Hillsboro, King City, Lake Oswego, portions of Portland, North Plains, Sherwood, Tigard, Tualatin, and West Linn. The urban area is served by four wastewater treatment plants (WWTPs), which are operated by the Unified Sewerage Agency (USA).

The Tualatin River is home to Winter Steelhead, Coho Salmon, and resident Cutthroat Trout. Winter Steelhead are currently listed as threatened by the National Marine Fishery Service under the Endangered Species Act. These fish are generally in decline in the subbasin and have been lost from some tributaries due to a variety of factors that also include changes in habitat and water quality. In addition, the Tualatin River is receiving increasing use for water contact recreation (e.g. canoeing, fishing, swimming) as the nearby population increases and access to the river through parks and boat ramps has increased.

The Tualatin River has experienced water quality problems over the years as human activity increased in the subbasin. The WWTPs in the subbasin were upgraded and were complying with their technology-based permits in the late 1970’s. Flow augmentation from Scoggins Dam (Hagg Lake) first occurred in June 1975. However, in the early 1980’s, it was clear that the Tualatin River was still experiencing water quality problems resulting from population growth in the subbasin. When technology-based controls are not sufficient to meet water quality standards and support the beneficial uses of a water body, the Federal Clean Water Act requires Total Maximum Daily Loads (TMDLs) to be developed for the pollutant(s) causing the impairment. In 1988, DEQ developed an ammonia TMDL to address problems with low dissolved oxygen (DO) and a total phosphorus TMDL to address problems with high pH and nuisance algal growth in the reservoir-like section of the Tualatin River.

The goal of the 1988 ammonia TMDL was to meet the DO criteria that are necessary to support the beneficial use of “resident fish and aquatic life.” The ammonia TMDL focused mainly on the discharge of the WWTPs, which were the major sources of ammonia to the river during the period between May to mid-November. After ammonia removal processes were added to the WWTPs, the levels of ammonia have dropped dramatically and DO has improved in the Tualatin River. In recent years, the water quality standard has been met for most of the year in the lower mainstem with the exception of a short period of time in September.

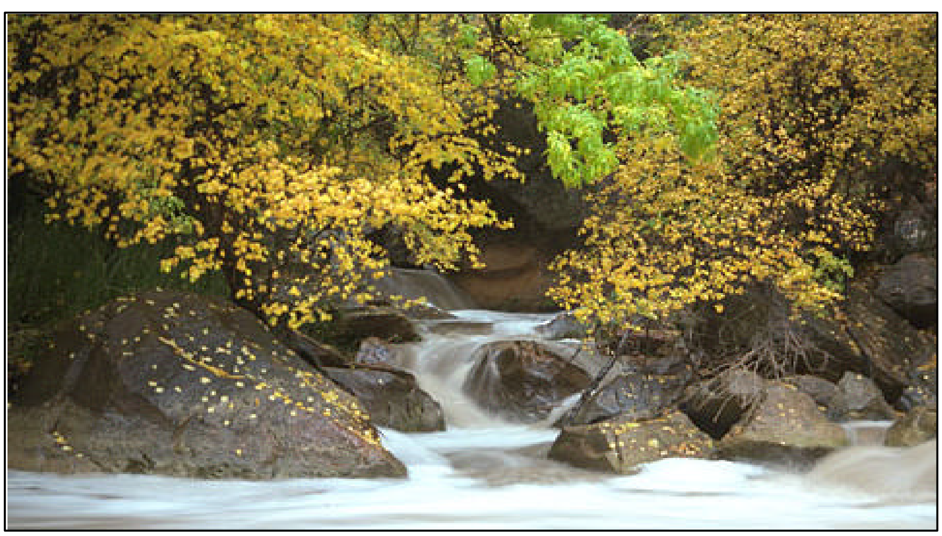
The goal of the 1988 total phosphorus TMDL was to reduce the nuisance algal growth and resultant high pH levels in the reservoir-like section of the Tualatin River. In addition, the goal was to reduce the phosphorus loading to Lake Oswego which also experiences nuisance algal growth and high pH levels. This was necessary to support the beneficial use of "resident fish and aquatic life" and "aesthetics." This TMDL had both a point source and non-point source component. The WWTPs upgraded their removal capacity of total phosphorus to meet the TMDL requirements. The Designated Management Agencies (DMAs), which include the Unified Sewerage Agency of Washington County, Clackamas County, Washington County, Multnomah County, City of Lake Oswego, City of West Linn, City of Portland, Oregon Department of Agriculture (ODA) and the Oregon Department of Forestry (ODF) are implementing best management practices (BMPs) to reduce the total phosphorus from non-point sources and urban runoff. The levels of total phosphorus have dropped dramatically in the Tualatin River since the WWTPs enhanced their total phosphorus removal capabilities. The BMPs, such as water quality facilities for storm water runoff, street sweeping and educational programs have been implemented and have been successful in reducing total phosphorus in the tributaries. As a result, in recent years, the peaks of the nuisance algal blooms have been reduced and pH values in the lower mainstem are being met. However, the tributaries and the mainstem are not fully achieving the total phosphorus limits set by the TMDL.

The Tualatin Basin Policy Advisory Committee (TBPAC) was appointed in April 1997 and met monthly from June 1997 through January 1998 to develop policy recommendations to DEQ on the Tualatin Subbasin TMDLs. Their focus was on the review of the existing TMDLs and the recommendations made by the Tualatin Basin Technical Advisory Committee that was formed earlier. The revisions proposed to the TMDLs at this time reflect many of the TBPAC recommendations – especially revising the load allocation to account for high background (groundwater) concentrations.

In 1996 and again in 1998, DEQ updated the Oregon 303(d) list based on revised EPA guidance. Additional waters in the Tualatin Subbasin were listed for temperature, bacteria, dissolved oxygen, pH, biological criteria, arsenic, iron, and manganese.

This document revises the TMDLs for phosphorus and ammonia and develops additional TMDLs for temperature, bacteria, and volatile solids.

The area covered by the Tualatin River Subbasin TMDLs corresponds to the fourth field hydrologic unit code (HUC) 17090010, which includes all lands that drain to the Tualatin River. The Tualatin River Subbasin drains urban, agricultural, and forested lands. These TMDLs are applicable to all areas and land uses in the Tualatin River Subbasin. The phosphorus TMDL is also applicable to the Oswego Lake Watershed.



2.2 TOTAL MAXIMUM DAILY LOADS

2.2.1 WHAT IS A TOTAL MAXIMUM DAILY LOAD (TMDL)

The quality of Oregon's streams, lakes, estuaries and groundwater is monitored by the Oregon Department of Environmental Quality (DEQ). This information is used to determine whether water quality standards are being violated and, consequently, whether the *beneficial uses* of the waters are *impaired*. *Beneficial uses* include fisheries, aquatic life, drinking water, recreation and irrigation. Specific State and Federal plans and regulations are used to determine if violations have occurred: these regulations include the *Federal Clean Water Act* of *1972* and its amendments 40 *Codified Federal Regulations* 131, and *Oregon's Administrative Rules* (OAR Chapter 340) and *Oregon's Revised Statutes* (ORS Chapter 468).

The term *water quality limited* is applied to streams, lakes and estuaries where required treatment processes are being used, but violations of State water quality standards occur. With a few exceptions, such as in cases where violations are due to natural causes, the State must establish *a Total Maximum Daily Load* or *TMDL* for any waterbody designated as *water quality limited*. A *TMDL* is the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards.

The total permissible pollutant load is allocated to point, non-point, background, and future sources of pollution. *Wasteload Allocations* are portions of the total load that are allotted to point sources of pollution, such as sewage treatment plants or industries. The *Wasteload Allocations* are used to establish effluent limits in discharge permits. *Load Allocations* are portions of the *Total Maximum Daily Load* that are attributed to either natural background sources, such as soils, or from non-point sources, such as urban, agriculture or forestry activities. *Allocations* can also be set aside in reserve for future uses. Simply stated, *allocations* are quantified measures that assure water quality standard compliance. The *TMDL* is the integration of all these developed *Wasteload* and *Load Allocations.*

2.2.1.1 ELEMENTS OF A TMDL

The U. S. Environmental Protection Agency (EPA) has the authority under the Clean Water Act to approve or disapprove TMDLs that states submit. When a TMDL is officially submitted by a state to EPA, EPA has 30 days to take action on the TMDL. In the case where EPA disapproves a TMDL, EPA would need to establish the TMDL within 30 days.

The required elements of a TMDL that must be submitted to EPA include:

1. A description of the geographic area to which the TMDL applies;
2. Specification of the applicable water quality standards;
3. An assessment of the problem, including the extent of deviation of ambient conditions from water quality standards;
4. Evaluation of seasonal variations
5. Identification of point sources and non-point sources;
6. Development of a loading capacity including those based on surrogate measures and including flow assumptions used in developing the TMDL;
7. Development of Waste Load Allocations for point sources and Load Allocations for non-point sources;
8. Development of a margin of safety.

2.2.1.2 TMDLS ADDRESSED IN THIS REPORT

This report contains TMDLs for the following parameters :

- **Temperature;**
- **Bacteria;**
- **Total Phosphorus;**
- **Ammonia;**
- **Volatile Solids.**

2.2.1.3 PARAMETERS ON 1998 303(D) LISTED IN THE TUALATIN SUBBASIN NOT BEING ADDRESSED BY A TMDL

The 303(d) List is intended to identify all waters not meeting water quality standards. EPA has interpreted that Total Maximum Daily Loads (TMDLs) are to be established only where a water body is water quality limited by a "pollutant."[2] In the case where the listings are for parameters such as for Habitat Modification or Flow Modification which are not pollutants[3], TMDLs would not need to be established and other approaches to address these concerns, such as through Management Plans, could be used to address these impairments. In the case of a Biological Criteria listing which could be due to either a pollutant (e.g. excessive temperature, low dissolved oxygen or sedimentation) or some form of pollution (flow or habitat modification), the likely cause for the Biological Criteria exceedance needs to be determined. If pollutants were the likely cause, a TMDL would need to be established. If some other form of pollution was involved, other appropriate measures could be used.

The 1998 303(d) list contains listings for waters in the Tualatin for low pH, Toxics (Arsenic, Iron and Manganese) and Biological Criteria for which DEQ is not submitting a TMDL. Detailed discussions regarding these parameters are provided in Appendices E, G and H respectively. A summary of the rationale for not developing TMDLs for these parameters follows:

Biological Criteria: Factors that were identified which affect fish assemblages include water quality, flow and habitat modification. TMDLs are being developed for temperature and dissolved oxygen throughout the subbasin which should address the water quality pollutants of concern and improve the water quality for the fish assemblages. Other factors such as habitat and flow improvements are not pollutants and a TMDL will not be developed. However, these factors will need to be addressed in management plans in order to have substantial improvements in the fish assemblages (See **Appendix H** for more detail).

Low pH: There are two stream segments within the Tualatin Subbasin that are on the 1998 303d list for low pH (less than 6.5 SU): Gales Creek (Clear Creek to Headwaters) and East Fork Dairy Creek (Mouth to Whiskey Creek). Upon closer examination of the data used to list Gales and East Fork Dairy Creeks on the 1998 303d list for pH, it appears that the data are questionable and that a TMDL should not be established for pH. It appears likely that improper calibration and/or maintenance of field pH meters, coupled with the difficulty of measuring pH in low ionic strength surface waters, resulted in erroneously low pH values (see **Appendix E** for more detail).

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[2] Section 303(d)(1)(C) states that "each State shall establish for the waters identified in paragraph (1)(A) of this subsection, and in accordance with the priority ranking, the total maximum daily load, for those pollutants which the Administrator identifies under section 304(a)(2) as suitable for such calculation.

[3] The term pollutant is defined in section 502(6) of the CWA and in the proposed 40 CFR 130.2(d) as follows: "The term "pollutant" means dredged spoil, solid waste, incinerator residue, sewage, garbage, sewage sludge, munitions, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and industrial, municipal, and agricultural waste discharged into water."

Toxics (arsenic, iron and manganese): Exceedances of water quality criteria for arsenic, iron and manganese are common throughout the Tualatin River Subbasin. It appears that arsenic, iron and manganese are mobilized in Tualatin River Subbasin groundwater due to their natural presence within local alluvial deposits and the predominance of reducing conditions within associated aquifers. Surface water concentrations of arsenic, iron, and manganese appear to be a reflection of the natural geo-chemical environment and regional groundwater hydrology within the Tualatin River Subbasin. The USGS concluded that regional patterns of arsenic occurrence in Tualatin River Subbasin ground water are not consistent with either industrial or agricultural sources of arsenic (see **Appendix G** for more detail).

2.3 TMDL IMPLEMENTATION

2.3.1 WATER QUALITY MANAGEMENT PLANS (WQMPS)

Implementation of TMDLs is critical to the attainment of water quality standards. The support of Designated Management Agencies (DMAs) in implementing TMDLs is essential. In instances where DEQ has no direct authority for implementation, DEQ works with DMAs on implementation to ensure attainment of water quality standards. The DMAs in the Tualatin River Subbasin include: Unified Sewerage Agency of Washington County, Clackamas County, Washington County, Multnomah County, City of Lake Oswego, City of West Linn, City of Portland, Oregon Department of Agriculture, Oregon Department of Forestry, and the Oregon Department of Transportation. These agencies have developed water quality management plans (WQMPs) to address phosphorus and ammonia loadings identified in the 1988 TMDLs and/or are operating under NPDES permits.[4]

DEQ intends to submit a TMDL WQMP to EPA concurrently with submission of TMDLs. Both the TMDLS and their associated WQMP will be submitted by DEQ to EPA as updates to the State's Water Quality Management Plan pursuant to 40 CFR 130.6. Such submissions will be a continuing update of the Continuing Planning Process (CPP).

The following are elements of the WQMPs that will be submitted to EPA:

1. **Condition assessment and problem description**
2. **Goals and objectives**
3. **Identification of responsible participants**
4. **Proposed management measures**
5. **Timeline for implementation**
6. **Reasonable assurance**
7. **Monitoring and evaluation**
8. **Public involvement**
9. **Costs and funding**
10. **Citation to legal authorities**

Appendix I contains the above elements for DMAs in the Tualatin River Subbasin and contains schedules for when permits and management plans will be updated.

[4] The exception is the Oregon Department of Transportation (ODOT). ODOT was not a designated management agency under the 1988 TMDLs.

2.3.2 IMPLEMENTATION AND ADAPTIVE MANAGEMENT ISSUES

The goal of the Clean Water Act and associated Oregon Administrative Rules is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where non-point sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

Total Maximum Daily Loads (TMDLs) are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met. DEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is also recognized that there is a varying level of uncertainty in the TMDLs depending on factors such as amount of data that is available and how well the processes listed above are understood. It is for this reason that the TMDLs have been established with a margin of safety. Subject to available resources, DEQ will review and, if necessary, modify TMDLs established for a subbasin on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDL are needed.

Water Quality Management Plans (WQMPs) are plans designed to reduce pollutant loads to meet TMDLs. DEQ recognizes that it may take some period of time—from several years to several decades--after full implementation before management practices identified in a WQMP become fully effective in reducing and controlling certain forms of pollution such as heat loads from lack of riparian vegetation. In addition, DEQ recognizes that technology for controlling some pollution sources such as nonpoint sources and stormwater is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established.

DEQ also recognizes that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought.

In this TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDL for some parameters. The purpose of the surrogates is not to bar or eliminate human access or activity in the subbasin or its riparian areas. It is the expectation, however, that WQMPs will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, WQMPs should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the wasteload allocation (CFR 122.44(d)(1)(vii)(B)). Similarly, the Department will work with nonpoint sources in developing management plans that are consistent in meeting the assumptions and requirements of the load allocations. These permits and plans will be developed/modified within 1-2 years following the develop/modification of a TMDL and include but not be limited to the following (February 2000 MOA between DEQ and EPA):

- Management measures tied to attainment of the TMDL,
- Timeline for implementation (including appropriate incremental measurable water quality targets and milestones for implementing control actions),
- Timeline for attainment of water quality standards including an explanation of how implementation is expected to result in the attainment of water quality standards,
- Monitoring and evaluation

If a source that is covered by this TMDL complies with its permit, WQMP or applicable forest practice rules, it will be considered in compliance with the TMDL.

DEQ intends to regularly review progress of WQMPs to achieve TMDLs. If and when DEQ determines that WQMP have been fully implemented, that all feasible management practices have reached maximum expected effectiveness and a TMDL or its interim targets have not been achieved, the Department shall reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance (OAR 340-41-026(3)(a)(D)(ii)).

The implementation of TMDLs and the associated management plans is generally enforceable by DEQ, other state agencies and local government. However, it is envisioned that sufficient initiative exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers and permit holders to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. In the case of nonpoint sources, this could occur first through direct intervention from land management agencies (e.g. ODF, ODA, counties and cities), and secondarily through DEQ. The latter may be based in departmental orders to implement management goals leading to water quality standards.

A zero waste load allocation does not necessarily mean that a point source is prohibited from discharging any wastes. A source may be permitted to discharge by DEQ if the holder can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when system temperature is achieved. Or, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source could be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

It is recognized that effluent trading may provide the possibility for regulated entities to achieve overall TMDL objectives in a more cost-effective manner. Regulated entities may pursue effluent trading to meet the allocations established in this document.

2.3.2.1 ADAPTIVE MANAGEMENT

In employing an adaptive management approach to this TMDL and WQMP, DEQ has the following expectations and intentions:

- Subject to available resources, DEQ will review and, if necessary, modify TMDLs and WQMPs established for a subbasin on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDL are needed.
- When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the wasteload allocation (CFR 122.44(d)(1)(vii)(B)).
- In conducting this review, DEQ will evaluate the progress towards achieving the TMDL (and water quality standards) and the success of implementing the WQMP.
- DEQ expects that each management agency will also monitor and document its progress in implementing the provisions of its component of the WQMP. This information will be provided to DEQ for its use in reviewing the TMDL.
- As implementation of the WQMP proceeds, DEQ expects that management agencies will develop benchmarks for attainment of TMDL surrogates, which can then be used to measure progress.
- Where implementation of the WQMP or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise the components of the WQMP to address these deficiencies.
- When DEQ, in consultation with the management agencies, concludes that all feasible steps have been taken to meet the TMDL and its associated surrogates and attainment of water quality standards, the TMDL, or the associated surrogates is not practicable, it will reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance (OAR 340-41-026(3)(a)(D)(ii)).

2.4 ORGANIZATION OF THIS REPORT

This report is structured to address the required elements of a TMDL for EPA approval. New TMDLs are being developed to address temperature, bacteria and dissolved oxygen problems found currently in the subbasin and to modify TMDLs that were developed to address dissolved oxygen, pH and chlorophyll a in the mainstem of the Tualatin. As such, report summarizes more detailed work, which can be found in the appendices. The following chapters summarize the TMDLs and provide the detail for the eight required elements of a TMDL listed above.

- Chapter 3 describes the geographic area of the Tualatin River Subbasin.
- Chapter 4 summarizes the other seven elements for each TMDL (temperature, bacteria, ammonia, total volatile solids and total phosphorus).
- Chapter 5 *describes* the reasonable assurance of implementation and provides an overview to the Water Quality Management Plans.

The appendices contain more detailed material - including analyses and references for each parameter.

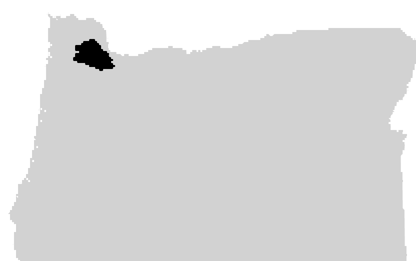
CHAPTER 3 - DESCRIPTION OF TUALATIN RIVER SUBBASIN

The area covered by the Tualatin River Subbasin TMDL corresponds to the fourth field hydrologic unit code (HUC) 17090010, which includes all lands that drain to the Tualatin River. In addition, the Lake Oswego drainage basin is included as water is withdrawn from the Tualatin and flows through Lake Oswego. These TMDLs are applicable to all areas and land uses in the Tualatin River Subbasin and the Lake Oswego drainage basin. (Please see Chapter 4 for details on which areas and streams are specifically addressed by each TMDL.)

3.1 GEOLOGY

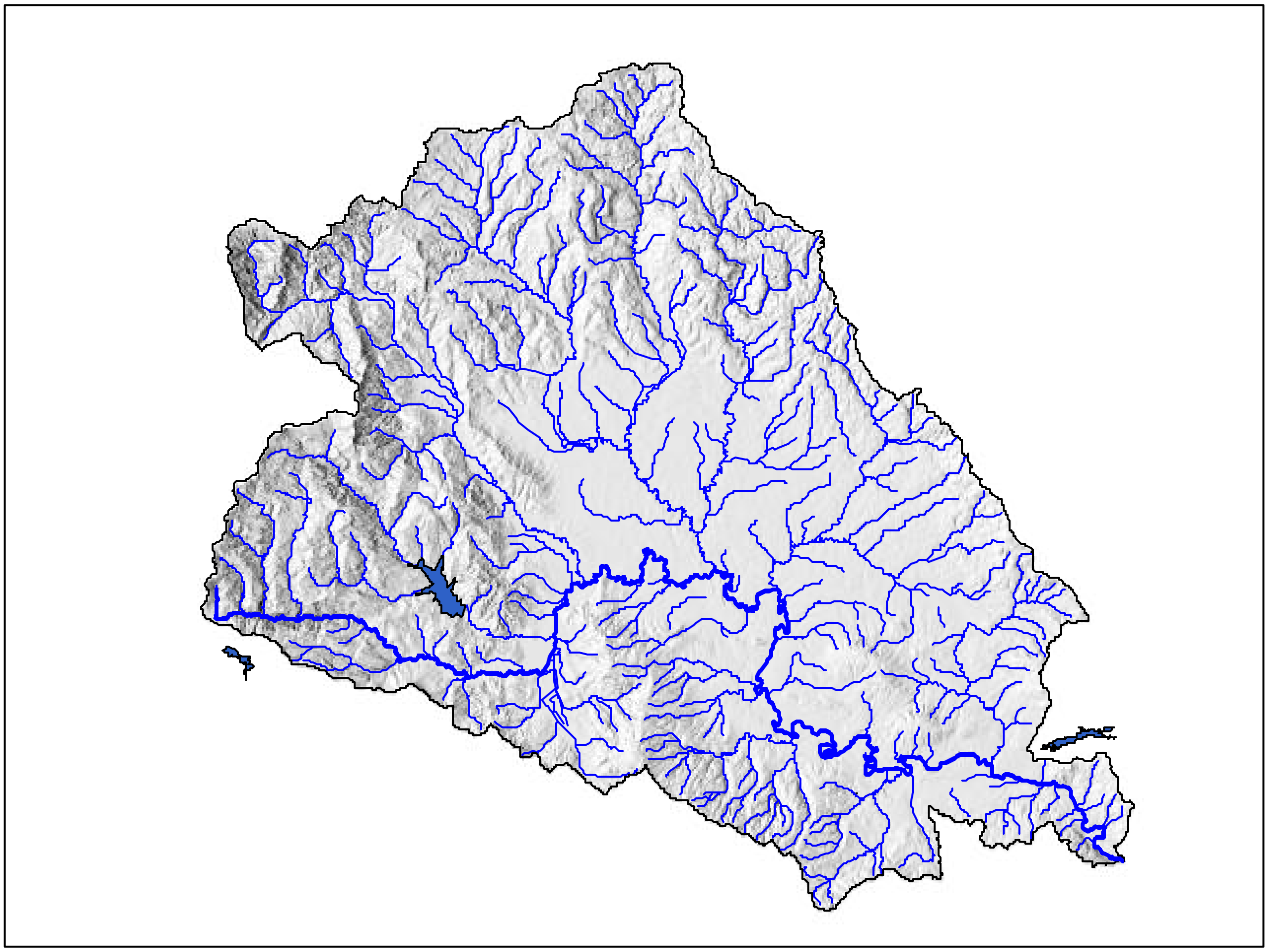
The Tualatin River Subbasin is in the northern part of Oregon occupying approximately 710 square miles and is situated west of the Portland metropolitan area. The Tualatin River is approximately 80 miles long, originating in the forested Coast Range mountains and flowing eastward to the Willamette River. Major tributaries include Gales Creek, Scoggins Creek (with Scoggins Reservior), Dairy Creek, Rock Creek (including Beaverton Creek) and Fanno Creek. Flow from the Tualatin River is diverted to Lake Oswego in the lower portion of the river near river mile 6.7.

Location of the Tualatin Subbasin in the State of Oregon



The Tualatin River headwaters predominately occur in the conifer forests of the Coastal Mountains at over 2,000 feet elevation (the highest point in the subbasin is 3,460 feet in elevation). All major tributaries flow through Willamette plains. The Tualatin mainstem enters the Willamette River at an elevation of 49 feet above sea level. This confluence occurs just upstream of Oregon City, Oregon (Willamette River mile 28.5). The hydrologic unit code for the Tualatin, classified accordingly as a 'SubBasin' or 4th field watershed, is 17090010 (USGS, 1989). Shaded relief topography is depicted in **Figure 1**. Most of the area, including the Coastal Mountain uplands, is gently sloping.

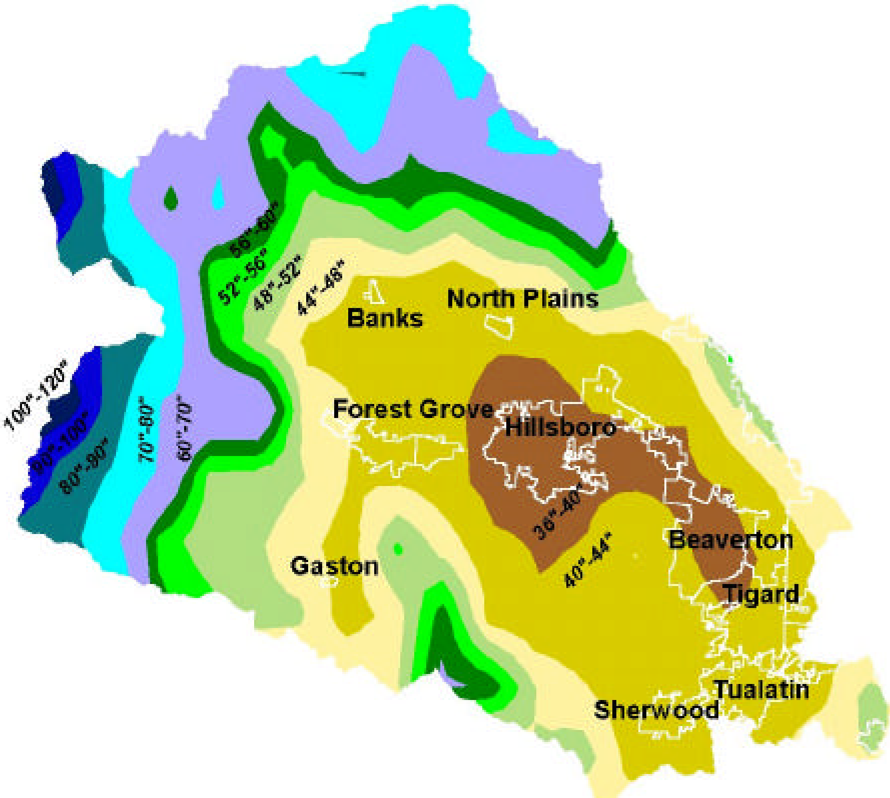
Figure 1. Illustration of Tualatin River Subbasin Shaded Relief Topography



3.2 CLIMATE

Mean winter air temperatures in the lower subbasin range from 32°F to 63°F (0°C to 17°C). Mean summertime (i.e. May through October) air temperatures range from 41°F to 82.5 °F (5°C to 28°C). Annual precipitation is extremely variable due to orographic effects (i.e. precipitation that is a function of elevation). Higher elevation annual precipitation can amount to 100-120 inches annually, largely received as rainfall. Lower elevations (Willamette Valley areas) receive 48 to 36 inches of rainfall annually. All of the Tualatin River Subbasin experiences a Mediterranean climate with prolonged winter rainfall and summer drought. **Figure 2** displays annual precipitation.

Figure 2. Tualatin Subbasin Precipitation (Oregon SSCGIS)



3.3 SEASONAL VARIATION

Low flows generally occur during the end of the summer months (July to October) due to decreased precipitation and increased agriculture water withdrawals. Attempts to augment summertime low flows balance the need for agriculture water withdrawals with dilution requirements for major point sources. Springhill Pump Station withdraws up to 183 cubic feet per second (cfs) from the Tualatin River at river mile 56.1. Scoggins reservoir augments the Tualatin River at river mile 62.8 via Scoggins Creek. Due to the limited storage capacity of Scoggins reservoir and the rather large withdrawals, low flows continue to pose a challenging problem in the Tualatin River Subbasin. A '7Q10' statistic has been calculated for tributary and mainstem gages.[*] **Figure 3 and Table 1** display the Tualatin River low flow statistics from Gaston (River Mile 63.9) to West Linn (River Mile 1.8).

[*] 7Q10 refers to a seven day averaged low flow condition that occurs on a ten-year return period. Mathematically, this low flow condition has a 10% probability of occurring every year. A Log Pearson Type III distribution was used to calculate the return period.

Figure 3. Tualatin River 7Q10 Low Flows (cfs)

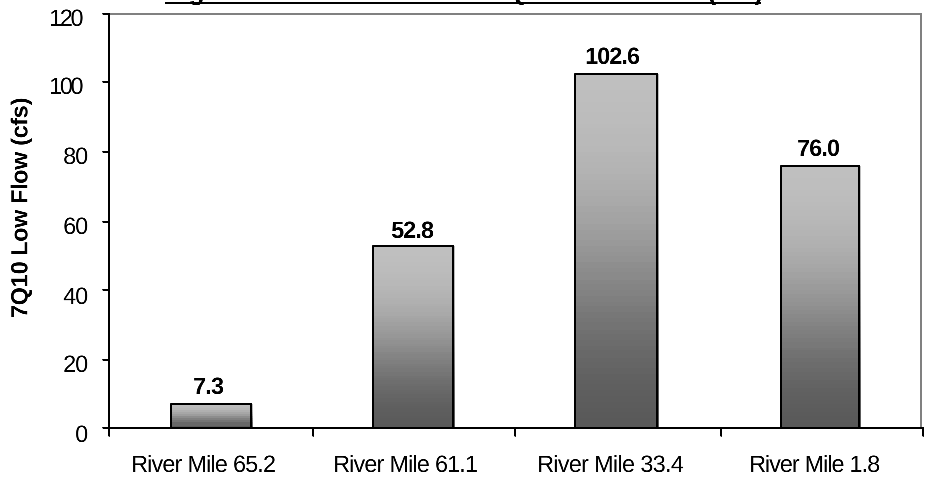


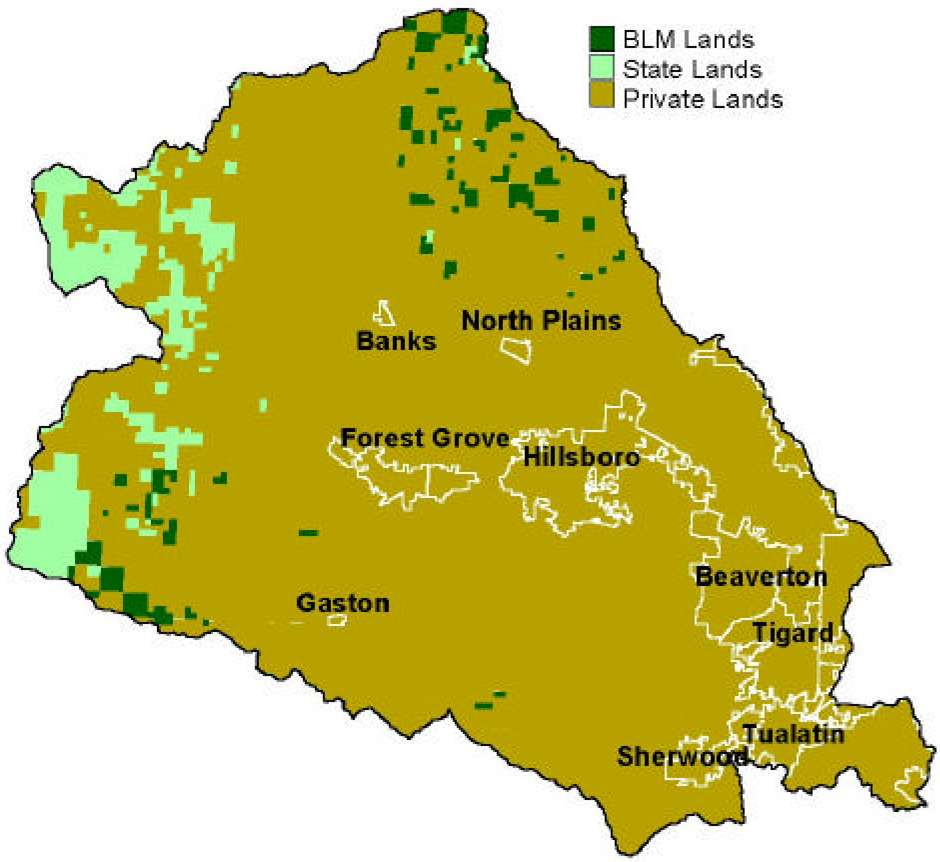
Table 1. Log Pearson Type III 7Q10 Low Flow				
Low Flow Averaged over 7 days with a Return Period of 10 Years				
	Location	**Period**	**River Mile**	**7Q10 Low Flows (cfs)**
Tualatin R.	Gaston	1977-1983	65.2	7.3
Tualatin R.	Dilley	1990-1996	61.1	52.8
Tualatin R.	Farmington Road	1990-1996	33.4	102.6
Tualatin R.	West Linn	1990-1996	1.8	76.0
Scoggins Cr.	D/S Hagg Lake	1990-1996	4.8	8.7
McKay Cr.	Cornelius	1971-1975	2.1	0.2
Fanno Cr.	56th Avenue	1990-1996	12.6	0.1
Fanno Cr.	Durham	1993-1995	1.2	1.9
Gales Cr.	Roderick Road	1970-1979	8.6	3.3
Bronson Cr.				No Data
Rock Cr.				No Data
Beaverton Cr.				No Data

3.4 LAND USE & OWNERSHIP

Land ownership is predominant private in the Tualatin River Subbasin, covering more than 93% percent of the total land area (i.e. 710 square miles). The State of Oregon manages 5% and the Bureau of Land Management (BLM) manages 2% of the land area, nearly all of which is forested. Spatial distributions of land ownership are displayed in **Figure 4**.

Land uses in the Tualatin River Subbasin are predominantly forestry and agriculture, 49% and 39% of the total surface area respectively. Twelve percent of the subbasin surface area is urban and rural residential. **Figure 5** shows the spatial distribution of major land use types.

Figure 4. Land Ownership/Management Spatial Distribution



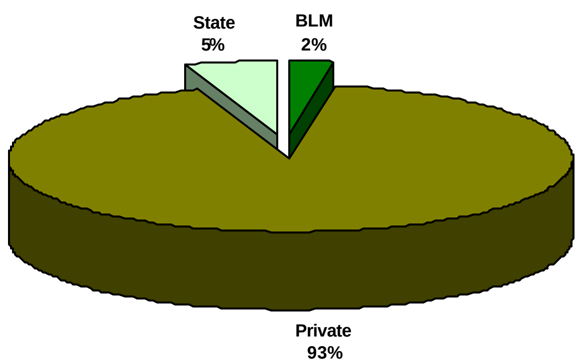
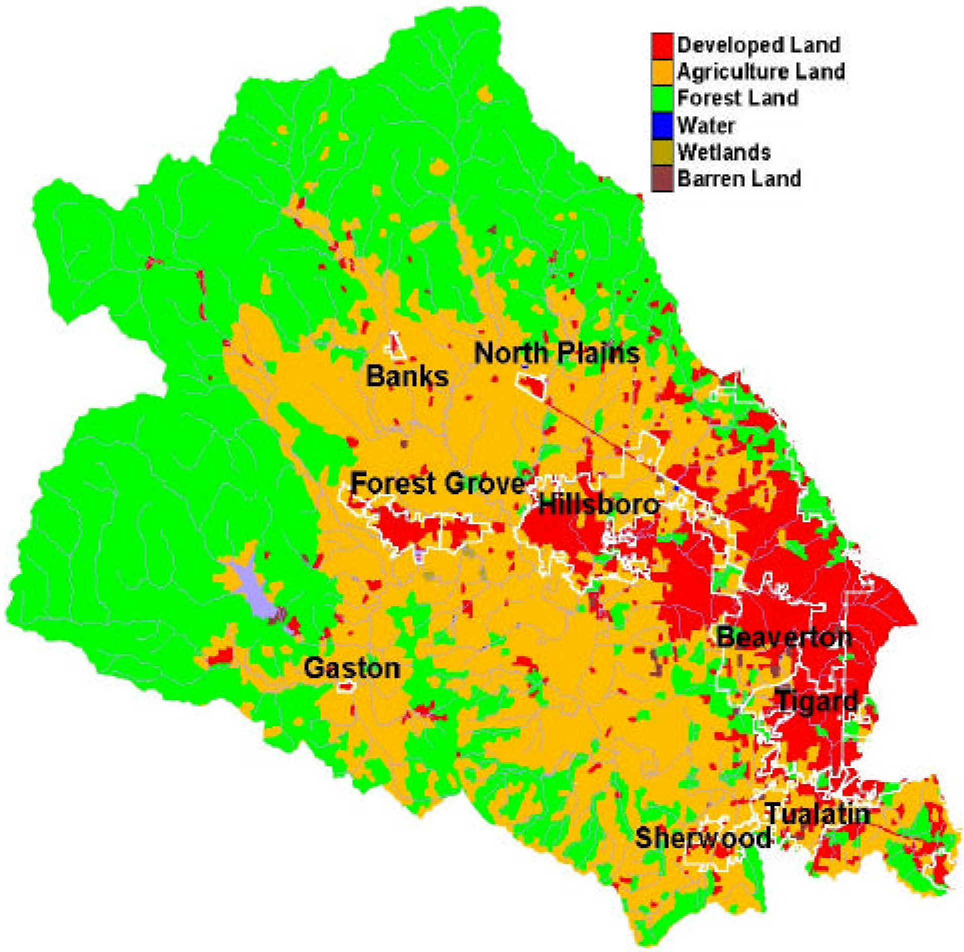
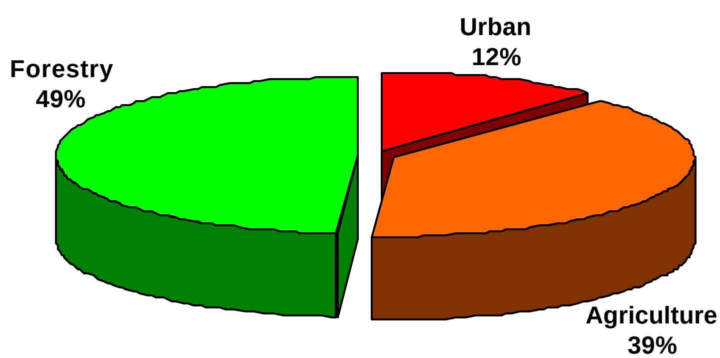


Figure 5.   Land Use Spatial Distribution





3.5 EXISTING WATER QUALITY PROGRAMS

OREGON FOREST PRACTICES ACT

The Oregon Forest Practices Act (FPA, 1994) contains regulatory provisions that include the objectives to classify and protect water resources, reduce the impacts of clearcut harvesting, maintain soil and site productivity, ensure successful reforestation, reduce forest management impacts to anadromous fish, conserve and protect water quality and maintain fish and wildlife habitat, develop cooperative monitoring agreements, foster public participation, identify stream restoration projects, recognize the value of bio-diversity and monitor/regulate the application of chemicals. Oregon's Department of Forestry (ODF) has adopted Forest Practice Administrative Rules (1997) that define allowable actions on State, County and private forestlands. Forest Practice Administrative Rules allow revisions and adjustments to the regulatory parameters it contains. Several revisions have been made in previous years and it is expected that the ODF, in conjunction with DEQ, will continue to monitor the success of the Forest Practice Administrative Rules and make appropriate revisions when necessary to address water quality concerns.

SENATE BILL 1010

Senate Bill 1010 allows the Oregon Department of Agriculture (ODA) to develop Water Quality Management Plans for agricultural lands where such actions are required by State or Federal Law, such as TMDL requirements. The Water Quality Management Plan should be crafted in such a way that landowners in the local area can prevent and control water pollution resulting from agricultural activities. Local stakeholders will be asked to take corrective action against identified problems such as soil erosion, nutrient transport to waterways and degraded riparian areas. It is ODA's intent to establish Water Quality Management Plans on a voluntary basis. However, Senate Bill 1010 allows ODA to use civil penalties when necessary to enforce against agriculture activity that is found to transgress parameters of an approved Water Quality Management Plan. ODA has expressed a desire to work with the local stakeholders and other State and Federal agencies to formulate and enforce approved Water Quality Management Plans.

OREGON PLAN

The State of Oregon has formed a partnership between Federal and State agencies, local groups and grassroots organizations, that recognizes the attributes of aquatic health and their connection to the health of salmon populations. The Oregon Plan considers the condition of salmon as a critical indicator of ecosystems (CSRI, 1997). The decline of salmon populations has been linked to impoverished ecosystem form and function. Clearly stated, the Oregon Plan has committed the State of Oregon to the following obligations: an ecosystem approach that requires consideration of the full range of attributes of aquatic health, focuses on reversing factors decline by meeting objectives that address these factors, develops adaptive management and a comprehensive monitoring strategy, and relies on citizens and constituent groups in all parts of the restoration process.

The intent of the Oregon Plan is to conserve and restore functional elements of the ecosystem that supports fish, wildlife and people. In essence, the Oregon Plan is different from the traditional agency approach, and instead, depends on sustaining a local-state-federal partnership. Specifically, the Oregon Plan is designed to build on existing State and Federal water quality programs, namely: Coastal Zone Non-point Pollution Control Programs, the Northwest Forest Plan, Oregon's Forest Practices Act, Oregon's Senate Bill 1010 and Oregon's Total Maximum Daily Load Program.

NORTHWEST FOREST PLAN

In response to environmental concerns and litigation related to timber harvest and other operations on Federal Lands, the United States Forest Service (USFS) and the Bureau of Land Management (BLM) commissioned the Forest Ecosystem Management Assessment Team (FEMAT) to formulate and assess the consequences of management options. The assessment emphasizes producing management alternatives that comply with existing laws and maintaining the highest contribution of economic and social well being. The "backbone" of ecosystem management is recognized as constructing a network of late-successional forests and an interim and long-term scheme that protects aquatic and associated riparian habitats adequate to provide for threatened species and at risk species. Biological objectives of the Northwest Forest Plan include assuring adequate habitat on Federal lands to aid the "recovery" of late-successional forest habitat-associated species listed as threatened under the Endangered Species Act and preventing species from being listed under the Endangered Species Act.

CHAPTER 4 –

TOTAL MAXIMUM DAILY LOADS

4.1 TEMPERATURE TMDL

Summary of Temperature TMDL Development and Approach

Water quality standards are developed to protect the most sensitive beneficial use. The temperature standard is designed to protect cold water fish (salmonids) as the most sensitive beneficial uses. Several numeric and narrative trigger conditions invoke the temperature standard. Numeric triggers are based on temperatures that protect various salmonid life stages. Narrative triggers specify conditions that deserve special attention, such as the presence of threatened and endangered cold water species. Dissolved oxygen violations are also a trigger for the temperature standard. The occurrence of one or more of the stream temperature trigger will invoke the standard.

Once invoked, the temperature standard specifies that *"no measurable surface water temperature increase resulting from anthropogenic activities is allowed"* (OAR 340-41-245(2)(b)(A)). A TMDL is to be developed for 303(d) listed waterbodies. For all temperature 303(d) listed waterbodies in the Tualatin River subbasin, the standard specifies a condition of no measurable anthropogenic related temperature increases. The temperature TMDL is scaled to the Tualatin River subbasin and includes all surface waters. Since stream temperature results from cumulative interactions between upstream and local sources, the TMDL considers all surface waters that affect the temperatures of 303(d) listed waterbodies. For example, the Tualatin River is 303(d) listed for temperature. To address this listing in the TMDL, the Tualatin River and all major tributaries are included in the TMDL analysis and TMDL targets.

The temperature standard specifies that "*no measurable surface water temperature increase resulting from anthropogenic activities is allowed*". An important step in the TMDL is to examine the anthropogenic contributions to stream heating. The pollutant is heat. Nonpoint source anthropogenic contributions of solar radiation heat loading results from varying levels of decreased stream surface shade throughout the subbasin. Decreased levels of stream shade are caused by near stream vegetation disturbance/removal. Point source contributions of heat result from warm water discharges into receiving waters.

The background solar radiation heat loading condition is estimated in the TMDL by simulating the heat loading that occurs when near stream vegetation is at system potential. For clarity, system potential, as defined in the TMDL, is the near stream vegetation condition that can grow and reproduce on a site, given elevation, soil properties, plant biology and hydrologic processes. (System potential does not consider management or land use as limiting factors.) In essence, system potential is the design condition used for TMDL analysis that meets the temperature standard:

- System potential <u>is</u> an estimate of a condition without anthropogenic activities that disturb/remove near stream vegetation.
- System potential <u>is not</u> an estimate of pre-settlement conditions. Although it is helpful to consider historic vegetation patterns, many areas have been altered to the point that the historic condition is no longer attainable given drastic changes in stream location and hydrology (channel armoring and wetland draining).

The Tualatin River temperature TMDL allocates heat loading to nonpoint sources (natural background and anthropogenic) and point sources. Allocated conditions are expressed as heat per unit time (kcal per day). Nonpoint and pint sources are expected to manage for no measurable surface water temperature increase. The nonpoint source heat allocation is translated to effective shade surrogate measures that linearly translates the nonpoint source solar radiation allocation. Effective shade surrogate measures provide site-specific targets for land managers. And, attainment of the surrogate measures ensures compliance with the nonpoint source allocations.

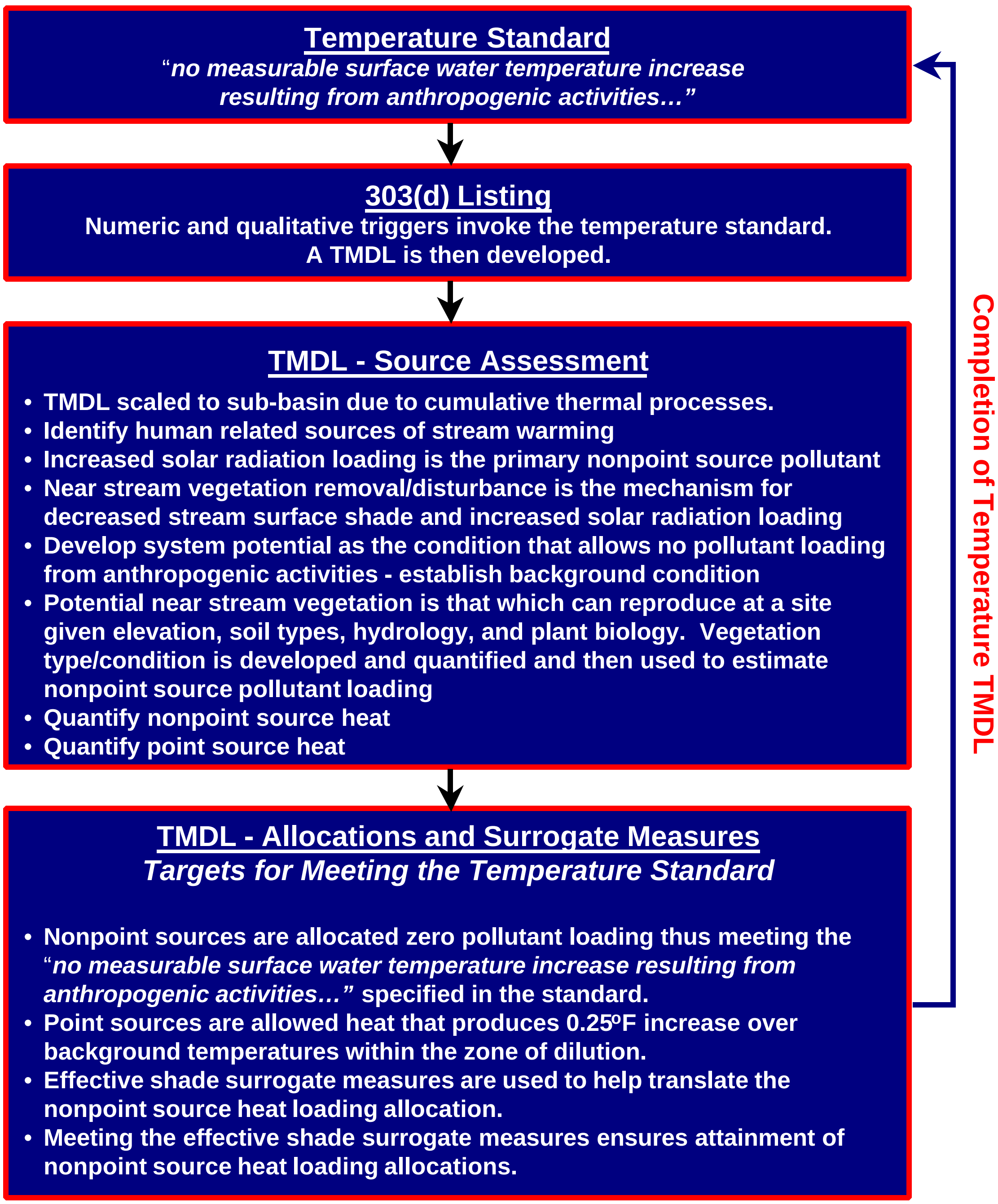


Table 2. Tualatin River Subbasin Temperature TMDL Components	
WATERBODIES	Perennial or fish bearing (as identified by ODFW, USFW or NFMS) streams within the 4th field HUC (hydrologic unit code) 17090010.
POLLUTANT IDENTIFICATION	*Pollutants:* Anthropogenic heat from (1) solar radiation loading and (2) warm water discharge to surface waters.
TARGET IDENTIFICATION (APPLICABLE WATER QUALITY STANDARDS) *CWA §303(D)(1)*	OAR 340-41-445(2)(b)(A) No measurable surface water temperature increase resulting from anthropogenic activities is allowed: In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64°F (17.8°C); In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation and fry emergence from the egg and from the gravels in a basin which exceeds 55°F (12.8°C); (vi) In waters determined by DEQ to be ecologically significant cold-water refugia; (vii) In stream segments containing federally listed Threatened and Endangered species if the increase will impair the biological integrity of the Threatened and Endangered population. (viii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin; (ix) In natural lakes.
EXISTING SOURCES *CWA §303(D)(1)*	Forestry, Agriculture, Transportation, Rural Residential, Urban, Industrial Discharge, Waste Water Treatment Facilities (NPS - 6,924,331,569 and PS - 923,486,036 kcal per day
SEASONAL VARIATION *CWA §303(D)(1)*	Peak temperatures occur throughout June, July, August, September, and October. Spawning occurs in the subbasin.
TMDL LOADING CAPACITY AND ALLOCATIONS *40 CFR 130.2(F)* *40 CFR 130.2(G)* *40 CFR 130.2(H)*	*Loading Capacity:* The water quality standard specifies a loading capacity based on the condition that meets the *no measurable surface water temperature increase resulting from anthropogenic activities.* Loading capacities in the Tualatin River Subbasin are the sum of (1) background solar radiation heat loading profiles for the mainstem Tualatin River and all major tributaries (expressed as kcal per day) based on potential near stream vegetation characteristics without anthropogenic disturbance and (2) allowable heat loads for NPDES permitted point sources based on the 0.25°F allowable temperature increase in the mixing zone. The heat loading capacity is 6,180,598,502 kcal/day. *Waste Load Allocations (Point Sources):* Maximum allowable heat loading based on system potential stream temperatures and facility design flow is 21,326,120 kcal per day for all permitted point sources. *Load Allocations (Non-Point Sources):* Maximum allowable heat loading associated with background solar radiation loading is 6,159,272,382 kcal per day.[5]
SURROGATE MEASURES *40 CFR 130.2(I)*	Translates Nonpoint Source Load Allocations • *Effective Shade targets translate the nonpoint source solar radiation loading capacity.*
MARGINS OF SAFETY *CWA §303(D)(1)*	*Margins of Safety* are demonstrated in critical condition assumptions and are inherent to methodology. No numeric margin of safety is developed.
WATER QUALITY STANDARD ATTAINMENT ANALYSIS *CWA §303(D)(1)*	• Analytical modeling of TMDL loading capacities demonstrates attainment water quality standards • The Temperature Management Plan will consist of Implementation Plans, Water Quality Management Plan (WQMP) and Facility Operation Plans that contain measures to attain load / wasteload allocations.

[5] These effluent temperatures and WLAs were based on calculating no measurable increase above system potential using the flows, temperatures and equations in Table 9 which shows loadings and effluent temperatures under one set of conditions. However as the permits are renewed, WLAs may be recalculated using the equations if flow rates or effluent temperatures differ. Also, a maximum allowable discharge temperature will be included that will ensure incipient lethal temperatures are not exceeded. Therefore, the maximum temperature allowed in the permit may be different from the values expressed here and will be determined at the time of permit renewal to determine no measurable increase above system potential using the equations in Table 9.

4.1.1 SALMONID THERMAL REQUIREMENTS

Salmonids, often referred to as cold water fish, and some amphibians are highly sensitive to temperature. In particular, Chinook salmon (*Oncorhynchus tshawytscha*) and bull trout (*Salvelinus confluentus*) are among the most temperature sensitive of the cold water fish species. Oregon's water temperature standard employs logic that relies on using these *indicator species,* which are the most sensitive. If temperatures are protective of *these indicator species*, other species will share in this level of protection.

If stream temperatures become too hot, fish die almost instantaneously due to denaturing of critical enzyme systems in their bodies (Hogan, 1970). The ultimate *instantaneous lethal limit* occurs in high temperature ranges (upper-90^{o}F). Such warm temperature extremes are rare in the Tualatin River Subbasin.

More common and widespread observed within the Tualatin River Subbasin, however, is the occurrence of temperatures in the mid-70^{o}F range (mid- to high-20^{o}C range). These temperatures cause death of cold-water fish species during exposure times lasting a few hours to one day. The exact temperature at which a cold water fish succumbs to such a thermal stress depends on the temperature that the fish is acclimated and on particular development life-stages. This cause of mortality, termed the *incipient lethal limit*, results from breakdown of physiological regulation of vital processes such as respiration and circulation (Heath and Hughes, 1973).

The most common and widespread cause of thermally induced fish mortality is attributed to interactive effects of decreased or lack of metabolic energy for feeding, growth or reproductive behavior, increased exposure to pathogens (viruses, bacteria and fungus), decreased food supply (impaired macroinvertebrate populations) and increased competition from warm water tolerant species. This mode of thermally induced mortality, termed indirect or *sub-lethal*, is more delayed, and occurs weeks to months after the onset of elevated temperatures (mid-60^{o}F to low-70^{o}F). **Table 3** summarizes the modes of cold water fish mortality.

Table 3. Modes of Thermally Induced Cold Water Fish Mortality
(Brett, 1952; Bell, 1986, Hokanson et al., 1977)

Modes of Thermally Induced Fish Mortality	Temperature Range	Time to Death
Instantaneous Lethal Limit – Denaturing of bodily enzyme systems	> 90^{o}F > 32^{o}C	Instantaneous
Incipient Lethal Limit – Breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation	70^{o}F - 77^{o}F 21^{o}C - 25^{o}C	Hours to Days
Sub-Lethal Limit – Conditions that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supply and increased competition from warm water tolerant species	64^{o}F - 74^{o}F 17.8^{o}C - 23^{o}C	Weeks to Months

4.1.2 POLLUTANT IDENTIFICATION

Heat originating from human increases in solar radiation loading and warm water discharge to surface waters.

With a few exceptions, such as in cases where violations are due to natural causes, the State must establish *a Total Maximum Daily Load* or *TMDL* for any waterbody designated on the 303 (d) list as violating water quality standards. A *TMDL* is the total amount of a pollutant (from all sources) that can enter a specific waterbody without violating the water quality standards

Water temperature change is an expression of heat energy exchange per unit volume:

$$\Delta Temperature \propto \frac{\Delta Heat \quad Energy}{Volume}$$

Anthropogenic heat sources are derived from solar radiation as increased levels of sunlight reach the stream surface, effluent discharges to surface waters and flow augmentation. The pollutants targeted in this TMDL are (1) heat from human caused increases in solar radiation loading to the stream network and (2) heat from warm water discharges of human origin.

4.1.3 TARGET IDENTIFICATION – CWA §303(D)(1)

4.1.3.1 SENSITIVE BENEFICIAL USE IDENTIFICATION

Salmonid fish spawning, incubation, fry emergence, and rearing are deemed the most temperature-sensitive beneficial uses within the Tualatin River Subbasin.

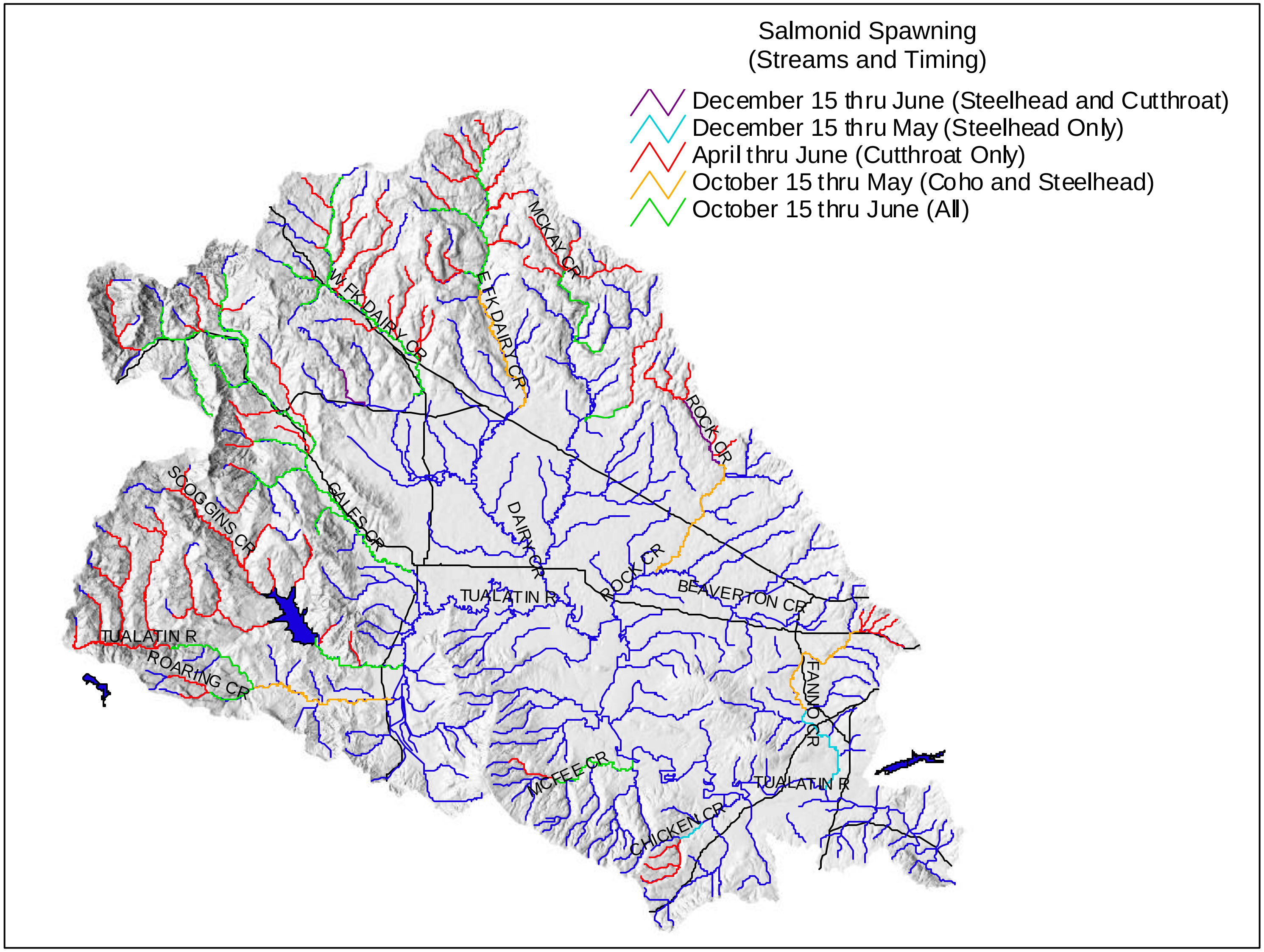
Beneficial uses and the associated water quality standards are generally applicable basin-wide (i.e. the Willamette Basin). Some uses require further delineation. At a minimum, uses are considered attainable wherever feasible or wherever attained historically. In applying standards and restoration, it is important to know where existing salmonid spawning locations are and where they are potentially attainable. Salmonid spawning and the quality of the spawning grounds are particularly sensitive to water quality and streambed conditions. **Figure 6** identifies the locations where salmonids are known to spawn in the Tualatin River Subbasin. Other sensitive uses (such as drinking water and water contact recreation) are applicable throughout the subbasin. Oregon Administrative Rules (OAR Chapter 340, Division 41, Section 443, Table 6) lists the "Beneficial Uses" occurring within the Tualatin River Subbasin (**Table 4**). Numeric and narrative water quality standards are designed to protect the most sensitive beneficial uses. Salmonid spawning and rearing are the most sensitive beneficial uses in the Tualatin River Subbasin.

Table 4. Beneficial uses occurring in the Tualatin River Subbasin

(OAR 340 – 41 – 442)
Temperature-Sensitive Beneficial uses are marked in gray

Beneficial Use	***Occurring***	***Beneficial Use***	***Occurring***
Public Domestic Water Supply	✓	Salmonid Fish Spawning (Trout)	✓
Private Domestic Water Supply	✓	Salmonid Fish Rearing (Trout)	✓
Industrial Water Supply	✓	Resident Fish and Aquatic Life	✓
Irrigation	✓	Anadromous Fish Passage	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Hydro Power		Water Contact Recreation	✓
Aesthetic Quality	✓		

Figure 6. Salmonid spawning areas based on known occurrence (ODFW)



4.1.3.2 WATER QUALITY STANDARD IDENTIFICATION

*The temperature standard applicable to the Tualatin River Subbasin mandates that **no measurable surface water increase resulting from anthropogenic activities is allowed**.*

Tualatin Subbasin Temperature Standard

OAR 340-41-445(2)(b)(A) No measurable surface water temperature increase resulting from anthropogenic activities is allowed:

(i) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64^{o}F (17.8^{o}C);

(iv) In waters and periods of the year determined by the Department to support native salmonid spawning, egg incubation and fry emergence from the egg and from the gravels in a basin which exceeds 55^{o}F (12.8^{o}C);

(vi) In waters determined by the Department to be ecologically significant cold-water refugia*;

(vii) In stream segments containing federally listed Threatened and Endangered species if the increase will impair the biological integrity of the Threatened and Endangered population.

(viii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10% saturation of the water column or intergravel DO criterion for a given stream reach or subbasin;

(ix) In natural lakes.

DEVIATION FROM WATER QUALITY STANDARD

Section 303(d) of the Federal Clean Water Act (1972) requires that water bodies that violate water quality standards, thereby failing to fully protect *beneficial uses*, be identified and placed on a 303(d) list. Nineteen stream segments in the Tualatin River Subbasin have been put on the 1998 303(d) list for water temperature violations (**Table 5 and Figure 7**). All segments were listed based upon the 64^{o}F rearing criteria. For specific information regarding Oregon's 303(d) listing procedures, and to obtain more information regarding the Tualatin River subbasin's 303(d) listed streams, visit the Department of Environmental Quality's web page at **http://www.deq.state.or.us/** .

* Ecologically Significant Cold-Water Refugia exists when all or a portion of a waterbody supports stenotype cold-water species (flora or fauna) not otherwise supported in the sub-basin, and either: (a) maintains cold water temperatures (below numeric criterion) throughout the year relative to other stream segments throughout the sub-basin, or (b) supplies cold water to a receiving stream or downstream reach that supports cold water biota.

Figure 7. 1998 303(d) List for Temperature (Bolded/Red Lines)

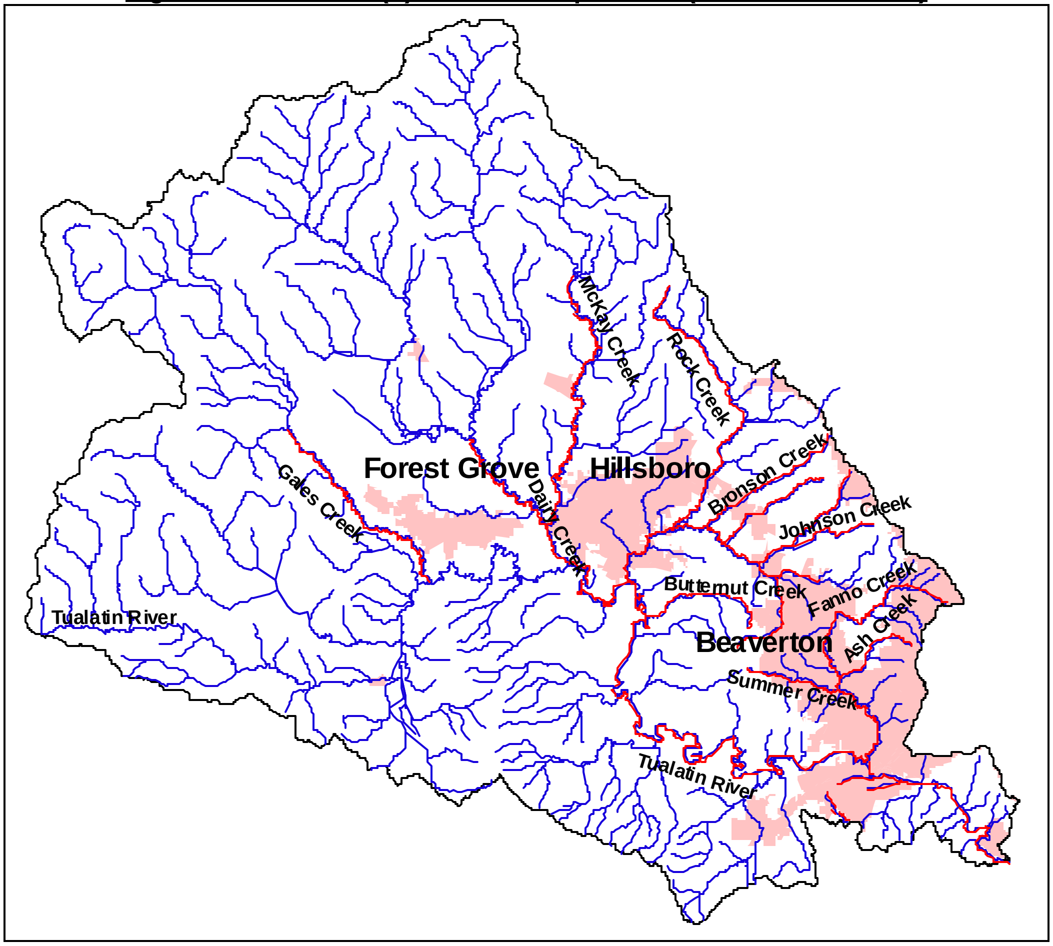


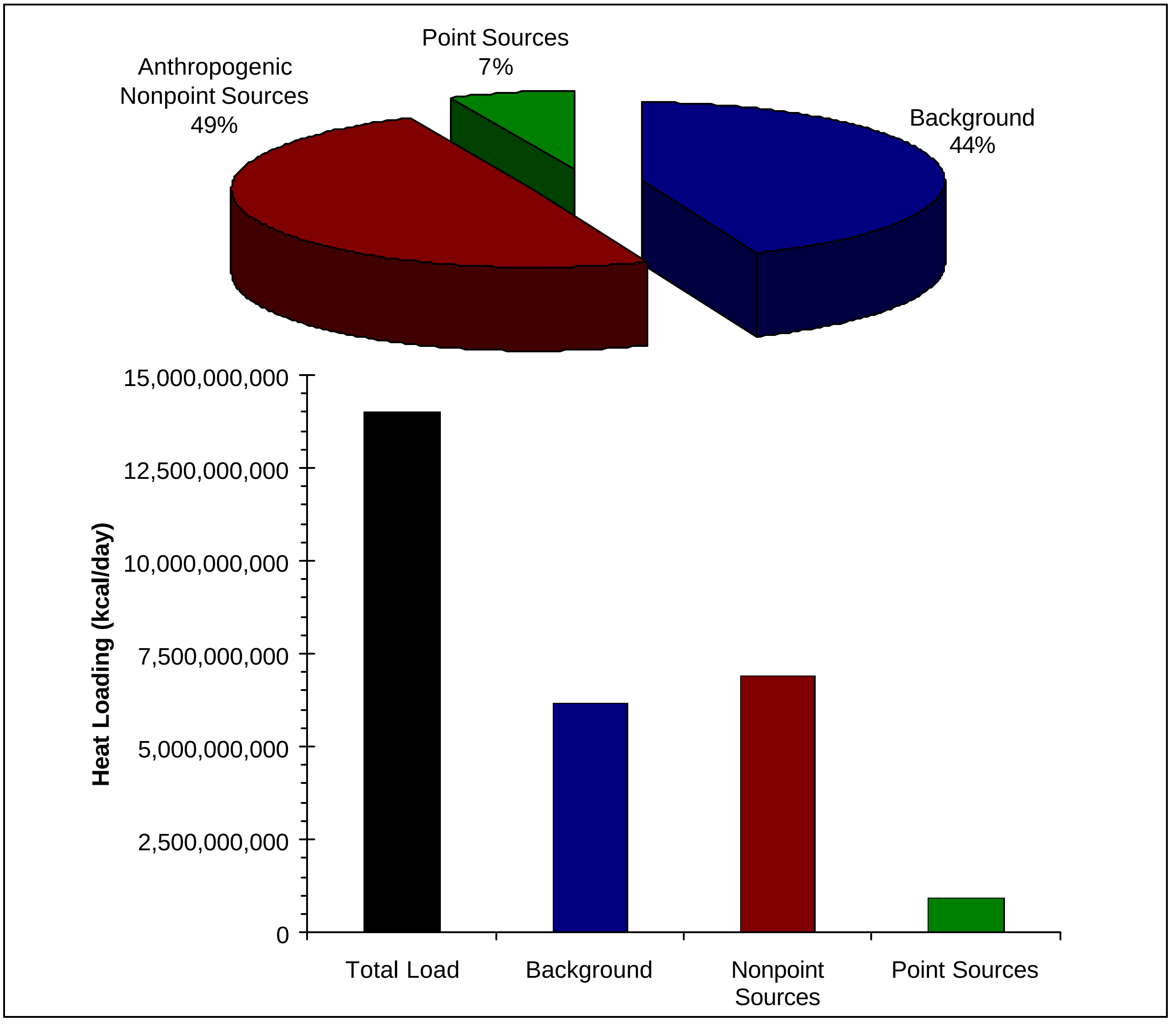
Table 5. Tualatin River Subbasin Stream Segments on the 1998 303(d) List for Temperature	
Stream Name	**Stream Segment Listed**
Ash Creek	Mouth to Headwaters
Beaverton Creek	Mouth to Headwaters
Bronson Creek	Mouth to Headwaters
Butternut Creek	Mouth to Headwaters
Cedar Mill Creek	Mouth to Headwaters
Dairy Creek	Mouth to East/West Forks
Dairy Creek, East Fork	Mouth to Whisky Creek
Dairy Creek, West Fork	Mouth to Headwaters
Fanno Creek	Mouth to Headwaters
Gales Creek	Mouth to Clear Creek
Hedges Creek	Mouth to Headwaters
Johnson Creek - North (Cedar Mill Creek)	Mouth to Headwaters
Johnson Creek - South (Beaverton Creek)	Mouth to Headwaters
McKay Creek	Mouth to East Fork McKay Creek
Nyberg Creek	Mouth to Headwaters
Rock Creek	Mouth to Headwaters
Summer Creek	Mouth to Headwaters
Tualatin River	Mouth to Dairy Creek
Willow Creek	Mouth to Headwaters

4.1.4 EXISTING HEAT SOURCES - CWA *§303(D)(1)*

The largest source of heat loading is from nonpoint sources. Anthropogenic nonpoint source heat loading is the dominant pollutant source. NPDES point source heat loading is relatively small.

Heat loading was calculated for both nonpoint and point sources. Of the total heat loading that occurs during the summertime critical condition, 44% is attributed to natural background, 49% is from anthropogenic nonpoint sources and 7% is derived from point sources.

Figure 8. Distribution of Current Condition Heat Loading



4.1.4.1 NONPOINT SOURCES OF HEAT

Elevated summertime stream temperatures attributed to nonpoint sources result from increased solar radiation heat loading. Near stream vegetation disturbance/removal has reduced levels of stream shading and exposed streams to higher levels of solar radiation (i.e. reduction in stream surface shading via decreased riparian vegetation height, width and/or density increases the amount of solar radiation reaching the stream surface). Anthropogenic nonpoint source contributions account for 52% of the total heat loading. The heat loading analysis is discussed in detail within ***Appendix A****.*

Settlement of the Tualatin River Subbasin in the mid-1800s brought about changes in the near stream vegetation and hydrologic characteristics of the Tualatin River. Historically, agricultural and logging practices have altered the stream morphology and hydrology and decreased the amount of riparian vegetation in the subbasin. More recently, dramatic increases in population have resulted in urbanization of the watershed. The subbasin includes urban, agricultural, and forested lands, with a growing population of over 300,000. Parts of the Tualatin River and many tributaries now flow through or under housing developments, shopping centers, industrial complexes, industrial forests, pastures and agricultural croplands. Due to both agricultural practices and the effects of urbanization, many streams in the lower watershed have undergone extensive channelization for drainage and flood control. Channel straightening, while providing relief from local flooding, increases flooding downstream and may result in the destruction of riparian vegetation and increased channel erosion.

Riparian vegetation, stream morphology, hydrology, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology and hydrology are affected by land use activities.

The term “ecoregion” is generally understood to describe regions of relative homogeneity in ecological systems or in relationships between organisms and their environments (Omernik and Gallant 1986).[+] Ecoregions are delineated on the premise that ecological regions can be identified through the analysis of the patterns and composition of biotic and abiotic components, such as soil composition, vegetation, climate and topography. Simply, areas within a specific ecoregion are likely to share a common set of ecological characteristics with respect to vegetation, climate and topography. The purpose of ecoregions is to provide a spatial map for research assessment, management, and monitoring of ecosystems and their components.

Currently, there are four levels of ecoregions in the United States, with level I being the coarsest and level IV being the most detailed. **Figure 9** shows a map of the level IV ecoregions within the Tualatin River Subbasin and **Table 6** provides a short narrative describing the terrain and near stream vegetation typical of the respective ecoregions.

[+] Ecoregions are a map of aquatic and terrestrial resources developed to group regional patterns and realistically attainable resources. Ecoregion groupings are based on factors including land use, land surface form, potential natural vegetation, and soils.

Figure 9. Ecoregions in the Tualatin River Subbasin (Omernik, 1986)

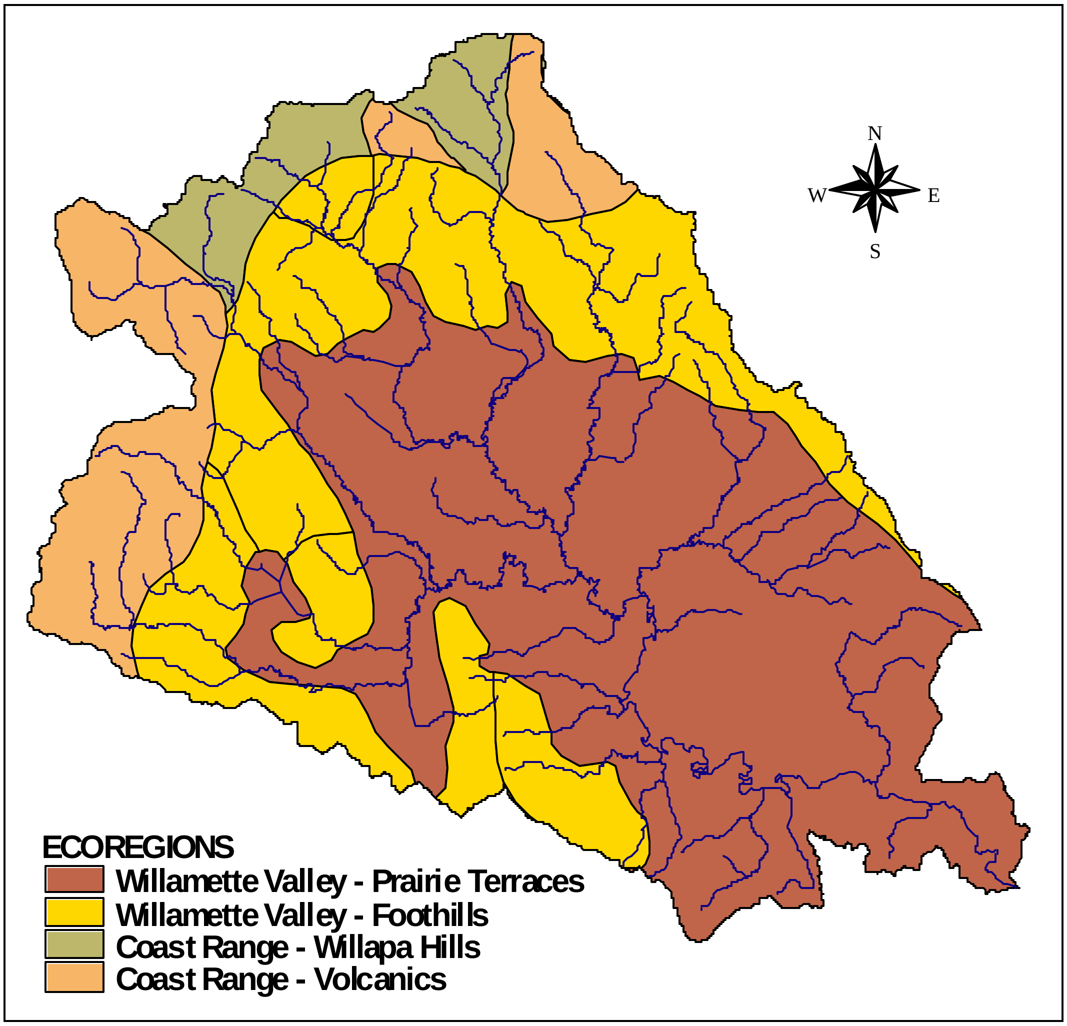


Table 6. Tualatin River Subbasin Ecoregions (Pater 1998 and Hawksworth 1999a)

Level III ecoregion	Level IV ecoregion	Terrain	Potential Overstory Near Stream Vegetation Characteristics: Historic Condition	Vegetation	Height	Assumed Overhang	Assumed Canopy Density
Coast Range	Willapa Hills	Low hills and mountains with moderate gradient streams and rivers. Elevation 500-2300 feet.	Western hemlock, Western red cedar, and Douglas fir forest.	Western hemlock Western red cedar Douglas fir Red alder Big leaf maple **Composite Dimension**	120 feet 120 feet 160 feet 100 feet 90 feet **118 feet**	12% of Height **14 feet**	**90%**
Coast Range	Volcanics	Steeply sloping mountains with moderate to high gradient streams. Elevation 400-2200 feet.	Historically Western hemlock, Western red cedar, and Douglas fir forest. Forests are intensively managed.	Western hemlock Western red cedar Douglas fir Red alder Big leaf maple **Composite Dimension**	120 feet 120 feet 160 feet 100 feet 90 feet **118 feet**	12% of Height **14 feet**	**90%**
Willamette Valley	Prairie Terraces	Undulating hills amid almost level terrain. Sluggish low gradient streams and rivers. Mountains. Dissected by low-gradient, meandering streams and rivers. Elevation 115-200 feet.	Oregon ash and Douglas fir occurred in wetter areas. Prairie and oak woodlands in dryer areas. Today extensively developed for agriculture and urban/rural residential development.	Oregon ash Western red cedar Douglas fir Red alder Big leaf maple **Composite Dimension**	75 feet 120 feet 160 feet 100 feet 90 feet **109 feet**	12% of Height **13 feet**	**90%**
Willamette Valley	Valley Foothills	Rolling hills mark the transitional zone between the Willamette Valley and the Coast Range. Elevation 200-1800 feet.	Oregon white oak in dryer areas and Douglas fir in wetter areas were originally dominant. Today rural residential development, tree farms, pastureland, and some urbanization are common.	Oregon white oak Douglas fir Red alder Big leaf maple **Composite Dimension**	60 feet 160 feet 100 feet 90 feet **102 feet**	12% of Height **12 feet**	**90%**

The total nonpoint source solar radiation heat load was derived for the Tualatin River and major tributaries. Current solar radiation loading was calculated by simulating current stream and vegetation conditions (the methodology is presented in detail in **Appendix A**). Background loading was calculated by simulating the solar radiation heat loading that resulted with system potential near stream vegetation. This background condition, based on system potential, reflects an estimate of nonpoint source heat load that would occur while meeting the temperature standard (i.e. ***no measurable surface water increase resulting from anthropogenic activities is allowed***). The relationship below were used to determine solar radiation heat loads for the current condition, anthropogenic contributions and loading capacity derivations based on system potential.

Total Solar Radiation Heat Load from All Nonpoint Sources,

$$H_{Total\ NPS} = H_{SP\ NPS} + H_{Anthro\ NPS} = \Phi_{Total\ Solar} \cdot A$$

Solar Radiation Heat Load from Background Nonpoint Sources (System Potential),

$$H_{SP\ NPS} = \Phi_{SP\ Solar} \cdot A$$

Solar Radiation Heat Load from Anthropogenic Nonpoint Sources,

$$H_{Anthro\ NPS} = H_{Total\ NPS} - H_{SP\ NPS}$$

**All solar radiation loads are the clear sky received loads that account for Julian time, elevation, atmospheric attenuation and scattering, stream aspect, topographic shading, near stream vegetation stream surface reflection, water column absorption and stream bed absorption.*

where,

$H_{Total\ NPS}$: Total Nonpoint Source Heat Load (kcal/day)
$H_{SP\ NPS}$: Background Nonpoint Source Heat Load based on System Potential (kcal/day)
$H_{Anthro\ NPS}$: Anthropogenic Nonpoint Source Heat Load (kcal/day)
$\Phi_{Total\ Solar}$: Total Daily Solar Radiation Load (ly/day)
$\Phi_{SP\ Solar}$: Background Daily Solar Radiation Load based on System Potential (ly/day)
$\Phi_{Anthro\ Solar}$: Anthropogenic Daily Solar Radiation Load (ly/day)
A: Stream Surface Area - calculated at each 100 foot stream segment node (cm^2)

Table 7. Nonpoint Source Solar Radiation Heat Loading - Current Condition with Background (Loading Capacity) and Anthropogenic Contributions

Stream	$H_{Total\ NPS}$ **Current Condition** Solar Radiation Heat Loading (kcal/day)	$H_{SP\ NPS}$ **Background** System Potential Solar Radiation Heat Loading[6] (kcal/day)	$H_{Anthro\ NPS}$ **Anthropogenic** Nonpoint Source Solar Radiation Heat Loading (kcal/day)	Portion of Current Solar Radiation Load from Anthropogenic Nonpoint Sources
Tualatin R.	$1.0 \cdot 10^{10}$	$5.6 \cdot 10^{9}$	$4.4 \cdot 10^{9}$	43.7%
Gales Cr.	$1.1 \cdot 10^{9}$	$1.8 \cdot 10^{8}$	$8.8 \cdot 10^{8}$	82.9%
WF Dairy Cr.	$3.5 \cdot 10^{8}$	$2.2 \cdot 10^{7}$	$3.3 \cdot 10^{8}$	93.8%
EF Dairy Cr.	$6.9 \cdot 10^{8}$	$1.1 \cdot 10^{8}$	$5.8 \cdot 10^{8}$	84.6%
Dairy Cr.	$4.3 \cdot 10^{8}$	$8.1 \cdot 10^{8}$	$3.5 \cdot 10^{8}$	81.2%
McKay Cr.	$2.8 \cdot 10^{8}$	$3.8 \cdot 10^{7}$	$2.4 \cdot 10^{8}$	86.4%
Rock Cr.	$4.5 \cdot 10^{7}$	$2.2 \cdot 10^{7}$	$2.3 \cdot 10^{7}$	51.4%
Beaverton Cr.	$1.1 \cdot 10^{8}$	$4.3 \cdot 10^{7}$	$6.6 \cdot 10^{7}$	60.6%
Fanno Cr.	$1.2 \cdot 10^{8}$	$3.8 \cdot 10^{7}$	$8.3 \cdot 10^{7}$	68.5%
Total	$1.3 \cdot 10^{10}$	$6.2 \cdot 10^{9}$	$6.9 \cdot 10^{9}$	52.9%

[6] Background solar radiation heat loading is based on effective shade resulting from system potential near stream vegetation.

Figures10 contrasts the longitudinal profile of the current solar radiation heat loading with the solar radiation heat loading that occurs with system potential overstory near stream vegetation appropriate for each ecoregion (ecoregions are listed in **Table 6**). **The solar radiation heat load calculated for system potential near stream vegetation is considered the background condition with anthropogenic sources removed.** **Figure 11** displays the total solar radiation heat loading associated with each major drainage, as well as, the portion of the load that is derived from background system potential sources. The anthropogenic portion of the total current condition solar radiation heat load is given as a percentage in **Figure 12**.

Figure 10. Solar Radiation Loading - Current Condition and Background - System Potential Conditions

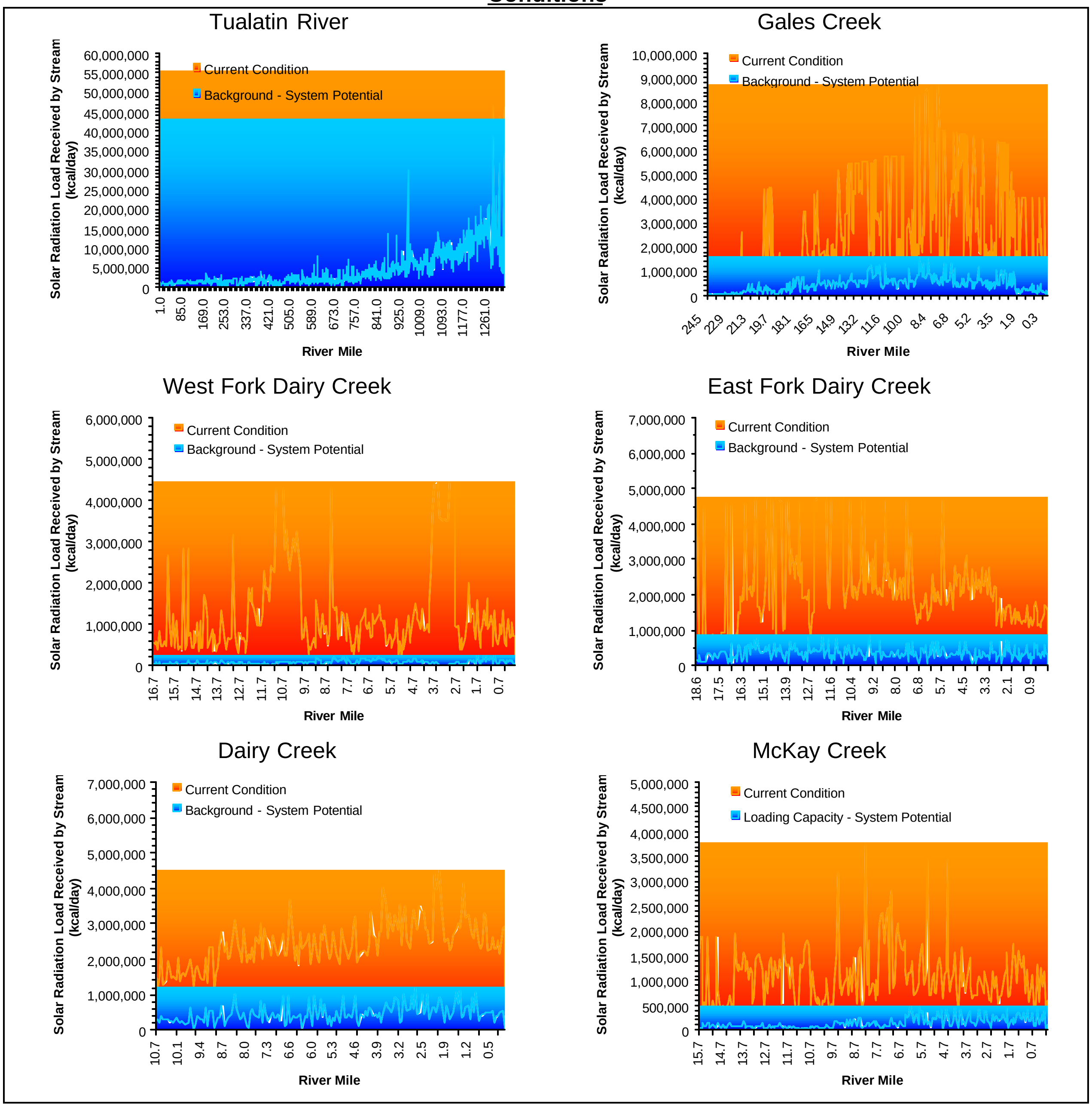


Figure 10 (continued). Solar Radiation Loading - Current Condition and Background - System Potential Conditions

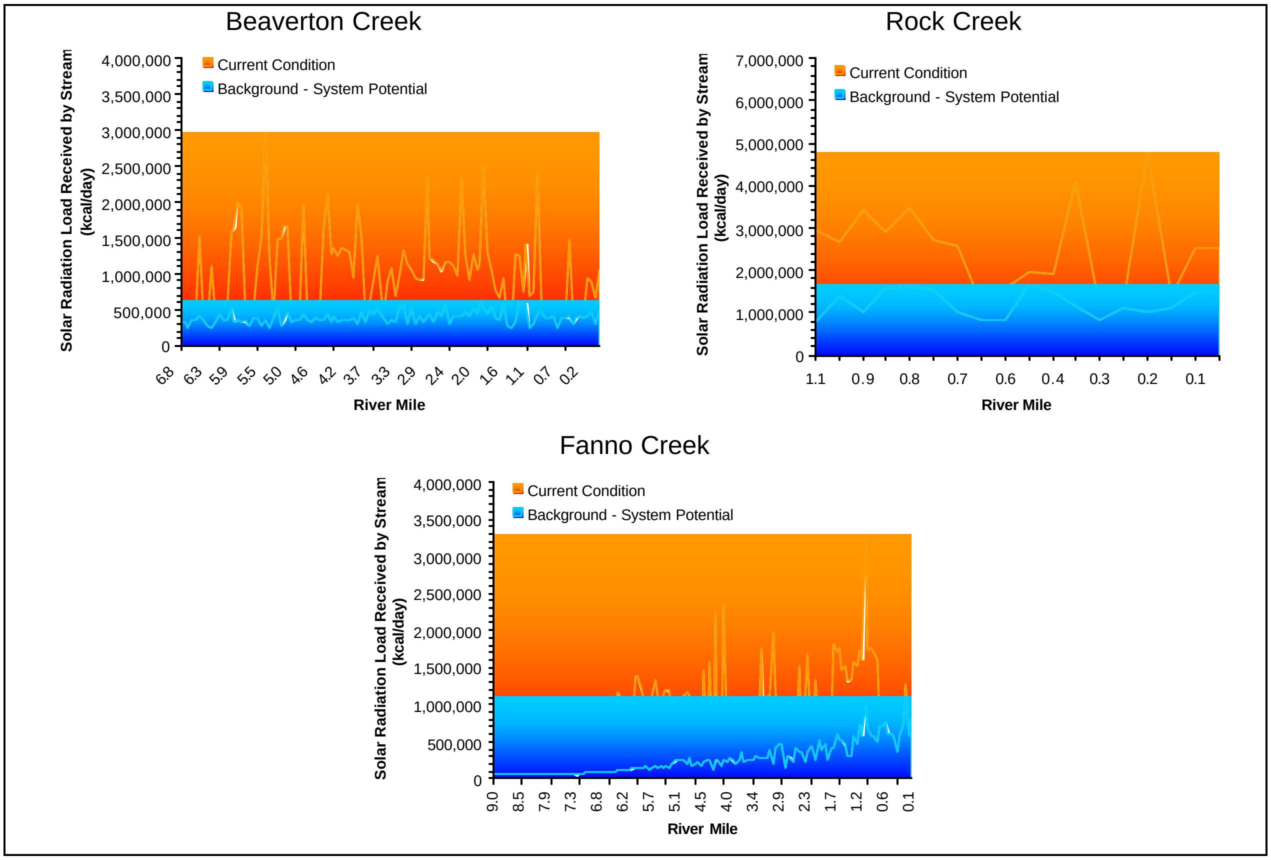


Figure 11. Nonpoint Sources of Solar Radiation Heat Loading by Drainage

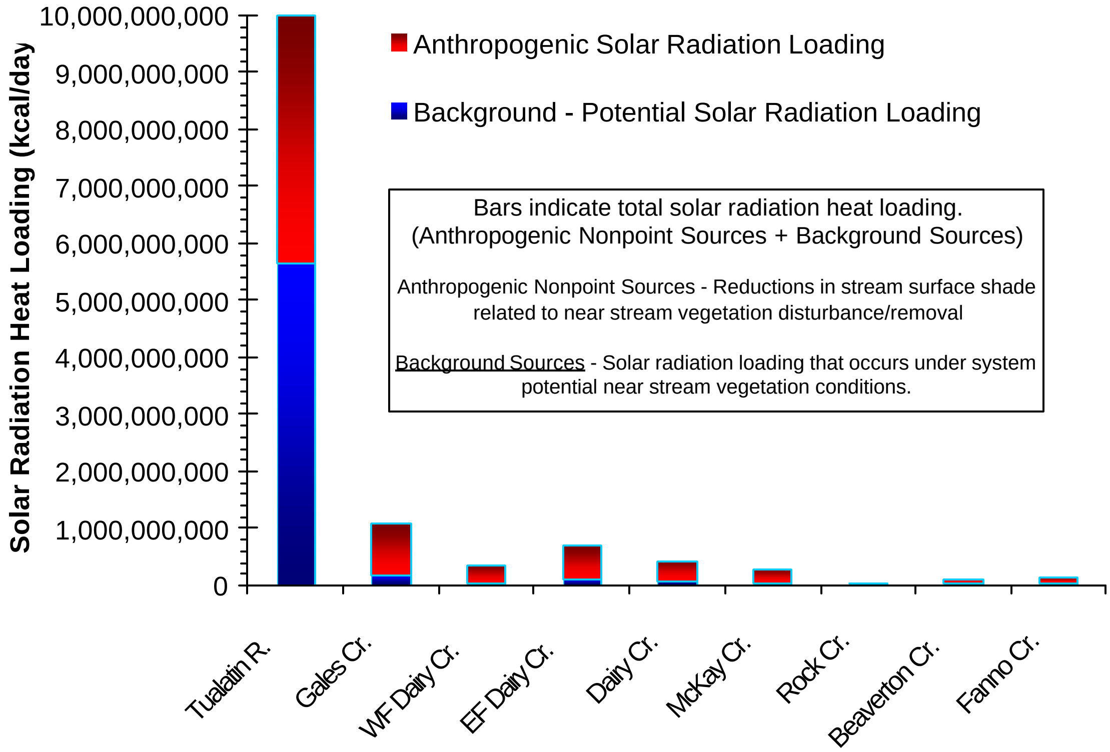
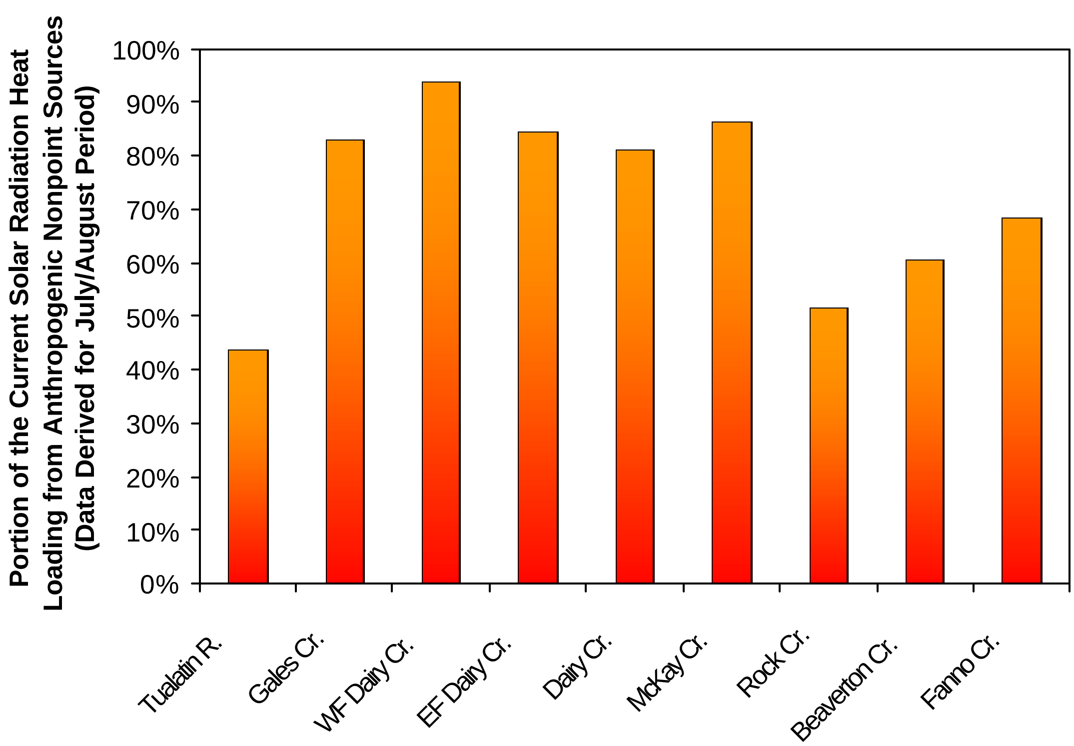


Figure 12. Portion of Current Solar Radiation Load from Anthropogenic Nonpoint Sources



4.1.4.2 POINT SOURCES OF HEAT

Fifteen NPDES permitted facilities discharge surface water to the Tualatin River and tributaries during the critical summertime temperature period. Point source contributions account for 7% of the total heat loading.

The locations of the NPDES permitted discharge points in the subbasin are mapped in **Figure 13**. There are twenty-one permitted facilities within the Tualatin River Subbasin, fifteen of which discharge during critical summertime periods. Facilities that discharge during the critical summertime temperature period are listed in **Table 8**. Discharge temperatures range from 66°F to 88°F. Discharge rates are generally very low, however two major wastewater treatment facilities discharge a combined 61 cfs into the Tualatin River (Rock Creek Waste Water Treatment Plant – RM 38.0 and Durham Waste Water Treatment Plant – RM 9.5).

Figure 13. Map of Tualatin River Subbasin Showing Urban Areas Including Point Sources of Pollution with Facility NPDES Permits.

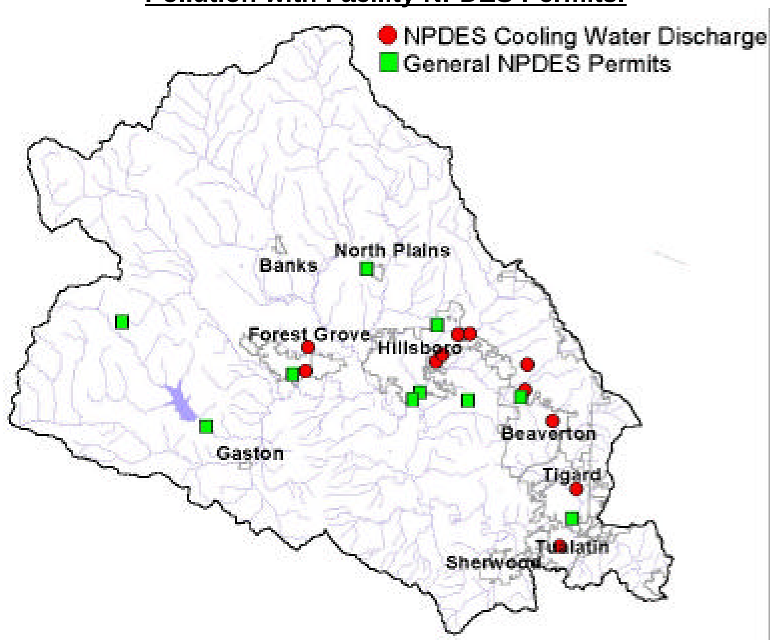
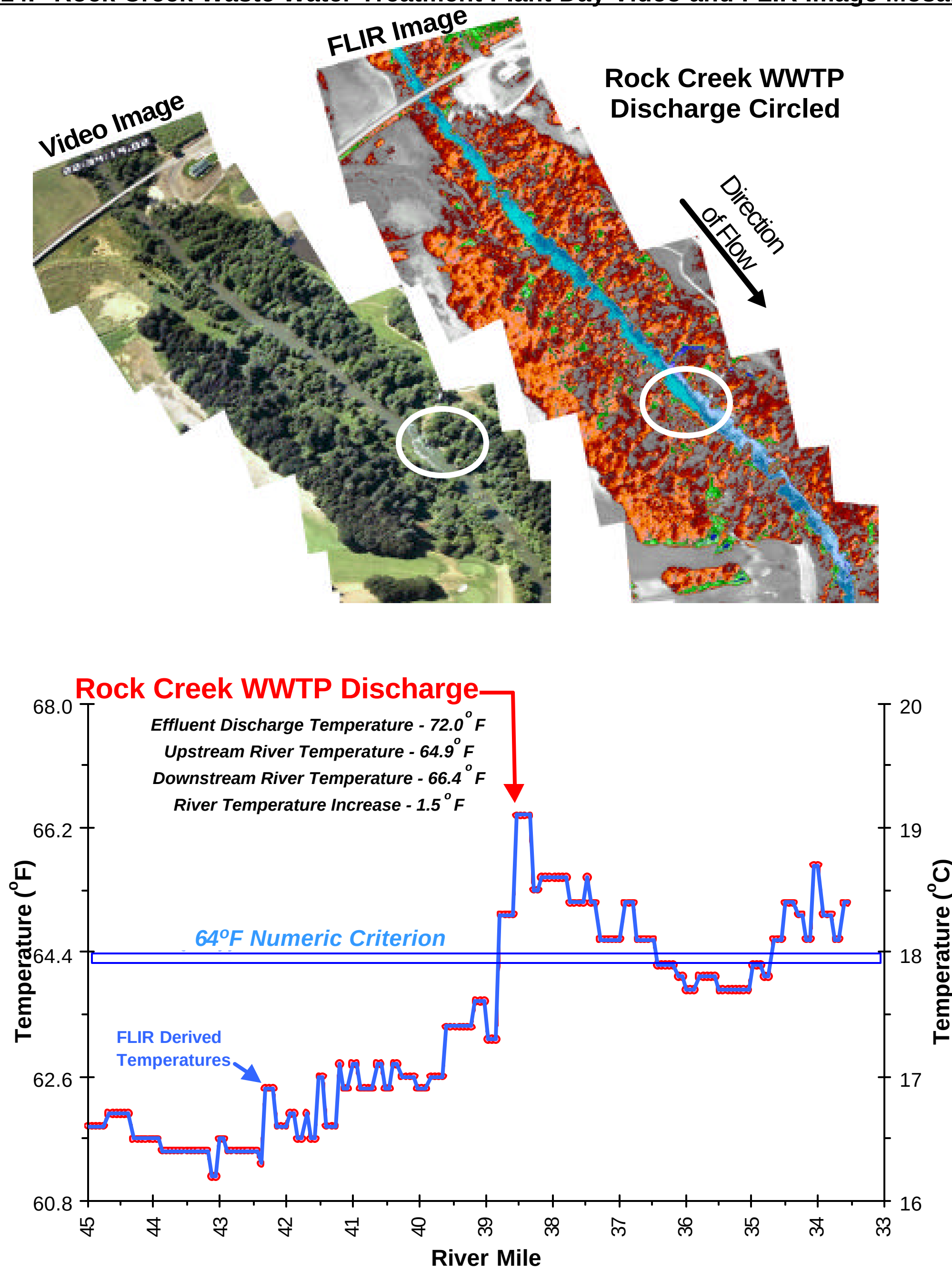


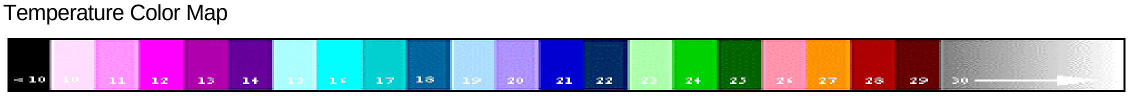
Table 8. NPDES Permitted Facilities for Cooling Water and General Discharge						
Facility Name	**City**	**Receiving Water**	**River Mile**	**Permit Type**	**Flow Rate (cfs)**	**Critical Temp.**
PACIFIC FOODS OF OR., INC.	TUALATIN	Tualatin R.	8.5	GEN01	0.0032	76 °F
USA DURHAM STP	TIGARD	Tualatin R.	9.5	NPDES	27.0	71 °F
USA ROCK CREEK STP	HILLSBORO	Tualatin R.	38.0	NPDES	33.9	71 °F
MATSUSHITA ELEC. MAT., INC.	FOREST GROVE	Tualatin R.	50.0	GEN01	0.0021	82 °F
WILLIAMS CONTROLS INC	PORTLAND	Fanno Cr.	1.5	GEN01	0.0267	81 °F
WILLAMETTE INDUSTRIES	BEAVERTON	Fanno Cr.	9.0	GEN01	0.0170	72 °F
PERMAPOST	HILLSBORO	Rock Cr.	1.0	NPDES	0.0572	70 °F
FUJITSU COMP. PROD. OF AMER., INC.	HILLSBORO	Rock Cr.	3.2	GEN01	0.0002	76 °F
KOEI AMERICA INCORP.	HILLSBORO	Rock Cr.	3.6	GEN01	0.0095	88 °F
EPSON PORTLAND INC.	HILLSBORO	Rock Cr.	7.0	GEN01	0.0004	90 °F
TEKTRONIX BEAV. CAMP. (INDUST. WWTP)	BEAVERTON	Beaverton Cr.	6.7	GEN01	0.0024	78 °F
MAXIM WAFER FAB OPER.	BEAVERTON	Beaverton Cr.	7.0	GEN01	0.0023	71 °F
OREGON-CANADIAN FOR. PROD.	NORTH PLAINS	McKay Cr.	8.5	NPDES	0.0010	82 °F
HENNINGSEN COLD STOR. CO.	FOREST GROVE	Council Cr.	10.0	GEN01	0.0081	69 °F
FORESTEX CO. (ABN)	GASTON	Scoggins Cr.	4.0	NPDES	0.0021	No data

FLIR imagery is used to display the warm water discharge of Rock Creek Wastewater Treatment Plant (see **Figure 14**). A distinct plume of 72°F effluent mixes with the Tualatin River, which had a temperature of 65°F at the time of FLIR sampling (roughly 3:30 on July 27, 1999). River temperatures after complete mixing occurs below the treatment plant were increased by 1.5°F for a distance that extended over one mile downstream.

Figure 14. Rock Creek Waste Water Treatment Plant Day Video and FLIR Image Mosaics*

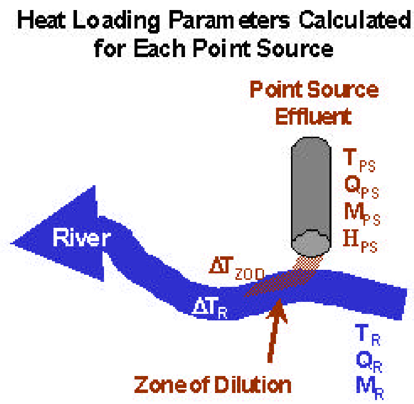


*FLIR Temperature Color Map



Simulated system potential stream temperatures during the critical condition in late July are estimated by removing anthropogenic sources of heat throughout the Tualatin River Subbasin. These system potential temperatures are developed using computer modeling (see **Appendix A**) and used to assign the wasteload allocations to the point sources. Often, there are a number of point sources in a subbasin, some on segments that would be below the numeric criteria at system potential and some for which system potential would be above the numeric criteria. On some small streams, there would likely be complete mix of effluent and the stream within the mixing zone. On larger streams, the mixing zone would be a portion of the river (e.g. 25% or as described through a mixing zone study). The assumptions that should be used in evaluating the "no measurable increase as measured by 0.25°F at the edge of the mixing zone" relates to both the interpretation of the standard and mixing zone policy.

Heat loading from point sources occurs when waters with differing temperatures are mixed. The temperature standard specifies that point sources cannot produce a temperature increase of greater than 0.25°F at the edge of the mixing zone. For computational purposes, ODEQ has defined the zone of dilution as 1/4 of the 7Q10 low flow. The design condition for point source is the heat from effluent that produces a 0.25°F increase (or less) in the zone of dilution. The equations for calculating the heat load from point sources are provided below. **Table 9** displays the calculated parameters for point source heat loading analysis. Current point source heat loading and point source heat loading allowed by the temperature standard is presented in **Figure 15**.



Point Source Parameter	Equation
Change in river temperature	$\Delta T_R = \frac{(Q_{PS} \cdot T_{PS}) + (Q_R \cdot T_R)}{(Q_{PS} + Q_R)} - T_R$
Mass of river flow	$M_R = Q_R \cdot \frac{1 \cdot m^3}{35.3 \cdot ft^3} \cdot \frac{1000 \cdot kg}{1 \cdot m^3} \cdot \frac{86400 \cdot sec}{1 \cdot day} = \frac{kg}{day}$
Mass of river flow at zone of dilution	$M_{ZOD} = Q_{ZOD} \cdot \frac{1 \cdot m^3}{35.3 \cdot ft^3} \cdot \frac{1000 \cdot kg}{1 \cdot m^3} \cdot \frac{86400 \cdot sec}{1 \cdot day} = \frac{kg}{day}$
Current point source heat loading on river	$H_{PS} = M_R \cdot c \cdot \Delta T_R \cdot \left(\frac{5^o C}{9^o F}\right)$
Change in river temperature at zone of dilution	$\Delta T_{ZOD} = \frac{H_{WLA}}{M_{ZOD} \cdot c} \cdot \left(\frac{9^o F}{5^o C}\right)$ $\Delta T_{ZOD} = \frac{(Q_{PS} \cdot T_{PS}) + (Q_{ZOD} \cdot T_R)}{(Q_{PS} + Q_{ZOD})} - T_R$
Allowable Temperature Change in Zone of Dilution	If $\Delta T_{ZOD} > 0.25^oF$ then Max $\Delta T_{ZOD} = 0.25\ ^oF$ If $\Delta T_{ZOD} \leq 0.25^oF$ then Max $\Delta T_{ZOD} = \Delta T_{ZOD}$
Allowable Point Source Heat Loading in Zone of Dilution	$H_{WLA} = M_{ZOD} \cdot c \cdot Max\Delta T_{ZOD} \cdot \left(\frac{5^o C}{9^o F}\right)$
Allowable Effluent Temperature	$T_{WLA} = \frac{[(Q_{PS} + Q_{ZOD}) \cdot (T_R + Max\Delta T_{ZOD})] - (Q_{ZOD} \cdot T_R)}{Q_{PS}}$ $T_{WLA} = \frac{\left[(Q_{PS} + Q_{ZOD}) \cdot \left(T_R + \frac{H_{WLA}}{M_{ZOD} \cdot c} \cdot \left(\frac{9^o F}{5^o C}\right)\right)\right] - (Q_{ZOD} \cdot T_R)}{Q_{PS}}$

where,

T_R: Upstream potential river temperature (^oF)
T_{PS}: Point source effluent temperature (^oF)
T_{WLA}: Maximum allowable point source effluent temperature (^oF)
ΔT_R: Change in river temperature (^oF)
ΔT_{ZOD}: Change in river temperature at edge of zone of dilution - 0.25^oF allowable (^oF)
Max ΔT_{ZOD}: Maximum Allowable Change in river temperature at edge of zone of dilution (^oF)

- If zone of dilution temperature change is greater than 0.25^oF then maximum allowable zone of dilution temperature change is 0.25^oF, or
- If zone of dilution temperature change is less than 0.25^oF then maximum allowable zone of dilution temperature change is the current zone of dilution temperature change.

Q_R: Upstream river flow - Calculated as 7Q10 low flow statistic (cfs)
Q_{ZOD}: Upstream river flow through zone of dilution - Calculated as 1/4 7Q10 low flow statistic (cfs)
Q_{PS}: Point source effluent discharge (cfs)
M_R: Daily mass of river flow (kg/day)
M_{ZOD}: Daily mass of river flow through zone of dilution (kg/day)
M_{PS}: Daily mass of effluent (kg/day)
H_{PS}: Heat from point source effluent received by river (kcal/day)
H_{WLA}: Allowable heat from point source effluent received by river (kcal/day)
c: Specific heat of water (1 kcal/kg ^oC)

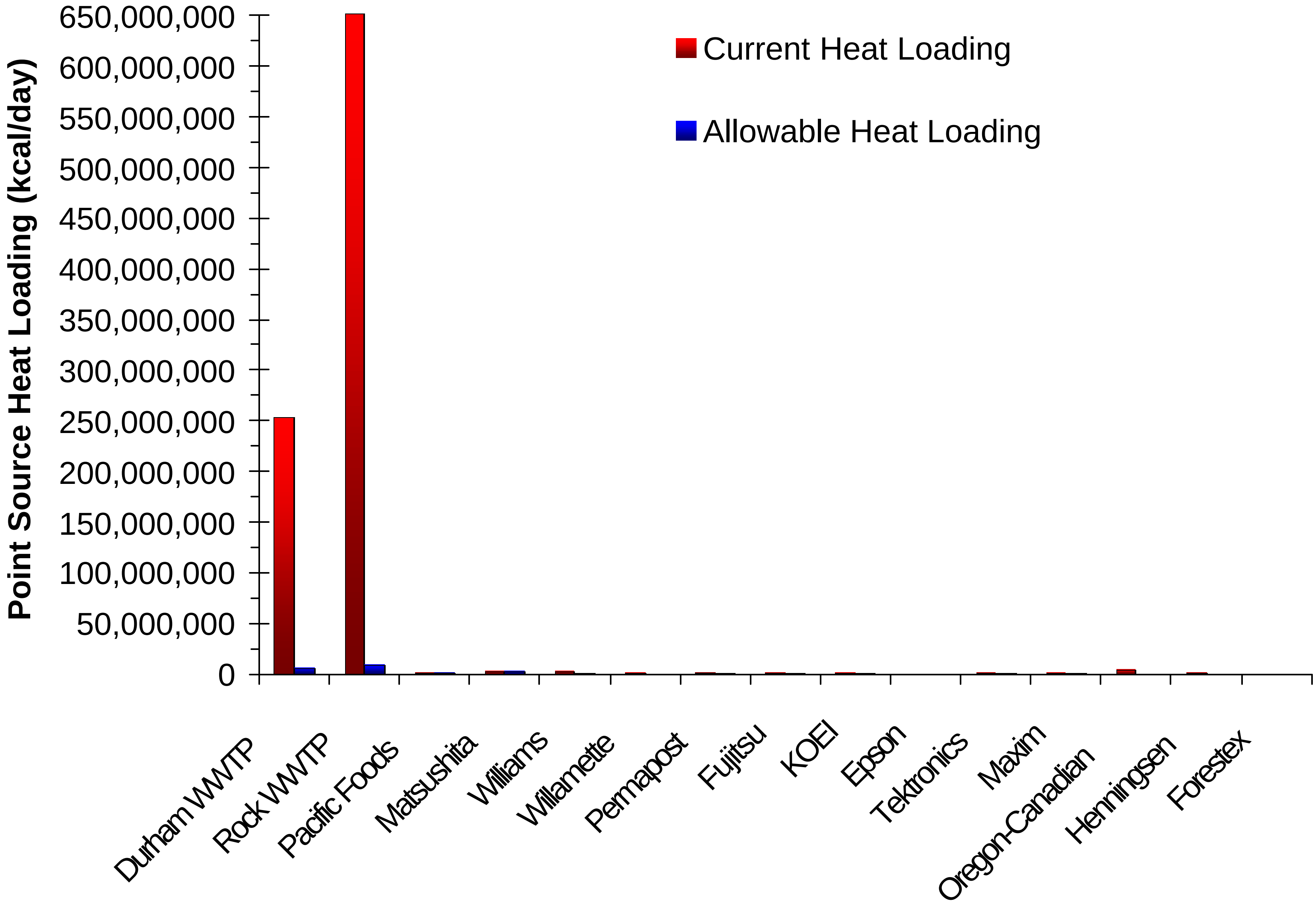
Table 9. Point Source Heat Loading Data[7]

		Q_R	Q_{PS}	T_{PS}	Max T_P	Ave ΔT_R	ΔT_{ZOD}	M_R	M_{ZOD}	H_{PS}	H_{WLA}		T_{WLA}
Facility Name	Receiving Water	Receiving Water 7Q10 Low Flow (cfs)	Facility Design Flow (cfs)	Point Source Effluent Temp. (°F)	Max Daily System Potential River Temp. (°F)	Ave River Temp Increase During Diurnal Cycle (°F)	Allowable Temperature Increase in Zone of Dilution (°F)	River Volume Daily Mass (kg/day)	Zone of Dilution Daily Mass (kg/day)	Current Excess Point Source Heat Loading on River (kcal/day)	Allowable Point Source Heat Loading in Zone of Dilution (kcal/day)	Percent Reduction in Point Source Heat Load	Allowable Effluent Temp. (°F)
Durham WWTP	Tualatin R. RM - 9.5	76.00	34.00	71.0	63.3	2.46	0.25	$1.9\cdot10^{8}$	$4.7\cdot10^{7}$	$2.5\cdot10^{8}$	$6.5\cdot10^{6}$	97%	64
Rock WWTP	Tualatin R. RM - 38.0	102.60	50.00	70.7	57.1	4.68	0.25	$2.5\cdot10^{8}$	$6.3\cdot10^{7}$	$6.5\cdot10^{8}$	$8.7\cdot10^{6}$	99%	58
Pacific Foods	Tualatin R. RM - 8.5	76.00	0.06	76.0	62.7	0.01	0.04	$1.9\cdot10^{8}$	$4.7\cdot10^{7}$	$1.1\cdot10^{6}$	$1.1\cdot10^{6}$	0%	77
Matsushita	Tualatin R. RM - 50.0	40.20	0.08	82.0	52.3	0.06	0.25	$9.8\cdot10^{7}$	$2.5\cdot10^{7}$	$3.4\cdot10^{6}$	$3.4\cdot10^{6}$	0%	83
Williams	Fanno Cr. RM - 1.5	1.87	0.08	81.0	58.1	1.00	0.25	$4.6\cdot10^{6}$	$1.1\cdot10^{6}$	$2.6\cdot10^{6}$	$1.6\cdot10^{5}$	94%	60
Willamette	Fanno Cr. RM - 9.0	0.10	0.04	72.0	60.5	3.66	0.25	$2.4\cdot10^{5}$	$6.1\cdot10^{4}$	$5.0\cdot10^{5}$	$8.5\cdot10^{3}$	98%	61
Permapost	Rock Cr. RM - 1.0	4.10	0.11	70.0	60.5	0.30	0.25	$1.0\cdot10^{7}$	$2.5\cdot10^{6}$	$1.7\cdot10^{6}$	$3.5\cdot10^{5}$	79%	63
Fujitsu	Rock Cr. RM - 3.2	4.10	0.04	76.0	61.0	0.18	0.25	$1.0\cdot10^{7}$	$2.5\cdot10^{6}$	$9.8\cdot10^{5}$	$3.5\cdot10^{5}$	64%	68
KOEI	Rock Cr. RM - 3.6	4.10	0.01	88.0	61.1	0.07	0.25	$1.0\cdot10^{7}$	$2.5\cdot10^{6}$	$3.7\cdot10^{5}$	$3.5\cdot10^{5}$	6%	89
Epson	Rock Cr. RM - 7.0	1.02*	0.00	90.0	61.1	0.06	0.24	$2.5\cdot10^{6}$	$6.2\cdot10^{5}$	$8.2\cdot10^{4}$	$8.2\cdot10^{4}$	0%	93
Tektronics	Beaverton Cr. RM - 6.7	2.08*	0.02	78.0	61.1	0.21	0.21	$5.1\cdot10^{6}$	$1.3\cdot10^{6}$	$6.0\cdot10^{5}$	$1.5\cdot10^{5}$	75%	66
Maxim	Beaverton Cr. RM - 7.0	2.08*	0.03	71.0	61.1	0.18	0.18	$5.1\cdot10^{6}$	$1.3\cdot10^{6}$	$5.1\cdot10^{5}$	$1.3\cdot10^{5}$	75%	64
Oregon-Canadian	McKay Cr. RM - 8.5	0.20	0.33	82.0	57.8	15.92	0.25	$4.9\cdot10^{5}$	$1.2\cdot10^{5}$	$4.3\cdot10^{6}$	$1.7\cdot10^{4}$	100%	58
Henningsen	Council Cr. RM - 10.0	0.15*	0.02	69.0	57.8	3.49	0.25	$3.7\cdot10^{5}$	$9.2\cdot10^{4}$	$7.1\cdot10^{5}$	$1.3\cdot10^{4}$	98%	59
									Totals	$9.2\cdot10^{8}$	$2.1\cdot10^{7}$	98%	

[7] These effluent temperatures and WLAs were based on calculating no measurable increase above system potential using the flows, temperatures and equations in Table 9 which shows loadings and effluent temperatures under one set of conditions. However as the permits are renewed, WLAs may be recalculated using the equations if flow rates, mixing zones, heat "credits" (see Section 4.1.4.3), or effluent temperatures differ. Also, a maximum allowable discharge temperature will be included that will ensure incipient lethal temperatures are not exceeded. Therefore, the maximum temperature allowed in the permit may be different from the values expressed here and will be determined at the time of permit renewal to determine no measurable increase above system potential using the equations in Table 9.

* 7Q10 flows are calculated at nearest stream gage.

Figure 15. Point Source Heat Loading - Current Condition and Allowable Loading



4.1.4.3 FLOW AUGMENTATION SOURCES OF HEAT: EXAMPLE CALCULATIONS

Flow augmentation can cause changes in heat loading. As an example, USA flow augmentation is a source of heat reduction in the Tualatin River.

Heat loading from flow augmentation can be calculated as follows,

$$H_{Aug} = M_R \cdot c \cdot \Delta T_R \cdot \left(\frac{5^oF}{9^oC}\right)$$

If we correct for units we can calculate heat from flow augmentation as,

$$H_{Aug} = Q_R \cdot c \cdot \Delta T_R \cdot \left(\frac{5^oF}{9^oC}\right) \cdot \left(2{,}447{,}592 \frac{ft^3 \cdot day}{kg \cdot sec}\right)$$

where,

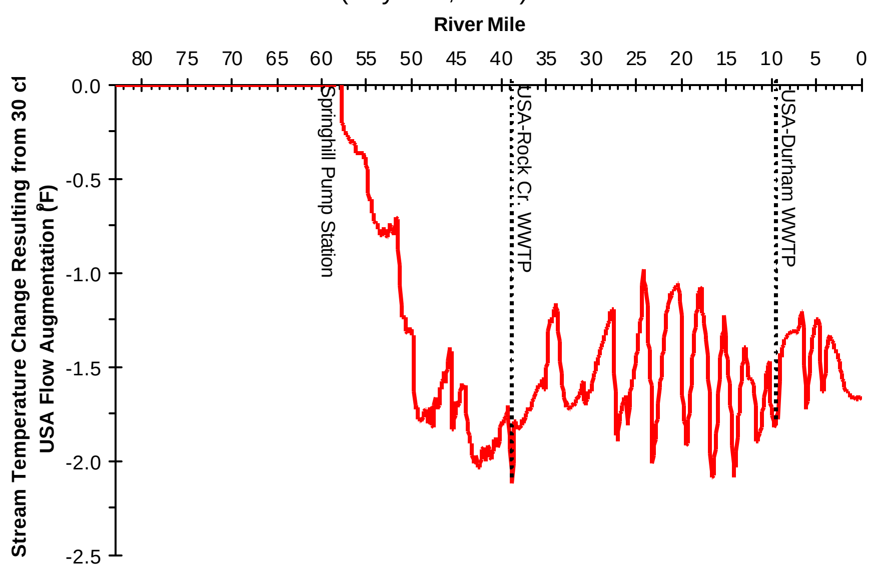
ΔT_R: Change in river temperature (^oF)
Q_R: Upstream river flow (cfs)
M_R: Daily mass of river flow (kg/day)
H_{Aug}: Heat from point source effluent received by river (kcal/day)
c: Specific heat of water (1 kcal/kg ^oC)

Flow augmentation is a possible source of heat transfer. Increasing stream flow can result in heat loads via two ways:

- Mixing river water with tributaries, augmentation flows or subsurface flows (with a different temperature) will cause a change in river water temperature (ΔT_R), and/or
- Increasing the assimilative capacity of a waterbody by changing the mass (M_R) of the waterbody.

For example, USA purchases flow augmentation water from Scoggins Reservoir If this water is released at a rate of 30 cfs, a temperature change occurs at USA Rock Creek WWTP ($\Delta T_R = -2.1^oF$) and USA-Durham WWTP ($\Delta T_R = -1.8^oF$).

Figure 16. Temperature Change that Results from 30 cfs USA Flow Augmentation
(July 29th, 1999)



Heat loading from flow augmentation can be calculated as follows,

$$H_{Aug} = M_R \cdot c \cdot \Delta T_R \cdot \left(\frac{5^oF}{9^oC}\right)$$

If we correct for units we can calculate heat from flow augmentation as,

$$H_{Aug} = Q_R \cdot c \cdot \Delta T_R \cdot \left(\frac{5^oF}{9^oC}\right) \cdot \left(2{,}447{,}592 \frac{ft^3 \cdot day}{kg \cdot sec}\right)$$

The heat reduction associated with 30 cfs USA flow augmentation in the Tualatin River at USA-Rock Creek WWTP is,

$$-5.7 \cdot 10^8 \frac{kcal}{day} = 200 \cdot cfs \cdot 1\frac{kcal}{day} \cdot -2.1^oF \cdot \left(\frac{5^oF}{9^oC}\right) \cdot \left(2{,}447{,}592 \frac{ft^3 \cdot day}{kg \cdot sec}\right)$$

where,

ΔT_R = -2.1^{o}F, Q_R = 200 cfs, c = 1 kcal/day

The heat reduction associated with 30 cfs USA flow augmentation in the Tualatin River at USA-Durham WWTP is,

$$-3.5 \cdot 10^8 \frac{kcal}{day} = 142 \cdot cfs \cdot 1\frac{kcal}{day} \cdot -1.8^oF \cdot \left(\frac{5^oF}{9^oC}\right) \cdot \left(2{,}447{,}592 \frac{ft^3 \cdot day}{kg \cdot sec}\right)$$

where,

ΔT_R = -1.8^{o}F, Q_R = 142 cfs, c = 1 kcal/day

It then becomes possible to relate the heat reductions associated with USA flow augmentation to the heat increases caused by effluent discharge to the Tualatin River.

	Q_R	DT_R	H_{PS}	H_{Aug}	$DH_R = H_{PS} - H_{Aug}$
USA Facility	River Flow at the USA Facility (July 29, 1999) (cfs)	Stream Temperature Reduction at USA Facility (^{o}F)	Current Point Source Heat Loading on River (kcal/day)	Heat Reduction Associated with USA Flow Augmentation (kcal/day)	Change in River Heat Due to USA Flow Augmentation and Effluent Discharge (kcal/day)
Durham WWTP	142	-1.8	$2.5 \cdot 10^8$	$-3.5 \cdot 10^8$	$-1.0 \cdot 10^8$
Rock Creek WWTP	200	-2.1	$6.5 \cdot 10^8$	$-5.7 \cdot 10^8$	$0.8 \cdot 10^8$

In a similar fashion the thermal effect of future flow augmentation can be calculated for other anthropogenic sources of heat and related to the overall heat budget. These heat "credits" can then be incorporated into point source discharge permits or through other implementation methods such as pollutant trading.

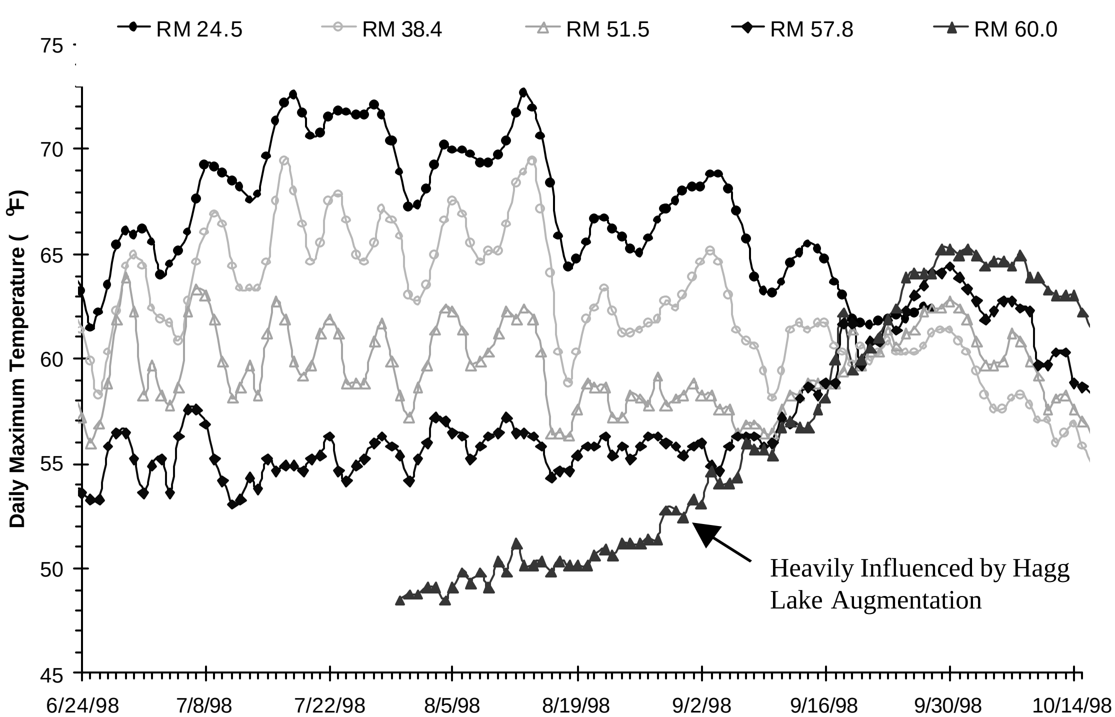
4.1.5 SEASONAL VARIATION - CWA §303(D)(1)

Critical temperature period spans June through October

The Tualatin River and tributaries experience prolonged warming. Maximum temperatures typically occur in July and August in the Tualatin River Subbasin (**Figure 17).** The TMDL focuses the analysis during the July period as a critical condition as identified by 1998 temperature data (**Figure 17)**. It should also be noted that the Tualatin River below river mile 38.4 is commonly above the 64°F numeric criterion during the entire sampling period (June through October).

The temperature monitoring site on Tualatin River downstream the Scoggins Creek confluence (River Mile 60.0) is unique because the water temperatures reflect Hagg Lake augmentation influences on the Tualatin River mainstem. During the summer of 1998 (June to August), it appears that the Hagg Lake augmentation water was significantly cooler than the Tualatin River mainstem. In contrast, the Hagg Lake augmentation water was warmer than the Tualatin River mainstem during the late summer and early fall months (August to October). This phenomenon can be explained by the fact that reservoirs are thermally stratified. Most summertime warming in reservoirs occurs in the top layer of water (this area is called the *epilimnion*), while temperatures of the deeper portions of the reservoir remain cool (this area is called the *hypolimnion*). Hagg Lake is a bottom release reservoir and draws from the deeper *hypolimnion* cool water, until the reservoir is drawn down to the point where the deeper *hypolimnion* has been fully released and the warmer *epilimnion* begin to influence discharge waters. Data from 1998 clearly depict these phenomena (**Figure 17 -** River Mile 60). A secondary change in reservoir release waters temperature can occur when the reservoir turns over. Hagg Lake thermal stratification ends in fall when surface epilimnion waters cool, become more dense and mix with deeper and cooler strata by wind and convective currents (Wetzel, 1983).

Figure 17. 1998 Observed daily maximum temperatures for the Tualatin River



4.1.6 LOADING CAPACITY – 40 CFR 130.2(F)

*The water quality standard (listed in Section 4.1.4.2) mandates a **loading capacity** based on the condition that meets the **no measurable surface water temperature increase resulting from anthropogenic activities.** This loading condition is developed as the sum of nonpoint source background solar radiation heat loading and the allowable point source heat load.*

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. EPA's current regulation defines loading capacity as "*the greatest amount of loading that a water can receive without violating water quality standards*." (40 CFR § 130.2(f)).

- The water quality standard states that ***no measurable surface water temperature increase resulting from anthropogenic activities*** is allowed in the Tualatin River and tributaries (OAR 340-41-445(2)(b)(A)).
- The pollutants are human increases in solar radiation loading (nonpoint sources) and heat loading from warm water discharge (point sources).
- **Loading capacities** in the Tualatin River Subbasin are the sum of (1) background solar radiation heat loading profiles for the mainstem Tualatin River and all major tributaries (expressed as kcal per day) based on potential near stream vegetation characteristics without anthropogenic disturbance and (2) allowable heat loads for NPDES permitted point sources based on the 0.25^{o}F allowable temperature increase in the zone of dilution.
- The calculations used to determine the loading capacity are presented in section **4.1.4 Existing Sources - CWA *§303(d)(1)***
- **Appendix A** describes the modeling results that lead to the development of system potential river temperatures.

The Heat Loading Capacity (H_{LC} = 6,180,598,502 kcal/day) is the sum of nonpoint source background based on system potential ($H_{SP\ NPS}$ = 6,159,272,382 kcal/day) and allowable point source heat (H_{WLA} = 21,326,120 kcal/day).

$$
\begin{array}{rlcrl}
 & H_{SP\ NPS} & \longrightarrow & & 6.2\cdot 10^{9}\ \text{kcal/day} \\
+ & H_{WLA} & \longrightarrow & + & 2.1\cdot 10^{7}\ \text{kcal/day} \\
\hline
= & H_{LC} & \longrightarrow & = & 6.2\cdot 10^{9}\ \text{kcal/day}
\end{array}
$$

4.1.7 ALLOCATIONS – 40 CFR 130.2(G) AND (H)

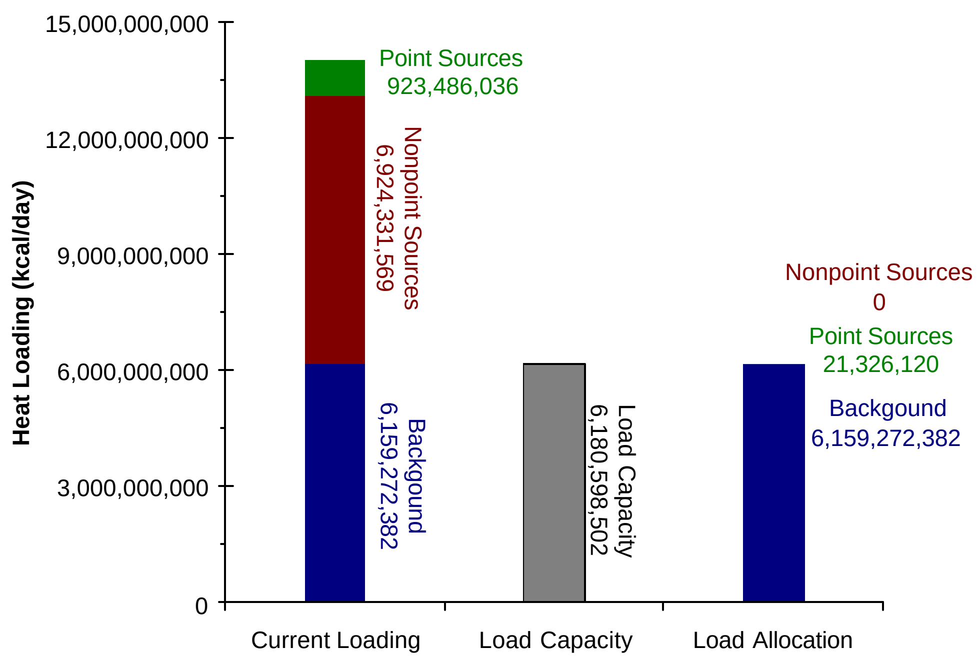
Load Allocations (Nonpoint Sources) *- The* ***temperature standard*** *targets system potential (i.e. no measurable temperature increases from anthropogenic sources). To meet this requirement the system potential solar radiation heat load (6,159,272,382 kcal/day) is allocated to background nonpoint sources. Anthropogenic nonpoint sources are given a heat load of zero.*

Wasteload Allocations (Point Sources) *- Surface water discharges into Tualatin River Subbasin receiving waters have been given a heat load based on the 0.25°F allowable increase in the zone of dilution as specified in the temperature standard. Heat loads have been converted to allowable effluent temperatures as well. It should be noted that the wasteload allocation is the point source heat load (21,326,120 kcal/day) and not the calculated maximum effluent temperatures. There are several options for meeting the allocated heat loads (i.e. passive effluent temperature reductions, changes in facility discharge operation, purchasing instream flows, pollutant trading, etc.).*[8]

Load Allocations are portions of the loading capacity divided between natural, human and future nonpoint pollutant sources. **Table 10** lists load allocations (i.e. distributions of the loading capacity) for the Tualatin River Subbasin according to land-use. Each DMA's portion of the WQMP (Appendix I) will address only the lands and activities within each identified stream segment to the extent of the DMA's authority. A *Waste Load Allocation* (WLA) is the amount of pollutant that a point source can contribute to the stream without violating water quality criteria.

Loading Capacity = Load Allocations + Wasteload Allocations
6,180,598,502 kcal/day = 6,159,272,382 kcal/day + 21,326,120 kcal/day

Figure 18. Heat Loading - Current Condition, Loading Capacity and Load Allocations



[8] These effluent temperatures and WLAs were based on calculating no measurable increase above system potential using the flows, temperatures and equations in Table 9 which shows loadings and effluent temperatures under one set of conditions. However as the permits are renewed, WLAs may be recalculated using the equations if flow rates, mixing zones, heat "credits" (see Section 4.1.4.3), or effluent temperatures differ. Also, a maximum allowable discharge temperature will be included that will ensure incipient lethal temperatures are not exceeded. Therefore, the maximum temperature allowed in the permit may be different from the values expressed here and will be determined at the time of permit renewal to determine no measurable increase above system potential using the equations in Table 9.

Table 10. Temperature Allocation Summary

Nonpoint Sources

Source	Loading Allocation Allowable Nonpoint Source Solar Radiation Heat Load (kcal/day)
Background - System Potential	6,159,272,382
Agriculture	∅
Forestry	∅
Urban/Rural/Transportation	∅
Total Allowable Nonpoint Source Solar Radiation Heat Load	**6,159,272,382 kcal/day**

Point Sources[9]

Facility Name	Receiving Water	Waste Load Allocation Allowable Point Source Heat Load (kcal/day)	Maximum Effluent Temperature (°F)
Durham WWTP	Tualatin R. RM - 9.5	$6.5 \cdot 10^6$	64
Rock WWTP	Tualatin R. RM - 38.0	$8.7 \cdot 10^6$	58
Pacific Foods	Tualatin R. RM - 8.5	$1.1 \cdot 10^6$	77
Matsushita	Tualatin R. RM - 50.0	$3.4 \cdot 10^6$	83
Williams	Fanno Cr. RM - 1.5	$1.6 \cdot 10^5$	60
Willamette	Fanno Cr. RM - 9.0	$8.5 \cdot 10^3$	61
Permapost	Rock Cr. RM - 1.0	$3.5 \cdot 10^5$	63
Fujitsu	Rock Cr. RM - 3.2	$3.5 \cdot 10^5$	68
KOEI	Rock Cr. RM - 3.6	$3.5 \cdot 10^5$	89
Epson	Rock Cr. RM - 7.0	$8.2 \cdot 10^4$	93
Tektronics	Beaverton Cr. RM - 6.7	$1.5 \cdot 10^5$	66
Maxim	Beaverton Cr. RM - 7.0	$1.3 \cdot 10^5$	64
Oregon-Canadian	McKay Cr. RM - 8.5	$1.7 \cdot 10^4$	58
Henningsen	Council Cr. RM - 10.0	$1.3 \cdot 10^4$	59
Future Growth	All	No Measurable Increase Above System Potential	64
Allowable Point Source Heat Loading		**21,326,120 kcal/day**	

[9] These effluent temperatures and WLAs were based on calculating no measurable increase above system potential using the flows, temperatures and equations in Table 9 which shows loadings and effluent temperatures under one set of conditions. However as the permits are renewed, WLAs may be recalculated using the equations if flow rates, mixing zones, heat "credits" (see Section 4.1.4.3), or effluent temperatures differ. Also, a maximum allowable discharge temperature will be included that will ensure incipient lethal temperatures are not exceeded. Therefore, the maximum temperature allowed in the permit may be different from the values expressed here and will be determined at the time of permit renewal to determine no measurable increase above system potential using the equations in Table 9.

4.1.8 SURROGATE MEASURES – 40 CFR 130.2(I)

The Tualatin River Subbasin Temperature TMDL incorporates measures other than "*daily loads*" to fulfill requirements of §303(d). Although a loading capacity for heat energy is derived [e.g. Langleys per day], it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat energy loads, this TMDL allocates "*other appropriate measures*" (or surrogates measures) as provided under EPA regulations [40 CFR 130.2(i)].

The *Report of Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program"* (FACA Report, July 1998) offers a discussion on the use of surrogate measures for TMDL development. The FACA Report indicates:

> *"When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not. The criterion must be designed to meet water quality standards, including the waterbody's designated uses. The use of BPJ does not imply lack of rigor; it should make use of the "best" scientific information available, and should be conducted by "professionals." When BPJ is used, care should be taken to document all assumptions, and BPJ-based decisions should be clearly explained to the public at the earliest possible stage.*
>
> *If they are used, surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve. Use of a surrogate environmental parameter should require additional post-implementation verification that attainment of the surrogate parameter results in elimination of the impairment. If not, a procedure should be in place to modify the surrogate parameter or to select a different or additional surrogate parameter and to impose additional remedial measures to eliminate the impairment."*

Water temperature warms as a result of increased solar radiation loads. A loading capacity for radiant heat energy (i.e., incoming solar radiation) can be used to define a reduction target that forms the basis for identifying a surrogate. The specific surrogate used is percent effective shade (expressed as the percent reduction in potential solar radiation load delivered to the water surface). The solar radiation loading capacity is translated directly (linearly) by effective solar loading. The definition of effective shade allows direct measurement of the solar radiation loading capacity.

Because factors that affect water temperature are interrelated, the surrogate measure (percent effective shade) relies on restoring/protecting riparian vegetation to increase stream surface shade levels, reducing stream bank erosion, stabilizing channels, reducing the near-stream disturbance zone width and reducing the surface area of the stream exposed to radiant processes. Effective shade screens the water's surface from direct rays of the sun. Highly shaded streams often experience cooler stream temperatures due to reduced input of solar energy (Brown 1969, Beschta et al. 1987, Holaday 1992, Li et al. 1994).

Over the years, the term shade has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, shade is defined as the percent reduction of potential solar radiation load delivered to the water surface. Thus, the role of effective shade in this TMDL is to prevent or reduce heating by solar radiation and serve as a linear translator to the solar loading capacities.

4.1.8.1 SITE SPECIFIC EFFECTIVE SHADE SURROGATE MEASURES

Site specific effective shade surrogates are developed to help translate the nonpoint source solar radiation heat loading allocations. Attainment of the effective shade surrogate measures is equivalent to attainment of the nonpoint source load allocations.

As mentioned above, a loading capacity of heat per day is not very useful in guiding nonpoint source management practices. Percent effective shade is a surrogate measure that can be calculated directly from the loading capacity. Additionally, percent effective shade is simple to quantify in the field or through mathematical calculations. **Figures 19** to **25** display the percent effective shade values that correspond to the loading capacities throughout the Tualatin River Subbasin (i.e., system potential).

Figure 19. Tualatin River Percent Effective Shade Surrogate Measures

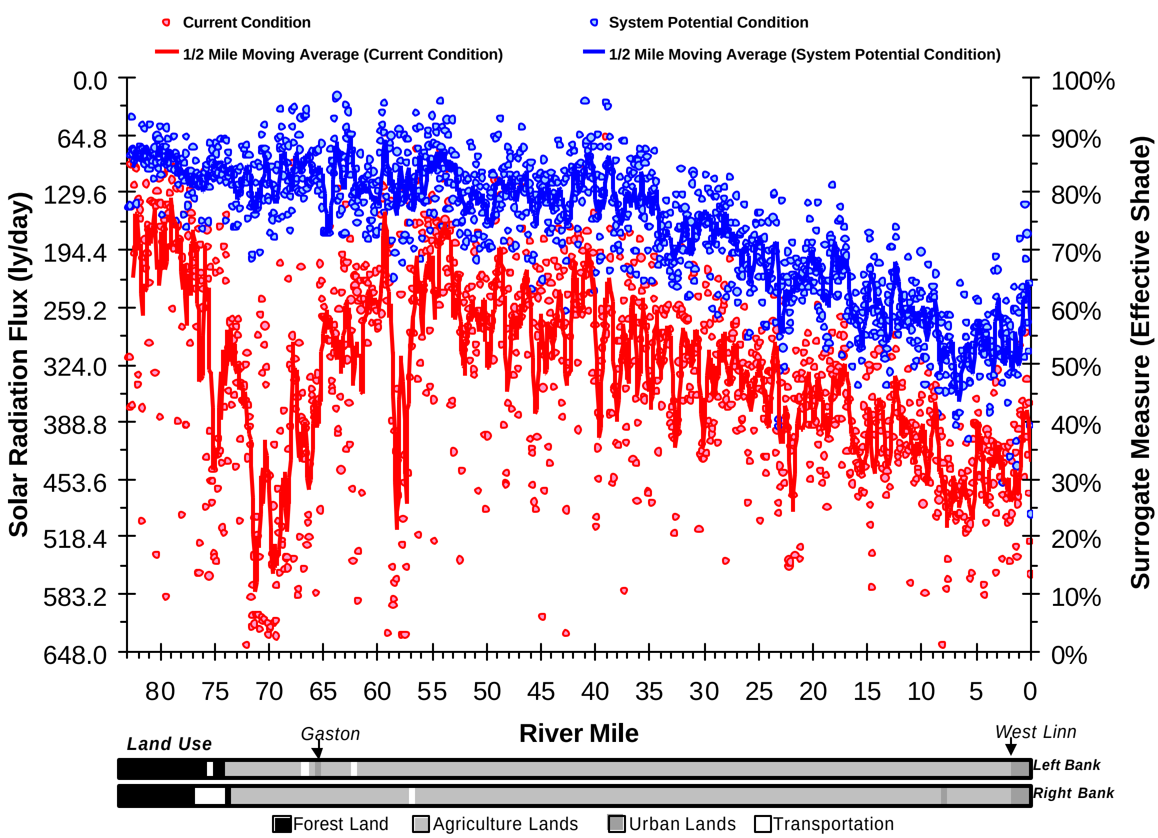


Figure 20. Gales Creek Effective Shade Surrogate Measure for Nonpoint Sources

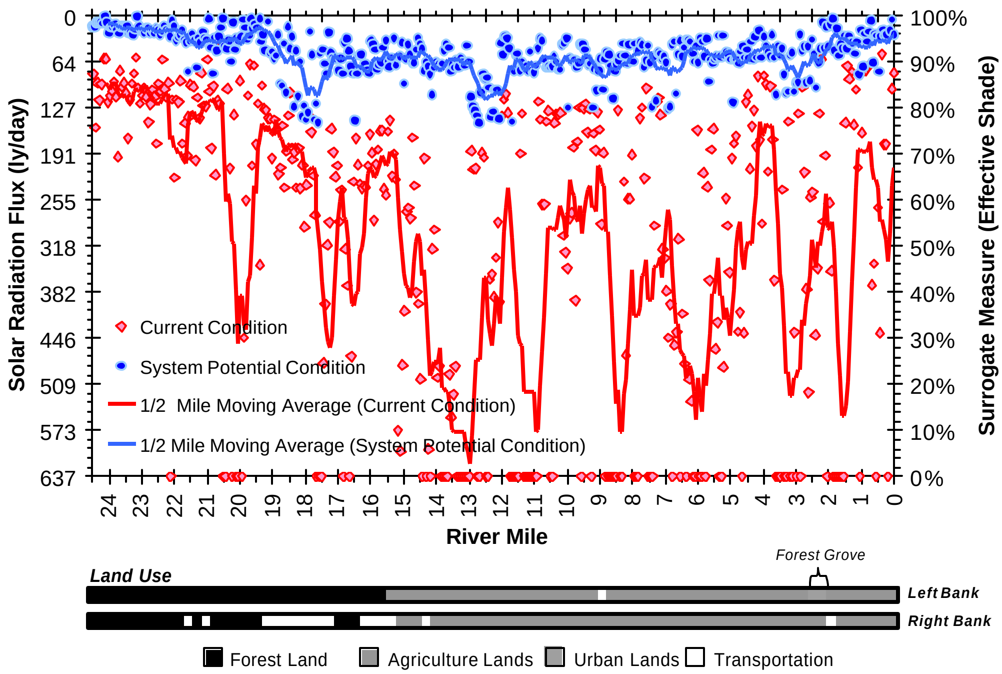


Figure 21. East Fork Dairy Creek Effective Shade Surrogate Measure for Nonpoint Sources

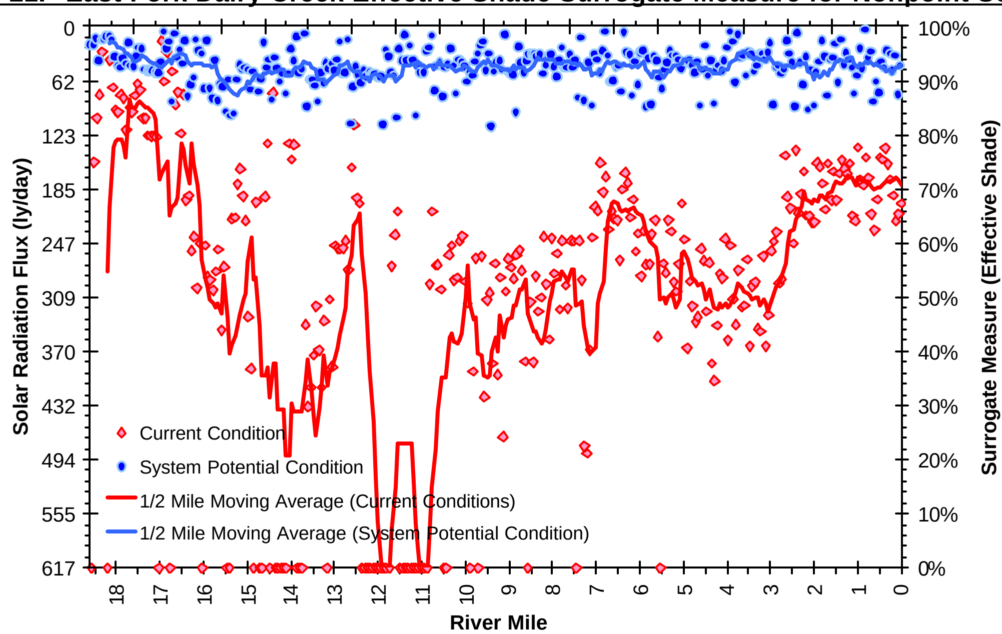


Figure 22. Dairy Creek Effective Shade Surrogate Measure for Non -Point Sources

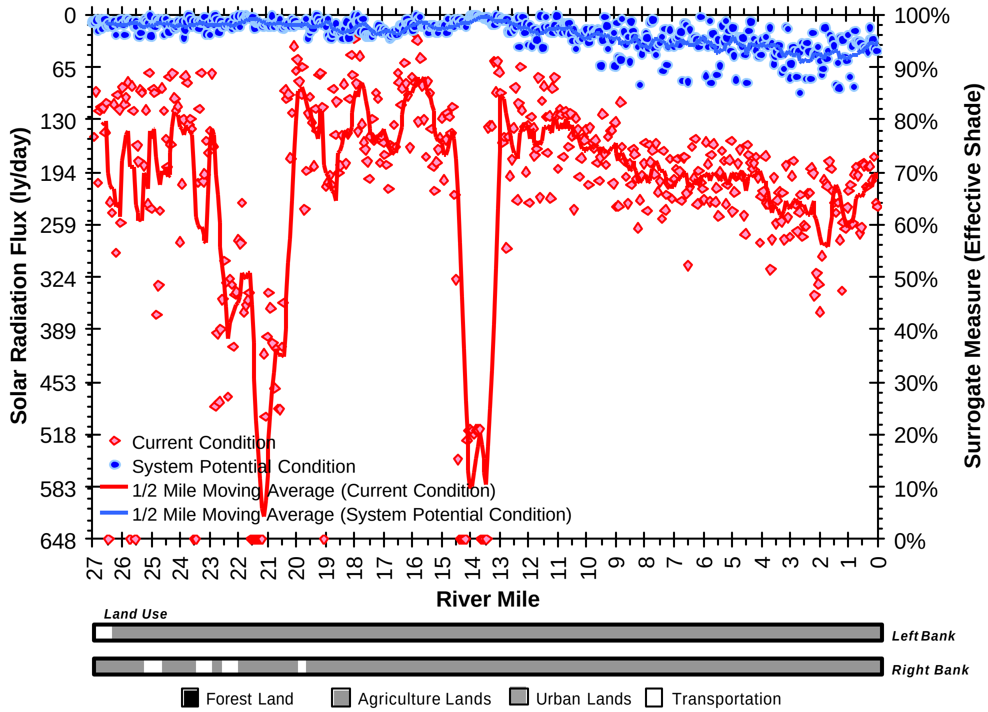


Figure 23. McKay Creek Effective Shade Surrogate Measure for Nonpoint Sources

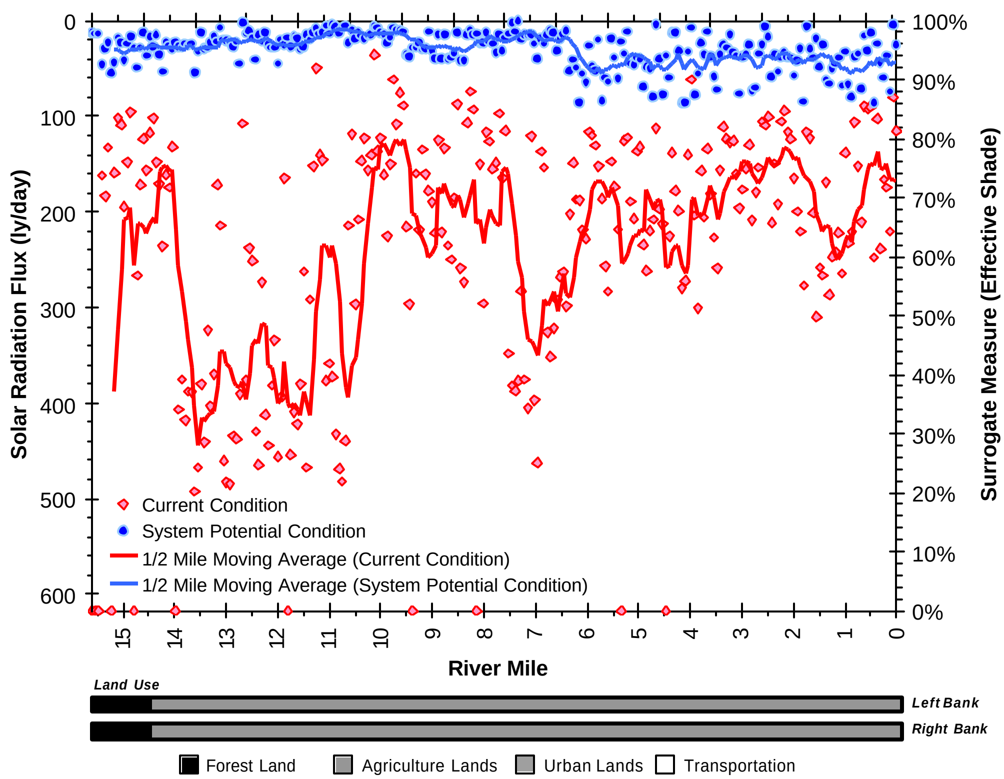


Figure 24. Rock and Beaverton Cr. Effective Shade Surrogate Measure for Nonpoint Sources

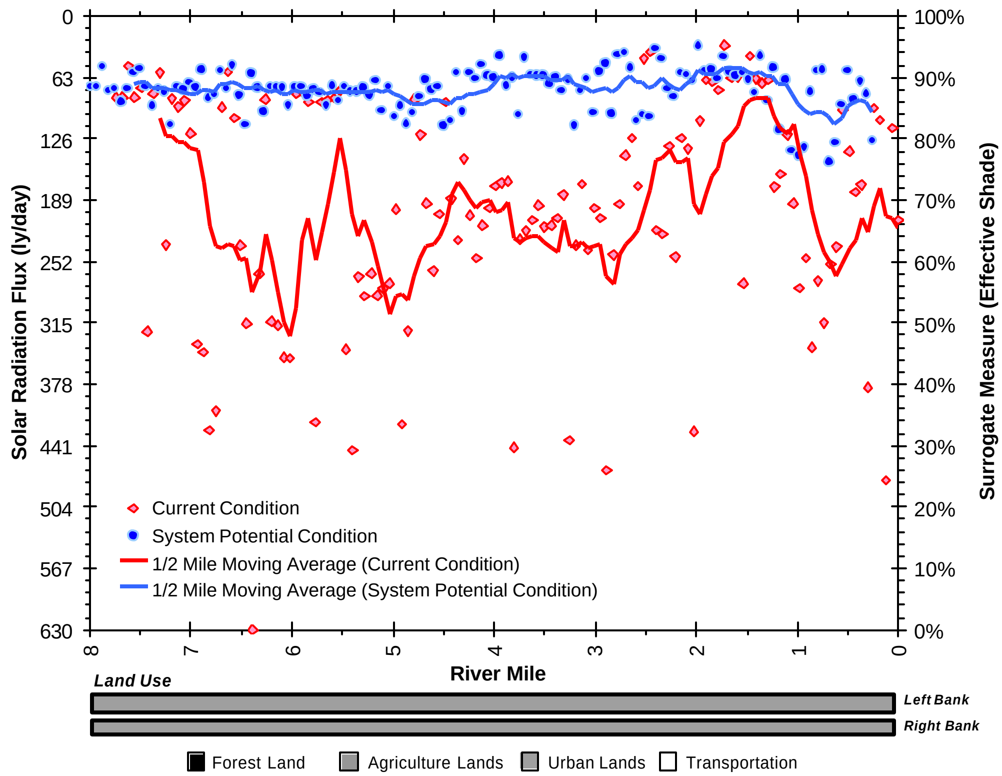
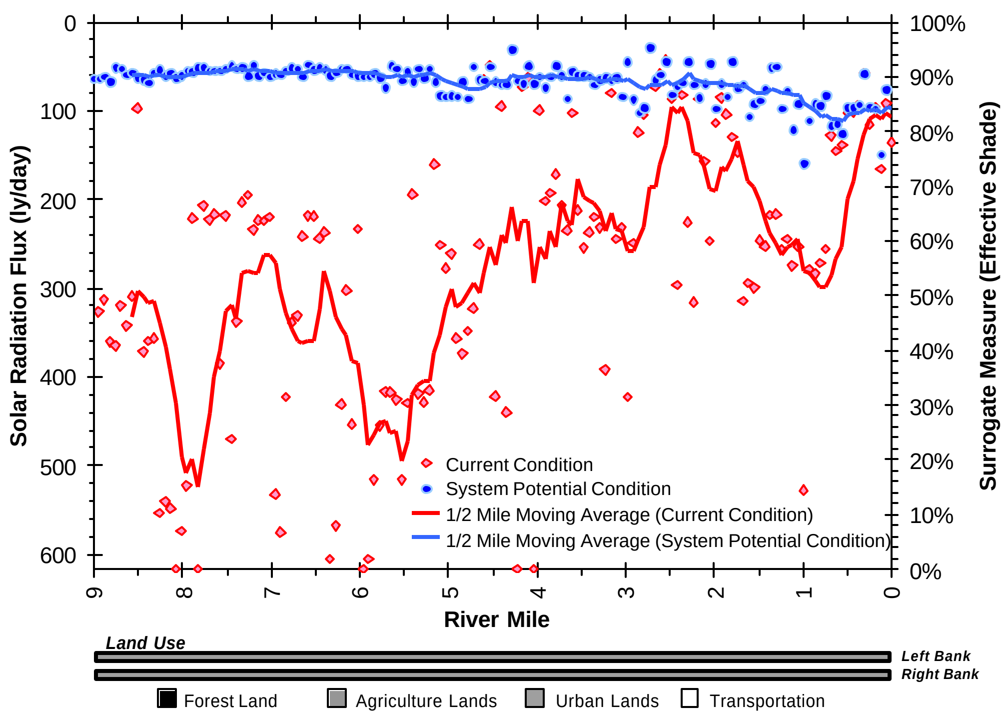


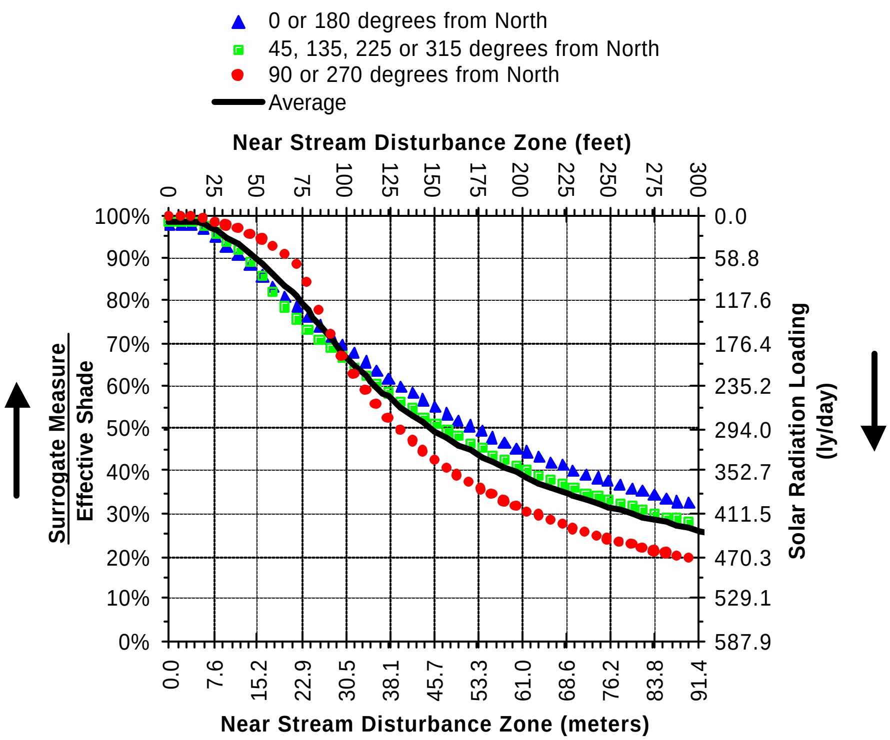
Figure 25. Fanno Creek Effective Shade Surrogate Measure for Nonpoint Sources



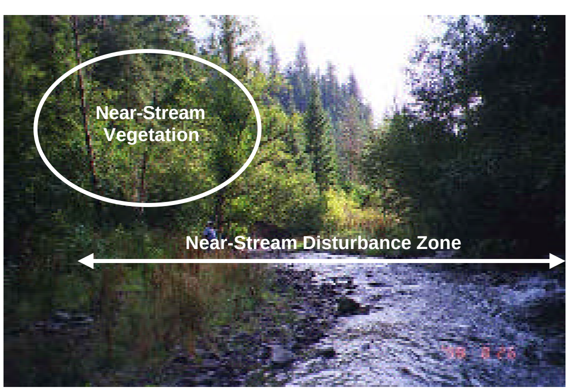
4.1.8.2 EFFECTIVE SHADE CURVES - SURROGATE MEASURES

Where specific effective shade levels are not specified in **Figures 19** to **25**, effective shade for the appropriate ecoregion (described in **Table 6**) and near stream disturbance zone width[++] are provided in **Figures 26** to **29**.

Figure 26. Effective Shade Curve - Applicable in Willamette Valley Prairie Terraces



[++] Near-Stream Disturbance Zone (NSDZ) is defined for purposes of the TMDL as the width between shade-producing near-stream vegetation. This dimension was measured from Digital Orthophoto Quad (DOQ) images and where near-stream vegetation was absent, the near-stream boundary was used, as defined as armored stream banks or where the near-stream zone is unsuitable for vegetation growth due to external factors (i.e., roads, railways, buildings, etc.).



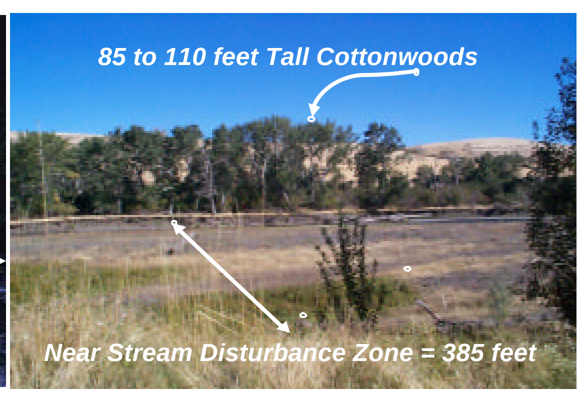


Figure 27. Effective Shade Curve - Applicable in Willamette Valley Foothills

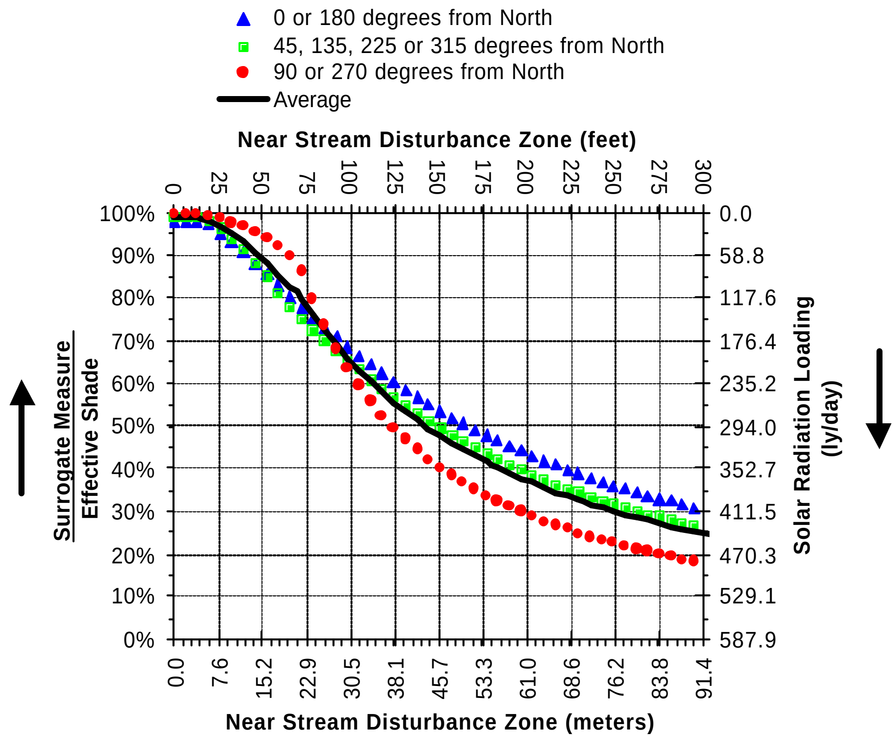


Figure 28. Effective Shade Curve - Applicable in Coast Range Willapa

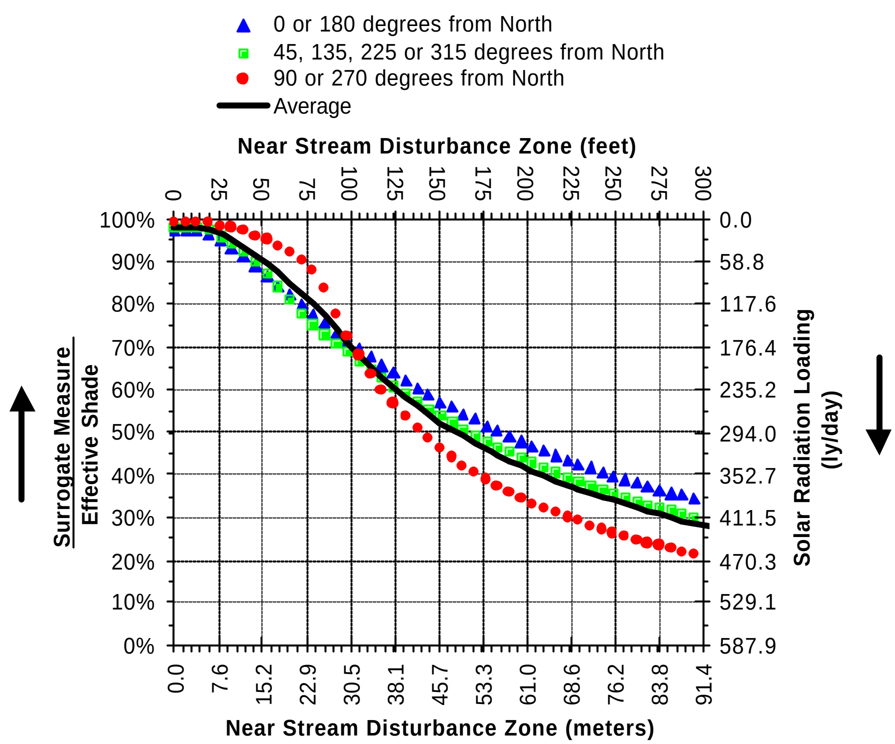
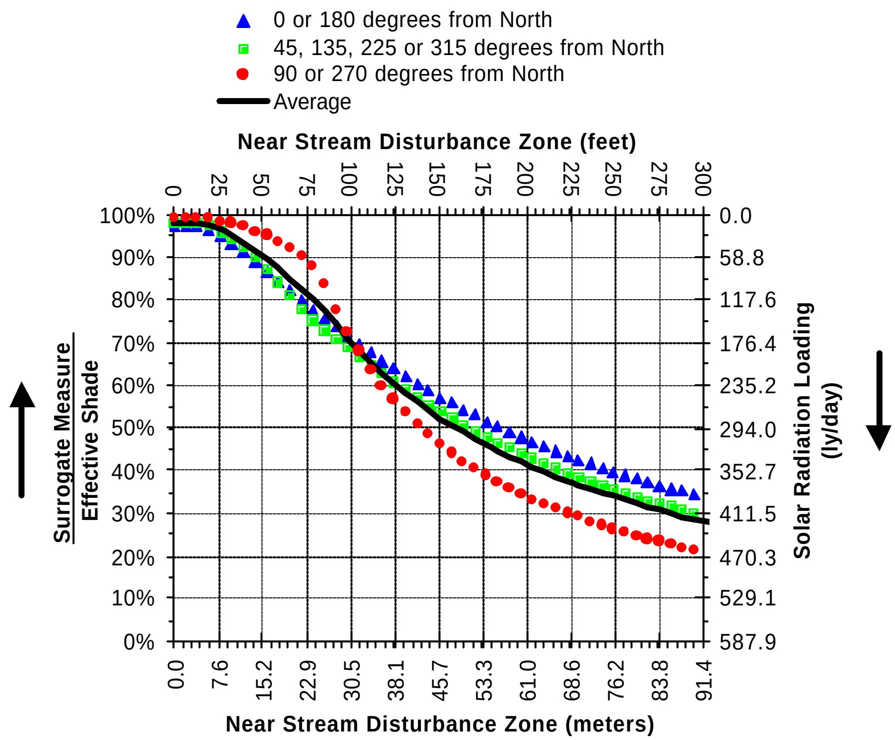


Figure 29. Effective Shade Curve - Applicable in Coast Range Volcanics



4.1.9 MARGINS OF SAFETY – CWA §303(D)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A MOS is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The MOS may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the MOS documented. The MOS is not meant to compensate for a failure to consider known sources. **Table 11** presents six approaches for incorporating a MOS into TMDLs.

Table 11. Approaches for Incorporating a Margin of Safety into a TMDL	
Type of Margin of Safety	*Available Approaches*
Explicit	1. Set numeric targets at more conservative levels than analytical results indicate. 2. Add a safety factor to pollutant loading estimates. 3. Do not allocate a portion of available loading capacity; reserve for MOS.
Implicit	1. Conservative assumptions in derivation of numeric targets. 2. Conservative assumptions when developing numeric model applications. 3. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

The following factors may be considered in evaluating and deriving an appropriate MOS:

- ✓ *The analysis and techniques used in evaluating the components of the TMDL process and deriving an allocation scheme.*
- ✓ *Characterization and estimates of source loading (e.g., confidence regarding data limitation, analysis limitation or assumptions).*
- ✓ *Analysis of relationships between the source loading and instream impact.*
- ✓ *Prediction of response of receiving waters under various allocation scenarios (e.g., the predictive capability of the analysis, simplifications in the selected techniques).*
- ✓ *The implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.*

A TMDL and associated MOS, which results in an overall allocation, represents the best estimate of how standards can be achieved. The selection of the MOS should clarify the implications for monitoring and implementation planning in refining the estimate if necessary (adaptive management). The TMDL process accommodates the ability to track and ultimately refine assumptions within the TMDL implementation-planning component.

4.1.9.1 IMPLICIT MARGINS OF SAFETY

Description of the MOS for the Tualatin River Subbasin Temperature TMDL begins with a statement of assumptions. A MOS has been incorporated into the temperature assessment methodology. Conservative estimates for groundwater inflow and wind speed were used in the stream temperature simulations. Specifically, unless measured, groundwater inflow was assumed to be zero. In addition, wind speed was also assumed to be at the lower end of recorded levels for the day of sampling. Recall that groundwater directly cools stream temperatures via mass transfer/mixing. Wind speed is a controlling factor for evaporation, a cooling heat energy process. Further, cooler microclimates and channel morphology changes associated with late seral conifer riparian zones were not accounted for in the simulation methodology.

Calculating a numeric MOS is not easily performed with the methodology presented in this document. In fact, the basis for the loading capacities and allocations is the definition of system potential conditions. It is illogical to presume that anything more than system potential riparian conditions are possible, feasible or reasonable.

4.1.11 WATER QUALITY STANDARD ATTAINMENT ANALYSIS – CWA §303(D)(1)

The temperature TMDL and the temperature water quality standards are achieved when (1) nonpoint source solar radiation loading is representative of a riparian vegetation condition without human disturbance and (2) point source discharges cause no measurable temperature increases (as defined in the temperature standard) in surface waters.

*Stream temperatures (displayed in **Figures 30** to **37**) that result from the system potential conditions represent attainment of the temperature standard **(no measurable surface water temperature increase resulting from anthropogenic activities)**.*

Simulations were performed to calculate the temperatures that result with the allocated measures that form the basis for the factors that represent the system potential condition with ***no measurable surface water temperature increase resulting from anthropogenic activities***. The resulting simulated temperatures represent attainment of system potential, and therefore, attainment of the temperature standard.

A total of 186.2 river miles in Gales Creek, East Fork Dairy Creek, West Fork Dairy Creek, McKay Creek, Dairy Creek, Rock Creek, Beaverton Creek, Fanno Creek and the Tualatin River were analyzed and simulated during the critical period (July 27 to July 30, 1999). **Figure 30** compares the current Tualatin River Subbasin maximum daily temperatures with those that result with system potential conditions. Generally speaking, the Tualatin River and tributaries currently experience critical condition maximum daily temperatures in the mid-60^{o}F to low 70^{o}F range. Under the allocated system potential condition, maximum daily temperatures shifted to the mid-50^{o}F to low 60^{o}F range. In 1999, 76% of the stream network had critical condition maximum daily temperatures greater than 64^{o}F. Under the system potential, 2.6% of the stream network experience maximum daily temperatures greater than 64^{o}F.

Figure 30. Distributions of Daily Maximum Temperatures for Current Conditions and the Allocated System Potential *(July 27 to July 30, 1999)*

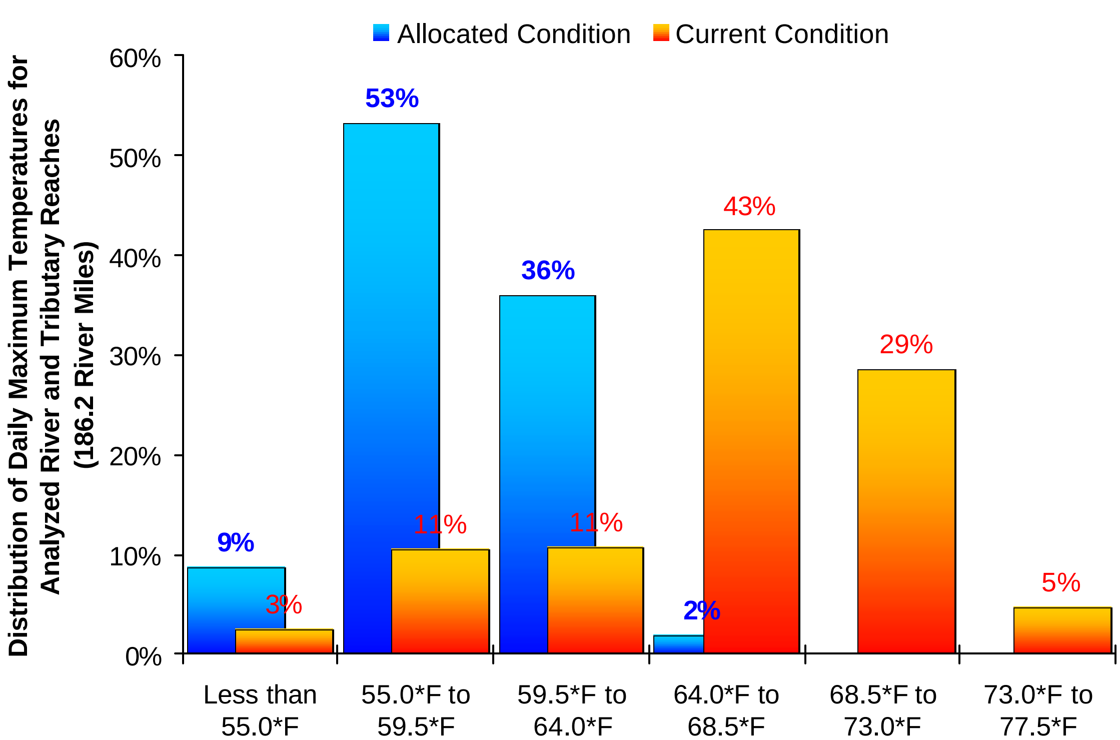


Figure 31. Tualatin River Diurnal Temperatures - Current Conditions and Allocated Condition
(July 27, 1999)

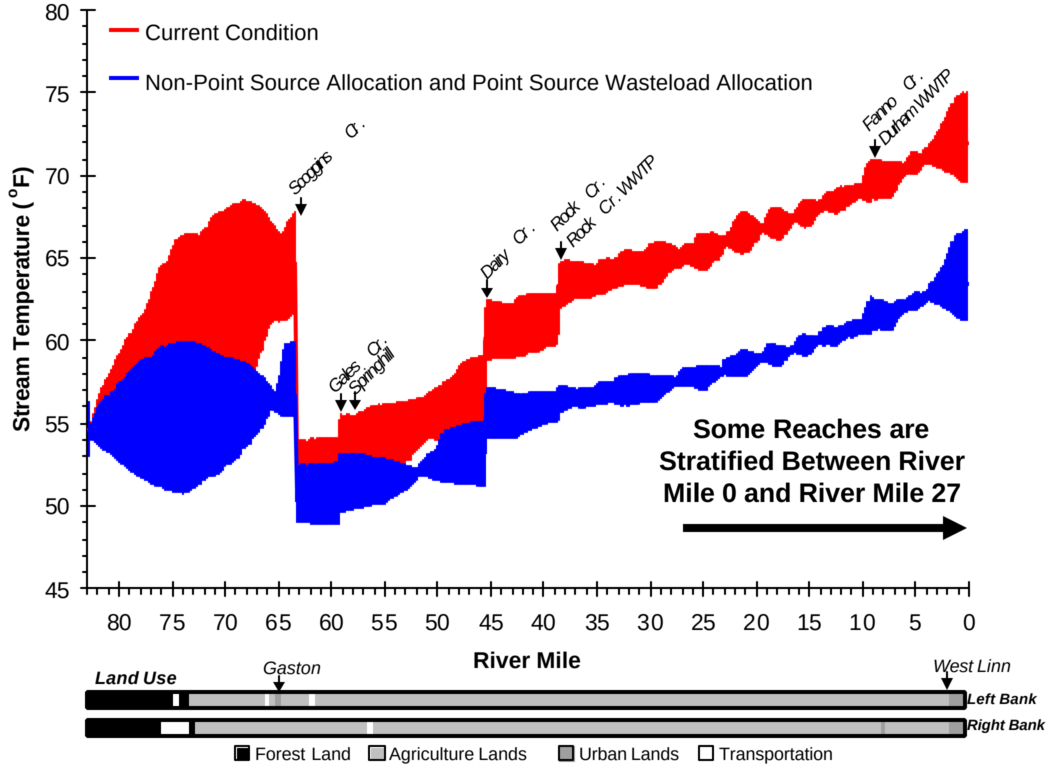


Figure 32. Gales Creek Diurnal Temperatures - Current Conditions and Allocated Condition
(July 28, 1999)

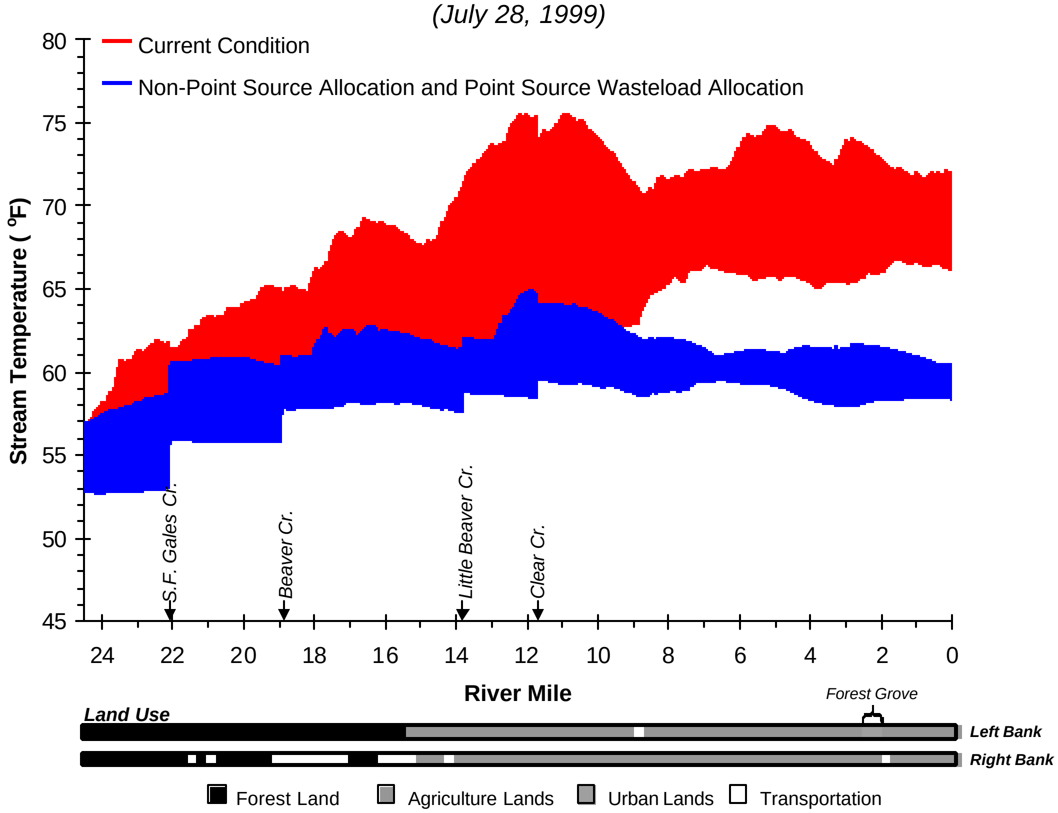


Figure 33. McKay Creek Diurnal Temperatures - Current Conditions and Allocated Condition
(July 28, 1999)

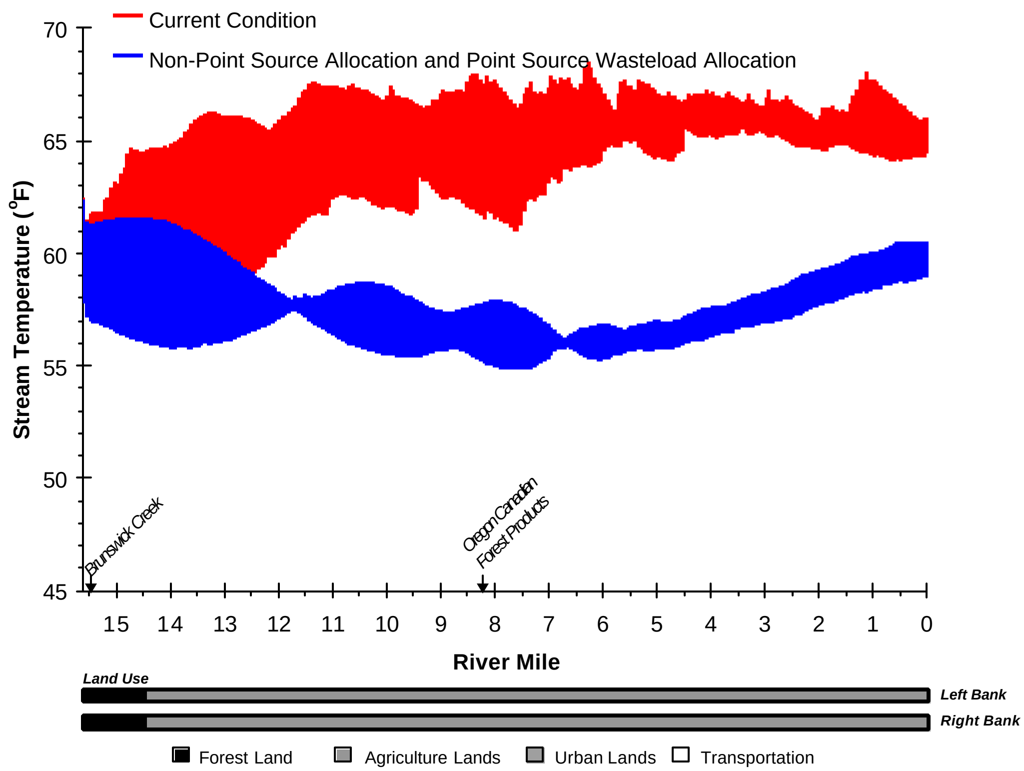


Figure 34. E.F. Dairy Creek Diurnal Temperatures - Current Conditions and Allocated Condition
(July 28, 1999)

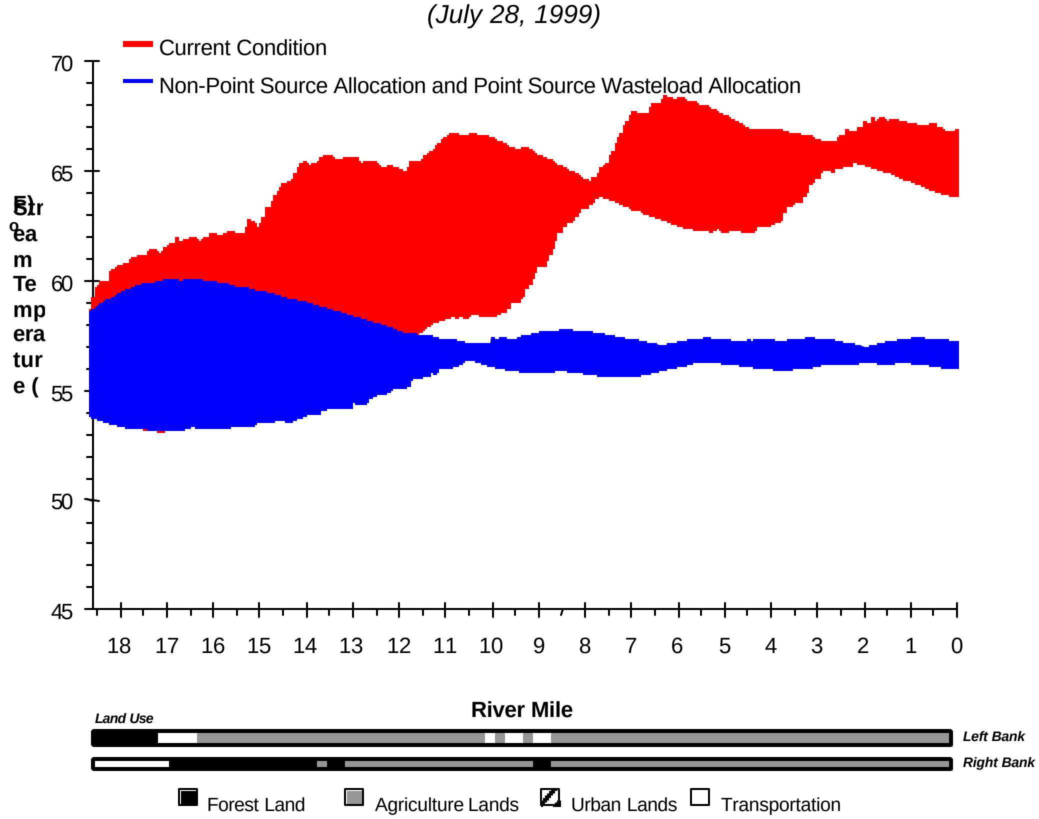


Figure 35. Dairy Creek Diurnal Temperatures - Current Conditions and Allocated Condition
(July 28, 1999)

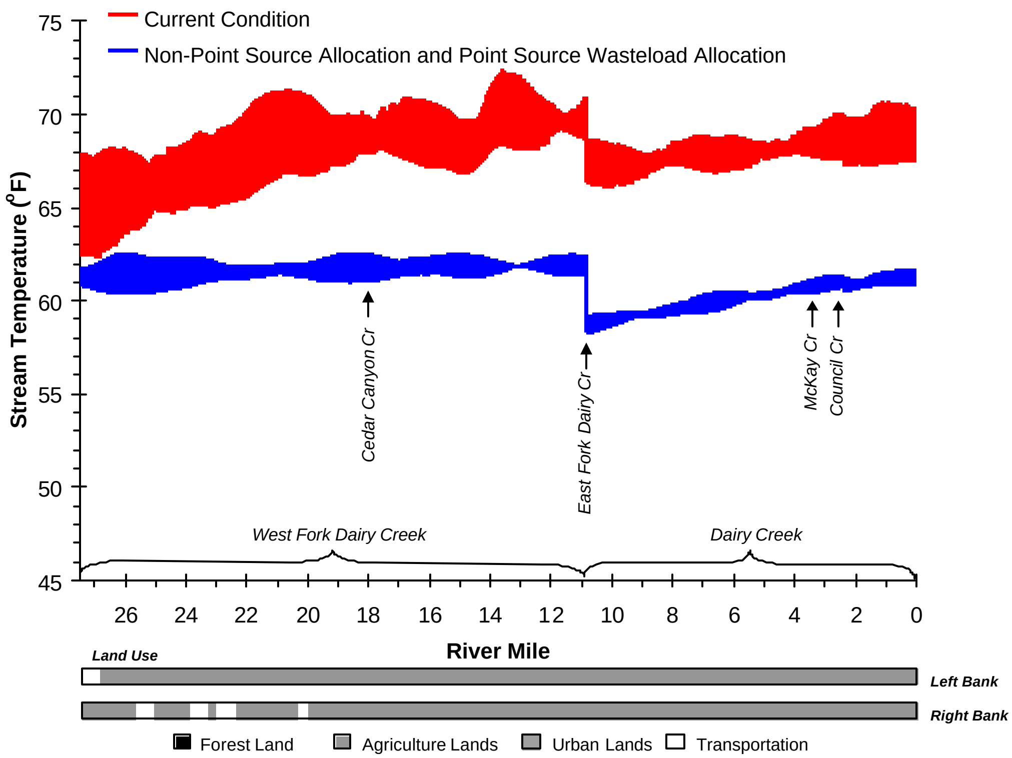


Figure 36. Beaverton Creek and Rock Creek Diurnal Temperatures - Current Conditions and Allocated Condition
(July 30, 1999)

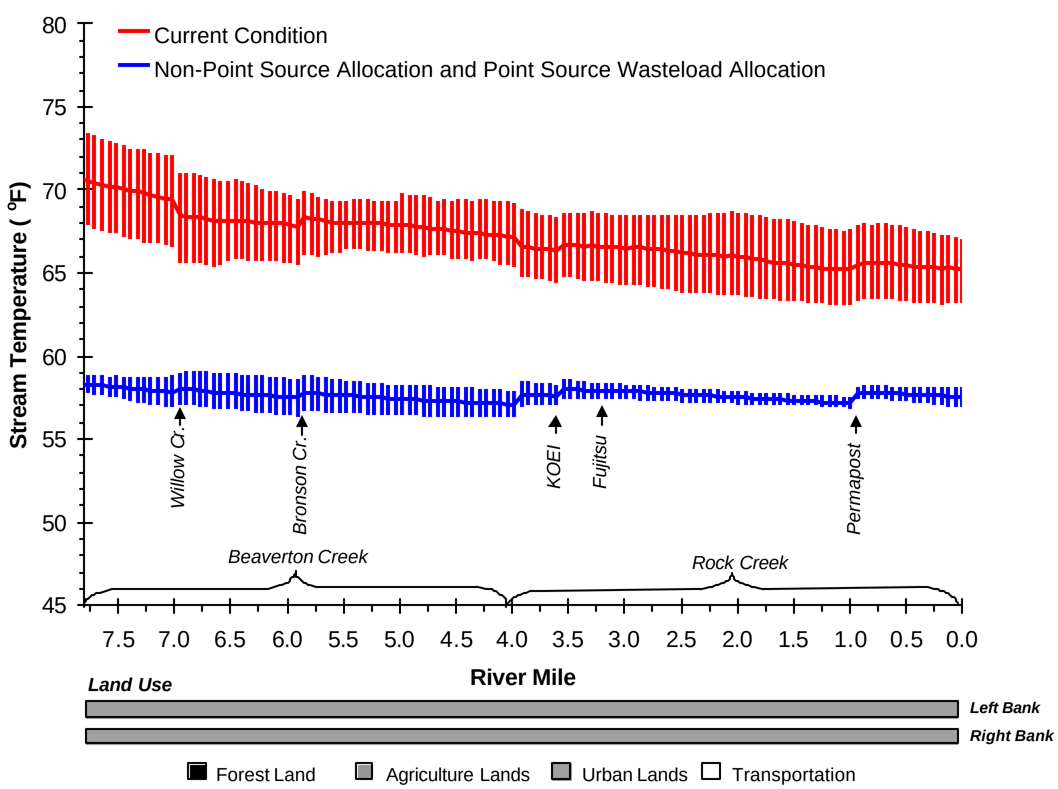
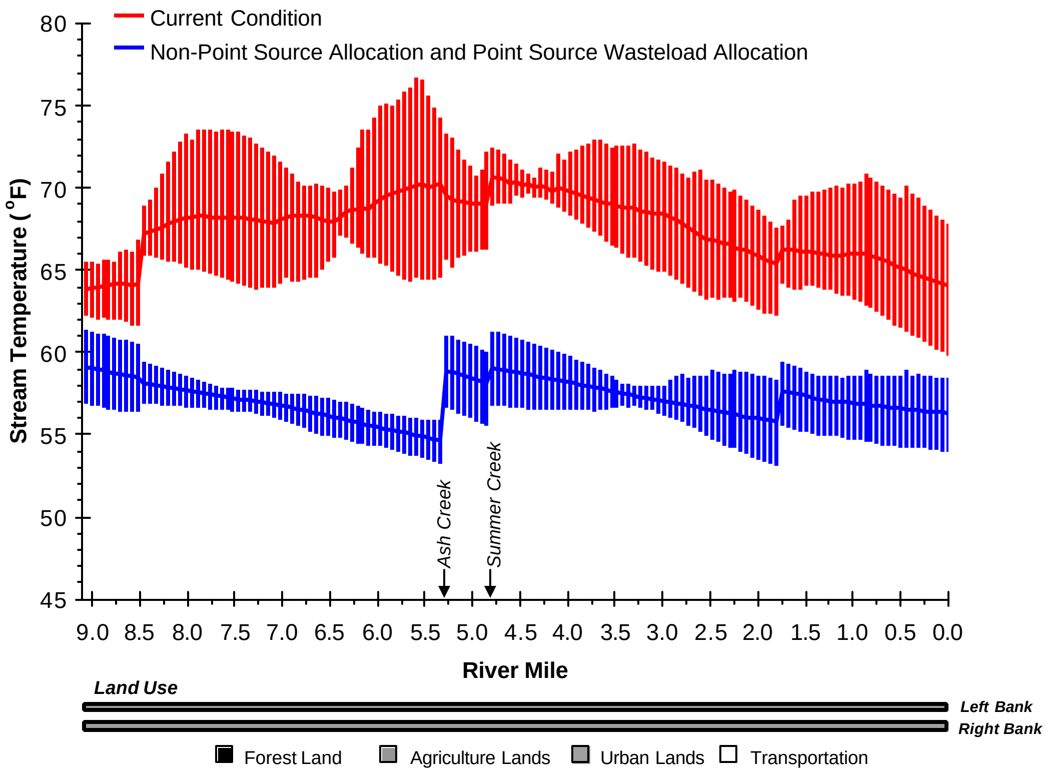


Figure 37. Fanno Creek Diurnal Temperatures - Current Conditions and Allocated Condition
(July 29, 1999)



4.2 BACTERIA TMDL

Table 12. Tualatin River Subbasin Bacteria TMDL Components	
WATERBODIES	All stream segments within the 4th field HUC (hydrologic unit code) 17090010.
POLLUTANT IDENTIFICATION	*Pollutants:* Human caused bacteria increases due to bacteria-laden runoff and other discharges.
TARGET IDENTIFICATION (APPLICABLE WATER QUALITY STANDARDS) *CWA §303(D)(1)*	**OAR 340-41-445 (2)(E):** (A) Numeric Criteria: Organisms of the coliform group commonly associated with fecal sources (MPN or equivalent membrane filtration using a representative number of samples) shall not exceed the criteria described in subparagraphs (i) and (ii) of this paragraph. Freshwaters and Estuarine Waters: (i) A 30-day log mean of 126 E. coli organisms per 100 ml, based on a minimum of five (5) samples; (ii) No single sample shall exceed 406 E. coli organisms per 100 ml. (Various other standards also apply as indicated in the bacteria section.)
EXISTING SOURCES *CWA §303(D)(1)*	Forestry, Agriculture, Transportation, Rural Residential, Urban, Industrial Discharge, Waste Water Treatment Facilities
SEASONAL VARIATION *CWA §303(D)(1)*	Violations of the bacteria standard occur throughout the year.
TMDL LOADING CAPACITY AND ALLOCATIONS *40 CFR 130.2(F)* *40 CFR 130.2(G)* *40 CFR 130.2(H)*	*Loading Capacity:* Due to the variable concentrations during storms, the loading capacity during runoff events is based on a log mean of 126 E. coli organisms per 100 ml. During non-runoff events the loading capacity is based on both the log mean and the single sample criteria. *Waste Load Allocations (Point Sources) and Load Allocations (Non-Point Sources):* Please see Tables 17 – 23
MARGINS OF SAFETY *CWA §303(D)(1)*	Margins of Safety demonstrated in critical condition assumptions and is inherent to methodology
WATER QUALITY STANDARD ATTAINMENT ANALYSIS *CWA §303(D)(1)*	• Analytical modeling of TMDL loading capacities demonstrates attainment of water quality standards
PUBLIC NOTICE *40 CFR 25*	Conducted by Oregon Department of Environmental Quality

4.2.1 BENEFICIAL USES

Oregon Administrative Rules (OAR Chapter 340, Division 41) lists the "Beneficial Uses" occurring within the Tualatin River Subbasin (**Table 13**). Numeric and narrative water quality standards are designed to protect the most sensitive beneficial uses. Water contact recreation is the most sensitive beneficial use related to bacteria in the Tualatin River Subbasin.

Table 13. Beneficial uses occurring in the Tualatin River Subbasin
(OAR 340 – 41 – 0442)Bacteria-sensitive beneficial uses are marked in gray

Beneficial Use	*Occurring*	*Beneficial Use*	*Occurring*
Public Domestic Water Supply	✓	Salmonid Fish Spawning (Trout)	✓
Private Domestic Water Supply	✓	Salmonid Fish Rearing (Trout)	✓
Industrial Water Supply	✓	Resident Fish and Aquatic Life	✓
Irrigation	✓	Anadromous Fish Passage	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Hydro Power	✓	Water Contact Recreation	✓
Aesthetic Quality	✓	Commercial Navigation & Transportation	

4.2.2 APPLICABLE WATER QUALITY STANDARDS

Table 14 summarizes the bacteria criteria for the Tualatin Subbasin. The beneficial use affected by elevated bacteria levels is primarily water contact recreation.

Table 14. Bacteria Criteria

Beneficial Use	Reference	Description
Recreational Contact in Freshwater	Historic	Prior to July 1, 1995: a geometric mean of five fecal coliform samples should not exceed 200 colonies per 100 mls, and no more than 10% should exceed 400 colonies per 100 mls. From July 1, 1995 to January 11, 1996: A geometric mean of 33 enterococci per 100 milliliters based on no fewer than five samples, representative of seasonal conditions, collected over a period of at least 30 days. No single sample should exceed 61 enterococci per 100 ml.
	Current - OAR 340-41-445 (2)(e)(A):	Effective January 11, 1996 through present: a 30-day log mean of 126 *E. Coli* organisms per 100 ml, based on a minimum of five samples; and no single sample shall exceed 406 *E. Coli* organisms per 100 ml.

Additional conditions in the State water quality standards pertinent to this Bacteria TMDL are as follows:

OAR 340-41-445 (2)(e)(B)

Raw Sewage Prohibition: No sewage shall be discharged into or in any other manner be allowed to enter the waters of the State unless such sewage has been treated in a manner approved by DEQ or otherwise allowed by these rules.

OAR 340-41-445 (2)(e)(C)

Animal Waste: Runoff contaminated with domesticated animal wastes shall be minimized to the maximum extent practicable before it is allowed to enter waters of the State.

OAR 340-41-445 (2)(f):

Bacterial pollution or other conditions deleterious to waters used for domestic purposes, livestock watering, irrigation, bathing, or shellfish propagation, or otherwise injurious to public health shall not be allowed.

OAR 340-41-026 (3)(a)(I):

In waterbodies designated by DEQ as water quality limited for bacteria, and in accordance with priorities established by DEQ, development and implementation of a bacteria management plan shall be required of those sources that DEQ determines to be contributing to the problem. DEQ may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited subbasin based on the contribution of the segment(s) to the problem. The bacteria management plans will identify the technologies, BMPs and/or measures and approaches to be implemented by point and non-point sources to limit bacterial contamination. For point sources, their National Pollutant Discharge Elimination System permit is their bacteria management plan. For non-point sources, the bacteria management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures and approaches.

4.2.3 303(D) LISTED STREAM SEGMENTS

Section 303(d) of the Federal Clean Water Act (1972) requires that water bodies that violate water quality standards, thereby failing to fully protect beneficial uses, be identified and placed on the state's 303(d) list. Twenty-six streams in the Tualatin Subbasin have been placed on the Oregon Department of Environmental Quality's (DEQ) 1998 303(d) list for bacteria. These waterbodies were evaluated based on *Escherichia coli (E. coli), Enterococci*, or fecal coliform data. Fecal coliform was the bacterial water quality standard prior to July 1, 1995, *Enterococci* was the standard from July 1, 1995 to January 11, 1996, and *E. coli* has been the bacterial water quality standard since January 11, 1996. High levels of bacteria limit the use of streams and river for swimming and other water contact recreation. **Figure 38** shows the stream segments listed on the 1998 303(d) list for elevated bacteria levels. **Table 15** lists the water quality limited streams.

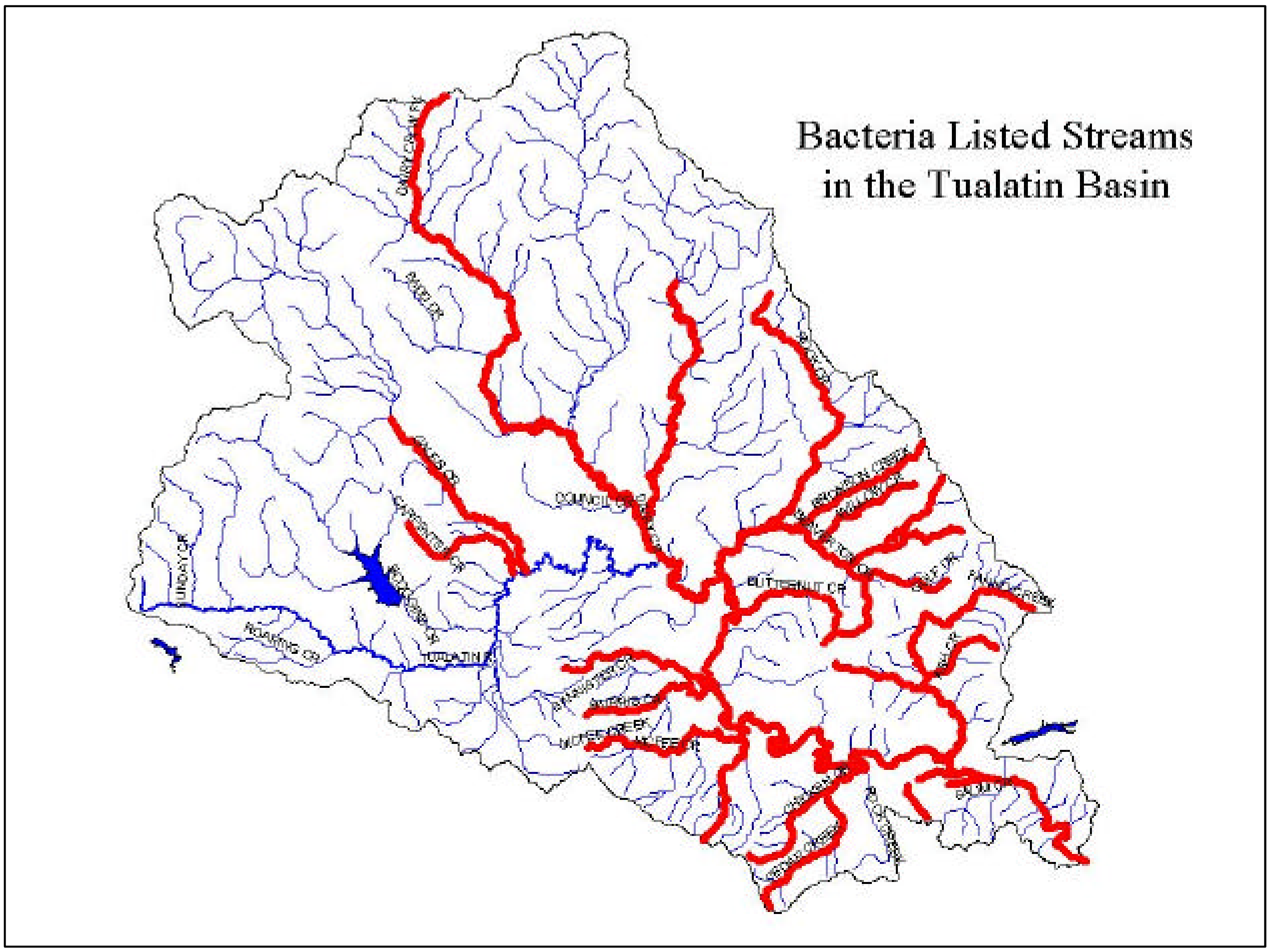


Figure 38. Water Quality Limited Streams- Bacteria

Table 15. Tualatin River Subbasin Bacteria Impaired Stream Segments			
Segment[10]	**Tributary To:**	**Listing Criterion[11]**	**Season of Violation**
Ash Ck.	Fanno Ck.	Fecal Coliform	All Year
Beaverton Ck.	Rock Ck.	E. coli	All Year
Bronson Ck.	Beaverton/Rock	E. coli	All Year
Burris Ck.	Tualatin R.	Fecal Coliform	All Year
Butternut Ck.	Tualatin R.	Fecal Coliform	All Year
Carpenter Ck.	Tualatin R.	E. coli	Summer
Cedar Ck.	Chicken Ck.	Fecal Coliform	All Year
Cedar Mill Ck.	Beaverton/Rock	Fecal Coliform	All Year
Chicken Ck.	Tualatin R.	E. coli	All Year
Christenson Ck.	Tualatin R.	Fecal Coliform	All Year
Dairy Ck. (Mouth to E/W Forks)	McKay Ck.	E. coli	All Year
Dairy Ck., West Fork	M/S Dairy Ck.	E. coli	Summer
Fanno Ck.	Tualatin R.	E. coli	All Year
Gales Ck. (Mouth to Clear Ck.)	Tualatin R.	E. coli	Summer
Hall Ck.	Beaverton Ck.	Fecal Coliform	All Year
Heaton Ck.	McFee Ck.	Fecal Coliform	All Year
Hedges Ck.	Tualatin R.	E. coli	All Year
Johnson Ck.-North	Cedar Mill Ck.	Fecal Coliform	All Year
Johnson Ck.-South	Beaverton Ck.	E. coli	All Year
McFee Ck.	Tualatin R.	Fecal Coliform	All Year
McKay Ck. (Mouth to E. Fork)	Tualatin R.	E. coli	All Year
Nyberg Ck.	Tualatin R.	Enterococci	All Year
Rock Ck.	Tualatin R.	E. coli	All Year
Summer Ck.	Fanno Ck.	Fecal Coliform	All Year
Tualatin R. (Mouth to Dairy Ck.)	Willamette	E. coli	All Year
Willow Ck.	Beaverton Ck.	Fecal Coliform	All Year

4.2.4 AVAILABLE MONITORING DATA

Bacteria data in the Tualatin Subbasin has been collected at numerous ambient water quality stations by DEQ, USGS, USA and the other designated management agencies (DMAs). In addition to regularly scheduled ambient water quality monitoring, the USGS and USA have conducted synoptic wet weather and dry weather bacteria studies on Fanno Creek. As part of their Stormwater NPDES permit, the DMAs have also collected stormwater bacteria samples both instream and from runoff of characteristic land uses in their service areas.

In addition to the change in the type of organisms measured (from fecal coliform to E. coli), the method of fecal coliform bacteria analysis has changed over time. Some samples were analyzed using the *Most Probable Number* (MPN) technique and some analyzed using *the membrane filtration* technique. According to *Bacterial Indicators of Pollution* (Pipes, 1982), "the differences between MPN estimates and MF counts were not of any practical significance mainly because of the inherently low degree of reproducibility of the MPN estimates". In the data analyses, samples analyzed using both techniques have been grouped together.

[10] Mouth to headwaters (unless otherwise noted)

[11] The "listing criterion" is the bacteria criterion from Table 13 (above) for which the water body had exceedances. (E.g., since "Fecal Coliform" is listed as the "listing criterion" for Summer Creek, exceedances of the fecal coliform criterion are what warranted the creek's placement on the 303(d) list.)

4.2.5 SEASONAL VARIATION AND WATER QUALITY ASSESSMENT

The assessment of the water quality related to bacteria has been broken down into two seasons: summer (June 1 to September 30), which is the period of highest use for water contact recreation; and fall-winter-spring (October 1 – May 31). These seasons also correspond to the seasonal listing of stream segments on the 303(d) list.

For the box plots below, only data sets for E. coli were used since these include the most recent data and correspond to the current bacteria criteria. USA generally began E. coli analyses in 1993 and DEQ began E. coli analyses at the end of 1995. These box plots are compared to the water quality criterion of 406 E. coli organisms per 100 ml (shown as a dashed line on the plots) since the data used to generate the plots were generally biweekly grab samples. There is not sufficient data (at least 5 per 30-day period) to compare with the 30-day log mean criterion (see **Table 14**).

4.2.5.1 MAINSTEM TUALATIN RIVER

The first two figures with box plots[12] show longitudinal trends for the mainstem of the Tualatin River and are based on USA data (the USA data set contains considerably more data points than the DEQ data set). **Figure 39** includes data from the summer season, while the data used in **Figure 40** are for the fall-winter-spring season. For reference, **Table 16** includes a listing of significant tributaries and features by river mile.

As noted in **Table 15**, the segment of the Tualatin River from the mouth to Dairy Creek was listed for exceedances of the bacteria criteria. **Figures 39 and 40** show more specifically where these exceedances are occurring.

Table 16. Significant Mainstem Tributaries and Features by River Mile

	River Mile
Lake Oswego Corp. Diversion Dam	3.4
Fanno Creek and Durham WWTP	9.3
Rock Creek South	15.2
Chicken Creek	15.5
McFee Creek	28.2
Rock Cr. and Rock Cr. WWTP	38.1
Dairy Creek	44.7
Gales Creek	56.8
Scoggins Creek	60
Cherry Grove	67.8

[12] For an explanation of how to read the box plots, see Appendix D-2.

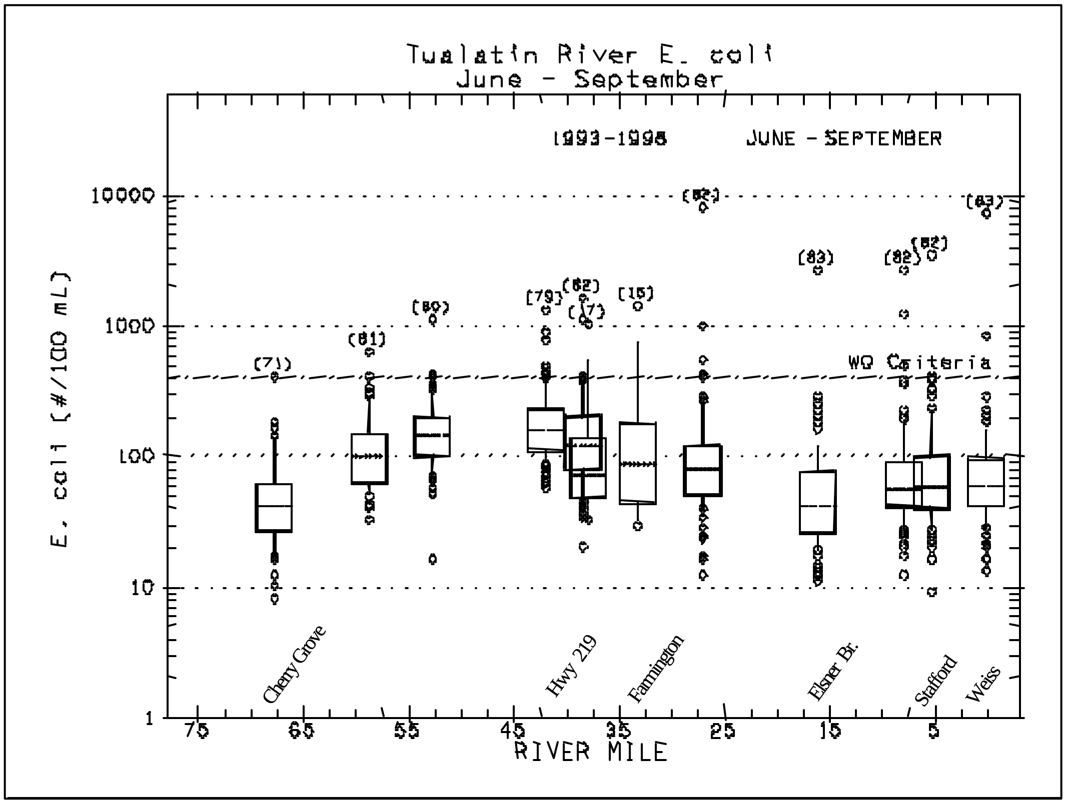


Figure 39. Tualatin River E. coli Concentrations June – September (1993-98)

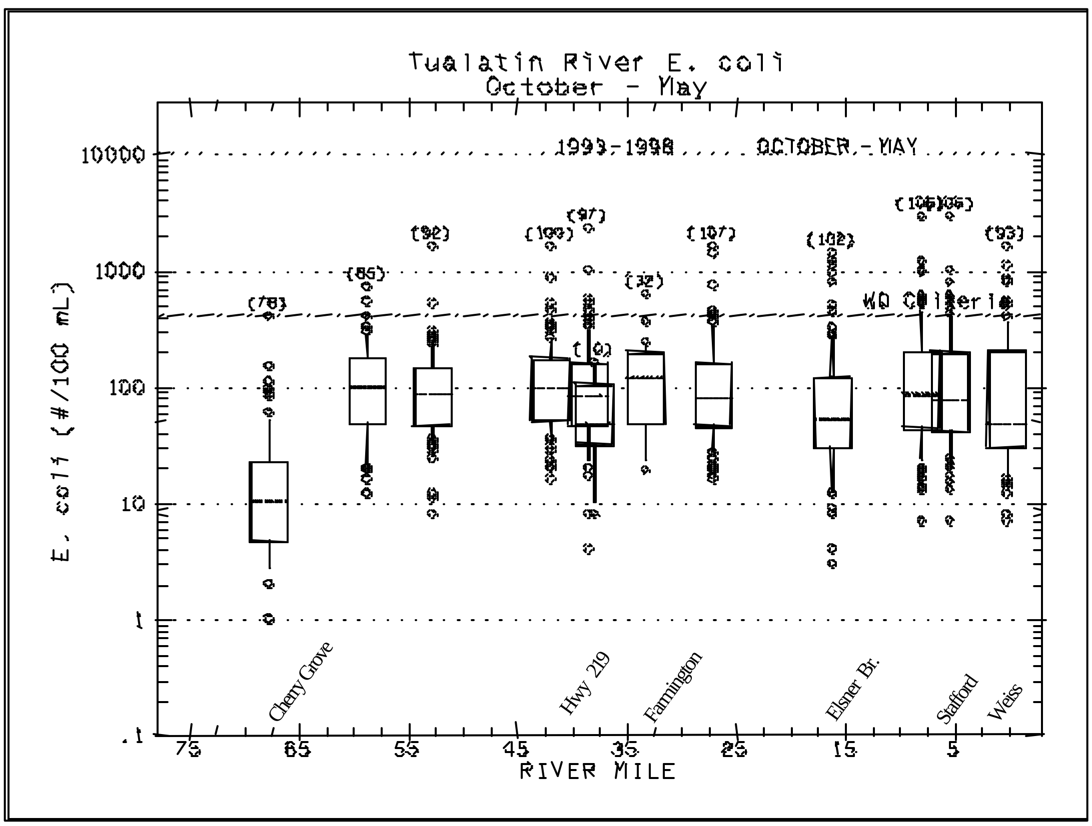


Figure 40. Tualatin River E. coli Concentrations October - May (1993-98)

An examination of **Figures 39 and 40** reveals that:

- All of the mainstem median E. Coli levels are below the water quality criterion of 406 organisms/100ml (the median is the value below which 50% of the samples fall).
- For the summer season (**Figure 39)** 9 of the 12 stations had 90% or more of the samples measuring below the criterion.
- For the fall-winter–spring season (**Figure 40**) 10 of the 12 stations had 90% or more of the samples measuring below the criterion.
- Comparisons between Figure 39 and Figure 40 shows no large variation in E. coli concentrations between the two seasons.

The data on the mainstem Tualatin River show that the water is close to meeting the water quality standard for bacteria. However, at almost every station samples have exceeded 1000 counts of E. coli per 100 mL. In addition, at several stations the standard is exceeded approximately ten percent of the time for one of more of the examined periods.

4.2.5.2 TRIBUTARIES

Figures 41 through 44 below contain seasonal box plots for two tributary streams in the subbasin. These plots are based on USA data for 1993 through 1998. **Figures 41 and 42** are seasonal box plots for Fanno Creek, a tributary stream draining a lower portion of the Tualatin Subbasin. Fanno Creek exhibits the elevated bacteria levels that are typical of a highly urbanized stream. During the summer season the median values for all of the Fanno Creek monitoring stations are at or above the criterion. During the fall/winter/spring season four of the six stations have median values at or above the criterion.

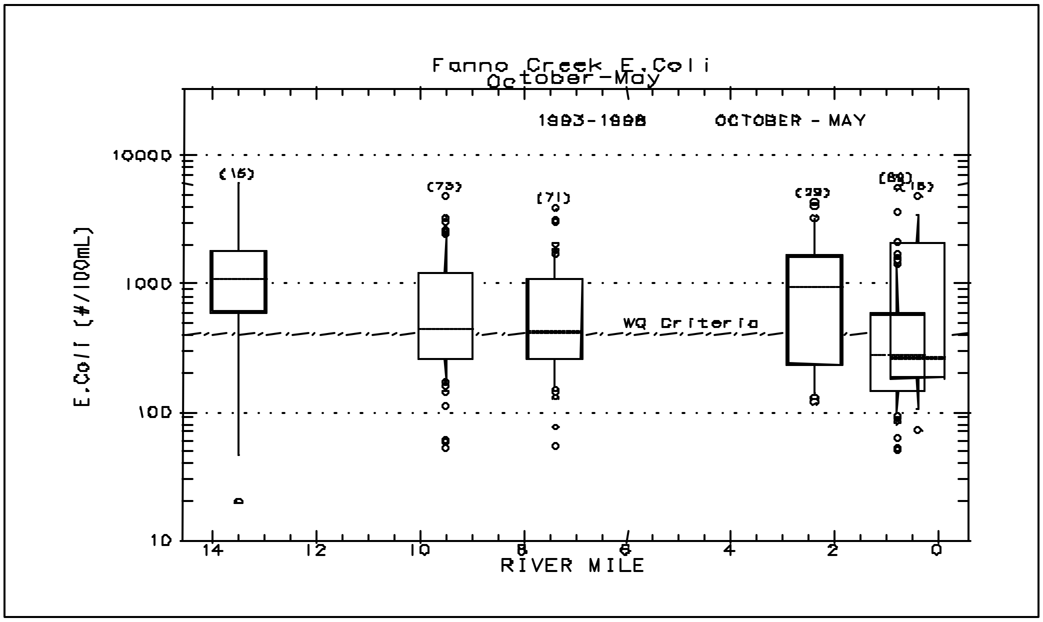


Figure 41. Fanno Creek E. coli Concentrations October - May (1993-98)

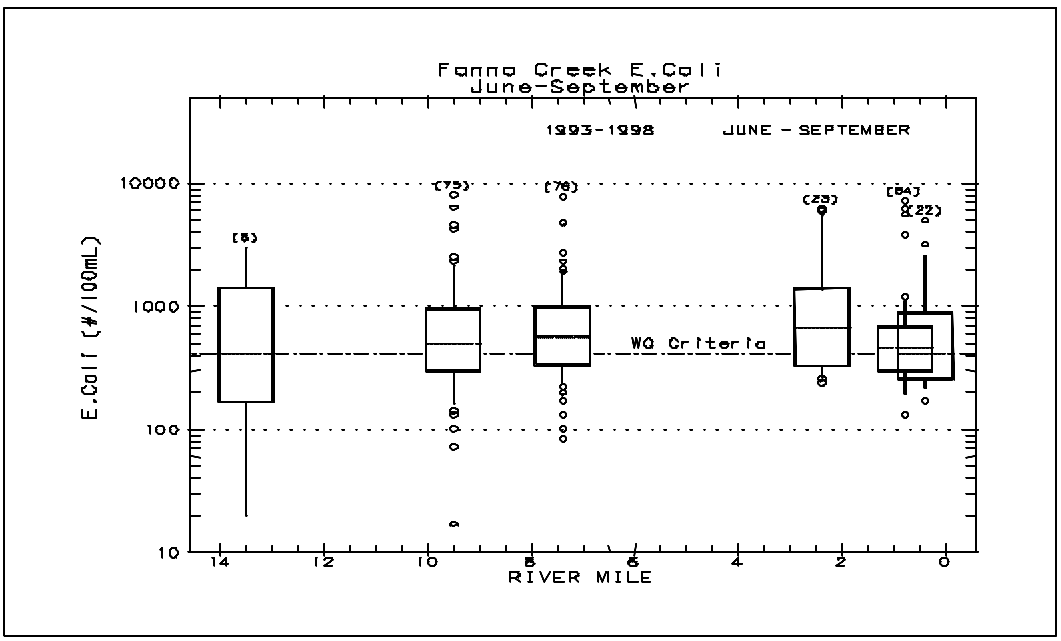


Figure 42. Fanno Creek E. coli Concentrations June – September (1993-98)

Figures 43 and 44 are seasonal box plots for Dairy Creek at river mile 2.0. These bacteria levels are typical of the forested/agricultural streams in the subbasin. At least 75% of the samples taken at this monitoring site, near the mouth of the creek, were below the bacteria criterion. As is typical of most monitoring sites in the subbasin, the winter median concentration is lower than the summer medians. The bacteria levels in Dairy Creek are also substantially lower than those observed in Fanno Creek.

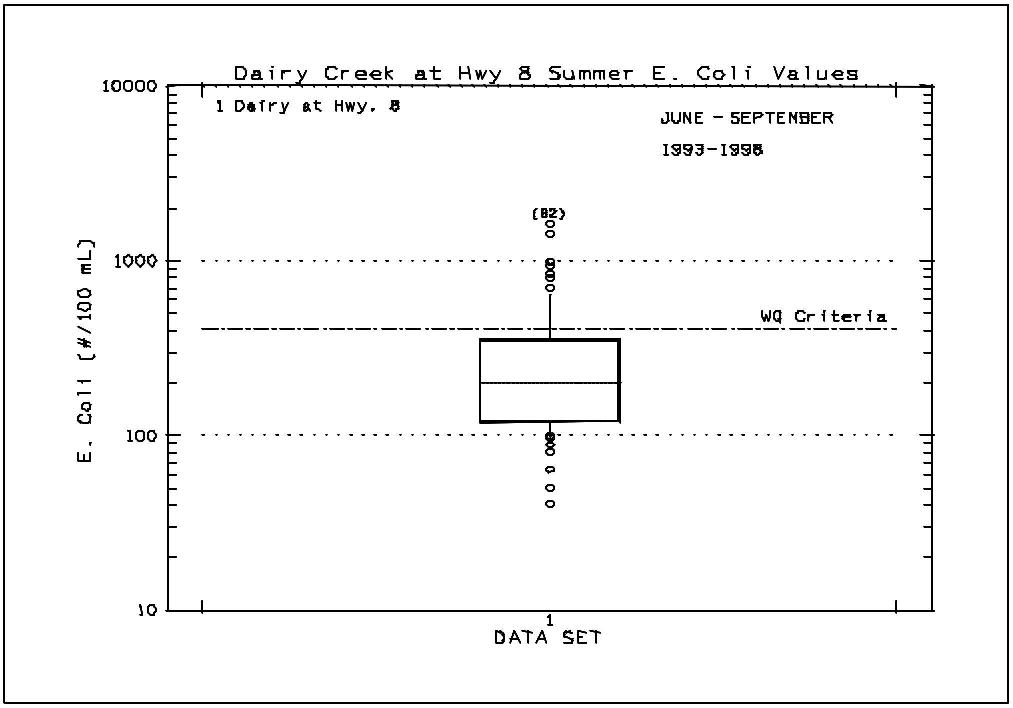


Figure 43. Dairy Creek E. coli Concentrations June – September (1993-98)

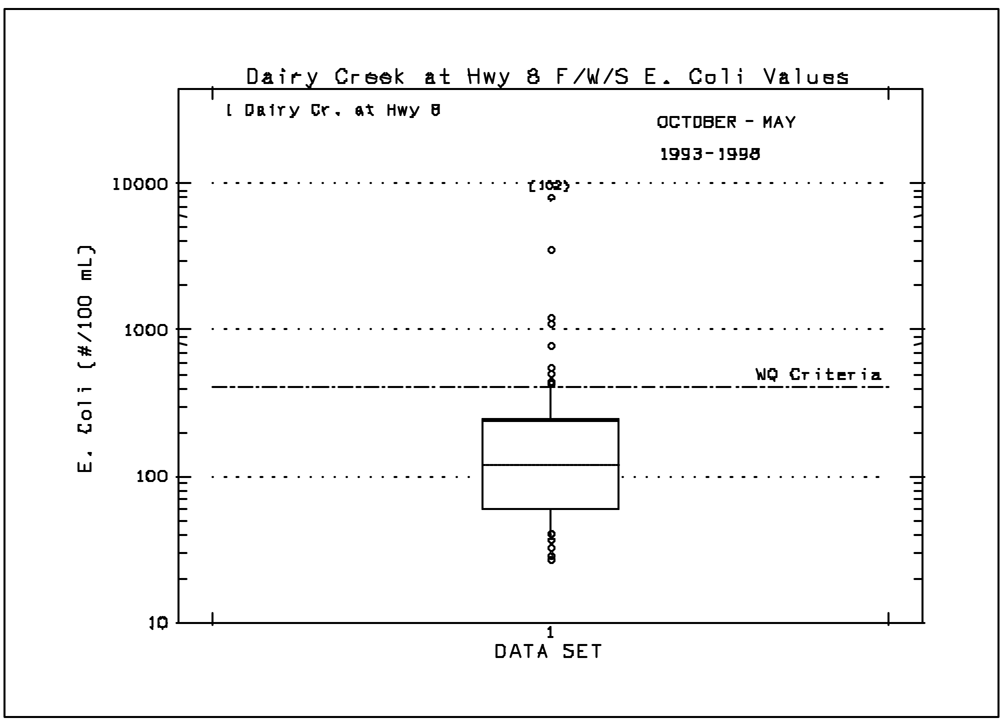


Figure 44. Dairy Creek E. Coli Concentrations Oct. - May (1993-98)

4.2.6 SOURCE ASSESSMENT

4.2.6.1 RUNOFF VS. NON-RUNOFF SOURCES

An initial bacteria source assessment for the subbasin was carried out to determine if sources were associated with runoff or not. This assessment was made by grouping the individual samples by whether or not there was likely to be runoff at the time of sampling. It was estimated that runoff would occur when the rainfall on the day of sampling was greater than 0.1 inches for urbanized watersheds and 0.2 for watersheds with mixed uses. The 0.1 value was selected based on an estimate by USA of the amount of rainfall required to produce urban runoff (1993 USA MS4 permit application). The 0.2 value used for watersheds with mixed land uses was based on an estimate of the precipitation necessary to start producing runoff from both urban and other areas.

By separating the data into runoff (wet weather) and non-runoff (dry weather) groupings, the two data sets could be statistically analyzed. **Figures 45 through 47** show the resulting box plots for three monitoring sites. The first box plot in each of these figures represents all of the data collected for the individual site for 1993 – 1998. The second box plot is of the data associated with wet weather (i.e., runoff), and the third box plot is of the data associated with dry weather (i.e., no runoff). (The source of the bacteria data for these figures is USA. The precipitation data are from the Beaverton 2 SSW Station for Figures 45 and 46, and the Hillsboro Station for Figure 47 [data available from the Oregon Climate Service]).

Figure 45, below, is for a site on the lower mainstem of the Tualatin River at river mile 5.4. It can be seen that the first box plot that the data set as a whole has relatively low bacteria concentrations with over 90% of the samples below the criterion. From the second and third box plots a comparison can be made between runoff (wet weather) and non-runoff (dry weather) conditions. The data sets were analyzed using standard statistical tests to determine whether the data associated with rainfall (the second box plot) was significantly greater than the data not associated with rainfall (the third box plot). Use of both the t-test (following log transformation) and the Mann-Whitney "U" test indicates that the data are significantly different at the 95 percent confidence level. Several of the outliers in the non-runoff data set are higher than would be expected, indicating possible sources other than stormwater runoff.

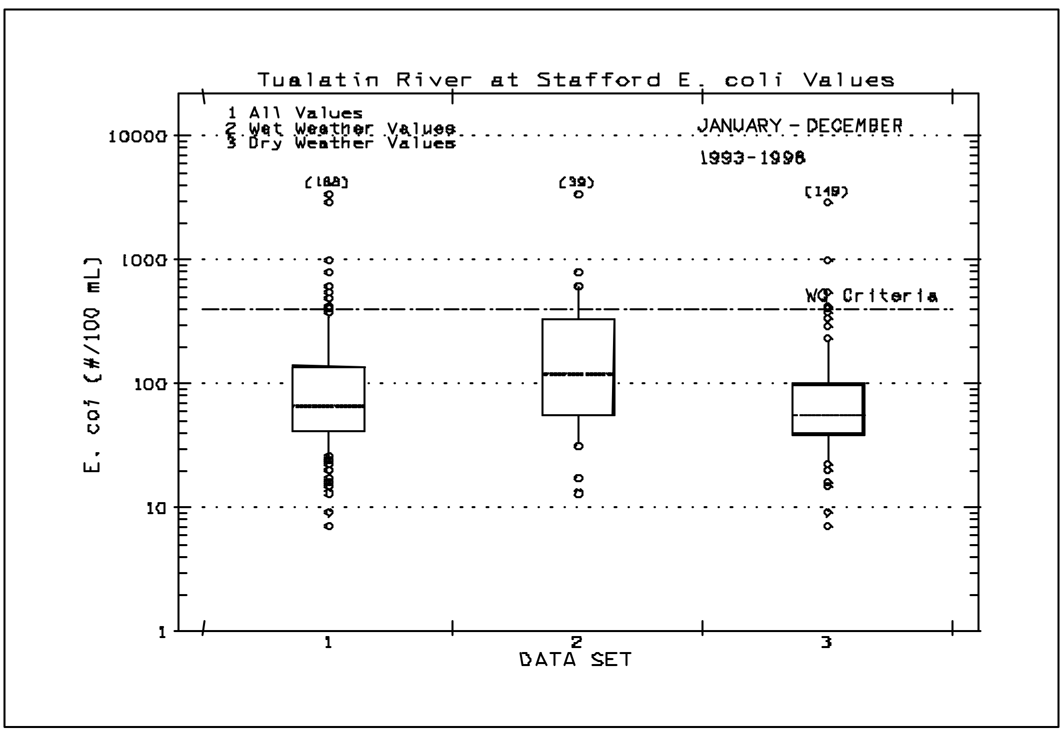


Figure 45. Tualatin River Runoff vs. Non-Runoff E. coli Concentrations (1993-98)

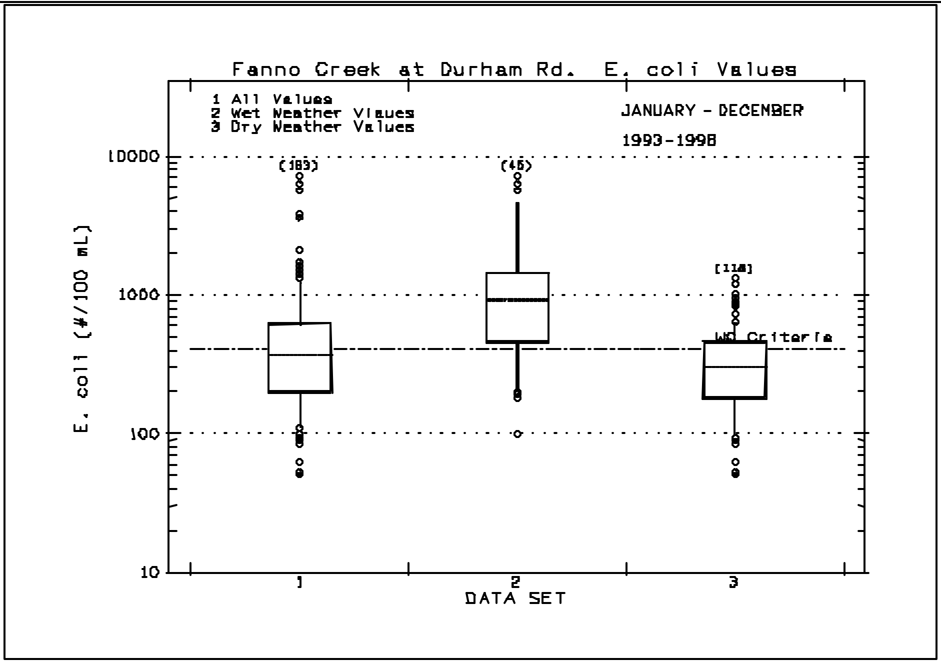


Figure 46. Fanno Cr. Runoff vs. Non-Runoff E. coli Concentrations (1993-98)

Figure 46 includes box plots for data at a site near the mouth of urbanized Fanno Creek. As is to be expected for an urbanized watershed, the overall bacteria levels shown in the first box plot are quite high. It can also be seen from the second and third plots that the runoff values are much higher than the non-runoff values, with over 75% of the runoff values greater than the criterion. The data sets were analyzed using standard statistical tests to determine whether the data associated with rainfall (the second box plot) was significantly greater than the data not associated with rainfall (the third box plot). Use of both the t-test (following log transformation) and the Mann-Whitney "U" test indicates that the data are significantly different at the 95 percent confidence level.

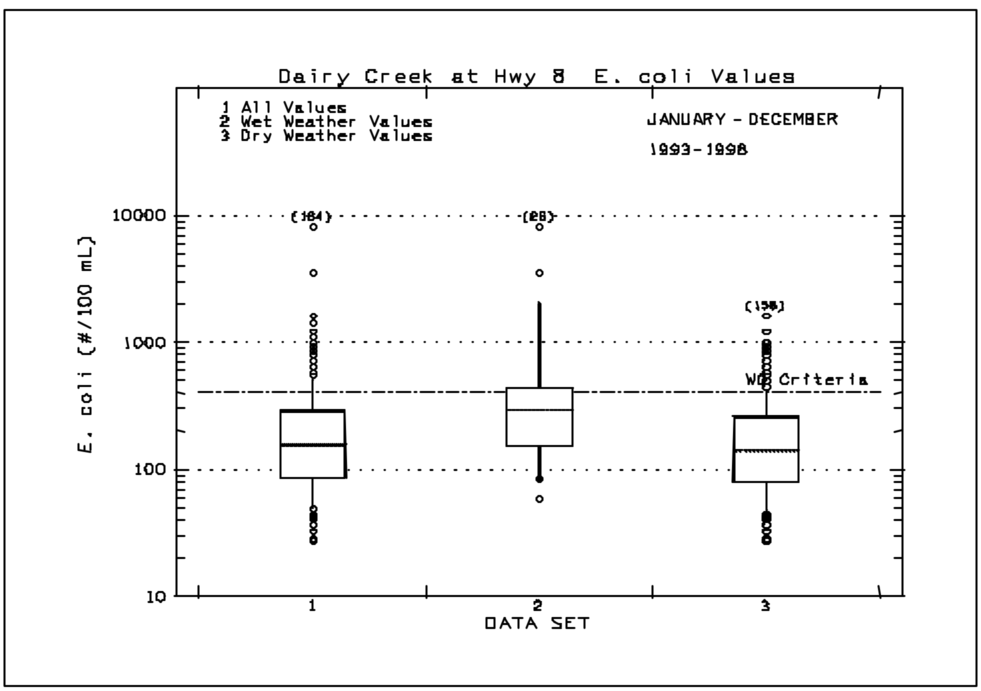


Figure 47. Dairy Cr. Runoff vs. Non-Runoff E. coli Concentrations (1993-98)

Figure 47 includes box plots for a site on Dairy Creek (at river mile 2.0), which drains primarily agricultural and forested land. The bacteria levels for this creek are quite a bit lower than those of Fanno Creek, but they are still elevated during wet weather indicating probable runoff sources of bacteria. The data sets were analyzed using standard statistical tests to determine whether the data associated with rainfall (the second box plot) was significantly greater than the data not associated with rainfall (the third box plot). Use of both the t-test (following log transformation) and the Mann-Whitney "U" test indicates that the data are significantly different at the 95 percent confidence level.

4.2.7 SOURCE IDENTIFICATION

The following is a listing of potential bacteria sources in the subbasin.

4.2.7.1 NON-RUNOFF SOURCES

Wastewater Treatment Plants and Sanitary Sewer Systems

There are four Wastewater Treatment Plants (WWTPs) in the subbasin: Durham, Rock Creek, Hillsboro and Forest Grove. Both Durham and Rock Creek discharge year-round, while Hillsboro and Forest Grove do not discharge during the summer. The bacteria discharge limits on each of the WWTPs is well below the criteria and therefore they generally have a diluting effect on bacteria concentrations.

Cross connections between sanitary and storm sewer systems may occur and can be a source of bacteria loading during both wet and dry weather.

Confined Animal Feeding Operations (CAFOs)

There are several Confined Animal Feeding Operations within the subbasin. Each of these sites has a State of Oregon Water Pollution Control Facility Permit, which does not allow the discharge of waste to surface waters.

Permitted Sites other than WWTPs and CAFOs

A review of sites permitted to discharge wastewater (other than the WWTPs) within the subbasin shows that none have potential to discharge significant bacteria loads if operating within their permit requirements.

Direct Deposition

Bacteria may be directly deposited into surface waters by birds and other animals. This is most evident in ponds where high temperatures, low velocities and high bird densities often result in elevated bacteria concentrations.

Illegal Dumping

The illegal dumping of wastes either to storm sewer systems or directly to surface waters is a potential bacteria source. This dumping may be of portable toilet wastes, recreational vehicle wastes, etc.

Contaminated Non-stormwater Discharges

During non-runoff periods water from springs, irrigation runoff and other sources may enter storm sewer systems and other conveyances and be discharged to streams. It is possible for this water to be contaminated with bacteria at the source or within the conveyance system.

Septic Systems

Failing septic systems have the potential to discharge bacteria during non-runoff periods as well as during runoff periods.

4.2.7.2 RUNOFF SOURCES

Urban Runoff

As seen in **Figure 46**, instream bacteria values in urban watersheds are very high during runoff events. This, and data from stormwater sampling, points to urban runoff as a significant source of bacteria in surface waters. The ultimate sources of this bacteria are most likely multiple and may include:

- Pet and other animal waste
- Illegal dumping
- Failing septic systems
- Sanitary sewer cross-connections and overflows

Rural Runoff

Rural runoff may contain bacteria from the same sources as urban runoff, with the possible exception of sanitary sewers. Additional potential sources are “hobby” farms, horse pastures and ranchettes (though these may be under the jurisdiction of the Department of Agriculture). These sites are often stocked densely. In general, the density of septic systems is often relatively high in rural areas and therefore the possibility of failing systems may also be quite high.

Agricultural Runoff

The primary source of bacteria in agricultural runoff is most likely animal waste. This animal waste may be from livestock grazing in pasture, inappropriate waste management practices, faulty waste systems, etc. (Direct discharges from confined animal feeding operations (CAFOs) are prohibited in Oregon.) Another potential source is faulty septic systems.

Forested Runoff

The potential for bacteria sources leading to surface water contamination in forested areas is very low. One potential source is faulty septic systems.

4.2.8 LOADING CAPACITY

Loading capacity is a term referred to in the Clean Water Act that establishes an accepted rate of pollutant introduction to a waterbody that is directly related to water quality standard compliance. The bacteria loading capacities for the subbasin are based on criteria listed at the bottom of **Table 14**. These criteria are two-fold: 1) a maximum 30-day log mean of 126 E. coli organisms per 100 mL, and 2) a maximum single sample of 406 E. coli organisms per 100 mL.

For purposes of determining this bacteria TMDL, loading capacity for runoff periods is set to a geometric mean (also known as the log mean) of 126 E. coli organisms per 100 milliliters as measured at the mouth of each fifth-field watershed (e.g., the mouth of Gales Creek). Instream samples were taken during storm events that provide sufficient data (5 samples or more per storm event) to use this criterion. This criterion is used because the load allocations are calculated using event mean concentrations (EMCs) for storm events. The achievement of this loading capacity is expected to also achieve the single sample criterion of 406 E. coli organisms per 100 milliliters.

The loading capacity for non-runoff periods is set to 406 E. coli organisms per 100 milliliters. This single sample criterion is used because it is appropriate for the more steady-state conditions typical of non-runoff periods.

4.2.9 BACTERIA MODELING

Model Description

To evaluate precipitation-driven bacteria loadings in the Tualatin Subbasin, an event based, unit load model was used. The model uses storm volumes, runoff concentrations for various land uses, and bacteria die off rates to predict bacteria concentration in the streams. Five major geographic databases were used in this project: soils, land use, precipitation pattern, watersheds, and distance from the stream. These five data bases were overlaid to create a composite geographical information system (GIS) database which was used for estimating storm volume, travel time of overland flow in the watershed, the bacteria die-off rate (a function of the travel time), and bacteria load. These parameters were modeled for all locations in the watershed. In addition, a bacteria die-off rate was incorporated for travel time instream. Each of these parameters is discussed in detail in **Appendix B**.

Impacts of Various Land Uses

Estimates of bacteria concentrations were used in the model to assess the relative contributions from the different land uses. These values are in the form of event mean concentrations (EMCs), which are flow weighted average bacteria concentrations during a storm event. The estimated bacteria concentrations for each land use were taken from several sources as detailed in **Appendix B**.

Design Event Magnitude (Seasonal Variation)

The load allocations for bacteria are based on storms of specified intensities, referred to as design storms. Two design storms were selected to model: a larger winter storm representing saturated ground conditions and a smaller summer event in which the soil was dry and only impervious areas contribute to instream concentrations. For the purposes of the design storm and TMDL allocations, summer is the period from May 1 to October 31. Winter is the period from November 1 to April 31.

The size of the modeled summer design storm is 0.11 inches of precipitation over a 24-hour period. This size storm was chosen because of the storms contributing runoff (greater than 0.1 inches) during the summer months, this size is the most common and thus represents a typical runoff event during the dry season.[13] The size of the modeled winter design storm is 1.96 inches of precipitation over a 96-hour (four-day) period. This size event was chosen because precipitation of 1.96 inches represents the 90th percentile for all four-day storms[14] (meaning that 90% of all four-day storms are smaller than this). Rainfall of this amount is predicted to result in saturated soil conditions and runoff from all major land uses in the subbasin.

Model Calibration

The hydrology model was calibrated by adjusting the precipitation and Soil Conservation Service (SCS) curve numbers to measured streamflow data collected at specified points on Gales and Fanno Creeks. These two creeks were selected since the represent mixed use and urban use watersheds, respectively. The same calibration parameters were applied to other watersheds. (For a more detailed description of the model calibration, see **Appendix B**.)

For the summer design storm of 0.1 inches (in 24 hours), the calibrated hydrology model predicted runoff primarily from the urban land uses. The SCS curve numbers for the hydrologic soil groups within the agricultural and forest land uses did not result in significant predicted runoff for the summer design precipitation. For the winter design storm of 1.96 inches (in 96 hours), the saturated soil conditions led to predicted runoff from all major land uses in the subbasin.

The model was also calibrated to meet measured instream bacteria concentrations at specified point on Gales and Fanno Creeks. This portion of the model was calibrated by adjusting the event mean concentrations (EMCs) for each land use.

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[13] This was based on Beaverton precipitation data for 1989 – 1998.

[14] Based on Beaverton precipitation data.

4.2.10 LOAD ALLOCATIONS / WASTELOAD ALLOCATIONS

4.2.10.1 FINAL COMPOSITE LOAD / CONCENTRATIONS

Following model calibration, target bacteria concentrations were determined through iterative adjustments of the EMCs for each land use. The EMCs were adjusted until the model's estimated bacteria concentrations at the mouth of each fifth field watershed were at or below the water quality standard of 126 E. coli counts/100 mL. These adjustments were made for both the summer design storm and the winter design storm.

The target concentrations for all of land uses, with the exception of forestry, were set equal to one another in an effort to achieve parity. (Forestry was set to an EMC of 10 E. coli count/100 mL since this is near the estimated existing concentration. Septic systems and CAFOs were set to zero discharge [an EMC of O E. coli counts/100 mL].) These target concentrations were then used as bacteria load and wasteload allocations, as detailed below.

The allocations during non-runoff periods are based on the maximum single-sample E. coli criterion of 406 counts/100 mL. Allocations at this level, combined with reductions in septic system discharges, illegal dumping and direct bacterial depositions, is expected to achieve the instream loading capacity of 406 E. coli counts/100 mL, based on biweekly sampling. By inspection of the non-runoff box plots above (e.g. the right box plot in Figure 45), this is also expected to achieve the 30-day log mean criterion of 126 counts/100 mL of E. coli.

4.2.10.2 SOURCES AND SEASONS ADDRESSED BY ALLOCATIONS

The bacteria modeling described above and in **Appendix B** was used to determine the allocations necessary to achieve the bacteria standard both in the tributary streams and the mainstem Tualatin River. Since the mainstem of the Tualatin River is listed on the 303(d) list for bacteria for the all seasons (see **Table 15**), it is necessary to control the bacteria loadings from all sources during the full year. For this reason the bacteria allocations will apply to all sources in the subbasin during the full year.

The allocations have been segregated into two periods: Summer (defined as May 1 – Oct. 31 for the purposes of these TMDL allocations), and Winter (defined as Nov. 1 – April 31 for the purposes of these TMDL allocations). Although these periods differ from the 303(d) listing periods, they are considered appropriate for this TMDL for several reasons:

1. They better reflect the seasonal precipitation patterns observed in the subbasin.
2. They coincide with the seasonal periods for the other TMDLS and thus will make management practice design and implementation more efficient and effective.
3. Their use will not impact the expected achievement of water quality standards.

4.2.10.3 WASTELOAD ALLOCATIONS

A *wasteload allocation* (WLA) is the amount of pollutant that a point source can contribute to the receiving water's loading capacity. The point sources that require WLAs for purposes of the bacteria TMDL are the four wastewater treatment plants, the sources covered by Municipal Separate Storm Sewer System (MS4) NPDES permits and direct discharges from confined animal feed operations (CAFOs).

The wasteload allocations are presented in the form of concentrations of E. coli organisms in **Tables 17, 18 and 19**, below.

Table 17. Summer (May 1 – October 31) Wasteload Allocations For Discharges from Municipal Separate Storm Sewer Systems and CAFO Sources (Concentrations)			
Designated Management Agency	**5th-Field Subbasin**	**Wasteload Allocation – E. coli counts/100 mL**	
	All Land Uses[15]/Sources Covered By MS4 Permits Except as Otherwise Noted	**During Runoff Events[16] (Measured as an event mean concentration)**	**All other times (Measured as a grab sample)**
City of Lake Oswego, City of Portland, City of West Linn, Clackamas Co., Oregon Dept. of Transportation, Multnomah Co., Unified Sewerage Agency, and Washington Co.	Gales	9500	406
	Rock	3000	406
	Dairy	7000	406
	Scoggins/Upper Tualatin	9500	406
	Middle Tualatin	12000	406
	Lower Tualatin	12000	406
Oregon Dept. of Agriculture	All CAFO Direct Discharges	0	0

Table 18. Winter (Nov. 1 – April 31) Wasteload Allocations For Discharges from Municipal Separate Storm Sewer Systems and CAFO Sources (Concentrations)			
Designated Management Agency	**5th-Field Subbasin**	**Wasteload Allocation – E. coli counts/100 mL**	
	All Land Uses/Sources Covered By MS4 Permits Except as Otherwise Noted	**During Runoff Events[17] (Measured as an event mean concentration)**	**All other times (Measured as a grab sample)**
City of Lake Oswego, City of Portland, City of West Linn, Clackamas Co., Oregon Dept. of Transportation, Multnomah Co., Unified Sewerage Agency, and Washington Co.	Gales	3500	406
	Rock	700	406
	Dairy	3500	406
	Scoggins/Upper Tualatin	1500	406
	Middle Tualatin	11000	406
	Lower Tualatin	5000	406
	All Septic Systems	0	0
Oregon Dept. of Agriculture	All CAFO Direct Discharges	0	0

Table 19. Wasteload Allocations for Tualatin Subbasin Wastewater Treatment Plants	
Wastewater Treatment Plant	**Bacteria Wasteload Allocations**
Durham, Forest Grove, Hillsboro, and Rock Creek	Monthly geometric mean of 126 E. coli counts per 100 mL with a single sample maximum of 406 E. coli organisms per 100 mL

[15] The land uses utilized in the DEQ bacteria model included forestry, meadow, open space, commercial, agricultural, industrial, residential and transportation.

[16, 17] Runoff Event is defined as the period when precipitation causes overland runoff to occur from the area of concern.

While wasteload allocations in the form of concentrations are given above, wasteload allocations in the form of loads (or counts) may be utilized instead. The wasteload allocations in the form of loads (or counts) may be determined by multiplying the appropriate land use or source by the estimated discharge volume for the source. Wasteload allocations in the form of counts for sources in **Tables 17 and 18** have been calculated for the specific design storms (see Section 4.2.9). These counts are given in **Table 20**, below (as counts per day). Allocations in the form of counts for other precipitation events, and/or using different runoff estimation techniques, may be calculated by the designated management agencies with DEQ approval. The equation used for the conversion of concentration-based allocations to load-based allocations is:

Wasteload Allocation (E. coli counts/day)
= Wasteload Allocation (E. coli counts/100 mL) x Daily Discharge Volume (ft^3) x 283 (100 mL/ft^3)

The concentrations listed in **Tables 17 and 18** can be used to assist in the assessment of monitoring data and to provide targets for runoff quality. Loads can be used to guide management strategies that are designed to reduce the quantity and/or quality of runoff. DEQ encourages management strategies that optimize reduction of runoff quantity and improvement of quality.

The wasteloads given in **Table 20** have been segregated by 5^{th}-field subbasin. In addition, USA wasteloads have been further segregated by the municipalities that are within their service district. It should be noted that these municipalities are not DMAs – USA is the DMA for these areas. These municipalities, along with their corresponding loads, are listed for reference purposes only.

Table 20. Bacteria Wasteload Allocations
(For Discharges from Municipal Separate Storm Sewer Systems and CAFO Sources)

		Wasteload Allocations E. coli Counts Per Day			
		Summer Design Storm		Winter Design Storm	
5th-Field Subbasin	DMA (or Municipality – see note)		USA Allocations Subdivided by Municipality		USA Allocations Subdivided by Municipality
Dairy	ODOT	2.56E+08		2.43E+12	
	USA	1.06E+14		2.76E+14	
	Banks		0		1.53E+13
	Cornelius		8.40E+12		1.82E+13
	Forest Grove		1.25E+13		2.71E+13
	Hillsboro		7.13E+13		1.55E+14
	North Plains		0		2.91E+13
	Other		1.36E+13		3.15E+13
	Washington Co.	2.04E+13		4.42E+13	
Rock	ODOT	6.06E+12		5.29E+12	
	USA	2.99E+14		3.05E+14	
	Beaverton		6.48E+13		6.64E+13
	Hillsboro		8.34E+13		8.51E+13
	Other		1.50E+14		1.53E+14
	Multnomah Co.	4.17E+12		4.27E+12	
	Washington Co.	1.50E+12		1.53E+12	
	Portland	6.22E+12		6.56E+12	
Lower Tualatin/Fanno Creek	ODOT	4.29E+13		4.15E+13	
	USA	8.98E+14		1.65E+15	
	Beaverton		1.43E+14		2.60E+14
	Rivergrove		3.11E+12		5.57E+12
	Sherwood		8.60E+13		1.59E+14
	Tigard		2.81E+14		5.21E+14
	Tualatin		1.91E+14		3.49E+14
	Durham		7.26E+12		1.46E+13
	King City		8.67E+12		1.61E+13
	Other		1.79E+14		3.26E+14
	Washington Co.	1.82E+13		3.27E+13	
	Clackamas Co.	2.83E+13		5.08E+13	
	Multnomah Co.	9.14E+11		1.64E+12	
	Lake Oswego	5.20E+13		9.35E+13	
	Portland	9.05E+13		1.65E+14	
	West Linn	2.48E+13		4.57E+13	
Upper Tualatin	ODOT	0		4.63E+11	
	USA	0		3.16E+12	
	Gaston		0		3.16E+12
Middle Tualatin	ODOT	1.62E+12		2.19E+12	
	USA	2.08E+14		8.58E+14	
	Cornelius		3.08E+13		1.28E+14
	Forest Grove		3.75E+13		1.55E+14
	Hillsboro		4.97E+13		2.05E+14
	Beaverton		2.93E+12		1.19E+13
	Other		8.72E+13		3.58E+14
	Washington Co.	2.46E+13		1.00E+14	
Gales	ODOT	6.06E+11		2.58E+12	
	USA	3.91E+13		9.56E+13	
	Forest Grove		3.83E+13		8.72E+13
	Other		8.06E+11		8.40E+12
	Washington Co.	1.30E+10		2.19E+10	

Notes:
1) The municipalities listed directly under USA are not DMAs – they are listed here with the allocations corresponding to their jurisdictions for reference only. USA is the DMA for these areas.
2) The allocations for the municipalities listed directly under USA are for reference only. The allocations may be met by addressing the aggregated allocations listed for USA.
3) “Other” under this heading refers to loads from areas outside of cities.

4.2.10.4 LOAD ALLOCATIONS

A *Load Allocation* (LA) is the amount of pollutant that natural plus nonpoint sources can contribute to a receiving water's loading capacity. The GIS-based model described above and in **Appendix B** was utilized to determine non-point source LAs. The bacteria load allocations for the Tualatin Subbasin are presented in **Tables 21 and 22**, below.

Table 21. Summer (May 1 – October 31) Load Allocations (Concentrations) for Runoff and Other Discharges

Designated Management Agency	5th-Field Subbasin	Load Allocation – E. coli counts/100 mL	
	All Land Uses/Sources Except as Otherwise Noted	During Runoff Events[18] (Measured as an event mean concentration)	All other times (Measured as a grab sample)
Clackamas Co., Multnomah Co., Oregon Dept. of Agriculture, and Washington Co.	Gales	9500	406
	Rock	3000	406
	Dairy	7000	406
	Scoggins/Upper Tualatin	9500	406
	Middle Tualatin	12000	406
	Lower Tualatin	12000	406
	All Septic Systems	0	0
Oregon Dept. of Forestry	Forest Land Use	10	10

Table 22. Winter (Nov. 1 – April 31) Load Allocations (Concentrations) for Runoff and Other Discharges

Designated Management Agency	5th-Field Subbasin	Load Allocation – E. coli counts/100 mL	
	All Land Uses/Sources Except as Otherwise Noted	During Runoff Events[19] (Measured as an event mean concentration)	All other times (Measured as a grab sample)
Clackamas Co., Multnomah Co., Oregon Dept. of Agriculture, and Washington Co.	Gales	3500	406
	Rock	700	406
	Dairy	3500	406
	Scoggins/Upper Tualatin	1500	406
	Middle Tualatin	11000	406
	Lower Tualatin	5000	406
	All Septic Systems	0	0
Oregon Dept. of Forestry	Forest Land Use	10	10

[18, 19] Runoff Event is defined as the period when precipitation causes overland runoff to occur from the area of concern.

While load allocations in the form of concentrations are given above, load allocations in the form of loads (or counts) may be utilized instead. The load allocations in the form of loads (or counts) may be determined by multiplying the appropriate land use or source by the estimated discharge volume for the source. Load allocations in the form of counts for sources in **Tables 21 and 22** have been calculated for the specific design storms (see Section 4.2.9). These counts are given in **Table 23**, below. Computer modeling has predicted that these sources would not have any runoff during the summer design storm. Therefore, the load allocations are zero for this specific storm. (Summer storms of a greater size, however, may result in runoff.)

Allocations in the form of counts for other precipitation events, and/or using different runoff estimation techniques, may be calculated by the designated management agencies with DEQ approval. The equation used for the conversion of concentration-based allocations to load-based allocations is:

Load Allocation (E. coli counts/day)
= Load Allocation (E. coli counts/100 mL) x Daily Discharge Volume (ft^3) x 283 (100 mL/ft^3)

The concentrations listed in **Tables 21 and 22** can be used to assist in the assessment of monitoring data and to provide targets for runoff quality. Loads can be used to guide management strategies that are designed to reduce the quantity and/or quality of runoff. DEQ encourages management strategies that optimize reduction of runoff quantity and improvement of quality.

Table 23. Bacteria Load Allocations
(For Runoff and Other Discharges)

5th-Field Subbasin	DMA	Summer Design Storm (E. coli Counts Per Day)	Winter Design Storm (E. coli Counts Per Day)
Dairy	ODA	0	2.72E+15
	ODF	0	1.61E+13
	Multnomah Co.	0	4.36E+12
	Washington Co.	0	1.86E+14
Rock	ODA	0	4.49E+13
	ODF	0	5.38E+12
	Multnomah Co.	0	2.16E+13
	Washington Co.	0	1.34E+13
Lower Tualatin/Fanno Creek	ODA	0	7.31E+14
	ODF	0	6.33E+13
	Washington Co.	0	7.68E+13
	Clackamas Co.	0	1.47E+14
	Multnomah Co.	0	0
Upper Tualatin	ODA	0	4.24E+14
	ODF	0	1.30E+13
	Washington Co.	0	4.33E+13
Middle Tualatin	ODA	0	6.54E+15
	ODF	0	1.87E+13
	Washington Co.	0	2.60E+14
Gales	ODA	0	4.02E+14
	ODF	0	1.95E+13
	Washington Co.	0	3.98E+13

Within each 5th-field subbasin, one or more DMAs have jurisdiction over land use and activities. Each DMA's WQMP (Appendix I) will address only the lands and activities within each identified stream segment to the extent of the DMA's authority.

4.2.11 MARGIN OF SAFETY

The margin of safety for this bacteria TMDL is implicitly defined. The margin of safety is addressed by the following conservative assumption:

- The allocations are set to meet the geometric mean of 126 E. coli counts per 100 mL. To determine compliance with the criteria, the 30 day log mean should be calculated, which would likely include dry weather sampling as well as wet weather sampling. Because the allocations are set for storm events, the allocations are more stringent than if they had been calculated based on dry weather as well.

4.3 DISSOLVED OXYGEN TMDL

Table 24. Tualatin River Subbasin Dissolved Oxygen TMDL Components	
WATERBODIES	All stream segments within the 4th field HUC (hydrologic unit code) 17090010
POLLUTANT IDENTIFICATION	*Pollutants:* Ammonia, volatile solids, phosphorus, and human caused increases in stream temperatures.
TARGET IDENTIFICATION (APPLICABLE WATER QUALITY STANDARDS) *CWA §303(D)(1)*	**OAR 340-041-0445(2)(A)** (IN PART) *(A) For waterbodies identified by DEQ as providing salmonid spawning, during the periods from spawning until fry emergence from the gravels, the following criteria apply:* *(i) The dissolved oxygen shall not be less than 11.0 mg/L.* *(D) For waterbodies identified by DEQ as providing cold-water aquatic life, the dissolved oxygen shall not be less than 8.0 mg/l as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/l, dissolved oxygen shall not be less than 90 percent of saturation. At the discretion of DEQ, when it is determined that adequate information exists, the dissolved oxygen shall not fall below 8.0 mg/l as a 30-day mean minimum, 6.5 mg/l as a seven-day minimum mean, and shall not fall below 6.0 mg/l as an absolute minimum;* *(E) For waterbodies identified by DEQ as providing cool-water aquatic life, the dissolved oxygen shall not be less than 6.5 mg/l as an absolute minimum. At the discretion of DEQ, when it is determined that adequate information exists, the dissolved oxygen shall not fall below 6.5 mg/l as a 30-day mean minimum, 5.0 mg/l as a seven-day minimum mean, and shall not fall below 4.0 mg/l as an absolute minimum;* (F) *For waterbodies identified by DEQ as providing warm-water aquatic life, the dissolved oxygen shall not be less than 5.5 mg/l as an absolute minimum. At the discretion of DEQ, when it is determined that adequate information exists, the dissolved oxygen shall not fall below 5.5 mg/l as a 30-day mean minimum, and shall not fall below 4.0 mg/l as an absolute minimum ;*
EXISTING SOURCES *CWA §303(D)(1)*	Forestry, Agriculture, Transportation, Rural Residential, Urban, Industrial Discharge, Waste Water Treatment Facilities
SEASONAL VARIATION *CWA §303(D)(1)*	Critical DO levels on the mainstem Tualatin River generally occur in late summer and early fall. Critical DO levels on the tributaries occur during the summer, with the exception of spawning criterion violations on Scoggins Creek which occur the during the winter.
TMDL LOADING CAPACITY AND ALLOCATIONS *40 CFR 130.2(F)* *40 CFR 130.2(G)* *40 CFR 130.2(H)*	*Loading Capacity:* The ammonia LC for the mainstem is presented in **Figure 63**. The sediment oxygen demand (SOD) LCs for the tributaries are presented in **Table 31**. The LCs for both phosphorus and temperature are presented in those TMDL sections. *Waste Load Allocations (Point Sources)*: The WLAs for ammonia are presented in **Figure 64**. The WLAs for settleable volatile solids sources (runoff) are presented in **Table 37**. The WLAs for phosphorus and temperature are presented in those TMDL sections. *Load Allocations (Non-Point Sources)*: The LAs for ammonia are presented in **Figure 64**. The LAs for volatile solids sources (runoff) are presented in **Table 37**. The LAs for phosphorus and temperature are presented in those TMDL sections.
MARGINS OF SAFETY *CWA §303(D)(1)*	Margins of Safety demonstrated in critical condition assumptions and is inherent to methodology.
WATER QUALITY STANDARD ATTAINMENT ANALYSIS *CWA §303(D)(1)*	• Analytical modeling of TMDL loading capacities demonstrates attainment water quality standards
PUBLIC NOTICE *40 CFR 25*	Conducted by Oregon Department of Environmental Quality

4.3.1 APPLICABLE WATER QUALITY STANDARDS

The primary benefit of maintaining adequate dissolved oxygen (DO) concentrations is to support a healthy and balanced distribution of aquatic life. **Table 25** lists the beneficial uses that occur in the Tualatin Subbasin and highlights those that are related to dissolved oxygen.

Table 25. Beneficial uses occurring in the Tualatin River Subbasin
(OAR 340 – 41 – 442)
Beneficial uses related to Dissolved Oxygen are marked in gray

Beneficial Use	Occurring	Beneficial Use	Occurring
Public Domestic Water Supply	✓	Salmonid Fish Spawning (Trout)	✓
Private Domestic Water Supply	✓	Salmonid Fish Rearing (Trout)	✓
Industrial Water Supply	✓	Resident Fish and Aquatic Life	✓
Irrigation	✓	Anadromous Fish Passage	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Hydro Power	✓	Water Contact Recreation	✓
Aesthetic Quality	✓	Commercial Navigation & Transportation	

The dissolved oxygen water quality criteria applicable to the Tualatin Subbasin are delineated in the Oregon Administrative Rules (OAR), shown in **Figure 48**, below.

Figure 48. Oregon Administrative Rule 340-041-0445

(2) No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause violation of the following standards in the waters of the Willamette River Basin:

(a) Dissolved oxygen (DO): The changes adopted by the Commission on January 11, 1996, become effective July 1, 1996. Until that time, the requirements of this rule that were in effect on January 10, 1996, apply:

(B) For waterbodies identified by DEQ as providing salmonid spawning, during the periods from spawning until fry emergence from the gravels, the following criteria apply:

(i) The dissolved oxygen shall not be less than 11.0 mg/L. However, if the minimum intergravel dissolved oxygen, measured as a spatial median, is 8.0 mg/L or greater, then the DO criterion is 9.0 mg/L;

(ii) Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 11.0 mg/L or 9.0 mg/L criteria, dissolved oxygen levels shall not be less than 95 percent of saturation.

(B) For waterbodies identified by DEQ as providing salmonid spawning during the period from spawning until fry emergence from the gravels, the spatial median intergravel dissolved oxygen concentration shall not fall below 6.0 mg/l;

Oregon Administrative Rule 340-041-0445 (Continued)
(C) A spatial median of 8.0 mg/l intergravel dissolved oxygen level shall be used to identify areas where the recognized beneficial use of salmonid spawning, egg incubation and fry emergence from the egg and from the gravels may be impaired and therefore require action by DEQ. Upon determination that the spatial median intergravel dissolved oxygen concentration is below 8.0 mg/l, DEQ may, in accordance with priorities established DEQ for evaluating water quality impaired waterbodies, determine whether to list the waterbody as water quality limited under the Section 303(d) of the Clean Water Act, initiate pollution control strategies as warranted, and where needed cooperate with appropriate designated management agencies to evaluate and implement necessary best management practices for nonpoint source pollution control; *(D) For waterbodies identified by DEQ as providing cold-water aquatic life, the dissolved oxygen shall not be less than 8.0 mg/l as an absolute minimum. Where conditions of barometric pressure, altitude, and temperature preclude attainment of the 8.0 mg/l, dissolved oxygen shall not be less than 90 percent of saturation. At the discretion of DEQ, when it is determined that adequate information exists, the dissolved oxygen shall not fall below 8.0 mg/l as a 30-day mean minimum, 6.5 mg/l as a seven-day minimum mean, and shall not fall below 6.0 mg/l as an absolute minimum;* *(E) For waterbodies identified by DEQ as providing cool-water aquatic life, the dissolved oxygen shall not be less than 6.5 mg/l as an absolute minimum. At the discretion of DEQ, when it is determined that adequate information exists, the dissolved oxygen shall not fall below 6.5 mg/l as a 30-day mean minimum, 5.0 mg/l as a seven-day minimum mean, and shall not fall below 4.0 mg/l as an absolute minimum;* *(F) For waterbodies identified by DEQ as providing warm-water aquatic life, the dissolved oxygen shall not be less than 5.5 mg/l as an absolute minimum. At the discretion of DEQ, when it is determined that adequate information exists, the dissolved oxygen shall not fall below 5.5 mg/l as a 30-day mean minimum, and shall not fall below 4.0 mg/l as an absolute minimum ;*

The applicable section(s) of the dissolved oxygen rule (OAR 340-041-0445) are determined by the presence of cool- or cold-water aquatic life, and the life stages of any salmonids present (i.e., spawning, rearing, etc.). These have been determined for specific stream segments in the subbasin as detailed in the DEQ paper *Tualatin River Subbasin Fish Habitat and Fish Community Information* (**Appendix F**). A map showing where salmonid spawning is a beneficial use is included in **Figure 49**. A map delineating where cool- and cold-water are beneficial uses is included in **Figure 50**.

Figure 49. Salmonid Spawning Streams and Timing

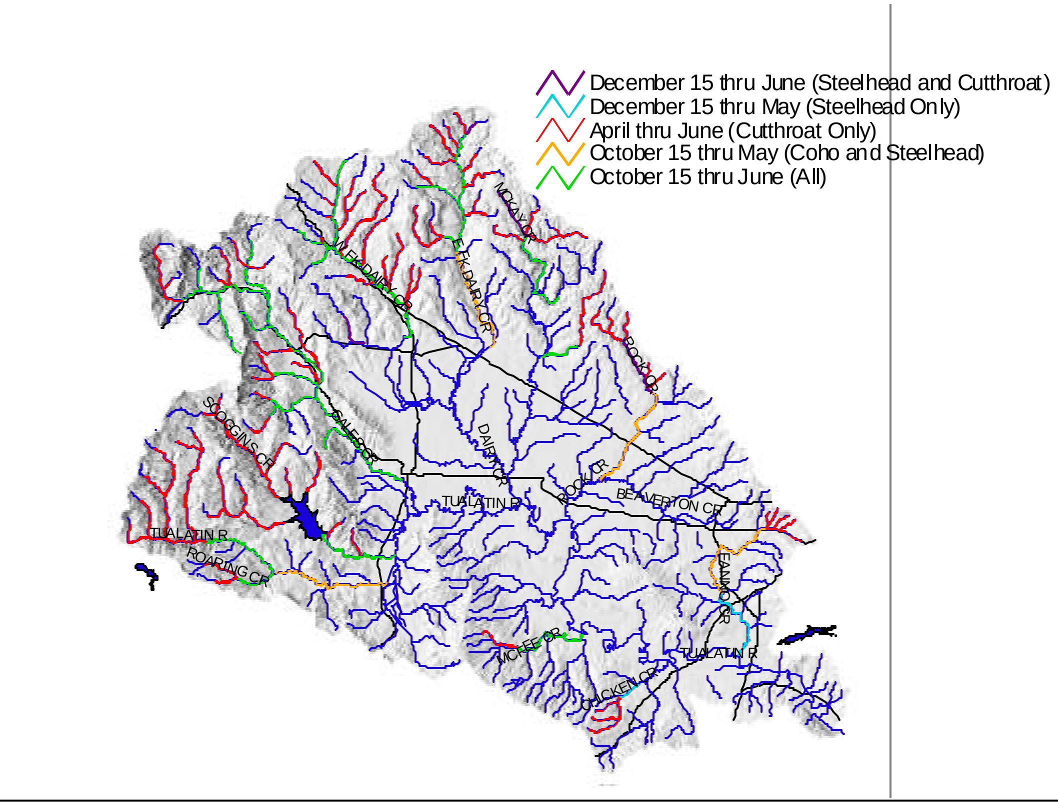
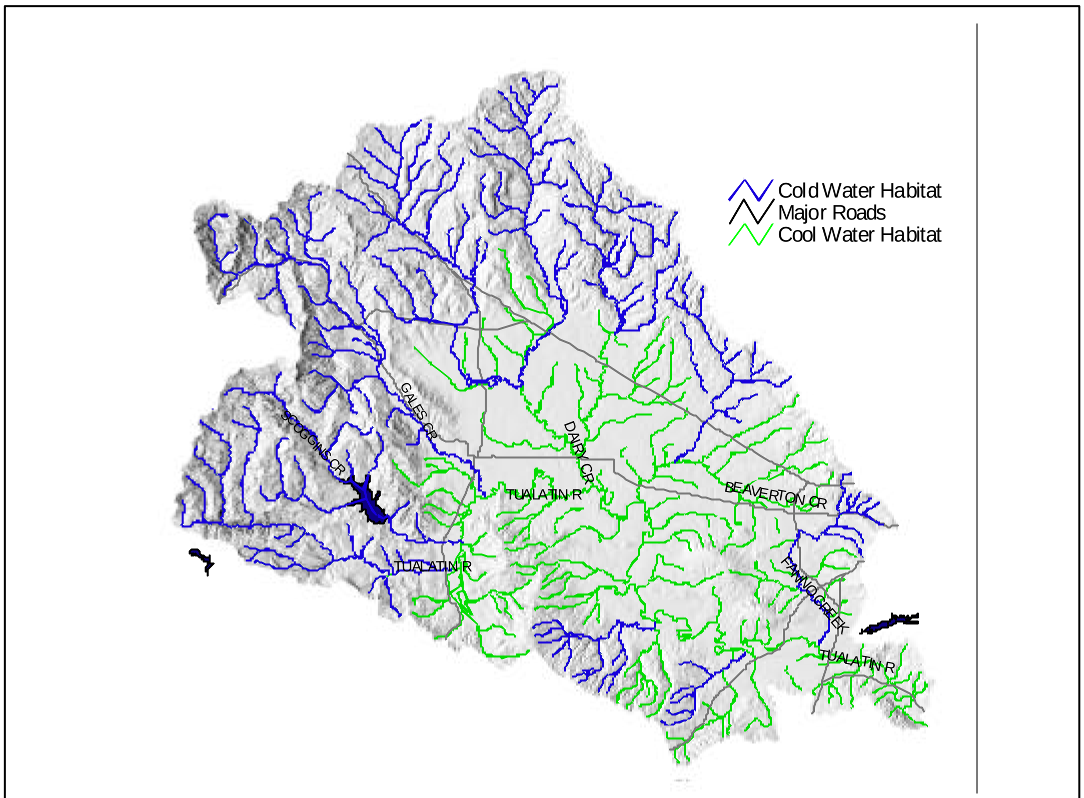


Figure 50. Tualatin River Subbasin Aquatic Communities



Cold-, cool-, and warm-water aquatic life are defined in Oregon Administrative Rule **(OAR) 340-041-0006** as follows:

(51) "Cold-Water Aquatic Life" – The aquatic communities that are physiologically restricted to cold water, composed of one or more species sensitive to reduced oxygen levels. Including but not limited to Salmonidae and cold-water invertebrates.
(52) "Cool-Water Aquatic Life" – The aquatic communities that are physiologically restricted to cool waters, composed of one or more species having dissolved oxygen requirements believed similar to the cold-water communities. Including but not limited to Cottidae, Osmeridae, Acipenseridae, and sensitive Centrarchidae such as the small-mouth bass.
(53) "Warm-Water Aquatic Life" – The aquatic communities that are adapted to warm-water conditions and do not contain either cold- or cool-water species.

Based on available fish survey information, habitat assessments and professional judgement, DEQ, with input from ODFW staff, the stream segments denoted in **Figure 50** are designated as providing cold- and cool-water aquatic life. Since all stream segments within the subbasin may contain cold- or cool-water species, no segments were identified as providing habitat solely for warm-water aquatic life.

4.3.2 CONDITION ASSESSMENT

4.3.2.1 303(D) LISTED STREAM SEGMENTS

Section 303(d) of the Federal Clean Water Act (1972) requires that waterbodies that violate water quality standards, thereby failing to fully protect beneficial uses, be identified and placed on the state's 303(d) list. Twenty-two streams in the Tualatin Subbasin have been placed on the Oregon Department of Environmental Quality's (DEQ) 1998 303(d) list for dissolved oxygen. **Table 26** shows the waters on the 303(d) list for low dissolved oxygen concentrations. The mainstem Tualatin River, river mile (RM) 3.4 to 39, is not on this list since a TMDL was developed in 1988 addressing dissolved oxygen for this stream segment. As is explained in Section 4.3.10.2 below, all stream segments within the Tualatin Subbasin (hydrologic unit code 17090010) are addressed in this TMDL.

Table 26. Tualatin Subbasin Stream Segments on the 1998 303(d) List for DO

Stream	Segment	Season
Ash Creek	Mouth to Headwaters	May 1 - Oct. 31
Beaverton Creek	Mouth to Headwaters	May 1 - Oct. 31
Bronson Creek	Mouth to Headwaters	May 1 - Oct. 31
Burris Creek	Mouth to Headwaters	May 1 - Oct. 31
Butternut Creek	Mouth to Headwaters	May 1 - Oct. 31
Carpenter Creek	Mouth to Headwaters	May 1 - Oct. 31
Cedar Creek	Mouth to Headwaters	May 1 - Oct. 31
Chicken Creek	Mouth to Headwaters	May 1 - Oct. 31
Christenson Creek	Mouth to Headwaters	May 1 - Oct. 31
Council Creek	Mouth to Headwaters	May 1 - Oct. 31
West Fork Dairy Cr.	Mouth to Headwaters	May 1 - Oct. 31
Fanno Creek	Mouth to Headwaters	May 1 - Oct. 31
Gales Creek	Mouth to Clear Creek	May 1 - Oct. 31
Hall Creek	Mouth to Headwaters	May 1 - Oct. 31
Hedges Creek	Mouth to Headwaters	May 1 - Oct. 31
Johnson Creek, South	Mouth to Headwaters	May 1 - Oct. 31
McFee Creek	Mouth to Headwaters	May 1 - Oct. 31
Nyberg Creek	Mouth to Headwaters	May 1 - Oct. 31
Rock Creek	Mouth to Headwaters	May 1 - Oct. 31
Scoggins Creek	Mouth to Scoggins Reservoir	Nov. 1 - April 30
Summer Creek	Mouth to Headwaters	May 1 - Oct. 31
Willow Creek	Mouth to Headwaters	May 1 - Oct. 31

4.3.2.1.1 Tributaries

Dissolved oxygen and related data in the Tualatin Subbasin have been collected at numerous ambient water quality stations by DEQ, USGS, USA and the other designated management agencies (DMAs). As part of its Stormwater NPDES permit, USA has also collected stormwater samples for DO and related parameters both instream and from runoff of characteristic land uses in USA's service area.

A more detailed assessment of the dissolved oxygen levels in the tributaries is included below.

4.3.2.1.2 Mainstem Tualatin River

Monitoring of DO levels on the mainstem of the Tualatin River is carried out at several locations. USA currently collects samples at nine sites in this section. Samples are collected at approximately one-week intervals during the May through November season. DEQ collects monthly water quality samples of the Tualatin River at Boones Ferry (RM 8.6) and Elsner Bridge (RM 16.2). The USGS also operates continuous monitoring stations at the Lake Oswego Diversion Dam (RM 3.4) and at RM 24.5.

A more detailed assessment of the dissolved oxygen levels on the mainstem Tualatin River is included below.

4.3.3 RELATIONSHIP BETWEEN DO AND POLLUTANTS

Dissolved oxygen in water bodies may fall below healthy levels for a number of reasons including carbonaceous biochemical oxygen demand (CBOD) within the water column, nitrogenous biochemical oxygen demand (NBOD, also known as nitrification), algal respiration, zooplankton respiration and sediment oxygen demand (SOD). Increased water temperatures will also reduce the amount of oxygen in water by decreasing its solubility and increasing the rate of nitrification and the decay of organic matter.

More detailed discussions of the relationships between dissolved oxygen and pollutants are included in the discussion below.

4.3.4 TRIBUTARY TMDLS

4.3.4.1 INTRODUCTION

The tributary stream segments placed on the 1998 303(d) list (**Table 26**) were all listed due to violations of the cool-water dissolved oxygen criteria, with the exception of Scoggins Creek, which was listed for violations of the salmonid spawning criteria. As explained above, the DEQ paper *Tualatin River Subbasin Fish Habitat and Fish Community Information* (**Appendix F**) was developed subsequent to the 1998 303(d) listing to assist in interpreting the dissolved oxygen standard in the Tualatin River Subbasin.

While it is not the intent of this TMDL to fully reexamine the 1998 listings (this will be done for the next iteration of the 303[d] list), it is appropriate to determine whether the basis for the vast majority of the listing criteria are still valid. Most of the stream segments in **Table 26** were listed based on violations of the cool-water criteria. A comparison of these listings with the cool- and cold-water habitat delineation provided in **Figure 50** reveals that several stream segments listed for cool-water habitat are actually cold-water habitat. These stream segments are: Chicken, West Fork Dairy, Fanno, Gales, McFee, and Upper Rock Creeks. Therefore, the TMDLs for these tributaries have been developed to meet the cold-water dissolved oxygen criteria.

4.3.4.2 SOURCE IDENTIFICATION

As explained above, there several factors which may contribute to the deficit of dissolved oxygen on the tributary streams in the Tualatin River Subbasin. These include nitrification, carbonaceous biochemical oxygen demand (CBOD) within the water column, algal growth, sediment oxygen demand (SOD), and temperature. These factors are explained below.

Nitrification - When nitrogen in the form of ammonia is introduced to natural waters, the ammonia may “consume” dissolved oxygen as nitrifying bacteria convert the ammonia into nitrite and nitrate. The process of ammonia being transformed into nitrite and nitrate is called nitrification. The consumption of oxygen during this process is called nitrogenous biochemical oxygen demand, NBOD. To what extent this process occurs, and how much oxygen is consumed, is related to several factors. These factors include residence time, water temperature, ammonia concentration in the water, and the presence of nitrifying bacteria. For every mg/L of ammonia nitrified, 4.33 mg/L of oxygen may be consumed.

CBOD - Water column carbonaceous biochemical oxygen demand (CBOD) is the oxygen consumed by the decomposition of organic matter in water. The sources of the organic matter can be varied, either resulting from natural sources such as direct deposition of leaf litter or from anthropogenic sources such as polluted runoff.

Algal Growth - In many waterbodies, dissolved oxygen concentrations may be violated because of algae. Excessive algae concentrations can cause large diel fluctuations in DO. Such streams generally exhibit supersaturated dissolved oxygen concentrations during the day and low DO concentrations at night. The State of Oregon has designated an action level of 15 ug/L concentration of chlorophyll a (a measure of algal content) to indicate when algal growth may be a problem.

Of the tributary streams in the Tualatin Subbasin which are 303(d) listed for dissolved oxygen, the following are also listed as exceeding the chlorophyll a action level: Bronson Cr., Burris Cr., Cedar Cr., Fanno Cr., Nyberg Cr., and Rock Cr. These chlorophyll a impairments are addressed within the Phosphorus TMDL (Section 4.4).

Sediment Oxygen Demand (SOD) - When solids that contain organics settle to the bottom of a stream they may decompose anaerobically or aerobically, depending on conditions. The oxygen consumed in aerobic decomposition of these sediments is called sediment oxygen demand (SOD) and represents another dissolved oxygen sink for a stream. The SOD may differ from both water column CBOD and nitrification in that SOD will remain a DO sink for a much longer period after the pollution discharge ceases (e.g., organic-containing sediment deposited as a result of rain-driven runoff may remain a problem long after the rain event has passed).

Table 27. USGS SOD Measurements on Tualatin Subbasin Tributaries
(Rounds et *al*, 1997 and unpublished addendum)

Site	Date	SOD_{20} (g/m^2d)	Site	Date	SOD_{20} (g/m^2d)
Beaverton Cr. at Arleda Park	07/16/96	4.1	Fanno at Englewood Park	07/15/1996	2.7
	“	4.7		"	4.4
Bronson Cr. at Walker	07/18/96	10.9		"	4.3
	“	4.2	Gales Creek at Zurcher Irrigation Pump	07/19/1996	9.0
	“	7.3		"	2.8
Cedar Mill Cr. near Jenkins Rd.	07/19/96	6.1		"	2.5
	“	2.8	Rock Creek at Rock Creek WWTP	07/17/1996	2.9
	“	6		"	4.2
	08/07/97	0.86		"	1.7
	“	2.12		08/06/1997	3.47
	“	2.61		"	2.19
Dairy Cr. at Dairy Creek Park	08/07/95	3.1		"	1.09
Fanno Creek at Durham City Park	07/15/1996	0.9	Rock Creek near Southeast 59th Ave.	08/07/1995	2.4
	"	0.2		07/18/1996	2.2
	08/06/1997	3.51		"	3.0
	"	0.99		"	6.0
	"	1.88	Willow Cr.	07/16/96	1.7
Fanno Creek at Fanno Creek Park	08/08/1995	2.7		"	4.7
				"	4.4

The Tualatin tributary SOD rates measured by the USGS are given in **Table 27**. As is typical of in-situ SOD measurements, the Tualatin tributary SOD rates show high variability. For all Tualatin tributaries, the overall median SOD_{20} rate (the SOD rate at 20 °C) is 2.9 g/m^2d, and the 25^{th} and 75^{th} percentiles are 2.2 and 4.4 g/m^2d, respectively. Such rates are significant and could cause significant water column dissolved oxygen deficits and standards violations. (For comparison, SOD_{20} rates measured during a USGS study along the lower Willamette River had a median value of 2.0 g/m^2d [Rounds *et al*, 1997]).

Temperature – Temperature has a significant impact on the dissolved oxygen in a stream in two ways. The first is that with increasing temperatures the amount of oxygen that can remain dissolved in water decreases. The second is that, in general, all of the other dissolved oxygen sinks listed above increase their oxygen consumption as temperature increases.

Other - While there are other factors such as stream flow which may influence the dissolved oxygen in the tributaries, these are not considered pollutants (or the result of pollutants) and therefore are not analyzed within the TMDL context for allocations.

4.3.4.3 REPRESENTATIVE STREAMS

4.3.4.3.1 Stream Categorization

The tributary stream segments that are on the 303(d) list for dissolved oxygen may be separated into four broad categories based on certain similarities (primarily land uses and aquatic habitat designation). These categories and the streams that fall into each category are presented in **Table 28**. The purpose of the categorization is to facilitate an efficient analysis of the streams.

Table 28. Tualatin River Subbasin Tributary Categorization

Tributary Stream Categories	Salmonid Spawning	Cold-Water Habitat/ Primary Land Uses: Ag & Forestry (Some Urban and/or Rural Residential)	Cool-Water Habitat/ Primary Land Uses: Mixed		Cold-Water Habitat/ Primary Land Use: Urban
Tributary Streams	**Scoggins Cr.**	**Gales Cr.**	Ash Cr.	Council Cr.	**Fanno Cr.**
		WF Dairy Cr.	**Beaverton Cr.**	Hall Cr.	
		Chicken Cr.	Bronson Cr.	Hedges Cr.	
		McFee Cr.	Burris Cr.	Johnson Cr. South	
		Upper Rock Cr.	Butternut Cr.	Nyberg Cr.	
			Carpenter Cr.	**Lower Rock Cr.**	
			Cedar Cr.	Summer Cr.	
			Christenson Cr.	Willow Cr.	

For each of the four tributary stream categories listed above, a representative stream was selected for which to complete a detailed analysis. The representative stream name for each category is in bold type in **Table 28**.

The bases for the selection of these streams are as follows: 1) Both Scoggins and Fanno Creeks were the only creeks within their categories. 2) Gales Creek exhibited many of the same attributes as the other streams in its category and was the largest stream in the category (and therefore had the most data associated with it). 3) Lower Rock and Beaverton Creeks combined are good representatives of a mixed-use system (which most of the others in this category are) and are also the largest streams within this category.

These representative streams were analyzed in detail as explained in the next section. The results of these analyses were then applied to other streams within the appropriate category, as is also detailed below.

4.3.4.4 GALES CREEK ANALYSIS

4.3.4.4.1 Introduction

Gales Creek has its headwaters in the Coastal Range in forested lands, flows down through agricultural and rural residential lands, and drains a portion of the City of Forest Grove near its mouth. The lower mainstem of the creek is 303(d) listed for violations of the DO cool-water criteria from May 1 through October 31. Subsequent to the 303(d) listing, the analysis performed in DEQ's discussion paper *Tualatin River Subbasin Fish Habitat and Fish Community Information* (**Appendix F**) determined that Gales Creek is cold-water habitat (see **Figure 50**). Therefore, the target DO criterion for individual grab sampling is 8.0 mg/L.

As explained above, this Gales Creek analysis is also being used to represent analyses for similar streams that are also 303(d) listed for dissolved oxygen. These streams are West Fork Dairy Creek, Chicken Creek, McFee Creek, and Upper Rock Creek (from the confluence with Beaverton Creek to the headwaters). Each of these streams is considered cold-water habitat and has a watershed that predominantly includes agricultural and forested lands with a small area of urban land. Due to the target criteria and land use similarities, these streams are also expected to benefit from pollutant reductions in the same manner as Gales Creek.

4.3.4.4.2 Dissolved Oxygen Monitoring

Available dissolved oxygen data for Gales Creek in the summer months (July 1 – Sept 30) are presented in **Figure 51** (see **Appendix D-2** for an explanation of box and whiskers plots). All data are grab sample data.

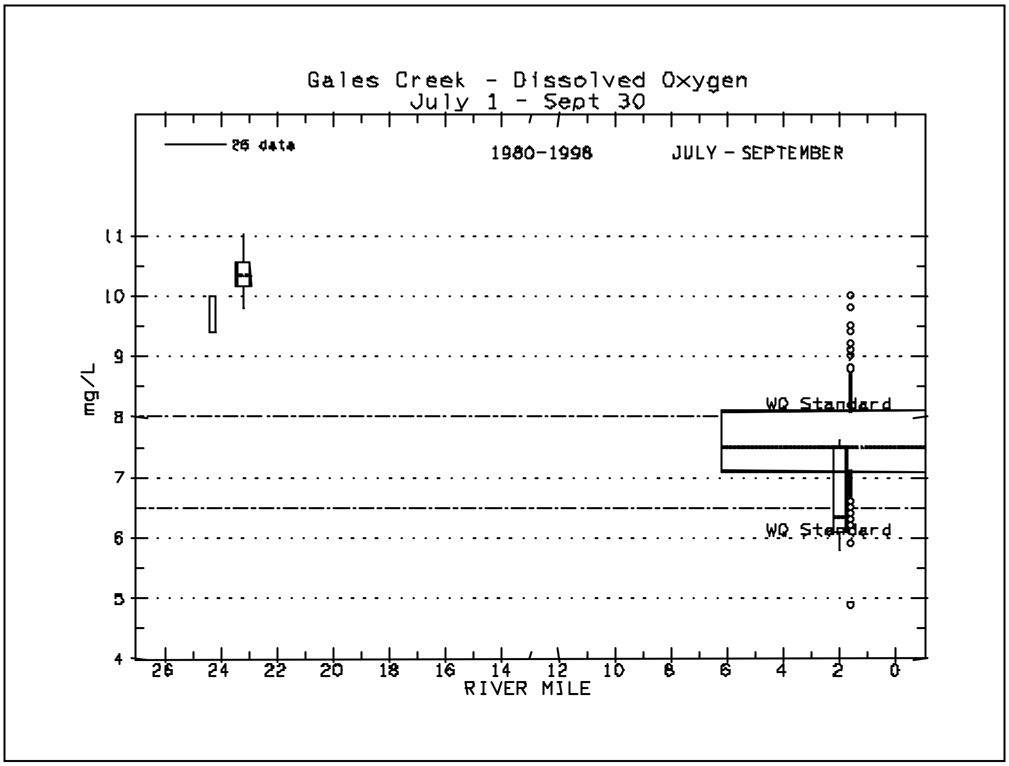


Figure 51. Gales Creek Dissolved Oxygen

As shown, extensive data is only available for one station (GALES CREEK @ HWY 47 BRIDGE, station name: 3810012, secondary station name: 402311, agency code: 21ORMISC, collection agency: USA, location: river mile 1.63). At this station, nearly 75% of DO observations were less than the 8.0 mg/L standard, the median observed DO was 7.5 mg/L, and nearly 25% of observations were less than 7.0 mg/L.

Figure 52 presents observed dissolved oxygen concentrations as percents of saturation. The median value was about 78% of saturation.

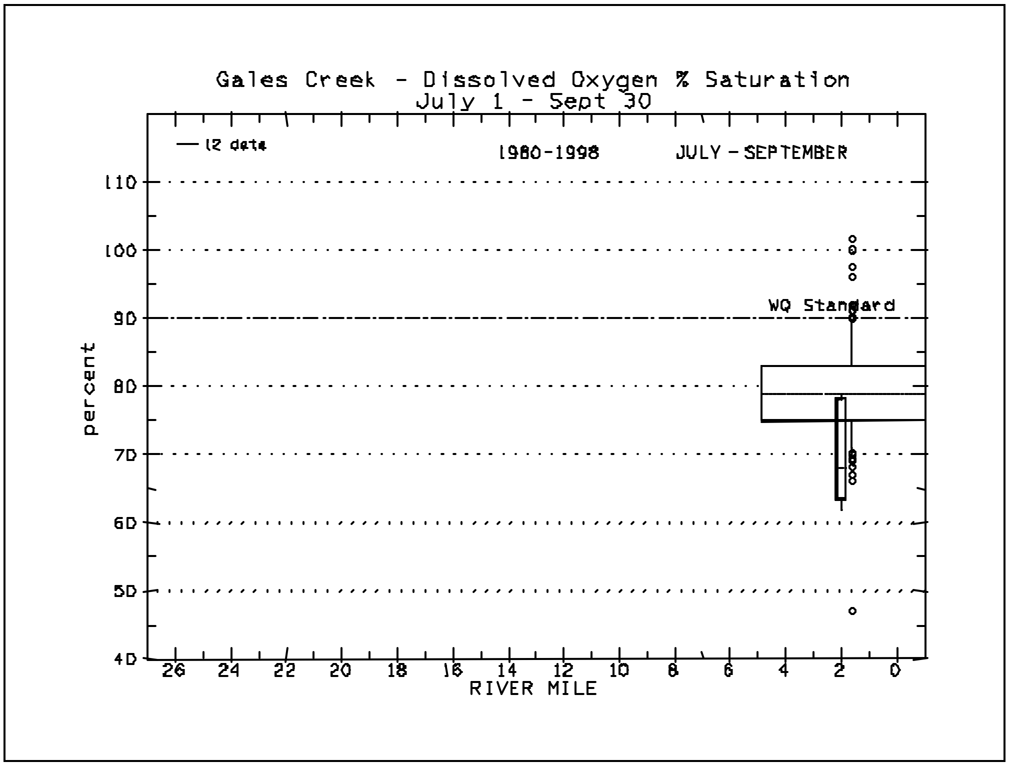


Figure 52. Gales Creek Dissolved Oxygen - Percent of Saturation

4.3.4.4.3 Contributors to Dissolved Oxygen Deficit

ALGAE

As shown in **Figure 52**, although most of the DO concentrations in Gales Creek were measured during the day, very few were above 90% saturation. In addition, no large phytoplankton (suspended algae) concentrations have been observed in the system. The median summertime chlorophyll a concentration is about 1.5 µ/L, which is only 10% of the action level for streams of 15.0 µ/L. The low DO saturation percentages and chlorophyll a concentrations indicate that algae is most likely not a major factor in the DO balance.

CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND

Carbonaceous biochemical oxygen demand (CBOD or BOD) is also a potential factor in the DO balance. The limited amount of available data for Gales Creek indicates that typical summer BOD levels are about 1 mg/L. This indicates that dissolved and suspended organic matter may contribute to the dissolved oxygen deficit in the stream, but it is not the primary DO sink.

AMMONIA

Another potential source of oxygen demand is ammonia. For every 1 mg/L of ammonia nitrified, 4.33 mg/L of oxygen may be consumed. The observed median concentration of ammonia as nitrogen in Gales Creek is less than 0.05 mg/L, which equates to an estimated nitrogenous oxygen demand of 0.22 mg/L. This indicates that ammonia is probably only a minor contributor to DO deficit in the system.

SEDIMENT OXYGEN DEMAND

The median value of the SOD values (normalized to 20°C) for Gales Creek was 2.8 g/m^2d, which is comparable to the median SOD value for all Tualatin tributary streams (2.9 g/m^2d). As mentioned above, SOD values of this magnitude may be significant dissolved oxygen sinks.

4.3.4.4.4 Water Quality Modeling

A steady state water quality model was developed of Gales Creek in order to evaluate the sensitivity of dissolved oxygen concentrations to temperature and sediment oxygen demand (the two parameters that appear to impact DO on Gales Creek the most). The modeling was calibrated using a critical July low-flow day, when DO levels are expected to be at or near their minimums. The details of this modeling work are included in **Appendix D-3**.

TARGET CRITERIA FOR MODEL SIMULATIONS

There are several factors within the modeling analysis that may lead to uncertainties, including the fact that no data is available on diel DO fluctuation. (DO will have diel variations due to temperature fluctuations as well as due to algae photosynthesis and respiration). In addition to this, seasonal median values of DO and pollutants were used to calibrate the model and the model results in estimates of daily average DO values. These two factors lead to modeled DO values that will be higher than actual critical DO values.

In order to account for these uncertainties, the target criterion for the modeling scenarios was increased from a minimum of 8.0 mg/L to a minimum concentration of approximately 9.0 mg/L.

MODEL SIMULATION – TEMPERATURE AND SOD REDUCTION

Following calibration of the model, simulations were performed to evaluate the impact of temperature and SOD reductions on dissolved oxygen. The temperature reductions used in these simulations were based on achieving the system potential of 90% shade density (the shade density allocated in the Temperature TMDL for Gales Creek). These simulations were run to determine the percent reduction in SOD needed (in addition to the temperature reduction) to maintain a daily average DO of approximately 9.0 mg/L. The model indicated that a 30% reduction in SOD, coupled with system potential shade conditions, would result in this DO concentration being met (see **Figure 53**). The upper line in **Figure 53** represents the simulated DO values with the temperature and SOD reductions. The lower line represents the current DO values (calibration scenario).

As shown, system potential shade conditions coupled with 30% SOD reductions result in a daily average DO of greater than 8.0 mg/L. The modeled daily average DO was close to 9.0 mg/L, which will adequately address the needed margin of safety.

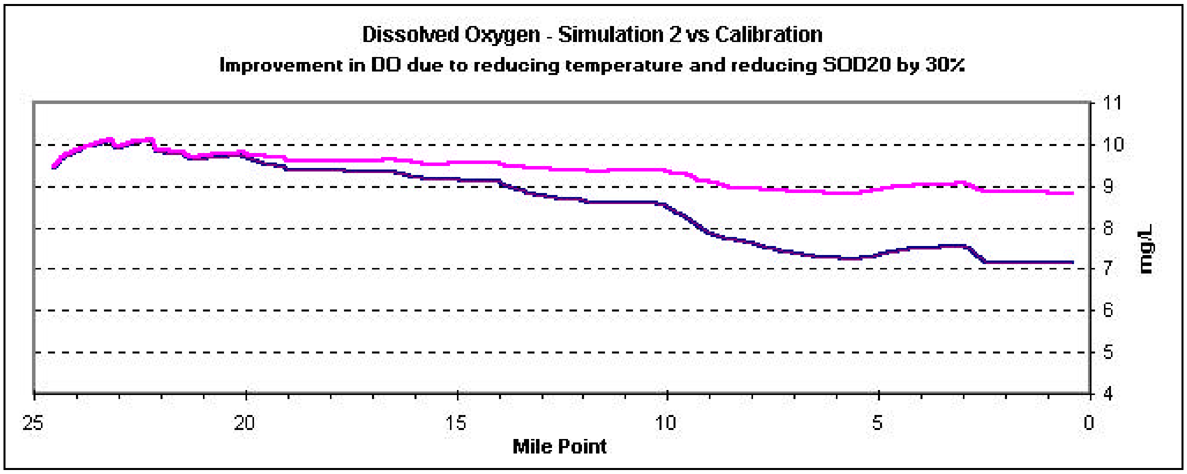


Figure 53. Dissolved Oxygen – Simulation with Temperature and SOD Reductions vs. Calibration on Gales Creek

4.3.4.5 FANNO CREEK ANALYSIS

4.3.4.5.1 Introduction

Fanno Creek drains a predominantly urban watershed with its headwaters in the Tualatin Mountains. The creek is 303(d) listed for violations of the DO cool-water criteria from May 1 through October 31. Subsequent to the 303(d) listing, the analysis performed in DEQ's discussion paper *Tualatin River Subbasin Fish Habitat and Fish Community Information* (**Appendix F**) determined that Fanno Creek is cold-water habitat (see **Figure 50**). Therefore, the target DO criterion for individual grab sampling is 8.0 mg/L.

While Fanno Creek is the only stream in the cold water habitat/urban land use category (see **Table 28**), it follows from the analysis below that it will be necessary for both Ash and Summer Creeks to meet the same pollutant allocations in order for Fanno Creek to meet the DO criteria.

4.3.4.5.2 Dissolved Oxygen Monitoring

Available dissolved oxygen data for Fanno Creek for summer months (July 1 – Sept 30) for the past ten years are presented in **Figure 54** (see **Appendix D-2** for an explanation of box and whiskers plots). All data are grab sample data.

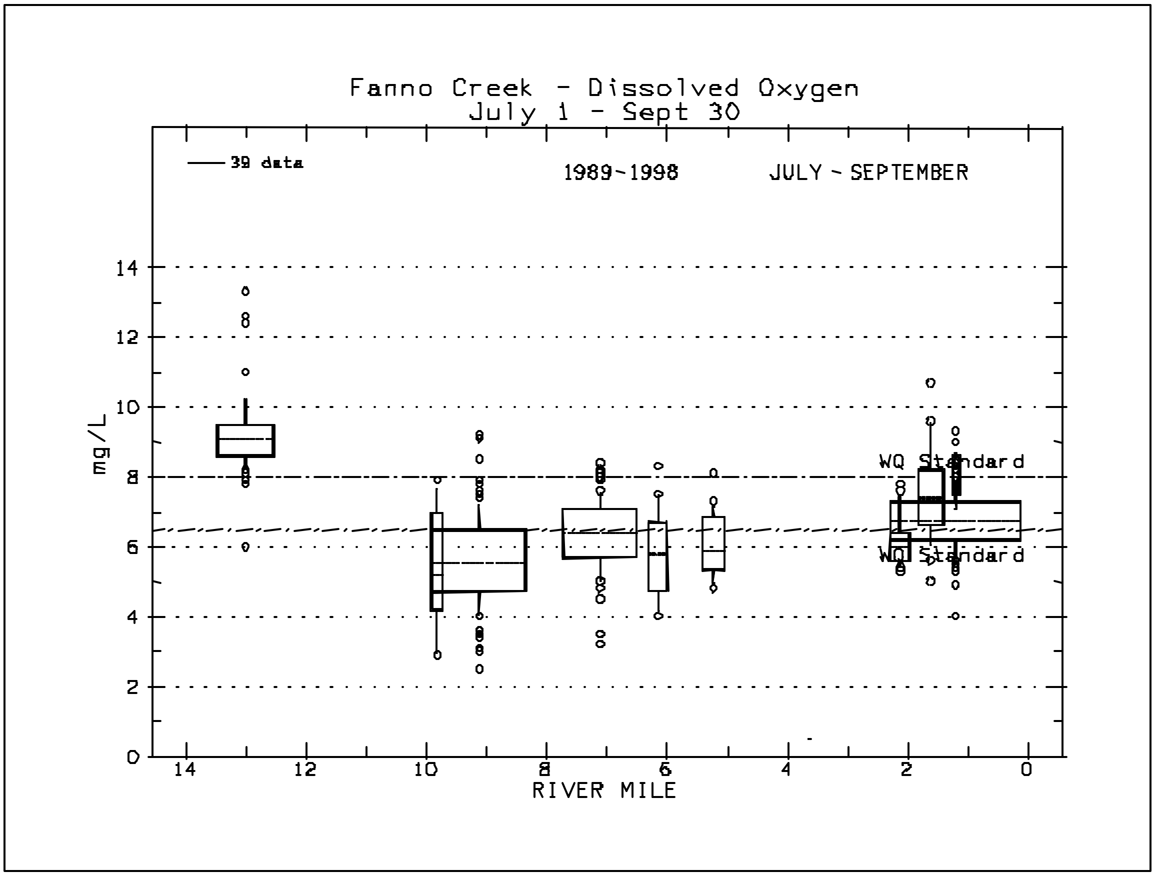


Figure 54. Fanno Creek Dissolved Oxygen

Most of the available data for Fanno Creek was collected at four stations:

Storet Number	Station Name	River Mile
3840135	Fanno Creek at 39th Ave	13.0
3840095	Fanno Creek near Allen Road	9.1
3840074	Fanno Creek at Tuckerwood	7.1
3840008	Fanno Creek on Durham Rd	1.2.

As shown in **Figure 54**, dissolved oxygen concentrations at river mile (RM) 13.0 are above standards, while at stations further downstream standards are frequently violated. Median concentrations at RM 9.1 are about 5.5 mg/L, at RM 7.1 about 6.5 mg/L and at RM 1.2 about 6.8 mg/L. Ash Creek and Summer Creeks enter Fanno Creek at RM 5.4 and RM 4.9. Dissolved oxygen concentrations in Ash and Summer Creeks are even lower than in Fanno Creek. Median observed summer concentrations in Ash Creek are 3.5 mg/l (38.8% of saturation) and in Summer Creek are 1.9 mg/L (21.4% of saturation).

4.3.4.5.3 Contributors to Dissolved Oxygen Deficit

ALGAE

Algae concentrations in Fanno Creek are quite high in some areas (see **Figure 55**). At RM 9.1 chlorophyll a concentrations exceed the 15 ug/L action level. However, at all other stations median concentrations are below 15 ug/L. Because chlorophyll a concentrations are high enough to potentially influence DO, algae has been included in the model (described below).

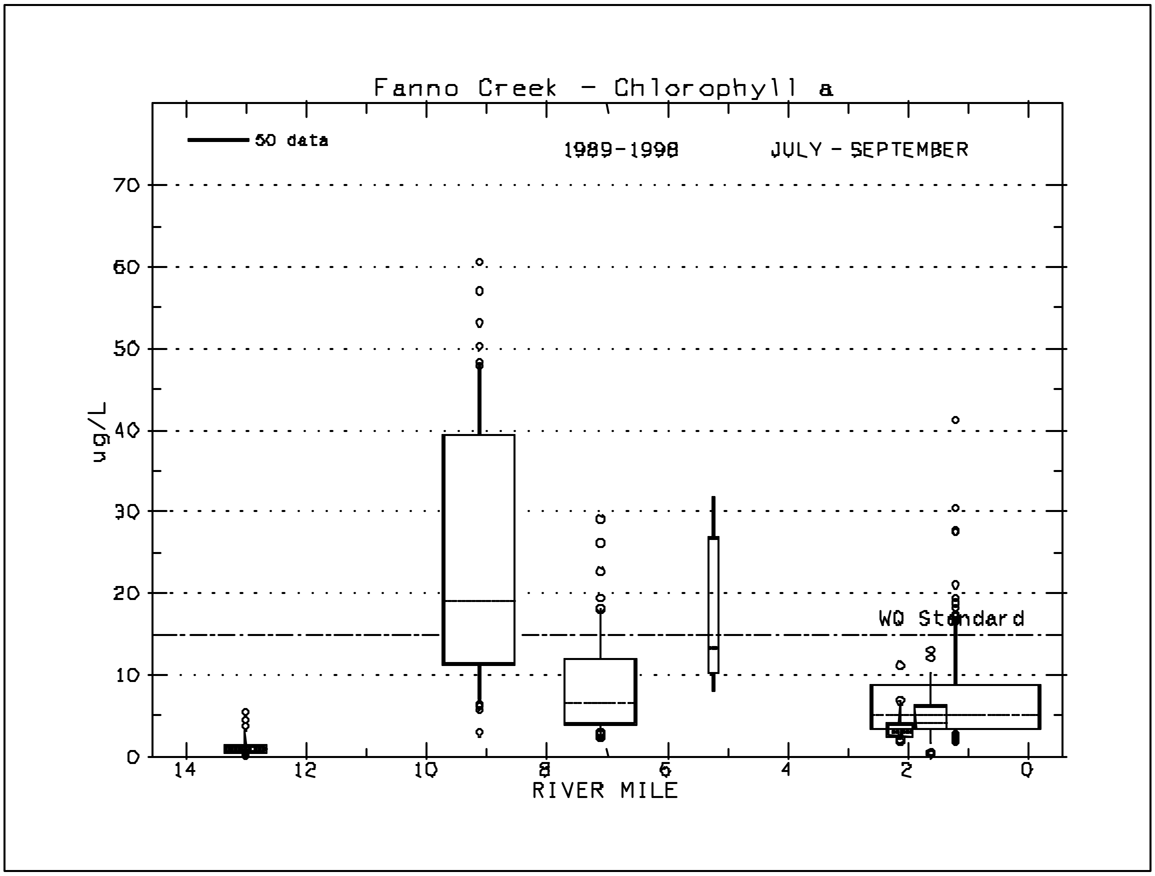


Figure 55. Fanno Creek Chlorophyll a

CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND

Biochemical oxygen demand (BOD) is also a potential factor in the DO balance. Only limited data is available on BOD. Most of the observed BOD_5 concentrations in Fanno Creek are in the range 1 to 3 mg/L. This indicates that dissolved and suspended organic matter may contribute to the dissolved oxygen deficit in the stream.

AMMONIA

Another potential source of oxygen demand is ammonia. For every mg/L of ammonia nitrified, 4.33 mg/L of oxygen may be consumed. The observed median concentration for ammonia as nitrogen in Fanno Creek is less than 0.1 mg/L, which equates to less than 0.5 mg/L of potential nitrogenous oxygen demand.

SEDIMENT OXYGEN DEMAND

As is typical of in-situ SOD measurements, the Fanno Creek SOD rates show high variability. For Fanno Creek, the overall median SOD rate is 2.7 $g/m^2/day$, and the 25th and 75th percentiles are 1.0 and 3.5 $g/m^2/day$, respectively. Such rates could cause significant water column dissolved oxygen deficits and standards violations.

4.3.4.5.4 Water Quality Modeling

A steady state water quality model was developed of Fanno Creek in order to evaluate the sensitivity of dissolved oxygen concentrations to temperature, sediment oxygen demand, and algae (the parameters that appear to impact DO on Fanno Creek the most). The modeling was calibrated using a critical July low-flow day, when DO levels are expected to be at or near their minimums. The details of this modeling work are included in **Appendix D-3**.

TARGET CRITERIA FOR MODEL SIMULATIONS

There are several factors within the modeling analysis that may lead to uncertainties, including the fact that no data is available on diel DO fluctuation. (DO will have diel variations due to temperature fluctuations as well as due to algae photosynthesis and respiration). In addition to this, seasonal median values of DO and pollutants were used to calibrate the model and the model results in estimates of daily average DO values. These two factors lead to modeled DO values that will be higher than actual critical DO values.

In order to account for these uncertainties, the target criterion for the modeling scenarios was increased from a minimum of 8.0 mg/L to a minimum concentration of approximately 9.0 mg/L.

MODEL SIMULATION – TEMPERATURE AND SOD REDUCTION

Following calibration of the model, simulations were performed to evaluate the impact of temperature and SOD reductions on dissolved oxygen. The temperature reductions used in these scenarios were based on achieving the system potential shade density (the shade density allocated in the Temperature TMDL for Fanno Creek). Since the percent shade allocations provided to meet the temperature standard will apply to all reaches of Fanno Creek, as well as Ash and Summer Creeks, it is reasonable to assume that boundary and tributary DO concentrations will be improved also. Therefore, for the simulations the DO levels at the boundaries and for the tributaries were increased to 75% saturation. This is similar to the predicted DO levels in Fanno Creek due to temperature reductions.

Modeling simulations were run to determine the percent reduction in SOD needed (in addition to the temperature reduction) to maintain a daily average DO of 9.0 mg/L or greater. The model indicated that a 50% reduction in SOD, coupled with system potential shade conditions, would result in this DO concentration being met (see **Figure 56**). The upper line in **Figure 56** represents the simulated DO values with the temperature and SOD reductions. The lower line represents the current DO values (calibration scenario).

As shown, system potential shade conditions coupled with 50% SOD reductions result in a daily average DO of close to 9.0 mg/L for all points along the stream. While at some points the DO concentration is predicted to fall slightly short of this concentration, a reasonable margin of safety is still achieved. In addition to this margin of safety, it is expected that management practices put in place to reduce SOD will also result in CBOD reductions. Since CBOD levels are relatively high (1 – 3 mg/L), any reduction will most likely increase the instream DO levels, adding to the margin of safety. Note that for this scenario, boundary and tributary DO concentrations were set to 90% of saturation for the simulations.

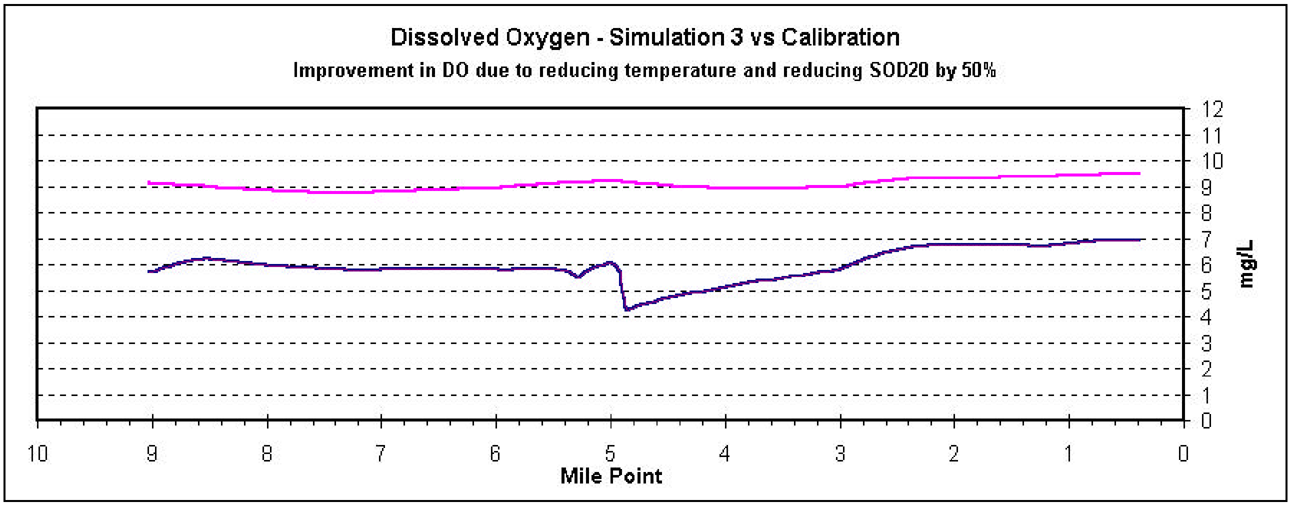


Figure 56. Dissolved Oxygen – Simulation with Temperature and SOD Reductions vs. Calibration for Fanno Creek

4.3.4.6 LOWER ROCK CREEK/BEAVERTON CREEK ANALYSIS

4.3.4.6.1 Introduction

Lower Rock Creek and Beaverton Creek drain a mixed-use watershed with a heavy urban influence. The two creeks are 303(d) listed for violations of the DO cool-water criteria from May 1 through October 31. Therefore, the target DO criterion for individual grab sampling is 6.5 mg/L.

As explained above, this Lower Rock Creek/Beaverton Creek analysis is also being used to represent analyses for similar streams that are also 303(d) listed for dissolved oxygen. These streams are Bronson, Burris, Butternut, Carpenter, Cedar, Christensen, Council, Hall, Hedges, Johnson South, Nyberg, and Willow Creeks. Each of these streams is considered cool-water habitat and has a watershed that includes varying mixes of land uses. Due to the target criteria and land use similarities, these streams are expected to benefit from SOD and temperature reductions in the same manner as Lower Rock and Beaverton Creeks.

4.3.4.6.2 Dissolved Oxygen Monitoring

Statistical summaries of the available dissolved oxygen data for Rock and Beaverton Creeks for summer months (July 1 – Sept 30) for the past ten years are presented in **Figure 57**. The figure follows Rock Creek from its mouth at the Tualatin River up to the confluence of Beaverton Creek at RM 4, and then follows Beaverton Creek up to Beaverton Creek RM 14, for a total distance of 18 miles. Beaverton Creek is followed rather than Upper Rock Creek because Beaverton has significantly more flow than Upper Rock and it is considered cool-water habitat (as is Lower Rock Creek). The distances shown are total distances from the Tualatin River. All data are grab sample data.

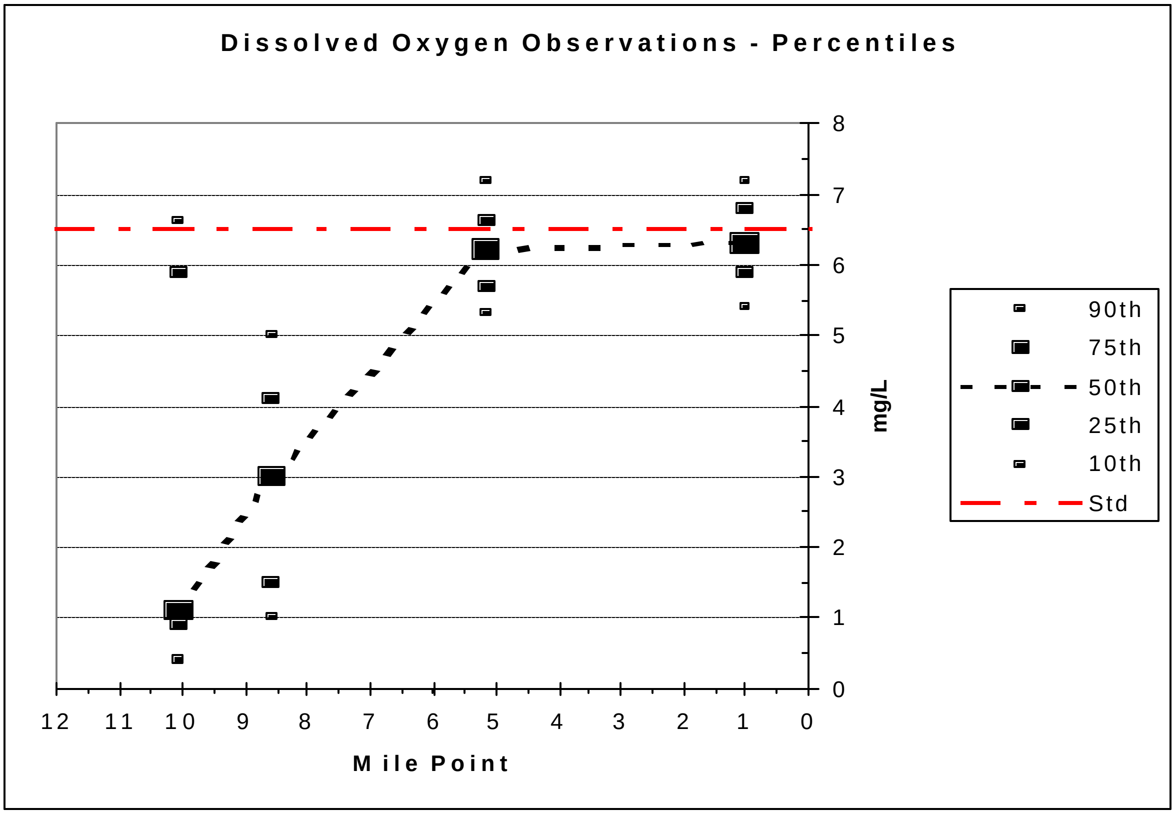


Figure 57. Rock and Beaverton Creeks Dissolved Oxygen

As shown, dissolved oxygen concentrations throughout the system are depressed, with the lowest concentrations in the upper reaches of Beaverton Creek. Dissolved oxygen concentrations of the tributary streams are also depressed (see **Table 29** for descriptions of significant monitoring stations and distances from the Tualatin River). Near their mouths Rock, Bronson, Willow and Johnson Creeks have seasonal median DO concentrations of 4.2, 5.3, 4.0, and 3.4 mg/L, respectively (see **Appendix D-3** for additional statistical summaries of water quality data for these stations).

Table 29. Water Quality Stations

Storet Code	Station Name	Rock Cr. River Mile (RM)	Beaverton Cr. RM	Tributary RM	RM as measured from confluence with the Tualatin
3820015	Rock Cr. @ Hwy 8	1.02			1.02
402147	Rock Cr. @ Hwy 8	1.02			1.02
3820047	Rock Cr. @ "Quatama" Road	4.32			4.32
N/A	Dawson Cr	2.8			2.8
N/A	Mouth of Beaverton Creek	3.96			3.96
3821050	Beaverton Cr. @ 170th Ave.		4.6		8.56
402150	Beaverton Cr. @ 216th (ORENCO)		1.16		5.12
3821012	Beaverton Cr. @ 216th		1.16		5.12
3821059	Beaverton Cr. @ Millikan Way		6.1		10.06
3824001	Bronson Creek @ 205th Ave		1.95 (Mouth)	0.1	5.91 (mouth)
3825004	Willow Creek @ 185th Ave and Baseline		3.03 (Mouth)	0.4	6.99 (mouth)
3827011	Johnson Cr South @ Glenbrook RM 1.1		5.7 (Mouth)	1.1	9.66 (mouth)
3829007	Hall Creek @ 110th Ave.		8 (Mouth)	0.7	11.96(mouth)
3823011	Cedar Mill Creek @Jay St.		4.8 (Mouth)	1.1	8.76 (mouth)

4.3.4.6.3 Contributors to Dissolved Oxygen Deficit

ALGAE

While chlorophyll a concentrations in Rock and Beaverton Creeks are generally not high relative to the 15 ug/L action level, at RM 10 the action level is frequently exceeded. In order to account for any impact that algae may have on dissolved oxygen, algae has been included in the model developed to determine allocations (described below).

CARBONACEOUS BIOCHEMICAL OXYGEN DEMAND AND AMMONIA

Biochemical oxygen demand (BOD) is also a potential factor in the DO balance. Only limited data is available on BOD. The BOD values indicate that dissolved and suspended organic matter may contribute to the dissolved oxygen deficit in the stream. Ammonia data shows less potential for impact on DO.

SEDIMENT OXYGEN DEMAND

As is typical of in-situ SOD measurements, the Lower Rock/Beaverton Creek system SOD rates show high variability. The overall median SOD rate is similar to other tributaries. Such rates could cause significant water column dissolved oxygen deficits and standards violations.

4.3.4.6.4 Water Quality Modeling

A steady state water quality model was developed of the Lower Rock Creek/Beaverton Creek system in order to evaluate the sensitivity of dissolved oxygen concentrations to temperature and sediment oxygen demand (the parameters that appear to impact DO in this system the most). The modeling was calibrated using a critical July low-flow day, when DO levels are expected to be at or near their minimums. The details of this modeling work are included in **Appendix D-3**.

TARGET CRITERIA FOR MODEL SIMULATIONS

There are several factors within the modeling analysis that may lead to uncertainties, including the fact that no data is available on diel DO fluctuation. (DO will have diel variations due to temperature fluctuations as well as due to algae photosynthesis and respiration). In addition to this, seasonal median values of DO and pollutants were used to calibrate the model and the model results in estimates of daily average DO values. These two factors lead to modeled DO values that will be higher than actual critical DO values.

In order to account for these uncertainties, the target criterion for the modeling scenarios was increased from a minimum of 6.5 mg/L to a minimum concentration of approximately 8.0 mg/L.

MODEL SIMULATION – TEMPERATURE AND SOD REDUCTION

Following calibration of the model, simulations were performed to evaluate the impact of temperature and SOD reductions on dissolved oxygen. The temperature reductions used in these scenarios were based on achieving the system potential shade density (the shade density allocated in the Temperature TMDL for Rock and Beaverton Creeks).

Modeling simulations were run to determine the percent reduction in SOD needed (in addition to the temperature reduction) to maintain a daily average DO of 8.0 mg/L or greater. The model indicates that a 20% reduction in SOD, coupled with system potential shade conditions, would result in this DO concentration being met (see **Figure 58**). (Note that for this scenario the boundary and tributary DO concentrations were set to 80% of saturation, which appears reasonable if similar temperature and SOD reductions occur in these areas.) The upper line in **Figure 58** represents the simulated DO values with the temperature and SOD reductions. The lower line represents the current DO values (calibration scenario).

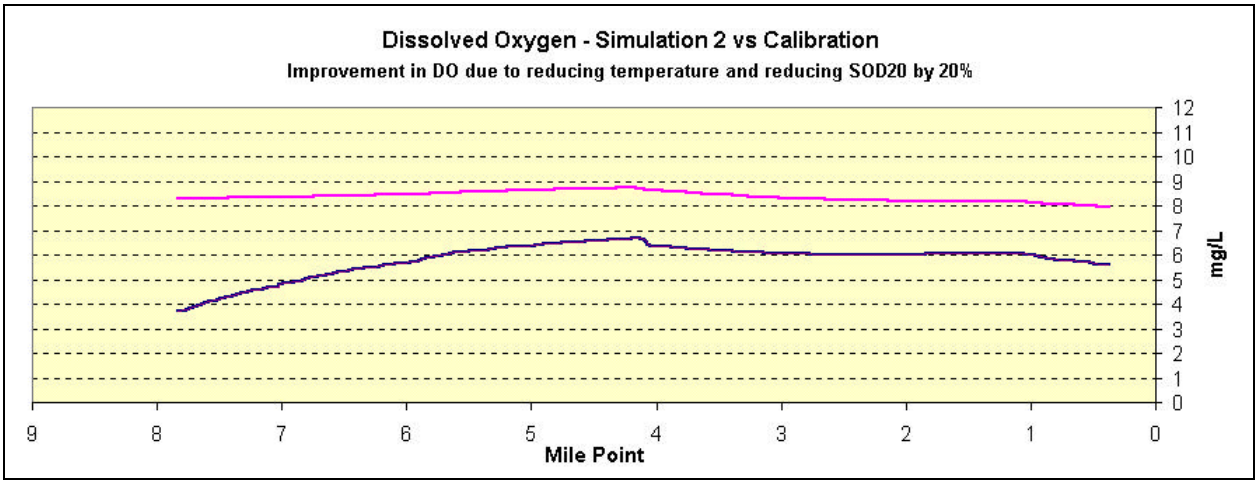


Figure 58. Dissolved Oxygen - System Potential Shade with 20% SOD Reduction

As shown, system potential shade conditions coupled with 20% SOD reductions result in a daily average DO of close to 8.0 mg/L for all points along the stream. While at one point the DO concentration is predicted to fall slightly short of this concentration, a reasonable margin of safety is still achieved.

4.3.4.7 SCOGGINS CREEK ANALYSIS

4.3.4.7.1 Introduction

The segment of Scoggins Creek from its mouth to Scoggins Dam is listed for dissolved oxygen violations from November 1 to April 30. Scoggins Creek is unique in the Tualatin watershed due to the fact that flow within the creek is primarily controlled by releases from Scoggins Reservoir, through Scoggins Dam. The portion of Scoggins Creek below the dam is considered spawning habitat for cutthroat trout, coho salmon and steelhead. Based on these beneficial uses, the dissolved oxygen water quality criterion from October 15 through June 30 is 11.0 mg/L (for full text of the criterion, see **Figure 48**).

4.3.4.7.2 Dissolved Oxygen Monitoring

Dissolved oxygen data are collected on Scoggins Creek at old Highway 47 (RM 1.5) by USA during the period from November 1 to April 30. The data collected also include chemical oxygen demand (COD), ammonia, nitrite, nitrate and temperature (among other parameters). For the rest of the year, data are collected at this site by the Tualatin Valley Irrigation District (TVID). These data do not include dissolved oxygen. Just below Scoggins Dam, at approximately RM 4.8, the TVID has also collected data, but only for May through October, and not dissolved oxygen. In addition to the water quality data, ample data also exist on flow in the creek.

For the years 1994 - 1998, dissolved oxygen concentrations on Scoggins Creek at old Hwy. 47 for November 1 to April 30 were below the water quality criterion of 11.0 mg/L for 19 of 55 samples collected. The median DO concentration was 11.4 mg/L and the median DO percent saturation was 94%. A monthly box plot for Scoggins Creek at Hwy 47 is attached as **Figure 59**.

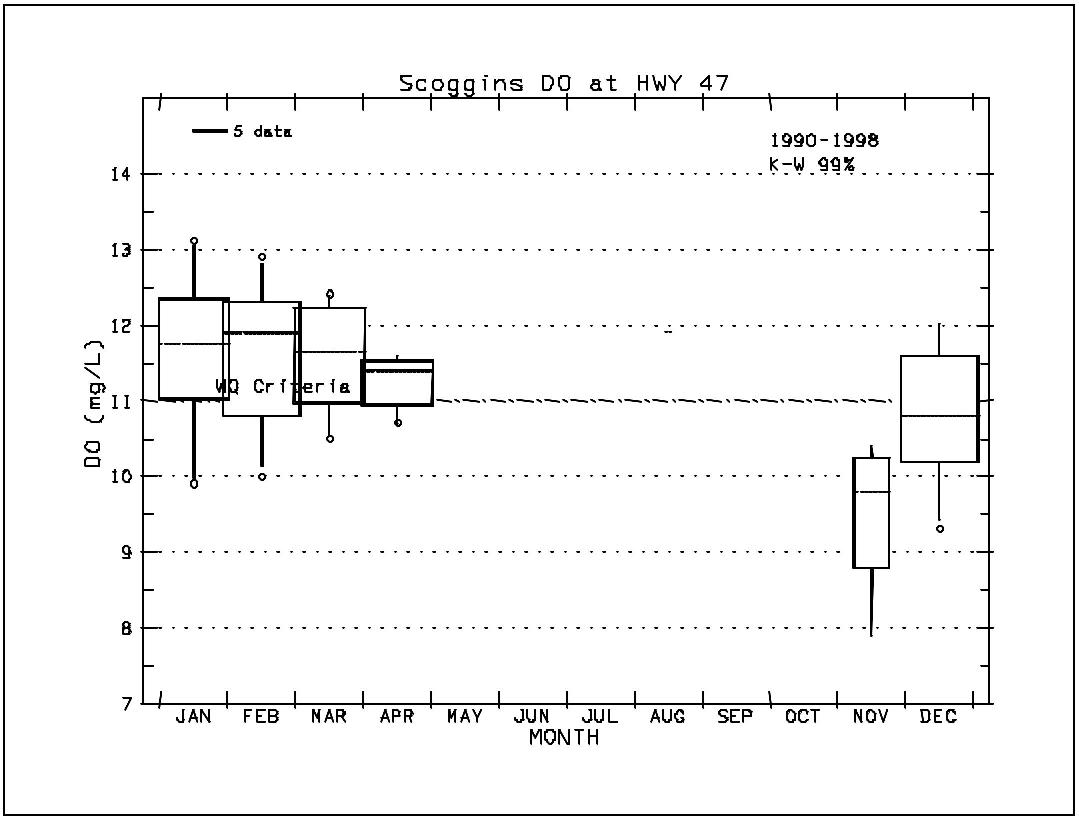


Figure 59. Dissolved Oxygen Concentration Box Plots for Scoggins Creek at Old Highway 47 (1990 – 1998)

4.3.4.7.3 Analysis of Dissolved Oxygen Violations

The below optimum levels of dissolved oxygen on Scoggins Creeks may be due to one of two factors. The first is that the DO levels in the water being released from the dam may be too low. The second is that there may be one or more dissolved oxygen sinks below the dam which are causing the low DO levels. The analysis of the DO levels in Scoggins Creek is complicated by the fact that no DO data are available for the creek just below Scoggins Dam.

The following are discussions of these factors:

Water Discharges from Scoggins Dam: The dam releases a minimum of 20 cfs into Scoggins Creek in October and November, and 10 cfs for all other months. These releases are usually made through a jet flow valve for flows up to 35 cfs, one or two gates for flows from 29 cfs to 350 cfs, and through the dam's spillway for greater flows. It is not known at this time how saturated with DO the discharged water is. If it is found that the discharged water is not saturated, it is possible that a separate "howell-bunger" valve may be used. This valve can most likely saturate the discharged water with DO. It is not currently used and has a capacity of about 5-10 cfs (Wally Otto, Tualatin Valley Irrigation District, personal communication. May, 2000).

Dissolved Oxygen Sinks: There appear to be three possible sinks for dissolved oxygen: high biochemical oxygen demand (BOD) in runoff, high BOD discharges from the Forestex lumber mill, and sediment oxygen demand (SOD).

High BOD in runoff: It is possible that BOD in runoff is contributing to the low DO levels in the creek. However, there does not appear to be a strong correlation between rainfall and DO violations. There are also no confined animal feeding operations (CAFOs) in the Scoggins watershed that could contribute high BOD runoff. It is possible that high BOD runoff from Forestex's property is contributing to the problem, but there are no data to support this.

Forestex (Stimpson) has a lumber mill at RM 4.0 that has a permit to discharge log pond overflow waters during the winter. The permit requires that they have a 50:1 dilution ratio. Process wastewater from the plant is land applied. It is possible that Forestex discharges are contributing to the dissolved oxygen problem, however with a dilution of 50:1 and average BOD's of approximately 30 mg/L, it doesn't appear that this is the only cause. This is highlighted by the fact that 4 of the 19 violations occurred when Forestex reported no discharge. (Unfortunately we do not have either DO, BOD, or COD measurements for the point upstream of Forestex during the winter. This makes the evaluation difficult.) Forestex did exceed its dilution ratio during one of the violation periods. This most likely contributed to the problem.

Sediment Oxygen Demand (SOD): While there are no data available on SOD levels in Scoggins Creek, it appears that with the low instream temperatures (median of 8.3°C) and relatively high flows during some of the problem periods this is not a primary factor in the DO violations.

It appears that relatively low DO waters being discharged from the dam may be the primary cause of the problem. This is at least partially supported by the fact that there does not appear to be any correlation between flow and DO. (However, this conclusion is speculative and will need to be further addressed through increased DO monitoring below the dam.) The DO concentrations in the stream may be further depleted by the discharges at Forestex.

4.3.4.7.4 Analysis of Forestex Discharges

While it appears that the primary cause of the low DO problems on Scoggins Creek may be dam releases with low DO water, any further DO depletion contributes to the problem. Oregon Administrative Rule 340-04-0026(3)(a)(C)(iii) states that if the conditions leading to DO violations in a waterbody are found to be natural, then loadings from point sources may be set to levels that result in no measurable reduction of DO. No measurable reduction is defined as no more than 0.10 mg/L reduction in instream DO for a single source.

If it is found that the DO levels in the dam releases are natural, or that they cannot be aerated to increase DO concentrations, then the lower DO levels in Scoggins Cr. may be considered natural. If this is the case, then it must be ensured that any releases from Forestex will not decrease the instream DO levels more than 0.10 mg/L anywhere on the impacted stream reach (which is from the mouth of Scoggins Creek to the dam).

In order to determine the possible impacts on Forestex if the upstream DO levels were below the criteria and were considered natural, a cursory analysis was made. This analysis of Forestex discharges was performed using the Streeter-Phelps equation (Metcalf and Eddy, 1991) in a spreadsheet format. In the analysis, impacts of Forestex's effluent on instream DO levels were examined for varying dilution ratios, effluent DO concentrations, and effluent BOD concentrations. The results of this analysis are given in **Table 30**. The allowable discharge conditions (given the specified conditions) are in the shaded rows.

Table 30. Forestex Discharge Scenarios							
Dilution Ratio	Effluent			Creek			
River: Effluent	DO (mg/L)	BOD_5 (mg/L)	Flow (MGD)	DO Upstream (mg/L)	DO Downstream (mg/L)	Flow (cfs)	DO Decrease (mg/L)
50:1	0	50	1	10.92	10.72	77.5	0.2
	3	50	1	10.92	10.76	77.5	0.2
	6	50	1	10.92	10.80	77.5	0.1
75:1	0	50	1	10.92	10.79	116	0.1
100:1	0	50	1	10.92	10.82	155	0.1
50:1	0	100	1	10.92	10.66	77.5	0.3
	3	100	1	10.92	10.70	77.5	0.2
	6	100	1	10.92	10.74	77.5	0.2
	9	100	1	10.92	10.77	77.5	0.2
	11	100	1	10.92	10.80	77.5	0.1
75:1	0	100	1	10.92	10.75	116	0.2
	6	100	1	10.92	10.80	116	0.1
100:1	0	100	1	10.92	10.79	155	0.1
Other input data: Temp Effluent = 11°C; Temp River = 11°C; K_1 = 0.1/day (effluent); K_d = 0.15/day (river); NH_3 (river) = 0.03 mg/L; vel.=1.1 ft/s, BOD_5 (river) = 2 mg/L; K_2=2.6/day; DO downstream is at the mouth of Scoggins Cr. (4 miles downstream) 1 million gallons per day (MGD) = 1.55 cubic feet per second (cfs)							

Since we are unsure as to whether the DO concentrations in the creek are natural or not, a conservative approach is being taken. This approach assumes that the levels are natural. Therefore, the flow and BOD levels in **Table 30** are the wasteload allocations for Forestex for November 1 through April 30. DEQ will collect DO data below Scoggins Dam at the earliest possible date to clarify the source of the DO problems. Subsequent to the findings of this data collection effort, if the dissolved oxygen levels are found to be anthropogenic, then new allocations will be derived for the sources.

4.3.4.8 TRIBUTARY LOADING CAPACITIES

The two primary pollutants associated with low dissolved oxygen levels on the Tualatin River Subbasin tributaries are solar loading resulting in increased water temperatures and pollutants leading to sediment oxygen demand (SOD). The loading capacities of the tributaries relating to solar loading are delineated in the Tualatin River Subbasin Temperature TMDL. This loading capacity is essentially equal to the natural solar loading.

The water quality modeling outlined above resulted in estimated reductions in SOD (coupled with the temperature controls) that would also be necessary to achieve the dissolved oxygen criteria. The streams represented by the Gales Cr. were estimated to require a 30% reduction in SOD. The streams represented by Beaverton/Lower Rock Cr. modeling were shown to need an estimated 20% reduction in SOD. The Fanno Cr. modeling estimated a needed SOD reduction of 50%.

While chlorophyll a concentrations were above the action level of 0.015 mg/L at some of the stations on two of the representative streams, the modeling results show that the impacts on DO concentrations will be offset if measures are implemented to reduce SOD adequately.

Based on the information above, the loading capacities for the tributary streams are given in **Table 31**, below. The loading capacities are in the form of sediment oxygen demand (at 20°C, in units of g/m^2d) for specific sites along the tributaries. For tributaries where SOD data are not currently available, the loading capacities are give as a percent reduction in SOD.

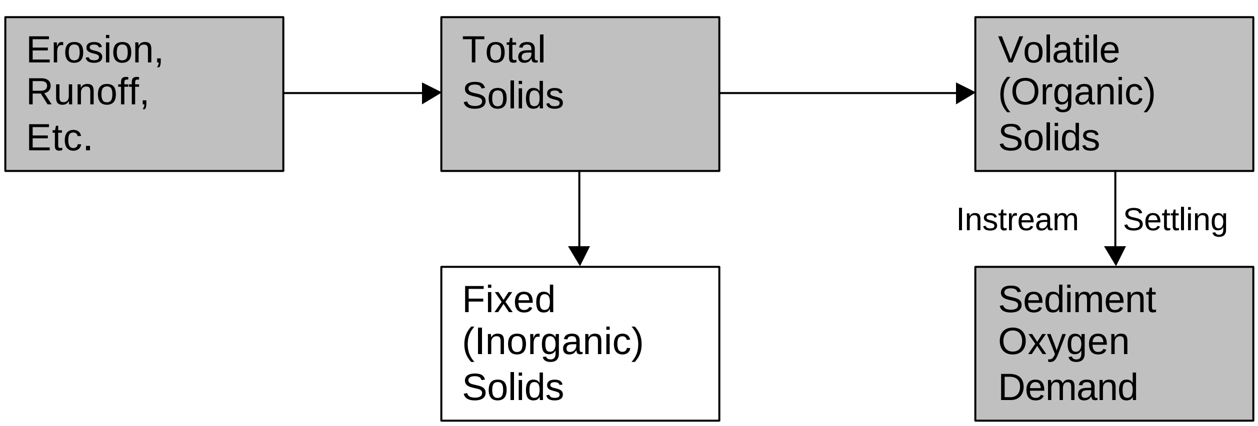
Table 31. Tualatin River Subbasin Tributary Loading Capacities Related to Dissolved Oxygen

Site	1995 – 1997 Median SOD_{20} Values (g/m^2d)	Percent Reduction Baseline Values	SOD_{20} Loading Capacity (g/m^2d)	Temperature Loading Capacity
Beaverton Cr. at Arleda Park	4.4	20	3.5	No anthropogenic increase above background (See Temperature TMDL)
Beaverton Cr. at Walker	7.3	20	5.8	
Dairy Cr. at Dairy Creek Park	3.1	30	2.2	
Fanno Creek at Fanno Creek Park	2.3	50	1.15	
Fanno at Englewood Park	4.3	50	2.2	
Gales Creek at Zurcher Irrigation Pump	2.8	30	2.0	
Rock Creek at Rock Creek WWTP	2.5	20	2	
Rock Creek near Southeast 59th Ave.	2.4	20	1.9	
Willow Cr.	4.4	20	3.5	
W.F. Dairy, Chicken, McFee, and Upper Rock Creeks	-	30	-	
Ash, Bronson, Burris, Butternut, Carpenter, Cedar, Christensen, Council, Hall, Hedges, Johnson (South), Nyberg, and Summer Creeks	-	20	-	
Scoggins Creek	No Measurable Decrease in DO Beyond Natural Conditions			

4.3.4.9 RELATIONSHIP BETWEEN SEDIMENT OXYGEN DEMAND AND POLLUTANTS

The pollutants leading to SOD in the tributaries consist of solids - which are at least partially composed of organics - entering and settling to the bottom of the streams. The organic fraction of solids is termed “volatile solids”. The inorganic fraction is termed “fixed solids”. A simplified schematic of the generation of SOD is presented in **Figure 60**, below. The reduction of volatile solids that settle out to the bottom of the tributaries and remain in a position to exert an oxygen demand during the critical summer season is essential if SOD reductions are to be achieved. While the simplified schematic below shows fixed and volatile solids to be completely separate, in the environment solids are often composed of both organic and inorganic fractions.

Figure 60. Simplified Schematic of Sediment Oxygen Demand Generation



It is very difficult to accurately predict the necessary reductions in volatile solids necessary to achieve specific SOD reductions. A study on Lake Erie has related the reduction of nutrients (which led to eutrophication) to SOD reductions (Lam *et al*, 1983). In this study, the SOD reductions were directly proportional to the annual load reductions of total phosphorus. While this is not the same as volatile solids reductions on a stream, it does give an indication of the response that may be expected of the SOD in a waterbody due to reductions of organics loadings. In a more directly relevant case, a TMDL assessment relating to SOD reductions for a watershed in Michigan estimated that SOD rates would respond proportionally to reductions in total suspended solid (TSS) loads (Suppnick, 1992). This response appears reasonable if the appropriate solids are targeted for reduction – the total suspended solids reductions would have to result in comparable reductions of settleable volatile solids.

As described above, the pollutant leading to elevated sediment oxygen demand (SOD) levels on the tributaries is settleable volatile solids. Based on the discussion above, it is estimated that volatile solids loading reductions will result in similar reductions in instream SOD.

(While the data and information available at the time of the development of this TMDL indicate the need to control settleable volatile solids, it is acknowledges that the exact relationship between this pollutant and SOD is not known. It is further acknowledged that data on the loadings of settleable volatile solids does not exist for the Tualatin Subbasin. The development of management plans to address this pollutant will need to address the development of baseline data, monitoring protocols, and various other issues.)

4.3.5 SEASONAL VARIATION – VOLATILE SOLIDS

As mentioned above, it is difficult to predict exactly how sediments delivered to the stream will contribute to the sediment oxygen demand during the critical summer period. The bulk of the sediment loadings are expected to be delivered to the stream during the wet part of the year (October through May) when runoff and stream flows are at their maximums. However, the higher instream velocities during these high flows will tend to both keep these sediments (especially less dense, organic sediments) entrained in the water column and scour any recently deposited sediments. In addition to this, sediments deposited earlier in the season may be covered by subsequent sediment deposits that may have a more direct impact on SOD. This may be especially true if any organic-laden (volatile) solids are deposited during the summer.

Considering these issues, it appears reasonable to target sediment deposition during the late wet season and the summer for control. The exact timing of the control period should be tailored to the specific land use and/or tributary.[20] The seasonal period for the volatile solids/SOD portion of the TMDL will be May 1 through October 31. This will allow for the control of pollutants during the latter part of the wet season and for control of any sediments that may be deposited during the critical summer season.

Additionally, based on the analysis in Section 4.3.4.7, the TMDL will also apply to Scoggins Creek from November 1 through April 30 for the pollutants impacting winter concentrations of DO. This includes the wasteload allocations addressed in Table 31, above.

4.3.6 VOLATILE SOLIDS SOURCE ASSESSMENT

As mentioned above, the pollutants leading to SOD in the tributaries consist of solids that are at least partially composed of organics entering the creek through erosion, discharges, and surface runoff. The following is an assessment of potential sources of these volatile solids.

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[20] For example, it is likely that very little deposition of sediments from agricultural runoff will occur during the drier summer months and so the latter part of the wet period should be the focus of control efforts. Conversely, depositions from urban sources may occur during the summer as well as in the latter part of the wet season.

4.3.6.1 INSTREAM AND NEAR-STREAM EROSION

There have been several studies in the Tualatin River Subbasin indicating that instream and near-stream (streambank) erosion contribute significant loadings of solids both to the tributaries and the mainstem Tualatin River. A study of an urban watershed in the Tualatin River Subbasin (USA, 1997) estimated that the annual total suspended solids loads from these sources in Fanno Creek is over 2.5 million pounds per year. This same study states that the geomorphic processes resulting from urban hydrology encourage a less complex stream system, excessive bank erosion and channel incision. It goes on to state that where the sediment transport in Fanno Creek is unbalanced, problems with sedimentation and channel scour were observed. A second study of a primarily agricultural and forested watershed in the subbasin also found excessive streambank erosion: "Although streambank erosion occurs under natural conditions, the magnitude of erosion has been increased due to altered hydrology, channelization and destruction of riparian vegetation" (Hawksworth, 1999).

While instream and near-stream erosion contributes a significant portion of the annual solids load to tributaries, the bulk of this erosion occurs during the winter months when instream flows are at their peak. As explained in the seasonal variation discussion above, winter solids loadings are not necessarily the most important solids loads to target for summer SOD reductions. These solids also may not contain as large a fraction of volatile solids as some other sources. This is because instream and bank erosion occurs throughout the soil profile, which usually consists of an upper layer of organic soil and lower layers that often contain primarily inorganic soils or soils with more aged organic materials. (It has been found that aged organic materials are more inert than recently-produced organic materials [Benninger and Martens, 1983].)

The reduction of the loads from the near-stream sources is addressed through the allocations given in the Tualatin River Subbasin Temperature TMDL. This TMDL has allocated surrogate measures that promote riparian conditions that will increase near-stream (streambank) area resistance to erosive energy (shear stress). Specifically, the restoration/protection of riparian areas called for in the temperature TMDL will serve to reduce stream bank erosion by increasing stream bank stability via rooting strength.

While hydrology plays a critical role in instream and near stream erosional processes, it is beyond the scope of the TMDL process to specifically address hydrologic modifications. Even so, management agencies are encouraged to implement practices that will lead to the restoration of more natural hydrologic patterns.

4.3.6.2 RUNOFF SOURCES

Runoff is probably the most important source of solids with regard to impacts on sediment oxygen demand (SOD). This is primarily due to two reasons. First, as mentioned above, the direct source of SOD is the deposition of solids that contain organics. Runoff sources may include pollutants from sheet, rill and gully erosion which are more likely than streambank erosion to carry organic matter (Hawksworth, 1999). Secondly, runoff from impervious surfaces can take place even during the relatively small rain events that occur in the May through October period. This runoff can deposit fresh, labile organic material over previous instream sediment deposits, resulting in increased or sustained SOD levels.

Runoff sources may be separated into three broad categories based on land use: urban, agricultural, and forested. These are discussed below.

URBAN AND INDUSTRIAL RUNOFF: Due to the altered hydrology of urban watersheds, urban and industrial runoff can be a source of runoff throughout the year. Even during the relatively dry summer months, small storm events can produce runoff that would not occur in less impervious watersheds. Associated with this runoff are loadings of volatile solids. For Fanno Creek, the total suspended solids (TSS) contributed by runoff sources has been estimated at 2.4 million pounds per year (USA, 1997). The portion of these loadings that is volatile is not known.

AGRICULTURAL, FORESTRY AND RURAL RUNOFF: Runoff from agricultural, forested and rural lands contribute solids to the streams primarily through surface erosion. This erosion may take place for a number of reasons, but primarily include any activities that increase runoff velocities, loosen soil and/or remove vegetative cover. Construction of roads and other impervious surfaces can disturb soils and loosen surface soils. Forestry and agricultural practices also often disturb soils and remove vegetative cover. Since these land uses generally have relatively low percentages of impervious area, runoff will usually only occur during the higher rainfalls of the wet season. As discussed above, by targeting volatile solids reductions in the latter part of the wet season it is expected that SOD reductions will occur. Therefore, reductions in volatile suspended solids reductions from these sources are a critical part of the TMDL.

4.3.6.2 POINT SOURCES OTHER THAN URBAN AND INDUSTRIAL RUNOFF

Point sources such as wastewater treatment plants (WWTPs) and non-runoff industrial discharges in the Tualatin River Subbasin are considered to have a minimal impact on volatile solids loads. This is especially true of the WWTPs, which do not discharge to the tributaries.

4.3.7 MAINSTEM TMDL

4.3.7.1 MAINSTEM DO MONITORING

Historically, the most critical site for dissolved oxygen levels on the mainstem Tualatin River has been at Stafford Rd. (RM 5.4). A summary of the 1997 through 1999 DO data collected for this station is presented graphically in **Figures 61 and 62** below. **Figure 61** presents the mean of the DO concentrations for samples collected down to a depth of ten feet below the water surface. This is considered to be representative of the region influenced by nitrification. **Figure 62** presents the mean of the DO concentrations for samples collected at all depths (usually 3, 6, 9, 12 and 15 feet below the surface). These concentrations often illustrate the impacts of other sources and sinks (especially sediment oxygen demand). For the 1997 – 99 period, the water column was generally well mixed and therefore the concentrations are generally considered to be representative of the DO levels as they are impacted by all sources and sinks.

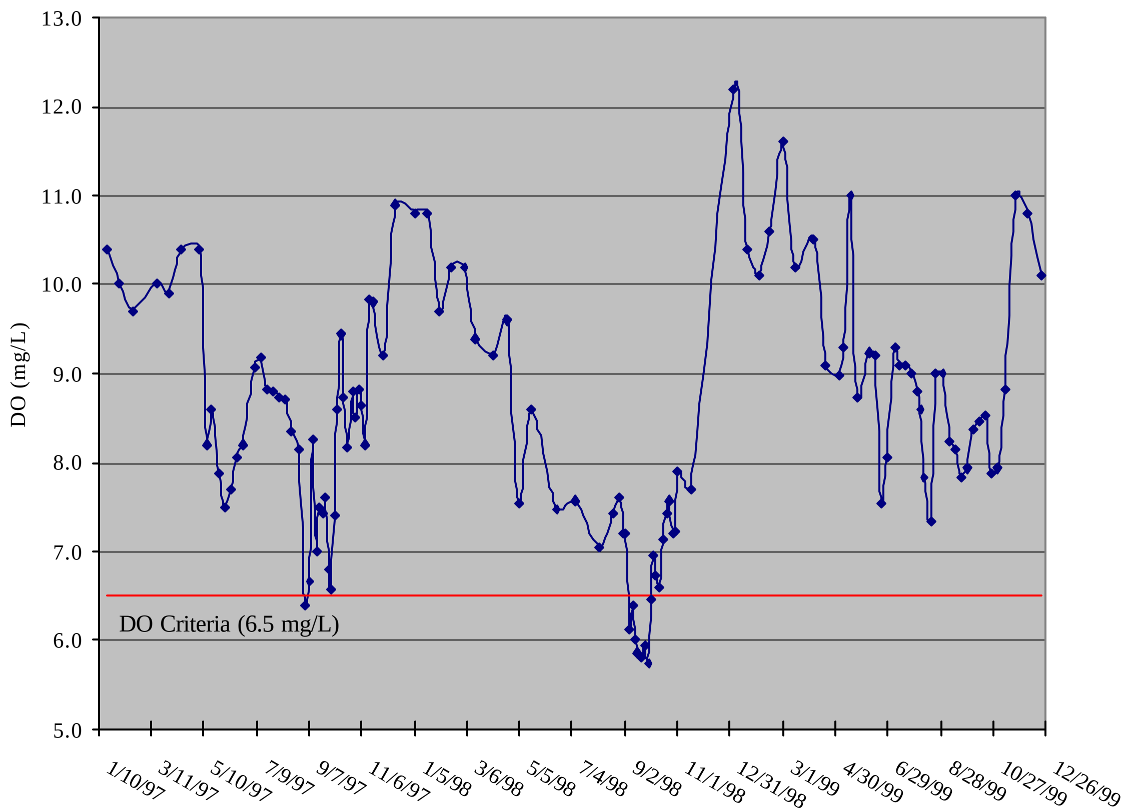


Figure 61. Tualatin River @ Stafford (RM 5.4) 10-Foot Average DO 1997-1999

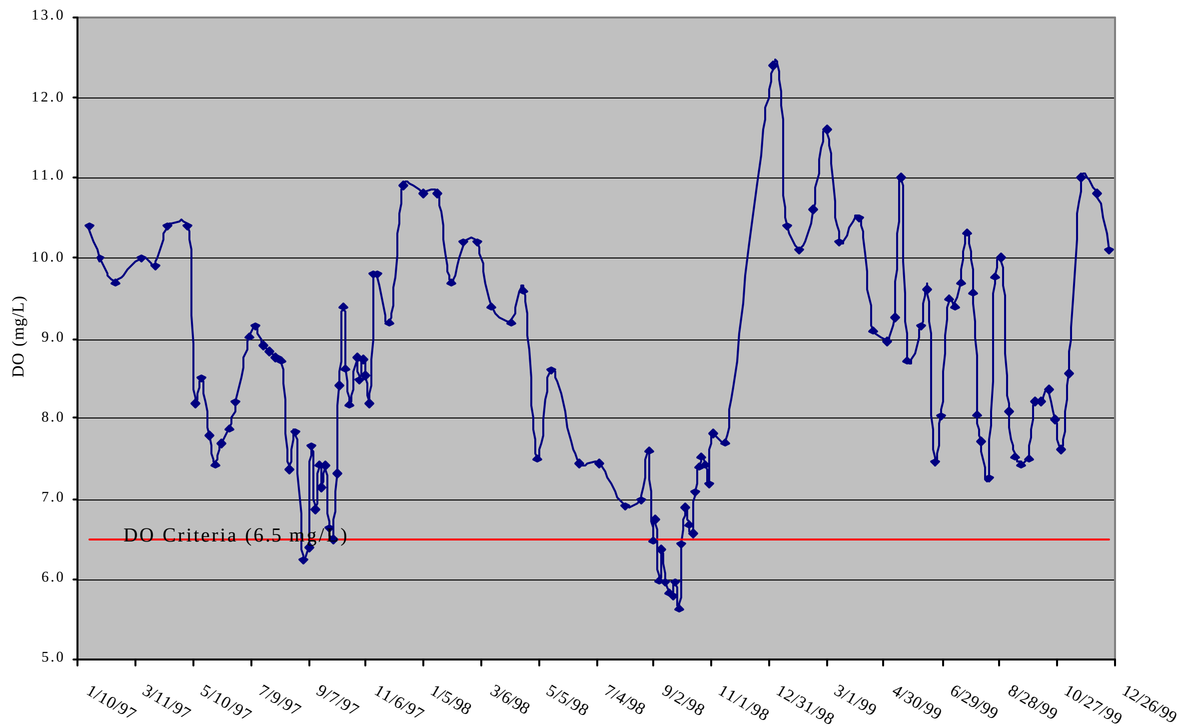


Figure 62. Tualatin River @ Stafford (RM 5.4) Total Depth Averaged DO 1997 – 1999

These figures are based on USA ambient water quality monitoring data – grab samples collected from January 1997 through December 1999. The summer data were generally collected on a weekly basis. The data have been corrected to account for supersaturation by adjusting supersaturated DO values down to the saturated values. Since the figures are based on weekly data, the lines between the data points do not represent actual DO values, but are presented to illustrate seasonal variability.

As can be seen from the plots above, the DO levels at this critical section of the Tualatin River generally meet the criteria, with the exception of the time period in late summer and early fall of 1997 and 1998. This may be explained by a number of factors such as longer residence times (which allow oxygen sinks such as nitrification and sediment oxygen demand more time to exert a demand on the instream oxygen levels) and the impacts of algal activity. The data for 1999 show no violations of the DO criteria for either the 10-foot averages or for the depth averaged DO.

It should be noted that there is not a large difference in DO concentrations between **Figures 61 and 62**. This is because the mainstem Tualatin River flow levels during these years (1997-99) were sufficient to prevent stratification at Stafford Road. In years with lower flows, stratification may occur that would lead to a larger difference between the DO in the portion of the river near the surface and the lower portion that is impacted by sediment oxygen demand (SOD). The higher flows lead to mixing that may mask the impacts of SOD.

4.3.7.1.2 Contributors to Dissolved Oxygen Deficit

Computer modeling of the mainstem Tualatin River by the USGS (see below) rank the components of oxygen demand currently found in the mainstem of the river as follows (in decreasing order of demand): SOD, CBOD, algal respiration, zooplankton respiration and NBOD. Computer modeling of some of the tributaries in the subbasin show that both SOD and water temperature are critical factors in the reduced levels of DO in the tributary streams.

On the mainstem Tualatin River, the knowledge base regarding the relationships between pollutant loadings and the factors in oxygen demand varies greatly. The relationship between the loadings of ammonia from the two summer discharging wastewater treatment plants (Durham WWTP and Rock Creek WWTP) is the best understood of the pollutant/DO relationships for the mainstem. A TMDL was developed for ammonia loadings from these sources in 1988 (**Appendix D-1**), but recent computer modeling has predicted that the allocations were set too high to meet the DO criteria in the critical late summer and early fall months and may be too stringent in the spring and early summer when the river's assimilative capacity is greater. Since the primary sources of ammonia and the technology to control these loadings are well understood, this pollutant is the primary target for TMDL development to address DO problems in the lower mainstem of the Tualatin River.

As discussed below, however, the control of ammonia alone will not lead to full attainment of the DO criteria. In September and October the modeling predicts that even with the wastewater treatment plants discharging no ammonia, violations of the DO water quality standard will still occur. This is most likely due to a combination of several factors. Essentially, lower flows in the late summer and early fall combined with a reduction in algal photosynthesis allow the high sediment oxygen demand (SOD) to reduce the DO levels to unacceptable levels.

For the periods when DO violations would occur without any ammonia loading from the WWTPs, either of two situations may occur:

1. If the conditions leading to the DO violations are found to be natural, then loadings from the WWTPs may be set to levels that result in no measurable reduction of DO. No measurable reduction is defined as no more than 0.10 mg/L DO reduction for a single source and no more than 0.20 mg/L for all anthropogenic activities in a water quality limited segment. (OAR 340-04-0026(3)(a)(C)(iii))
2. If the conditions leading to the DO violations are not found to be natural, then either the allocations must be set to zero or the other anthropogenic causes of the violations must be addressed.

Therefore, both ammonia and other pollutants leading to the DO violations need to be examined to determine their sources and their controllability.

AMMONIA

When nitrogen in the form of ammonia is introduced to natural waters, the ammonia may "consume" dissolved oxygen as nitrifying bacteria converts the ammonia into nitrite and nitrate. The process of ammonia being transformed into nitrite and nitrate is called nitrification. The consumption of oxygen during this process is called nitrogenous biochemical oxygen demand (NBOD). To what extent this process occurs, and how much oxygen is consumed, is related to several factors, including residence time, water temperature, ammonia concentration in the water, and the presence of nitrifying bacteria. It is because of this somewhat complex relationship than a computer model was used to determine the amount of ammonia that can be attenuated by the river and still meet the DO standards.

SEDIMENT OXYGEN DEMAND

Sediment oxygen demand (SOD) is the oxygen demand exerted by the aerobic decomposition of sediments on the stream bottom. As explained in the tributary TMDL section above, SOD is considered a significant contributor to oxygen depletion on the tributaries. In the mainstem Tualatin River, data analysis and USGS modeling (see modeling discussion below) have shown that SOD is the primary sink of dissolved oxygen. As explained below, the reduction of ammonia loadings to the mainstem Tualatin River is not expected to be adequate to meet the DO criteria during critical periods. Reductions in SOD on the mainstem will be necessary if the criteria are to be met.

4.3.7.1.3 Ammonia Sources

During the summer and fall, when dissolved oxygen levels may reach critical levels due to nitrification, the major sources of ammonia are the two USA summer discharging wastewater treatment plants: Durham (RM 9.3) and Rock Creek (RM 38.0). Other sources of ammonia are considered to be relatively insignificant and will retain their current load allocations (see allocation section below).

4.3.7.1.4 Ammonia Modeling

It is often difficult in natural waters to determine if a reduction in dissolved oxygen is due to CBOD, NBOD, SOD or some other process such as respiration. In order to better understand this relationship in the Tualatin River (as well as other relationships), the USGS has developed a water quality model for lower mainstem of the river (Rounds *et al*, 1999). The development and calibration of the model involved the collection of a substantial amount of data for the May through October periods of 1991-1993. These three years included a broad range of flow and weather conditions, and are considered to span the array of conditions typically seen in the subbasin. The exception was for the months of September and October, where the flow for the modeled years was lower that what may typically occur. In order to model these months with higher instream flows, results from model runs for 1996 and 1997 were also used.

For 1991 to 1993, model runs were made that simulated WWTP discharge loads that varied from 0 lb./day to 6000 lb./day for each of the treatment plants. All other data inputs (temperature, SOD, etc.) were left unchanged. The model predicted DO values that would have occurred at different points along the Tualatin River May through October given these ammonia loads. The predicted DO values were averaged over the top ten feet of water since this is the area considered to be most representative of waters impacted by control of ammonia discharges. Two sites on the river were generally found to be representative of the river for the reaches impacted by ammonia discharges: Stafford Rd. (RM 5.4) and Elsner Rd. (RM 16.2) (TBTAC, 1997). Because of this, the data for these sites were used in the analysis to determine the river's loading capacity.

Since the Tualatin River flows during September and October for the years 1991 through 1993 were relatively low, additional runs were made for the years 1994 to 1997, when the September and October flows were higher. The loads for these model scenarios were varied from 0 lb./day to 1000 lb./day for each of the treatment plants.

The results of the simulations described above are summarized in matrices included in **Appendix D-4**. These matrices show the percent of time during any given month that any of the DO criteria were violated in the simulations. The critical analysis of the simulations was to determine the maximum amount of ammonia (as nitrogen in lb./day) that could be discharged from each of the treatment plants without causing a violation of the State's DO criteria. This maximum ammonia load was then used to derive the river's loading capacity.

Additional modeling analyses were also performed by the USGS to investigate other discharge scenarios. These efforts are described below.

AMMONIA LOADING CAPACITIES

The model results (summarized in **Appendix D-4**) predict that the amount of discharged ammonia that can be assimilated by the river (the loading capacity, or *LC*) varies according to season and flow. This is to be expected since the season and flow rate both impact the primary factors influencing nitrification and all other sources and sinks of DO (see above).

An analysis of the simulated results for each month has been made in **Appendix D-5**. The purpose of this analysis was to determine for each month which combination of maximum loading and flow would give the minimum assimilative capacity of the river (use of the minimum values results in the most conservative assimilative capacity estimate). This was done by comparing "design concentrations", which are given by dividing the sum of the ammonia loads by the flow at Farmington and a conversion factor. (**Note**: The design concentrations are not the same as instream concentrations. They are theoretical concentrations that are used as scaling factors to determine allowable loads at different flows.)

For September and October it was found that even if the discharges from each of the treatment plants were reduced to zero there would still be violations of the criteria during certain conditions. This is because nitrification is not the only sink for DO. As explained above, sediment oxygen demand (SOD) is the primary DO sink for the mainstem of the Tualatin River, and during the late summer and early fall SOD is the primary cause of the simulated criteria violations.

The maximum allowable discharge for September and October for each treatment plant has been set at 100 lb./day (for a flow of 120 cfs – the median flow during the critical 1992 modeled period) as recommended by the Tualatin Basin Policy Advisory Committee (TBPAC, 1998). The reason that this load is used is two-fold:

1) When the DO criteria are not met due to factors other than ammonia, this is the amount of ammonia that is expected to result in an additional 0.10 mg/L of oxygen depletion for each WWTP (for a total of 0.20 mg/L of additional oxygen depletion). This would be the amount of depletion allowed if the other factors are found to be natural in origin. (Based on OAR 340-04-0026(3)(a)(C)(iii))

2) This is the minimum amount of ammonia that the Tualatin Basin Policy Advisory Committee found would be achievable and cost-effective for the treatment plants to discharge. If the other factors leading to violations of the DO criteria are found to be of anthropogenic origin, then this amount may be allowed to be discharged if the other sources could be reduced so that the criteria are met.

The most conservative of the design concentrations given in **Appendix D-5** are used to determine the final design concentrations for a specific time period and location. This is one margin of safety for the TMDL. For the period of September through November 15, design concentrations based on 100 lb./day loadings from each of the WWTPs and a flow of 120 cfs were used. Since the November period was not modeled, the October data is used for this month. This will result in a conservative loading since the river's assimilative capacity is generally considered to be greater in November (given lower stream temperatures and higher flows). These design concentrations, given in **Table 32**, vary by season and location (either below Rock Creek or below Fanno Creek).

Table 32. Ammonia-Nitrogen Loading Capacity Design Concentrations*

Month	Maximum Loading Capacity Design Concentration* below Rock Creek WWTP (Ammonia as Nitrogen – mg/L)	Maximum Loading Capacity Design Concentration* below Durham WWTP (Ammonia as Nitrogen – mg/L)
May	1.25	1.17
June	1.31	1.23
July	0.68	0.65
August	0.29	0.26
September – Nov. 15	0.20	0.16
* See text for explanation of design concentration and their use in determining loading capacities.		

Subsequent to this initial analysis, the USGS performed a set of analyses to: 1) determine if there is a river flow above which the TMDL need not apply in the fall, and 2) determine if short-term increases in WWTP effluent loads (spikes) would result in any additional violations of the DO standard. The USGS also proposed that the WWTP effluent concentrations be capped at 30 mg/L (NH_3 as N) to avoid unnecessarily large allocations during higher flow periods.

The first USGS analysis investigated whether there is a mainstem flow (as measured at Farmington) in the September through November period above which the TMDL need not apply. It is known that as flow increases, and water temperature decrease, the nitrification process slows and becomes less of oxygen sink. The analysis performed by the USGS indicates that during the September through November 15th period, nitrification at the WWTPs is no longer necessary once flows reach 350 cfs or greater (measured as median of the flows for the previous 7 days). If the flows fall under 350 cfs (measured in the same manner), nitrification at the WWTPs would need to be reestablished.

In the second USGS analysis, model runs were made using input values for the WWTP discharges that included short-term increases in loads. It was found that 1-day increases of 50% and 7-day increases of 30% (both increases are based on the loads that correspond to the design concentrations) would not significantly impact attainment of the DO criteria. This is contingent on the mean ammonia loads being no greater than that specified by the design concentrations over a period twice the duration of the spike. In short, it was found that the loading capacities (and corresponding allocations) could be based on steady-state values and also include short-term increases.

As explained above, the design concentrations presented in **Table 32** are to be used in conjunction with the monthly median flows of the Tualatin River at Farmington to determine the river's loading capacity. The formula for generating ammonia loading capacities for each month on the Tualatin River is given in **Figure 63**, below.

Figure 63. Ammonia Loading Capacity of the Mainstem Tualatin River

Monthly Mean Loading Capacity in the Mainstem Tualatin River (lb. NH_3-N/day) =
Loading Capacity Design Concentration x Monthly Median Flow
x 5.39 (lb./day)/(mg/L)(cfs)

Additional Loading Capacity provisions:

1) There is a cap of a maximum concentration of 30 mg/L NH_3 as N on WWTP effluent.
2) WWTP loadings are allowed temporary increases as follows:
   - ♦ Increases in loadings for a 1-day period of 50% over those indicated by the loading capacities above (and the corresponding allocations) – provided the 2-day mean loading is equal to or below the capacities above (and the corresponding allocations).
   - ♦ Increases in loadings for a 7-day period (or less) of 30% over those indicated by the loading capacities above (and the corresponding allocations) – provided the mean loading over a period twice the duration of the spike is equal to or below the capacities above (and the corresponding allocations).
3) For the period of September 1 through Nov. 15, the TMDL does not apply if the median flow at Farmington for the previous 7 days is equal to or greater than 350 cfs.

Notes:

- The design concentration (mg NH_3-N/L) is determined from **Table 32** for the specific time period and location.
- The monthly median flow (cfs) is measured at the Farmington gaging station.
- 5.39 is a conversion factor.

In order to determine the monthly mean loading capacity in pounds per day, the appropriate design concentration from **Table 32** is multiplied by the monthly median flow at Farmington and a conversion factor (5.39 [lb./day]/[mg/L][cfs]). For example, if the median monthly flow at Farmington for July is measured as 150 cfs, then the monthly mean loading capacity below Rock Creek in pounds per day (for July) would be:

Example
Monthly mean loading capacity in the mainstem Tualatin River below Rock Creek
(given conditions above)
= 0.68 (mg NH_3-N/L) x 150 (cfs) x 5.39 (lb./day)/(mg/L)(cfs) = 550 lb. NH_3-N/day

This loading capacity would also include the provisions detailed in **Figure 63**.

4.3.8 MAINSTEM SEDIMENT OXYGEN DEMAND

As explained in the ammonia loading capacities section above, for the September through November 15 period ammonia reductions alone are not expected to achieve the dissolved oxygen criteria during critical years. For these periods the sediment oxygen demand (SOD) on the mainstem Tualatin River will need to be reduced.

4.3.8.1 MAINSTEM LOADING CAPACITY

The USGS has run modeling scenarios that simulate ammonia loads from each wastewater treatment plants at 100 lb. (the minimum ammonia wasteload allocation) and varying reductions of SOD. The purpose for running these scenarios was to determine the amount of SOD reductions necessary, in conjunction with ammonia reductions, to achieve the DO standard under all reasonable conditions. The results of this modeling effort are presented in **Appendix D-6**.

An analysis of the modeling results shows that with a 20% reduction in the modeled SOD baseline value (1.8 g/m^2/day), the DO criteria would be met for all modeled years except for in October of 1992. Given the observed conditions for this month, with ammonia loads set at the wasteload allocations and with SOD reductions set at 20%, the model predicted that the DO criteria would still be violated some of the time. While reductions in SOD were only modeled up to 20% over baseline values, it appears reasonable to assume that an SOD reduction of 20 to 30% will result in achieving the DO criteria under all foreseeable conditions.

Both the temperature of the overlying water and the organic content of the sediments impact SOD rates. Water temperature will directly impact SOD, with the SOD rate decreasing by approximately 5-6% for every 1°C drop in water temperature (depending on the temperature range). While modeling was not completed to determine the specific quantitative impacts of temperature reductions, it appears reasonable to assume that implementation of the temperature TMDL will result in a reduction of SOD rates. While not necessarily impacting SOD rates, increases in water velocity will also reduce the residence time of a specific mass of water, thereby reducing the DO deficit due to SOD. Since 1992, flows in the mainstem of the Tualatin River have been augmented the Unified Sewerage Agency through releases from Scoggins Reservoir. While it is not definite that flows will remain above the median October 1992 flows of 123 cfs (as measured at Farmington), the likelihood of such low flows has been diminished.

Given expected flow conditions and temperature decreases, it appears reasonable to estimate that the reduction of the organic content in the sediment by approximately 20% will result in the DO criteria being met under all expected scenarios.

4.3.8.2 VOLATILE SOLIDS SOURCE ASSESSMENT

As explained in the tributary loading capacity section above, the pollutant leading to elevated SOD consists of settleable solids, which are at least partially composed of organics, entering the creek through erosion, direct discharge, or surface runoff. These solids are termed settleable volatile solids. In addition to the deposition of volatile solids from these upland sources, detrital algal deposition is also a concern.

The upland sources of settleable volatile solids loads to the mainstem are similar to the sources for the tributaries: instream erosion, runoff (including upland erosion) and direct discharges. In addition to these sources, analyses by the USGS have found that the deposition of algal detritus on the lower mainstem may contribute to the SOD at some sites. The Tualatin River at Stafford Rd., the site most susceptible to dissolved oxygen problems, is the primary site where algal detritus may be contributing to the increased SOD rate (Rounds *et al*, 1997).

4.3.8.3 IMPACT OF TRIBUTARY SOLIDS REDUCTIONS ON MAINSTEM SOD

In **Table 31**, loading capacities for sediment oxygen demand were given for most of the subbasin's major tributaries. In order to determine whether the attainment of these capacities would likely result in attaining the mainstem SOD reductions, a previous mass balance analysis of total suspended solids was reviewed (Vedanayagam and Nelson, 1995). This analysis was of all suspended solids (fixed and volatile) and not specifically the targeted settleable volatile solids. Since the ratio of settleable volatile solids to total suspended solids may vary depending on the source, this mass balance does not equate exactly to a mass balance analysis of volatile solids. However, it still provides the best tool readily available to examine solids sources and should give a relatively good estimate of a settleable volatile solids mass balance.

The suspended solids mass balance analysis gave several insights into the sources of suspended solids in the Tualatin River:

- *During the summer months of 1992 (defined as June through October), approximately 79% of the average suspended solids in the river were contributed by the five major tributaries (Dairy, Fanno, Gales, Rock and Scoggins Creeks).*
- *During the non-summer months of 1992 approximately 90% of the average suspended solids in the river were contributed by these tributaries.*
- *Gales Creek was the major contributor of suspended solids to the river during the non-summer 1992 period.*
- *Scoggins Creek was the major contributor of suspended solids to the river during the summer 1992 period. According to an analysis of summer 1991 data, approximately half of these solids entered Scoggins Creek between the dam and Highway 47.*
- *In the summer of 1991, Fanno Creek had an average suspended solids mass loading of approximately 2500 kg/day – more than all of the other major tributaries combined. This large loading was attributed to a June storm event.*

It appears from this analysis that most of the suspended solids loadings throughout the year are coming from the tributaries. For drier periods, a large percentage of the loading to the mainstem is apparently coming from Scoggins Creek. This may be expected since Scoggins Reservoir, which discharges to Scoggins Creek, contributes the bulk of the summer flows to the mainstem. What may not be expected is that the summer solids loading in the creek may increase by approximately 50% between the dam and the mouth of the creek. The report does not venture to explain this observation or whether it was observed for years other than 1991.

It should be noted that the mass balance analysis mentioned above used ambient water quality monitoring data and did not specifically target storm events. The non-summer analysis undoubtedly includes some impacts of storm events due to the frequency of storms during this season. The summer analysis probably does not include data from very many of these events. The increase of suspended solids loadings from storm events can be substantial. (This is apparent when the large increase of Fanno Creek loadings due to one large storm in 1991 is considered.) The result of this is that the relative loadings from streams other than Scoggins were probably underestimated, while the relative loadings from Scoggins Reservoir were probably overestimated. (This is because only the largest storm events would be likely to have a substantial impact on Scoggins Reservoir discharges.)

Table 33, below, lists the estimated percent contributions of each tributary to the overall lower mainstem Tualatin River total suspended solids (TSS) loadings.

Table 33. Estimated Percent Contributions to Lower Mainstem Tualatin River Total Suspended Solids Loadings (Data Source: Vedanayagam and Nelson, 1995)

Stream	Estimated Percent Contributions to Tualatin Subbasin TSS Loadings	
	Summer	Non-Summer
Rock Creek	8	11
Dairy Creek (Total)	13	26
EF Dairy	44*	17*
WF Dairy Cr.	44*	19*
McKay Cr.	12*	2*
Mainstem Dairy Cr.	0*	62*
Fanno Creek	10	20
Scoggins Creek	43	1
Gales Creek	5	32
Mainstem/Other Tributaries	21	10
* Estimated percent contribution to Dairy Subbasin TSS loadings		

A simple mathematical analysis was performed to estimate what impact the reductions listed in **Table 33** would have on the overall mainstem TSS mainstem loading. This analysis entailed applying the percent reductions given for each tributary in **Table 29** to the estimated tributary TSS contributions. For example, **Table 33** above gives Fanno Creek's contribution to the total summer TSS loading as 10%. **Table 29** calls for a 50% reduction of volatile solids loadings to Fanno Creek. If this 50% reduction in Fanno Creek loadings is applied to the creek's contribution of 10% to the mainstem, then the resulting mainstem reduction is:

(10%) * 0.50 = 5% Reduction in TSS loading to the mainstem Tualatin River

In addition to the reductions listed in **Table 33**, it is necessary to also apply 20% reductions to each stream not listed. The reduction for Scoggins Creeks was only made to the loadings estimated to occur between the dam and the creek's mouth (since the loadings from the lake are probably much more difficult to control). The results of this analysis are given in **Table 34**.

Table 34. Estimated Percent Reduction to Lower Mainstem Tualatin River TSS Loadings Based on Tributary Loading Capacities

Stream	Summer	Non-Summer
Rock Creek	2	2
Dairy Creek	3	6
Fanno Creek	5	10
Scoggins Creek	4	0
Gales Creek	2	10
Mainstem/Other Tributaries	4	2
Total Tualatin Subbasin TSS Loading Reduction	**20**	**30**

The period for this TMDL will be May 1 through October 31 (see Section 4.3.5). This spans the entire summer period and a small portion of the non-summer period addressed by the values in **Table 33**. Based on **Table 34**, it is apparent that the estimated total TSS loading reduction for the Tualatin River Subbasin for the TMDL period will be between 20 and 30 percent.

As explained above, this mass balance analysis for TSS provides the best tool readily available to examine solids sources and should give a relatively good estimate of a settleable volatile solids mass balance. It appears reasonable to assume that settleable volatile solids load reductions will result in subbasin-wide reductions similar to the estimated TSS reductions. Therefore, settleable volatile solids reductions of the same percentages indicated for TSS in **Table 34**, combined with 20% reductions for all other sources, are estimated to result in a 20 to 30 percent reduction of volatile solids loadings from upland and tributary sources to the mainstem Tualatin River.

4.3.8.3.1 Algal Detritus

The mainstem of the Tualatin River can experience large blooms of phytoplankton during the summer and early fall. These blooms create a large amount of biomass, some of which settles to the bottom of the river and decomposes along with other detrital material (Rounds *et al*, 1997). As mentioned above, the Tualatin River at Stafford Rd., which shows the greatest DO deficit in the USGS modeling runs, is also the site which may be most impacted by the deposition of this relatively labile material. Deposition of algal detritus is of particular concern since the critical period for algal blooms is similar to the critical period for DO problems. The detrital deposits may therefore be in a position to have a significant SOD impact relative to the organic sediment material derived from wet weather deposition.

The control of algal blooms on the mainstem Tualatin River is addressed in the Phosphorus TMDL. The loading capacity contained within that TMDL is expected to limit the large blooms that may contribute to the lower mainstem SOD rates.

4.3.9 SEASONAL VARIATION – AMMONIA

The seasonal period for the portion of this TMDL related to ammonia will remain unchanged from the original (1988) TMDL: May 1 through November 15. The exceptions are the periods in September through November 15 when the median 7-day flow for Farmington is 350 cfs or above. (The reasoning for this is presented in Section 4.3.7.1.4, above.)

4.3.10 ALLOCATIONS

The pollutant allocations necessary to achieve the various dissolved oxygen criteria on the mainstem Tualatin River and the listed Tualatin River Subbasin tributaries are given below. In order to achieve the criteria, reductions are necessary for ammonia, sediment oxygen demand (SOD), and temperature. The continued control of algal blooms is also necessary. The ammonia allocations are given in section 4.3.10.1 below. The settleable volatile solids allocations related to runoff are given in section 4.3.10.2 below. The allocations related in instream sediment sources and temperature are given in the temperature TMDL as explained 4.3.10.3 below. The allocations related to algal growth are given in the phosphorus TMDL and is also explained in section 4.3.10.3.

4.3.10.1 AMMONIA ALLOCATIONS

The ammonia loading capacity design concentrations determined above (**Table 32**) were subdivided into load allocations (for background and non-point sources), waste load allocations (for the WWTPs), and a margin of safety (MOS). A margin of safety of 5% is deemed adequate since the modeling effort is considered relatively accurate, a conservative approach was used to determine the wasteload allocations (design concentrations), and expected reductions in SOD and temperature will provide an additional MOS.

Since the load allocations (for non-point sources) developed for the previous ammonia TMDL are still appropriate, the load allocation design concentrations were set to result in allocations similar to the previous ammonia load allocations. One or more DMAs have jurisdiction over land use and activities within each stream segment. Each DMA's portion of the WQMP (Appendix I) will address only the lands and activities within each identified stream segment to the extent of the DMA's authority. The wasteload allocation design concentrations were set at the level that will result in total loadings at or below the loading capacities, given the necessary margin of safety and the appropriate load allocations. The results are shown in **Tables 35 and 36** below. **Table 35** gives the allocation design concentrations for Fanno Creek and the Durham WWTP. **Table 36** gives the allocation design concentrations for Rock Creek, the Tualatin River upstream of Rock Creek, and the Rock Creek Wastewater Treatment Plant (WWTP).

Table 35. Ammonia Design Concentrations for Fanno Creek and the Unified Sewerage Agency's Durham WWTP

Seasonal Period	Loading Capacity Design Conc.	Margin of Safety (5%)	Fanno Creek Load Allocation Design Conc.	Durham WWTP Wasteload Allocation Design Conc.
	Given as Design Concentration (mg NH_3-N/L)			
May	1.17	0.06	0.01	1.10
June	1.23	0.06	0.01	1.16
July	0.65	0.03	0.0085	0.61
August	0.26	0.01	0.007	0.24
Sept. – Nov. 15	0.162	*	0.007	0.16

Table 36. Ammonia Design Concentrations for Rock Creek, the Tualatin River upstream of Rock Creek, and the Unified Sewerage Agency's Rock Creek WWTP

Seasonal Period	Loading Capacity Design Conc.	Margin of Safety (5%)	Tualatin R. Upstream of Rock Cr. Load Allocation Design Conc.	Rock Cr. Load Allocation Design Conc.	Rock Cr. WWTP Wasteload Allocation Design Conc.
	Given as Design Concentration (mg NH_3-N/L)				
May	1.25	0.06	0.05	0.015	1.12
June	1.31	0.07	0.05	0.015	1.18
July	0.68	0.03	0.035	0.0125	0.60
August	0.29	0.01	0.03	0.01	0.24
Sept. – Nov. 15	0.195	[1]	0.03	0.01	0.155

* No margin of safety as a portion of the loading capacity was allocated for this period. See discussion above and in Section 4.3.11.

These design concentrations are to be used in conjunction with the monthly median flows of the Tualatin River at Farmington to determine the specific load allocations and wasteload allocations. The formulas for generating ammonia load and wasteload allocations for each month in the Tualatin River Subbasin, along with additional provisions, are given in **Figure 64**, below.

Figure 64. Ammonia Allocations for the Tualatin River Subbasin
Wasteload Allocations
Monthly Mean Wasteload Allocation (lb. NH_3-N/day) = Wasteload Allocation Design Concentration x Monthly Median Flow x 5.39 (lb./day)/(mg/L)(cfs)
Load Allocations
Monthly Mean Load Allocation (lb. NH_3-N/day) = Load Allocation Design Concentration x Monthly Median Flow x 5.39 (lb./day)/(mg/L)(cfs)
Additional Allocation provisions: 1) There is a cap of a maximum concentration of 30 mg/L NH_3 as N on WWTP effluent. 2) WWTP loadings are allowed temporary increases as follows: ♦ Increases in loadings for a 1-day period of 50% over those indicated by the wasteload allocations (as determined above) – provided the 2-day mean loading is equal to or below the total wasteload allocation for this period. ♦ Increases in loadings for a 7-day period (or less) of 30% over those indicated by the wasteload allocations (as determined above) – provided the mean loading over a period twice the duration of the spike is equal to or below the wasteload allocation for this period. 3) For the period of September 1 through Nov. 15, the TMDL does not apply if the median flow at Farmington for the previous 7 days is equal to or greater than 350 cfs.
Notes: • The allocation design concentration (mg NH_3-N/L) is determined from either **Table 35** or **Table 36** for the specific time period and discharge (or location). • The monthly median flow (cfs) is measured at the Farmington gaging station. • 5.39 is a conversion factor.

In order to determine the daily loading capacity in pounds per day, the appropriate design concentration from either **Table 35 or Table 36** would be multiplied by the monthly median flow at Farmington and a conversion factor (5.39 [lb./day]/[mg/L][cfs]). For example, if the median monthly flow at Farmington for July is 150 cfs, then the maximum daily wasteload allocation for Rock Creek WWTP in pounds per day (for July) would be:

Example
Monthly mean wasteload allocation for Rock Creek WWTP (given conditions above) = 0.60 (mg NH_3-N/L) x 150 (cfs) x 5.39 (lb./day)/(mg/L)(cfs) = <u>485 lb. NH_3-N/day</u>

This same method would result in a margin of safety of 24 lb./day, a load allocation of 28 lb./day for the Tualatin River upstream of Rock Creek, and a load allocation of 10 lb./day for Rock Creek (all given as a maximum daily load of ammonia as nitrogen). This loading capacity would also include the provisions detailed in **Figure 64**.

4.3.10.2 SETTLEABLE VOLATILE SOLIDS ALLOCATIONS

As explained above, sediment oxygen demand (SOD) reductions will be addressed through the allocation of the settleable volatile solids and total phosphorus (see below). Settleable volatile solids reductions will be necessary to meet the SOD loading capacities for the tributaries as well as the mainstem Tualatin River. Since the current loadings of volatile solids are not known, it is appropriate to express these allocations as percent reductions as opposed to mass per unit time reductions.

The settleable volatile solids loading capacities for the tributaries listed as water quality impaired due to low DO levels call for reductions of between 20 and 50 percent (see Section 4.3.4.8). Allocations based on these capacities are also expected to lead to the reduction of volatile solids being discharged from the tributaries into the mainstem. These reductions alone are not expected to be adequate to meet the necessary SOD loading capacity in the mainstem Tualatin River. Based on the analysis in Section 4.3.8 above, additional volatile solids reductions will need to occur in order to achieve the mainstem loading capacity for SOD. These necessary additional reductions require that each stream in the subbasin have a reduction in volatile solids loading to the mainstem. Each stream in the subbasin not listed as impaired due to low DO levels (**Table 26**) will need to have volatile solids reductions of 20 percent.

The allocations for settleable volatile solids from runoff for the Tualatin River Subbasin are given in **Table 37**, below. These reductions are based on achieving reductions in SOD levels as measured by the USGS in 1995-97, and therefore the allocations are based on reducing pollutants from this baseline period.

Since there is a lack of data on the levels of settleable volatile solids being discharged in the basin, it is expected that the management plans to meet the allocations will initially be based on a similar parameter for which data exists. One such parameter is total suspended solids (TSS).

Table 37. Tualatin River Subbasin Settleable Volatile Solids Allocations (Applicable May 1 – October 31)

Designated Management Agency	Stream	Load Allocations	Wasteload Allocations
City of Lake Oswego, City of Portland, Clackamas Co., Multnomah Co., ODOT, Unified Sewerage Agency, and Washington Co.	Ash Creek, Fanno Creek, Summer Creek	50% Reduction of Settleable Volatile Solids in Runoff	50% Reduction of Settleable Volatile Solids in Stormwater Runoff
City of Portland, Multnomah Co., Oregon Dept. of Agriculture, Oregon Dept. of Forestry, ODOT, Unified Sewerage Agency, and Washington Co.	Gales Cr., West Fork Dairy Cr., Chicken Cr., McFee Cr., Upper Rock Cr.	30% Reduction of Settleable Volatile Solids in Runoff	30% Reduction of Settleable Volatile Solids in Stormwater Runoff
City of Lake Oswego, City of Portland, City of West Linn, Clackamas Co., Multnomah Co., Oregon Dept. of Agriculture, Oregon Dept. of Forestry, ODOT, Unified Sewerage Agency, and Washington Co.	All other streams	20% Reduction of Settleable Volatile Solids in Runoff	20% Reduction of Settleable Volatile Solids in Stormwater Runoff

The DMAs will be allowed to use combinations of management scenarios that may include flow management designed to integrate with solids reductions to meet the instream dissolved oxygen concentration criteria. One or more DMAs have jurisdiction over land use and activities within the area for each identified stream. Each DMA's portion of the WQMP (see Appendix I) will address only lands and activities to the extent of that DMA's authority.

4.3.10.3 OTHER ALLOCATIONS

In addition to the load allocations addressing solids reductions, the temperature TMDL contains allocations in the form of percent shading. It is anticipated that the vegetation planted to achieve the temperature allocations will result in additional reductions in volatile solids loadings by stabilizing stream banks and reducing near-stream erosion. The bulk of any additional loading from the vegetation (in the form of leaves, etc.) would be expected to occur in the late fall and early winter. As explained in the "Seasonal Variation" section above, organic material deposited at this time is expected to be mostly scoured from the system during subsequent high flows.

The allocations set for the mainstem in the phosphorus TMDL will help to ensure that large algal blooms on the mainstem are controlled as much as possible. This will help to minimize the impacts on SOD from algal detritus.

For Scoggins Creek, the wasteload allocations for Forestex have been set to the effluent flows and BOD levels shown in Table 31. If, upon further investigation, the dissolved oxygen concentrations above Forestex's discharge are found to be natural, then the allocations will continue to be based on **Table 30**, above. If the conditions are found to be due to discharges from Forestex, then allocations will be set that result in the stream meeting the DO criteria. It is possible that releases from Scoggins dam may be further aerated so that no allocations will be necessary. The determination of the appropriate allocation will be made based on a study of Scoggins Creek in the winter of 2000 – 2001.

4.3.11 MARGINS OF SAFETY

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate a margin of safety is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. A margin of safety is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions or effectiveness of proposed management actions).

The margin of safety may be implicit, as in conservative assumptions used in calculating the loading capacity, Waste Load Allocation, and Load Allocations. The margin of safety may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the margin of safety documented. The margin of safety is not meant to compensate for a failure to consider known sources.

Table 38 presents six approaches for incorporating a margin of safety into TMDLs.

Table 38. Approaches for Incorporating a Margin of Safety into a TMDL

Type of Margin of Safety	Available Approaches
Explicit	1. Set numeric targets at more conservative levels than analytical results indicate. 2. Add a safety factor to pollutant loading estimates. 3. Do not allocate a portion of available loading capacity; reserve for MOS.
Implicit	1. Conservative assumptions in derivation of numeric targets. 2. Conservative assumptions when developing numeric model applications. 3. Conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

The margins of safety for the mainstem dissolved oxygen TMDL are outlined below.

For the May through August period, the margins of safety are:

- Implicit in the derivation of the design concentrations. The design concentrations were derived by examining the ammonia loads that would result in zero violations of the DO criteria. The modeled loads did not represent a continuous spectrum of possible loads, but discrete increments varying from 50 to 1000 lbs/day of ammonia for each treatment plant. This resulted in conservative design concentrations. While it is not possible to determine the magnitude of the MOS without additional modeling, it represents the potential to underestimate ammonia loading capacity from 0 to 1000 lbs/day.
- Explicit in the addition of a 5% MOS (based on loading capacity) in the derivation of allocations.
- Reductions of sediment oxygen demand (SOD) during this period were not included in the modeling but should provide a significant additional MOS.
- The allocations were set based on existing stream temperatures. The lower stream temperatures expected to result from measures addressing the temperature TMDL will lead to increase DO values, adding an extra MOS.

For the September through November 15 period, the margins of safety are:

- Implicit in the derivation of the design concentrations (see discussion above).
- Implicit in the reduction of water column BOD that is expected to be reduced along with volatile solids in runoff.
- Implicit in the increased dissolved oxygen levels in the water contributed by the tributaries. (The modeling of the mainstem utilized the observed DO levels being discharged from the tributaries. The increased DO levels in these discharges that are expected to result from the tributary DO TMDL will lead to increases in mainstem DO levels that were not reflected in the model outputs.)
- The allocations were set based on existing stream temperatures. The lower stream temperatures expected to result from measures addressing the temperature TMDL will lead to increase DO values, adding an extra MOS.

The margins of safety for the tributary dissolved oxygen TMDL are outlined below.

- Implicit in the reduction of water column BOD that is expected to be reduced along with volatile solids in runoff.
- Explicit in the increased (more conservative) dissolved oxygen levels used as target criteria for the modeling effort.

4.4 PH AND CHLOROPHYLL A (TOTAL PHOSPHORUS) TMDL

Table 39. Tualatin River Subbasin pH and Chlorophyll a (Phosphorus) TMDL Components	
WATERBODIES	All stream segments within the 4th field HUC (hydrologic unit code) 17090010 as well as the streams tributary to Oswego Lake.
POLLUTANT IDENTIFICATION	*Pollutants:* Human caused increases in instream phosphorus concentrations.
TARGET IDENTIFICATION (Applicable Water Quality Standards) CWA §303(d)(1)	Contained in: The Nuisance Phytoplankton Growth Rule (OAR 340-041-0150 sections 1 – 3), and; The relevant text of OAR 340-041-0150 (for pH): *No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause violation of the following standards in the waters of the Willamette River Basin:* *pH (hydrogen ion concentration): pH values shall not fall outside the ranges identified in paragraphs (A), (B), and (C) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if DEQ determines that the exceedance would no occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria:* • *All other basin waters (except Cascade lakes): 6.5 – 8.5*
EXISTING SOURCES *CWA §303(D)(1)*	Forestry, Agriculture, Transportation, Rural Residential, Urban, Industrial Discharge, Waste Water Treatment Facilities
SEASONAL VARIATION *CWA §303(D)(1)*	The potential for excessive algal growth and resulting pH criterion violations occurs predominately in the summer. Phosphorus control for algal growth is necessary from May through October.
TMDL LOADING CAPACITY AND ALLOCATIONS *40 CFR 130.2(F)* *40 CFR 130.2(G)* *40 CFR 130.2(H)*	*Loading Capacity:* Based on the attainment of the pH criteria and background chlorophyll a concentrations, phosphorus loading capacities listed in **Table 45** were developed for specific stream segments. *Waste Load Allocations (Point Sources):* WLAs for the WWTPs are presented as phosphorus concentrations in **Table 50**. WLAs for point sources other than WWTPs are presented in **Tables 47, 49** and **54**. *Load Allocations (Non-Point Sources):* LAs are presented as loads in **Tables 48, 49** and **54**
MARGINS OF SAFETY *CWA §303(D)(1)*	Margins of Safety demonstrated in critical condition assumptions and is inherent to methodology
WATER QUALITY STANDARD ATTAINMENT ANALYSIS *CWA §303(D)(1)*	• Attainment of the pH standard is determined through the analysis of current and historical system response to phosphorus concentrations.
PUBLIC NOTICE *40 CFR 25*	Conducted by Oregon Department of Environmental Quality

4.4.1 OVERVIEW

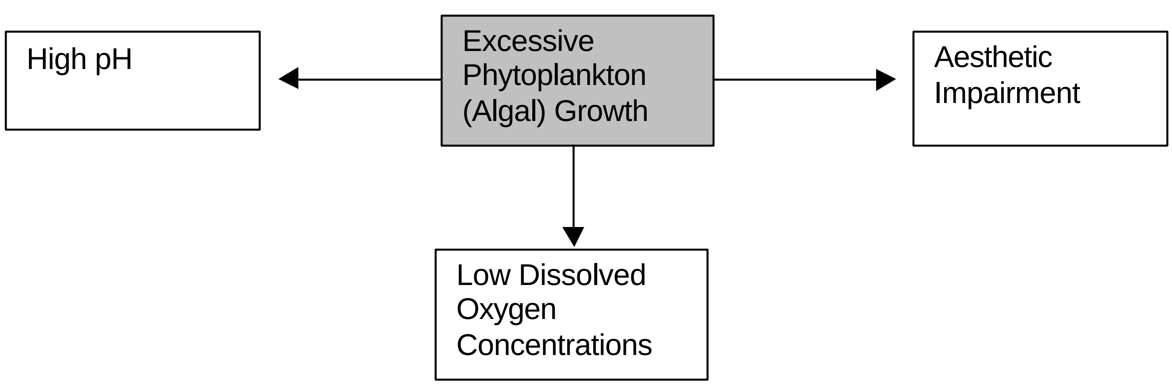
Chlorophyll a[21] concentrations in excess of the action level contained in the pertinent State of Oregon's water quality standard are observed in the Tualatin River and some of its tributaries. Specifically, six stream segments within the Tualatin River Subbasin are on Oregon's 1998 303(d) list for chlorophyll *a* violations[22]. In addition to these six stream segments, the mainstem Tualatin River and Oswego Lake experience exceedances of the state's chlorophyll *a* action level.

An initial Total Maximum Daily Load (TMDL) was developed to address the mainstem Tualatin River chlorophyll *a* and associated pH violations in 1988.[23] The purpose of this current TMDL is to update the 1988 TMDL by addressing new data and information, and also to extend the TMDL to address water quality impairment on the tributaries. (A more complete description of the background of the phosphorus TMDL is included in **Appendix C-1**.)

4.4.2 APPLICABLE WATER QUALITY STANDARDS

The Tualatin River Subbasin has listed beneficial uses of (among others) water contact recreation and aesthetic quality (**Table 40**). Excessive algal growth in waterbodies affects aesthetics, reduces water clarity, and restricts contact recreation. Algal blooms also often elevate the pH level in waterbodies, leading to possible detrimental impacts on salmonids (DEQ, 1995) and possibly resulting in eye irritations for swimmers. In addition to the impairment of these beneficial uses, excessive algae can also lead to problems with low dissolved oxygen levels. Adequate dissolved oxygen in water is critical for aquatic life, especially salmonids. **Figure 65** presents a simplified schematic of the possible impacts of excessive phytoplankton (algal) growth.

Figure 65. : Simplified Schematic of Possible Impacts of Excessive Algal Growth



[21] Chlorophyll *a*, an algal pigment, is commonly used as an indicator of the concentration of phytoplankton (a type of algae).

[22] Oregon's 1998 303(d) list is available via the internet at http://www.deq.state.or.us/

[23] The initial phosphorus TMDL was in the form of instream compliance concentrations (OAR 340-041-0470 [9][a], Appendix C-2) and mass load allocations (TMDL Number 22M-02-004, Appendix C-3).

Table 40. Beneficial uses occurring in the Tualatin River Subbasin

(OAR 340 – 41 – 442)
Beneficial uses related to Algal Growth are marked in gray

Beneficial Use	Occurring	Beneficial Use	Occurring
Public Domestic Water Supply	✓	Salmonid Fish Spawning (Trout)	✓
Private Domestic Water Supply	✓	Salmonid Fish Rearing (Trout)	✓
Industrial Water Supply	✓	Resident Fish and Aquatic Life	✓
Irrigation	✓	Anadromous Fish Passage	✓
Livestock Watering	✓	Wildlife and Hunting	✓
Boating	✓	Fishing	✓
Hydro Power	✓	Water Contact Recreation	✓
Aesthetic Quality	✓	Commercial Navigation & Transportation	

4.4.2.1 PHYTOPLANKTON WATER QUALITY STANDARD

The applicable water standard for the State of Oregon related to phytoplankton growth in the Tualatin River Subbasin is included in Oregon Administrative Rule (OAR) 340-041-0150 as follows:

OAR 340-041-0150
Nuisance Phytoplankton Growth

The following values and implementation program shall be applied to lakes, reservoirs, estuaries and streams, except for ponds and reservoirs less than ten acres in surface area, marshes and saline lakes:

(1) The following average Chlorophyll a values shall be used to identify water bodies where phytoplankton may impair the recognized beneficial uses:

(a) Natural lakes which thermally stratify: 0.01 mg/l;
(b) Natural lakes which do not thermally stratify, reservoirs, rivers and estuaries: 0.015 mg/l;
(c) Average Chlorophyll a values shall be based on the following methodology (or other methods approved by DEQ): A minimum of three samples collected over any three consecutive months at a minimum of one representative location (e.g., above the deepest point of a lake or reservoir or at a point mid-flow of a river) from samples integrated from the surface to a depth equal to twice the secchi depth or the bottom (the lesser of the two depths); analytical and quality assurance methods shall be in accordance with the most recent edition of Standard Methods for the Examination of Water and Wastewater.

(2) Upon determination by DEQ that the values in section (1) of this rule are exceeded, DEQ shall:

(a) In accordance with a schedule approved by the Commission, conduct such studies as are necessary to describe present water quality; determine the impacts on beneficial uses; determine the probable causes of the exceedance and beneficial use impact; and develop a proposed control strategy for attaining compliance where technically and economically practicable. Proposed strategies could include standards for additional pollutant parameters, pollutant discharge load limitations, and other such provisions as may be appropriate. Where natural conditions are responsible for exceedance of the values in section (1) of this rule or beneficial uses are not impaired , the values in section (1) of this rule may be modified to an appropriate value for the water body;

(1) Conduct necessary public hearing preliminary to adoption of a control strategy, standards or modified values after obtaining Commission authorization;

(2) Implement the strategy upon adoption by the Commission.

(3) In cases where waters exceed the values in section (1) of this rule and the necessary studies are not completed, DEQ may approve new activities (which require DEQ approval), new or additional (above currently approved permit limits) discharge loading from point sources provided that it is determined that beneficial uses would not be significantly impaired by the new activity or discharge.

For the Tualatin River and its tributaries, the applicable average chlorophyll *a* value used to determine possible beneficial use impairment (hereafter called the action level) is 0.015 mg/L (section (1)(b), above).

4.4.2.2 PH WATER QUALITY STANDARD

The pH water quality standard for the Tualatin River Subbasin is given Oregon Administrative Rule (OAR) 340-041-0445 as follows:

Relevant Text of OAR 340-041-0150

No wastes shall be discharged and no activities shall be conducted which either alone or in combination with other wastes or activities will cause violation of the following standards in the waters of the Willamette River Basin:
pH (hydrogen ion concentration): pH values shall not fall outside the ranges identified in paragraphs (A), (B), and (C) of this subsection. The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if DEQ determines that the exceedance would no occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria:
All other basin waters (except Cascade lakes): 6.5 – 8.5

4.4.2.3 DISSOLVED OXYGEN WATER QUALITY STANDARD

The dissolved oxygen (DO) water quality standard is fully delineated in the DO TMDL, Section 4.3.

4.4.2.4 AESTHETICS WATER QUALITY STANDARD

The Tualatin River Subbasin and Oswego Lake Subbasin water quality standard related to aesthetic conditions is given in Oregon Administrative Rule (OAR) 340-041-0445 as follows:

OAR 340-041-0150 (2)(l)

Aesthetic conditions offensive to human senses of sight, taste, smell, or touch shall not be allowed;

4.4.3 CONDITION ASSESSMENT

4.4.3.1 EXCEEDANCES OF CHLOROPHYLL A ACTION LEVEL

On the mainstem of the Tualatin from river mile (RM) 3.4 to 33.3 and in Oswego Lake, concentrations of chlorophyll *a* routinely exceed the action level that indicates when phytoplankton growth may create a nuisance condition. On six other tributaries chlorophyll *a* concentrations have also exceeded this action level. (See **Table 41** for a listing of stream segments that were included on the 1998 303(d) list for chlorophyll *a*. The mainstem Tualatin River and Oswego Lake are not on this list since a TMDL was previously developed to address chlorophyll *a* for these two waterbodies.) Although phosphorus is not the only factor that stimulates algal growth, studies conducted during the development of the initial TMDL in 1988 indicated that it has a major effect on the abundance and type of algae produced.

Table 41. Tualatin River Subbasin Stream Segments on the 1998 303(d) List for Chlorophyll *a*	
Stream Name	Stream Segment Listed
Bronson Creek	Mouth to Headwaters
Burris Creek	Mouth to Headwaters
Cedar Creek	Mouth to Headwaters
Fanno Creek	Mouth to Headwaters
Nyberg Creek	Mouth to Headwaters
Rock Creek	Mouth to Headwaters

4.4.4 BENEFICIAL USE IMPAIRMENT

As outlined above, water contact recreation, aesthetic quality, resident fish and aquatic life, salmonid fish rearing, and salmonid fish spawning are beneficial uses that may be impaired by excessive algal growth.

In the period since the adoption of the original phosphorus TMDL, substantial progress has been made in reducing phosphorus discharges (especially by the wastewater treatment plants) and in improving mainstem flow through augmentation flows from Scoggins Reservoir. The associated algal blooms have dropped off in intensity with corresponding benefits for aesthetics, pH and dissolved oxygen. More detailed discussions of the impairment related to specific water quality standards are given below.

4.4.4.1 pH Impairment

As explained above, high pH values have been associated with the detrimental impacts on salmonids (DEQ, 1995). The lower mainstem of the Tualatin River has been listed as water quality impaired due to high pH values. This listing did not appear on the most recent (1998) DEQ 303(d) list since the original phosphorus TMDL addressed pH.

The high pH problems that were previously associated with algal blooms in the Tualatin River Subbasin have been all but nonexistent in recent years.[24] The last year that experienced any significant pH violations associated with algal blooms was 1995 (as measured at the USGS monitoring station at RM 3.4). Substantial violations of the pH standard occurred in 1992. (1992 is considered a critical year for water quality assessment since it was the year that had the lowest median summer flows for the last ten years.)

It appears that the combination of the control of phosphorus (from both point and non-point sources) and increased flows due to augmentation and favorable meteorological conditions during the last several years have led to this significant reduction in pH violations. There still remains a possibility, however, that pH violations will occur if the controlling factors return to 1992 conditions and result in large algal blooms.

An examination of monitoring data on the tributary streams listed for chlorophyll a shows that there were no samples with a pH greater the 8.5 (i.e., all tributaries are in compliance with the pH standard as it relates to chlorophyll a).

[24] In the last four years (1996-1999) the pH criterion of 8.5 was exceeded during only one period at the USGS continuous monitoring site at RM 3.4.

4.4.4.2 Dissolved Oxygen Impairment

The most critical beneficial uses related to dissolved oxygen in the Tualatin River Subbasin are salmonid spawning, rearing, and passage. The mainstem Tualatin River, along with many of its tributary streams, has been listed as water quality impaired due to low dissolved oxygen (DO) concentrations (see previous section on DO for a more complete discussion.) Recent modeling by the USGS, however, has shown that during critical conditions (such as those that occurred in 1992) the control of ammonia discharges alone will not result in achievement of the DO criteria. As is explained in the DO section of this document , significant reductions in sediment oxygen demand in the lower mainstem Tualatin River will have to be achieved in order to attain the DO criteria during critical conditions.

Algal blooms in the lower Tualatin can create a large amount of biomass, some of which settles to the bottom of the river and decomposes along with other detrital material (Rounds *et al*, 1997). The Tualatin River at Stafford Rd., the site most susceptible to dissolved oxygen problems, is also the primary site where algal detritus may be contributing to the increased SOD rates (Rounds *et al*, 1997). As explained above, large algal blooms appear to be currently under control due to a combination of phosphorus controls and flow management. It is apparent that there will be a continuing need to ensure that large algal blooms do not occur if SOD rates at this and other sites are to be reduced.

4.4.4.3 Aesthetic Condition Impairment

Aesthetic quality is specifically listed as a beneficial use in the Tualatin River Subbasin (see **Table 40**). The assessment of when a water body is impaired due to its aesthetic condition is often difficult to determine. By all accounts, the lower mainstem of the Tualatin River has improved significantly in the last ten years. The extremely large algal blooms and algal “rafts” often observed in the river prior to adoption of the first Phosphorus TMDL rarely occur now.

However, Oswego Lake, which receives water and associated pollutants from both the Tualatin River and the lake’s natural watershed, still experiences significant impairment of aesthetic quality. Algal growth on the lake, with its associated discoloration and other negative impacts, is considered by many residents to be an offensive aesthetic condition.

4.4.5 RELATIONSHIP BETWEEN CHLOROPHYLL A AND POLLUTANTS

4.4.5.1 Mainstem Tualatin River

The relationship between algal growth and the pollutants being discharged to the mainstem Tualatin River is very complex. In addition to pollutant loadings, the flow of the river (which affects the travel times) greatly influences algal growth. In-depth analyses of the river were performed during the development of initial Phosphorus TMDL. These analyses concluded that phosphorus was the key nutrient supporting the excessive algal growth in the Tualatin River and that phosphorus levels below 0.15 mg/L are required to control algal growth (DEQ, 1988). Subsequent to these analyses, the USGS developed a water quality model that has allowed further investigation of the relationship between phytoplankton growth and other factors. This modeling indicates that water temperature, travel time in the river, and incident solar radiation are the primary factors affecting the timing and extents of algal blooms on the river. The model predicts that substantial decreases in phosphorus concentrations (with tributaries attaining median concentrations of approximately 0.07 mg/L total phosphorus) would significantly limit the size of algal blooms, though the nuisance algal growth action level of 15 ug/L chlorphyll a would still be violated (Rounds *et al*, 1999).

Taking into account high phosphorus concentrations naturally occurring in groundwater sources, the phosphorus concentrations modeled by the USGS are most likely unachievable (see Section 4.4.6, below). It is apparent, however, that phosphorus is the limiting factor for algal growth during certain periods. Unified Sewerage Agency (USA) analyses have indicated that the size of algal blooms on the lower mainstem Tualatin River have been reduced due to the reduction of phosphorus (USA, 1999a). This supports earlier analyses based on algal assays that estimated that reductions in total phosphorus concentrations below 0.15 mg/L would result in the reduction of algal growth. By maintaining phosphorus concentrations to what are considered background concentrations, it is expected that the size and frequency of large algal blooms will further decline.

4.4.5.2 Tributary Streams

As noted above, six tributary streams in the Tualatin River Subbasin have been included on the state's 1998 303(d) list for exceedances of the chlorophyll a action level. The relationship between phosphorus and chlorophyll a specifically in the tributaries has not been studied in detail. However, the general relationship between phosphorus and chlorophyll a in the subbasin was analyzed through a series of algal assays performed by DEQ in preparing the 1988 TMDL (DEQ, 1988).

The results of the algal assays completed by DEQ for the mainstem predicted that phosphorus levels under 0.15 mg/L are required to control algal growth. While these assays were developed to determine the relationship between phosphorus and algal growth on the mainstem, their results provide the best estimate available to determine the impacts of phosphorus concentrations on algal growth in the tributaries.

4.4.5.3 Oswego Lake

The relationship between phosphorus and chlorophyll a has been studied extensively in Oswego Lake in a 1987 lake analysis (SRI, 1987). This report concluded that the reduction of phosphorus loads from both the lake's natural watershed and the Tualatin River is essential if algal growth is to be limited. (A more detailed discussion of Oswego Lake is presented in Section 4.4.12. The reassessment of the phosphorus TMDL as is pertains to Oswego Lake is also given in that section.)

4.4.6 PHOSPHORUS

As explained in the previous section, phosphorus has been identified as the primary pollutant leading to exceedances of the chlorophyll a action level (though light and travel time may often have greater impacts). Prior to the establishment of the original Phosphorus TMDL in 1988, these exceedances led to numerous violations of the pH water quality standard and may have contributed to violations of the DO water quality standard. Since the implementation of management efforts to meet the 1988 Phosphorus TMDL, pH and DO standards violations have been greatly reduced (see *the Condition Assessment* section above).

The goal of this TMDL is to determine the appropriate instream and discharge levels of phosphorus allowed in the Tualatin River Subbasin as they relate to algal growth. This is done by examining the appropriate water quality standards, the relationship of phosphorus to algal growth (see the preceding section), and the sources and controllability of phosphorus.

In this section, the background concentrations of phosphorus are estimated and an examination is made of the expected impacts on water quality standards due to the attainment of background concentrations of phosphorus. Based on this information, appropriate loading capacities are then determined. (**Note**: Background phosphorus concentrations and phosphorus loading capacities for Oswego Lake are determined in Section 4.4.12, below.)

4.4.6.1 BACKGROUND SOURCES AND CONCENTRATIONS

Subsequent to the development of the initial phosphorus TMDL in 1988, studies were conducted that indicated natural phosphorus loads from groundwater may constitute a significant portion of low flow (non-runoff period) tributary loads. The results of these studies have subsequently been published (Kelly *et al*, 1999 and Wilson *et al*, 1999). These studies also reasoned that the most probable sources of the elevated levels of phosphorus in groundwater are natural.

In order to investigate the possibility of significant background phosphorus sources (and to look at other TMDL-related issues), the Tualatin Basin Technical Advisory Committee (TBTAC) and Policy Advisory Committee (TBPAC) were formed. The resulting recommendations from the TBPAC to ODEQ included the recommendation that the tributary load allocations for background should be increased to account for high background (groundwater) concentrations. The sections below include a discussion of the groundwater contributions to total phosphorus loads and concentrations.[25]

When it is determined that natural conditions are responsible for the exceedance of the chlorophyll a action level, the pertinent water quality standard states that the action level may be modified to an appropriate level (from **OAR 340-041-0150[2][a]**):

> *Where natural conditions are responsible for exceedance of the values in section (1) of this rule or beneficial uses are not impaired , the values in section (1) of this rule may be modified to an appropriate value for the water body;*

The determination of what phosphorus concentrations would occur in truly natural conditions in the Tualatin River Subbasin is for all practical purposes impossible. The hydrology and physical/chemical processes affecting phosphorus in the subbasin are severely impacted by flow augmentation, flow withdrawals, urbanization, channel and riparian modifications, tile drain installation and many other non-natural factors. For the purpose of this TMDL, it is deemed reasonable to primarily consider "natural conditions" to include flow and precipitation patterns typical of the subbasin for the past ten years. It is also deemed reasonable to estimate the "natural" tributary concentrations of total phosphorus as discussed in **Appendix C-4** (and Section 4.4.12 for Oswego Lake) and to estimate the "natural" mainstem concentrations as discussed in **Appendix C-5**.

For the portion of **OAR 340-041-01509(2)(a)** cited above, the conditions listed above are considered to be equitable to "natural conditions". For the remainder of this document, these conditions will be referred to as "background" conditions and the resulting phosphorus levels will be referred to as "background" phosphorus concentrations and loadings.

[25] A more complete discussion of the phosphorus TMDL background issues is included in Appendix C-1.

4.4.6.1.1 Tributary Background

In order to approximate the impacts of groundwater on tributary phosphorus concentrations, DEQ has examined instream concentrations during non-runoff periods.[26] During non-runoff periods (periods when there is not enough rainfall to generate surface run-off) the sources of phosphorus in the tributaries are considered to be primarily from groundwater. The median concentrations of total phosphorus during these periods were determined for each major Tualatin tributary for several years. A similar, but less rigorous analysis (due to a lack of sufficient flow data) was completed for several of the smaller tributaries (Nyberg, Burris, Bronson and Cedar creeks). Since several smaller tributaries have very little phosphorus data, they were estimated to have background phosphorus concentrations similar to nearby tributaries. Based on this, Baker, McFee and Christensen are estimated to have concentrations similar to Burris Cr.; Chicken, Nyberg, Saum and Rock Cr. South are estimated to have concentrations similar to Cedar Cr.

The concentrations of phosphorus contributed by groundwater are expected to fluctuate throughout the season as different geologic strata, with different phosphorus concentrations, contribute flows to the tributary streams. For this reason, the seasonal median values, as opposed to the minimum values, have been chosen to represent the seasonal background concentrations. For this same reason, the background concentrations are expected to fluctuate from year to year.

Within the analyses used to estimate the background concentrations of total phosphorus, it is probable that the resulting values are elevated due to anthropogenic sources that are not accounted for. These sources may be indirect such as releases from sediments deposited during runoff events, or direct such as irrigation runoff, car washing, etc. For this reason, it is necessary to include a margin of safety in determining the background concentrations of phosphorus for the tributary streams. The margin of safety selected is the use of the lowest of the annual medians of the phosphorus concentrations measured during non-runoff periods (see Appendix C-4). (The exception is Burris Creek where the loading capacity was set at a slightly higher level due to the relatively small data set obtained during one year.) The total phosphorus concentrations estimated to represent background conditions in the tributaries of the Tualatin River Subbasin are presented in **Table 42**.

Table 42. Estimated Tributary Background Concentrations of Phosphorus During TMDL Season

Tributary	Total Phosphorus Median Concentration Range (mg/L)
Bronson Cr.	0.13
Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.	0.12
Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr.	0.14
Dairy Cr.	0.09
Fanno Cr.	0.13
Gales Cr.	0.04
Rock Cr.	0.19

[26] The discussion on the analysis process for groundwater contributions of phosphorus is included in Appendix C-4.

4.4.6.1.2 Mainstem Background

The background (groundwater) sources of phosphorus in the mainstem Tualatin River are relatively difficult to quantify, but their median loadings within discrete segments may be estimated by examining the median mainstem flow and phosphorus concentrations. An analysis similar to the one performed for the tributaries was performed for the mainstem Tualatin River, but using a mass balance approach. A mass balance analysis was performed in order to estimate background conditions on the mainstem Tualatin River (see **Appendix C-5** for a detailed discussion of the estimation process).

The estimation of the background concentrations for the mainstem Tualatin River most likely contains errors, including unaccounted for anthropogenic influences such as tributary sources not addressed in the analysis. To address these, it is necessary to include a margin of safety. The margin of safety selected is similar to that used in the tributary analysis – the lowest of the annual medians of the phosphorus concentrations were selected to represent estimated background concentrations. These estimated total phosphorus concentrations, given as summer median concentrations, are presented in **Table 43**.

Table 43. Tualatin River Subbasin Estimated Total Phosphorus Background Concentrations During TMDL Season

Stream Segment	Total Phosphorus Concentrations (Summer Median - mg/L)
Mainstem Tualatin River @ Stafford Rd. (RM 5.5)	0.10
Mainstem Tualatin River @ Hwy 99W (RM 11.6)	0.11
Mainstem Tualatin River @ Elsner (RM 16.2)	0.11
Mainstem Tualatin River @ Farmington (RM 33.3)	0.10
Mainstem Tualatin River @ Rood Rd. (RM 38.4)	0.09
Mainstem Tualatin River @ Golf Course Rd. (RM 51.5)	0.04

4.4.6.2 PHOSPHORUS LOADING CAPACITIES

While the background concentrations of phosphorus in the subbasin have been estimated above, it is necessary to examine whether these concentrations will meet water quality standards, or will result in standards violations. In addition, if it is determined that achieving background concentrations will result in compliance with standards, it is necessary to determine whether some concentration above background will also result in compliance with the standards.

As detailed in earlier sections of this TMDL, the three water quality standards impacted by elevated chlorophyll a concentrations are pH, DO and aesthetics. On the mainstem Tualatin River, water quality data shows compliance with pH the last several years - with the exception of one short-term exceedance. DO compliance, detailed in the Section 4.3, has substantially improved in recent years and full compliance with the standard is expected through implementation of the new DO TMDL (Section 4.3). Compliance with the aesthetic condition standard is also essentially being met with the marked reduction in large algal blooms. Examination of the recent data shows that water quality standards related to algal growth on the mainstem Tualatin River are essentially being met. The small number of violations that do occur, however, indicate that increases in chlorophyll a concentrations will most likely result in increased standards violations. This is supported by the analysis within the DO TMDL (Section 4.3) indicating that the continued control of algal blooms are necessary to minimize potential impacts on SOD.

Based on the above, it appears reasonable to consider the current phosphorus concentrations on the mainstem Tualatin River as being the upper limits of acceptable. The TMDL period median concentrations observed at two critical sites, Stafford Rd. and Elsner Rd., are given for recent years in **Table 44**, below.

Table 44. May-October Observed Median Phosphorus Concentrations (mg/L)

Year	Stafford Rd.	Elsner Rd.
1994	0.09	0.09
1995	0.09	0.09
1996	0.11	0.11
1997	0.10	0.10
1998	0.09	0.09

A comparison of these observed concentrations with the estimated background concentrations in Table 41 shows that the observed levels are similar to the estimated background levels.[27] It should be noted that this comparison is rather course since the values are seasonal medians and short-term fluctuations are not necessarily reflected. It stands to reason, however, that by setting the mainstem phosphorus loading capacity equal to the estimated background concentrations of phosphorus, the applicable water quality standards can be expected to be met during flow scenarios that may include slightly longer residence times than observed in recent years.

The water quality standard violations associated with algal growth on the Tualatin Subbasin tributaries are limited to DO. (No exceedances of the upper pH criterion have been observed on the tributaries.) As detailed in the DO TMDL (Section 4.3), the DO water quality standard is expected to be met on the tributaries through volatile solids and temperature reductions. Therefore, phosphorus loading capacities on the tributaries are not necessary to meet water quality standards on the tributaries themselves. However, since the tributaries loads of phosphorus impact the mainstem Tualatin River, tributary loading capacities are necessary to achieve standards on the mainstem. As explained above, it is appropriate to set these loading capacities based on the estimated background concentrations.

The loading capacity of a river is defined as the greatest amount of pollutant loading that a waterbody can receive without violating a water quality standard. TMDLs can be expressed in the form of mass per time, toxicity, or other appropriate measure that relates to a state's water quality standard (EPA, 1991). Since the applicable water quality standards are dependent on the instream phosphorus concentrations (along with other factors), loading capacities in the form of concentrations are considered more appropriate than mass loads.

Based on the discussion above, it is appropriate to set the loading capacities at the estimated background concentrations of phosphorus. The loading capacities for tributary streams for which specific background concentrations were not calculated are set at the median of the estimated background concentrations for nearby streams. The total phosphorus loading capacities for the Tualatin River Subbasin are given in **Table 45**.

[27] These levels are most likely being achieved by a combination of low effluent concentrations from the wastewater treatment plants, flow augmentation from Hagg Lake, and the initiation of controls on runoff and nonpoint sources.

Table 45. Tualatin River Subbasin Total Phosphorus Loading Capacities	
Stream Segment	Total Phosphorus Concentrations (Summer Median - mg/L)
Mainstem Tualatin River @ Stafford Rd. (RM 5.5)	0.10
Mainstem Tualatin River @ Hwy 99W (RM 11.6)	0.11
Mainstem Tualatin River @ Elsner (RM 16.2)	0.11
Mainstem Tualatin River @ Farmington (RM 33.3)	0.10
Mainstem Tualatin River @ Rood Rd. (RM 38.4)	.09
All Tributaries to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04
All Tributaries to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14
Mainstem Tualatin River @ Golf Course Rd. (RM 51.5)	.04
Bronson Creek @ Mouth (205th)	0.13
Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.(all @ Mouth)	0.12
Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr.(all @ Mouth)	0.14
Dairy Creek @ Mouth	0.09
Fanno Creek @ Mouth	0.13
Gales Creek @ Mouth	0.04
Rock Creek @ Mouth	0.19

As explained in the "TMDL Approach" section above, if background conditions are determined to be responsible for the exceedance of the chlorophyll *a* action level, then the action level may be modified to an appropriate level. Since the estimation of the chlorophyll *a* concentrations in the Tualatin River Subbasin due to background concentrations of phosphorus is impractical, the most appropriate chlorophyll *a* action level related to phosphorus is narrative:

The Tualatin River Subbasin chlorophyll a action level related to phosphorus is the chlorophyll a concentration resulting from the achievement of background phosphorus concentrations, as defined in the Phosphorus TMDL.

4.4.7 SOURCE ASSESSMENT

The sources of total phosphorus in the Tualatin River Subbasin may be divided into four broad categories:

1) Background Sources
2) Wastewater treatment plants (WWTPs)
3) Runoff
4) Other Sources

4.4.7.1 BACKGROUND SOURCES

The background sources of phosphorus in the subbasin have been identified and their contributions estimated in Section 4.4.6.1, above.

4.4.7.1.3 Wastewater Treatment Plants

The Unified Sewerage Agency (USA) has four wastewater treatment plants in the subbasin. Only two of these plants (are Durham [RM 9.3] and Rock Creek [RM 38.1]) discharge during the TMDL period. Of the four broad phosphorus source categories, the discharges from the two summer-discharging wastewater treatment plants are the best characterized. These two plants are currently discharging at loads below the allocations given under the original TMDL. Since the total phosphorus concentrations of these flows have been averaging well below the observed instream summer values, they have a general diluting effect on the phosphorus levels of the waters downstream of their discharge points. The flows from these two plants are expected to increase as the population of Washington County increases.

4.4.7.2 RUNOFF SOURCES

In addition to the groundwater sources of phosphorus, surface runoff is known to contribute total phosphorus loadings to both the mainstem Tualatin River and to the tributary streams. The amount of runoff and the concentration of phosphorus in the runoff will vary with precipitation and land use. What follows is a broad characterization of the contribution of runoff to total phosphorus loadings in the Tualatin River Subbasin. A more detailed discussion of the total phosphorus concentrations and loadings in runoff is included in Appendices C-6 and C-7.

4.4.7.2.1 Urban Runoff

Urbanized land areas, with their high percentages of impervious surfaces and extensive drainage systems, have surface runoff even during relatively small rainfall events. Examination of hydrographs (plots of stream flow vs. time) over the last several years for urbanized watersheds in the Tualatin River Subbasin show distinct runoff curves over the course of the summer season. Also, a comparison of concentrations of phosphorus in urban runoff with the values in **Table 43** indicates that phosphorus in this runoff would usually exceed the background concentrations in the tributaries. (See **Appendix C-6** for a more detailed discussion of urban runoff in the subbasin.)

4.4.7.2.2 Runoff from Rural, Agricultural and Forested Lands

While runoff from rural, agricultural and forested lands differs from runoff from urban areas, much of the discussion above applies to these land uses as well. The main difference between the two broad source categories is that the volume of runoff for a given area from non-urbanized watersheds is generally less, especially during the summer season. Data on total phosphorus concentrations for agricultural and forested land runoff in the subbasin is lacking, but general values for these concentrations are available. As is the case with urban runoff, these concentrations exceed the background concentrations given in **Table 43**. (See **Appendix C-7** for a more detailed discussion of rural, agricultural and forested runoff in the subbasin.)

4.4.7.3 OTHER SOURCES

While the majority of the phosphorus loading to the Tualatin River and its tributaries is most likely coming from the three source categories identified above, there are other potential sources that should be examined.

4.4.7.3.1 Unregulated (Unpermitted) Upland Sources

There may be upland sources other than runoff and other permitted discharges that are contributing phosphorus loads. Possible sources include faulty septic and sewer systems, and illegal or illicit discharges. While these sources are not readily quantifiable, the phosphorus loads are expected to be relatively small due to the aggressive control programs that were established previously. It is important that these programs continue to be implemented and are updated based on new monitoring or other information.

4.4.7.3.2 Instream and Riparian Sources

The primary instream source of phosphorus is considered to be groundwater (Kelly *et al*, 1999). Another probable source is the release of phosphorus in sediment due to anoxic conditions. While these releases are estimated to be relatively small in the mainstem (Kelly *et al*, 1999), they may have a larger impact in areas with very low oxygen levels such as tributary ponds.

The contribution of riparian bank erosion to water column and sediment phosphorus levels is also difficult to quantify. While the smaller instream flows during the summer season (when algal blooms are an issue) most likely result in only a small portion of the total bank erosion taking place, this remains a potential source of total phosphorus.

4.4.7.3.3 Tile Drains

Tile drains, installed primarily in agricultural areas to drain shallow groundwater, are briefly examined in a USGS report on phosphorus sources in the Tualatin River Subbasin (Kelly *et al*, 1999). This report concluded that "(t)he data suggest that agricultural practices in the Tualatin River Subbasin did not significantly increase concentrations of phosphorus in water entering streams during the low-flow [non-runoff] period of this study". This is primarily referring to agricultural impacts on shallow groundwater and tile drains.

4.4.7.3.4 Other Permitted Point Sources

Within the Tualatin River Subbasin there are approximately 59 permitted point sources other than municipal wastewater treatment plants or stormwater sources. An initial examination of these permits does not indicate any significant sources of phosphorus (most of these point sources discharge cooling water or treated groundwater). However, all permits in the subbasin will be reviewed and, if necessary, modified to include phosphorus limits based on **Table 47**, below.

4.4.8 SEASONAL VARIATION

Historically, the nuisance algal blooms in the Tualatin River Subbasin are limited to the summer and late summer season when sufficient light and water temperatures commonly exist that support algal growth. While most algal growth occurs during these times, there are two reasons to apply the phosphorus TMDL to a slightly longer period. First, there is the potential for early summer deposition of phosphorus-laden sediments into instream pools on the mainstem Tualatin River and its tributaries. As is discussed under the source assessment section above, these sediments may release phosphorus under anoxic conditions. Second, there is a chance during very warm, dry years for algal growth to occur earlier in the season. For these reasons, the phosphorus TMDL for the Tualatin Subbasin will apply from May 1 through October 31 ("the phosphorus TMDL season"). The exception to this is the portion of this TMDL that applies to the natural watershed of Oswego Lake. A discussion of seasonal variation for that portion of the TMDL is included in Section 4.4.12.

In general, the flow and precipitation data that were analyzed during the development of this TMDL were in the May 1 through October 31 period. The exception to this was the work done to determine background concentrations in the mainstem Tualatin River (**Appendix C-5**). Since this analysis was performed for specific years, the applicable low flow periods were used. These periods were generally July 1 through October 31.

4.4.9 ALLOCATIONS

Load allocations (for non-point sources and background sources) and wasteload allocations (for point sources) are allocated to existing and future sources of phosphorus. The total of these allocations are designed to meet water quality standards by remaining at the loading capacities presented in Table 46.

As explained above, TMDLs can be expressed in the form of mass per time, toxicity, or other appropriate measure that relates to a state's water quality standard. In this case, the appropriate measures for the allocations will be a combination of concentrations and loads based on meeting these concentrations. This combination of measures is considered appropriate since it both addresses the water quality standard and will lend itself to the design of control measures.

The following is a discussion of the allocation for each of the pollutant sources considered to contribute significant total phosphorus loads (as assessed in Section 4.4.7).

4.4.9.1 BACKGROUND

Both mainstem and tributary background (groundwater) sources of total phosphorus are assigned load allocations. Since it is not reasonable to assess the volume of these background sources, these allocations will be in the form of concentrations, as estimated in **Section 4.4.6** and **Appendix C-4**. The load allocations for background sources in the Tualatin River Subbasin are selected to meet the loading capacities and are listed in **Table 46**.

Table 46. Tualatin River Subbasin Total Phosphorus Load Allocations for Background (Groundwater) Sources

Stream Segment	Total Phosphorus Concentrations (Summer Median - mg/L)
All Tributaries to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14
All Tributaries to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04
Bronson Creek @ Mouth (205th)	0.13
Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.(all @ Mouth)	0.12
Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr. (all @ Mouth)	0.14
Dairy Creek @ Mouth	0.09
Fanno Creek @ Mouth	0.13
Gales Creek @ Mouth	0.04
Rock Creek @ Mouth	0.19

4.4.9.2 RUNOFF ALLOCATIONS

The allocations for point sources other than WWTPs were selected to meet the loading capacities (which include margins of safety). The wasteload allocations for these sources are presented in the form of concentrations (mg/L of total phosphorus) in **Table 47**, below. The load allocations for runoff are presented in the form of concentrations (mg/L of total phosphorus) in **Table 48**, below.

Table 47. Tualatin River Subbasin Total Wasteload Allocations for Point Sources (other than WWTPs)

Designated Management Agency/Source	Source Discharging to: (Subbasin)	Total Phosphorus Concentrations (Summer Median - mg/L)
City of Lake Oswego, City of Portland, City of West Linn, Clackamas Co., Oregon Dept. of Transportation, Multnomah Co., Unified Sewerage Agency, and Washington Co. (And other point sources other than WWTPs)	All Sources to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14
	All Sources to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04
	Bronson Creek @ Mouth (205th)	0.13
	Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.(all @ Mouth)	0.12
	Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr. (all @ Mouth)	0.14
	Dairy Creek @ Mouth	0.09
	Fanno Creek @ Mouth	0.13
	Gales Creek @ Mouth	0.04
	Rock Creek @ Mouth	0.19

Table 48. Tualatin River Subbasin Total Load Allocations for Nonpoint Sources

Designated Management Agency/Source	Source Discharging to: (Subbasin)	Total Phosphorus Concentrations (Summer Median - mg/L)
Clackamas Co., Oregon Dept. of Agriculture, Oregon Dept. of Forestry, Multnomah Co. and Washington Co.	All Sources to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14
	All Sources to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04
	Bronson Creek @ Mouth (205th)	0.13
	Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.(all @ Mouth)	0.12
	Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr. (all @ Mouth)	0.14
	Dairy Creek @ Mouth	0.09
	Fanno Creek @ Mouth	0.13
	Gales Creek @ Mouth	0.04
	Rock Creek @ Mouth	0.19

While allocations in the form of concentrations are given above, allocations in the form of loads may be utilized instead. The allocations in the form of loads (or counts) may be determined by multiplying the appropriate land use or source by the estimated discharge volume for the source. Wasteload allocations in the form of loads for sources in **Tables 47 and 48** have been calculated for the mean seasonal precipitation (see Appendix C-8). These loads are given in **Table 49**, below. For reference purposes, these loads have been segregated by 5^{th}-field subbasin and the USA wasteloads have been further segregated by the municipalities that are within their service district. It should be noted that these municipalities are not DMAs – USA is the DMA for these areas. These municipalities, along with their corresponding loads, are listed for reference purposes only.

As explained in Section 4.4.6.2, the loading capacities – and therefore the allocations – contained in this portion of the TMDL were developed to address water quality issues specific to the lower mainstem Tualatin River. As such, the aggregate loading from all sources to the lower mainstem is the critical factor. Therefore, the allocations given to each DMA in Table 49 may be met by addressing the aggregate of the 5^{th}-field subbasin loadings for the DMA.

Allocations in the form of load for specific precipitation events, and/or using different runoff estimation techniques, may be calculated by the designated management agencies with DEQ approval. The equation used for the conversion of concentration-based allocations to load-based allocations is:

Allocation (lb. of Total Phosphorus/season)
= Allocation (mg/L Total Phosphorus) x Seasonal Discharge Volume (ft^3/season) x 6.24×10^{-5} (lb.–L/ft^3-mg)

The resulting allocations are in the form of loads per unit time. The wasteload allocations (assigned to point sources) are given in units of pounds per season (May 1 – October 31). The concentrations listed in Tables **47 and 48** can be used to assist in the assessment of monitoring data and to provide targets for runoff quality. Loads **(Table 49)** can be used to guide management strategies that are designed to reduce the quantity and/or quality of runoff. DEQ encourages management strategies that optimize reduction of runoff quantity and improvement of quality.

The allocations in the form of loads for sources other than WWTPs are given below in **Table 49**. It should be noted that these values are designed to both meet the loading capacities of the receiving waters and to allocate loadings that allow for some human influence.

For each of the subbasins listed in Tables 47,48, and 49, one or more DMAs have jurisdiction over land and activities. Each DMA's portion of the WQMP (Appendix I) will address only the lands and activities within each identified stream segment to the extent of the DMA's authority.

Table 49. Tualatin River Subbasin Total Phosphorus Allocations for Runoff Sources				
5th-Field Subbasin	**DMA (or Municipality – see note)**	**Load Allocation (Pounds per TMDL Season)**	**Wasteload Allocation (Pounds per TMDL Season)**	**USA Wasteload Allocations Subdivided by Municipality (Pounds per TMDL Season)**
Dairy	ODOT	0	3.7	
	USA	0	213	
	Banks			0.1
	Cornelius			16.7
	Forest Grove			25.4
	Hillsboro			143.2
	North Plains			0.1
	Other			27.5
	Washington Co.	1.1	42.2	
Rock	ODOT	0	49.3	
	USA	0	2974.5	
	Beaverton			629.7
	Hillsboro			796.2
	Other			1548.6
	Multnomah Co.	0	61.4	
	Washington Co.	0	14.9	
	Portland	0	100.8	
Lower Tualatin/Fanno Creek	ODOT	0	230.1	
	USA	0	1271.6	
	Beaverton			217.5
	Rivergrove			3.4
	Sherwood			132.5
	Tigard			371.5
	Tualatin			279.1
	Durham			4.8
	King City			8.1
	Other			254.8
	Clackamas Co.	0.8	37.4	
	Multnomah Co.	0	1.5	
	Washington Co.	0.2	33.1	
	West Linn	0	26.4	
	Lake Oswego	0	73.0	
	Portland	0	134.9	
Upper Tualatin	ODA	26.4	0	
	ODF	17.1	0	
	USA	0	0.2	
	Gaston			0.2
	Washington Co.	8.6	0	
Middle Tualatin	ODOT	0	4.9	
	USA	0	203.1	
	Cornelius			15.9
	Forest Grove			19.4
	Hillsboro			58.2
	Beaverton			3.5
	Other			106.0
	Washington Co.	1.60	26.9	
Gales	ODOT	0	1.3	
	Forestry	0.1	0	
	USA	0	25.9	
	Forest Grove			25.4
	Other			0.5
	Washington Co.	0.1	0	

Notes:
1) As explained in the text preceding this table, the allocations given to each DMA may be met by addressing the aggregate 5th-field subbasin loadings for the DMA.
2) The municipalities listed directly under USA are not DMAs – they are listed here with the allocations corresponding to their jurisdictions for reference only. USA is the DMA for these areas. "Other" under this heading refers to loads from areas outside of cities.
3) The seasonal loads may be divided by 184 to give the average daily loading.

4.4.9.3 WASTEWATER TREATMENT PLANTS

The wasteload allocations set in the initial TMDL process for the two summer discharging wastewater treatment plants (WWTPs) were designed to achieve loading capacities in the mainstem Tualatin River that were lower than the new loading capacities. Based on the new loading capacities and estimated background concentrations of total phosphorus in the mainstem Tualatin River (see **Appendix C-5**), target concentrations for the WWTPs' effluent have been developed (**Table 50**). These target concentrations have been set at background concentrations, which include a margin of safety (MOS). Discharges at these concentrations will meet the loading capacities given in Table 45. (A more detailed discussion is included in **Appendix C-5**).

Table 50. Tualatin River Subbasin Total Phosphorus Target Concentrations for Wastewater Treatment Plant Effluent

USA Rock Creek Wastewater Treatment Plant	
Wasteload Allocation (Monthly Median Effluent Concentration)	0.08 mg/L
USA Durham Wastewater Treatment Plant	
Wasteload Allocation (Monthly Median Effluent Concentration)	0.11 mg/L

4.4.9.4 OTHER PERMITTED SOURCES

Permitted sources other than the wastewater treatment plants and municipal separate storm sewer systems have been given allocations in the form of target concentrations. These target concentrations are given in **Table 47** (above) and will be incorporated into the sources' NPDES permits either directly as concentrations, or as loads based on these concentrations. If current discharge levels are below the WLA concentrations, the WLA to be given within the permit will be equivalent to "current performance".

4.4.10 RIPARIAN BANK EROSION

While phosphorus loads from riparian bank erosion are estimated to be relatively small during the TMDL season, they are still a potential source of pollutants. Due to limitations in the available data, it is not possible to develop a quantitative estimate of phosphorus from riparian bank erosion. Therefore, the load allocation for this source is narrative: No excessive riparian bank erosion may occur in the Tualatin River Subbasin during the TMDL season. This issue is best addressed through the Tualatin River Subbasin Temperature TMDL, which will require system potential shading. It is reasonable to assume that the best management practices resulting in system potential shading will also result in bank stabilization and the elimination of excessive riparian bank erosion, especially during the TMDL season.

4.4.11 TUALATIN SUBBASIN MARGIN OF SAFETY

The margins of safety (MOS) for this portion of the TMDL are implicit in the process used to select the allocation target concentrations (see **Section 4.4.9** and **Appendix C-8**). These margins of safety are in the form of conservative estimations of the background concentrations of phosphorus. Since these background concentrations are the basis for the allocations, the allocations are also conservative.

4.4.12 OSWEGO LAKE

As part of the Tualatin River Subbasin Phosphorus TMDL developed in 1988, phosphorus loads were allocated for runoff to Oswego Lake. This section is an update to the Oswego Lake portion of the phosphorus TMDL. The primary focus of the update is to take into account the better understanding of groundwater sources of phosphorus to the tributaries in the subbasin.

4.4.12.1 BACKGROUND

Oswego Lake receives water both from the lower mainstem of the Tualatin River (via the Oswego Canal) and from the tributary streams in its natural watershed. The Lake Oswego Corporation, which owns and operates the lake, has a water right of 57.5 cfs of mainstem Tualatin River water for the purpose of power generation at the outlet of the lake. Runoff, spring, and groundwater also discharge to the lake from the surrounding natural watershed.

In 1987 a diagnostic and restoration analysis of the lake was completed by Scientific Resources, Inc. (SRI, 1987). This report (which hereafter will be referred to as the SRI report) determined that excessive algal growth in the lake was caused, in part, by loadings of phosphorus from the Tualatin River (via the Oswego Canal) and from the streams tributary to the lake. Using an empirically derived model (the Vollenweider model) to examine the relationship between phosphorus loadings and the trophic state in the lake, an allowable total annual phosphorus loading to the lake was determined. This allowable loading was the basis for the watershed's 1988 TMDL loading capacity and associated allocations.

Since the development of the 1988 TMDL, new information has been presented that indicates natural groundwater sources in the Tualatin River Subbasin area may be contributing significant loads to surface waters. The following assessment is not meant to be a new diagnostic and restoration analysis for the lake, but rather a reassessment of the TMDL allocations based on this new knowledge of groundwater sources of phosphorus.

4.4.12.2 SOURCE ASSESSMENT

The various sources of phosphorus loads to the lake were delineated in the 1987 SRI report. Five primary sources of phosphorus were identified: precipitation, groundwater, releases from sediments, input from the Tualatin River (via Oswego Canal), and input from the local watershed tributaries. Load allocations were given in the original TMDL to the tributary sources in the lake's natural watershed and to the sources contributing to the loads to the Tualatin River. The allocations relating to the phosphorus loads coming from the Tualatin River via the Oswego Canal are derived in other sections of this TMDL. The allocations for the tributary streams in the natural Oswego Lake watershed are derived below.

4.4.12.3 BACKGROUND SOURCES OF PHOSPHORUS

As mentioned in this TMDL, since the development of the original TMDL in 1988 new information has been presented regarding the contribution of phosphorus to tributary streams via groundwater. This background source will have an impact on loads from both the Oswego Canal and the tributary streams. Estimates of the current loads due to background conditions are given below.

4.4.12.3.1 Tributary Background Phosphorus Concentrations

Determination of the background concentrations associated with the tributary streams in the watershed was performed using the same methodology as used for the other Tualatin River Subbasin streams (see **Section 4.4.6** and **Appendix C-4**). The premise for using this methodology is that the instream values observed during non-runoff events during the summer (May 1 – Oct. 31) season are approximately equal to the background values due to natural groundwater sources. Since typical summer season storm events in natural watersheds would result in very little, if any, runoff and only moderate (and gradual) increases in stream flows, these values are considered to be background throughout the summer with the exception of atypically large storm events.

In order to determine the background concentrations for the Oswego Lake tributaries, data for Springbrook Creek were used to represent all tributaries. These data were used because only a small amount of data exist for the other tributaries, Springbrook is the largest of the tributaries, and, since most of the streams in the watershed share similar geology and soils, it is expected that the phosphorus concentrations would also be similar. Due to a lack of continuous stream flow data for Springbrook Creek, the analysis of base flow concentrations was based on rainfall data instead of flow data. If a sample was collected on a day when gauged precipitation was greater than 0.1 inches, or if the precipitation data was missing, then the data were not used in the analysis (see **Appendix C-4** for a general overview of the methodology).

Table 51, below, gives the summer non-runoff median total phosphorus concentrations for Springbrook Creek. The 1990 value of 0.460 mg/L total phosphorus is considerably higher than the other concentrations that are considered representative of groundwater concentrations. There is no known physical reason why the local groundwater in its natural state would increase so significantly for one summer. Considering this and that the value is based on only three samples, the 1990 data are not considered representative of background concentrations. Removal of the 1990 data does not change the overall median concentration. The overall median of the total phosphorus concentrations for summer non-runoff periods is 0.110 mg/L. Using the same logic as presented for other Tualatin River Subbasin tributary streams, this value is considered representative of background conditions for the May 1 – October 31 period.

Table 51. Estimated Springbrook Creek Summer Background Concentrations of Phosphorus

Summer (May 1 – October 31) Non-Runoff Median Total Phosphorus Concentrations (mg/L)							Total Phosphorus Seasonal Median Concentration Range (mg/L)
1986	1987	1990	1991	1997	1998	1999	
0.099	0.115	0.460	0.090	0.110	0.110	0.110	0.090 – 0.115

Estimating the background concentrations of phosphorus in Springbrook Creek during the wetter November – April season is more difficult. Under natural conditions, larger wet season storms (along with saturated soil conditions) may result in significant runoff. This runoff increases stream flows and velocities leading to naturally occurring instream and near-stream erosion. This is different from most summer season storm events in natural watersheds. The typical summer storm events in a natural watershed will result in very little, if any, runoff and only moderate (and gradual) increases in stream flows.

The naturally occurring runoff and erosion during wet season storm events precludes the use of the analysis employed to determine the summer phosphorus allocations. A more accurate method to determine the appropriate allocation is to use data from a reference stream that has stream characteristics similar to Springbrook Creek (soil, gradient, drainage area, etc.), but does not have a developed watershed. Storm data from such a stream may be used to determine what the background levels of phosphorus would be for Springbrook.

Wet season storm data are available for upper Gales Creek in the western Tualatin River Subbasin. However, while this section of Gales Creek is relatively undeveloped, it is different geologically and drains a larger watershed. A second stream that is monitored by the City of Portland is much more appropriate. Balch Creek is approximately eight miles due north of Springbrook Creek and therefore the two watersheds share a similar climate. Balch Creek's watershed is of similar size (approximately 1500 acres), the average slope of the watershed is similar, and the soils are similar (except that the soils in the Balch watershed are better drained). The land use within the Balch Creek watershed is primarily open space with some roads, park use and residential use. Based on these factors, Balch Creek appears to be a good reference stream to determine background wet weather storm concentration of phosphorus.

The base flow sampling for Balch Creek is also reported at 0.08 mg/L TP (City of Portland, 1999). An analysis of non-storm data collected on Springbrook Creek during the wet season shows that the median total phosphorus concentration is 0.080 mg/L.[28] The median value of composite storm samples for Balch Creek is reported as 0.19 mg/L. The 15 storms monitored on Balch Creek were primarily in the November through April period. Based on these data, it appears reasonable to estimate that the background Springbrook median total phosphorus concentrations during wet season storm events would be 0.19 mg/L.

4.4.12.3.2 Tributary Background Phosphorus Loads

SUMMER TRIBUTARY BACKGROUND LOADS:

A report by OTAK, Inc. (OTAK, 1992) completed for the City of Lake Oswego and Clackamas County, estimated the 1992 May 1 – October 31 average stormwater runoff for Oswego Lake watershed to be 6.2×10^5 m^3. The report also estimated that the average stormwater runoff for the May 1 – October 31 period would be 7.8×10^5 m^3 if the natural watershed were fully developed according to City's Comprehensive Plan. Estimating that the existing runoff lies at the midway point between these two values, average stormwater runoff from the lake's watershed is approximately 7.0×10^5 m^3 for the May 1 – October 31 period.

The report also estimated that the base flow volume is 1.8 times the 1992 summer storm water volume. Considering that the sum of the average storm and base flow volumes will likely remain constant, the current estimated base flow volume for an average summer is 1.0×10^6 m^3.

During this period the base flow target concentration is 0.11 mg/L of total phosphorus (TP). Based on these values, the summer phosphorus loads that are considered background are given in **Table 52** below.

[28] The median concentration of non-storm total phosphorus during the wet season (0.080 mg/L) is about 30% lower than the median concentration for the dry season (0.110 mg/L). This is possibly due to the increased contribution of shallow groundwater during the wet season. The shallow groundwater follows a shorter (both in length and time) flow path that reduces the contact time with phosphorus containing soils.

WINTER (NOV. – APRIL) TRIBUTARY BACKGROUND LOADS:

In a similar manner (and using data from the OTAK report for the November through April period) the estimated winter average storm flow volume is 2.6 x 10^6 m^3. The report also estimated that the base flow volume is 1.9 times the 1992 storm water volume. Considering that the sum of the average storm and base flow volumes will likely remain constant, the current estimated base flow volume for an average winter is 4.3 x 10^6 m^3.

For this period the target base flow concentration is 0.08 mg/L TP and the target storm flow concentration is 0.19 mg/L TP. Again, this storm concentration is a composite of both the phosphorus contributed prior to water entering the stream and the phosphorus contributed instream (through erosion, etc.). Therefore, the total phosphorus load to the lake may be divided between each of these sources. The stormwater target concentration is assigned a value of 0.15 mg/L TP, with the corresponding load leading to an increase to 0.19 mg/L assigned to instream sources. Based on these values, the winter phosphorus loads that are considered background are given in **Table 52,** below.

Table 52. Total Phosphorus Tributary Background Loads for Oswego Lake

May 1 through October 31 (Summer)	
Storm Loads	169 lb. (77 Kg.) Total Phosphorus
Base Flow Loads	242 lb. (110 Kg.) Total Phosphorus
November 1 through April 30 (Winter)	
Storm Loads	1087 lb. (494 Kg.) Total Phosphorus
Base Flow Loads	757 lb. (344 Kg.) Total Phosphorus

4.4.12.3.3 Total Summer External Background Lake Loadings

Oswego Canal: The current flow from the Tualatin River to Oswego Lake via the Oswego Canal is approximately 3.77 x 10^6 m^3/yr., all of which takes place during the Summer (Steve Lundt, Lake Oswego Corporation, personal communication. March, 2000).[29] The background concentration of this water is estimated as 0.10 mg/L of total phosphorus (see **Section 4.4.6** and **Appendix C-5**). Using these two values, the background annual phosphorus load to the lake from the Tualatin River is approximately 829 lb./yr. Since all of the flow from the Tualatin River to the lake takes place during the summer, this is also the Summer phosphorus loading from this source.

The SRI report (SRI, Table 4-8) estimates the direct precipitation loading and direct groundwater loadings for the summer period to be 15 lb. and 175 lb., respectively (the direct groundwater loading is considered a high estimate). This, along with the tributary data in **Table 52**, gives the estimated background total phosphorus percent loadings for the summer season as presented in **Figure 66**, below.

[29] This flow is much less than the Lake Oswego Corporation's water right allows. Reductions in flow have been made in an effort to reduce nutrient loadings from the Tualatin River to the lake.

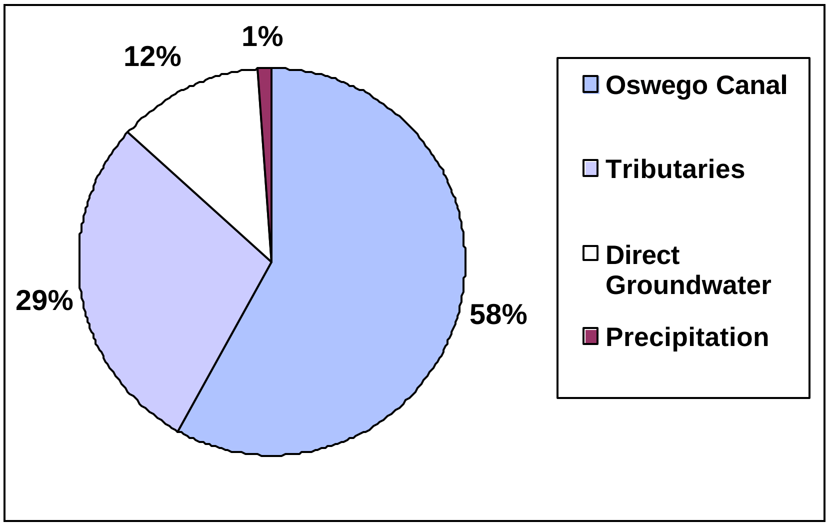


Figure 66. : Estimated Background Condition Summer Total Phosphorus Loadings to Oswego Lakes

4.4.12.3.4 Total Annual External Background Loadings

The estimated annual total phosphorus load to the lake from background tributary sources is therefore 2255 lb./yr. (from **Table 52**). As detailed above, the estimated background load from the Tualatin River via the Oswego Canal is 829 lb./yr. This gives a total estimated background load from surface water sources of 3084 lb./yr. If the direct groundwater load is estimated at 350 lb./yr. (considered by SRI to be a high estimate) and the direct precipitation load at 87 lb./yr. (both figures are from the SRI report), total loading would be approximately 3521 lb./yr. This gives the estimated background annual total phosphorus percent loadings as presented in **Figure 67**.

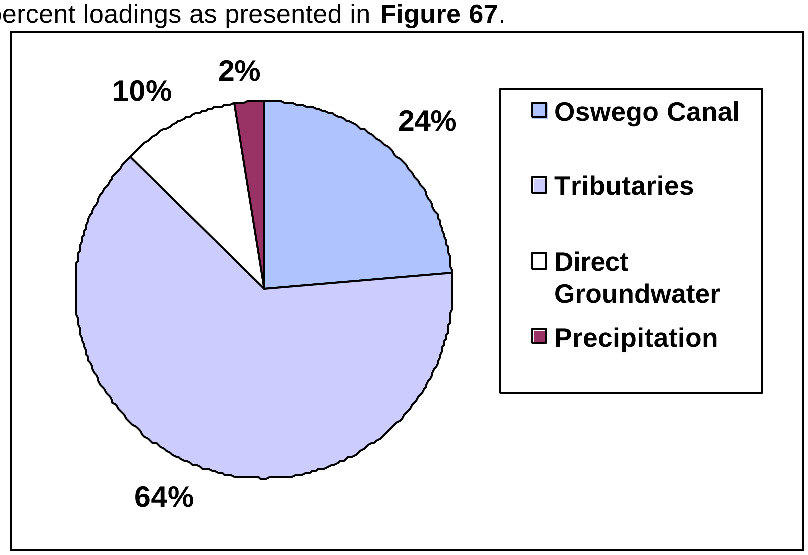


Figure 67. : Estimated Background Condition Annual Total Phosphorus Loadings to Oswego Lake

4.4.12.4 CURRENT PHOSPHORUS LOADS

4.4.12.4.1 Current Tributary Loads

An analysis of storm and base flow phosphorus data for Springbrook Creek for 1986, 1987, 1990, 1991, and 1997-99 gives a median storm concentration of total phosphorus of 0.326 mg/L. (The source of this data was the City of Lake Oswego, the Lake Oswego Corporation, OTAK and SRI.) Further analyses of the same data give a median summer base flow concentration of total phosphorus of 0.110 mg/L and a winter median concentration of total phosphorus of 0.080 mg/L. Using these data and the flow volumes given in Section 4.4.13.2, the current total phosphorus loadings from Oswego Lake are estimated as given in **Table 53**, below.

Table 53. Current Estimated Total Phosphorus Tributary Loads for Oswego Lake

May 1 through October 31 (Summer)	
Storm Loads	502 lb. (228 Kg.) Total Phosphorus
Base Flow Loads	242 lb. (110 Kg.) Total Phosphorus
November 1 through April 30 (Winter)	
Storm Loads	1866 lb. (848 Kg.) Total Phosphorus
Base Flow Loads	757 lb. (344 Kg.) Total Phosphorus

If current loadings from the Oswego Lake tributaries were reduced to background levels, the loading of total phosphorus to the lake would be reduced by approximately 1110 lb. This is an approximate tributary loading reduction of 33%.

4.4.12.4.2 Current Oswego Canal Loads

The flows coming into the Lake from the Tualatin River currently comprise approximately 65% of the total summer flow volume into the lake and 28% of the total annual flow volume. Unfortunately, little water quality data exist that would allow the loads coming into Oswego Lake from the Tualatin River via the Oswego Canal to be estimated.

By measuring both non-runoff and storm period concentrations, the SRI report estimated the 1987 total phosphorus concentration coming into the canal at an average of 0.302 mg/L. Since 1987, the non-runoff period total phosphorus concentrations in the Lower Tualatin have greatly improved. However, the current total phosphorus concentrations coming into the canal during (or following) storm events are not known. In their report, SRI estimated the total phosphorus coming in from the Tualatin River during storm events to average at least 0.428 mg/L. It is expected that these values have also improved; however, this is not based on any actual instream data. (USA-collected data for summer storms at the mouth of Fanno Creek give median total phosphorus concentrations as approximately 0.40 mg/L. This may be diluted with water in the Tualatin, however it is not known to what degree instream Tualatin concentrations during storms would also be elevated due to runoff.)

Due to this lack of data, total phosphorus loads coming into the Lake from the Tualatin River were not estimated. However, it is estimated in **Appendix C-6** that, on average, 15% of the days between May 1 and October 31 experience enough rainfall to cause runoff in urban areas. Based on this statistic, 15% of the water being brought into the Lake via the canal is most likely being impacted by anthropogenic sources of phosphorus. The percentage may be even greater when it is considered that rainfall is unevenly disbursed throughout the Tualatin River Subbasin and an individual event may have impacts lasting several days.

4.4.12.5 SEASONAL VARIATION

Typical of most algal problems, the growth within Oswego Lake is primarily during the summer season. As opposed to the TMDL for the Tualatin Subbasin, however, the controls on phosphorus loadings to the lake are necessary year-round. This is based on the well documented relationship in lakes between the annual phosphorus loadings and the resulting trophic state (see discussion in SRI,1987, p. 85). For this reason, this portion of the TMDL (Section 4.4.13) applies year-round.

4.4.12.6 IMPACTS ON WATER QUALITY

As was explained above, this assessment is not meant to be a new diagnostic and restoration analysis for the lake. However, a brief analysis of the impacts of reducing phosphorus from current loads to what are considered background loads is warranted.

It can be seen that the estimated background loadings to the lake are higher than the allocations given in the original TMDL (which included total allocations of 1500 lb. of total phosphorus per year). The estimated background loadings are also significantly lower than the estimated current loadings to the lake. In order to quantitatively estimate what water quality impacts would result from reducing the phosphorus loads from their current levels to background levels, a new diagnostic analysis for the lake would have to be undertaken. Qualitatively, however, it can be seen from Figure 7.3.2 in the SRI report that a reduction in the annual phosphorus loading is predicted to result in decreased mean summer chlorophyll a values, increased mean summer secchi depths, and decreased hypolimnetic oxygen depletion rates. Estimating the significance of these reductions would be part of a full lake diagnostic analysis and would have to take into account other restoration efforts (e.g., artificial aeration, etc.).

In addition to the benefits gained by reducing the annual phosphorus loads to the lake, the large influx of phosphorus immediately following storms may often result in short-term algal blooms that present water quality problems. The reduction of phosphorus concentrations in storm water to background levels, especially during the summer, will most likely result in noticeable reductions of these blooms.

4.4.12.7 OSWEGO LAKE LOADING CAPACITY

Since the loads that would lead to the lake achieving a “permissible” trophic state are lower than the total background loading to the lake, the loading capacity of the lake will be set at the estimated background external loading. This external loading capacity, including loads from the Tualatin River based on current flows through Oswego Canal, is 3084 lb./yr. (see Section 4.4.12.3.4). Since the loads coming from the Tualatin River via Oswego Canal are addressed by allocations in Section 4.4.9, the loading capacity addressed here will be solely for the tributary sources. This loading capacity is 2255 lb./yr., the estimated external background loading to the lake (see Table 52).

As detailed above, this reduction of phosphorus loads is expected to have beneficial impacts for the lake (though a quantitative analysis is beyond the scope of this TMDL). (Since the contribution of phosphorus from sediment releases is considered a function of the external loads to the lake, this source is not included in the loading capacity. By reducing external loads to the lake, the releases from sediment may be reduced also – both through the reduction of available phosphorus in the sediment and through decreased hypolimnetic oxygen depletion rates.)

4.4.12.8 OSWEGO LAKE ALLOCATIONS

The load and wasteload allocations are set equal to the background loadings listed in **Table 52**. These have been separated into load allocations for non-point sources and wasteload allocations for point sources. The wasteload allocations are for discharges from the City of Lake Oswego’s municipal separate storm sewer system (MS4). The load allocations are for all other discharges and for instream contributions (instream erosion, etc.)

The storm background concentrations are composites of both the phosphorus contributed prior to water entering the stream and the phosphorus contributed instream (through erosion, etc.). Therefore, the total phosphorus load to the lake may be divided between each of these sources. The summer stormwater background concentration (point source) is assigned a value of 0.09 mg/L total phosphorus (TP), with the corresponding load leading to an increase to 0.11 mg/L assigned to instream (non-point) sources. The winter stormwater target concentration (point source) is assigned a value of 0.15 mg/L TP, with the corresponding load leading to an increase to 0.19 mg/L assigned to instream (nonpoint) sources. Based on these values, the total phosphorus allocations for the City of Lake Oswego are given in **Table 54,** below.

Table 54. Total Phosphorus Allocations for the City of Lake Oswego	
May 1 through October 31 (Summer)	
Wasteload Allocations (Stormwater Discharges)	139 lb. (63 Kg.) Total Phosphorus
Load Allocation (Base Flow and Instream Contributions)	272 lb. (124 Kg.) Total Phosphorus
November 1 through April 30 (Winter)	
Wasteload Allocations (Stormwater Discharges)	858 lb. (390 Kg.) Total Phosphorus
Load Allocation (Base Flow and Instream Contributions)	986 lb. (448 Kg.)Total Phosphorus

4.4.12.9 OSWEGO LAKE MARGINS OF SAFETY

The margins of safety for this portion of the TMDL are considered to be implicit in the selection of the concentrations that represent background levels of phosphorus. The winter background concentration was derived from a representative watershed that had soils that were better draining that the tributary watershed soils. This most likely led to a concentration that is slightly lower than actual background concentrations in the Oswego Lake watershed. The summer background concentrations were set to levels that do not consider any increased loading during summer storm events. While this is most likely accurate for most summer storm events, a few larger summer storms would probably naturally have increased loadings due to the high gradient of the Oswego Lake watershed and its highly erodible soils. Therefore the concentration selected to represent summer background conditions is most likely conservative and provides an adequate margin of safety.

CHAPTER 5 - WATER QUALITY MANAGEMENT PLAN

A Water Quality Management Plan (**Appendix I**) has been developed and is intended to describe strategies for how the Tualatin River Subbasin TMDLs will be implemented and, ultimately, achieved. The main body has been prepared by DEQ and includes a description of DEQ activities, programs, legal authorities and other measures for which DEQ has some regulatory responsibilities. Various DMAs named in the Tualatin River Subbasin TMDLs will submit specific implementation plans that will be appended to this document. The intent is to provide an overview of activities in the main body and to allow the individual DMAs to describe their specific TMDL-related activities.

DEQ recognizes that TMDL implementation is critical to the attainment of water quality standards. Additionally, the support of DMAs in TMDL implementation is essential. In instances where DEQ has no direct authority for implementation, it will work with DMAs on implementation to ensure attainment of water quality standards. Where DEQ has direct authority, it will use that authority to ensure attainment of water quality standards.

REASONABLE ASSURANCE OF IMPLEMENTATION

There are several programs that are either already in place or will be put in place to help assure that this water quality management plan will be implemented. Many of these programs were developed in response to the phosphorus and ammonia TMDLs developed in 1988. Some of these are traditional regulatory programs such as discharge permit programs for point source discharges. In these cases, the pollutants of concern in the Tualatin River Subbasin will be considered and the regulation will be carried out as required by federal, state, and local law. The state Forest Practices Act, implemented by the Oregon Department of Forestry, regulates forest activities. The Agricultural Water Quality Management Area Plans, implemented by the Oregon Department of Agriculture, provide the assurance that agricultural activities are addressed. An interdepartmental review of these programs will provide the assurance that standards will be met.

Other programs, while structured, are not strictly regulatory. In these cases, local implementing agencies agree to make a good faith effort to implement the program. Structured programs that provide reasonable assurance of implementation include (for more complete information on these programs see Tualatin River Subbasin Water Quality Management Plan [**Appendix I**]):

1. **NPDES and WPCF Permit Programs**: DEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. The statute requires that no person shall discharge waste into waters of the state or operate a waste disposal system without obtaining a permit from DEQ. In addition, runoff from stormwater is regulated through a Municipal Separate Storm Sewer System (MS-4 Permit) stormwater permit. Permitees in the Tualatin River Subbasin include Unified Sewerage Agency of Washington County (USA), Oregon Department of Transportation, Clackamas County and Multnomah County.
2. **Municipal & Rural Residential**: Cities and Counties in the Tualatin River Subbasin have ordinances and policies that are relevant to the implementation of the management practices discussed in the Management Plan – especially related to the protection of riparian area. These Ordinances and Policies will be reviewed and revised to insure that they adequately address non-point source pollution control.

3. **Forestry**: The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on nonfederal forestlands and outside the urban growth boundaries (ORS 527.722). The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe best management practices (BMPs) for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness.
4. **Agriculture**: The Oregon Department of Agriculture (ODA) has primary responsibility for control of pollution from agricultural sources (ORS 561.191). This is done through the Agricultural Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010, adopted by the Oregon State Legislature in 1993.

There are also many voluntary, non-regulatory, watershed improvement programs (activities) that are already in place and are helping to address the water quality concerns in Tualatin River Subbasin. Both technical expertise and partial funding are provided through these programs. Examples of activities promoted and accomplished through these programs include:

- planting of trees and other riparian vegetation along streams;
- relocating legacy roads that may be detrimental to water quality; replacing problem culverts with adequately sized structures, and improvement/ maintenance of legacy roads known to cause water quality problems; and
- active channel restoration.

These activities have been and are being implemented to improve watersheds and enhance water quality. Many of these efforts are helping resolve water quality related legacy issues. The programs addressing these problems include, but are not limited to, the:

- The Oregon Plan
- Landowner Assistance Programs
- Forestry Incentive Program (FIP)
- Stewardship Incentive Program (SIP)
- Environmental Quality Incentives Program (EQIP)
- Wildlife Habitat Incentive Program (WHIP)
- Conservation Reserve Program (CRP)
- Conservation Reserve Enhanced Program (CREP)
- Forest Resource Trust (FRT)
- Private Lands Forest Network (PLFN)
- Oregon Department of Fish and Wildlife Programs

IMPLEMENTATION AND ADAPTIVE MANAGEMENT ISSUES

The goal of the Clean Water Act and associated Oregon Administrative Rules is that water quality standards shall be met or that all feasible steps will be taken towards achieving the highest quality water attainable. This is a long-term goal in many watersheds, particularly where non-point sources are the main concern. To achieve this goal, implementation must commence as soon as possible.

Total Maximum Daily Loads (TMDLs) are numerical loadings that are set to limit pollutant levels such that in-stream water quality standards are met. DEQ recognizes that TMDLs are values calculated from mathematical models and other analytical techniques designed to simulate and/or predict very complex physical, chemical and biological processes. Models and techniques are simplifications of these complex processes and, as such, are unlikely to produce an exact prediction of how streams and other waterbodies will respond to the application of various management measures. It is also recognized that there is a varying level of uncertainty in the TMDLs depending on factors such as amount of data that is available and how well the processes listed above are understood. It is for this reason that the TMDLs have been established with a margin of safety. Subject to available resources, DEQ will review and, if necessary, modify TMDLs established for a subbasin on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDL are needed.

Water Quality Management Plans (WQMPs) are plans designed to reduce pollutant loads to meet TMDLs. DEQ recognizes that it may take some period of time—from several years to several decades--after full implementation before management practices identified in a WQMP become fully effective in reducing and controlling certain forms of pollution such as heat loads from lack of riparian vegetation. In addition, DEQ recognizes that technology for controlling some pollution sources such as nonpoint sources and stormwater is, in many cases, in the development stages and will likely take one or more iterations to develop effective techniques. It is possible that after application of all reasonable best management practices, some TMDLs or their associated surrogates cannot be achieved as originally established.

DEQ also recognizes that, despite the best and most sincere efforts, natural events beyond the control of humans may interfere with or delay attainment of the TMDL and/or its associated surrogates. Such events could be, but are not limited to, floods, fire, insect infestations, and drought.

In this TMDL, pollutant surrogates have been defined as alternative targets for meeting the TMDL for some parameters. The purpose of the surrogates is not to bar or eliminate human access or activity in the subbasin or its riparian areas. It is the expectation, however, that WQMPs will address how human activities will be managed to achieve the surrogates. It is also recognized that full attainment of pollutant surrogates (system potential vegetation, for example) at all locations may not be feasible due to physical, legal or other regulatory constraints. To the extent possible, WQMPs should identify potential constraints, but should also provide the ability to mitigate those constraints should the opportunity arise. For instance, at this time, the existing location of a road or highway may preclude attainment of system potential vegetation due to safety considerations. In the future, however, should the road be expanded or upgraded, consideration should be given to designs that support TMDL load allocations and pollutant surrogates such as system potential vegetation.

When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the wasteload allocation (CFR 122.44(d)(1)(vii)(B)). Similarly, the Department will work with nonpoint sources in developing management plans that are consistent in meeting the assumptions and requirements of the load allocations. These permits and plans will be developed/modified within 1-2 years following the develop/modification of a TMDL and include but not be limited to the following (February 2000 MOA between DEQ and EPA):

- Management measures tied to attainment of the TMDL,
- Timeline for implementation (including appropriate incremental measurable water quality targets and milestones for implementing control actions),
- Timeline for attainment of water quality standards including an explanation of how implementation is expected to result in the attainment of water quality standards,
- Monitoring and evaluation

If a source that is covered by this TMDL complies with its permit, WQMP or applicable forest practice rules, it will be considered in compliance with the TMDL.

DEQ intends to regularly review progress of WQMPs to achieve TMDLs. If and when DEQ determines that WQMP have been fully implemented, that all feasible management practices have reached maximum expected effectiveness and a TMDL or its interim targets have not been achieved, the Department shall reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance (OAR 340-41-026(3)(a)(D)(ii)).

The implementation of TMDLs and the associated management plans is generally enforceable by DEQ, other state agencies and local government. However, it is envisioned that sufficient initiative exists to achieve water quality goals with minimal enforcement. Should the need for additional effort emerge, it is expected that the responsible agency will work with land managers and permit holders to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. In the case of nonpoint sources, this could occur first through direct intervention from land management agencies (e.g. ODF, ODA, counties and cities), and secondarily through DEQ. The latter may be based in departmental orders to implement management goals leading to water quality standards.

A zero waste load allocation does not necessarily mean that a point source is prohibited from discharging any wastes. A source may be permitted to discharge by DEQ if the holder can adequately demonstrate that the discharge will not have a significant impact on water quality over that achieved by a zero allocation. For instance, a permit applicant may be able to demonstrate that a proposed thermal discharge would not have a measurable detrimental impact on projected stream temperatures when system temperature is achieved. Or, in the case where a TMDL is set based upon attainment of a specific pollutant concentration, a source could be permitted to discharge at that concentration and still be considered as meeting a zero allocation.

ADAPTIVE MANAGEMENT

In employing an adaptive management approach to this TMDL and WQMP, DEQ has the following expectations and intentions:

- Subject to available resources, DEQ will review and, if necessary, modify TMDLs and WQMPs established for a subbasin on a five-year basis or possibly sooner if DEQ determines that new scientific information is available that indicates significant changes to the TMDL are needed.
- When developing water quality-based effluent limits for NPDES permits, DEQ will ensure that effluent limits developed are consistent with the assumptions and requirements of the wasteload allocation (CFR 122.44(d)(1)(vii)(B)).
- In conducting this review, DEQ will evaluate the progress towards achieving the TMDL (and water quality standards) and the success of implementing the WQMP.
- DEQ expects that each management agency will also monitor and document its progress in implementing the provisions of its component of the WQMP. This information will be provided to DEQ for its use in reviewing the TMDL.
- As implementation of the WQMP proceeds, DEQ expects that management agencies will develop benchmarks for attainment of TMDL surrogates, which can then be used to measure progress.
- Where implementation of the WQMP or effectiveness of management techniques are found to be inadequate, DEQ expects management agencies to revise the components of the WQMP to address these deficiencies.

- When DEQ, in consultation with the management agencies, concludes that all feasible steps have been taken to meet the TMDL and its associated surrogates and attainment of water quality standards, the TMDL, or the associated surrogates is not practicable, it will reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary. The determination that all feasible steps have been taken will be based on, but not limited to, a site-specific balance of the following criteria: protection of beneficial uses; appropriateness to local conditions; use of best treatment technologies or management practices or measures; and cost of compliance (OAR 340-41-026(3)(a)(D)(ii)).

ACRONYM LIST

BLM – Bureau of Land Management

BOD - Biological Oxygen Demand

CFR - Code of Federal Regulations

cfs - cubic feet per second

CPP – Continuous Planning Process

CSRI - Coastal Salmon Restoration Initiative

CWA - Clean Water Act

DBH - Diameter at Breast Height

DEM - Digital Elevation Model

DEQ - Department of Environmental Quality (Oregon)

DMA – Designated Management Agency

DO – Dissolved Oxygen

DOQ - Digital Orthophoto Quad

DOQQ - Digital Orthophoto Quarter Quad

EPA - (United States) Environmental Protection Agency

EQC - Environmental Quality Commission

FLIR - Forward Looking Infrared Radiometry

FPA - Forest Practices Act

GPS - Geographic Positioning System

HUC - Hydrologic Unit Code

LA - Load Allocation

LC - Loading Capacity

MOS - Margin of Safety

MS4 – Municipal Separate Storm Sewer System

NPDES - National Pollutant Discharge Elimination System

NRCS – Natural Resource Conservation Service (formerly the Soil Conservation Service)

NSDZ - Near-Stream Disturbance Zone

NTU - Nephelometric Turbidity Units

OAR - Oregon Administrative Rules

ODA - Oregon Department of Agriculture

ODEQ - Oregon Department of Environmental Quality

ODF - Oregon Department of Forestry

ODFW - Oregon Department of Fish and Wildlife

ORS - Oregon Revised Statutes

OWRD - Oregon Water Resources Department

RM - River Mile

SCS – Soil Conservation Service (now the NRCS)

SE - Standard Error

SOD –Sediment Oxygen Demand

SSCGIS - State Service Center for Geographic Information Systems

TMDL - Total Maximum Daily Load

TP – Total Phosphorus

TSS - Total Suspended Solids

TVS – Total Volatile Solids

USA – Unified Sewerage Agency

USBR (US BOR) - United States Bureau of Reclamation

US COE - United States Army Corps of Engineers

USDA - United States Department of Agriculture

USFS - United States Forest Service

USGS - United States Geological Survey

W:D - Width to Depth (ratio)

WLA - Waste Load Allocation

WQMP - Water Quality Management Plan

WQS - Water Quality Standard

WWTP - Waste Water Treatment Plant

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