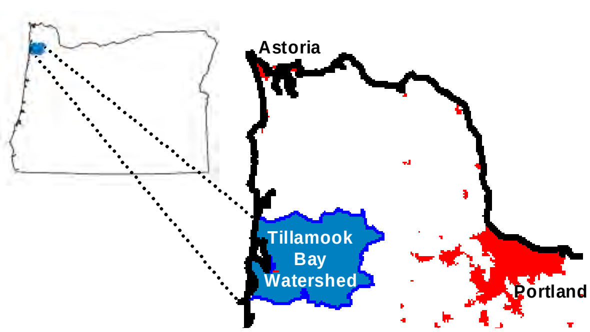
Tillamook Bay Watershed
Total Maximum Daily Load (TMDL)






DEQ
State of Oregon
Department of
Environmental
Quality



Prepared by,
Oregon Department of Environmental Quality
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EXECUTIVE SUMMARY

Introduction

The following document contains the required components for a Total Maximum Daily Load (TMDL) as described by the USEPA (EPA) for compliance with the Federal Clean Water Act. As well, the document and its appendices provide a thorough analysis of pollutant sources and accumulation processes in the Tillamook Bay Watershed. The analyses and modeling that followed are in many cases complex. Every attempt has been made to thoroughly describe and explain assumptions and methods and to make the results as clear as possible. In this spirit, we are providing this summary to provide the essential results that the reader and land managers will see “on the ground.”

Water Quality Summary

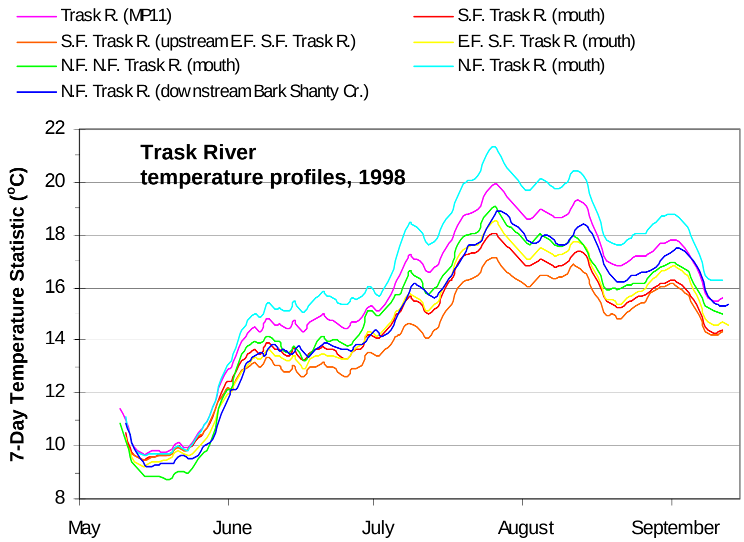
Legal Requirements

Under Section 303(d) of the Clean Water Act, the EPA or its state delegates are required to develop a list of the surface waters in each state that do not meet Water Quality Standards (WQS). These standards are developed by each of the states to protect “beneficial uses” and must be approved by EPA. The resulting “303(d) list” is based on the best available data and , in most cases, must be revised every 2 years. The list submitted by the State of Oregon in 1998 and approved by the EPA is the most recent source of this information. Water bodies that are listed as impaired must have Total Maximum Daily Loads (TMDL) developed for each pollutant for which that waterbody is “listed.” There may be waterbodies that are listed for “pollution” (e.g., habitat modification, flow modification). These waterbodies do not require a TMDL.

Listed Parameters

The Tillamook Bay Watershed includes 5 major drainages (rivers) that discharge to Tillamook Bay – the Miami, Kilchis, Wilson, Trask, and Tillamook Rivers. Each of these drainages provide beneficial uses of their own as well as being sources of pollutants to the Bay. The beneficial uses that are affected by pollutant loads are cold water aquatic life and water contact recreation in the rivers, and shellfish harvesting in the Bay. As required by law, the most sensitive beneficial uses were considered for listing. In the Rivers, the migration, rearing and spawning of salmonid fish are put at risk by high water temperatures (those that exceed 64°F for migration and rearing, or 55°F for spawning) in the summer. The Rivers are also impaired for water contact recreation at times throughout the year resulting from high concentrations of fecal bacteria (indicators of fecal waste, may be Fecal Coliform group or *E. coli*). These bacteria are also the source of the impairment of Bay waters, which support commercial shellfish harvesting. Shellfish harvesting is dependent on waters with minimal concentrations of fecal bacteria, and is currently restricted from commercial shellfish harvesting whenever flow in the Wilson River exceeds 2500 cfs (or a stage of 7 feet) due to the risk of bacterial contamination. The TMDLs are developed for these parameters to protect the salmonid fish, and recreational use in the rivers, and commercial shellfish harvesting in the Bay.

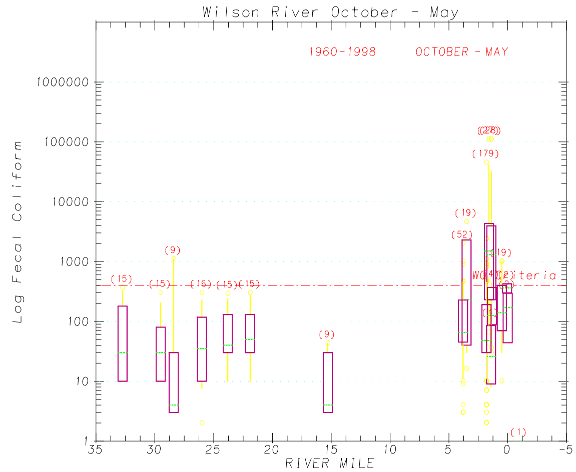
Temperature

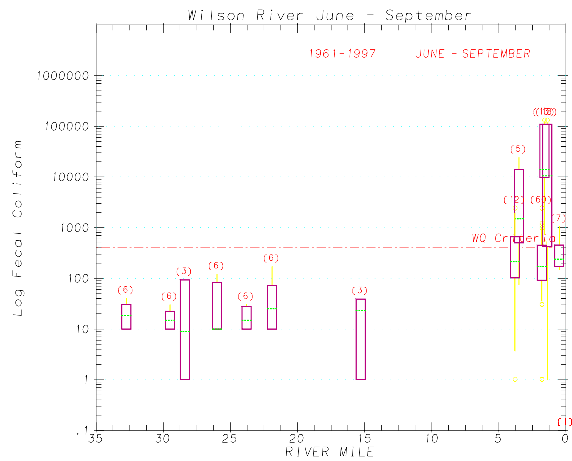


The temperature of surface waters commonly exceeds the WQS for migration and rearing of salmonid fishes [64°F (17.8°C) as a 7-day average of daily maximum temperatures] in the mainstems of all of the Rivers and many of their tributaries during summer months. Temperatures increase with distance from the headwaters of each river, and show the influence of warm or cold water from various tributaries. DEQ has determined that the source of stream heating derives from the combined effects of ongoing and past removal of riparian vegetation and the subsequent widening of streams. These combined landscape changes from what the streams would reflect without human intervention result in reduced effectiveness of shade from natural vegetation and local topography. Although topography cannot be controlled, presence of riparian vegetation can be managed to provide necessary shade and result in stabilized channels that will become narrower over time. The narrowing of streams will increase the effectiveness of riparian vegetation in shading streams and reducing incident solar radiation. Contributions from point source discharges will also be regulated under the terms of discharge permits.

Bacteria

Routinely collected water quality data from DEQ's ambient monitoring program show violations of the bacteria criteria occur in the 5 major rivers and in several creeks in the basin. Concentrations are particularly high during storms and tend to be highest in the lower elevations of each of the basins; the areas associated with the greatest concentrations of agriculture, urban development, and roads.



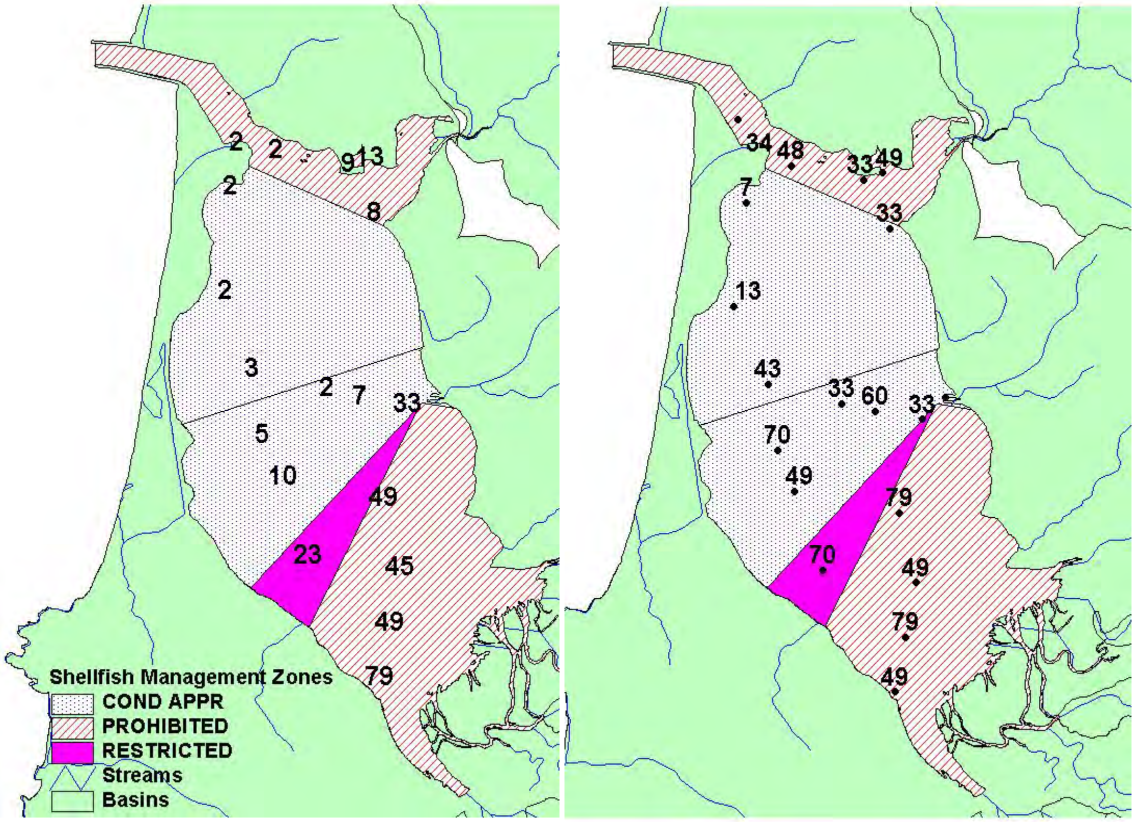


Median concentrations of bacteria commonly exceed one or more of the Water Quality Standards for protection of recreational use in the Rivers.

Waters of the Bay are routinely sampled by the Oregon Department. of Agriculture. Concentrations in the Bay are also commonly elevated above the WQS in the Bay, especially when river flows increase in response to rainfall and runoff.

Elevated concentrations of bacteria in rivers can affect water contact recreational use of the rivers for swimming and result in large loads of fecal bacteria entering the Bay. Concentrations in the Bay that exceed a median of 14 MPN/100 ml limit its use for shellfish harvesting. As a result, harvesting is prohibited in much of the Bay near the mouths of the Rivers and near wastewater discharges. Sources of bacteria in the watershed include rural and urban residential development (homes in some areas have failing septic systems), urban stormwater runoff, livestock management and other agricultural activities, and several wastewater treatment plants that discharge either to the Rivers or the Bay.

Based on the association of high bacterial concentrations during high-flow storm events, the conditionally approved harvesting areas are closed when river flow or rainfall increase beyond limits specified in the Tillamook Management Plan for Commercial Shellfish Harvesting (Appendix E). Data support the closure of these areas during high flow events, as concentrations during closures typically exceed the standard and are higher than during open periods. ODA must react to changes into an area's compliance with the fecal coliform standard for shellfish growing waters. Reactions may include temporary closures or bay management plan changes requiring closures for predictable increases in fecal coliform levels.



Median Fecal Coliform Concentrations when Tillamook Bay is Open (left) and Closed (right) to shellfish harvesting (1991-98).

Allocations

Load Allocations were developed for each of the parameters for non-point sources (NPS) and Wasteload Allocations were developed for point sources. NPS sources are land uses that contribute pollutants from diffuse areas. These include forestry, agriculture, and rural residential and urban development. Point sources discharge directly to waterbodies and their contributions are controlled through limits set in National Pollutant Discharge Elimination System (NPDES) permits. These include sewage treatment plants and industrial sources such as the Tillamook Creamery.

Temperature

Load Allocations for non-point sources are aimed at controlling heat from solar radiation and are expressed in terms of system potential effective shade and channel width. Effective shade is the most straightforward parameter to measure and is easily translated into quantifiable water management objectives. System potential was determined through analysis of shade from topography, potential tree heights and densities, and narrowed channel widths relative to existing conditions in all basins. System potential conditions are the most protective allocation and rely on the environment to provide as much natural effective shade as possible. By simulating these system potential conditions in each of the basins, potential temperatures were calculated for the mainstems of each of the 5 rivers. Overall, under system potential conditions, 74% of these river miles along mainstem reaches are expected to achieve temperatures less than the standard of

64°F (17.8°C), and none of the rivers would be expected to have segments with temperatures in excess of 68°F (20°C).

Wasteload Allocations for point sources assume that effluent will not cause an increase in ambient temperature outside a defined "mixing zone." Mixing zones have been defined for some sources but are generally a corridor no wider than 25% of the river. The allowable effluent temperature is a function of the flow rate of the river, the flow rate of the discharge and the system potential temperature of the water at the point of discharge. In general, the discharges are located near the mouths of the Rivers, where temperatures will be the highest. Wasteload allocations will have different limits depending on the time of year. The facilities that discharge during the critical period (low flow) will have to meet the 64°F (migration and rearing) criterion from June through September, and the 55°F (spawning) criterion from October through May. The spawning criterion reflects the use of the lower reaches of the rivers by chum salmon. Some have slightly higher temperature allocations because sufficient information exists to calculate the facility's wasteload allocation.

Bacteria

Bacterial and flow accumulation rates were analyzed with an event-based unit-load model. The model uses estimated peak flow, runoff concentrations of bacteria for various land uses, and bacteria die off rates to predict total bacteria concentrations and loads in streams. This model was calibrated with flow and bacterial data from recent storms. The dilution of the rivers with saltwater as they enter the bay was determined through analysis of salinity gradients between the river mouth and shellfish harvesting sites in the bay, resulting in a dilution ratio of 2:1. Therefore to achieve the bacterial standard of 14 fecal coliforms/100 ml in the Bay would require each river to meet an instream limit of 28 fecal coliforms/100ml at the mouth.

Allocations are determined separately for each river, and are based on subbasin specific percent reductions in runoff concentrations from all land uses as a function of flow. Each river will be required to meet the instream limit at the mouth. The allowable runoff concentrations range from fairly high in cleaner rivers to very low depending on land use and flow rate in the rivers. Runoff concentrations refer to incipient runoff prior to flowing into creeks, streams, or rivers. This assumes that bacteria will decay and be diluted sufficiently to meet the instream targets. Overall, allocated instream concentrations reflect reductions ranging from 90% to 99% relative to current conditions.

Margin of Safety (MOS)

The Margin of Safety provides assurance that water quality standards will be met if the allocations are higher than the loading capacity of the water body. The MOS for both of these TMDLs are implicit; they derive from using conservative assumptions in modeling so that the allocations will also be conservative relative to the loading capacity

Water Quality Management Plan

A Water Quality Management Plan (WQMP) is included as a companion document to the TMDLs. This document explains the roles of various land management agencies, federal, state, and local governments, as well as private landowners in implementing the actions necessary to meet the allocations in the TMDLs. It also includes directly or by reference the statutes, rules, ordinances, local plans, and all other known mechanisms for implementation. The WQMP is based largely on the Comprehensive Conservation and Management Plan developed for the Tillamook Bay National Estuary Program through a public process that included a range of interests. The WQMP for the Tillamook Bay Watershed focuses specifically on:

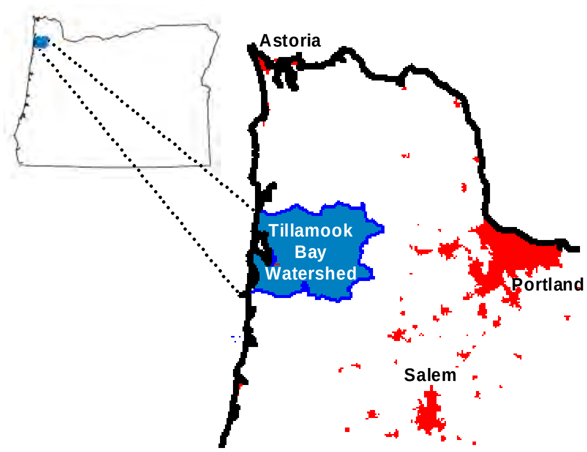
- State Forest Lands (Forest Practices Act);
- Federal Forest Lands (Northwest Forest Plan);

- Private Agricultural Lands (North Coast Basin Agricultural Water Quality Management Area Plan – SB1010);
- County Ordinances;
- Tillamook Bay National Estuary Program – Coordinated Conservation and Management Plan
- Regional stormwater controls, including the option of a storm water permit for Small Cities.

CHAPTER I – OVERVIEW AND BACKGROUND

1.1 Introduction

The Tillamook Bay Watershed lies near the northwest corner of Oregon on the western side of the Coast Range Mountains. Aside from some small creeks and sloughs that drain directly to the Bay, the majority of water entering the Tillamook Bay is carried by 5 large rivers – the Miami, Kilchis, Wilson, Trask, and Tillamook. These Rivers have their headwaters at varying elevations up to nearly 3700ft (~1100 m) in the Coast Range. The majority of the watershed is contained within Tillamook County, though there are small portions in Washington and Yamhill Counties.



The watershed includes vast forests, rich agricultural lands, several small communities, a large bay supporting commercial shellfish, and abundant habitat for salmon and trout. The forests are included mostly within the Tillamook State Forest, though there are significant private holdings of forestland. Agricultural lands are all privately owned and predominantly support a thriving dairy and cheese-making industry. The towns of Tillamook, Bay City, and Garibaldi are located near or on the shore of the Bay. Commercial shellfish harvesting has been continuous since the 1930's. The Tillamook Bay Watershed has historically supported some of the largest human populations along the coast and has sustained a popular sport fishing industry and the breeding grounds and nursery for offshore fisheries.

The Tillamook Bay Watershed supports populations of Spring Chinook, Fall Chinook, Summer Steelhead, Winter Steelhead, Coho Salmon, Chum Salmon, Sea-Run Cutthroat, and Resident Cutthroat Trout. Coho are currently listed as threatened, and Winter Steelhead are a candidate for listing by the National Marine Fisheries Service under the Federal Endangered Species Act. Habitat for these species has been in decline in the watershed for many years resulting from a variety of problems including large, intense forest fires, removal of riparian vegetation communities, flow modification, and direct habitat modification. These events have resulted in rivers that are wider and shallower, and which receive more direct sunlight than what would be expected under natural conditions. Excessive summertime temperatures, diminished availability of appropriate spawning gravels, and reduced cover all make the habitat of poorer quality than historical conditions.

Tillamook Bay also supports commercial shellfish harvesting, and the rivers are used for recreational swimming and wading. Concentrations of bacteria in the waters of the rivers and the Bay are commonly too high to allow safe use for either of these activities. Sources of bacteria in the watershed include rural and urban residential development (many homes have failing septic systems), urban stormwater runoff, livestock management and other agricultural activities, and several wastewater treatment plants that discharge either to the rivers or the Bay.

As a result of these problems, parts of the rivers and Bay have been listed under section 303(d) of the Clean Water Act as impaired water bodies. This listing requires development of a Total Maximum Daily Load (TMDL) for temperature and bacteria.

1.2 Total Maximum Daily Loads

1.2.1 What is a Total Maximum Daily Load

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. Section 303(d) of the Federal Clean Water Act requires the EPA or delegated states such as Oregon to set water quality standards and to prepare a list of water bodies whose water quality does not meet these approved water quality standards. The resulting list (the "303(d) list") is a comprehensive catalog of all waterbodies in the state that fail to meet one or more water quality criteria based on available data.

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.*

1.2.1.1 Elements of a TMDL

The U. S. Environmental Protection Agency (EPA) has the responsibility 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 must establish the TMDL.

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.

TMDLs addressed in this report

This report contains TMDLs for the following parameters :

- **Temperature** – based on the 303(d) listing of approximately 101 miles of rivers and streams in the Tillamook Bay Watershed;

- **Bacteria** – based on the 303(d) listing of approximately 64 miles of rivers and of Tillamook Bay due to elevated concentrations of fecal coliform bacteria that exceed the criteria for recreational use (rivers) and commercial shellfish harvest (Bay), respectively.

1.3 TMDL Implementation

1.3.1 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.

DEQ intends to submit a WQMP to EPA concurrently with submission of TMDLs. This WQMP is appended to the TMDL document as Appendix D.

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*

A Total Maximum Daily Load (TMDL) has been developed to address fisheries and human health concerns for all streams in the Tillamook Bay Watershed that builds upon the current land management programs:

- ***Tillamook National Estuary Program (NEP - all lands)***
- ***Northwest Forest Plan and Forest Ecosystem Management Assessment Team (FEMAT) protection/restoration measures (federal forest lands),***
- ***Oregon's Forest Practices Act (state and private forest lands),***
- ***Senate Bill 1010 (agricultural lands), and***
- ***Oregon Plan (all lands).***

1.3.2 Existing Water Quality Programs

Tillamook National Estuary Program

The Comprehensive Conservation and Management Plan (CCMP) of the Tillamook Bay National Estuary Program (NEP) was completed in 1999 with broad community, state and federal participation. EPA provides funding for the NEP. Water quality is one of the four major sections of the CCMP, and stream temperature and bacteria are addressed directly. The CCMP is to be implemented by the Tillamook County Performance Partnership, an organization specially created to implement or track actions related to the CCMP. The basic premise of the CCMP is that it incorporates the recommendations of all these plans and local ordinances (Oregon Forest Practices, SB1010, Tillamook County, local governments and the Oregon Plan) into one overall plan for Tillamook County.

Following development of the CCMP, the Natural Resource Conservation Service has recently published a Watershed Plan/Environmental Assessment for the Lower Tillamook Bay Watershed (NRCS 2001) with sponsorship from the Tillamook Soil and Water Conservation District. The Plan is designed as an implementation measure for the Comprehensive Conservation and Management Plan developed by the TBNEP. This document describes the development of agricultural facilities, practices and restoration activities that will address TMDL-related water quality issues in the Tillamook Bay Watershed. In addition to description of these activities, the Plan identifies large-scale matching funding available through NRCS for its implementation. Modeling performed as part of the Environmental Assessment indicates significant improvements are possible through implementation of the Plan.

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 management alternatives that comply with existing laws while maintaining the highest contribution of economic and social well being. The “backbone” of ecosystem management is construction of 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*. 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.

Oregon Forest Practices Act

The Oregon Forest Practices Act (FPA) contains regulatory provisions intended 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 biodiversity; 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 requires 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. ODA is developing these plans for Basins throughout the state, and the North Coast Basin Agricultural Water Quality Management Area Plan was approved by the Board of Agriculture in June 2000. The Water Quality Management Plan was crafted so that landowners in the local area can determine the best means of preventing and controlling 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 the ODA’s intent to establish individual farm plans on a voluntary basis. However, Senate Bill 1010 allows the ODA to use civil penalties when necessary to enforce against agricultural activity that is found to transgress parameters of administrative rules ODA has adopted in association with an approved basin Water Quality Management Plan. ODA has expressed its intention to work with the local stakeholders and other state and federal agencies to implement the North Coast Basin Water Quality Management Plan and to enforce the associated Oregon Administrative Rules where necessary.

National Pollutant Discharge Elimination System (NPDES)

The Oregon Department of Environmental Quality (DEQ), under delegation from the EPA, requires permits for any point-source discharges of wastewater to waters of the state. These discharges include those from sewage treatment plants, industries, food processors, and a variety of other activities that require discharge through a defined conveyance. Permits establish the amount of a given pollutant that may be discharged to waters of the state, and are designed to ensure that the load of that pollutant will not result in impairment of the waterbody. There are also permits required for certain types of non-point source discharges from municipalities, industries, and construction activities that result in runoff directly or as a result of stormwater management.

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. In response, 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 for 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. The Oregon Plan is designed to build on existing State and Federal water quality programs, namely: the Federal Clean Water Act, Coastal Zone Non-point Pollution Control Programs, the Northwest Forest Plan, Oregon's Forest Practices Act, Oregon's Senate Bill 1010 and Oregon's TMDL Program.

1.3.3 Implementation and Adaptive Management Issues

1.3.3.1 Implementation Measures

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.

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 for this reason that the TMDLs have been established with a margin of safety.

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 non-point source pollution. In addition, DEQ recognizes that technology for controlling non-point source pollution 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 temperature. 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.

If a non-point source that is covered by this TMDL complies with its 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 WQMPs 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, DEQ shall reopen the TMDL and adjust it or its interim targets and its associated water quality standard(s) as necessary.

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 to overcome impediments to progress through education, technical support or enforcement. Enforcement may be necessary in instances of insufficient action towards progress. 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 standard attainment.

An unlisted source may be issued a permit for discharge of the pollutant causing impairment, without modification of the TMDL, if it is demonstrated that the discharge will not cause or contribute to a violation of the water quality standard (See 40 CFR 122.44(d) in the NPDES permitting regulations). New discharges that achieve water quality standards at end-of-pipe would be candidates for permitting without a TMDL modification. For instance, it may be allowable for a new facility to discharge at a concentration lower than the water quality criterion (where accumulation of the pollutant is not a concern). Similarly, in temperature impaired waters, it may be allowable for a new facility to discharge wastewater that is cooler than the temperature standard without modification of the TMDL. The demonstration that the new discharge will not cause or contribute to a violation of the water quality standard would be included in the Fact Sheet for the permit in question.

1.3.3.2 Adaptive Management

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

- On a five-year periodic basis, DEQ will review the progress of the TMDL and the WQMP.
- 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 revise it as appropriate. DEQ would also consider reopening the TMDL should new information become available indicating that the TMDL or its associated surrogates should be modified.

CHAPTER 2 – DESCRIPTION OF THE TILLAMOOK BAY WATERSHED

Tillamook Bay and its watershed are situated in typical Pacific Northwest coastal terrain. A relatively straight coastline consists of miles of sandy beaches punctuated with cliffs of igneous rock and small inlets such as the Bay. East of the Pacific Coast, the high, steep ridges of the coast range climb up to 3,700 feet. These upland areas consist mostly of volcanic basalt base material overlying soils formed from basalt, shale, and sandstone material. Primarily an Astoria-Hembre Association, moderately deep upland soils cover the gently sloping to very steep terrain of the forested uplands.

-Tillamook Bay National Estuary Project, 1997

2.1 Geographic Description

The Tillamook Bay Watershed is located in northwest Oregon occupying approximately 572 square miles. This sub-basin is contained within the "4th-field watershed designated by the USGS as Hydrologic Unit Code (HUC) 17100203 (USGS, 1989). The watershed includes the land areas that drain to Tillamook Bay and Netarts Bay. There are five major rivers in the watershed: the Miami, Kilchis, Trask, Wilson and Tillamook Rivers. All originate in the forested Coast Range Mountains and flow westward to estuary/tidal areas. Two major estuary/bay areas occur: Tillamook Bay and Netarts Bay. The Tillamook Bay is the northernmost and receives the Miami River, Kilchis River, Wilson River, Trask River and Tillamook River.

Headwater streams generally originate in the conifer forests of the Coastal Mountains at elevations over 2,000 feet (the highest point in the watershed is 3,691 feet in elevation). All of the river systems flow for a short length through low gradient and tidally influenced areas as is easily seen in the shaded relief developed for topography.

Five rivers enter Tillamook Bay from the south, east, and north. Salmon fishermen still recognize the Bay and its five rivers – the Tillamook, Trask, Wilson, Kilchis, and Miami – as some of the most productive fishing spots on the West Coast. Yet their bounty of chinook, chum, coho, and steelhead pales compared with earlier harvests. Today coho salmon is listed as a threatened species and chum and steelhead fish populations have been declining. Scientists point to the dramatic loss of spawning and rearing habitat as one of the principal reasons for the decline of Tillamook Bay salmonids. Today's salmon rivers drain 550 mi^2 (1,424 km^2) watershed that includes some of North America's richest timber and dairy lands. Although essential to the economy and character of Tillamook County, forestry, agriculture, and fishing activities have taken a high toll on salmon and other living resources dependent on the aquatic environment.

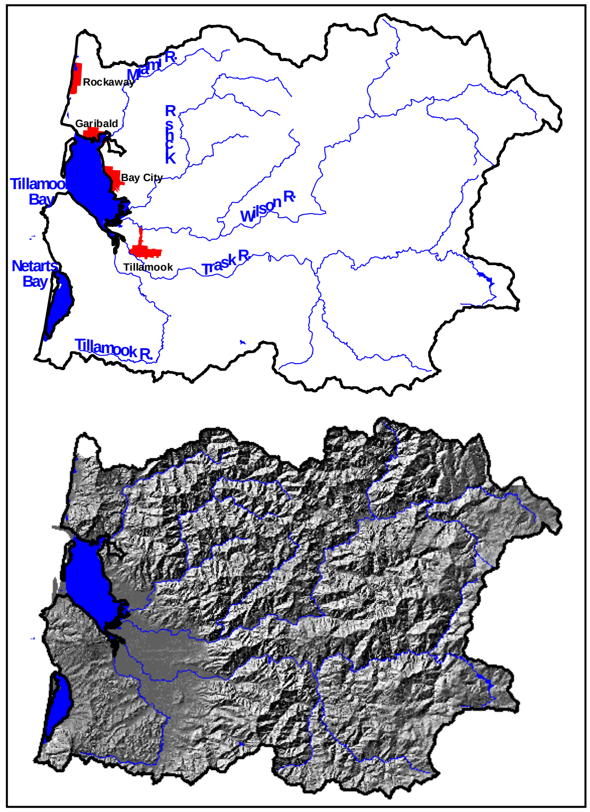
Like most Pacific Northwest estuaries, Tillamook Bay is part of a coastal, temperate rainforest ecosystem. The Bay is surrounded by rich forests that blanket the rainy Coast Range. With mean annual precipitation around 100 inches per year in the lower basin and close to 140 inches per year in the uplands, the Watershed's coniferous forests – trees such as Douglas fir, true fir, spruce, cedar, and hemlock – cover about 89% of the total land area. Hardwood species such as alder and maple also grow throughout the region, especially as second growth riparian areas. Most of the older trees have been lost to fire and timber harvest. Today, Douglas fir is the dominant species. Foresters describe this environment as a highly productive ecosystem – from both biological and commodity perspectives.

In the lower Watershed, the forest gives way to rich alluvial plains used primarily for dairy agriculture. Early settlers recognized the rich agricultural potential of the lowlands and drained the area with numerous dikes, levees, and ditches. Once characterized by meandering rivers and networks of small channels that provided fish habitat, woody debris, and organic matter; today's 40 mi^2 (104 km^2) lowland supports about 30,000 dairy cattle and produces half of Oregon's cheese. It is also the source of hundreds of thousands of tons of manure annually and much of the bacteria that washes into the estuary.

-Tillamook Bay National Estuary Project, 1997

2.2 Land Ownership and Land Uses

The largest landholder in the Tillamook Bay Watershed is the State of Oregon (59% of the surface area) with 338 square miles that is predominately forested lands. Private lands account for 206 square miles (36% of the surface area) distributed throughout the watershed. The Bureau of Land Management manages 15 square miles of the Tillamook Bay Watershed (3% of the surface area). Other smaller land ownership designations include Oregon lands (2% of the surface area), County lands (0.4% of the surface area), **Figure 1** displays land ownership within the Tillamook Bay Watershed.



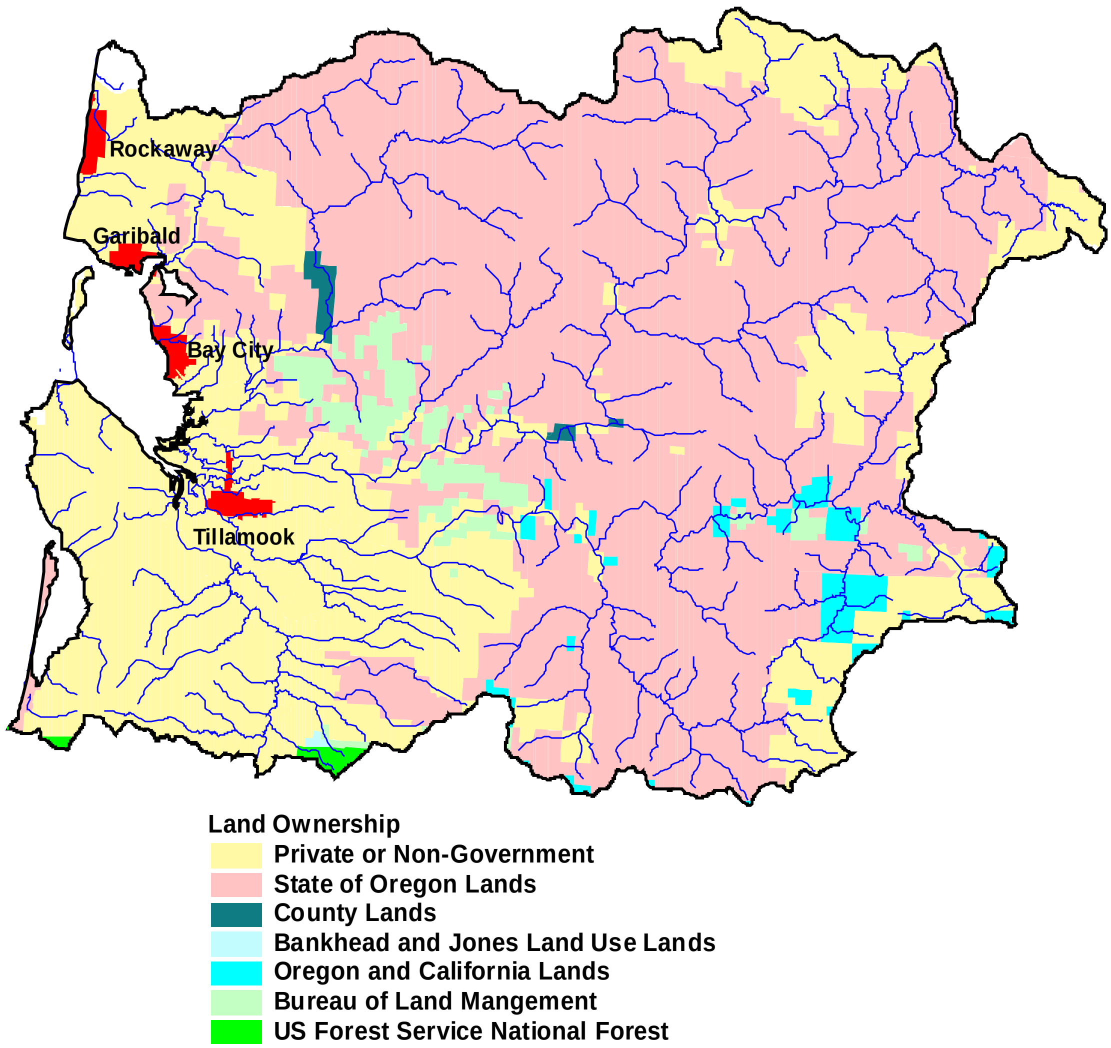
Tillamook Bay is a shallow estuary about 6.2 miles long (10 km) and 2.1 miles (3.4 km) wide with strong tidal influence. Depth of the Bay averages only 6.6 feet (2 m) over a total area of 13 square miles (34 km^2) with mixed semi-diurnal tides that can reach over 13 feet (TBNEP, September 1998). Oysters have been grown commercially in Tillamook Bay since the 1930's (TBNEP, July 1998).

Tillamook Bay has a long history of bacterial pollution problems (Jackson and Glendening, 1982*).* Bacterial concentrations in the Bay have historically been high during the wet seasons of the year: fall, winter and early spring (TBNEP, July 1998). Because of the varying water quality in the Bay and the proximity of five wastewater treatment plants, oyster harvesting is allowed in specified areas of the Bay and only under certain conditions. Conditionally approved areas are closed when the Wilson River rises to 7 feet (TBNEP, July 1998).

The five rivers that enter Tillamook Bay cut through the steep uplands and drain to the alluvial plain and estuary below. The 40 square miles of lowland supports rural residential, rural industrial, and urban land uses as well as 28,600 dairy cattle (TBNEP, July 1998), all of which are important sources of bacterial contamination

Figure 2 shows the land uses within the Tillamook Bay Watershed as identified by USGS (1979). Forest land uses predominate in the Tillamook Bay Watershed, with 93.8% if the watershed area mapped as conifer and mixed forests. Crop and pasture land uses are confined to low gradient areas near tidally influenced areas and comprise 5.0% of the watershed area.

Figure 1. Land Ownership within the Tillamook Bay Watershed



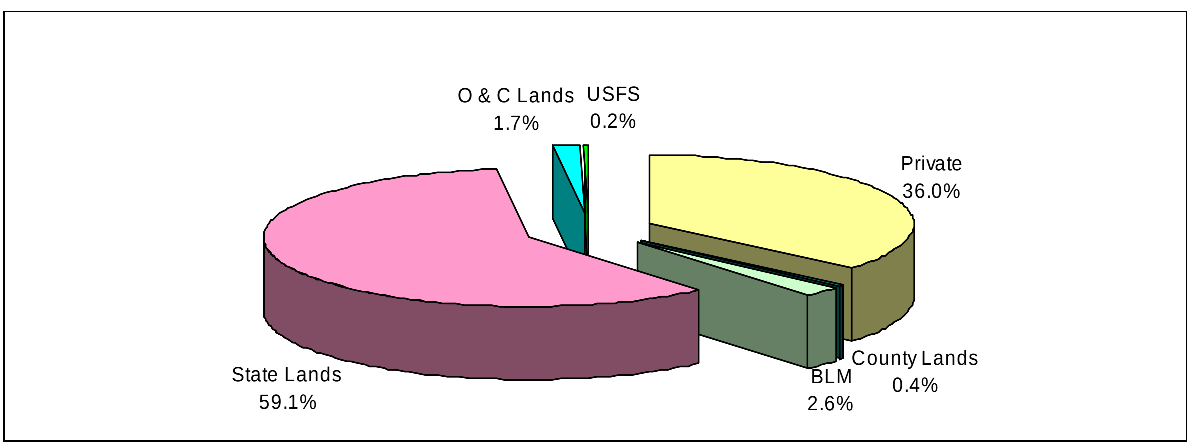
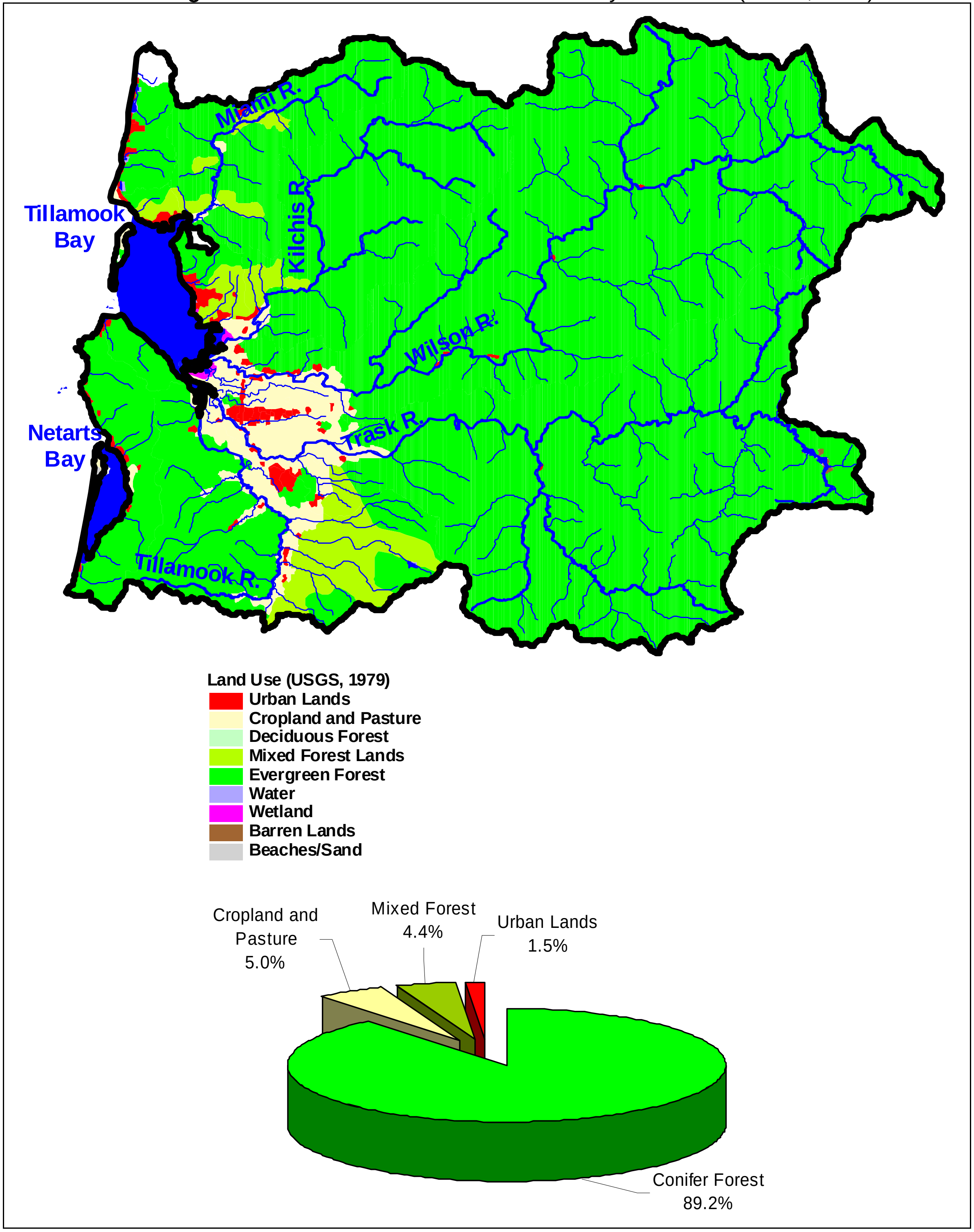


Figure 2. Land Use within the Tillamook Bay Watershed (USGS, 1979)



The seasonal, episodic nature of precipitation defines the natural system. Fall chinook migrate upstream with the first heavy rains in late autumn. Big storms cause major landslides in the steeply sloped upland regions. Although heavy storms have characterized the natural system for thousands of years, human activities have exacerbated the impacts and consequences of high rainfall (Coultan, et al. 1996). Westerly winds predominate and carry the temperature-moderating effects of the ocean over all of western Oregon. Summers are cool and dry; winters wet and moderate (USDA 1964). Winds blow nearly continuously throughout the year and often reach gale force in the winter. Prevailing winds come from the south and southwest during the summer.

Temperatures in Tillamook County are moderate. The mean annual temperature is 10.2°C (50.4°F), with yearly mean and maximum temperatures documented at 15.1°C (59.3°F) and 5.4°C (41.6°F), respectively. Those 30 years [1961-1990] *averaged less than one day per year with a temperature over 32°C (90°F). September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 38.89°C (102°F).*

-Tillamook National Estuary Project, 1997

2.3 Climate

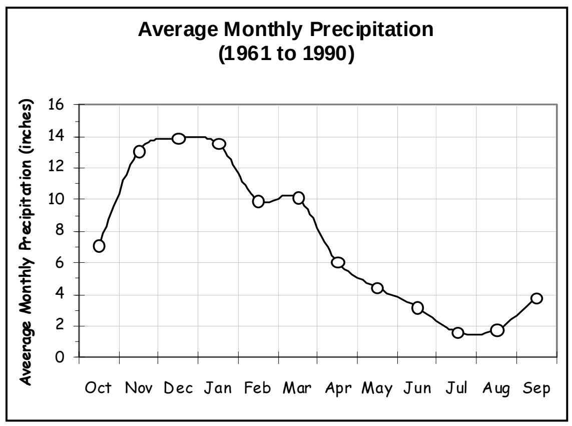
The Tillamook Bay Watershed receives an average of 125 to 200 inches of precipitation annually, comprised largely as rainfall. Fall, winter and spring are usually wet seasons, while summertime is often drier. However, rainfall patterns vary considerably throughout the watershed and from year to year.

2.3.1 Annual Patterns

Tillamook Bay Watershed climate is influenced by proximity to the Pacific Ocean and elevation. Climatic conditions can vary considerably, and are a function of *orographic*[1] influence and ocean effects. The Coastal Mountains that surround the city of Tillamook to the east often receive between 125 and 200 inches of annual precipitation, most as rainfall. Lower portions of the watershed, closer to the City of Tillamook, receive average annual precipitation totals between 80 and 125 inches. **Figure 3** displays the average annual precipitation (rainfall equivalent).

2.3.2 Seasonal Variation

Precipitation totals are greatest in winter and spring months (November through April), while less precipitation is received in summer and early fall months (May through October). Air temperatures in the Tillamook Bay Watershed are mild throughout the year (Table 1). The Pacific Ocean has a moderating effect on air temperature, much more so at close proximity to the ocean. Summertime air temperatures may be much greater in areas only a few miles inland, relative to areas near the ocean.



[1] Orographic Precipitation is caused by surface winds that are forced to rise against mountains. The winds cool as they rise against the mountain slopes the moisture in the air condenses and changes into rain. Precipitation formed by winds rising against mountains is orographic (from the Greek word oros, "mountain").

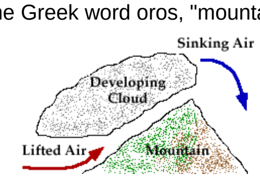


Figure 3. Average Annual Precipitation in the Tillamook Bay Watershed

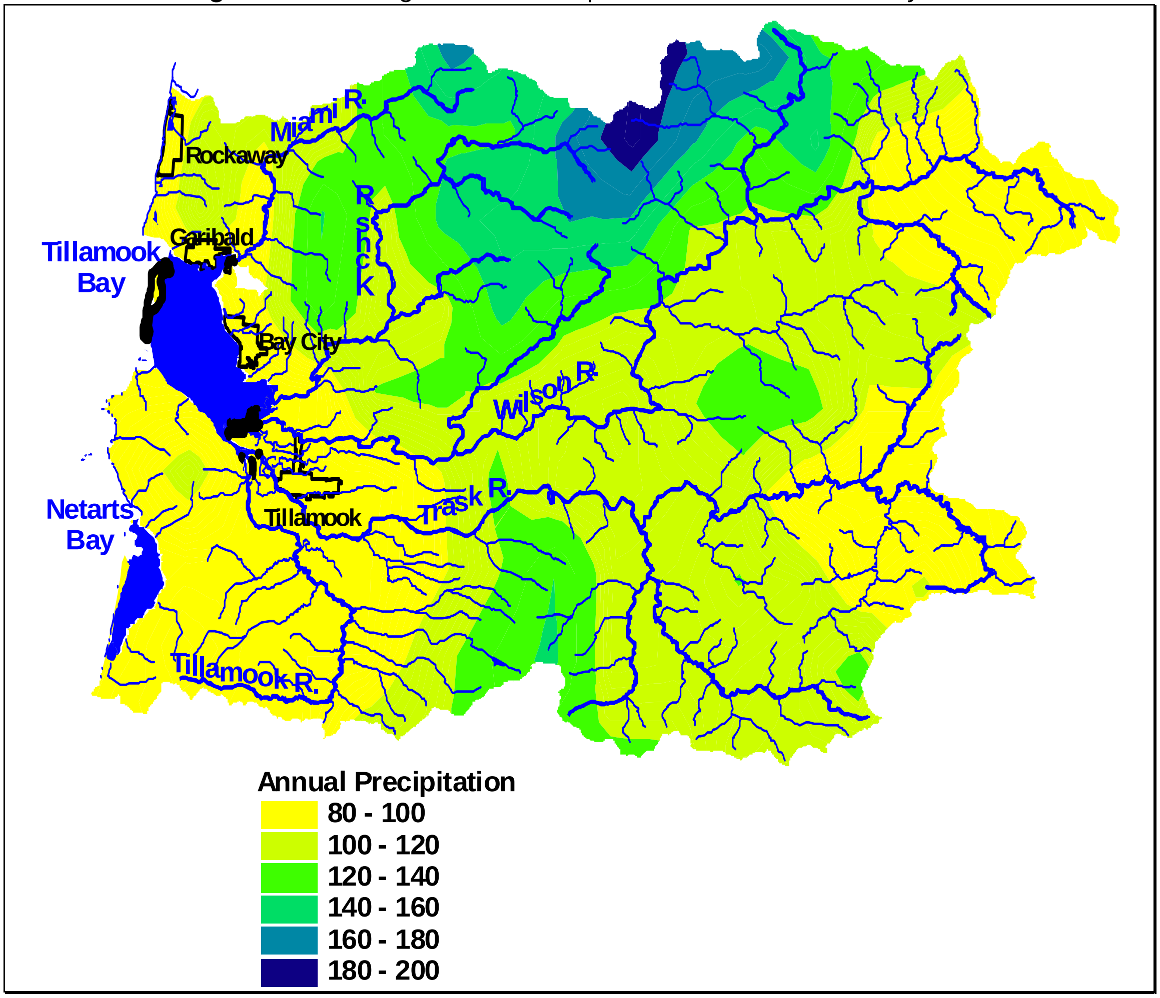


Table 1. Average Monthly Climate Data for Tillamook, Oregon (1961 to 1990)

Parameter	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Year
Air Temperature (^{o}F)													
Mean	53	47	43	43	45	46	48	52	56	58	59	58	50
Maximum	92	80	66	69	73	73	84	86	92	102	102	97	102
Minimum	22	14	4	11	8	21	23	27	31	35	34	27	4
Precipitation (inches)													
Mean	7	13	14	14	10	10	6	4	3	2	2	4	89
Extreme 24 hour	4	4	5	5	3	4	3	2	3	2	2	3	5
Precipitation (days)													
.01 inches or more	15	21	23	21	19	21	18	15	10	7	7	11	187
.10 inches or more	11	18	19	18	16	17	13	10	7	4	4	7	143
.50 inches or more	6	10	10	10	8	9	4	3	2	1	1	3	65
1.00 inches or more	2	4	4	4	3	3	1	1	1	0	0	1	24

2.4 Flow

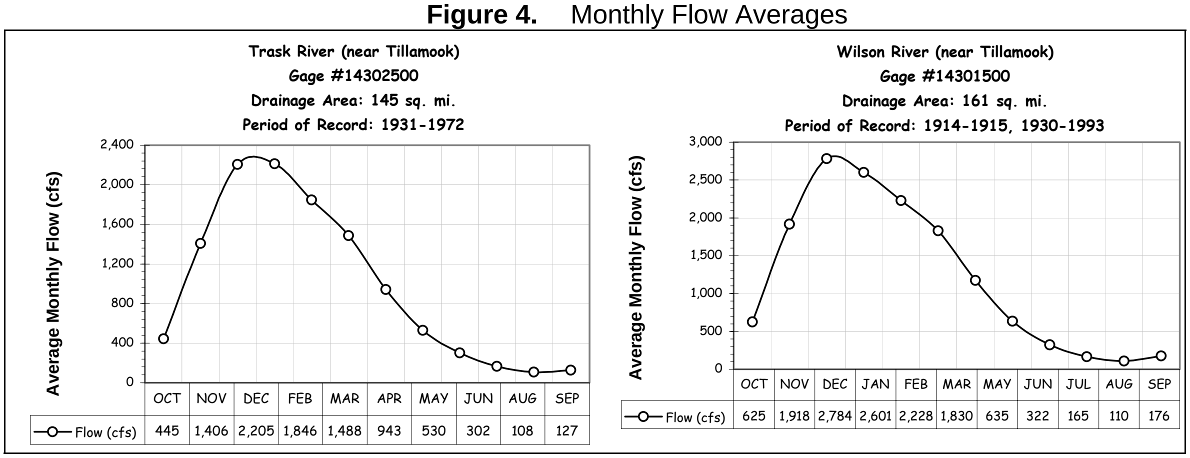
Flow data has been collected in the Tillamook Bay Watershed by 4 U.S. Geological Survey (USGS) gages. Two of these gages have been collecting daily stream flow measurements since 1930 (USGS #14301500 and USGS #14302500). Flow data files were processed by DEQ staff to quantify *return periods*[2] for both high and low flow conditions. Long-term flow data collection has not been high priority in the Tillamook Bay watershed. Statistical descriptions of temporal and spatial flow regimes/patterns require many years of daily collected flow data. This level of data duration does not exist in the Miami River, Kilchis River and Tillamook River.

Using historical gage data for the Trask River and Wilson River:

- ***10 year low flows are roughly 50 cfs.***
- ***Yearly average low flows are approximately 110 cfs.***
- ***Wintertime high flows are generally greater than 2,000 cfs.***
- ***Ten year high flows are 10,000 cfs for the Wilson River and 8,000 cfs for the Trask River.***

Long-term average monthly flow values for the lower Trask and Wilson Rivers reflect the seasonal precipitation patterns (**Figure 4**). Flow in these systems is associated with rain events, and as a result, both rivers exhibit flashy flow regimes during periods of intense rainfall. *Perennial* streams are those with flow throughout the year. *Intermittent* streams experience a period of time during the year without flow, becoming completely de-watered. This intermittance produces harsh conditions for aquatic life and water quality. Intermittent streams are determined as such when the 7Q10 values were *zero*. The Wilson River has a 7Q10 low flow of 48 cfs and the Trask River has a 7Q10 low flow of 54 cfs.

Figure 4. Monthly Flow Averages



[2] Duration periods for which flows were averaged were 1 day, 7 days and 14 days. Return period estimations were performed using the Log Pearson Type III distribution for the following *return periods*: 1 year, 2 years, 5 years, 10 years, 25 years, 50 years and 100 years. Average monthly flows were also calculated for many of the gages, depending on the length of the period of recorded flow values. Return flows are presented as *XQY*, where "*X"* represents the flow duration (days) and "*Y*" represents the return period (years). For example, a *7Q10* would represent the 7-day average flow that occurs on average once every 10 years. Therefore, the probability that seven-day duration 10-year *return period* flow (7Q10) conditions will occur during any year is 10%.

CHAPTER 3 – TOTAL MAXIMUM DAILY LOADS

Summary of Temperature TMDL Development and Approach

Why Is Temperature Important?

Excessive summer water temperatures in several tributaries and mainstem reaches throughout the Tillamook Bay Watershed are reducing the quality of rearing habitat for chinook, coho and chum salmon, as well as steelhead trout and cutthroat trout. Primary watershed disturbance activities that contribute to surface water temperature increase include past forest and fishery management within riparian areas, current timber harvest in near stream areas and outside the riparian zone, agricultural land use within the riparian area, road construction and maintenance, and rural residential development near streams and rivers. Point source discharges of warm water also contribute to stream heating in the lower watershed. As a result of water quality standards (WQS) exceedances for temperature, waters in the Tillamook Bay Watershed are on Oregon's 1998 303(d) list.

Scope

All lands (572 square miles) with intermittent or perennial streams that drain to the Tillamook Bay within HUC 17100203 are included in the temperature TMDL. All land uses and both point-sources and nonpoint sources of heat are included: lands managed by the State of Oregon, the U.S. Forest Service (USFS) and Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, military lands and urban areas.

Applying Oregon's Temperature Standard

The reduction in thermal loading needed to meet the water quality standard is evaluated using a variety of data (ground level, GIS and remote sensing) and analytical modeling. Attainment of the temperature standard relies on simulating the thermal effects of "system potential" riparian vegetation and channel morphology that reduce thermal patterns to those that minimize human caused increases in stream temperatures. In areas where the numeric criteria are being exceeded, DEQ considers attainment of system potential conditions as measured by % effective shade to demonstrate compliance with the temperature standard. This is obtained through restoration/protection of riparian vegetation, channel morphology, and hydrologic processes.

Development of System Potential Conditions

System potential conditions are determined by riparian and channel morphology parameters. DEQ assessed potential vegetation with field measurements and literature regarding vegetation distributions. Channel morphology was assessed via the application of hydrologic principles and distributions of current channel geometry. Flows were evaluated with instream measurements and gage data. A current condition flow profile was derived. DEQ calculated the thermal effects associated with achieving both riparian and channel morphology system potential conditions. Other factors, such as groundwater/stream interactions and floodplain/stream connection, are more difficult to quantitatively assess and are indirectly addressed through the riparian and channel morphology TMDL targets.

Temperature TMDL Overview

Stream temperature pollutants are identified as human-caused increases in solar radiation that reaches the stream surface and warm water discharges. The resultant TMDL loading capacities are expressed as pollutant loading limits for both non-point and point sources of pollution. Allocations of the pollutant load are provided to all sources of pollution in the Tillamook Bay Watershed. Surrogate measures are also provided to non-point sources of pollution to help translate the loading capacity and to provide a clear list of site-specific targets for management and implementation considerations.

3.1 Stream Temperature TMDL

3.1.1 Temperature Pollutant Identification

The pollutants identified for stream temperature pollution are human caused increases solar radiation loading at the stream surface 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 causing violation of 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 increase in heat energy is derived from solar radiation as increased levels of sunlight reach the stream surface and raise water temperature. The pollutants targeted in this TMDL are (1) human caused increases in solar radiation loading to the stream network and (2) warm water discharges of human origin.

3.1.2 Temperature Target Identification – CWA §303(d)(1)

The stream temperature TMDL targets protection of the most sensitive beneficial use: salmonids. Oregon's stream temperature standard, which is based on the temperature requirements of salmonids, is designed for protection during all salmonid life stages. Several numeric criteria and other triggers for the temperature standard establish factors for designating surface waters as water quality limited. The temperature standard specifies that anthropogenic (i.e. human caused) impacts that cause stream heating should be removed. The TMDL targets this no anthropogenic warming condition. A stream condition that has no anthropogenic induced warming is considered to be at the system potential.

3.1.2.1 Salmonid Stream Temperature Requirements

Stream temperatures above 64^{o}F (17.8^{o}C) are considered sub-lethal and can be stressful for cold water fish species, such as salmon and trout.

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 may never occur in the Tillamook Bay Watershed.

More common and widespread within the Tillamook Bay Watershed, 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 to, and on life-stage of development. 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 2** summarizes the modes of cold water fish mortality.

Table 2. 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 20^{o}C - 23^{o}C	Weeks to Months

3.1.3 Sensitive Beneficial Use Identification

Beneficial uses and the associated water quality standards are generally applicable throughout the Tillamook Bay Watershed (Table 3). 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 5** identifies occurrence of anadromous salmonids (*Oncorhynchus*) in the Tillamook subbasin and the various habitat uses (migration, spawning and rearing) for four important anadromous salmonids present in the Tillamook Bay Watershed (ODFW data):

Salmonid fish spawning, incubation, fry emergence, and rearing are deemed the most temperature-sensitive beneficial uses within the Tillamook Bay Watershed.

- Chinook Salmon (Spring and Fall) – *Oncorhynchus tshawytscha*
- Chum Salmon (Dog Salmon) - *Oncorhynchus keta*
- Coho Salmon (Silver Salmon) - *Oncorhynchus kisutch*
- Steelhead (Winter and Summer) - *Oncorhynchus mykiss*

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 202, Table 1) lists the “Beneficial Uses” occurring within the Tillamook Bay watershed (Table 3). Numeric and narrative water quality standards are designed to protect the most temperature sensitive *beneficial uses*. In the Tillamook Bay Watershed, resident fish and aquatic life and salmonid spawning, rearing and migration are designated the most sensitive *beneficial uses*. Use for various life history stages or events are presented in Table 4. The distribution of fish in the watershed varies through the year and temperature impairment is in part a function of fish habitat requirements.

Table 3. Beneficial uses occurring in the Tillamook Bay Watershed

(OAR 340 – 41 – 202)
Temperature-Sensitive Beneficial uses are marked in gray

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

Figure 5. Chinook Salmon, Coho Salmon, Chum Salmon and Steelhead Trout Distributions (ODFW). Range of dates indicate spawning and incubation periods for each species.

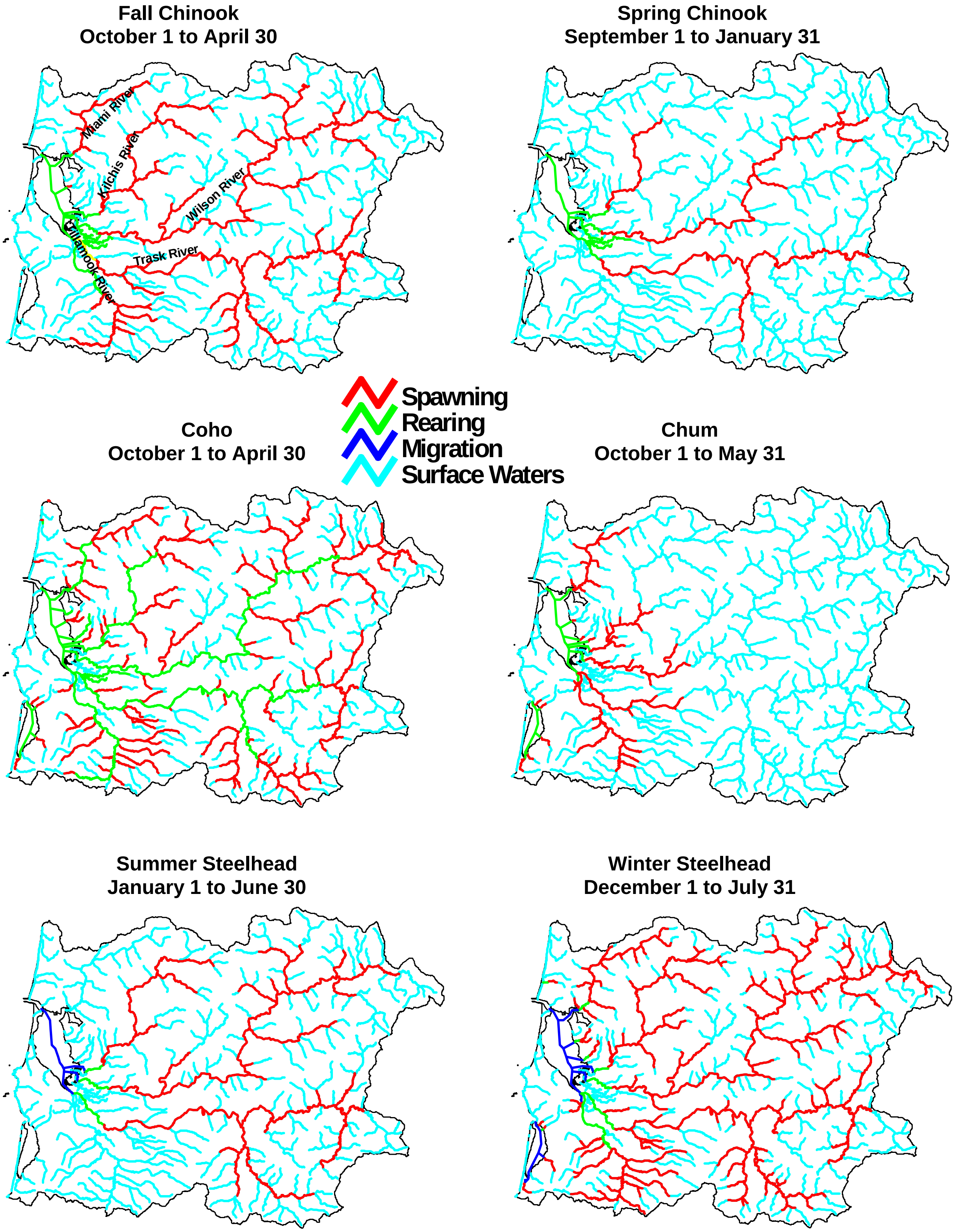


Table 4. Tillamook Bay Watershed Spawning Periods of Use by Species

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Adult Migration/Holding												
Spring Chinook					Range	Peak	Range	Range	Range			
Summer Steelhead	Range	Range			Range	Peak	Peak		Range	Range	Range	Range
Sea-Run Cutthroat	Range	Range	Range	Range	Range	Peak	Peak	Peak	Peak	Peak	Peak	Range
Coho	Range	Range							Range	Range	Peak	Peak
Chum										Range	Peak	Peak
Fall Chinook								Range	Range	Range	Peak	Range
Winter Steelhead	Range	Peak	Peak	Peak							Range	Range
Resident Cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Spawning												
Spring Chinook									Peak	Peak		
Summer Steelhead	Range	Peak	Range	Range								
Sea-Run Cutthroat	Range	Peak	Peak									Range
Coho	Range	Range								Range	Peak	Peak
Chum	Range									Range	Peak	Peak
Fall Chinook	Peak	Range	Range							Range	Range	Peak
Winter Steelhead	Range	Range	Range	Peak	Peak							
Resident Cutthroat	Range	Peak	Peak									Range
Incubation												
Spring Chinook	Range								Range	Range	Peak	Peak
Summer Steelhead	Range	Peak	Peak	Range	Range	Range						
Sea-Run Cutthroat	Range	Range	Peak									Range
Coho	Range	Range	Range	Range	Range					Range	Range	Peak
Chum	Peak	Range	Range	Range	Range					Range	Peak	Peak
Fall Chinook	Range	Peak	Peak	Range						Range	Range	Range
Winter Steelhead	Range	Range	Range	Range	Peak	Peak	Peak					Range
Resident Cutthroat	Range	Range	Peak	Peak	Peak							Range
Rearing												
Spring Chinook	Range	Range	Range	Range	Range	Range	Range	Range				Range
Summer Steelhead	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Sea-Run Cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Coho	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Chum	No Freshwater Rearing Period											
Fall Chinook	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range		
Winter Steelhead	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Resident Cutthroat	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range	Range
Peak Smolt Outmigration												
Spring Chinook					Peak	Peak						
Summer Steelhead					Peak							
Sea-Run Cutthroat					Peak	Peak						
Coho				Peak	Peak							
Chum				Peak								
Fall Chinook					Peak	Peak						
Winter Steelhead					Peak							
Resident Cutthroat	Grow to Adulthood and Remain in River											

Peak = Peak Use Period
Range = Range of Use

3.1.4 Water Quality Standard Identification

A seven-day moving average of daily maximums (7-day statistic) was adopted as the statistical measure of the stream temperature standard. Absolute numeric criteria are deemed action levels and indicators of water quality standard compliance. Unless specifically allowed under a DEQ-approved surface water temperature management plan (as required under (OAR 340-041-0026(3)(a)(D)), no measurable surface water temperature increase resulting from anthropogenic activities is allowed in State of Oregon Waters determined out of compliance with the temperature standard. A much more extensive analysis of water temperature related to aquatic life and supporting documentation for the temperature standard can be found in the *1992-1994 Water Quality Standards Review Final Issue Papers (ODEQ, 1995)*.

It is important to understand the State of Oregon's temperature standard and that there is more to it than just a 64^{o}F criterion. Specifics for the Tillamook Bay Watershed temperature standard can be found in OAR 340-041-202(2)(b)(A) and in **Appendix C**.

The temperature standard applicable in the Tillamook Bay Watershed specifies that "no measurable surface water temperature increase resulting from anthropogenic (human induced) activities is allowed" unless specifically allowed under a DEQ-approved management plan, when trigger temperatures are exceeded (see temperature standard below - i through viii).

Tillamook Bay Watershed Temperature Standard - OAR 340-041-202(2)(b)(A)(i-viii)

To accomplish the goals identified in OAR 340-041-120(11), unless specifically allowed under a DEQ-approved surface water temperature management plan as required under OAR 340-041-026(3)(a)(D), 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 64.0°F (17.8°C);
(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface waters exceed 68.0°F (20.0°C);
(iii) In waters and periods of the year determined by DEQ to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);
(iv) In waters determined by DEQ to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);
(v) In waters determined by DEQ to be ecologically significant cold-water refugia;
(vi) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;
(vii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or Basin; and
(viii) In natural lakes.

3.1.4.1 Deviation from Water Quality Standard (Temperature Impairments)

Monitoring has shown that water temperatures in the Tillamook Bay Watershed often exceed numeric criteria of the State water quality standard. There are approximately 100 miles of stream segments within the Tillamook Bay Watershed on the 1998 §303(d) list for exceeding numeric temperature criteria (Table 5). Generally, stream temperatures follow a longitudinal (downstream) heating pattern, where smaller tributaries are cooler than the mainstem reaches. **Figure 6** displays stream heating as a function of measured perennial stream distance from headwaters. Headwater temperatures are in the mid-50^{o}F to upper-50^{o}F range, and warm roughly 15^{o}F to

20°F to tidewater influences. **Figure 7** displays the locations and corresponding 7-day temperature statistic ranges (based on temperature data collected in the Tillamook Bay Watershed during the 1997 and 1998 summertime seasons using temperature monitoring instruments that recorded hourly stream temperatures).

Many reaches of the Tillamook Bay Watershed are designated as temperature limited on Oregon's 1998 303(d) list. In total, 101 stream miles are temperature limited (triggers for the standard are exceeded and/or occur).

Table 5. Tillamook Bay Watershed Temperature Limited Waterbodies and miles of listed stream. (Oregon 303(d) List, 1998)

Location:	• Kilchis River (Mouth to headwaters)	7.0
	• Miami River (Mouth to Moss Creek)	1.5
	• Tillamook River (Mouth to Yellow Fir)	13.6
	• Trask River (Mouth to S.F. Trask River)	19.2
	• Wilson River (Mouth to headwaters)	32.8
	• Coal Creek (Mouth to headwaters)	2.3
	• Fawcett Creek (Mouth to headwaters)	6.75
	• Mill Creek (Mouth to headwaters)	2.6
	• Murphy Creek (Mouth to headwaters)	2.5
	• Myrtle Creek (Mouth to headwaters)	1.3
	• Trask River, North Fork (Mouth to Bark Shanty Creek)	4.4
	Trask River, North Fork of North Fork (Mouth to headwaters)	7.1
Supporting Data:	• ODEQ (1997 – 2000) • NRCS (1992 – 1994)	Total = **101**

Figure 6. Maximum Daily Temperature Values Related to Distance from Headwaters *(ODEQ, August 12, 1998)*

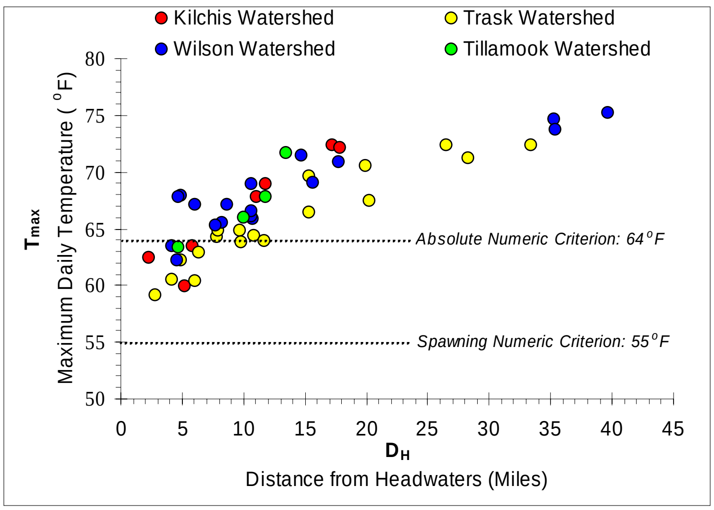
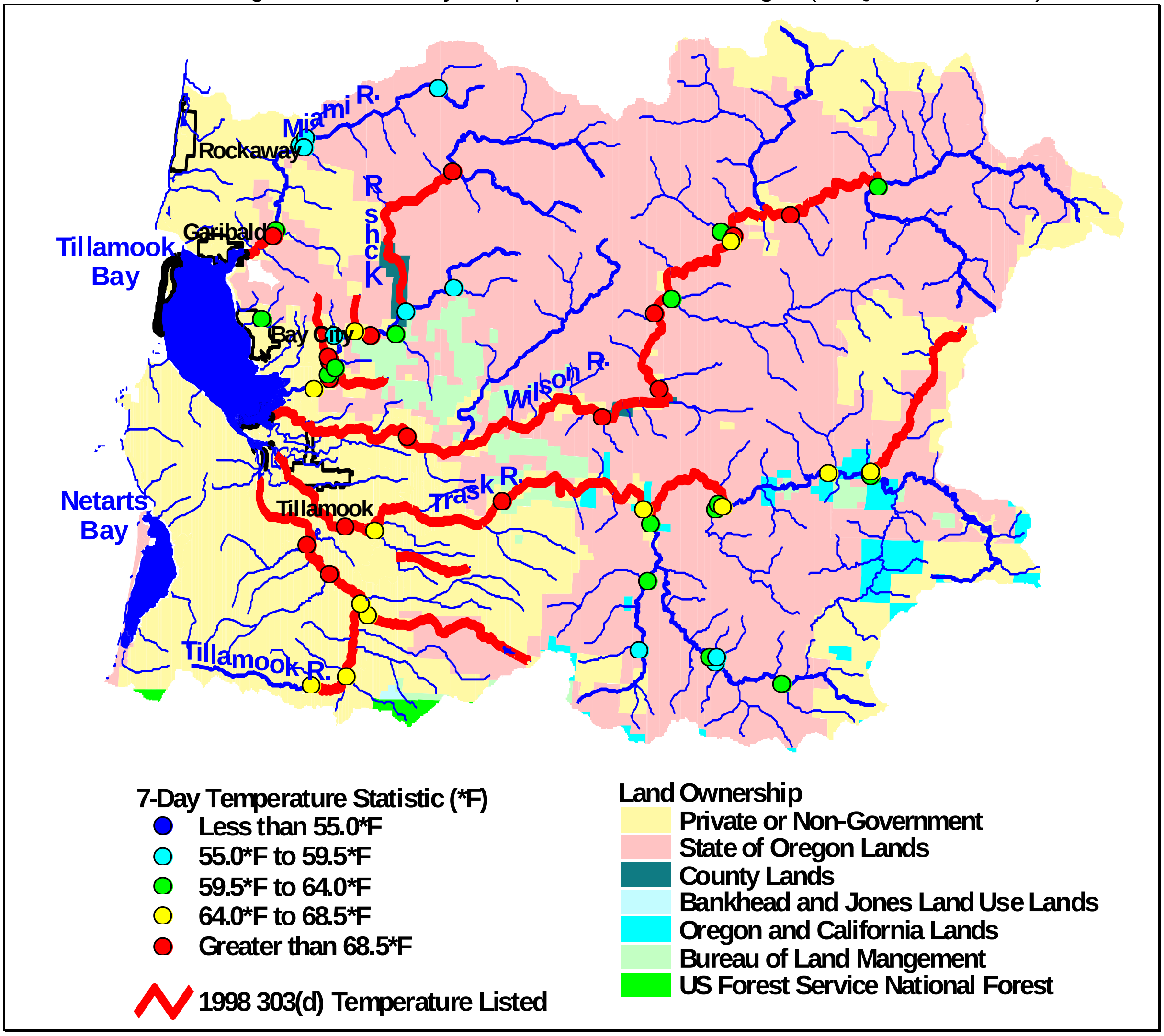


Figure 7. Segments on the 1998 §303(d) List for Temperature and Continuous Temperature Monitoring Sites with 7-Day Temperature Statistic Ranges (DEQ, 1997 to 1998)



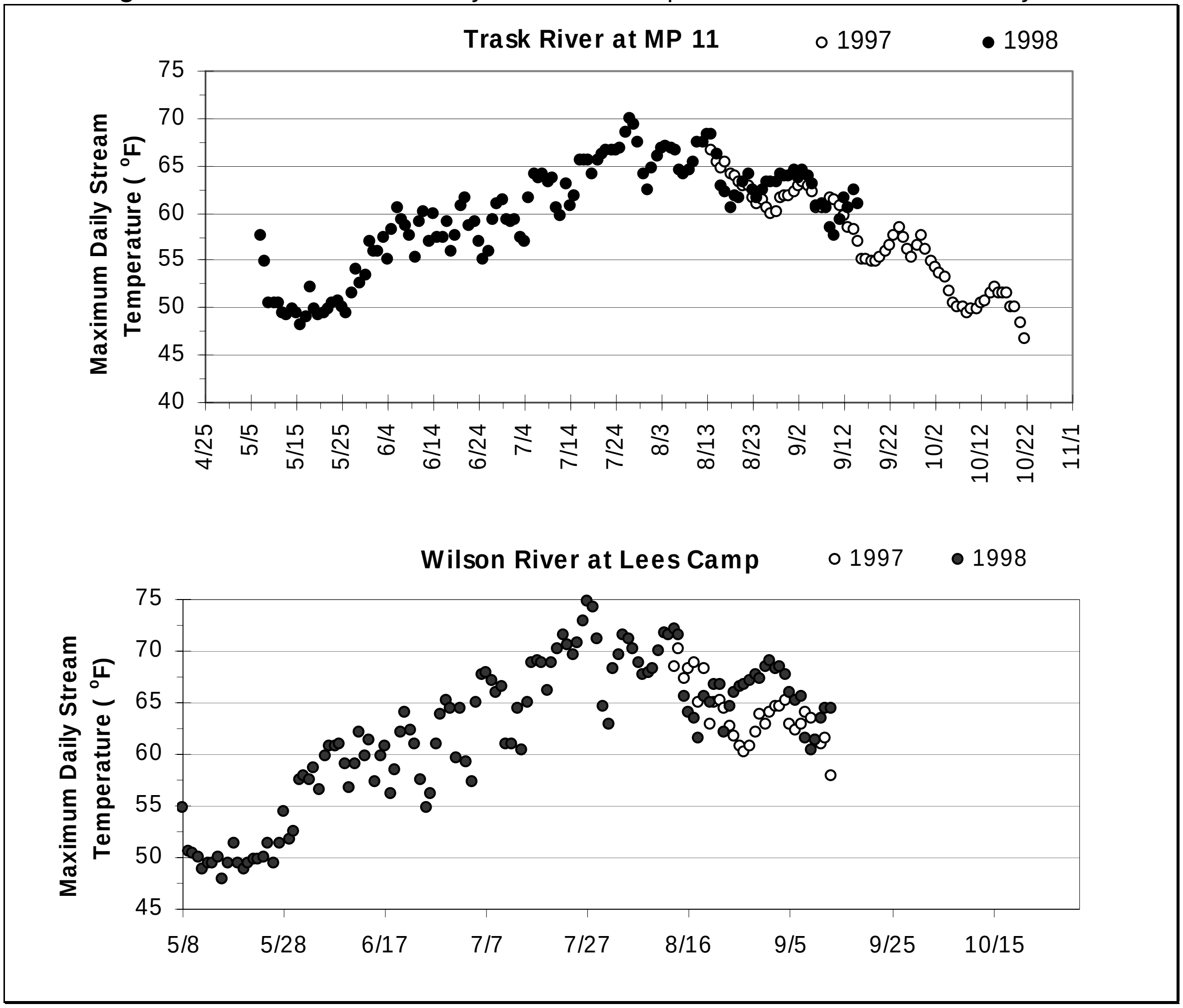
3.1.5 Seasonal Variation – CWA §303(d)(1)

The Tillamook Bay Watershed mainstem and tributaries stream reaches experience prolonged warming starting in late spring and extending into the fall. Maximum temperatures typically occur in July and August (**Figure 8).** The TMDL focuses the analysis during the late July and early August period as a critical condition as identified by 1998 temperature data. It should also be noted that the Tillamook Bay watershed streams are commonly above the 55^{o}F numeric criterion during the period that spans June through October. The 64^{o}F numeric criterion is exceeded in the period between mid-June through mid-September.

The critical temperature period occurs when stream temperatures are above the numeric criterion.

The critical temperature period occurs from May through October

Figure 8. 1998 Observed Daily Maximum Temperatures for the Tillamook Bay Watershed



3.1.6 Existing Sources – CWA §303(d)(1)

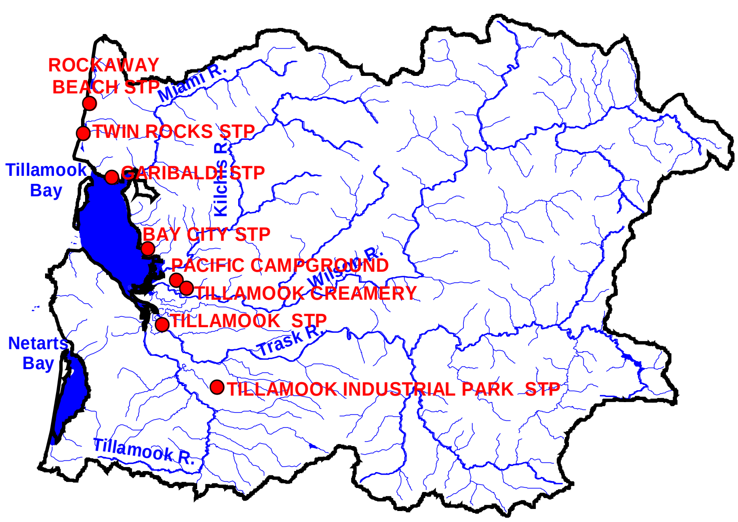
3.1.6.1 Point Sources

Warm point source discharges in the Tillamook Bay Watershed are sources of stream heating. Eight NPDES permitted discharges are mapped and presented below. Discharge temperature data is limited for many of the facilities, and discharge flow rates are generally very low. Discharge temperatures are typical of small wastewater treatment facilities (≈70°F), however the Tillamook Creamery has a warm effluent temperature ranging as high as 92°F. The STPs for Rockaway Beach and Twin Rocks discharge to the Pacific Ocean, and Garibaldi and Bay City facilities discharge to Tillamook Bay. Receiving waters for these discharges are not water quality limited for temperature, and will not receive temperature allocations.

Table 6. NPDES Permitted Facilities

Facility Name	City	Receiving Water	River Mile	Permit Type	Flow Rate (cfs)	Critical Temp.
Rockaway Beach STP	Rockaway	Clear Lake		NPDES	NA	NA
Twin Rocks STP[3]	Twin Rocks	Watseco Cr.	0.2	NPDES	NA	NA
Garibaldi STP	Garibaldi	Tillamook Bay		NPDES	0.77	NA
Bay City STP	Bay City	Tillamook Bay		NPDES	0.33	NA
Pacific Campground	Tillamook	Wilson R.	0.9	NPDES	0.08[4]	70 °F
Tillamook Creamery	Tillamook	Wilson R.	1.7	NPDES	0.75[5]	92 °F
Tillamook STP	Tillamook	Trask R.	1.9	NPDES	1.64	71 °F
Tillamook Industrial Park STP[6]	Tillamook	Trask R.	5.2	NPDES	No Data	No Data

NPDES Permitted Facilities



There are eight point sources that discharge into surface waters in the Tillamook Bay Watershed.

Effluent temperature range from 68°F to 92°F.

[3] Rockaway Beach STP, Twin Rocks STP, do not discharge to tributaries of Tillamook Bay.

[4] Pacific Campground has no reported dry weather design flow. Reported value is maximum value recorded during May to October for 1998.

[5] Tillamook Creamery has no reported dry weather design flow. Reported value is maximum value recorded during May to October for 1998.

[6] Tillamook Industrial Park STP does not discharge from June 1 to October 31.

3.1.6.2 Non-point Sources

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. Human activities that contribute to degraded thermal water quality conditions in the Tillamook Bay Watershed are associated with agriculture, forestry, roads, urban development and rural residential related riparian disturbance.

Elevated summertime stream temperatures attributed to nonpoint sources in the Tillamook Bay Watershed result from riparian vegetation disturbance (reduced stream-surface shade) and channel widening (increased stream surface area exposed to solar radiation).

Specifically, the elevated summertime stream temperatures attributed to anthropogenic non-point sources result from:

1. ***Near stream vegetation disturbance/removal*** *reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent effective shade or open sky percentage). Riparian vegetation also plays an important role in shaping channel morphology, resisting erosive high flows and maintaining floodplain roughness.*
2. ***Channel modifications and widening*** *(increased width to depth ratios) increases the stream surface area exposed to energy processes, namely solar radiation. Near-Stream Disturbance Zone (NSDZ) widening decreases potential shading effectiveness of shade-producing near-stream vegetation.*

Both shade and channel morphology are affected by riparian vegetation. Trees and shrubs along streambanks control erosion and maintain the width of the stream. Sediment loads entering the streams cause the depths to decrease and the channels to widen. By controlling erosion, streams maintain narrower and deeper channels that allow trees to more effectively shade the surface of the water. There is a strong inverse relationship between effective shade and temperature evident in data collected in the Tillamook Bay Watershed (Figure 9). These data suggest that an effective shade of 80% averaged over all reaches would result in instream temperatures below the water quality standard of 64°F (17.8°C) throughout the basin.

Riparian vegetation and channel widths were characterized in all of the river basins through analysis of a combination of satellite data, digital orthophoto quadrats, and direct measures in the field. Current conditions were measured directly from one or more of these sources and system potential shade conditions were estimated/modeled by altering vegetational characteristics and modifying Near-Stream Disturbance Zone widths (See Appendix A for details). The resulting curves can be compared to assess the current quality of riparian areas relative to potential throughout each of the basins (Figures 10 and 11).

Figure 9. Reach Length Averaged Effective Shade and Maximum Daily Stream Temperature (DEQ, August 12, 1998

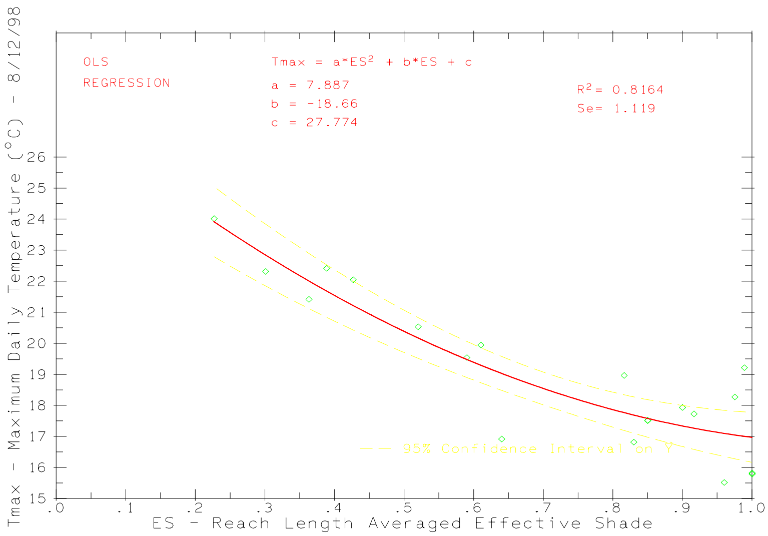


Figure 10. Effective Shade Profile – Current Condition and System Potential

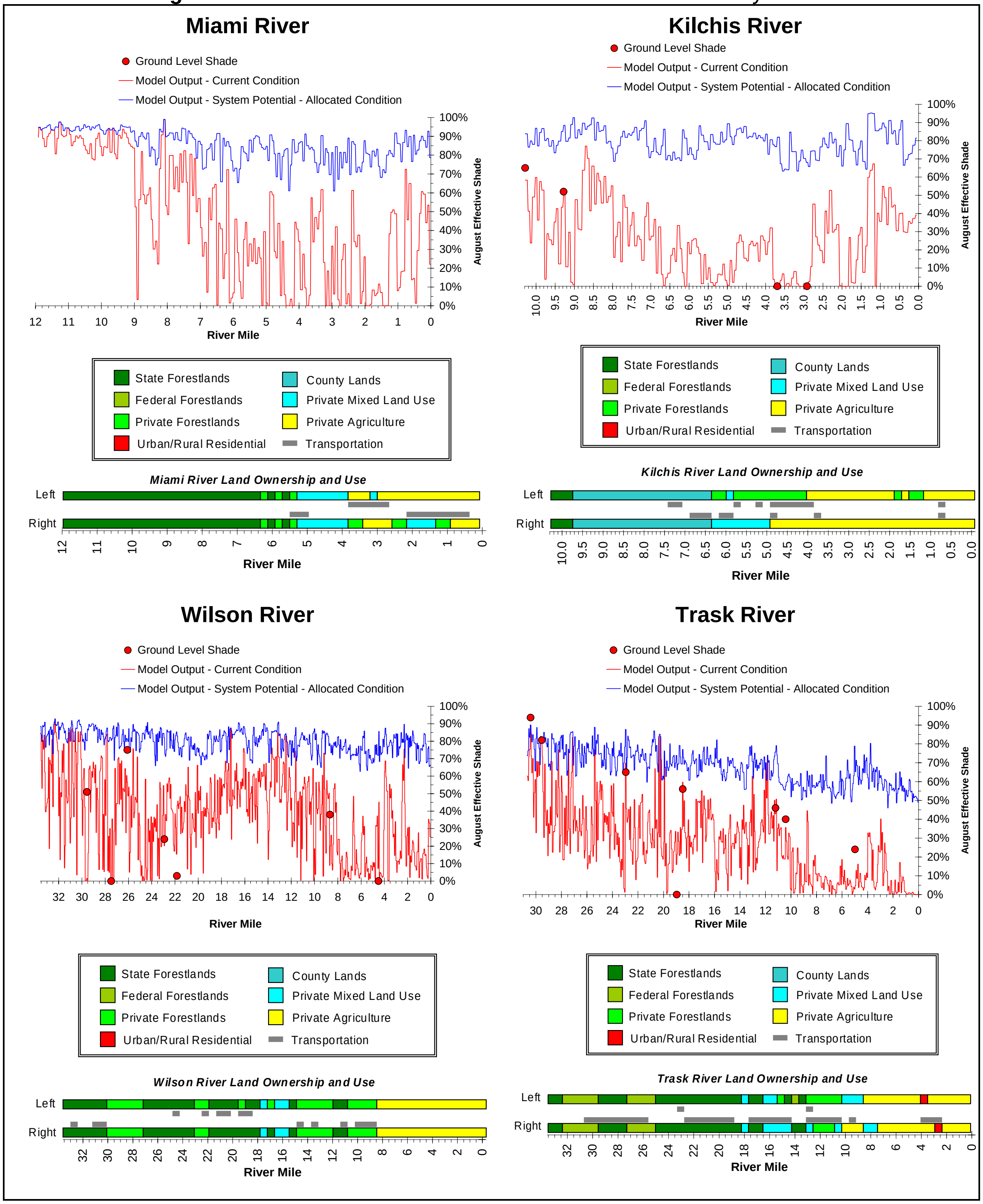
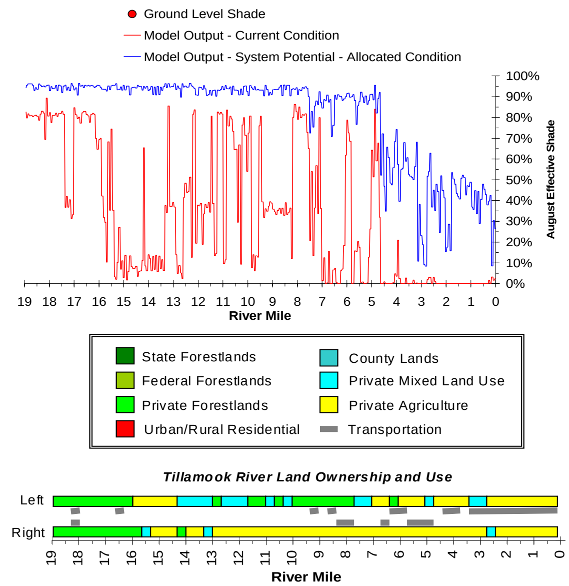


Figure 10 (continued). Effective Shade Profile – Current Condition and System Potential

Tillamook River



Comparison of these curves demonstrates a significant difference between the current condition and the potential in all of the sub-watersheds. The lack of effective shading has resulted from removal of trees throughout the watershed, and a subsequent widening of stream and river channels.

Natural Sources and Stream Temperature

Natural conditions that may impact riparian vegetation and result in elevated stream temperature include drought, fires, insect damage to riparian vegetation, diseased riparian vegetation and windthrow and blowdown in riparian areas. The processes in which natural conditions affect stream temperatures include increased stream surface exposure to solar radiation and decreased summertime flows. Legacy conditions (increased width to depth ratios and decreased levels of stream surface shading) that currently exist are, in part, a result of the extensive Tillamook burn, and fires that occurred prior to the burn.

3.1.7 Loading Capacity – 40 CFR 130.2(f)

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 Tillamook Bay Watershed when the appropriate criteria are exceeded. The pollutants are human-caused increases in solar radiation loading (non-point sources) and warm water discharge (point sources).

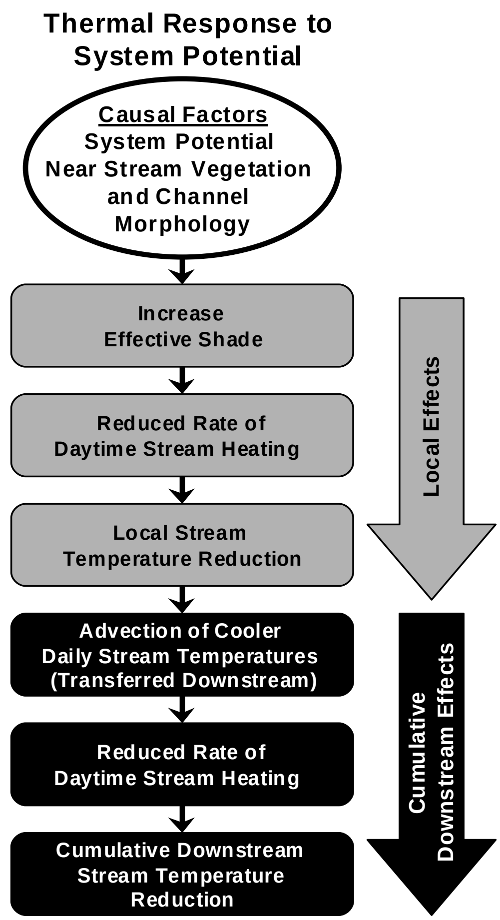
*The Water Quality Standard mandates a **Loading Capacity** based on the condition that meets the **no measurable surface water temperature increase resulting from anthropogenic activities when the temperature standard is exceeded.** This condition is termed **System Potential** and is achieved when (1) non-point source solar radiation loading is representative of a near stream vegetation and channel morphology conditions without human disturbance and (2) point source discharges cause no measurable temperature increases in surface waters.*

Loading capacities in the Tillamook Bay Watershed consist of (1) NPDES permitted point source effluent discharge temperature limits, and (2) solar radiation loading profiles for the Miami, Kilchis, Wilson, Trask and Tillamook Rivers (expressed as Langleys per day) based on potential near stream vegetation characteristics and channel morphology conditions without anthropogenic disturbance

3.1.7.1 System Potential Simulation

Loading capacity in the Tillamook Bay Watershed is largely controlled by non-point source influences of heat to the system. Heat accumulates through much of the watershed by direct solar radiation loading. System potential was estimated as August solar radiation levels that would reach the stream surface under conditions where anthropogenic activities would not measurably increase temperature. **The system potential radiation load is the loading capacity (Figure 11).**

Current conditions were modeled and calibrated using recently collected data. These data included continuous temperature, flow, near-stream vegetation, channel width and depth. System potential conditions were derived from existing conditions and characteristics of each of the sub-watersheds. Effective shade, tree height and density, channel width and depth were all measured in the field. These features were measured on a very fine scale using existing GIS databases and by digitizing Digital Orthophoto Quadrats (See Appendix A). Simulations were performed by increasing near stream vegetation to potential height, width and density and adjusting channel morphology as described in **Appendix A**. Simulations were performed only for the Wilson, Trask, and Kilchis Rivers, although all of the rivers were characterized with respect to the data described. Significant reductions in daily maximum stream temperature resulted from system potential conditions. Diurnal temperature fluctuations were also moderated. Daily minimum stream temperatures were reduced slightly.



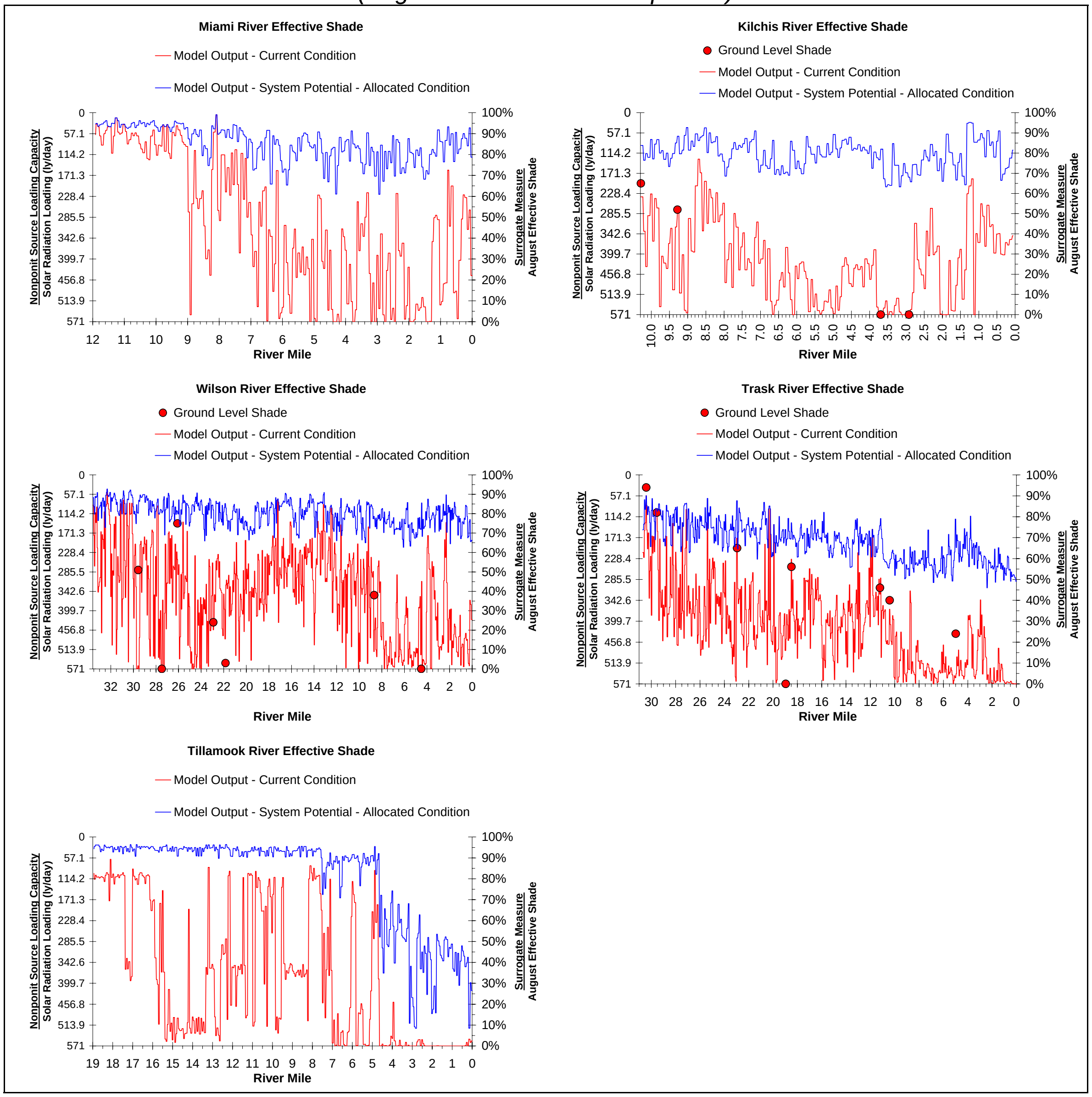
System Potential shade was simulated in a mathematical model (Heatsource 6.5) by increasing tree heights and densities to those expected in mature riparian communities. These tree heights were obtained from foresters with the Oregon Department of Forestry, Tillamook State Forest (Wayne Auble, personal communication) and the US Forest Service (Hebo Ranger District, Siuslaw National Forest, John Johanssen, personal communication). Tree heights for all species that this information was available for averaged 175 feet in upland areas and 125 feet in lowland areas. The lesser averages in the lowlands were due to greater proportions of deciduous trees in these areas.

System potential channel widths were based on existing channel widths as measured through analysis of aerial photos. System potential widths are reduced to an estimate of the current median channel width (Figure 12), which steadily increases with distance from headwaters to mouth. This resulted in a reduced overall channel width, but simulated channels below headwaters were never narrower than a significant portion of the river upstream, thus would provide adequate capacity for normal flow in the river.

Individual near stream vegetation and channel morphology simulations were performed for each mainstem stream segment. Results from these single parameter simulations confirm the importance of both riparian vegetation and channel morphology as stream parameters that influence stream heating processes (Figures 13 and 14).

When both system potential riparian vegetation and channel morphology were simulated together, the stream heating rate was affected to a greater extent than for either factor singly. Increasing height and width of near stream vegetation increased the effective shade throughout each stream system. In effect, the shadows created by the vegetation are longer. Decreased near-stream disturbance zone widths and wetted widths decrease the stream surface area and allow vegetation to more effectively shade this surface area (Figure 12). Healthy near-stream vegetation and channel morphology are physically related. Channel morphology is often affected by riparian vegetation condition. Improvements in riparian condition would likely lead to improvements in channel morphology. In the case of stream thermodynamics, the riparian vegetation and channel morphology combine to increase the effect of casting shadows across the stream surface.

Figure 11. Site Specific Solar Radiation Loading and Effective Shade under Current and System Potential Conditions.
(August Solar Radiation Exposure)



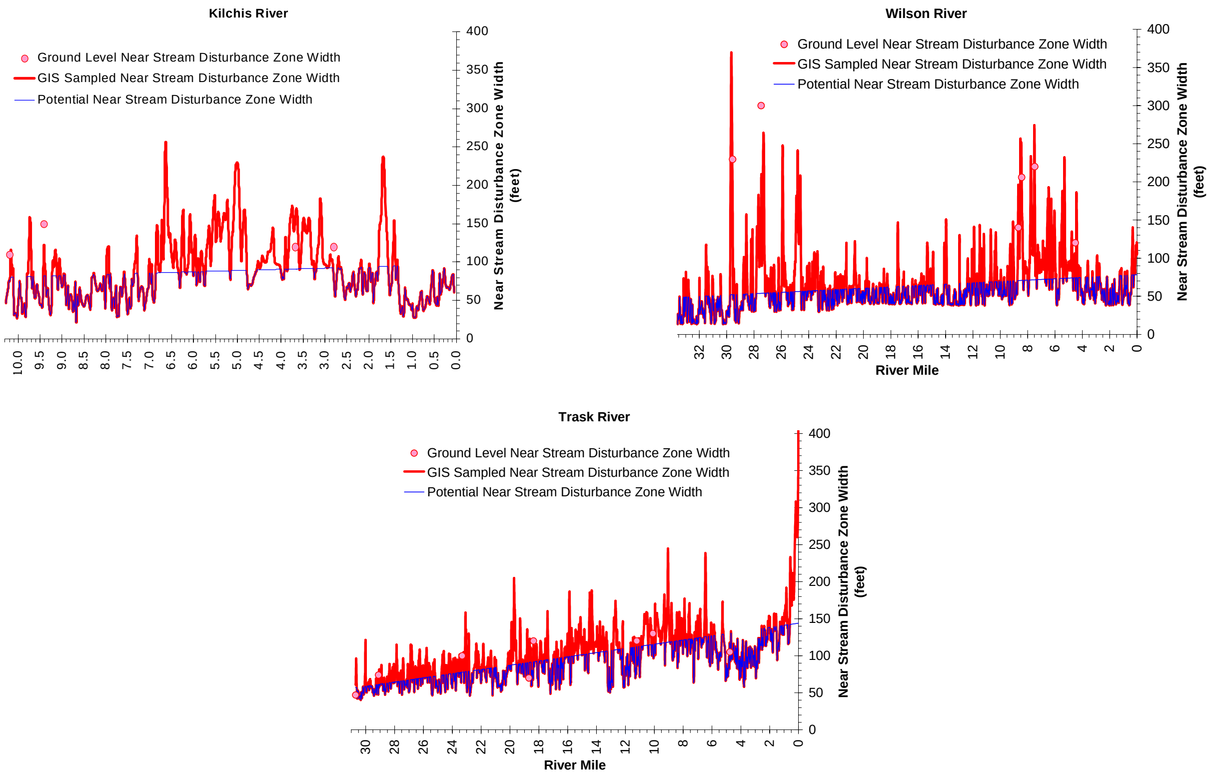
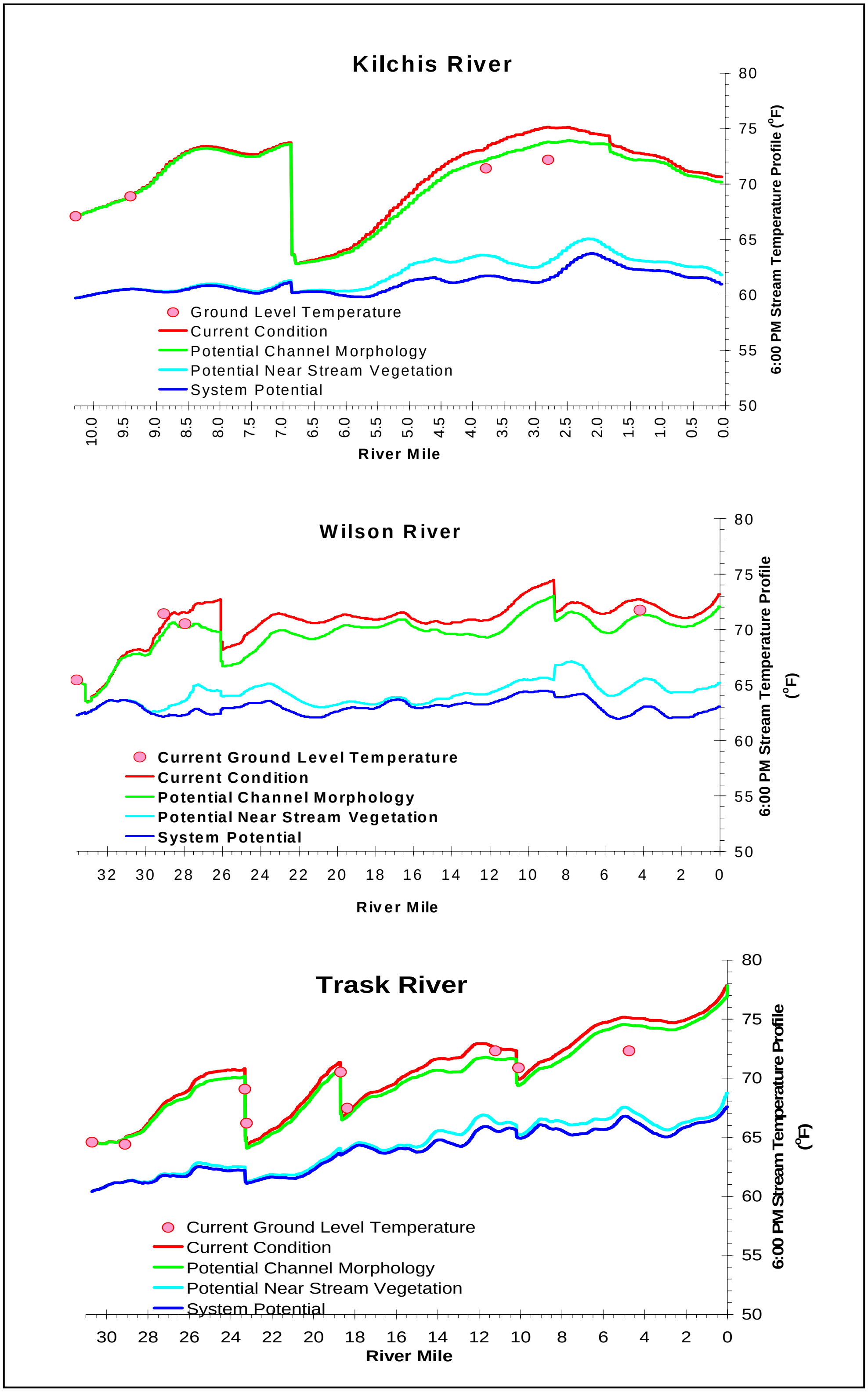


Figure 12. Current and Potential Channel Widths. Blue Areas are Existing Widths Less than the 1000-ft Median Value.

While the TMDL is primarily concerned with maximum daily stream temperature, it is important to consider the cumulative downstream effects that produce daily maximum stream temperatures. System potential conditions produce local effects that include site-specific increases in shade, reductions in daytime stream heating and stream temperature reductions. Cumulative downstream effects also impact stream temperatures. The transport of cooler water downstream coupled with the reduced rate of daytime heating produce the cumulative effect of stream

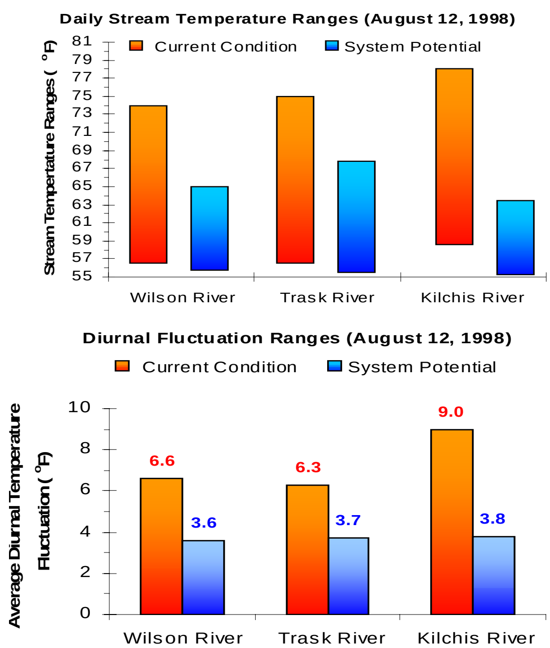
Figure 13. Stream Temperature Profiles (August12, 1998 - 6:00 PM) for current conditions, potential channel morphology and effective shade, and for the two combined (system potential) on the Kilchis, Wilson, and Trask Rivers.



temperature reductions. Changes in upstream temperature often affect the temperatures of downstream areas.

The cumulative effect of the system potential conditions is demonstrated in the simulated cooler downstream steam temperatures and narrower range of daily temperatures (Figure 11). The daily minimum temperatures reflect less daytime heat absorption, less daytime heat retention, and less heat advection (downstream transfer). When upstream sources of heat energy are reduced, the cumulative effect is reduced nighttime and morning stream temperatures that allow for a cooler starting point for the daily heating. Since daily heating processes are reduced, the diurnal rate of stream warming is also lower.

Figure 14. System potential temperature ranges
- *Less diurnal fluctuation*
- *Lower daily maximum values*
- *Lower daily minimum values*



The observed system potential temperatures are caused by the following relationships:
- Reduced rates of daytime heating,
- Less diurnal temperatures fluctuation.
- Lower daily maximum temperatures, and
- Cumulative effect - advection of cooler downstream temperatures and reduced rates of daytime heating.

3.1.7.2 Loading Capacity (Point Sources)

The Loading Capacity is dependent on the available assimilative capacity of the receiving water (river). For rivers whose system potential temperatures are at or above the temperature standard for a given period, there is no assimilative capacity and the loading capacity is zero. This means that the discharge of pollutants would not be allowed to increase the concentration of that pollutant outside of an appropriate mixing zone. The loading capacities of the 5 rivers in the watershed were presented in **Figure 11**. These loading rates are in terms of solar radiation and % effective shade, and provide the amount the river will absorb with the system potential riparian conditions in place. Ultimate temperatures at system potential were presented in Figure 13 and indicate what the temperature will be relative to the numeric criteria of the water quality standard.

Point Source Discharges currently are permitted only for sources on the Trask and Wilson Rivers. Under system potential conditions, the Trask River will still not meet the numeric criteria of the water quality standard in many places, particularly in the lower reaches of the watershed, and there is no allocable assimilative capacity. Temperatures in the Wilson River are expected to decrease below the migration and rearing temperature criterion (64°F) in the area where the Tillamook County Creamery Association (TCCA) operates at wastewater discharge to approximately 62.5°F (Figure 13). This means there will be approximately 1.5°F of assimilative capacity for the TCCA discharge.

3.1.7.3 Loading Capacity (Non-Point Sources)

Results of the simulations demonstrate that even with system potential conditions, water temperatures in some reaches of each of the rivers will continue to be above the numeric criteria of the water quality standard during the critical period. Though temperatures may decrease below the criteria in upper parts of the watershed, loading in these areas will typically result in failure to meet the criteria in lower reaches. Since there is no additional decrease in loading that can be obtained by control or management measures, there is no available loading capacity for anthropogenic non-point sources of heat.

3.1.8 Allocations – 40 CFR 130.2(g) and 40 CFR 130.2(h)

Loading capacity will be available for allocation where surface water temperatures throughout a given river decrease below the standard by an amount sufficient to accommodate either point-source or non-point source influences. In general, modeling has indicated there will be no assimilative capacity for non-point sources of heat in the watershed.

3.1.8.1 Wasteload Allocations (Point Sources) - Temperature wasteload allocations are determined based on defined conditions, or may be calculated for a discharge given site-specific flow and temperature information. Surface water discharges into receiving waters must not exceed the temperatures listed in **Table 8** or those calculated for other river flows as specified in **Table 8**. The wasteload allocation is the maximum allowable effluent temperature that, in combination with all sources, will remain within the loading capacity (as calculated through Equations 1 or 2). Permitted pointsource discharges only occur on the Wilson and Trask Rivers. Allocations are not provided for Rockaway Beach STP or Twin Rocks STP, which discharge to the Pacific Ocean, or for the City of Garibaldi STP and Bay City STP, which discharge to Tillamook Bay. These waterbodies are not water quality limited due to temperature.

Point Source allocations (Table 8) are the allowable effluent temperatures derived by DEQ (**using Equations 1 or 2**) and apply during the appropriate critical period. The assumptions used in evaluating the “no measurable increase as measured by 0.25°F at the edge of the mixing zone relate to both the standard and mixing zone policy. Wasteload allocations generally are based on 0.25°F allowable increase above system potential at edge of mixing zone using 25% of the receiving water volume for mixing, or other appropriate proportion related to the mixing zone as provided by the responsible permit writer. In the case of discharges to reaches with available assimilative capacity when system potential conditions are achieved (e.g., Wilson River) and additional allowance is given while ensuring that the WQS is met (e.g., Tillamook Creamery discharge). This latter case is calculated through **Equation 2**.

Critical Period

Critical periods for wasteload allocations are determined by distribution and use of the rivers by salmonid fishes based on information from ODFW (refer to Table 4). Wasteload allocations are calculated for the period of June through September based on the salmonid migration and rearing criterion of 64°F for all salmonid species. Spawning of chum salmon occurs in the lower reaches of the rivers from October through May. River flows are typically higher during this period (i.e., fall-winter-spring) than in the lower flow periods of the year, but allocations must be based on the spawning criterion of 55°F. October flows may still be quite low, so the low flow condition (7Q10) is included in Table 8 for the spawning period. An option to calculate the allocation based on real-time flow rates in the river would generally allow a higher allocation than that of 7Q10 flow conditions, and this would be appropriate for much of the summer and as flows increase in October.

Long-term flow records demonstrate that average monthly flows were lowest in August overall. These flows averaged 108 cfs in the Trask River and 110 cfs in the Wilson River. The use of these values in allocating effluent temperatures is meant as an example of how the volume of river flow affects the allocation at a given discharge rate. Discharging lesser volumes of effluent, or effluent at different temperature would have allocations derived from the appropriate formula.

Equation 1. Wasteload Allocation Calculation when system potential temperature is greater than the appropriate numeric criterion.

$$WLA = \frac{\left[\left(Q_E + \tfrac{1}{4}Q_R\right)\cdot\left(T_P + \Delta T\right)\right] - \left(\tfrac{1}{4}Q_R \cdot T_P\right)}{Q_E}$$

where,
WLA = Load Allocation (Allowable Effluent Temperature)
T_P = System Potential Temperature
T_C = Numeric Criterion
ΔT = Allowable Temperature Increase at Edge of Mixing Zone (0.25°F)
Q_E = Facility Design Flow
Q_R = Receiving Water Flow

In rivers where system potential conditions will result in temperatures below the migration and rearing standard, there will be some degree of assimilative capacity for point sources. This capacity will be divided among sources according to the following proportions (Table 7). The bulk of this assimilative capacity is reserved for future uses, some of which may be available for pollution trading scenarios.

Table 7. Proportions of Assimilative Capacity Provided to Various Uses.

Source	**Percentage**
Future Growth and development	75
Agriculture	0
Forestry	0
Urban Development	0
Permitted Discharges	25

Only the Wilson River has both a point source discharge (Tillamook County Creamery Association -- TCCA) and expected assimilative capacity. TCCA will be given half of the capacity provided to dischargers, or 12.5% of the total assimilative capacity for the river. The remainder will be held as a reserve. The effluent temperature allocation for TCCA when there is some assimilative capacity will be based on Equation 2. This allocation will only be realized when temperatures have decreased sufficiently to provide the expected assimilative capacity. Results are in Table 9.

Equation 2. Wasteload Allocation Calculation with assimilative capacity available.

$$WLA = \left[\left(Q_E T_P\right) + \left(Q_R\left(T_c - T_P\right)\times P_{WLA}\right)\right]$$

where,
WLA = Wasteload Allocation (Allowable Effluent Temperature)
T_P = System Potential Temperature
T_C = Numeric Criterion
Q_E = Facility Design Flow
Q_R = Receiving Water Flow
P_{WLA}= Proportion of Assimilative capacity for source.

Table 8. Temperature Wasteload Allocations for Point Sources at System Potential (SP).

Facility Name/Flow Conditions	Q_R River Flow Rate	Q_E Facility Flow (cfs)	T_E Critical Condition Effluent Temp.	T_C Numeric Criterion	ΔT Allowable Temp. Increase	T_A Load Allocation Allowable Effluent Temp.
Pacific Campground	**Wilson River**					
June through September Low Flow -- **7Q10**	48 cfs	0.08 cfs	70 °F	64 °F		77°F[2]
June through September Average Flow [1]	110 cfs	0.08 cfs	70 °F	64 °F	0.25°F	77°F[2]
October through May **7Q10**	48 cfs	0.08 cfs	70 °F	55 °F		77°F[2]
Other River and Effluent Flow Rates	**See Equation 1**					
Tillamook Creamery	**Wilson River**					
June through September Low Flow - **7Q10**	48 cfs	0.75 cfs	92 °F	64°F		68.25 °F
June through September Average Flow [1]	110 cfs	0.75 cfs	92 °F	64°F		73.4 °F
October through May **7Q10**	48 cfs	0.75 cfs	92 °F	55 °F	0.25°F	59.25°F
June through September Low Flow at SP-**7Q10**	48 cfs	0.75 cfs	92 °F	62.5°F		74.5 °F [3]
Other River and Effluent Flow Rates	**Equation 1 until System Potential achieved, then Equation 2**					
City of Tillamook STP	**Trask River**					
June through September Low Flow **7Q10**	54 cfs	1.64 cfs	71 °F	64°F		66.3 °F
June through September Average Flow [1]	108 cfs	1.64 cfs	71 °F	64°F	0.25°F	68.4 °F
October through May **7Q10**	54 cfs	1.64 cfs	71 °F	55°F		57.3 °F
Other River and Effluent Flow Rates	**See Equation 1**					
Tillamook Ind. Park STP **No Discharge June 1-October 31**	**Trask River**					
June through September Low Flow[4] **7Q10**	54 cfs	No Data	71 °F **[4]**	64°F		64°F
June through September Average Flow [1]	108 cfs	No Data	71 °F **[4]**	64°F	0.25°F	64°F
October through May **7Q10**	54 cfs	No Data	71 °F **[4]**	55°F		55°F
Other River and Effluent Flow Rates	**See Equation 1**					

1=Average Flows for August, which are typically lowest of the year.
2= Maximum allowable effluent temperature based on incipient lethality to salmonids (see Table 2).
3= Based on one-half of allocable assimilative capacity or one-eighth of total assimilative capacity.
4= Assumed temperature – no monitoring data available

3.1.8.2 Surrogate Measures and Load Allocations (Non-point Sources – *40 CFR 130.2(i)*

Load Allocations (Non-Point Sources) *- Since the* ***Loading Capacity*** *targets system potential (i.e. no measurable temperature increases from anthropogenic sources), 100% of the* ***Loading Capacity*** *is allocated to natural sources.*

Portions of the loading capacity are typically divided among natural, human and future non-point pollutant sources. **Table 9** lists load allocations (i.e. distributions of the loading capacity) according to land-use. In the Tillamook Bay Watershed, the loading capacity of the system is all allocated to natural sources since, even at system potential conditions, temperatures in the watershed will still exceed the standard in some reaches of some rivers. No assimilative capacity exists for the other sources. This requires that heat from non-point sources reduce temperature inputs to reach system potential conditions. The means of achieving these conditions is through restoration and protection of riparian vegetation and narrowing of stream channel widths. The remainder of this section describes how those conditions are assessed.

The Tillamook Bay Watershed 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."*

The non-point source assessment demonstrates that stream temperatures warm as a result of increased solar radiation loads, due to anthropogenic disturbance to near stream vegetation and channel morphology. 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 direct beam 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.

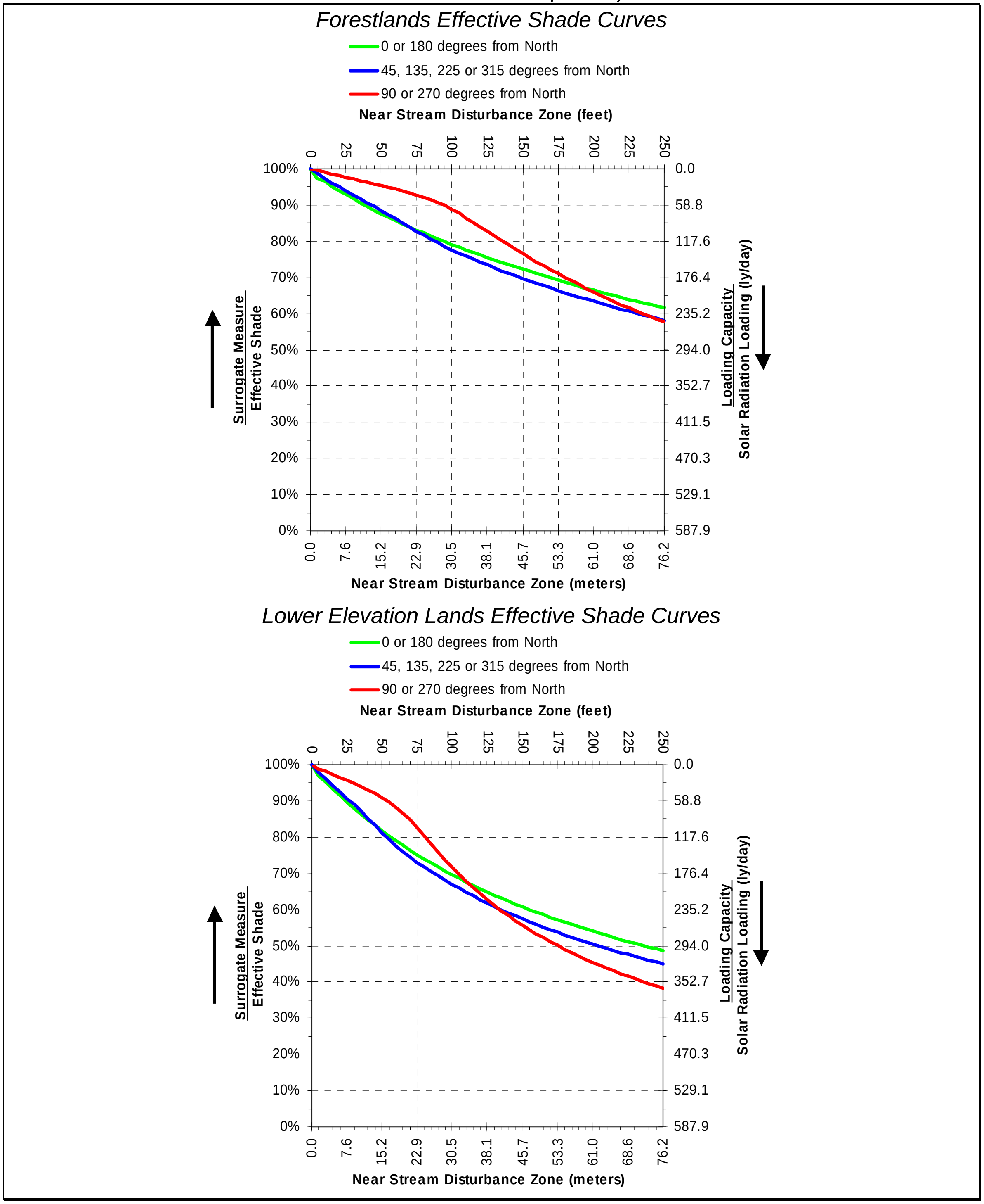
Table 9. Temperature Non-Point Source Allocation Summary

Non-Point Sources	
Source	*Loading Allocation* *Distribution of Solar Radiation Loading Capacity*
Natural	100%
Agriculture	0%
Forestry	0%
Urban	0%
Future Sources	0%

3.1.9 Site Specific Effective Shade Surrogate Measures

A load allocation in terms of Langleys per day is not very useful in guiding non-point 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. **Figure 15** displays effective shade curves that can be applied across areas where the site-specific surrogate measures are not developed.

Figure 15. Effective Shade Surrogate Measures as a Function of Channel Width *(August Solar Radiation Exposure)*



3.1.10 Water Quality Standard Attainment Analysis - – CWA §303(d)(1)

Simulations were performed to calculate the hourly 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.

*Maximum daily temperatures (displayed in **Figure 46**) represent the system potential when **no measurable surface water temperature increase resulting from anthropogenic activities** is allowed.*

A total of 74.6 river miles in the Kilchis, Wilson and Trask Rivers were analyzed and simulated during the critical period (August 12, 1998). **Figure 16** compares the current maximum daily temperatures with those that result with system potential conditions. Generally speaking, all of the analyzed rivers currently experience critical condition maximum daily temperatures in the upper-60^{o}F to low 70^{o}F range. Under the allocated system potential condition, maximum daily temperatures shifted to the lower-60^{o}F range. In 1998, 98.4% of the analyzed mainstem reaches had critical condition maximum daily temperatures greater than 64^{o}F, with approximately 85% exceeding 68°F. Under the system potential, 26% of the these reaches would experience maximum daily temperatures greater than 64^{o}F and none would exceed 68°F. The distribution of temperatures throughout the analyzed reaches is detailed in Figure 17.

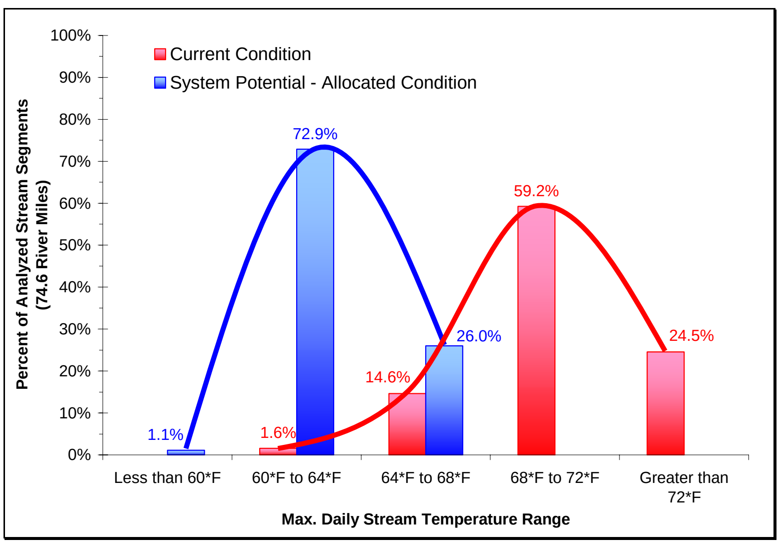


Figure 16. Distribution of Current Condition and System Potential Maximum Daily Stream Temperatures (August 12, 1998)

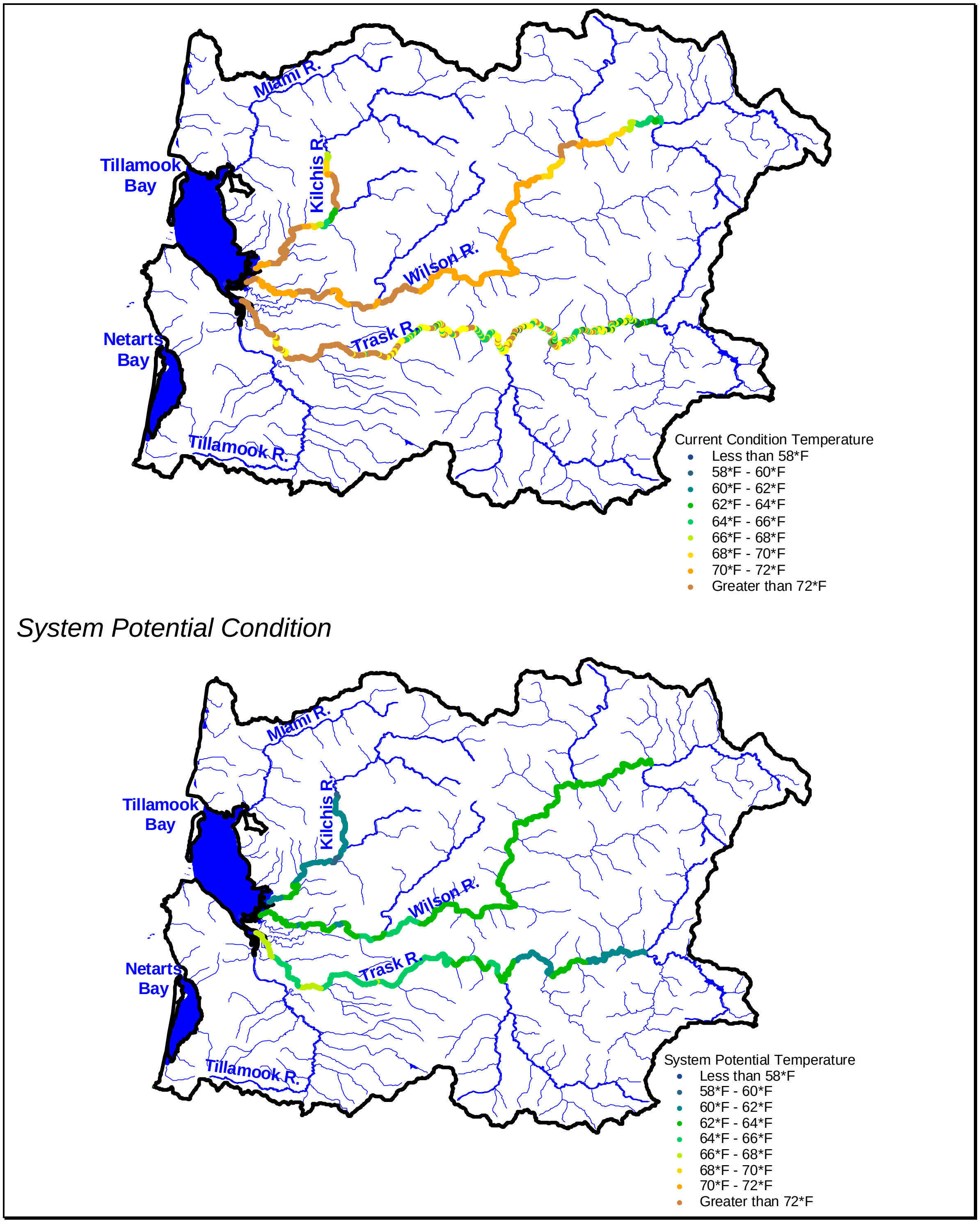


Figure 17. Current Condition and System Potential temperature distributions in the Tillamook Bay Watershed

3.2 Bacteria TMDL

Summary of Bacterial TMDL Development and Approach

Why Is Bacterial Contamination Important?

Bacterial contamination from a variety of sources accumulates in rivers, streams and Tillamook Bay throughout the year. This contamination is most severe during winter storms, but is sufficiently concentrated during dry weather to impair water quality relative to the beneficial uses described for the basin; particularly those of recreational use and commercial shellfish harvesting.

Scope

All lands (572 square miles) with streams that drain to Tillamook Bay within HUC 17100203 are included in the bacterial TMDL. All land uses are included: lands managed by the State of Oregon, the U.S. Forest Service (USFS) and Bureau of Land Management (BLM), private forestlands, agricultural lands, rural residences, military lands and urban areas.

Assessing Bacterial Contamination Processes and Setting Loads

To evaluate bacteria loading in the Tillamook Bay Watershed, an event based, unit load model was used. The model uses estimated peak flow, Event Mean Concentrations (EMC) for various land uses, and bacteria die off rates to predict total bacteria concentration and loads in the streams. Five major geographic data bases were used in this project: soils, land use, precipitation pattern, watersheds, and distance from the stream. These five data bases were overlaid in ArcView to create a composite GIS database, with over 12000 entries, which was used for estimating peak flow, travel time of overland flow in the watershed, the bacteria die-off rate as function of the travel time, and bacteria load. These parameters were modeled for all locations in the watershed. To calculate loading to the Bay, a bacteria die-off rate was incorporated for travel time instream to the Bay. Each of these parameters is discussed below.

Bacterial TMDL Overview

The bacteria TMDL provides an analysis of the sources and concentrations of fecal bacteria throughout the year in the Tillamook Bay Watershed. Loading capacity of the Bay is determined as a function of concentrations at the mouths of rivers that drain to the Bay. Allocations are expressed in terms of percent reductions for each land use in each of five major river subbasins.

3.2.1 Pollutant Identification

The pollutants identified for stream and bay bacterial pollution are human caused point and non-point source discharges of fecal bacteria loading to surface waters.

The pollutant causing impairment of 303(d) listed waters is fecal coliform bacteria. These bacteria are produced in the guts of warm-blooded vertebrate animals, and indicate the presence of pathogens that cause illness in humans. Although non-domestic animals are sources of the bacteria, human controlled sources demonstrably account for the greatest proportion in rivers and Tillamook Bay.

The method of fecal coliform bacteria analysis has also changed over time, with some DEQ samples 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.” Fecal coliform data have been combined for this report regardless of the analytical technique.

3.2.2 Target Identification – CWA §303(d)(1)

The bacterial TMDL is designed to protect two sensitive beneficial uses in two different landscape situations. Bacteria impair the recreational use of rivers if concentrations exceed those determined through epidemiological studies to cause illness through body contact at a rate of 8 or more cases per 1000 swimmers. Bacterial levels in estuarine shellfish harvesting waters must be lower than those used for body contact, as shellfish filter large volumes of water and accumulate bacteria and the pathogens they are associated with at concentrations higher than found in ambient water. Although recreational uses in rivers are considered safe if bacterial concentrations are higher than those allocated in this TMDL, protection of shellfish harvesting is a more sensitive beneficial use, and requires lower concentrations in the rivers to ensure low concentrations in the Bay. The TMDL targets river concentrations that will limit the loading to the Bay and result in low concentrations in shellfish harvesting beds.

The indicator bacterium used by DEQ for assessing bacterial contamination for recreational waters changed in 1996 from fecal coliform bacteria to *E. coli*, the species associated with gut flora of warm-blooded vertebrates. In general, *E. coli* are a subset of Fecal Coliform bacteria. This change was made in part because *E. coli* is a more direct reflection of contamination from sources that also carry pathogens harmful to humans and is correlated more closely with human disease. Fecal coliform bacteria are still used in the standard as the indicator for protection of human health in assessing water quality in commercial shellfish harvesting areas. These areas and monitoring of water quality associated with them are under the jurisdiction of the Oregon Department of Agriculture (ODA). Since there are two standards that use two different indicators, DEQ still samples and analyzes water for both. This has resulted in a large data set of paired samples that allow statistical analysis and development of a mathematical relationship. Although the relationship is significant, bacterial concentration estimates in environmental samples are not very precise, as indicated by substantial variability among paired and duplicate samples. This results in relatively large errors in estimates of fecal coliform from *E. coli* concentrations or vice-versa.

3.2.3 Sensitive Beneficial Use Identification

Beneficial uses in the Tillamook Bay Watershed are defined in the Oregon Administrative Rules (Table 10). The key beneficial uses affected by elevated concentrations of fecal bacteria are body contact recreation in rivers, and fishing (commercial shellfish harvesting) in the Bay. The Bay is divided by the ODA into areas with specific use designations for shellfish harvesting. Some areas do not support harvesting, while harvesting is allowed in others depending on flow rates in the Wilson River. There is potential for harvesting in areas that are currently categorized as restricted or prohibited for use.

Table 10. Beneficial uses occurring in the Tillamook Bay Watershed
(OAR 340 – 41 – 202)
Bacteria -Sensitive Beneficial uses are marked in gray

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

3.2.4 Water Quality Standard Identification

Bacterial criteria for the waters of the North Coast-Lower Columbia Basin are contained in the Oregon Administrative Rules (Table 11 and Appendix C of this document). The criteria for "bacteria in shellfish waters" apply to Tillamook Bay and the criteria for "recreational contact in water" applies to all other waters in the watershed. The beneficial uses affected by elevated bacteria levels are primary contact recreation (swimming) and shellfish harvesting (fishing).

Table 11. Water quality standards for the North Coast Basin of Oregon.

Parameter	**Description**
Bacteria in Shellfish Waters Marine Waters and Estuarine Shellfish Growing Waters: OAR 340-41-205 (2)(e)(A)(ii) and OAR 603-100-0010:	A fecal coliform median concentration of 14 organisms per 100 ml, with not more than ten percent of the samples exceeding 43 organisms per 100 ml. Fecal coliform median or geometric mean MPN of the water sample results shall not exceed 14 per 100 ml, and not more than 10% of the samples shall exceed 43 colonies per 100 ml for a 5 tube decimal dilution test. A minimum of the most recent 15 samples collected under adverse pollution conditions from each sample station shall be used to calculate the median or geometric mean and percentage to determine compliance with this standard.
Recreational Contact in Water OAR 340-41-205 (2)(e)(A)(i):	Prior to March 1996: a geometric mean of five fecal coliform samples should not exceed 200 colonies per 100 ml, and no more than 10% should exceed 400 colonies per 100 ml. Effective March 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.

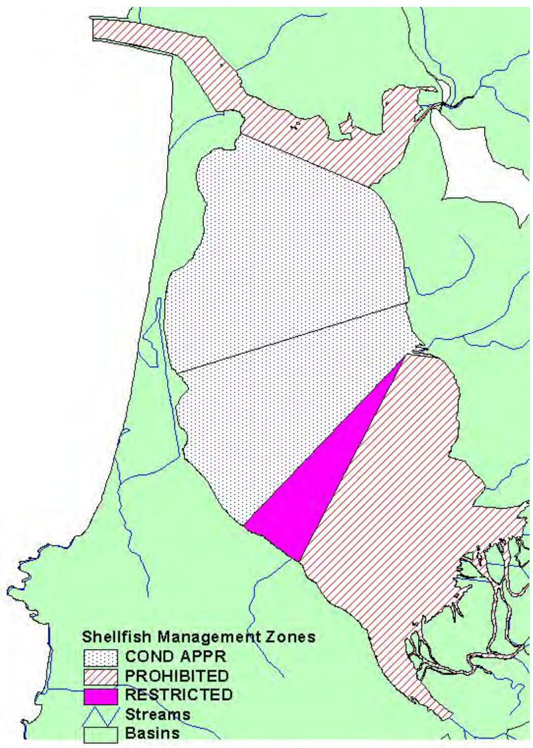
As stated earlier, the shellfish harvesting standard is still based on fecal coliform bacteria indicator, because the national standard has not changed. The appropriate WQS for comparison of data in this document are those in effect prior to March 1996, which specify a geometric mean of five fecal coliform samples must not exceed 200 colonies/100 ml, and no more than 10% may exceed 400 colonies per/100 ml.

Much of the data available for this watershed were fecal coliform concentrations as these were collected for years before the standard changed, and ambient monitoring has included both fecal coliform and *E. coli*. Since the shellfish harvesting standard is still based on fecal coliform, all analyses and descriptive statistics are based on this indicator. This necessitates observance of the recreational contact standard in effect prior to 1996 in describing concentrations in rivers.

3.2.5 Deviation from Water Quality Standard (Bacterial Impairments)

3.2.5.1.Tillamook Bay

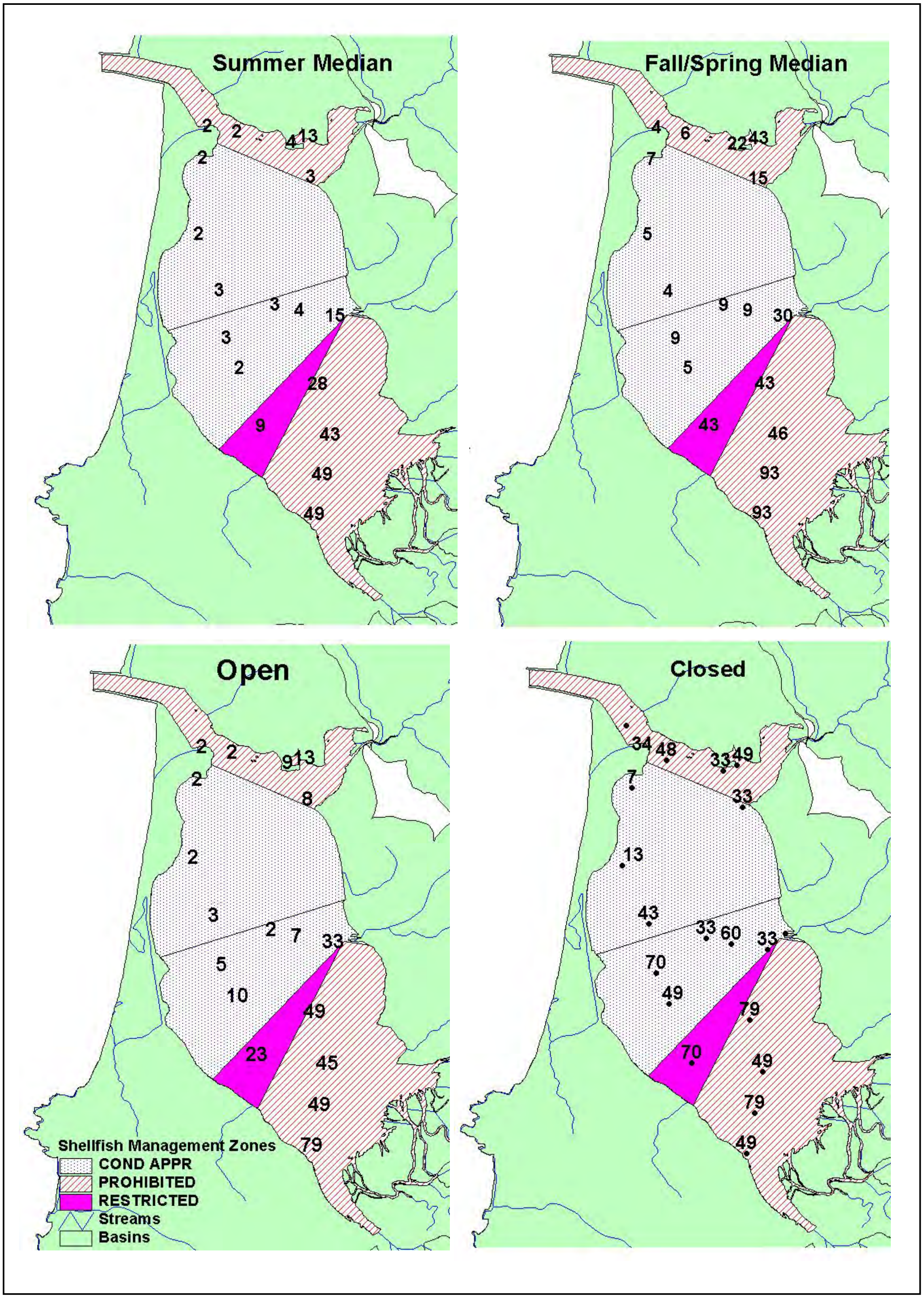
Tillamook Bay is categorized among three conditional use states for shellfish harvesting based on likelihood of contamination by fecal coliform bacteria (example at right). These are conditionally approved, restricted and prohibited areas. Shellfish harvesting is allowed in the conditionally approved areas unless river flow or rainfall increase beyond limits specified in the Tillamook Management Plan for Commercial Shellfish Harvesting (Appendix E). When these conditional limits are exceeded, harvesting is prohibited, and cannot resume during a period specified for a given conditionally approved area. Restricted use has a limited degree of pollution to the extent that shellfish may be made safe for human consumption by *relaying or depuration*[7] Prohibited areas are principally designated around the mouths of the Rivers that enter the bay, and where sewage treatment plants discharge to the Bay. Shellfish harvesting is not allowed in any prohibited area. Although the commercial harvest of shellfish is regulated under a management plan, ODA must react to changes into an area's compliance with the fecal coliform standard for shellfish growing waters. Reactions may include temporary closures or bay management plan changes requiring closures for predictable increases in fecal coliform levels.



Fecal coliform concentrations in the Bay are routinely monitored by ODA when the bay is open to commercial shellfish harvesting as part of the shellfish program. Median concentrations in both summer and winter generally meet the standard for shellfish harvesting when the conditionally approved areas are open for harvesting (Figure 18). Concentrations in the Prohibited sections of the Bay exceed the standard for protection of shellfish harvesting more often than not regardless of flow conditions in the rivers. Concentrations in the Restricted area typically meet the standard when flows are low in the summer period and exceed the standard throughout the fall-winter-spring period and when flows are above the 7-foot stage.

[7] Relaying or Depuration of shellfish requires moving the live animals to purified, controlled conditions for sufficient time to become safe for consumption.

Figure 18. Median Concentrations of fecal coliform bacteria in Tillamook Bay during (l-r;t-b): summer, Fall through spring, Open to harvesting, closed to harvesting.



3.2.5.2 Rivers of the Tillamook Bay Watershed – Long-Term Data

Concentrations of fecal coliform bacteria in rivers throughout the basin often exceed one or more water quality standards (WQS). Routine and synoptic water quality data show violations of the bacteria criteria occur in the 5 major rivers and in several creeks in the basin. Violations were more common in the lower elevations of the watersheds associated with agriculture, rural and urban development.

To determine if there are spatial or temporal distributions of the bacteria apparent in the historical data, seasonal box plots were created for each of the five rivers in the Tillamook Bay Watershed. An explanation and description of box plots is provided in the Glossary. The summer season is defined as the period from June through September (Figure 19), when primary contact recreation is most likely. The remaining months of the year are designated as fall through spring (Figure 20). Water quality data for each river basin are discussed separately below. The data was retrieved from STORET for the dates and locations listed on the plots. Because the data was collected intermittently, sampling may not have occurred during rain events.

The Kilchis River basin covers an area of about 65 mi^2, with forest as the predominant land use (63 mi^2). Agriculture covers a relatively small area of the Kilchis basin (1.3 mi^2). The observed data indicate common violations of the bacteria criterion in the summer months near the mouth of the river. More than 10% of the samples exceed 400 fecal coliform/100 ml. During the fall-spring period, the fecal coliform criterion was not violated on the river

The Miami River basin covers an area of about 36 mi^2. The predominant land use is forest (34 mi^2), followed by agriculture (1.4 mi^2). The observed data exceed the bacteria criterion near the mouth throughout the year.

The Trask River basin includes approximately 169.5 mi^2. Forested areas cover 156 mi^2 and agriculture covers about 11 mi^2 in the basin. Urban and rural residential development covers 1.2 mi^2 and 1.4 mi^2, respectively. Two wastewater treatment plants discharge to the Trask River; the Port of Tillamook Bay wastewater treatment plant discharges to the river during the fall-spring period at river mile 5.2 and the City of Tillamook discharges year around at river mile 1.9. The Trask River is not on the 303(d) list for bacteria, however examination of the historical data reveals violations of the criterion. At the lower river miles, the criterion (no more than 10% of the samples can be greater than 400 counts/100 ml) is exceeded throughout the year.

The Tillamook River Basin extends over approximately 62 mi^2, with forests covering 45 mi^2. Of the five river basins, agriculture covers the largest percentage in the Tillamook Bay Watershed; about 20% or 13 mi^2. Rural residential and rural industrial land uses each cover about 1.6 mi^2. Many of the samples in this data set were not diluted adequately, resulting in underestimates of concentration. This makes the comparison of stations along the river ill-advised. However, the data clearly indicate the WQS are exceeded throughout the year over much of the river.

The Wilson River basin covers about 192 mi^2, with 184 mi^2 covered with forests. Agriculture accounts for about 5 mi^2 and rural residential development covers about 3 mi^2. The Tillamook County Creamery Association (TCCA) discharges a mix of treated domestic and industrial waste to the Wilson River at river mile 1.6 throughout the year. Dilution of TCCA effluent varies with tidal cycles, as velocity of the receiving water varies. The Wilson River data set (DEQ data) also contains many estimated values in samples collected from river miles 1.4 to 1.8. Despite this, these data indicate that fecal coliform concentrations exceed the WQS near the mouth throughout the year below river mile 4. Concentrations were relatively low in the upper, forested part of the watershed.

Based on review of these data, two segments of the Bay and 13 reaches of streams or rivers were included on the 1998 303(d) list submitted by DEQ (Tables 12 and 13). These listed reaches account for nearly 65 miles of waterway within the watershed.

Table 12. Segments listed for Bacteria (Marine and shellfish growing area – fecal coliform) in Tillamook Bay on the 1998 303(d) List:

Waterbody Name	Location	Year-around
Tillamook Bay - Main	Marker No. 19 to South Bay	X
Tillamook Bay - Upper	Southeast Bay to Dick Point	X

Table 13. Segments listed for Bacteria [Water Contact Recreation (fecal coliform-96 Std)] in the Tillamook Bay Watershed on the 1998 303(d) List:

Waterbody Name	Miles	Fall-Winter-Spring	Summer
Bewley Creek (mouth to river mile 2)	2.0	X	X
Doherty Slough (mouth to headwaters)	4.9	X	X
Holden Creek (mouth to headwaters)	3.6	X	X
Hoquarton Slough (mouth to headwaters)	3.1	X	X
Kilchis River (mouth to Little So. Fork Kilchis River)	6.3	X	X
Killam Creek (mouth to headwaters)	5.8	X	X
Miami River (mouth to Stuart Creek)	5.6	X	X
Mill Creek (mouth to headwaters)	1.4	X	X
Mills Creek (mouth to USFS boundary)	1.2	X	X
Murphy Creek (mouth to headwaters)	2.5	X	X
Simmons Creek (mouth to 0.5 mi. upstream Hwy 101)	1.0	X	X
Tillamook River (mouth to headwaters)	18.5	X	X
Wilson River (mouth to Little North Fork Wilson River)	8.5	X	X
Total Miles	**64.4**		

Figure 19. Concentrations of fecal coliform bacteria in each river during the low-flow period of the year; June through September. Duration of data record and number of samples varies for each river. River Mile 0 represents the mouth of each river.

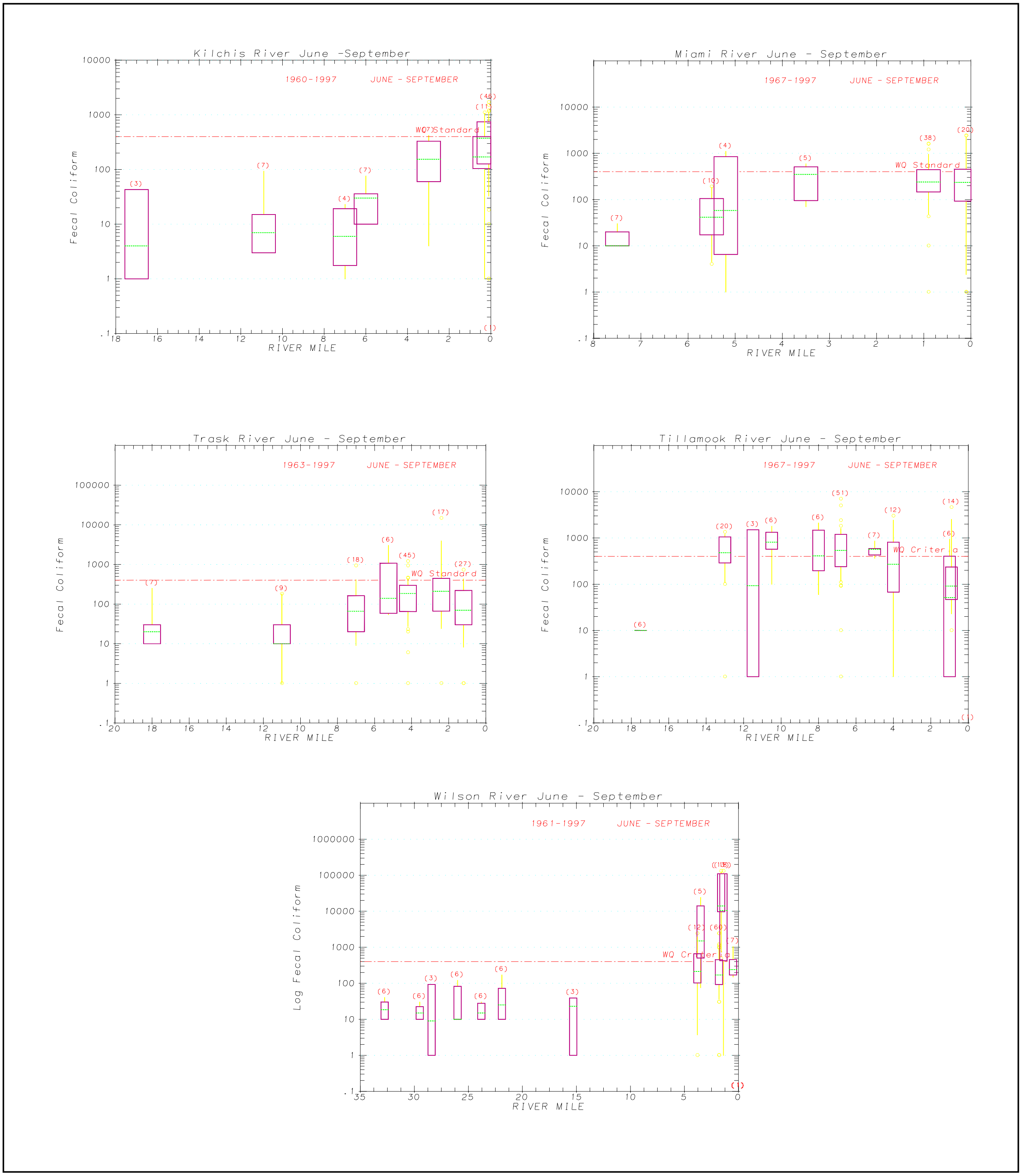
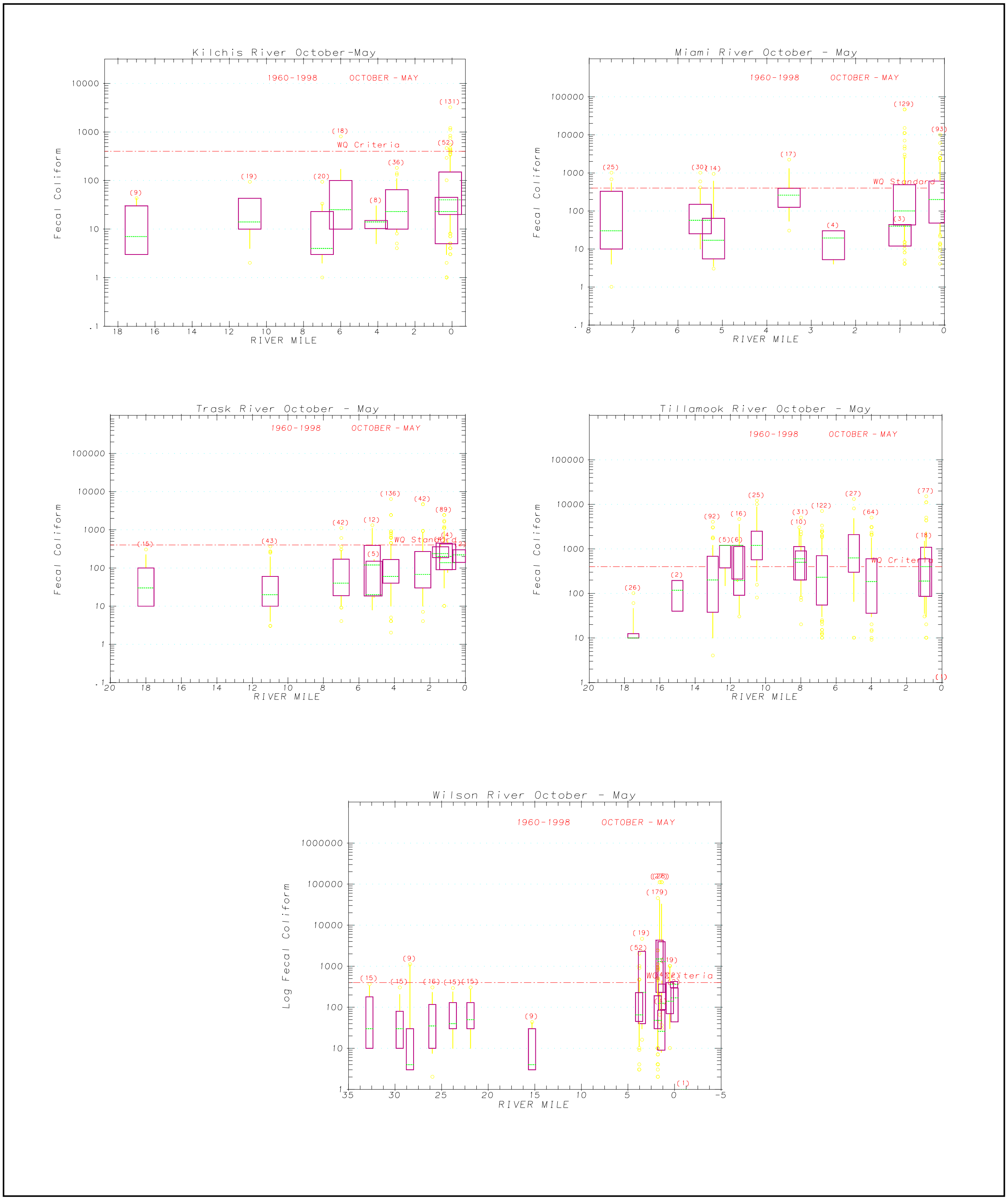


Figure 20. Concentrations of fecal coliform bacteria in each river during the wet period of the year; October through May. Duration of data record and number of samples varies for each river. River Mile 0 represents the mouth of each river.



3.2.5.3 Tillamook Bay Watershed – Stormwater Sampling

Intensive storm sampling has been conducted on all 5 rivers at various times over the years. The most recent data was collected in October 1997 and March 1998 (Figure 21). The Tillamook Bay National Estuary Program, DEQ and Tillamook County Creamery Association (TCCA) shared sampling responsibility in the March 1998 event. In general, concentrations were higher in the October 1997 event than in the March event. The observed differences in concentration may be explained by rainfall intensity or by prior rainfall patterns. Though somewhat different, both storms were relatively large, with peak rainfall rates of 0.48 and 0.30 inches per hour (measured at the Oregon Department of Forestry gage in Tillamook), in October and March, respectively. Early rainy-season storm events typically show higher concentrations of pollutants in runoff due to accumulation on land over the dry period. Additionally, review of historical data suggests that instream concentrations in later storms would be lower.

Concentrations in the Kilchis and Miami Rivers were comparatively low during storms, and did not exceed the standard for contact recreation. These two rivers were only sampled in the late winter storm, when concentrations were lower among the other rivers.

The Trask River exceeded the recreational standard (200 COUNTS/100ml geometric mean) at all sites during the October 1997 storm. During the March 1998 storm, however, geometric mean concentrations were generally below the standard. This pattern was also observed in the Tillamook River data for the two storm events. All sites violated the criteria in the October storm, while only the sites near the mouth violated the fecal criteria in March.

During the October 1997 storm, all concentrations exceeded the criteria in all samples collected below river mile 7.4 on the Wilson River. In March 1998 the criteria were exceeded only at river mile 1.3. These data cannot be directly compared to DEQ historical ambient monitoring data since DEQ did not sample the same sites as TCCA. In particular, DEQ has limited data from river mile 3.8 to river mile 15.3. However, increases in bacteria concentrations generally occur as the land use changes from predominantly forest to include agriculture, residential and the TCCA wastewater discharge.

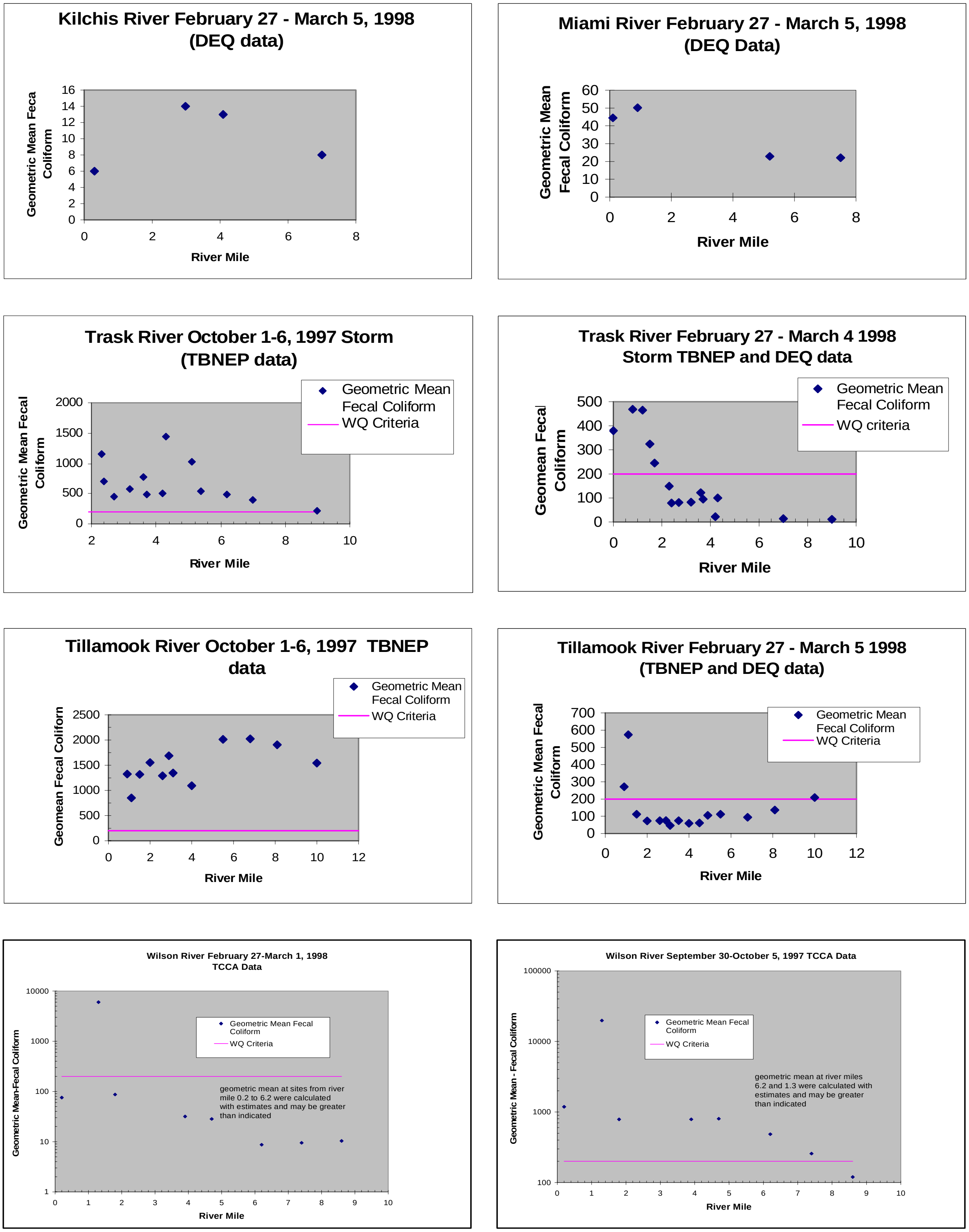
3.2.5.4 Summary of Bacterial Contamination Data

River bacterial concentrations were generally slightly higher during the summer (June-September) than in fall-spring (October-May). This is likely due to dilution by rainfall during the high runoff period, despite this runoff also carrying accumulated bacteria to the rivers.

Bacterial concentrations were lowest in the Kilchis and Miami Rivers throughout the year, followed by the Trask, Wilson and Tillamook. Concentrations were low through most of the Trask and Wilson watersheds, where higher elevation forests are the primary landuse, while they were relatively high through most of the Tillamook except the uppermost reaches.

Stormwater runoff resulted in some of the highest concentrations observed in the watershed. However, concentrations were much higher in the fall storm than in a late-spring storm. This is most likely a result of cleansing of the land by early season storms and comparatively less accumulation during the winter months than over the summer.

Figure 21. Geometric Means of bacterial concentration during storms in each of the major rivers.



3.2.6 Source Identification

3.2.6.1 Point Sources:

The Tillamook Bay drainage basin has four domestic wastewater treatment plants that discharge to the Bay or rivers. The Tillamook County Creamery Association (TCCA) operates a combined domestic and industrial treatment plant that discharges to the Wilson River. The locations and permit limits are summarized below in Table 13. Table 14 lists the remaining facilities covered by NPDES permits in Tillamook Bay Watershed (except for construction permits).

Table 14. Individual NPDES Permits

Facility Name	Discharge Point	Permit Limits
Port of Tillamook Bay	Trask River at RM 5.2	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
City of Tillamook	Trask River at RM 1.9	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
City of Bay City	Tillamook Bay	Monthly geometric mean of 80 /100 ml Weekly geometric mean of 160 /100 ml
City of Garibaldi	Tillamook Bay	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
Pacific Campground[8]	Smith Creek →Boquist Slough→Wilson River	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
TCCA	Wilson River RM 1.3	Monthly geometric mean of 200 /100 ml No more than 10% of monthly samples > 400 /100 ml

3.2.6.2 Non-point Sources

There are several types of land use in the Tillamook Bay Watershed (Table 15), each of which is a potential source of bacterial runoff. Land uses have been broken down into more discreet categories for bacteria than for temperature. These uses differentiate between agriculture, agriculture/forest margins, farm buildings, and rural residential uses for instance. Confined animal feeding operations (CAFOs) are included in the farm building and farm building/agriculture category. Runoff from each of the land use types contributes to instream fecal coliform concentration and each category was included in the modeling of bacterial accumulation. Failing septic systems, which may be associated with either urban or rural residential development, may also contribute bacterial loads to the rivers. Concentrations typically associated with each land use are described in Appendix B.

Although land uses were divided into many categories, the majority of the area was accounted for by just a few of these land uses (Figures 22 and 23). Concentrations of bacteria in runoff from these land use types were derived from literature and from analysis of samples from the basin (Table 15). Proportions of a given land use were relatively similar among the Miami, Kilchis, Wilson, and Trask River watersheds, with more than 90% covered by forest lands and 7% or less in agriculture. The Tillamook River Watershed had significantly more land devoted to agricultural uses (approximately 21%) than the other basins. The Tillamook watershed also has the greatest proportion of land in the rural industrial and rural residential land use categories.

[8] Model resolution not detailed enough to identify sources to mainstem.

Table 15. General NPDES Permits

Facility Name	Receiving Water	Permit Type		Status
Tillamook County Landfill	Tillamook	GEN17	Vehicle Wash Water	Wash water not expected to contain fecal coliform
Pacific Coast Timber Company	Kilchis	GEN12A	Quarries	Discharge not expected to contain fecal coliform
Smith's Pacific Shrimp Company[9]	Tillamook Bay	GEN09	Seafood Processing	Permit limits based on effluent guidelines, fecal coliform not expected in effluent
East Fork Trask Pond	East Fork of Trask River	GEN03	Fish Hatcheries	No reasonable potential for fish hatcheries to be a significant source of fecal coliform (cold blooded animals)
Trask River Hatchery	Trask	GEN03	Fish Hatcheries	No reasonable potential for fish hatcheries to be a significant source of fecal coliform (cold blooded animals)
S-C Paving Company	Trask	GEN12A	Quarries	Discharge not expected to contain fecal coliform
Tillamook Lumber Company[10]	Holden Creek →Trask River	12Z Industrial Storm Water	Pulp, Paper or Hardwood	Sampled, average runoff concentration of 1900 FC/100 ml, modeled as point source
Tillamook County Landfill	Tillamook River	12Z Industrial Storm water	Inactive Landfill	Sampled, median of values from 1985-1997 is 43 FC/100 ml, modeled as point source
Northwest Hardwoods[11]	Tillamook Bay	12Z Industrial Storm water	Wood Products	April 99: 500 FC/100 ml, May 99: < 10 FC/100 ml, impact on Bay not modeled
Merrill Auto wrecking	Tillamook Bay	12Z Industrial Storm water	Auto wrecking	Discharge not expected to contain fecal coliform
Tillamook Creamery	Wilson River	12Z Industrial Storm water	Milk Products Processing	Sampled, results used in model
Port of Tillamook Bay	Anderson Crk. →Trask River	12Z Industrial Storm water	Domestic wastewater treatment facility	Sampled, results used in model, modeled under industrial land use category

[9] Contribution not included in model, discharges to Bay not river mainstems.

[10] Modeled as a source to the mainstem, model resolution not detailed enough to include tributary sources

[11] Contribution not included in model, discharges to Bay, not river mainstems.

Figure 22. Percentage of area in various land uses for each of the major river watersheds. Land uses with less than 1% area are not included in chart.

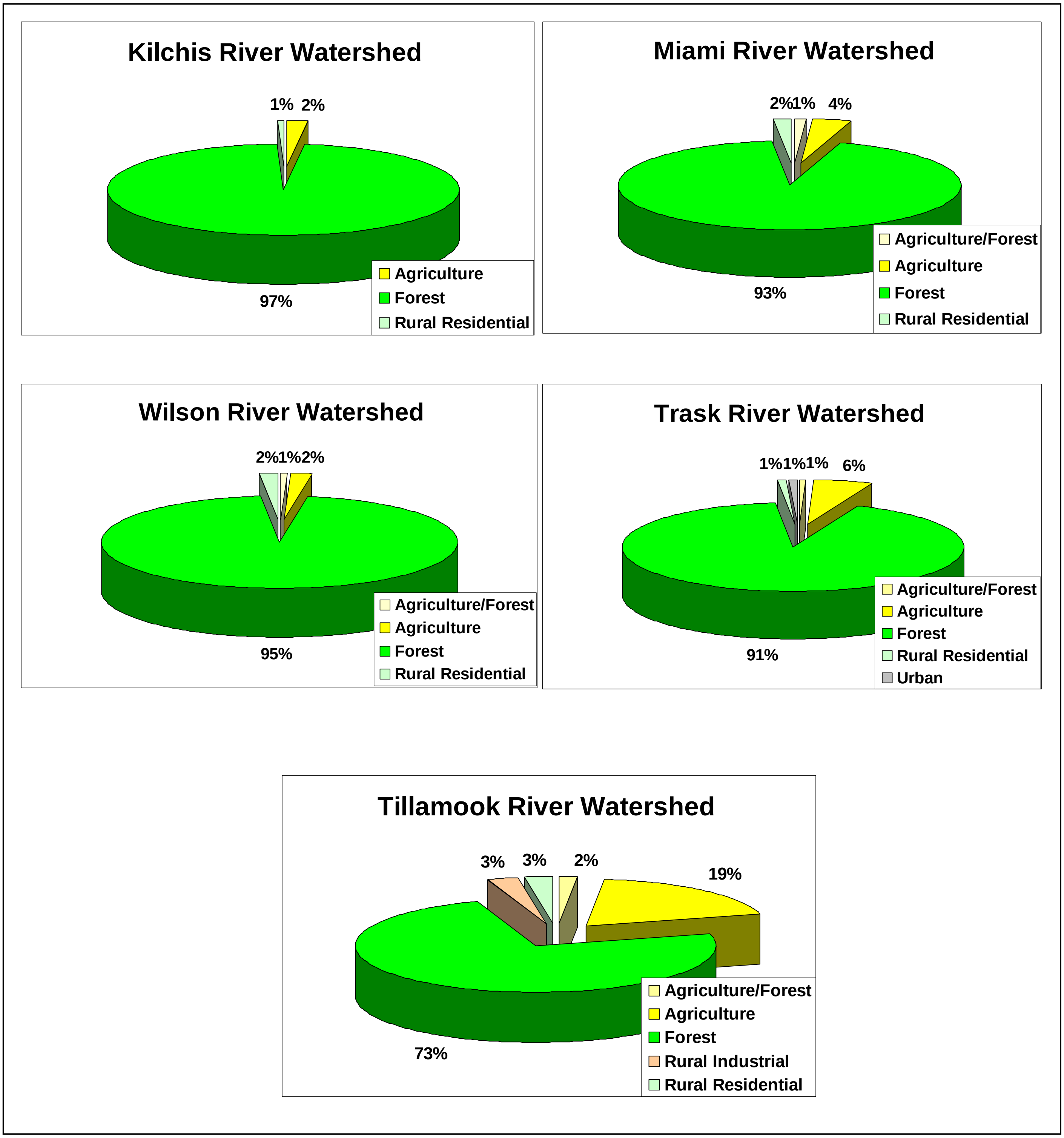


Figure 23. Landuse distributions and watershed boundaries in the Tillamook Bay Watershed.

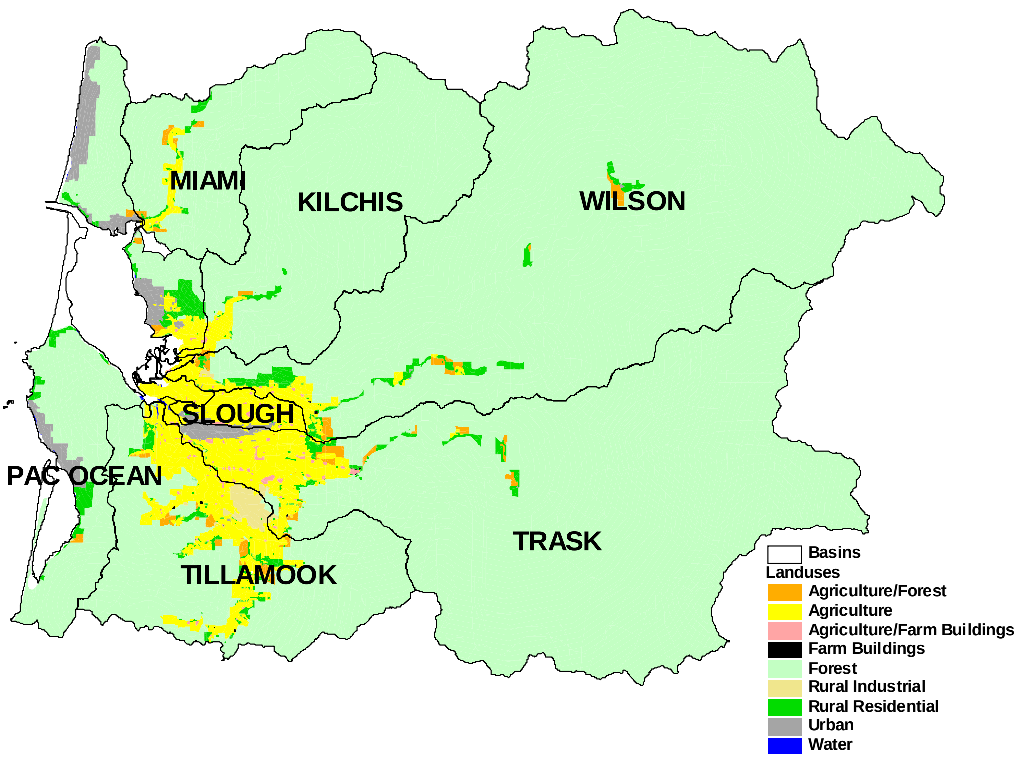


Table 16. Bacterial Concentrations associated with various Land Uses.

Land Use	Concentrations used in calibration to October 1997 storm data (counts/100ml)	Concentrations after 95% reductions (counts/100ml)	Concentrations after 99 % reduction (counts/100ml)
Agriculture/Forest[1]	25	1	0
Agriculture[2]	20000	500	100
Agriculture/Farm Bldg.[2]	100000	0	0
Farm Buildings[2]	100000	0	0
Forest[1]	25	1	0
Rural Industrial	1500	75	15
Rural Residential	9000	450	90
Urban	7000	350	70
Failing Septic[3] Systems	20000	0	0

1 = Considered natural minimum; will not be assigned an allocation.
2 = Assigned a discharge limit of zero based on terms of CAFO permits.
3 = Assigned a discharge limit of zero based on state requirement.

3.2.7 Loading Capacity:

The loading capacity is set to meet the shellfish criterion requiring that the median of fecal coliform concentration be no greater than 14 COUNTS/100mL in the Bay. This loading capacity relies on achieving low concentrations of bacteria in the rivers and dilution with bacteria free water in the Bay. River water is diluted by saline Bay water and conductivity increases with distance into the Bay from the river mouths. A dilution ratio of approximately 3:1 was determined based on examination of the conductivity data from shellfish monitoring stations throughout the Bay. Details of this dilution calculation are in Appendix B. There was no seasonal variation in the dilution at sites in the conditionally approved zones in the Bay. Therefore, given a concentration of 42 COUNTS/100 ml at the River mouths and the 3:1 dilution ratio, the fecal coliform standard would be met at the conditionally approved shellfish harvesting areas. The load capacity of 42 COUNTS/100 ml at the river mouths is in effect throughout the year to attain the shellfish criterion in the Bay. This load will also result in attainment of the recreational criterion in the Rivers and Bay.

3.2.7.1 Current loads

To evaluate bacteria loading in the Tillamook Bay Watershed, an event-based, unit-load model was used. The model uses estimated peak flow, Event Mean Concentrations (EMC) for various land uses, and bacteria die off rates to predict total bacteria concentration and loads in the streams. Details of this model are discussed in Appendix B. Concentrations were estimated based on data or literature values (see Appendix B for details of landuse runoff concentrations) and then adjusted to provide the best fit to measured concentrations of bacteria.

3.2.7.2 Background:

Background is defined as the concentration of bacteria in water where there are very limited human sources. Sites in forest lands that had historical data available were selected for data review. The median concentration of all the instream fecal coliform samples collected at the sites was 10 COUNTS/100 ml in all seasons. The value was chosen as the background instream concentration.

3.2.7.3 Seasonal Variation:

Seasonal differences were addressed in the allocations in two ways. First, winter (October through May) and summer (June – September) flows were simulated as described in Table 14, using daily mean flow. The Wilson River was chosen for simulation because the period of record (1932 through 1998) was the longest of the five rivers and could be used for frequency analysis, and closure of shellfish harvesting is based on Wilson River flow. Once the flow distribution was calculated for the river (Table 16), storms with rainfall intensities that resulted in these flows were modeled to determine loading rates. Secondly, the instream decay coefficient was increased for the summer allocation simulation to reflect higher decay during summer.

Table 17. Seasonal Wilson River Flows. Values are 90^{th} percentile of flow distribution from 1932-1998.

Season	Flow at gage (CFS)
Summer (June-September)	356
Winter (October-May)	3700
Closure Periods	6515
Minimum Flow for Bay closure	2500

3.2.8 Allocations:

Allocations are the amounts of bacteria that various sources are allowed to discharge. In the case of point sources, these allocations will guide the development of NPDES permit limits. In the case of nonpoint sources, they will be targets that management practices will be designed to meet.

3.2.8.1 Point Source Allocations

The shellfish standard has two components. Meeting either of these components defines compliance with the standard. The limits in the standard are based on two points in the distribution of sample values; the 50th percentile (or "median" can also be met with a geometiric mean) may not exceed 14 MPN/100 ml, and the 90th percentile ("no more than 10% of samples may exceed") value of 43 MPN/100 ml.

The basic allocation allows a dilution ratio of 3:1, but does not give any allowance for decay. This basic allocation was given to the discharges to the Bay resulting in a concentration of 42 MPN/100 ml prior to dilution, with no more than 10% of samples to exceeding a limit of 129 MPN/100 ml prior to dilution. Discharges to the Bay are not given an allowance for decay, since the time of travel to the shellfish beds is variable and generally short throughout the year.

Discharges to the river were given the basic allocation described above, but are also given an allowance for decay based on temperature and velocity in the rivers. These factors result in the allocations presented in Table 18. Calculations resulted in concentrations that exceeded the criteria set for recreational contact (based on the fecal coliform standard used by DEQ prior to 1996) in some cases. These concentrations (City of Tillamook and Port of Tillamook Bay in summer only) were reduced to those criteria for allocations.

Table 18. Allocations of bacterial concentrations for individual NPDES permitted facilities.

Facility Name	Discharge Point	**FWS** Geometric Mean	**Summer** Geometric Mean	**FWS** 90th percentile	**Summer** 90th percentile
City of Bay City	Tillamook Bay	42	42	129	129
City of Garibaldi	Tillamook Bay	42	42	129	129
Port of Tillamook Bay	Trask River at RM 5.2	65	200[a]	200	400 [a]
City of Tillamook	Trask River at RM 1.9	49	200 [a]	151	400 [a]
Pacific Campground[12]	Smith Creek - Boquist Slough→Wilson River	46	74	140	226
TCCA	Wilson River RM 1.7	48	109	149	336

a = Calculated concentrations were higher than recreational contact standard criteria and were set at those criteria.
FWS = Fall-Winter-Spring

As indicated in Table 15, general permits for most other operations and facilities in the basin were not expected to produce or discharge bacteria, so are not allocated. Those that were expected to discharge bacteria were included in the model.

3.2.8.2 Non-point Source Allocations

As discussed previously, the allocations are set to meet a concentration of 42 counts/100mL at the mouth of each river. The allocation method allows for attainment of the criteria to be determined for each river separately through different runoff concentrations (Table 18). Runoff concentrations also vary by flow rate (a seasonal consideration). Allocation concentrations presented below are those associated with each land use prior to mixing with a waterbody. These concentrations in runoff would be diluted locally by the indicated volume of river water without causing the concentration to exceed the instream recreational standard or the river mouth allocation. The categories Farm buildings and Agriculture Farm Buildings (refer to Table 15)

[12] Model resolution not detailed enough to identify sources to mainstem.

receive a zero allocation as they are allowed zero discharge under the terms of their CAFO permits. Failing septic systems also receive a zero allocation since the failure is a result of maintenance and is not permitted under state law.

Each run of the model produced target runoff concentrations for each land use and an instream concentration at the mouth of a given river. Initial runoff concentrations for each land use were calibrated for the October 1997 storm. Simulations for each river were run at a range of flows that corresponded to the Wilson River flow at various sized flow events. The cumulative loads for each river were reduced with subsequent model runs until the instream concentration at the mouth approximated the allocation target of 42 COUNTS/100 ml. Reductions of 90% or greater relative to the October 1997 storm were required to meet the instream allocation. Where a reduction of 99% did not meet the targeted instream concentration, the runoff targets resulting from this degree of reduction is the allocation. Allocations were reduced by the same proportion across all land uses except forestry, which was considered at a natural minimum.

The Tillamook River will require the greatest percent reduction of the rivers under all flow conditions. This is due to the density of agricultural land in the basin and the small size of the basin (62 mi^2), which results in less flow available to dilute runoff concentrations. Some apparent land uses are included in the overall allocation. Farm buildings and pastures that have had manure applied to them are set at zero allocation because of the effluent guideline requiring CAFOs to have a zero discharge to surface waters.

Table 19. Allocations for bacteria in runoff from various land uses[1] in rivers of the Tillamook Bay Watershed. All flow scenarios are based on events that caused the indicated flow in the Wilson River[2].

Miami River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Miami River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
1042	38	800	280	360	60	96
623	40	1000	350	450	75	95
93	42	15400	5390	6930	1155	23

Kilchis River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Kilchis River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
2826	41	3000	1050	1350	225	85
1678	42	3600	1260	1680	270	82
224	21.7	20000	7000	9000	1500	0

Wilson River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Wilson River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
6548	40	1200	420	540	90	94
3820	42	1400	490	630	105	93
366	42	5600	1960	2520	420	72

Trask River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**					
Trask River Flow (cfs)[2]	*Instream Target*	**Ag**	**Urban**	**Rural Resid.**	**Rural Industrial**	**Percent Decrease**
5389	39	600	210	270	45	97
3187	40	800	280	360	60	96
398	41	4600	1610	2070	345	77

Tillamook River	**Target Runoff Allocations by Land Use (FC cts/100 ml)**

Tillamook River Flow (cfs)[2]	*Instream Target*	Ag	Urban	Rural Resid.	Rural Industrial	Percent Decrease
1061	36	200	70	90	15	99
623	34	200	70	90	15	99
68	37	1200	420	540	90	94

1 = Forest bacterial concentrations were considered at a natural minimum, so were not given allocations. Farm Buildings, and Ag/Farm Buildings are not allowed to discharge under conditions of CAFO permits, and failing septic systems are not allowed under state law, so were not given allocations.
2 = Flows in the Wilson River were used to model flows in the other rivers, and all modeling was based on these relationships.

3.3 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).

3.3.1 Two Types of Margin of Safety

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 21** presents six approaches for incorporating a MOS into TMDLs.

Table 20. 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.

3.3.2 Implicit Margins of Safety used in Tillamook Bay Watershed TMDLs

Description of the MOS begins with a statement of assumptions. A MOS has been incorporated into both the temperature and bacteria assessment methodology.

For temperature, 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.

The margin of safety for the bacteria TMDL is also addressed through conservative modeling. First, no salinity or temperature effects on bacteria decay rate in the Bay were considered. Increased salinity in the Bay would be expected to decrease the bacteria concentrations through higher decay rates. Secondly, the model accounted for dilution by summer storm baseflow under all conditions; winter storm baseflow would be higher and lead to greater dilution instream for a given runoff load. By underestimating the dilution effects of baseflow in winter storms the modeled concentrations will appear higher than actual.

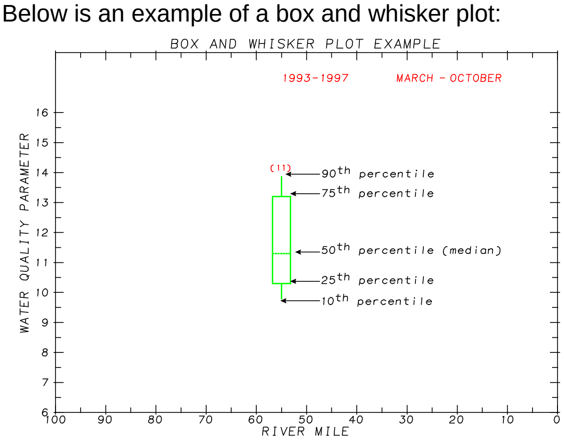
GLOSSARY OF TERMS

A

Abatement -- Reducing the degree or intensity of, or eliminating, pollution.
Acidic -- The condition of water or soil that contains a sufficient amount of acid substances to lower the pH below 7.0.
Acre -- A measure of area equal to 43,560 square feet (4,046.87 square meters). One square mile equals 640 acres.
Active Bank Erosion: Estimates from observation of the active stream bank erosion as a percentage (%) of the total reach length.
Adaptation -- Changes in an organism's structure or habits that allow it to adjust to its surroundings.
Adaptive management -- The process of implementing policy decisions as scientifically driven management experiments that test predictions and assumptions in management plans, and using the resulting information to improve the plans.
Alevin -- The developmental life stage of young salmonids and trout that are between the egg and fry stage. The alevin has not absorbed its yolk sac and has not emerged from the spawning gravels.
Allocation – Refers to the load allocation (nonpoint sources) and wasteload allocation (point sources). Specifically, an allocation is the division of the loading capacity between nonpoint and point sources of pollution.
Alluvial -- Deposited by running water.
Alluvium -- Sediment or loose material such as clay, silt, sand, gravel, and larger rocks deposited by moving water.
Anadromous -- Fish that hatch rear in fresh water, migrate to the ocean (salt water) to grow and mature, and migrate back to fresh water to spawn and reproduce.
Anthropogenic Sources of Pollution: Pollutant deliver to a water body that is directly related to humans or human activities.
Appropriate -- To authorize the use of a quantity of water to an individual requesting it.
Aquatic ecosystem -- Any body of water, such as a stream, lake or estuary, and all organisms and nonliving components within it, functioning as a natural system.
Aquatic habitat -- Habitat that occurs in free water.
At-risk fish stocks -- Stocks of anadromous salmon and trout that have been identified by professional societies, fish management agencies, and in the scientific literature as being in need of special management consideration because of low or declining populations.
Augmentation (of stream flow) -- Increasing steam flow under normal conditions, by releasing storage water from reservoirs.

B

Bank stability -- The properties of a stream bank that counteract erosion, for example, soil type, and vegetation cover.
Bank Building Event: A hydrologic event (usually high flow condition) that deposits sediments and organic debris in the flood plain and along stream banks.
Bankfull width -- The width of a river or stream channel between the highest banks on either side of a stream.
Bar (stream or river bar) -- An accumulation of alluvium(gravel or sand) caused by a decrease in water velocity.
Barrier -- A physical block or impediment to the movement or migration of fish, such as a waterfall (natural barrier) or a dam (man-made barrier).
Base flow -- The sustained portion of stream discharge that is drawn from natural storage sources, and not effected by human activity or regulation.
Bed load -- Sediment that moves near the streambed.
Bed Material -- The sediment mixture of which a streambed, lake, pond, reservoir, or estuary bottom is composed.
Beneficial Use: Legislatively approved use of water for the best interest of people, wildlife and aquatic species.
Blowdown -- Trees felled by high winds.
Boulder -- A large substrate particle that is larger that cobble, >256 mm in diameter.
Box and Whisker Plots: Water quality parameters and instream physical parameters are reviewed below using box and whisker plots for illustration. Below is an example of a box and whisker plot:



Example of box and whisker plot.

The box plots have river mile on the X-axis with the water quality parameter on the Y-axis. The box represents the data at the sampling sites, from upstream to downstream. Each box represents a summary of the data:

The upper corner of each box is the 75th percentile (75 percent of the data are below that concentration), and the lower corner is the 25th percentile (25 percent of the data are below that concentration). The upper and lower tails are the 90th and 10th percentiles, respectively. Points above and below the tails represent data higher and lower than the 90th and 10th percentiles. The dashed line in the box is the median concentration for that site (half of the data fall above and below that concentration).

Brackish -- Having a somewhat salty taste, especially from containing a mixture of seawater and fresh water.

Braided stream -- A complex tangle of converging and diverging stream channels (Anabranches) separated by sand bars or islands. Characteristic of flood plains where the amount of debris is large in relation to the discharge.

Buffer strip -- A barrier of permanent vegetation, either forest or other vegetation, between waterways and land uses such as agriculture or urban development, designed to intercept and filter out pollution before it reaches the surface water resource.

Buoyancy -- The tendency of a body to float or rise when submerged in a fluid.

C

Canopy -- A layer of foliage in a forest stand. This most often refers to the uppermost layer of foliage, but it can be used to describe lower layers in a multistoried stand. Leavs, branches and vegetation that are above ground and/or water that provide shade and cover for fish and wildlife.

Canopy closure -- The degree to which the canopy (forest layers above one's head) blocks sunlight or obscures the sky.

Canopy density -- The degree to which the canopy (forest layers above one's head) covers a unit area. Commonly measured with a concave or convex densiometer or estimated from aerial photography.

Carrying capacity -- The maximum number of organisms that a certain habitat can sustain over the long term.

Catchment -- (1) The catching or collecting of water, especially rainfall. (2) A reservoir or other basin for catching water. (3) The water thus caught.

Channel -- An area that contains continuously or periodically flowing water that is confined by banks and a stream bed.

Channelization -- The process of changing and straightening the natural path of a waterway.

Channel Complexity: Implied high pool frequency of pools and large woody debris (instream roughness).

Channel Simplification: The loss (absence) of pools and large woody debris that is important for creating and maintaining channel features such as: substrate, stream banks and pool:riffle ratios.

Check dam -- A small dam constructed in a gully or other small water course to decrease the streamflow velocity, minimize channel erosion, promote deposition of sediment and to divert water from a channel.

Classic old growth -- Forest stands with unusually old and large trees that also meet criteria for old-growth forest.

Clay -- Substrate particles that are smaller than silt and generally less than 0.004 mm in diameter.

Clean Water Act: Established in 1977, is an amendment to the 1972 Federal Water Pollution Control Act which set the groundwork for regulating pollutant discharges into U.S. waters. The Clean Water Act makes discharging pollutants from a point source to navigable waters illegal without a permit. The Clean Water Act amendments of 1977 were aimed at toxic pollutants. In 1987, the Clean Water Act was reauthorized and focused on sewage treatment plants, toxic pollutants, and authorized citizen suit provisions. The Clean Water Act allows the EPA to delegate administrative and enforcement aspects of the law to the state agencies. In states with this EPA given authority of Clean Water Act implementation, the EPA still plays the role of supervisor.

Clear-cut harvest -- A timber harvest method in which all trees are removed in a single entry from a designated are, with the exception of wildlife trees or snags, to create an even-aged stand.

Climax -- The culminating stage in plant succession for a given site where the vegetation has reached a highly stable condition.

Coarse woody debris (CWD) -- Portion of a tree that has fallen or been cut and left in the woods. Usually refers to pieces at least 20 inches in diameter.

Cobble -- Substrate particles that are smaller than boulders and are generally 64-256 mm in diameter. Can be further classified as small and large cobble. Commonly used by salmon in the construction of a redd.

Coefficient of determination (r-squared) -- The percentage of variation of the independent variable (y) that is attributed to its linear regression in the dependent variable (x).

Confluence -- (1) The act of flowing together; the meeting or junction of two or more streams; also, the place where these streams meet. (2) The stream or body of water formed by the junction of two or more streams; a combined flood.

Conifer -- A tree belonging to the order Gymnospermae, comprising a wide range of trees that are mostly evergreens. Conifers bear cones

(hence, coniferous) and needle-shaped or scalelike leaves.
Contaminate -- To make impure or unclean by contact or mixture.
Correlation Coefficient (R): Used to determine the relationship between two data sets. R-values vary between –1 and 1, where "–1" represents a perfectly inverse correlation relationship and "1" represents a perfect correlation relationship. A "0" R-value indicates that no correlation exists:

$$R = \frac{1}{n} \cdot \sum_{i=1}^{n} \left(x_i - \mu_x\right) \cdot \left(y_i - \mu_y\right)$$

Cover -- Vegetation used by wildlife for protection from predators, or to mitigate weather conditions, or to reproduce. May also refer to the protection of the soil and the shading provided to herbs and forbs by vegetation.
Crown -- The upper part of a tree or other woody plant that carries the main system of branches and the foliage.
Crown cover -- The degree to which the crowns of trees are nearing general contact with one another.
Cubic feet per second (cfs) -- A unit used to measure water flow. One cfs is equal to 449 gallons per minute.
Culvert -- A buried pipe that allows streams, rivers, or runoff to pass under a road.
Cumulative Effects -- The combined environmental impacts that accrue over time and space from a series of similar or related individual actions, contaminants, or projects.

D

Dam -- A concrete or earthen barrier constructed across a river and designed to control water flow or create a reservoir.
Debris flow -- A rapid moving mass of rock fragments, soil, and mud, with more that half of the particles being larger that sand size.
Debris torrent -- Rapid movement of a large quantity of materials (wood and sediment) down a stream channel during storms or floods. This generally occurs in smaller streams and results in scouring of streambed.
Deciduous -- Trees and plants that shed their leaves at the end of the growing season.
Decommission: The removal of a road to improve hillslope drainage and stabilize slope hazards.
Depressed stock -- A stock of fish whose production is below expected levels based on available habitat and natural variations in survival levels, but above the level where permanent damage to the stock is likely.
Determinate Coefficient (R^2): The R^2 value represents "goodness of fit" for a linear regression. An R^2 value of "1" would indicate that all of the data variability is accounted for by the regression line. Natural systems exhibit a high degree of variability; R^2 values approaching "1" are uncommon. A value of "0" would indicate that none of the data variability is explained by the regression.
Dewatering -- Elimination of water from a lake, river, stream, reservoir, or containment.
Dike -- (1) (Engineering) An embankment to confine or control water, especially one built along the banks of a river to prevent overflow of lowlands; a levee. (2) A low wall that can act as a barrier to prevent a spill from spreading. (3) (Geology) A tabular body of igneous (formed by volcanic action) rock that cuts across the structure of adjacent rocks or cuts massive rocks.
Discharge -- Volume of water released from a dam or powerhouse at a given time, usually expressed in cubic feet per second.
Distribution (of a species) -- The spatial arrangement of a species within its range.
Disturbance -- A force that causes significant change in structure and/or composition through natural events such as fire, flood, wind, or earthquake, mortality caused by insect or disease outbreaks, or by human-caused events, e.g., the harvest of forest products.
Ditch -- A long narrow trench or furrow dug in the ground, as for irrigation, drainage, or a boundary line.
Diversion -- The transfer of water from a stream, lake, aquifer, or other source of water by a canal, pipe, well, or other conduit to another watercourse or to the land, as in the case of an irrigation system.
Draft -- Release of water from a storage reservoir.
Drainage -- An area (Basin) mostly bounded by ridges or other similar topographic features, encompassing part, most, or all of a watershed and enclosing some 5,000 acres.
Dredging -- Digging up and removing material from wetlands or waterways, usually to make them deeper or wider.
Drought -- Generally, the term is applied to periods of less than average or normal precipitation over a certain period of time sufficiently prolonged to cause a serious hydrological imbalance resulting in biological losses (impact flora and fauna ecosystems) and/or economic losses (affecting man). In a less precise sense, it can also signify nature's failure to fulfill the water wants and needs of man.
Duff layer -- The layer of loosely compacted debris underlying the litter layer on the forest floor.

E

Early seral stage forest -- Stage of forest development that includes seedling, sapling, and pole-sized trees.
Ecological Health -- The state of an ecosystem in which processes and functions are adequate to maintain diversity of biotic communities commensurate with those initially found there.
Ecological interaction -- The sum total of impacts of one species on another species, or on other members of the same species.
Ecologically significant -- Species, stands, and forests considered important to maintain the

structure, function, and processes of particular ecosystems.
Ecosystem -- The biological community considered together with the land and water that make up its environment. Or a unit comprising interacting organisms considered together with their environment.
Ecosystem diversity -- The variety of species and ecological processes that occur in different physical settings.
Ecosystem management -- A strategy or plan to manage ecosystems to provide for all associated organisms, as opposed to a strategy or plan for managing individual species.
Eddy -- A circular current of water, usually resulting from an obstruction.
Edge -- Where plant communities meet or where successional stages or vegetative conditions with plant communities come together.
Edge effect -- "The drastically modified environmental conditions along the margins, or ""edges,"" of forest patches surrounded partially or entirely by harvested lands."
Effective old-growth forest -- Old-growth forest largely unmodified by external environmental influences from nearby, younger forest stands.
Effluent -- (1) Something that flows out or forth, especially a stream flowing out of a body of water. (2) (Water Quality) Discharged wastewater such as the treated wastes from municipal sewage plants, brine wastewater from desalting operations, and coolant waters from a nuclear power plant.
Elevation -- Height in feet above sea level.
Embankment -- An artificial deposit of material that is raised above the natural surface of the land and used to contain, divert, or store water, support roads or railways, or for other similar purposes.
Embeddedness -- The degree to which dirt is mixed in with spawning gravel.
Embryo -- The early stages of development before an organism becomes self supporting.
Emergence -- The process during which fry leave their gravel spawning nest and enter the water column.
Emigration -- Referring to the movement of organisms out of an area. See immigration and migrating.
Empirical -- (Statistics) Based on experience or observations, as opposed to theory or conjecture.
Endangered species -- Any species of plant of animal defined through the Endangered Species Act as being in danger of extinction throughout all or a significant portion or its range, and published in the Federal Register.
Endangered Species Act (ESA) -- A 1973 Act of Congress that mandated that endangered and threatened species of fish, wildlife, and plants be protected and restored.
Endemic -- Native to or limited to a specific region.
Energy -- The ability to work (i.e., exert a force over distance). Energy is measured in calories, joules, KWH, BTUs, MW-hours, and average MWs.
Enhancement -- Emphasis on improving the value of particular aspects of water and related land resources.
Entrainment -- (Streams) The incidental trapping of fish and other aquatic organisms in the water, for example, used for cooling electrical power plants or in waters being diverted for irrigation or similar purposes.
Ephemeral Streams -- Streams which flow only in direct response to precipitation and whose channel is at all times above the water table.
Epilimnion -- The upper region of a thermally stratified lake, above the thermocline, and generally warm and well oxygenated.
Erosion -- Wearing away of rock or soil by the gradual detachment of soil or rock fragments by water, wind, ice, and other mechanical, chemical, or biological forces.
Escapement (Spawning) -- The portion of a fish population that survives sources of natural mortality and harvest to reach its natal spawning grounds.
ESU -- "Evolutionarily Significant Unit; a ""distinct"" population of Pacific salmon, and hence a species, under the Endangered Species Act."
Eutrophic -- Usually refers to a nutrient-enriched, highly productive body of water.
Eutrophication -- The process of enrichment of water bodies by nutrients.
Evaporation -- The physical process by which a liquid (or a solid) is transformed to the gaseous state. In Hydrology, evaporation is vaporization that takes place at a temperature below the boiling point.
Evolutionarily significant unit (ESU) -- "A definition of ""species"" used by NMFS in administering the Endangered Species Act. An ESU is a population (or groups of populations) that (1) is reproductively isolated from other conspecific population units, and (2) represents an important component in the evolutionary legacy of the species."
Exotic species -- Introduced species not native to the place where they are found (e.g., Atlantic salmon to Oregon or Washington).
Extinction -- The natural or human induced process by which a species, subspecies or population ceases to exist.

F

Fauna -- (1) A term used to describe the animal species of a specific region or time. (2) All animal life associated with a given habitat, country, area, or period.
Federal land managers -- This category includes the Bureau of Indian Affairs; the Bureau of Land Management; the National Park Service, all part of the U.S. Department of the Interior; and the Forest Service, U.S. Department of Agriculture.
Federal project operators and regulators -- Federal agencies that operate or regulate hydroelectric projects in the Columbia River Basin. They include the Bonneville Power Administration,

the Bureau of Indian Affairs, the Bureau of Reclamation, the Corps of Engineers and the Federal Energy Regulatory Commission.
Fill -- (Geology) Any sediment deposited by any agent such as water so as to fill or partly fill a channel, valley, sink, or other depression.
Fine Sediment: Sand, silt and organic material that have a grain size of 6.4 mm or less.
Fingerling -- Refers to a young fish in its first or second year of life.
Fire Regime: The frequency, extent, intensity and severity of naturally occurring seasonal fires in an ecosystem.
Fish and wildlife agencies -- This category includes the Fish and Wildlife Service, U.S. Department of the Interior; the Idaho Department of Fish and Game; the Montana Department of Fish, Wildlife and Parks; the National Marine Fisheries Service, U.S. Department of Commerce; the Oregon Department of Fish and Wildlife; and the Washington Department of Fish and Wildlife.
Fishery -- The act, process, or occupation of attempting to catch fish, which may be retained or released.
Fitness -- The relative ability of an individual (or population) to survive and reproduce (pass on it's genes to the next generation) in a given environment.
Flash Flood -- A sudden flood of great volume, usually caused by a heavy rain. Also, a flood that crests in a short length of time and is often characterized by high velocity flows. It is often the result of heavy rainfall in a localized area.
FLIR Thermal Imagery: Forward looking infrared radiometer thermal imagery is a direct measure of the longer wavelengths emitted by all bodies. The process by which bodies emit longwave radiation is described by the Stefan-Boltzmann 4^{th} Order Radiation Law. FLIR monitoring produces spatially continuous stream and stream bank temperature information. Accuracy is limited to $0.5^{o}C$. FLIR thermal imagery often displays heating processes as they are occurring and is particularly good at displaying the thermal impacts of shade, channel morphology and groundwater mixing.
Flood Plain: Strips of land (of varying widths) bordering streams that become inundated with floodwaters. Land outside of the stream channel that is inside a perimeter of the maximum probable flood. A flood plain is built of sediment carried by the stream and deposited in the slower (slack waters) currents beyond the influence of the swiftest currents. Flood plains are termed “living” if it experiences inundation in times of high water. A “fossil” flood plain is one that is beyond the reach of the highest current floodwaters.
Floodplain (100-year) -- The area adjacent to a stream that is on average inundated once a century.
Flood Plain Roughness: Reflects the ability of the flood plain to dissipate erosive flow energy during high flow events that over-top streams banks and inundate the flood plain.
Flora -- (1) A term used to describe the entire plant species of a specified region or time. (2) The sum total of the kinds of plants in an area at one time. All plant life associated with a given habitat, country, area, or period. Bacteria are considered flora.
Flow -- The amount of water passing a particular point in a stream or river, usually expressed in cubic-feet per second (cfs).
Flow augmentation -- Increased flow from release of water from storage dams.
Fluvial -- Migrating between main rivers and tributaries. Of or pertaining to streams or rivers.
Forest canopy -- The cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.
Forest fragmentation -- The change in the forest landscape, from extensive and continuous forests of old-growth to mosaic of younger stand conditions.
Forest land -- Land that is now, or is capable of becoming, at least 10 percent stocked with forest trees and that has not been developed for nontimber use.
Forest landscape -- Land presently forested or formerly forested and not currently developed for nonforest use.
Fragmentation -- The process of reducing size and connectivity of stands that compose a forest.
Freshet -- A rapid temporary increase in stream flow due to heavy rains or snow melt.
Fry -- A stage of development in young salmon or trout. During this stage the fry is usually less than one year old, has absorbed its yolk sac, is rearing in the stream, and is between the alevin and parr stage of development.

G

Gabion -- A wire basket or cage that is filled with gravel and generally used to stabilize stream banks and improve degraded aquatic habitat.
Gaging station -- A particular site in a stream, lake, reservoir, etc., where hydrologic data are obtained.
Gallery -- "(1) A passageway within the body of a dam or abutment; hence the terms ""grouting gallery,"" ""inspection gallery,"" and ""drainage gallery."" (2) A long and rather narrow hall; hence the following terms for a power plant: ""valve gallery,"" ""transformer gallery,"" and ""busbar gallery."""
Gallons per minute (Gpm) -- A unit used to measure water flow.
Gap Analysis -- A method for determining spatial relationships between areas of high biological diversity and the boundaries of National Parks, National Wildlife Refuges (NWR), and other preserves.
Geographic information system (GIS) -- A computer system capable of storing and manipulating spatial (i.e., mapped) data.

Glide -- A section of stream that has little or no turbulence.
Gradient -- Vertical drop per unit of horizontal distance.
Grass/Forb -- An early forest successional stage where grasses and forbs are the dominant vegetation.
Gravel -- See cobble.
Gray Water -- Waste water from a household or small commercial establishment which specifically excludes water from a toilet, kitchen sink, dishwasher, or water used for washing diapers.
Groundwater -- Subsurface water and underground streams that can be collected with wells, or that flow naturally to the earth's surface though springs.

H

Habitat -- The local environment in which a organism normally lives and grows.
Habitat conservation plan (HCP) -- An agreement between the Secretary of the Interior and either a private entity or a state that specifies conservation measures that will be implemented in exchange for a permit that would allow taking of a threatened or endangered species.
Habitat diversity -- The number of different types of habitat within a given area.
Habitat fragmentation -- The breaking up of habitat into discrete islands through modification or conversion of habitat by management activities.
Hazardous materials -- Anything that poses a substantive present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed.
Headwater -- Referring to the source of a stream or river
Healthy stock -- A stock of fish experiencing production levels consistent with its available habitat and within the natural variations in survival for the stock.
Heavy metals -- Metallic elements with high atomic weights, e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.
Herbaceous -- Vegetation or parts of plants with little or no woody tissue.
Homing -- The ability of a salmon or steelhead to correctly identify and return to their natal stream, following maturation at sea.
Hydraulic head -- The vertical distance between the surface of the reservoir and the surface of the river immediately downstream from the dam.
Hydric -- Wet.
Hydrologic unit -- A distinct watershed or river Basin defined by an 8-digit code.
Hydrology -- The scientific study of the water of the earth, its occurrence, circulation and distribution, its chemical and physical properties, and its interaction with its environment, including its relationship to living things.
Hypolimnion -- The lower zone of a thermally stratified lake, below the thermocline, and usually depleted in oxygen during summer stagnation.
Hyporheic zone -- The area under the stream channel and floodplain that contributes to the stream.

I

Impact -- A spatial or temporal change in the environment caused by human activity.
Impoundment -- A body of water formed behind a dam.
Impaired waterbody: Any waterbody of the United States that does not attain water quality standards (designated uses, numeric and narrative criteria and antidegradation requirements defined at 40 CFR 131), due to an individual pollutant, multiple pollutants, pollution, or an unknown cause of impairment.
In-situ -- In place. An in-situ environmental measurement is one that is taken in the filed, without removal of a sample to the laboratory.
Incidental take -- """Take"" of a threatened or endangered species that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity."
Incipient Lethal Limit: Temperature levels that cause breakdown of physiological regulation of vital bodily processes, namely: respiration and circulation.
Incised River -- A river which cuts its channel through the bed of the valley floor, as opposed to one flowing on a floodplain; its channel formed by the process of degradation.
Indicator (Organism) -- (Water Quality) An organism, species, or community that shows the presence of certain environmental conditions.
Indicator Species: Used for development of Oregon's water temperature standard as sensitive species that if water temperatures are reduced to protective levels will protect all other aquatic species.
Indigenous -- Existing naturally in a region, state, country, etc.
Infiltration (soil) -- The movement of water through the soil surface into the soil.
Inflow -- Water that flows into a reservoir or forebay during a specified period.
Instantaneous flows -- The velocity of a volume of water.
Instantaneous Lethal Limit: Temperature levels where denaturing of bodily enzymes occurs.
Instantaneous Rate Of Mortality -- The natural logarithm (with sign changed) of the survival rate. The ratio of number of deaths per unit of time to population abundance during that time, if all deceased fish were to be immediately replaced so that population does not change. Also called; *coefficient of decrease.

Instream cover -- The layers of vegetation, like trees, shrubs, and overhanging vegetation, that are in the stream or immediately adjacent to the wetted channel.
Instream Roughness: Refers to the substrate (both organic and inorganic) that is found in the stream bank.
Instream flow work group -- An interagency group that simulated the effects of various fish flow regimes by using hydropower regulation computer models. The group was composed of technical experts and water resource managers from the fish and wildlife agencies, federal dam operators and regulators, and state water management agencies.
Instream flows -- See flows.
Intermittent Flow: Stream flow that ceases seasonally, at least once a year.
Intermittent stream -- Any nonpermanent flowing drainage feature having a definable channel and evidence of scour or deposition. This includes what are sometimes referred to as ephemeral streams if they meet these two criteria.
Irrigation diversion -- Generally, a ditch or channel that deflects water from a stream channel for irrigation purposes.
Isolation -- Absence of genetic crossing among populations because of distance or geographic barriers.

J

Jeopardy -- A finding made through consultation under the Endangered Species Act that the action of a federal agency is likely to jeopardize the continued existence of a threatened or endangered species.
Juvenile -- Fish from one year of age until sexual maturity.

K

Key watershed -- As defined by National Forest and Bureau of Land Management District fish biologists, a watershed containing (1) habitat for potentially threatened species or stocks of anadromous salmonids or other potentially threatened fish, or (2) greater than 6 square miles with high-quality water and fish habitat.
Kilowatt (KW) -- The electrical unit of power which equals 1,000 watts or 1.341 horsepower.
Kilowatt-hour (kWh) -- A basic unit of electrical energy that equals one kilowatt of power applied for one hour.

L

Landing -- Any place on or adjacent to the logging site where logs are assembled for further transport.
Landscape -- A heterogenous land area with interacting ecosystems that are repeated in similar form throughout.
Landscape diversity -- The size, shape, and connectivity of different ecosystems across a large area.
Landscape features -- The land and water form vegetation, and structures that compose the characteristic landscape.
Landslide -- A movement of earth down a steep slope.
Large woody debris -- Pieces of wood larger than 10 feet long and 6 inches in diameter, in a stream channel.
Langley: A unit of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface.
Late seral stage forest -- Stage in forest development that includes mature and old-growth forest.
Leave strips -- Generally narrow bands of forest trees that are left along streams and rivers to buffer aquatic habitats from upslope forest management activities.
Legacy Condition: Past land management and historical disturbance affect the conditions that are currently observed in a stream channel. Present conditions may reflect chronic or episodic events that no longer occur.
Levee -- An embankment constructed to prevent a river from overflowing (flooding).
Limiting factor -- "A requirement such a food, cover or spawning gravel that is in shortest supply with respect to all resources necessary to sustain life and thus ""limits"" the size or retards production of a fish population."
Limnetic -- Referring to a standing water Ecosystem (ponds or lakes).
Limnology -- The study of lakes, ponds and streams.
Litter layer -- The loose, relatively undercomposed organic debris on the surface of the forest floor made up typically of leaves, bark, small branches, and other fallen material.
Littoral zone -- The region of land bordering a body of water.
Load Allocation (LA): A term referred to in the Clean Water Act that refers to the portion of the receiving waters loading capacity attributed to either to one of its existing or future non-point sources of pollution or to natural background sources.
Loading Capacity: 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.

M

Macroinvertebrate -- Invertebrates visible to the naked eye, such as insect larvae and crayfish.
Mainstem -- The principle channel of a drainage system into which other smaller streams or rivers flow.
Managed forest -- Any forestland that is treated with silvicultural practices and/or harvested.

Margin of safety – When establishing the loading capacity a portion may be reserved (i.e. not allocated to non-pointed or point sources of pollution) so that the allowed pollutant loading becomes conservative.
Mass movement -- The downslope movement of earth caused by gravity. Includes but is not limited to landslides, rock falls, debris avalanches, and creep. It does not however, include surface erosion by running water. It may be caused by natural erosional processes, or by natural disturbances (e.g., earthquakes or fire events) or human disturbances (e.g., mining or road construction).
Maximum Sustainable Yield -- The largest average catch or yield that can continuously be taken from a stock under existing environmental conditions. (For species with fluctuating recruitment, the maximum might be obtained by taking fewer fish in some years than in others.) Also called; maximum equilibrium catch ; maximum sustained yield; sustainable catch.
Mean (μ): Refers to the arithmetic mean:

$$\mu = \frac{1}{n} \cdot \sum x_i \ .$$

Mean Seal Level (MSL) -- A measure of elevation above sea level.
Measured Daily Solar Radiation Load: The rate of heat energy transfer originating from the sun as determined by using a Solar Pathfinder©.
Median: A value in the data in which half the values are above and half are below.
Megawatt-hour (MWh) -- A unit of electrical energy equal to one megawatt or power applied for one hour.
Megawatts (MW) -- A megawatt is one million watts or one thousand kilowatts, a measure of electrical power or generating capacity. A megawatt will typically serve about 1,000 people. The Dalles Dam produces an average of about 1,000 megawatts.
Mesic -- Moderately wet.
Migrant -- Life stage of anadromous and resident fish species which moves from one locale, habitat or system (river or ocean) to another.
Migrating -- Moving from one area of residence to another.
Minimum spanning tree -- A means of depicting nearest genetic neighbors. The tree is an undirected network of smallest genetic distances between genetic samples superimposed on multidimensional scaling graphs to reveal local distortion (pairs of points which look close together in one dimension, but which are far apart in other dimensions).
Mitigating measures -- Modifications of actions that (1) avoid impacts by not taking a certain action of parts of an action; (2) minimize impacts by limiting the degree or magnitude of the action and its implementation; (3) rectify impacts by repairing, rehabilitating, or restoring the affected environment; (4) reduce or eliminate impacts over time by preservation and maintenance operations during the life of the action; or (5) compensate for impacts by replacing or providing substitute resources or environments.
Mitigation -- The act of alleviating or making less severe. Generally refers to efforts to alleviate the impacts of hydropower development to the Columbia Basins salmon and steelhead runs.
Monitor -- To systematically and repeatedly measure conditions in order to track changes.
Morphology -- The structure, form and appearance of an organism.
Mortality -- The number of fish lost or the rate of loss.

N

Natal stream -- Stream of birth.
Native stock -- An indigenous stock of fish that has not been substantially affected by genetic interactions with non-native stocks or by other factors, and is still present in all or part of its original range.
Natural Mortality -- Deaths in a fish stock caused by predation, pollution, senility, etc., but not fishing.
Natural selection -- Differential survival and reproduction among members of a population or species in nature; due to variation in the possession of adaptive genetic traits.
Natural Sources of Pollution: Pollutant delivered to a water body that is directly related to processes that are inherent to normal processes unaffected by humans.
Naturally spawning populations -- Populations of fish that have completed their entire life cycle in the natural environment without human intervention.
Near Stream Disturbance Zone – The distance between shade producing near stream vegetation. This dimension is measured from digital orthophoto quads (DOQs) images at less than 1:5,000 scales. Where near stream vegetation is absent, the near stream boundary is used, as defined by armored streambanks or where near stream areas are unsuitable for vegetation growth due to external factors (i.e. roads, railroads, building, rock surfaces, etc.)
Non-point source pollution -- Pollution that does not originate from a clear or discrete source.

O

Off-channel area -- Any relatively calm portion of a stream outside of the main flow.
Old-growth associated species -- Plant and animal species that exhibit a strong association with old-growth forests.
Old-growth forest -- A forest stand usually at least 180-220 years old with moderate to high canopy closure; a multilayered, multispecies canopy dominated by large overstory trees; high incidence of large trees; some with broken tops and other indicators of old and decaying wood (decadence);

numerous large snags; and heavy accumulations of wood, including large logs on the ground.
On-site -- Usually refers to projects or activities designed to address harm caused to fish and wildlife at the site of the harm.
Outfall -- The mouth or outlet of a river, stream, lake, drain or sewer.
Outmigration -- The migration of fish down the river system to the ocean.
Overstory -- Trees that provide the uppermost layer of foliage in a forest with more that one roughly horizontal layer of foliage.
Oxbow -- An abandoned meander in a river or stream, caused by neck cutoff. Used to describe the U-shaped bend in the river or the land within such a bend of a river.

P

Parameter -- "A ""constant"" or numerical description of some property of a population (which may be real or imaginary). Cf. statistic."
Pathogens -- Any agent that causes disease, such as a virus, protozoan, bacterium or fungus.
Peak flow -- Refers to a specific period of time when the discharge of a stream or river is at its highest point.
Perennial Flow: Stream flow that persists throughout all seasons, yearlong.
Perennial streams -- Streams which flow continuously.
Physiological -- Pertaining to the functions and vital processes of living organisms and the organs within them.
Phytoplankton -- Microscopic floating plants, mainly algae, that live suspended in bodies of water and that drift about because they cannot move by themselves or because they are too small or too weak to swim effectively against a current.
Plankton -- Minute floating forms of microscopic plants and animals in water which cannot get about to any extent under their own power. They form the important beginnings of food chains for larger animals.
Plume -- The area of the Pacific Ocean that is influenced by discharge from the Columbia River, up to 500 miles beyond the mouth of the river.
Pluvial -- Of rain, formed by the action of rain, for example a body of water.
Point Source (PS) -- (1) A stationary or clearly identifiable source of a large individual water or air pollution emission, generally of an industrial nature. (2) Any discernible, confined, or discrete conveyance from which pollutants are or may be discharged, including (but not limited to) pipes, ditches, channels, tunnels, conduits, wells, containers, rolling stock, concentrated animal feeding operations, or vessels. Point source is also legally and more precisely defined in federal regulations. Contrast with Non-point Source (NPS) Pollution.
Point Source (PS) Pollution -- Pollutants discharged from any identifiable point, including pipes, ditches, channels, sewers, tunnels, and containers of various types. See Non-Point Source (NPS) Pollution.
Pollutant -- (1) Something that pollutes, especially a waste material that contaminates air, soil, or water. (2) Any solute or cause of change in physical properties that renders water unfit for a given use.
Pool -- A reach of stream that is characterized by deep low velocity water and a smooth surface.
Pool/riffle ratio -- The ratio of surface area or length of pools to the surface area or length of riffles in a given stream reach; frequently expressed as the relative percentage of each category. Used to describe fish habitat rearing quality.
Population -- A group of individuals of the same species occupying a defined locality during a given time that exhibit reproductive continuity from generation to generation.
Population density -- Number of individuals of a species per unit of area.
Population dynamics -- The aggregate of changes that occur during the life of a population.
Population viability -- Probability that a population will persist for a specified period across its range despite normal fluctuations in population and environmental conditions.
Potential Daily Solar Radiation Load: Based on the Julian calendar, for any particular location on earth, there exists a potential rate of heat energy transfer originating from the sun.
Primary Channel Length: Length of the primary channel located in the survey reach. Units are meters.
Primary Channel Width: Bankfull width of a stream reported in meters.
Productivity -- A measure of the capacity of a biological system. Also used as a measure of the efficiency with which a biological system converts energy into growth and production.

R

Range (of a species) -- The area or region over which an organism occurs.
Rate: A measurable occurrence over a specified time interval.
Reach -- A section of stream between two defined points.
Reach Averaged: An average that is based on the occurrence of a property weighted by the occurrence frequency over perennial stream length.
Rearing habitat -- Areas in rivers or streams where juvenile salmon and trout find food and shelter to live and grow.
Recovery -- Action that is necessary to reduce or resolve the threats that caused a species to be listed as threatened or endangered.
Recovery/restoration -- The reestablishment of a threatened or endangered species to a self-sustaining level in its natural ecosystem (i.e., to the

point where the protective measures of the Endangered Species Act are no longer necessary).
Redd -- A nest of fish eggs covered with gravel.
Redd Counts -- A spawning female salmon prepares a series of nests, called a redd, in suitable areas of streams by turning onto her side and beating her caudal fin up and down. Primary factors affecting suitability of spawning habitat include the size of rocks in the substrate and stream flow (high enough to provide adequate aeration for the eggs; low enough to prevent erosion of the nest). A completed redd is a shallow depression in the stream bottom with a rim extending to the downstream end. During spawning, the female continuously digs upstream, covering previously deposited eggs with gravel. Most redds occur in predictable areas and are easily identified by an experienced observer by their shape, size, and color (lighter than surrounding areas because silt has been cleaned away). Redd counts are conducted annually in certain heavy use areas of streams called index streams, which are usually surveyed repeatedly through the spawning season. Colored flags are sometimes placed on nearby trees to identify redds so that they will not be counted repetitively. Annual redd counts are used to compare the relative magnitude of spawning activity between years.
Rehabilitation -- Short-term management techniques that restore fish stocks decimated or destroyed by natural or man-made events.
Reservoir -- A body of water collected and stored in an artificial lake behind a dam.
Restoration -- The renewing or repairing of a natural system so that its functions and qualities are comparable to its original, unaltered state.
Riffle -- A reach of stream that is characterized by shallow, fast moving water broken by the presence of rocks and boulders.
Riparian area -- An area of land and vegetation adjacent to a stream that has a direct effect on the stream. This includes woodlands, vegetation, and floodplains.
Riparian habitat -- The aquatic and terrestrial habitat adjacent to streams, lakes, estuaries, or other waterways.
Riparian vegetation -- The plants that grow rooted in the water table of a nearby wetland area such as a river, stream, reservoir, pond, spring, marsh, bog, meadow, etc.
Riprap -- Usually refers to rocks or concrete structures used to stabilize stream or river banks from erosion.
River Channels -- Natural or artificial open conduits which continuously or periodically contain moving water, or which forms a connection between two bodies of water.
River Kilometer (RKm) -- Distance, in kilometers, from the mouth of the indicated river. Usually used to identify the location of a physical feature, such as a confluence, dam, or waterfall.
River miles (RM) -- Miles from the mouth of a river to a specific destination or, for upstream tributaries, from the confluence with the main river to a specific destination.
River Reach -- Any defined length of a river.
River Stage -- The elevation of the water surface at a specified station above some arbitrary zero datum (level).
Riverine -- Relating to, formed by, or resembling a river including tributaries, streams, brooks, etc.
Riverine habitat -- The aquatic habitat within streams and rivers.
Rock -- See cobble.
Rootwad -- The mass of roots associated with a tree adjacent or in a stream that provides refuge and nutrients for fish and other aquatic life.
Run (in stream or river) -- A reach of stream characterized by fast flowing low turbulence water.
Runoff -- Water that flows over the ground and reaches a stream as a result of rainfall or snowmelt.

S

Salmonid -- Fish of the family Salmonidae, that includes salmon and steelhead.
Sand -- Small substrate particles, generally referring to particles less than 2 mm in diameter. Sand is larger than silt and smaller than cobble or rubble.
Scour -- The erosive action of running water in streams, which excavates and carries away material from the bed and banks. Scour may occur in both earth and solid rock material.
Secchi Depth -- A relatively crude measurement of the turbidity (cloudiness) of surface water. The depth at which a Secchi Disc (Disk), which is about 10-12 inches in diameter and on which is a black and white pattern, can no longer be seen.
Secchi Disc -- A circular plate, generally about 10-12 inches (25.4-30.5 cm) in diameter, used to measure the transparency or clarity of water by noting the greatest depth at which it can be visually detected. Its primary use is in the study of lakes.
Sediment -- The organic material that is transported and deposited by wind and water.
Sedimentation -- Deposition of sediment.
Self-sustaining population -- "A population that perpetuates itself, in the absence of (or despite) human intervention, without chronic decline, in its natural ecosystem. A self-sustaining population maintains itself at a level above the threshold for listing under the Endangered Species Act. In this document, the terms ""self- sustaining"" and ""viable"" are used interchangeably."
Sensitive species -- Those species that (1) have appeared in the Federal Register as proposed for classification and are under consideration for official listing as endangered or threatened species or (2) are on an official state list or (3) are recognized by the U.S. Forest Service or other management agency as needing special management to prevent their being placed on federal or state lists.

Seral Stage: Refers to the age and type of vegetation that develops from the stage of bare ground to the climax stage.
Seral Stage - Early: The period from bare ground to initial crown closure (grass, shrubs, forbs, brush).
Seral Stage - Mid: The period of a forest stand from crown closure to marketability (young stand of trees from 25 to 100 years of age, includes hardwood stands).
Seral Stage - Late: The period of a forest stand from marketability to the culmination of the mean annual increment (mature stands of conifers and old-growth).
Shear Stress: The erosive energy associated with flowing water.
Silt -- Substrate particles smaller than sand and larger than clay.
Siltation -- The deposition or accumulation of fine soil particles.
Silviculture -- The science and practice of controlling the establishment, composition, and growth of the vegetation of forest stands.
Sinuosity -- The amount of bending, winding and curving in a stream or river.
Site Potential: Physical and biological conditions that are at maximum potential, taking into account local natural environmental constraints and conditions.
Slope -- The side of a hill or mountain, the inclined face of a cutting, canal or embankment or an inclination from the horizontal.
Slope stability -- The resistance of a natural or artificial slope or other inclined surface to failure by landsliding (mass movement).
Slough -- A shallow backwater inlet that is commonly exposed at low tide.
Sluiceway -- An open channel inside a dam designed to collect and divert ice and trash in the river (e.g., logs) before they get into the turbine units and cause damage. (On several of the Columbia River dams, ice and trash sluiceways are being used as, or converted into, fish bypass systems.)
Smolt -- Refers to the salmonid or trout developmental life stage between parr and adult, when the juvenile is at least one year old and has adapted to the marine environment.
Snag -- Any standing dead, partially dead, or defective (cull) tree at least 10 inches in diameter at breast height and at least 6 feet tall.
Soft Water -- Water that contains low concentrations of metal ions such as calcium and magnesium. This type of water does not precipitate soaps and detergents. Compare to Hard Water.
Soil Compaction: Activities/processes, vibration, loading, pressure, that decrease the porosity of soils by increasing the soil bulk density

$$\left(\frac{\text{Weight}}{\text{UnitVolume}}\right).$$

Spawn -- The act of reproduction of fishes. The mixing of the sperm of a male fish and the eggs of a female fish.
Spawning surveys -- Spawning surveys utilize counts of redds and fish carcasses to estimate spawner escapement and identify habitat being used by spawning fish. Annual surveys can be used to compare the relative magnitude of spawning activity between years.
Species -- A group of closely related individuals that can interbreed and produce fertile offspring.
Spill -- Releasing water through the spillway rather than through the turbine units.
Spillway -- "The channel or passageway around or over a dam through which excess water is released or ""spilled"" past the dam without going through the turbines. A spillway is a safety valve for a dam and, as such, must be capable of discharging major floods without damaging the dam, while maintaining the reservoir level below some predetermined maximum level."
Standard Deviation (σ): The measure of how widely values are dispersed from the mean (μ).

$$\sigma = \sqrt{\frac{n \cdot \sum x^2 - \left(\sum x\right)^2}{n \cdot (n-1)}}.$$

Standardization -- The procedure of maintaining methods and equipment as constant as possible.
State water management agencies -- State government agencies that regulate water resources. They include the Idaho Department of Water Resources; the Montana Department of Natural Resources and Conservation; the Oregon Water Resources Department; and the Washington Department of Ecology.
Steelhead -- The anadromous form of the species Oncorhynchus mykiss. Anadromous fish spend their early life history in fresh water, then migrate to salt water, where they may spend up to several years before returning to fresh water to spawn. Rainbow trout is the nonanadromous form of Oncorhynchus mykiss.
Stock -- A specific population of fish spawning in a particular stream during a particular season.
Stock status -- The current condition of a stock, which may be based on escapement, run size, survival, or fitness level.
Stone -- Rock fragments larger than 25.4 cm (10 inches) but less than 60.4 cm (24 inches).
Stream -- A general term for a body of flowing water; natural water course containing water at least part of the year. In Hydrology, the term is generally applied to the water flowing in a natural channel as distinct from a canal. More generally, as in the term Stream Gaging, it is applied to the water flowing in any channel, natural or artificial.
Stream Bank Erosion: Detachment, entrainment, and transport of stream bank soil particles via fluvial processes (i.e. local water velocity and shear stress).
Stream Bank Failure: Gravity related collapse of the stream bank by mass movement.

Stream Bank Retreat: The net loss of stream bank material and a corresponding widening of the stream channel that accompanies stream bank erosion and/or stream bank failure.
Stream Bank Stability: Measure of detachment, entrainment, and transport of stream bank soil particles by local water velocity and shear stress.
Stream Channel -- The bed where a natural stream of water runs or may run; the long narrow depression shaped by the concentrated flow of a stream and covered continuously or periodically by water.
Stream gradient -- A general slope or rate of change in vertical elevation per unit of horizontal distance of the water surface of a flowing stream.
Stream morphology -- The form and structure of streams.
Stream order -- A hydrologic system of stream classification. Each small unbranched tributary is a first order stream. Two first order streams join to make a second order stream. A third order stream has only first and second order tributaries, and so forth.
Stream reach -- An individual first order stream or a segment of another stream that has beginning and ending points at a stream confluence. Reach end points are normally designated where a tributary confluence changes the channel character or order.
Stream type -- Stream-type chinook salmon populations emigrate to the ocean as one- and two-year-old smolts. As juveniles, stream-type fish exhibit behavioral and morphological characteristics consistent with establishing and maintaining territories in freshwater systems (aggressive behavior, and larger, more colorful, fins). Little is known about the oceanic migration patterns of stream-type chinook salmon.
Streambank erosion -- The wearing away of streambanks by flowing water.
Streambank stabilization -- Natural geological tendency for a stream to mold its banks to conform with the channel of least resistance to flow. Also the lining of streambanks with riprap, matting, etc., to control erosion.
Streambed -- The channel through which a natural stream of water runs or used to run, as a dry streambed.
Streamflow -- The rate at which water passes a given point in a stream or river, usually expressed in cubic feet per second (cfs).
Sub-Lethal Limit: Temperature levels that cause decreased or lack of metabolic energy for feeding, growth or reproductive behavior, encourage increased exposure to pathogens, decreased food supplies, and increased competition from warm water tolerant species.
Sub-basin -- Major tributaries to and segments of the Columbia and Snake rivers.
Subdrainage -- A land area (basin) bounded by ridges or similar topographic features, encompassing only part of a watershed, and enclosing on the order of 5,000 acres; smaller than, and part of, a watershed.
Substrate -- The composition of a streambed, including either mineral or organic materials.
Succession -- A series of dynamic changes by which one group of organisms succeeds another through stages leading to potential natural community or climax.
Surface erosion -- The detachment and transport of soil particles by wind, water, or gravity. Or a groups of processes whereby soil materials are removed by running water, waves and currents, moving ice, or wind.
Surface Water -- All waters whose surface is naturally exposed to the atmosphere, for example, rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc., and all springs, wells, or other collectors directly influenced by surface water.
Surrogate Measures (Load Allocation): A term referenced in the Clean Water Act that refers to “other appropriate measures” that can be allocated to meet an established and accepted pollutant loading capacity.
Survival Rate -- Number of fish alive after a specified time interval, divided by the initial number. Usually on a yearly basis.
Suspended sediment -- Sediment suspended in a fluid by the upward components of turbulent currents, moving ice, or wind.

T

Take -- Under the Endangered Species Act, take means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect an animal, or to attempt to engage in any such conduct.
Temperature Limited Waterbody: Refers to a stream or river that has been placed on the §303(d) list for violating water quality numeric criteria based on measured data.
Tempertaure Statistic: The maximum seasonal seven (7) day moving average of the daily maximum stream tempertaures.
Thalweg -- (1) The lowest thread along the axial part of a valley or stream channel. (2) A subsurface, ground-water stream percolating beneath and in the general direction of a surface stream course or valley. (3) The middle, chief, or deepest part of a navigable channel or waterway.
Thermocline -- That layer of water in a lake in which the temperature changes 10C with each meter increase in depth.
Threatened Species: Species that are likely to become endangered through their normal range within the foreseeable future.
Threatened waterbody: Any waterbody of the United States that currently attains water quality standards (designated uses, numeric and narrative criteria and antidegradation requirements defined at 40 CFR 131), but for which existing and readily available data and information on adverse declining

trends or anticipated load measures indicate that water quality standards will likely be exceeded by the time the next list is required to be submitted to EPA.
Total Maximum Daily Load (TMDL): TMDLs are written plans and analyses established to ensure that the waterbody will attain and maintain water quality standards. The OAR definition is “The sum of the individual WLAs for point sources and LAs for non-point sources and background. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any non-point sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other non-point source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for non-point source control tradeoffs” (340-04l-006(21))
Torrent -- (1) A turbulent, swift-flowing stream. (2) A heavy downpour; a deluge.
Toxic Materials -- Any liquid, gaseous, or solid substance or substances in a concentration which, when applied to, discharged to, or deposited in water or another medium may exert a poisonous effect detrimental to people or to the propagation, cultivation, or conservation of animals, or other aquatic life.
Travel corridors -- Paths animals use during their migrations.
Trend -- (1) A statistical term referring to the direction or rate of increase or decrease in magnitude of the individual members of a time series of data when random fluctuations of individual members are disregarded. (2) A unidirectional increasing or decreasing change in the average value of a variable.
Tributary -- A stream that flows into another stream, river, or lake.
Turbidity -- "The term ""turbid"" is applied to waters containing suspended matter that interferes with the passage of light through the water or in which visual depth is restricted."

U

Urban runoff -- Storm water from city streets and gutters that usually contains a great deal of litter and organic and bacterial wastes into the sewer systems and receiving waters.

V

Velocity -- In this concept, the speed of water flowing in a watercourse, such as a river.
Viscosity -- A measure of the resistance of a fluid to flow. For liquids, viscosity increases with decreasing temperature.

W

Warmwater fish -- A broad classification on non-salmonid fish that generally have at least one spiny ray, have pelvic and pectoral fins located behind the gills, and are usually suited for water that consistently exceeds 70 degrees F.
Wash -- (1) To carry, erode, remove, or destroy by the action of moving water. To be carried away, removed, or drawn by the action of water. Removal or erosion of soil by the action of moving water. (2) A deposit of recently eroded debris. (3) Low or marshy ground washed by tidal waters. A stretch of shallow water. (4) (Western United States) The dry bed of a stream, articularly a watercourse associated with an alluvial fan, stream, or river channel. Washes are often associated with arid environments and are characterized by large, high energy discharges with high bed-material load transport. Washes are often intermittent and their beds sparsely vegetated. (5) Turbulence in air or water caused by the motion or action of an oar, propeller, jet, or airfoil.
Washout -- (1) Erosion of a relatively soft surface, such as a roadbed, by a sudden gush of water, as from a downpour or floods. (2) A channel produced by such erosion.
Wasteload Allocation (WLA): A term referenced in the Clean Water Act that refers to point source rates of pollutant delivery that can be specifically linked to an established and accepted pollutant loading capacity.
Wasteway -- An open ditch or canal that discharges excess irrigation water or power plant effluent into the river channel.
Water Conservation -- The physical control, protection, management, and use of water resources in such a way as to maintain crop, grazing, and forest lands, vegetative cover, wildlife, and wildlife habitat for maximum sustained benefits to people, agriculture, industry, commerce, and other segments of the national economy.
Water Pollution -- Generally, the presence in water of enough harmful or objectionable material to damage the water's quality.
Water quality -- A term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water Quality Limited: Can mean one of the following categories: (a) A receiving stream which does not meet in-stream water quality standards during the entire year or defined season even after the implementation of standard technology; (b) A receiving stream which achieves and is expected to continue to achieve in-stream water quality standard but utilizes higher than standard technology to protect beneficial uses; (c) A receiving stream for which there is insufficient information to determine if water quality standards are being met with higher than standard treatment technology or where through professional judgment

the receiving stream would not be expected to meet water quality standards during the entire year or defined season without higher than standard technology. (OAR 340-04l-006(30))
Water Resources -- The supply of groundwater and surface water in a given area.
Water rights -- "Priority claims to water. In western States, water rights are based on the principle ""first in time, first in right,"" meaning older claims take precedence over newer ones."
Water yield -- The quantity of water derived from a unit area of watershed.
Waterfall -- A sudden, nearly vertical drop in a stream, as it flows over rock.
Watershed restoration -- Improving current conditions of watersheds to restore degraded fish habitat and provide long-term protection to aquatic and riparian resources.
Watt -- A measure of the rate at which energy is produced, exchanged, or consumed.
Wet meadow -- Areas where grass predominate. Normally waterlogged within a few inches of the ground surface.
Width:Depth Ratio: The width of bankfull divided by the average depth in the survey reach of a stream.
Wildfall -- Trees or parts of trees felled by high winds.
Windthrow -- A tree or trees uprooted or felled by the wind.
Woody debris -- Referring to wood in streams.

ACRONYM LIST

BLM – Bureau of Land Management

CFR - Code of Federal Regulations

cfs - cubic feet per second

CSRI - Coastal Salmon Restoration Initiative

CWA - Clean Water Act

DBH - Diameter at Breast Height

DEM - Digital Elevation Model

DEQ - Department of Environmental Quality (Oregon)

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

NPDES - National Pollutant Discharge Elimination Program

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

SE - Standard Error

SSCGIS - State Service Center for Geographic Information Systems

TMDL - Total Maximum Daily Load

TSS - Total Suspended Solids

USBR (US BOR) - United States Bureau of Reclamation

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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APPENDICES

State of Oregon
Department of
Environmental
Quality

APPENDIX A : TEMPERATURE TECHNICAL ANALYSIS

STREAM HEATING PROCESSES – BACKGROUND INFORMATION

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. Specifically, the elevated summertime stream temperatures attributed to anthropogenic sources in the Tillamook Bay Watershed result from the following:

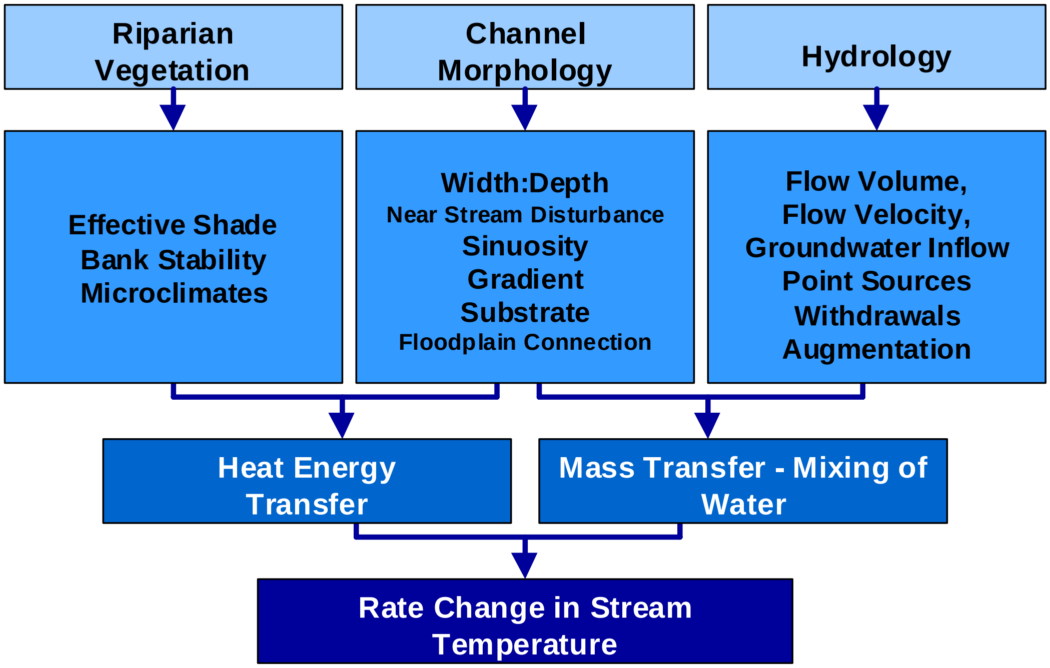
- ✓ Riparian vegetation disturbance reduces stream surface shading via decreased riparian vegetation height, width and/or density, thus increasing the amount of solar radiation reaching the stream surface; and
- ✓ Localized near-stream disturbance zone (NSDZ) widening decreases potential shading effectiveness of shade-producing near-stream vegetation.
- ✓ Localized channel widening (increased wetted width to depth ratios) increases the stream surface area exposed to energy processes, namely solar radiation; and
- ✓ Point source discharges.

Human activities that contribute to degraded water quality conditions in the Tillamook Bay Watershed include timber harvest, agriculture activities, road location, and rural/urban residential development related riparian disturbances. The relationships between percent effective shade, channel morphology, hydrology and stream temperature are illustrated in **Figure 24**.

Direct analysis of temperature data and mathematical modeling were used to assess current and potential conditions in the Tillamook Bay Watershed. Temperature data was collected in two years. The data was continuous (hourly data) over the course of the summer (critical) period and was geographically distributed over the entire basin. Each of the five rivers was characterized for temperature, vegetational structure, channel morphology, hydrology, and geographical shading geometry. Each of these classes of features was measured directly in the field, and all except temperature were measured further with automated means through GIS. The resulting descriptive dataset described the basin in great detail and generally matched the field measurements. These data were used to model temperature accumulation rates in each of the five rivers. The model was calibrated with field measurements and provided a rich view of the watershed as a whole, and of stream heating in particular. Once developed, the model allowed the comparison of the current condition with respect to riparian vegetation, channel morphology, and hydrology, to potential conditions of the same features given management of streams and riparian areas for providing shade.

This appendix describes the current conditions of the basin in the context of the importance of each physical or biological characteristics to heating of surface waters. The information is both general, in discussing heating processes, and specific, in discussing the analysis of data collected within the Tillamook Bay Watershed. Wherever possible, data collected from the basin has been used in analysis and modeling.

Figure 24. Stream Heating Processes in the Tillamook Bay Watershed.



RIPARIAN VEGETATION

The Dynamics of Shade

Stream surface shade is a function of several landscape and stream geometric relationships. Some of the factors that influence shade are listed in **Table 22**. Geometric relationships important for understanding the mechanics of shade are displayed in **Figure 24**. In the Northern Hemisphere, the earth tilts on its axis toward the sun during summertime months allowing longer day length and higher solar altitude, both of which are functions of solar declination (i.e.,, a measure of the earth's tilt toward the sun). Geographic position (i.e., latitude and longitude) fixes the stream to a position on the globe, while aspect provides the stream/riparian orientation. Riparian height, width and density describe the physical barriers between the stream and sun that can attenuate and scatter incoming solar radiation (i.e., produce shade). The solar position has a vertical component (i.e.,, altitude) and a horizontal component (i.e., azimuth) that are both functions of time/date (i.e., solar declination) and the earth's rotation (i.e., hour angle). While the interaction of these shade variables may seem complex, the mathematics that describes them is relatively straightforward geometry.

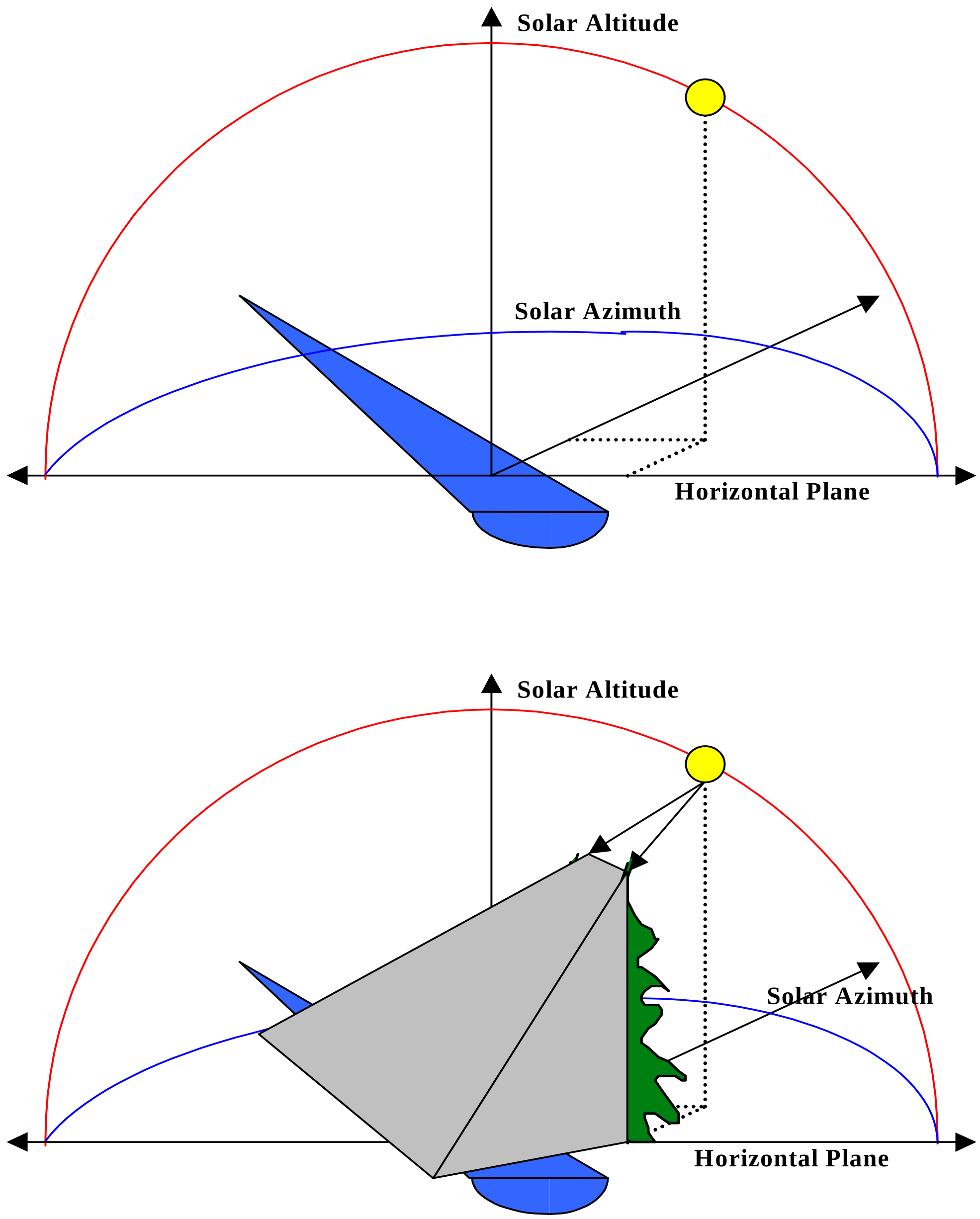
Table 21. Factors that Influence Stream Surface Shade

Description	*Measure*
Season/Time	Date/Time
Stream Characteristics	Aspect, Near-Stream Disturbance Zone Width
Geographic Position	Latitude, Longitude
Vegetative Characteristics	Buffer Height, Buffer Width, Buffer Density
Solar Position	Solar Altitude, Solar Azimuth

Figure 25. Geometric Relationships that Affect Stream Surface Shade

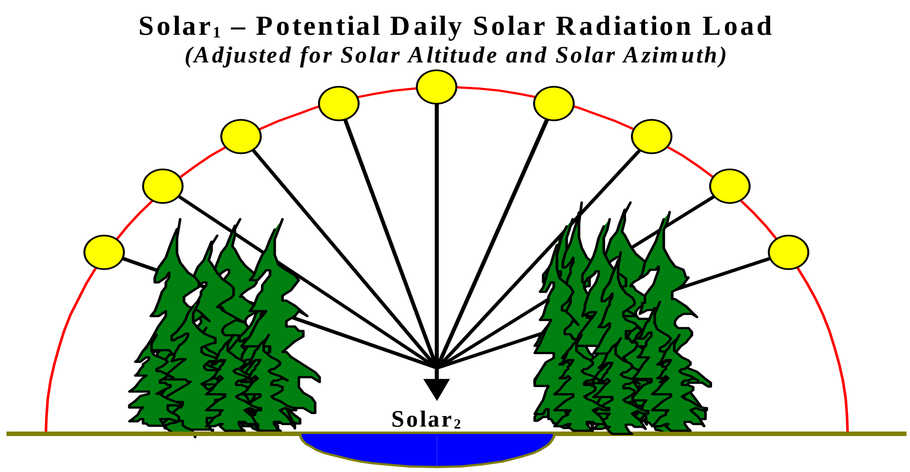
Solar Altitude and **Solar Azimuth** are two basic measurements of the sun's position. When a stream's orientation, geographic position, riparian condition and solar position are known, shading characteristics can be simulated.

Solar Altitude measures the vertical component of the sun's position
Solar Azimuth measures the horizontal component of the sun's position



Percent effective shade is perhaps the most straightforward stream parameter to monitor/calculate and is easily translated into quantifiable water quality management and Geometric Relationships that Affect Stream Surface Shade recovery objectives. **Figure 25** demonstrates how effective shade is monitored/calculated. Using solar tables or mathematical simulations, the *potential daily solar load* can be quantified. The *measured solar load* at the stream surface can easily be measured with a Solar Pathfinder© or estimated using mathematical shade simulation computer programs (Boyd, 1996 and Park, 1993).

Figure 26. Effective Shade - Defined



Effective Shade Defined:

$$\text{Effective Shade} = \frac{(\text{Solar}_1 - \text{Solar}_2)}{\text{Solar}_1}$$

Where,

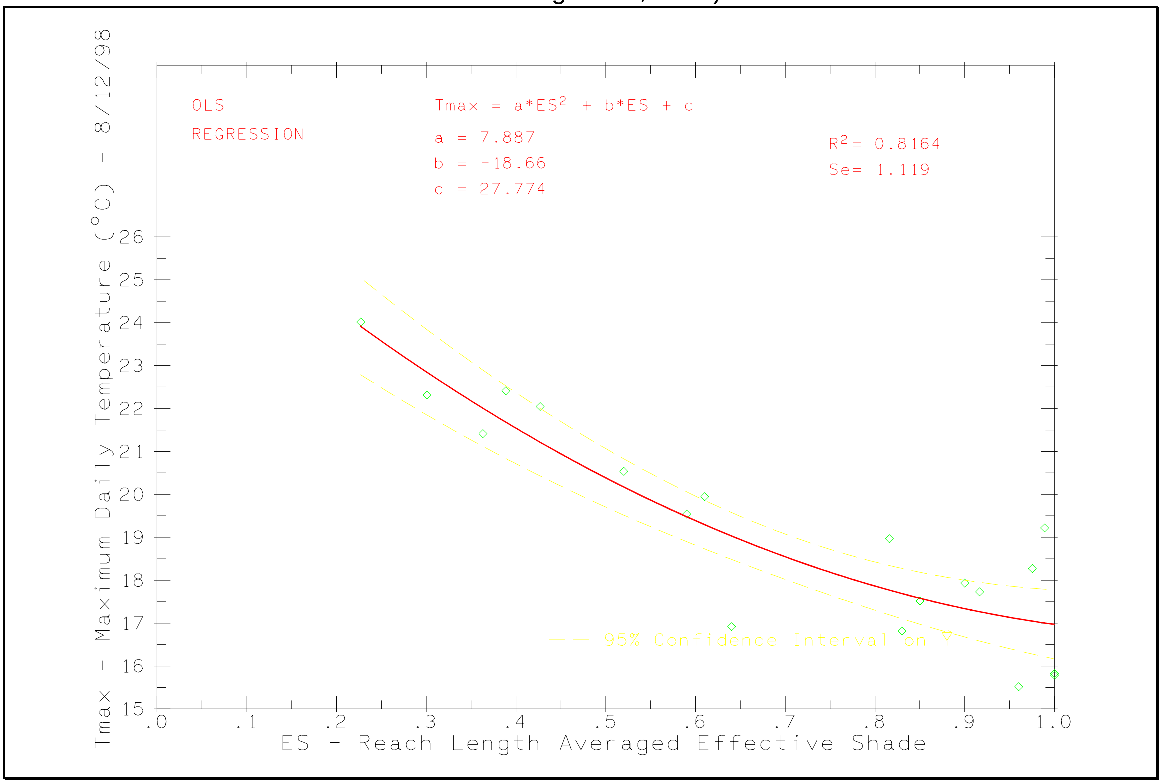
$Solar_1$: Potential Daily Solar Radiation Load
$Solar_2$: Measured Daily Solar Radiation Load at Stream Surface

Stream Surface Shade and Stream Temperature

Longitudinal heating is a natural process. However, rates of heating can be dramatically reduced with adequate levels of shade exist and when solar radiation loading is minimal. The overriding justification for a reduction in solar radiation loading is to minimize longitudinal heating. A limiting factor in reducing longitudinal stream heating is the natural maximum level of shade that a given stream is capable of attaining (see above subsection - ***Site Potential Effective Shade - Defined***).

Data collected in the Tillamook Bay Watershed indicate a significant relationship between effective shade and maximum daily stream temperature levels (correlation coefficient = R^2= 0.82, Highly Significant – $p < 0.01$). Effective shade measurements were averaged over the individual upstream reach lengths where data were collected in the Tillamook Bay Watershed. These values were then plotted against the maximum temperature (for August 12, 1998) recorded at the lowest end of each stream reach (**Figure 27**). High effective shade levels correspond to lower daily maximum stream temperature values. Stream temperature may also exhibit a threshold condition in which slight reductions in shade allow considerable stream heating. Larger stream temperature increase is possible when the stream surface moves from a highly shaded condition to partial shade (Boyd, 1996). There are several other parameters that affect the daily maximum stream temperature in addition to effective shade: relative humidity, flow rates, surface and subsurface mixing, air temperature and wind speed, to name a few. However, data confirm the relationship between effective shade and maximum daily stream temperature levels (Figure 26).

Figure 27. Reach Length Averaged Effective Shade and Maximum Daily Stream Temperature (ODEQ, August 12, 1998)



Riparian Vegetation – Current Condition

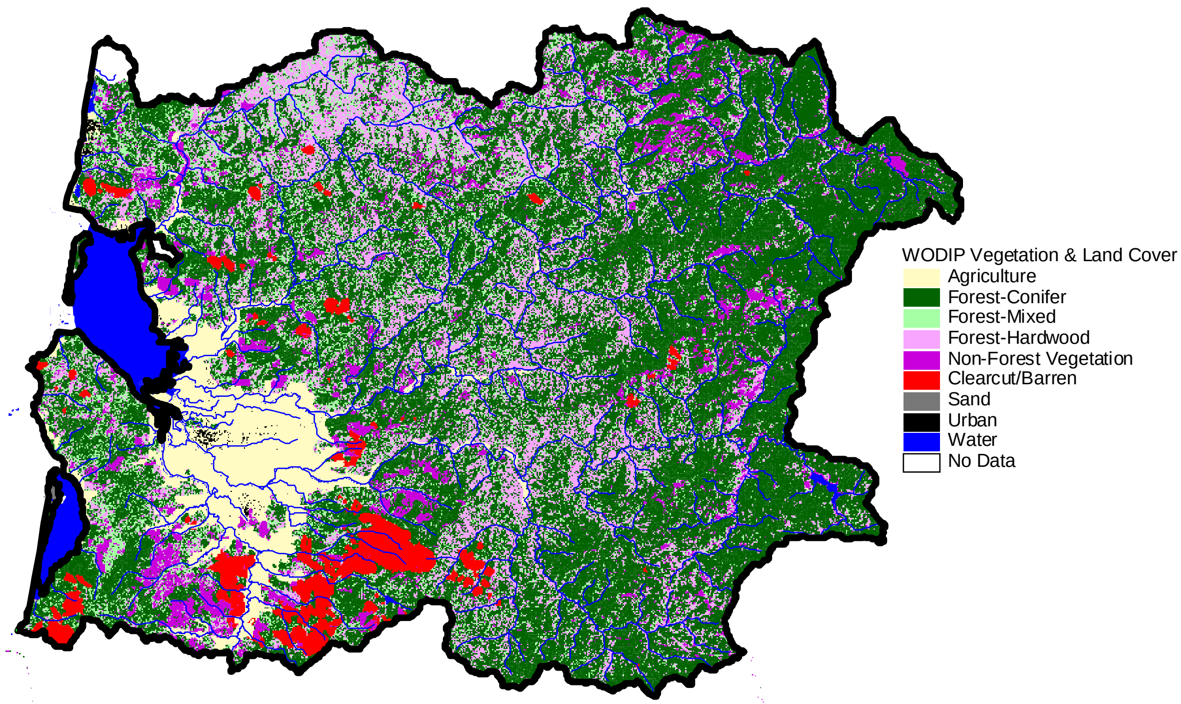
Riparian vegetation in the Tillamook Bay Watershed varies over elevation and among land uses, as well as reflecting a complex history of uses and natural events. The watershed historically supported a thriving timber industry and has been one of the most important farming areas in the state. The following are some excerpts from *Tillamook Bay Environmental Characterization* (Tillamook Bay National Estuary Project, 1997), which describes the vegetation present in the Tillamook Bay Watershed.

> *The spruce zone covers the lower regions of the watershed and normally occurs at elevations below 450 feet (150 meters).*
>
> *Dense, tall stands of Sitka spruce, western hemlock, western red cedar (Thuja plicata), Douglas fir (Psuedotsuga menziesii), and grand fir (Abies grandis) dominate the spruce zone…hardwood species occurring in the zone include red alder (Alnus rubra), bigleaf maple (Acer macrophyllum), and occasional California bay (Umbellularia californica) with red alder dominating recently disturbed sites and some riparian areas.*
>
> *Successional patterns in the spruce zone following fire or logging are often dominated by a dense shrub community composed of salmonberry (Rubus spectabilis), sword fern, elderberry, and huckleberry, with relative dominance varying with the site conditions. The shrub community can persist for quite some time due to the excellent growing conditions, but at some point it yields to one of two types of seral forest stands. The conifer type is a mixture of spruce, hemlock, and Douglas fir and the hardwood type is a monotypic, dense stand of red alder.*
>
> *The hemlock zone normally extends in elevation between 450 feet (150 meters) and the subalpine zone of the Coast Range.*
>
> *In the hemlock zone, the dominant vegetation is dense conifer forest. Forest stands are dominated by Douglas fir, western hemlock and western red cedar, with other conifers mixed in, such as grand fir, Sitka spruce, and Pacific yew (Taxus brevifolia). Hardwood species occurring in the hemlock zone include red alder, bigleaf maple, black cottonwood (Populus trichocarpa) and Oregon ash (Fraxinus latifolia).*
>
> *Successional patterns in the hemlock zone following fire or clearcut logging bring the first year residual species and invading herbaceous species from the genera Senecio and Epilobium. This community is replaced during years two to five by one dominated by fireweed (Epilobium angustifolium), thistle (Cirsium vulgare) and bracken fern (Pteridium aquilinum). The next community is dominated by shrubs such as vine maple, Oregon grape, rhododendron, salal and blackberry species (Rubus spp.). Eventually the shrubs are overtopped by conifers such as Douglas fir.*
>
> *- Tillamook Bay National Estuary Project, 1997*

Sampling/Measuring Riparian Vegetation

Basin-wide vegetative conditions can be observed using Western Oregon Digital Inventory Project (WODIP) satellite images. WODIP is a vegetation mapping project using Thematic Mapper Satellite data collected in 1993, existing field inventory data, and advanced computer technology to produce a forest vegetation map of western Oregon. Its intended use is for watershed analysis, habitat analysis, and other environmental assessment projects. WODIP satellite data has a resolution (pixel size) of 25 meters, meaning that the sensor on board the satellite records energy reflected from an area on the ground measuring 25 meters by 25 meters. The WODIP coverage for the Tillamook Bay Watershed (see **Figure 27**) illustrates vegetation fragmentation on a watershed-wide scale, with a portion of the lower watershed cultivated for agriculture, urban areas in the lower watershed, and timber harvests dotting the upper basin.

Figure 28. Western Oregon Digital Inventory Project Coverage in the Tillamook Bay Watershed.



Riparian vegetation can be effectively mapped at a 25-meter pixel when vegetation characteristics (vegetation type) exceed sampling resolution. However, in many areas of the Tillamook Bay Watershed riparian characteristics are more variable and require a higher resolution than that sampled by Landsat/WODIP. To increase the resolution of riparian vegetation characterizations, digital orthophoto quadrats (DOQ) were used to refine both the polygons and the classifications in the near stream area (300 feet on either side of the stream channel) over most of each of the main rivers (Figure A-6). Ground level measurements were collected throughout the Tillamook Bay Watershed to assist in vegetation classifications. **Figure 28** displays vegetation and land cover polygons derived from orthophotos at a scale of 1:5,000 and validated with ground level measurements. The extent of near stream vegetation sampling and analysis is provided below.

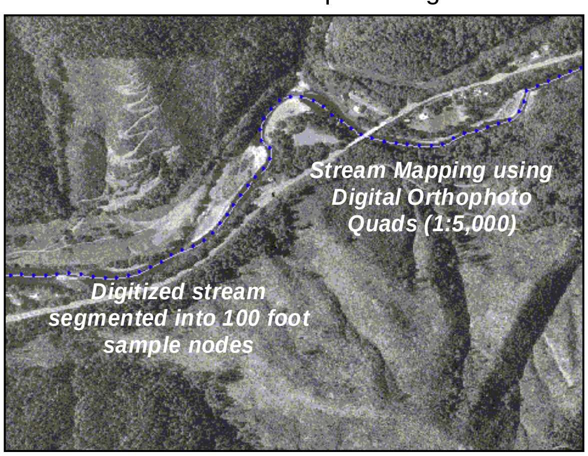
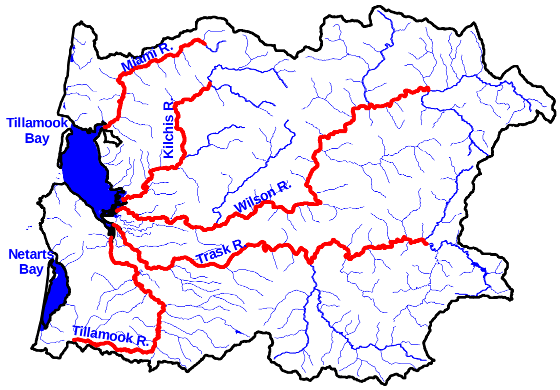


Figure 29. Number of miles with vegetation classified for each of the rivers of Tillamook Bay Watershed.



Kilchis River – mouth to river mile 10.3
Trask River – mouth to river mile 30.7
Wilson River – mouth to river mile 33.6
Miami River – mouth to river mile 11.9
Tillamook River - mouth to river mile 18.9

105.4 total river miles

Near stream vegetation classifications were determined from infrared satellite data (WODIP LandSat), digital orthophoto quads and ground level data. All classifications identified dominant species type, canopy density, and stand size and used ground truthing. Additionally, the Oregon DEQ collected riparian species, height, and density data at several sites in the Tillamook Bay Watershed during the summer of 1999. Every near-stream vegetation code was quality checked against aerial photographs (digital orthophoto quads) and was ground-truthed by DEQ.

All near stream vegetation data is coded for species type, canopy density, and size/structure. Species type is coded according to the dominant existing over-story species. Canopy density is presented as the percentage of ground that is covered by over-story vegetation when viewed from directly above or measured by a densiometer at ground level. LandSat size/structure classes are divided by diameter at breast height (DBH) for woody vegetation. The LandSat size/structure class denotes whether the stand is single or multiple story.

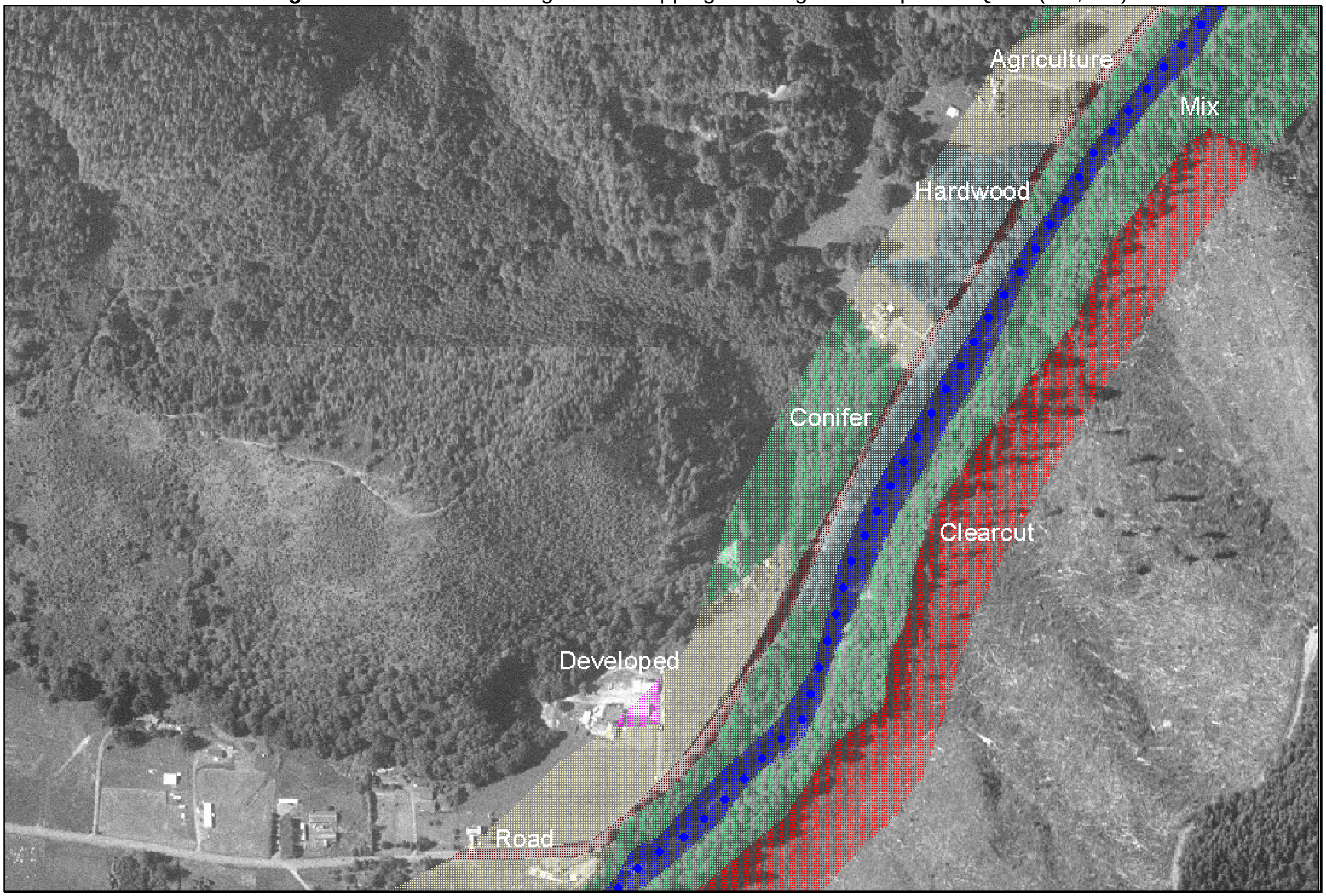
Non Forest – If the total tree crown closure was <10%, then the site was labeled with the appropriate Non Forest class.

Canopy Layer – Single-storied if over 85% of the total tree crown closure is present in one canopy layer, otherwise was multi-storied.

Stream reaches were digitized from orthophoto quads at less than 1:5,000. These stream data layers were then segmented into data points at a 100-foot interval. These point data layers form the basis for automated sampling performed using Ttools[13]. At every distance node (i.e. every 100 feet) along the stream, vegetation was sampled at 15-foot intervals out to 120 feet from the channel edge for both stream banks. A total of 18 vegetation samples are taken at each stream distance node.

[13] Ttools is a automated sampling tool that was developed by DEQ to sample the following spatial data: stream aspect, channel width, FLIR derived temperatures, near stream vegetation and topographic shade angles. Sampling resolution is user defined and was set at 100 foot intervals longitudinally (i.e. along the stream) and 15 feet in the transverse direction (i.e. perpendicular to the stream).

Figure 30. Trask River Vegetation Mapping from Digital Orthopohoto Quad (1:5,000)



Riparian Vegetation Composition

As described above, automated sampling of the near stream area classified vegetation types at a vector perpendicular to the stream aspect, starting the stream channel edge and sampling at eight 15-foot intervals to a distance of 120 feet. Automated near stream vegetation sampling was completed for 105.4 miles of mainstem reaches in the Tillamook Bay Watershed (Figures A-8 to A-12). Given that 240 feet of near stream area (120 feet of each side of the stream) was sampled, a total of 4.79 square miles (3066 acres) of near stream vegetation was classified and analyzed. Near stream vegetation was grouped as one of the following: conifer forests, mixed (conifer and deciduous) forests, deciduous forests, scrub/shrub (woody vegetation less than 20 feet in height), agriculture/pasturelands, timber harvest, roads and developed lands (both urban and rural residential). Agriculture and pasturelands comprise 24.9% of the sampled near stream areas. Forestlands combined were the most common uses, though they were broken down into conifer (24.6%), mixed forests (20.7%), deciduous forests (17.6%), scrub/shrub (2.4%) and timber harvested areas (5.7%). Roads occupied 3.7% of the near stream area and 1.8% of the near stream lands were developed as urban or rural residential. The high proportion of land in agricultural uses reflects common clearing and agricultural use through much of the basin.

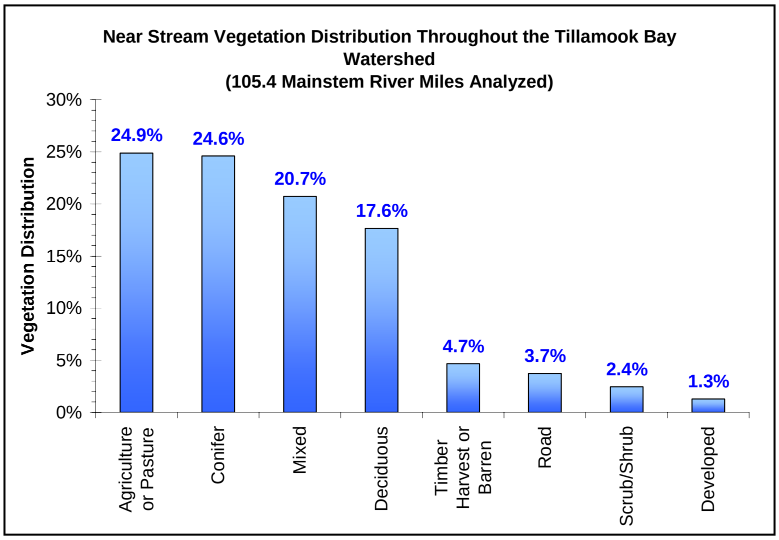


Figure 31. Miami River Vegetation Distribution, Current Height and Potential Height (mouth to river mile 11.9)

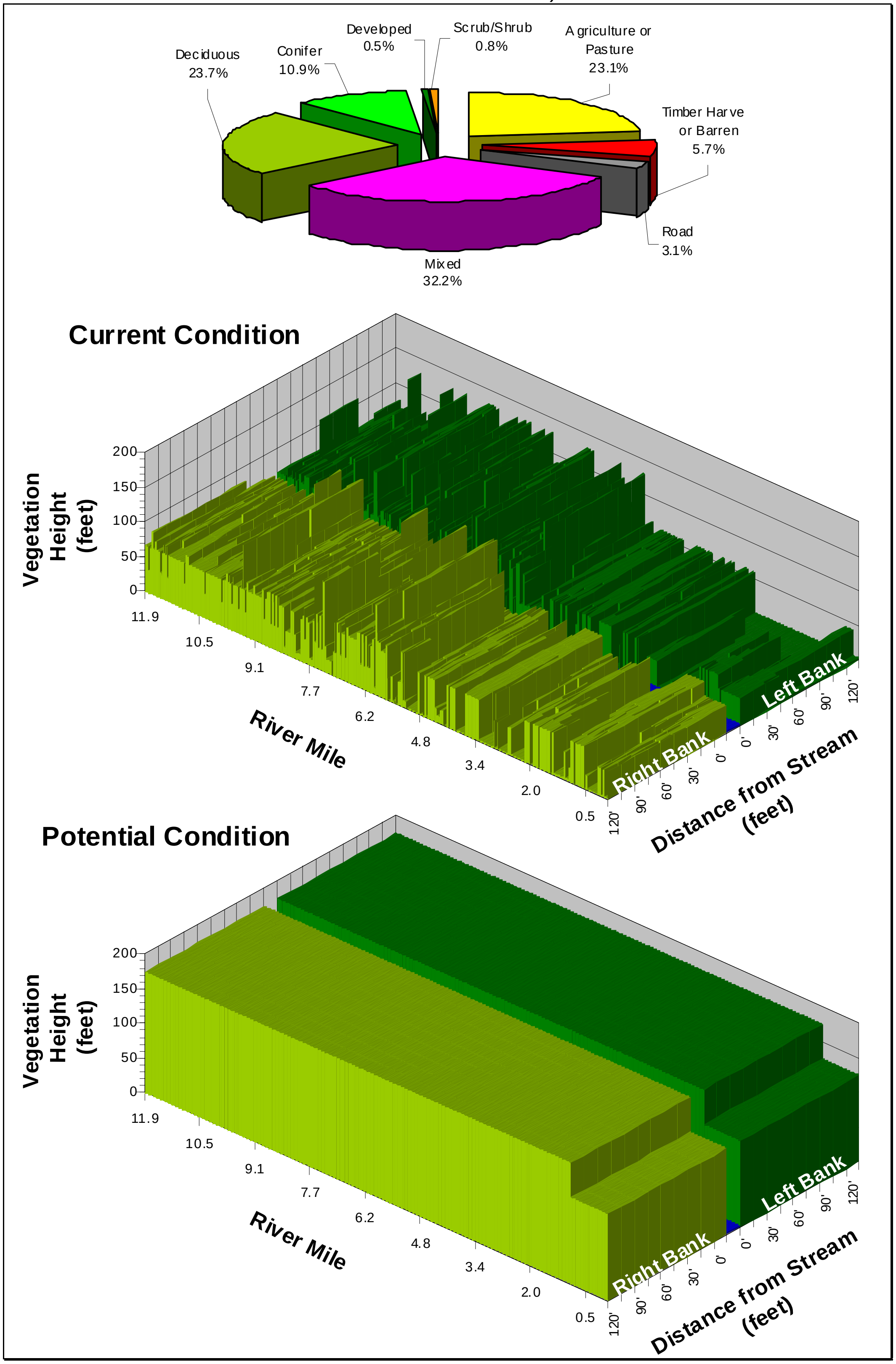


Figure 32. Kilchis River Vegetation Distribution, Current Height and Potential Height (mouth to river mile 10.3)

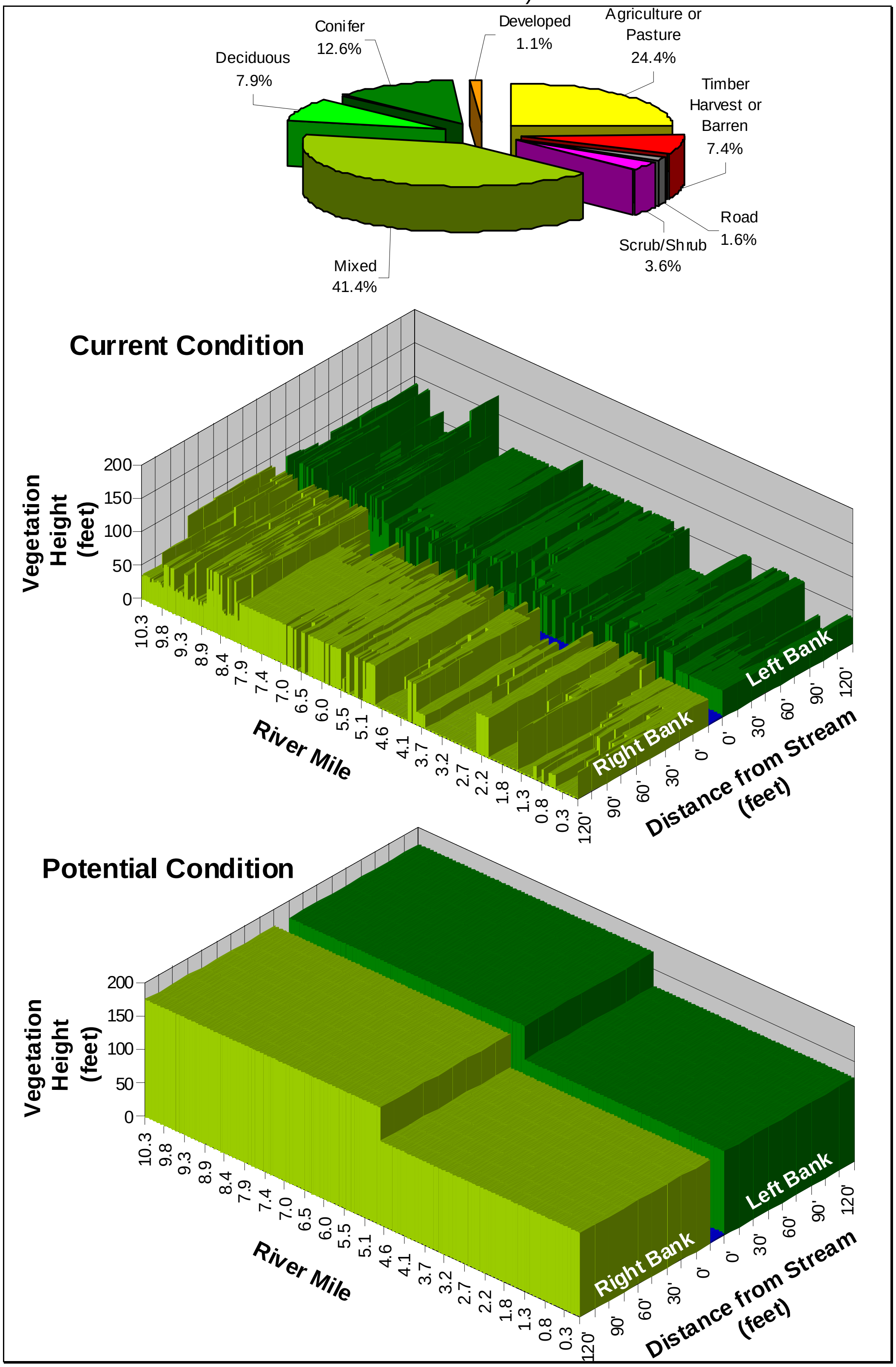


Figure 33. Wilson River Vegetation Distribution, Current Height and Potential Height (mouth to river mile 33.6)

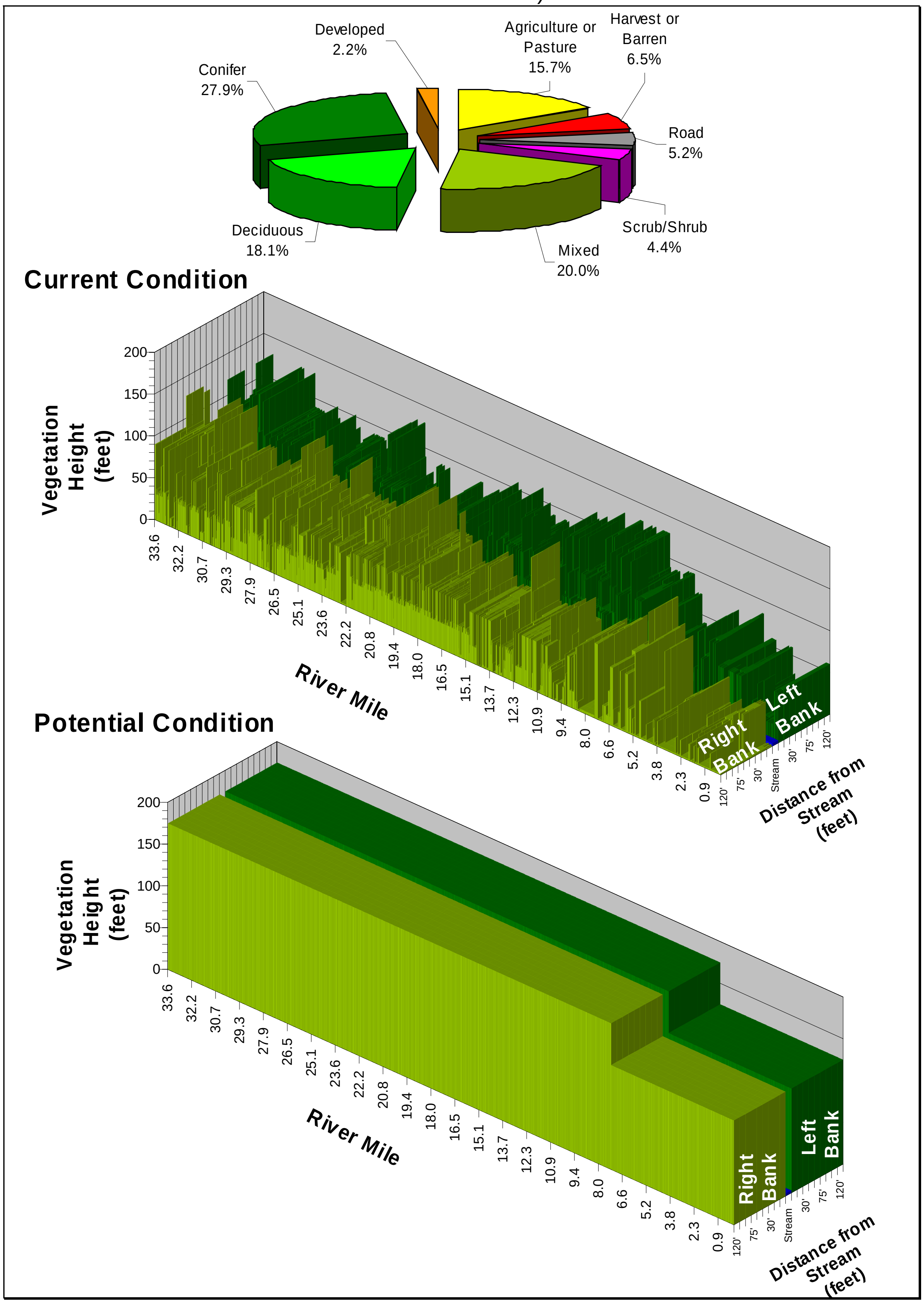


Figure 34. Trask River Vegetation Distribution, Current Height and Potential Height (mouth to river mile 30.7)

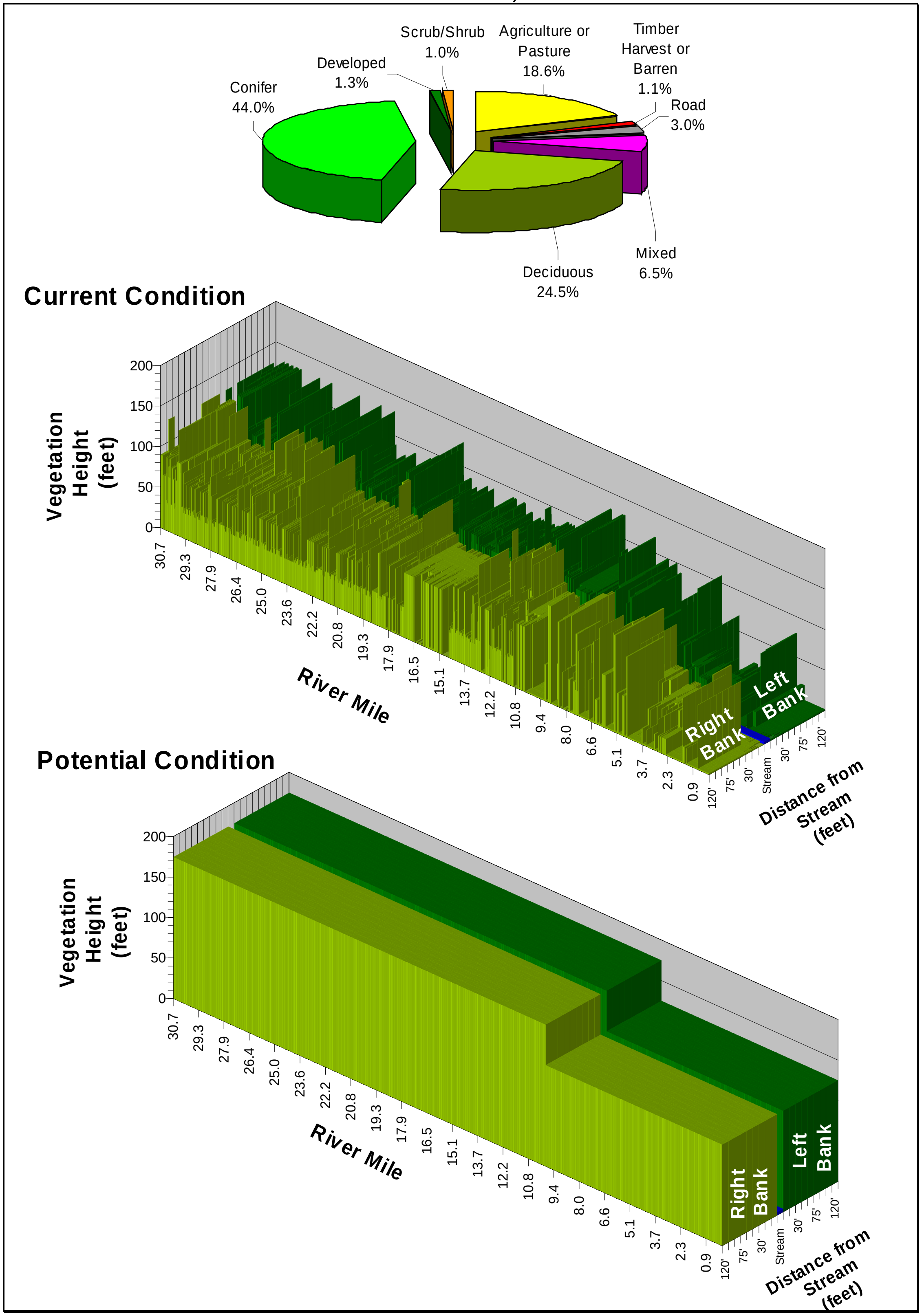
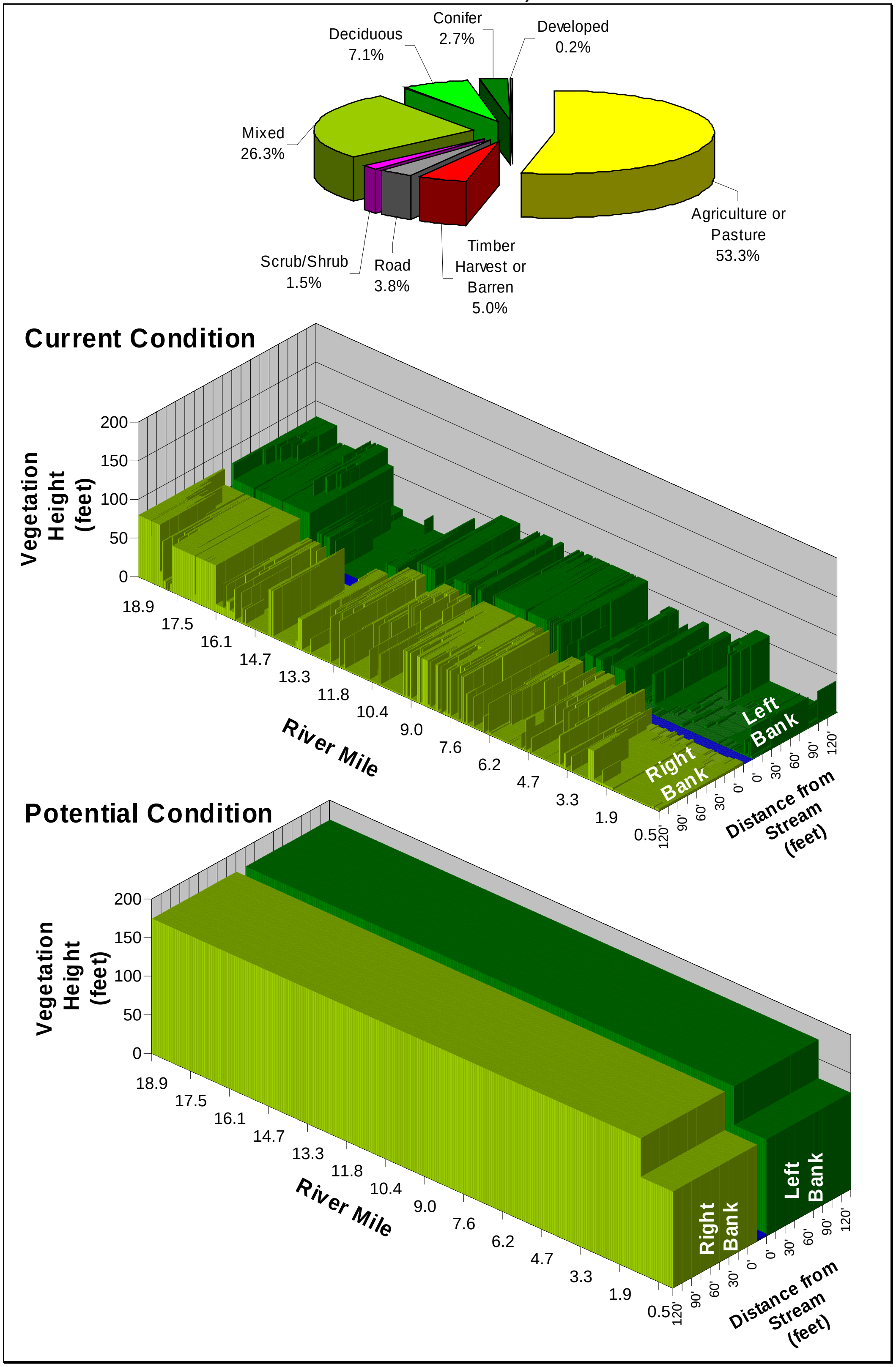


Figure 35. Tillamook River Vegetation Distribution, Current Height and Potential Height (mouth to river mile 18.9)



Riparian Vegetation Height

Existing tree heights were either calculated from the specified LandSat DBH using species-specific growth curves (Hann, 1997 and Richards 1959) or derived from ground level data. LandSat classifications provide DBH in ranges allowing calculation of vegetation height based on "growth curve" information developed for forestry practices. DEQ applied the middle (average) value of the range for each size/structure class (Table A-2). Below is the Chapman-Richards Asymptotic Nonlinear Regression Module equation that is used to determine heights based on known DBH values (Richards, 1959).

Table 23 displays tree height as a function of DBH using the Chapman-Richards Asymptotic Nonlinear Regression Module (**Equation 1**) and the coefficients presented in **Table 24**. The Tillamook Bay Watershed is home to tall-growing conifers such as: douglas fir, western hemlock, sitka spruce, noble fir and western red cedar. Predominant deciduous trees include red alder and big-leaf maple.

Equation 1. Chapman-Richards Asymptotic Nonlinear Regression Module (Hann, 1997 and Richards 1959),

$$H = 1.37 + \left(b_0\left[1 - \exp\left(b_1 \cdot DBH\right)\right]^{b_2}\right)$$

Where,

H = Height of Tree
b_0 = regression variable
b_1 = regression variable
b_2 = regression variable
DBH = Diameter at Breast Height

Table 22. Mean vegetation DBH and Height for North Coastal Tree Species (Hann, 1997 and Richards 1959)

Species	**Mean DBH (inches)**	**Mean Height (feet)**	**Sample Size N**
Bigleaf Maple	11.3	62.6	627
Douglas Fir	19.1	100.7	8332
Noble Fir	17.1	71.8	68
Red Alder	9.2	57.4	1641
Sitka Spruce	40.0	147.3	423
Western Hemlock	14.9	97.7	3152
Western Red Cedar	18.9	72.8	582

Table 23. Chapman-Richards Asymptotic Nonlinear Regression Module Coefficients (Hann, 1997 and Richards 1959)

Species	b_0	b_1	b_2	R^2
Bigleaf Maple	30.17141	-0.03738	0.81291	0.69
Douglas Fir	85.60765	-0.01023	0.93495	0.92
Noble Fir	75.47281	-0.00861	0.97062	0.94
Red Alder	37.36855	-0.02340	0.76164	0.75
Sitka Spruce	65.27757	-0.01236	0.96792	0.71
Western Hemlock	60.87614	-0.02195	1.07827	0.86
Western Red Cedar	55.19896	-0.01211	0.91076	0.91

Potential Riparian Vegetation Characteristics

System potential vegetation was developed with information from the Oregon Department of Forestry (Wayne Auble, ODF, Tillamook State Forest) and DEQ staff. ODF provided average height of mature trees[14] for the species listed in **Table 21**. Potential tree height was derived for forestlands, cropland/pasture and urban land (see **Figure A-13** for map of land use). Tree height targets provided by ODF seem appropriate when compared to tree heights listed in **Figure A-14** (Tree Height as a function of DBH) and **Figure A-15** (Expected Tree Height as a Function of Age) and observed ranges of tree heights in the watershed (Whitney 1997, Figure A-16). Potential vegetation density is assumed to be 90% for all tree species.

Trees were also measured directly in the Tillamook Bay Watershed to develop a set of known potential tree heights for important riparian species. This cataloging of tree heights and best professional judgement from local foresters led us to set mature riparian communities in the uplands (forested areas) at a height of 175 feet, and those in the lowlands (croplands, pasture, and urban lands) at 125 feet. The lesser height in the lowlands was based on the expectation of greater proportions of deciduous species in mature lowland riparian communities.

Table 24. Potential Tree Heights (personal communications with Wayne Auble, ODF)

Species	**Average Height**	**Age**
Douglas Fir	160 to 180 feet	80 years
Western Hemlock	140 feet	
Western Red Cedar	120 to 140 feet	
Sitka Spruce	140 feet	
Red Alder	100 feet	
Bigleaf Maple	100 feet	
Land Use Area	**Dominant Tree Species and Mature Tree Height**	***Targeted Height***
Forestlands	Douglas Fir - 175 feet	*175 feet*
Cropland, Pasture and Urban Lands	50% Douglas Fir – 175 feet Western Hemlock – 140 feet Western Red Cedar – 140 feet Sitka Spruce – 140 feet	125 feet
	50% Red Alder - 100 feet Bigleaf Maple - 100 feet	

14 Mature trees were defined in terms of average age and height at which a growth curve would begin to flatten out; e.g., for Douglas Fir that would be at approximately 80-100 years of age.

Figure 36. Land Use for Determination of Potential Dominant Tree Species and Mature Tree Heights (USGS, 1979)

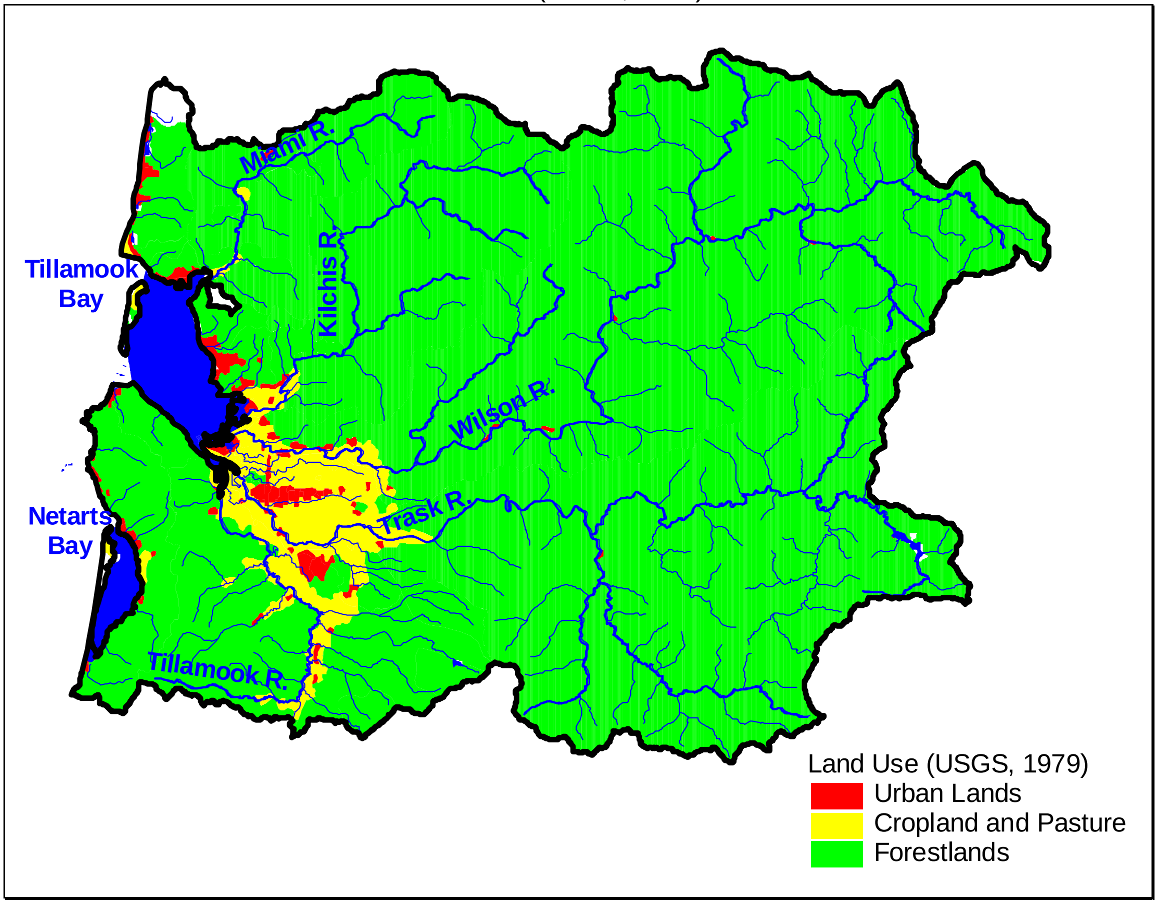


Figure 37. Tree Height as a Function of Diameter Breast Height (DBH) (Hann, 1997 and Richards 1959)

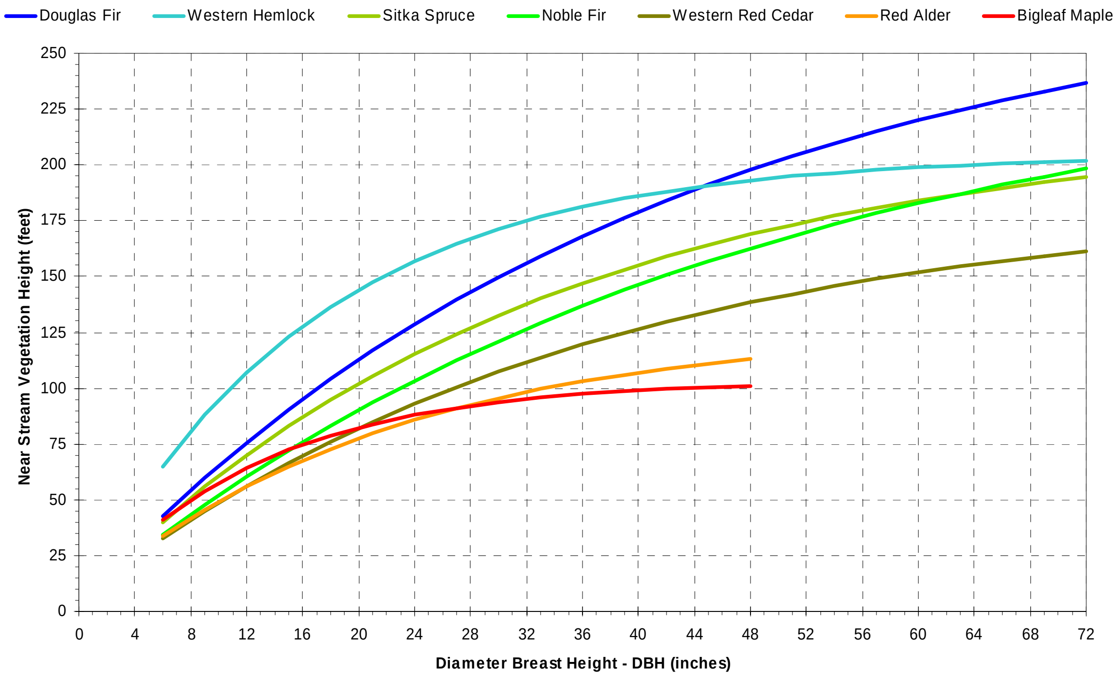


Figure 38. Expected Tree Height for Douglas Fir as a Function of Stand Age – Site Quality I (McArdle and Meyer, 1961)

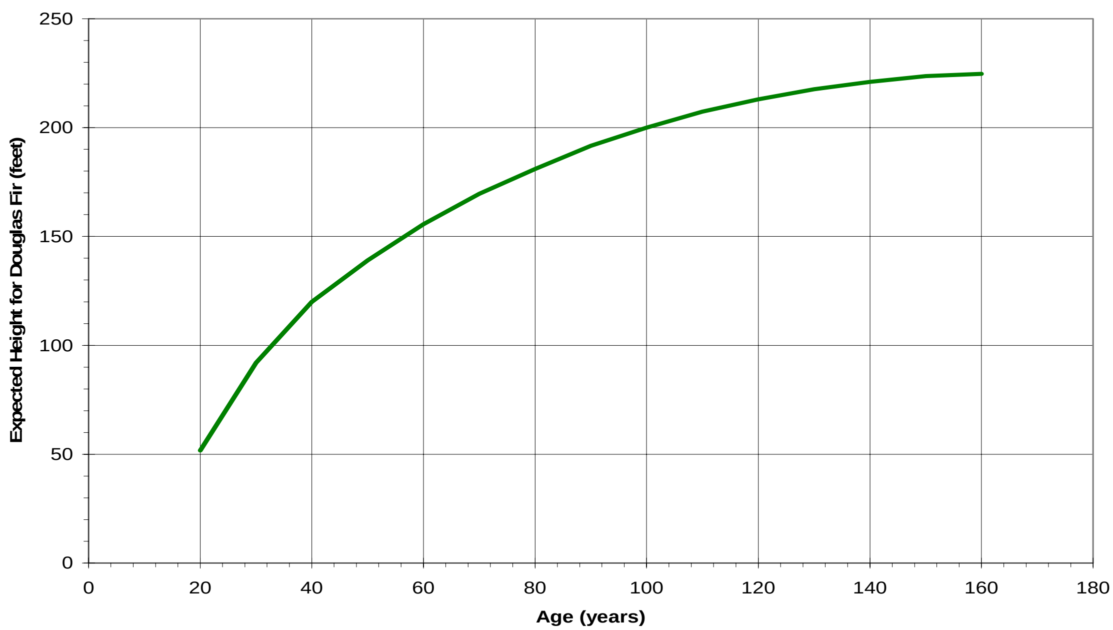
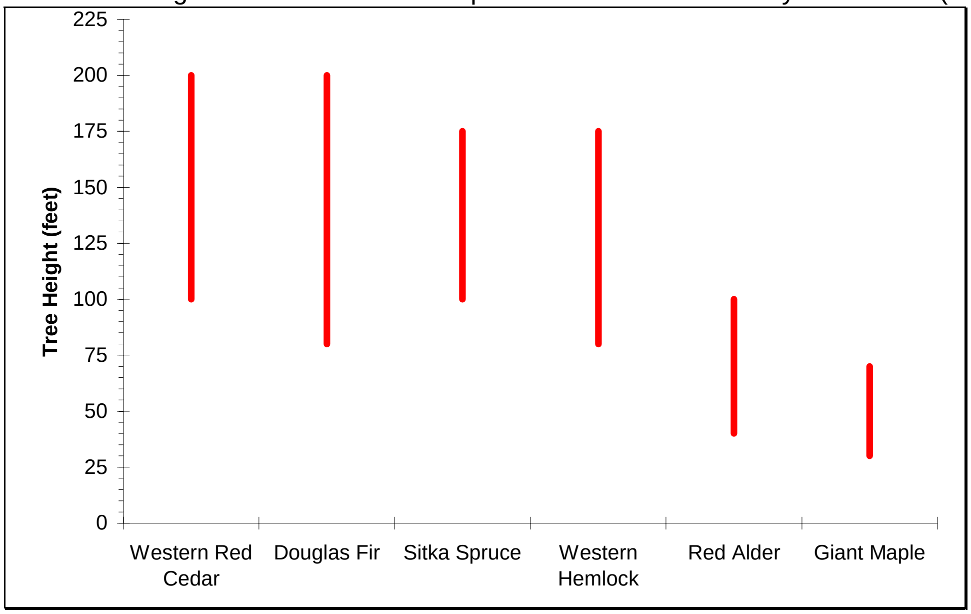


Figure 39. Tree Heights for Dominant Tree Species in the Tillamook Bay Watershed (Whitney, 1997)



Microclimate - Surrounding Thermal Environment

Although solar radiation generally is the greatest source of heat energy to surface waters, secondary sources such as air convection and substratum conduction, can also be significant.

Air affects stream temperatures at a slower *rate.* Nevertheless, this should not be interpreted to mean that air temperatures do not affect stream temperature. Air can deliver heat to a stream via the convection/conduction pathway, which is the slowest of the water energy transfer processes (Bowen, 1926; Beschta and Weatherred, 1984; Boyd, 1996; Chen, 1996). However, prolonged exposure to air temperatures warmer than the stream can induce gradual stream heating. Thus, a cooler microclimate will induce less stream warming.

Riparian corridors often produce a microclimate that surrounds the stream where cooler air temperatures, higher relative humidity and lower wind speeds are characteristic. Riparian microclimates tend to moderate daily air temperatures. Relative humidity increases result from the evapotranspiration that occurs in riparian plant communities. Wind speed , which cools surface waters by increasing evaporation, is reduced by riparian vegetation. Dong et al. (1998) analyzed microclimate data along 20 small streams in western Washington and found that riparian vegetation removal via timber harvests increased near stream air temperatures by up to 8^{o}F. Chen et al. (1995) detected that edge effects (i.e. atmospheric conditions outside of the near stream buffer) penetrated to depths greater than 600 feet into a well-vegetated area. Riparian buffers commonly occur on both side of the stream, compounding the edge influence on the microclimate.

Near-stream ground temperatures can be a source of heat energy to the stream. When the ground is warmer than the stream, heat will transfer from the stream bank to the water column. In fact, ground surfaces can conduct heat to the stream hundreds of times faster than that of the air column surrounding the stream. Solids (ground surfaces) have higher conductivity than gases (air). Conductivities of soils are on the order of 500 to 3,500 times greater than that of air (Halliday and Resnick, 1988). Impoverished riparian areas that allow excessive stream bank warming will introduce heat into the stream faster than cooler, highly vegetated stream banks. Brosofske et al. (1997) reported that a minimum stream buffer width of 150 feet was required to maintain soil temperatures that reflect those of a normal microclimate. Riparian condition is again implicated as a controlling factor in stream temperature dynamics in part because ground/soil temperatures are a function of the shading.

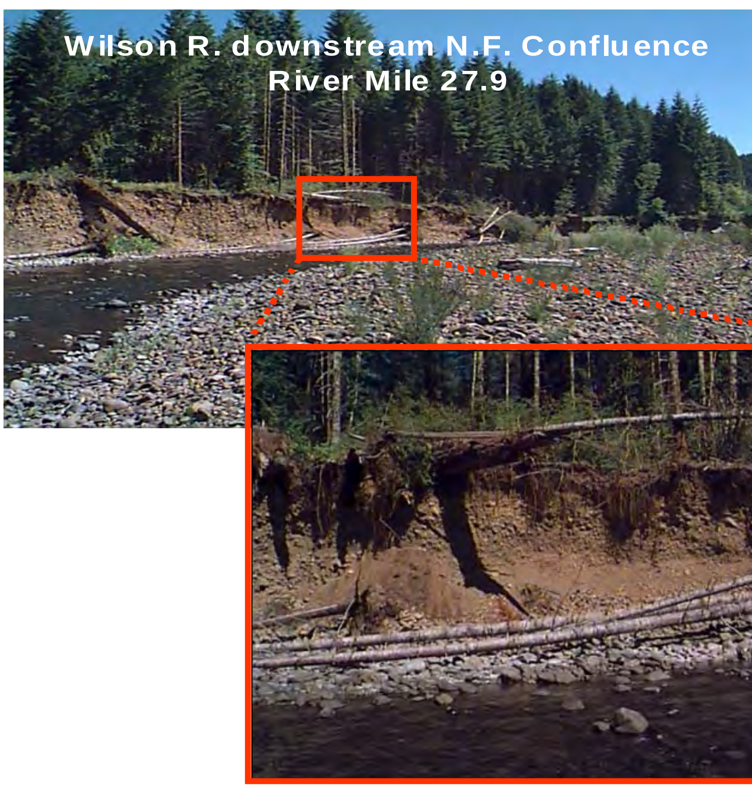
Channel Morphology

Thermal Role of Channel Morphology

Changes in channel morphology, namely channel widening, impacts stream temperatures. As a stream widens, the surface area exposed to radiant sources and ambient air temperature increases, resulting in increased energy exchange between the stream and its environment (Boyd, 1996). Further, wide channels are likely to have decreased levels of shade due to the increased distance created between vegetation and the wetted channel and the increased surface area to shade. Conversely, narrow channels are more likely to experience higher levels of shade and a higher frequency of pools that provide to aquatic habitat.

Channel widening is often related to degraded riparian conditions that allow increased stream bank erosion and sedimentation of the streambed, both of which correlate strongly with riparian vegetation type and condition (Rosgen 1994). Riparian vegetation contributes to rooting strength and flood plain/stream bank roughness that dissipates erosive energies associated with flowing water. Established/Mature woody riparian vegetation adds the highest rooting strengths and flood plain/stream bank roughness. Annual (grassy) riparian vegetation communities offer less rooting strength and flood plain/stream bank roughness.

Stream bank erosion rates are often a function of near stream vegetation type and condition



Channel morphology is related to riparian vegetation composition and condition by:

- ✓ ***Building stream banks:*** *Trap suspended sediments, encourage deposition of sediment in the flood plain and reduce incoming sources of sediment.*
- ✓ ***Maintaining stable stream banks:*** *High rooting strength and high stream bank and flood plain roughness prevent stream bank erosion.*
- ✓ ***Reducing flow velocity (erosive kinetic energy):*** *Supplying large woody debris to the active channel, high pool:riffle ratios and adding channel complexity that reduces shear stress exposure to stream bank soil particles.*

Stream bank erosion relationships were analyzed using ODFW survey data. High rates of active stream bank erosion (greater than 22.5% of stream banks actively eroding) correlate with annual (grass dominated) riparian vegetation types. Annual vegetation types have a *median* active stream bank erosion rate of 37%. Moderate active stream bank erosion rates (7.5% to 22.5% of stream banks actively eroding) correlate with seedling and young hardwood and conifer riparian vegetation communities, 18% and 16% respectively. Low rates of active stream bank erosion (less than 7.5% of stream banks actively eroding) almost exclusively occur in areas with established mature hardwood or conifer riparian vegetation communities. The lowest active stream bank erosion rates occurred in mature conifer riparian vegetation communities, where the median active stream bank erosion rate is zero (i.e. no active stream bank erosion is observed). **Figure A-18** displays the range of active erosion rates that correspond to riparian vegetation types: annuals, hardwood (seedling/young), hardwood (established/mature), conifer (seedling/young) and conifer (established/mature).

The width to depth ratio is a common measure of channel morphology. Streams with naturally occurring (i.e. unarmored stream banks) low width to depth ratios generally have more stable stream banks resulting from mature near stream vegetation (i.e. increased rooting strength and floodplain roughness). ODFW stream survey data demonstrate the relationship between near stream vegetation and channel width. **Figure A-19** displays various width:depth ratios related to various riparian vegetation types. Median width to depth ratios are similar for annual, hardwood and conifer comparisons (18 to 20). However, amount of variation within each of the data sets varies widely among vegetation types. The interquartile range (25^{th} to 75^{th} percentile values) of values is a good indicator of this variability. This range was 7-57, 18-38, and 17-22 for annuals, seedling deciduous and conifer trees, and mature deciduous or conifer trees, respectively. Clearly, the mature tree communities were associated with the lowest width to depth ratios, and hence the greatest streambank stability.

Channel morphology is not solely dependent on riparian conditions. Sedimentation can deposit material in the channel, fill pools and agrade the streambed, reducing channel depth and increasing channel width. Flow events play a major role in shaping the stream channel. Channel modification usually occurs during high flow events. Naturally, land uses that affect the magnitude and timing of high flow events may negatively impact channel width and depth. Riparian vegetation conditions will affect the resilience of the stream banks/flood plain during periods of sediment introduction and high flow. Disturbance processes may have drastically differing results depending on the ability of riparian vegetation to shape and protect channels.

Figure 40. Active Stream Bank Erosion Related to Various Riparian Vegetation Types

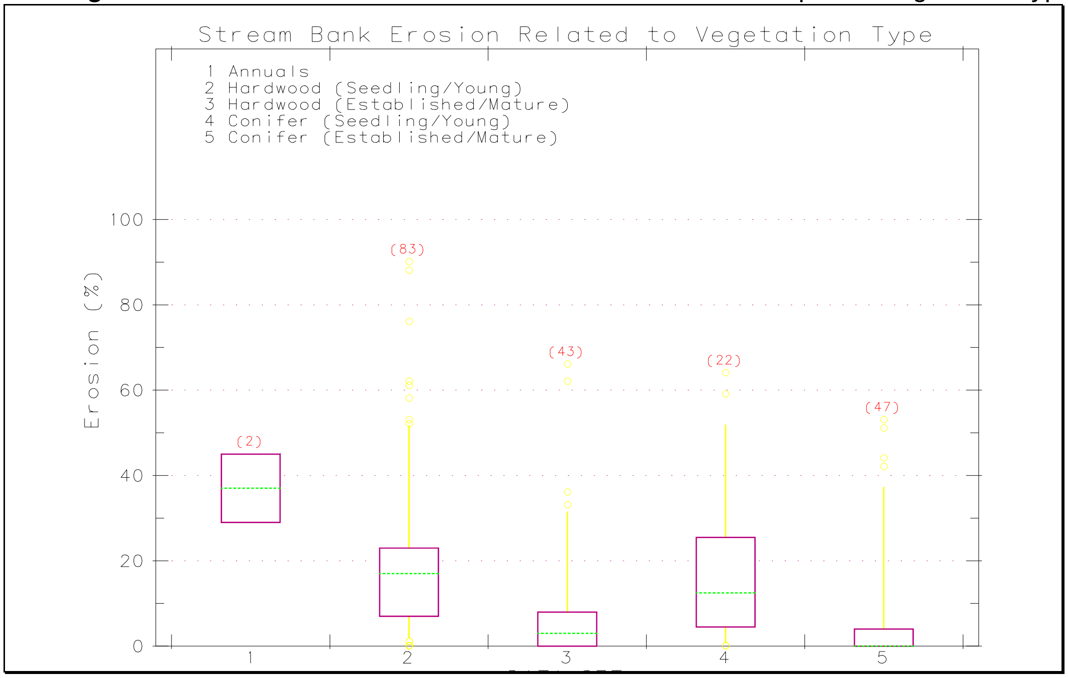
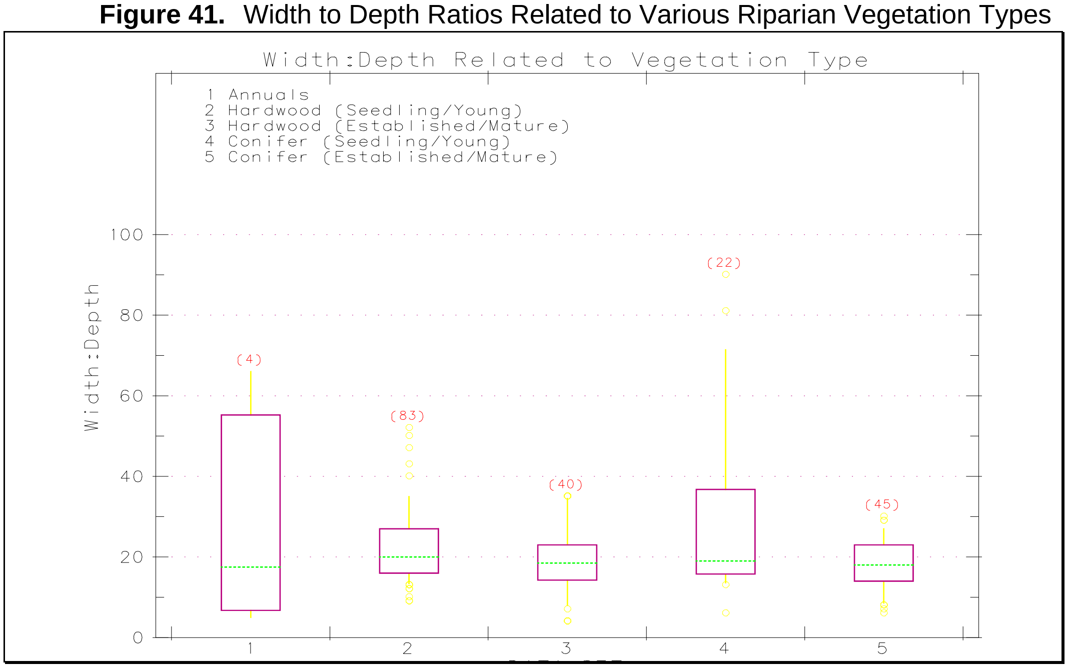


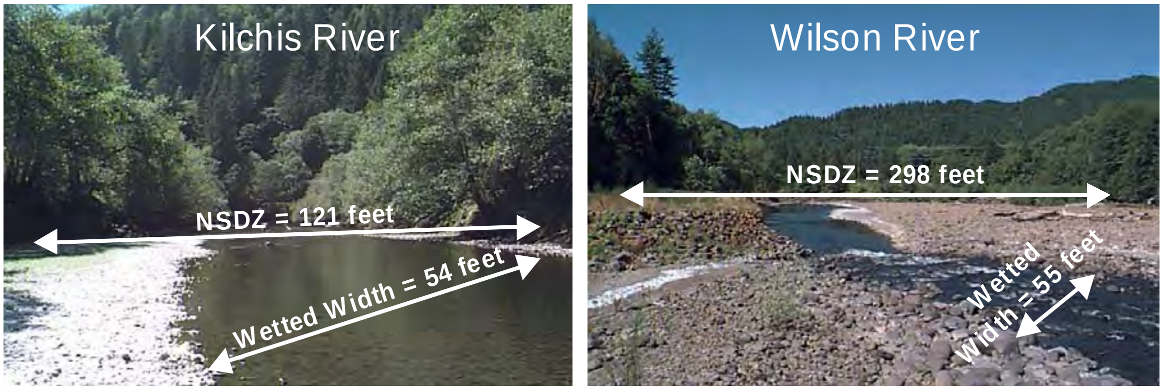
Figure 41. Width to Depth Ratios Related to Various Riparian Vegetation Types



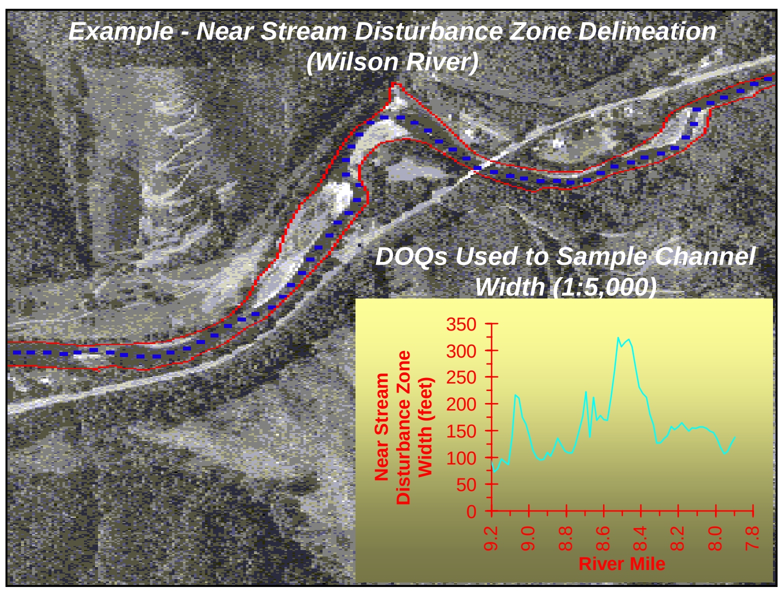
Channel Width

Two channel parameters were sampled/measured: the near stream disturbance zone width and the wetted channel width. The 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 ground level measurements. Where near-stream vegetation was absent, the near-stream boundary was used, 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.). The near stream disturbance zone width serves as a estimate of the bankfull width. This parameter is used to determine the distance of the near stream vegetation to the wetted channel. In essence, the near stream disturbance zone allows for positioning of the near stream vegetation relative to the stream channel. **Figure 20** shows the sampled near stream disturbance zone widths sampled for the Kilchis, Wilson and Trask Rivers.

Example - Near Stream Disturbance Zone and Wetted Width Ground Level Measurements



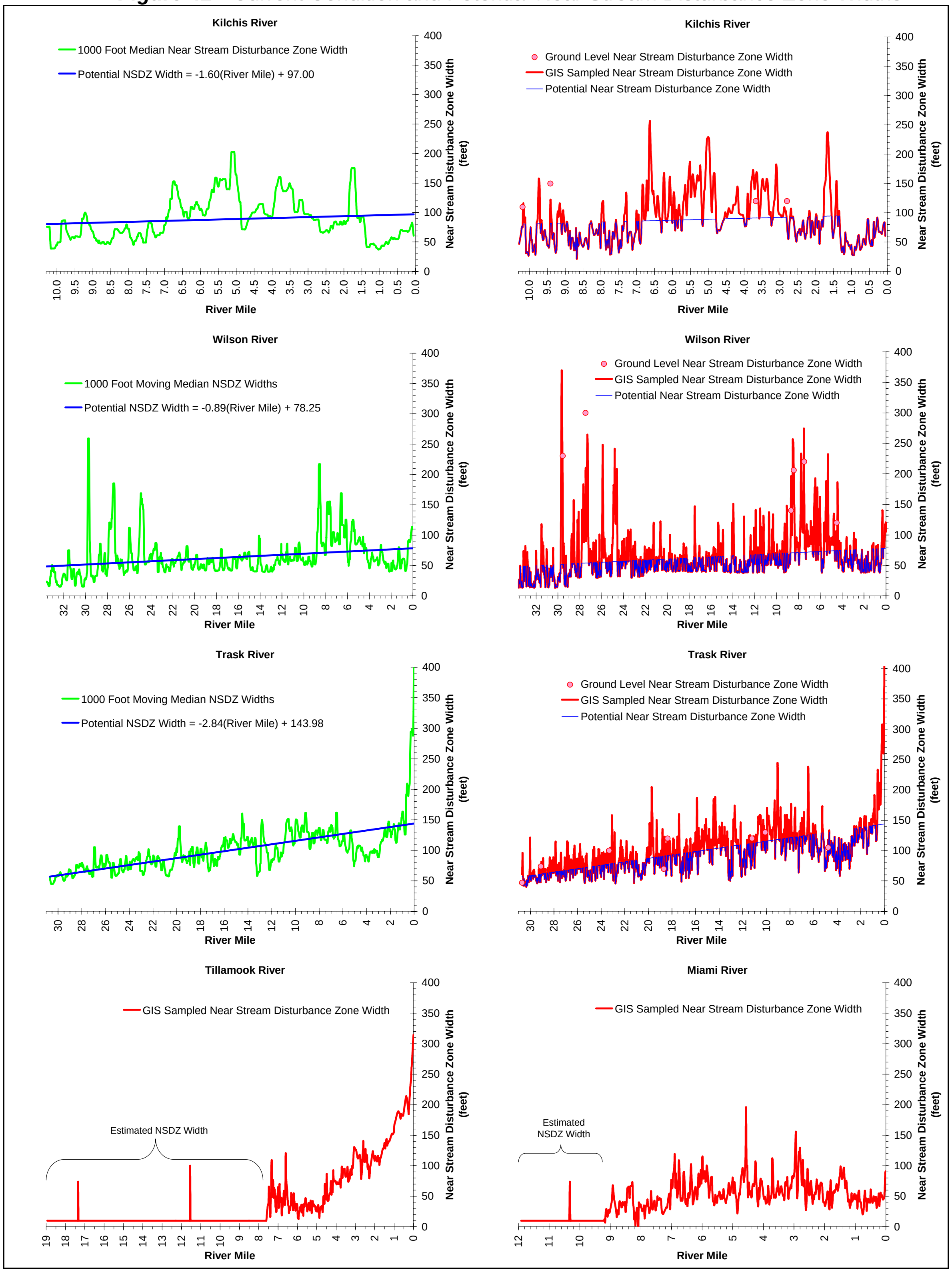
Near stream disturbance zone width data from each river were analyzed to assess the pattern of widening from headwaters to mouth and to estimate the effects of narrowing as a result of future passive restoration expected resulting from near stream vegetation protection/restoration. Widths were quite variable in each of the rivers, though there was generally an overall tendency toward increasing width with distance downstream. Given that the streams were narrower at some places downstream of very wide places, it follows that these narrow places were sufficiently wide to accommodate high flow volumes. Further, channel width reductions do not target a single width, but instead provide an upper limit as a function of distance along the stream channels.



The moving median[15] width value was calculated from 10 measurements along each 1000-foot stream segments. These values were calculated sequentially from the headwaters to the mouth of each river. The pattern of median widths still indicated considerable variability throughout each watershed, though peaks were less pronounced. A best-fit line and associated slope equation were fitted to the data set of each river. This line was used to determine an upper limit on the near stream disturbance zone width for each river system.

[15] The median is the middle value within a group, with half of the values lower and half that are higher than other samples within the group.

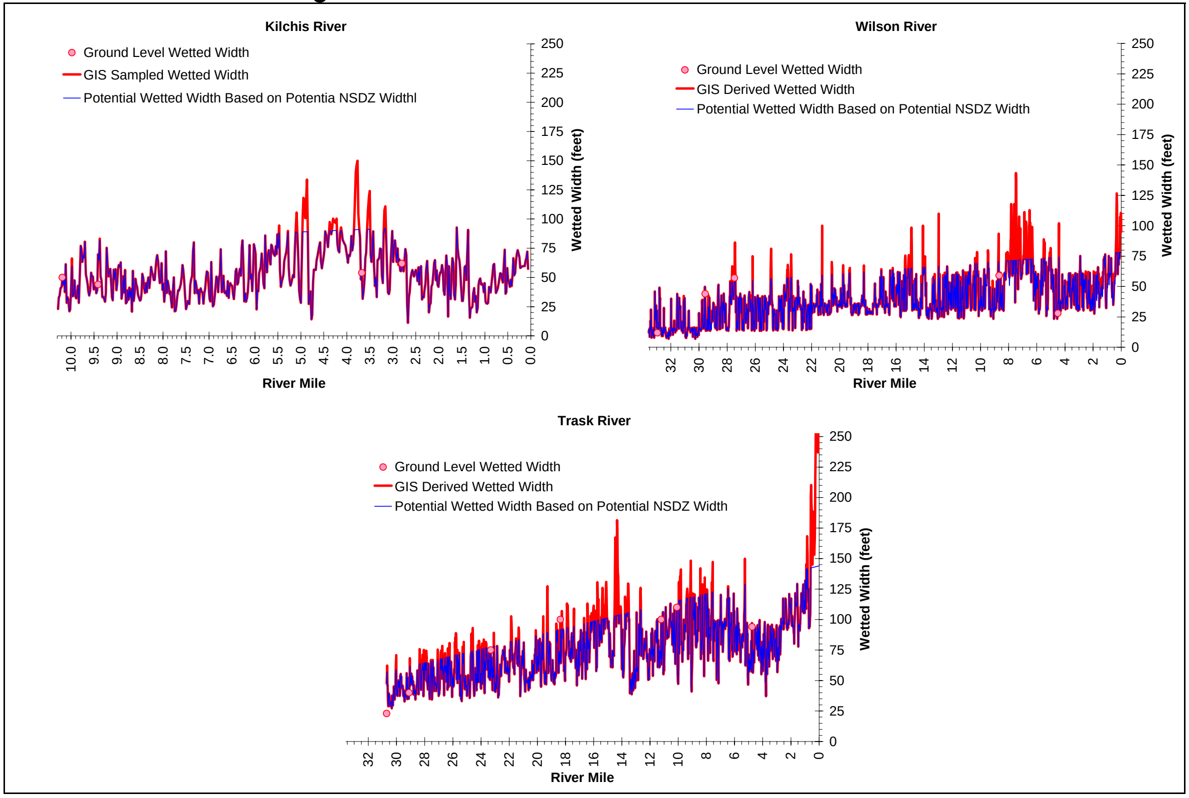
Figure 42. Current Condition and Potential Near Stream Disturbance Zone Widths



The potential near stream disturbance zone width was derived from these regression lines fitted to the moving median channel width. Where the existing width at a given point was less than the upper limit derived for near stream disturbance zone width, the existing width was retained and deemed at potential. Where the existing width was wider than the calculated width, the calculated width replaced the existing to become the potential near stream disturbance zone width. This composite data set was used to model the effects of decreased near stream disturbance zone width on stream temperature. Using the regression of median width and distance is a conservative approach, since there are narrower existing widths than the calculated width downstream of virtually any point on the line.

Wetted widths are used to calculate other hydrologic parameters: flow velocity and average wetted depth. Further, the area exposed to surface thermodynamic processes is controlled by the wetted width. Therefore, wetted width data (Figure A-21) is used for multiple calculations in this analysis. Where near stream disturbance zone width reductions impinged upon wetted widths (i.e. NSDZ width became less than wetted widths), the wetted width was also reduced to that of the potential near stream disturbance zone width. In this fashion, wetted widths were evaluated and reduced locally. Since wetted depth is a function of wetted width, areas with reductions in wetted width had wetted depth adjustments (see **Average Wetted Depth**).

Figure 43. Current Condition and Potential Wetted Widths



Average Wetted Depth

The wetted dimensions of the channel are interrelated. If it is assumed that stream channels are rectangular in shape, average wetted depth can be estimated when wetted width, flow volume and flow velocity is known.

Flow is calculated as,

$$Q = V \cdot A = V \cdot W \cdot D$$

Which can be rearranged to,

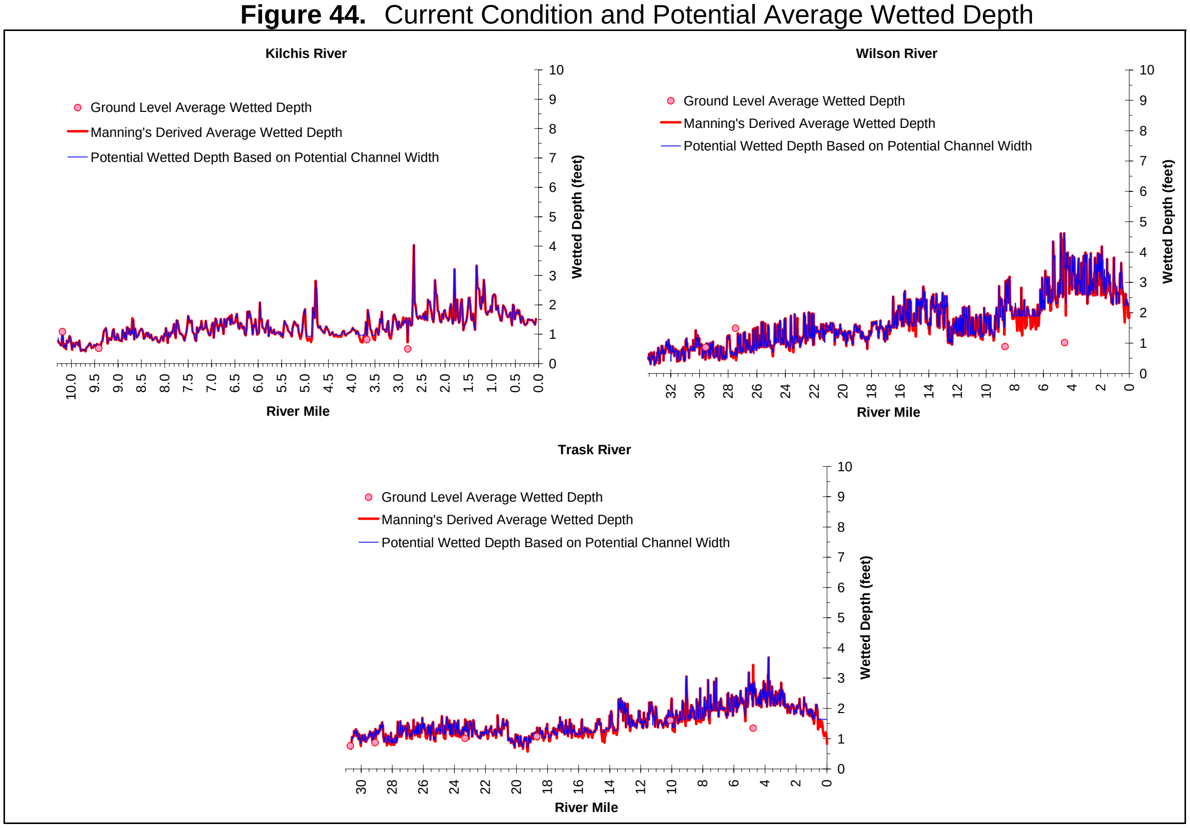
$$D = \frac{Q}{V \cdot W}$$

where,

Q: Stream flow volume (ft^3/s)
V: STREAM VELOCITY (FT/S)
A: Wetted cross-sectional area (ft^2)
W: Wetted width (ft)
D: Average wetted depth (ft)

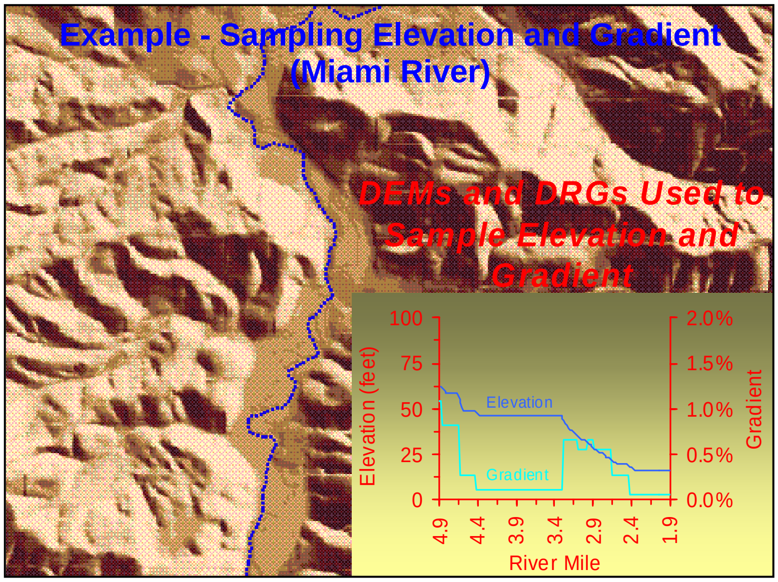
If flow is unchanged, a narrowing of the stream channel will result in deeper wetted depth and perhaps a slightly altered stream velocity. Therefore, wetted depth increases when wetted stream width is reduced. Potential stream width was narrowed in localized stream reaches for the Kilchis, Wilson and Trask Rivers. In all of these cases, Manning's equation and the calculated wetted depth equation allow for the deepening of the average wetted depths, a reduction in stream surface area and less exposure to surface thermodynamic processes. **Figure 44** displays the wetted depths used in this analysis.

Figure 44. Current Condition and Potential Average Wetted Depth



Stream Elevation and Gradient

Stream elevation and gradient were sampled from 10-meter digital elevation models (DEMs) and checked against digital raster graphics (DRGs) at each model data node. Both sampled elevation and gradient data are plotted for the areal extent displayed (Figure A-23). In this fashion, stream elevation and gradient was derived for all stream reaches analyzed. Stream elevation data is used for calculating solar radiation loading and solar position. Stream gradient data is used as input for calculating stream flow velocity, average wetted depth and wetted width via the Manning equation.



Stream Aspect

Stream aspect is the direction of flow relative to true north, and was sampled at every stream data node (every 100 feet) (Figure A-24). Stream surface shading is influenced by stream aspect in terms of timing and shadow length relative to the stream. Stream aspect is used in this analysis for positioning the stream and near stream vegetation relative to direct beam solar radiation.

Topography and Topographic Shade

Topographic features produce shade to the stream system that controls the local sunrise and sunset. Such features include distant mountain ranges, canyons or other near stream relief. At each stream data node (every 100 feet), the topographic shade angle was sampled from 10-meter digital elevation models (DEMs) to the west, south and east. **Figure A-25** displays a sample of topographic shade angle sampling.

Example - Sampling Topographic Shade Angles (Miami River)

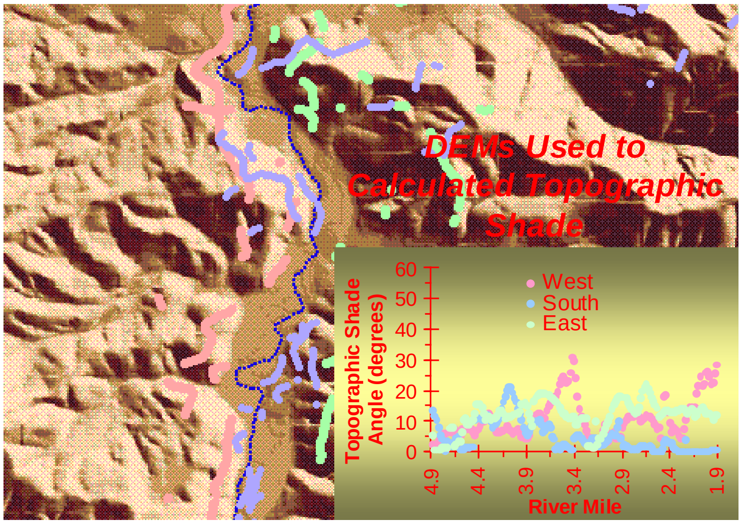


Figure 45. Stream Elevation and Gradient

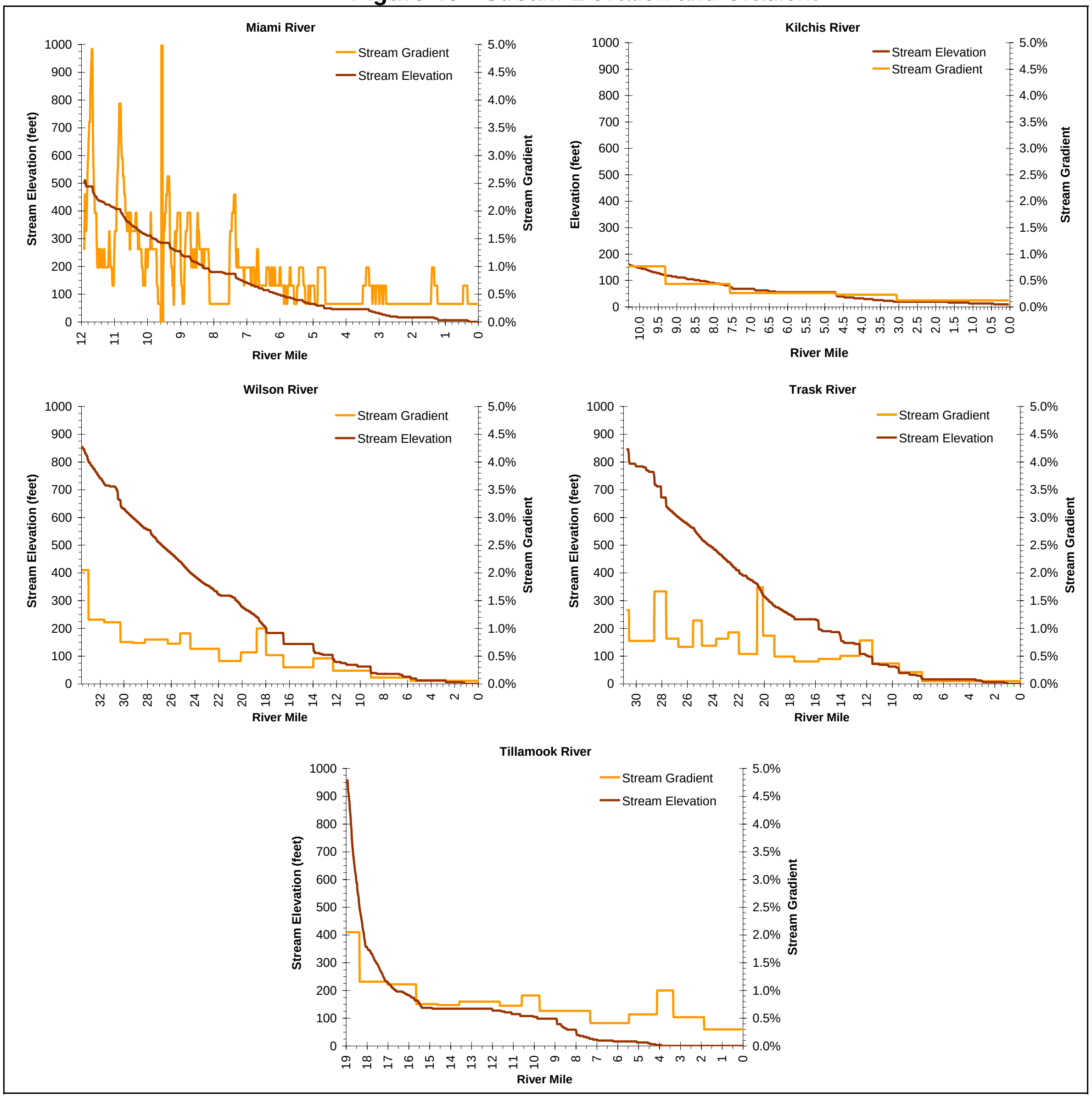


Figure 46. Stream Aspect

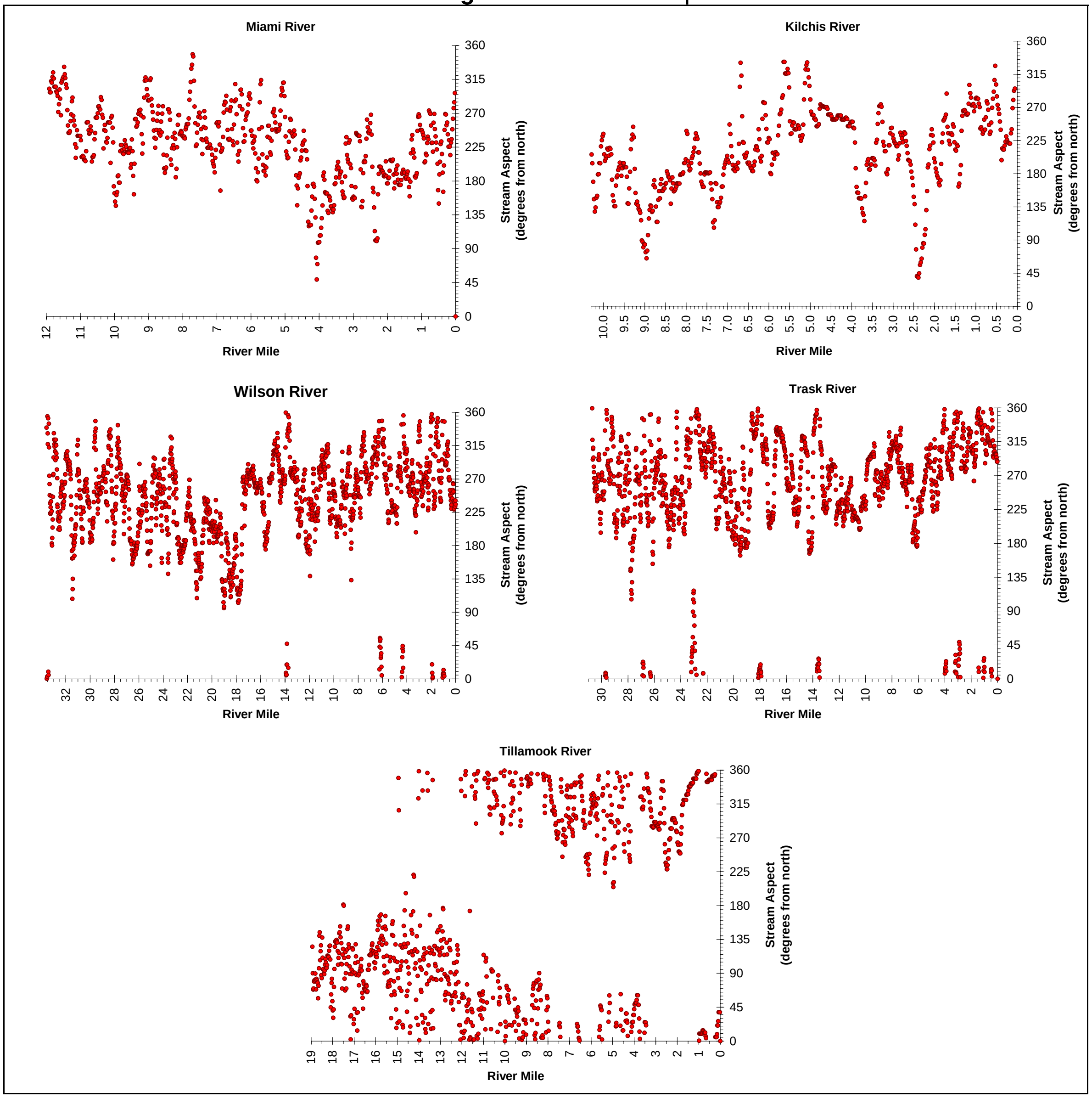
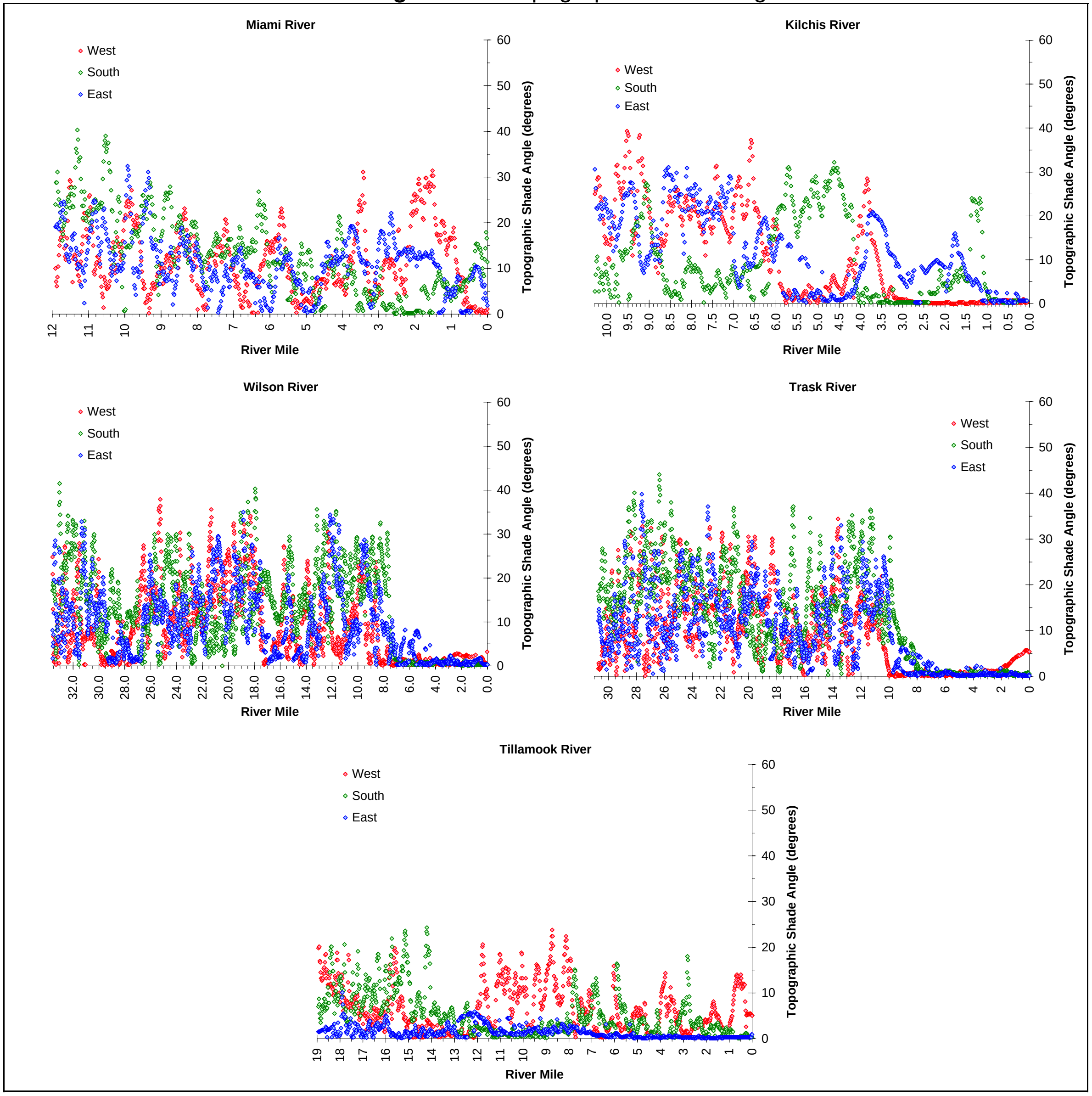


Figure 47. Topographic Shade Angles



THERMAL ROLE OF HYDROLOGY

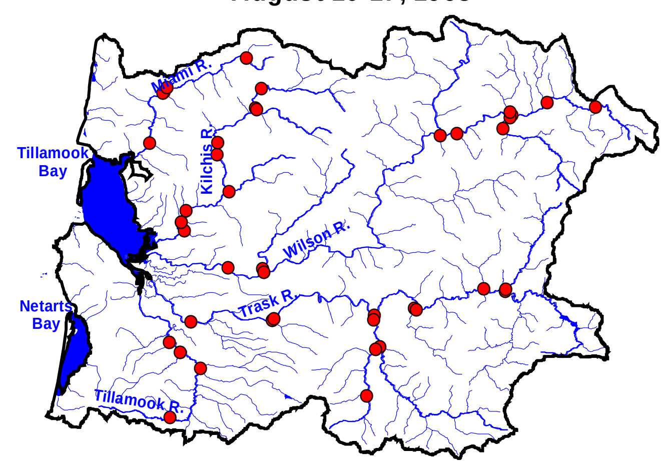
Flow Volume and Velocity

Stream temperature change is generally inversely related to flow volume. As flows decrease, stream temperature tends to increase if energy processes remain unchanged (Boyd, 1996). Runoff in the Tillamook Bay Watershed is primarily derived from rainfall precipitation, with peaks runoff typically occurring in the winter. Late summer low flows are common for many streams in the watershed due to low summer precipitation. The 7Q10[16] low flows calculated for the Wilson and Trask Rivers were 48 cfs (Figure A-26) and 54 cfs (Figure A-27), respectively.

Flow Measurements and Statistics.

Long-term flow measurements were available from each of 8 gages in the Tillamook Bay Watershed. Only two of the gages had a sufficient flow record to allow a high and low flow analysis. Flow return periods and 7Q10 flows were determined for the Trask and Wilson Rivers.

Stream flow was sampled throughout the Tillamook Bay Watershed in August, 1998 by DEQ staff. Flow profiles derived from these measurements are displayed in **Figure A-28**.



Stream flow is used extensively in this analysis for calculating Manning's equation for stream velocity and average wetted depth.

Manning's Equation,

$$Q = A \cdot V = 1.49 \cdot A \cdot \frac{1}{n} \cdot R_h^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$$

which can be rearranged to calculate velocity, where,

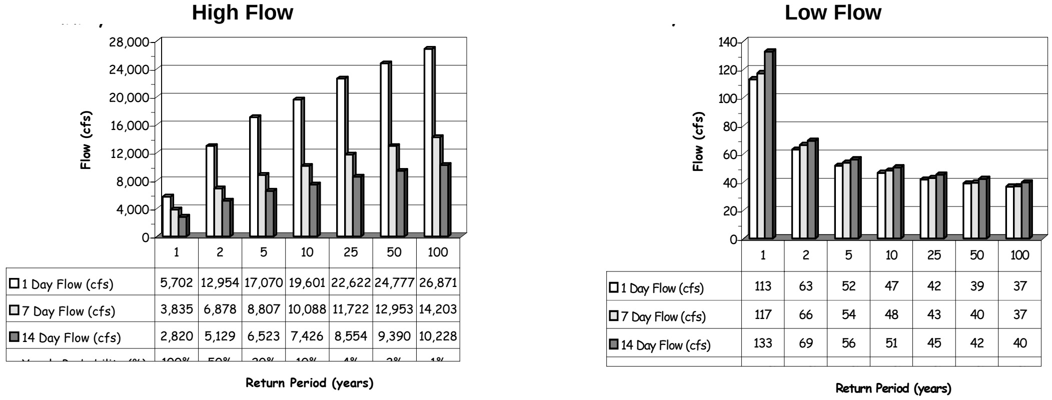
- Q: Stream flow volume (ft^3/s)
- V: Stream velocity (ft/s)
- A: Wetted cross-sectional area (ft^2)
- R_h: Hydraulic radius (ft)
- S: Stream gradient
- n: Mannings's n

In addition to affecting wetted channel dimensions, stream velocity is used in the hydraulic routing of water downstream. Advection, the movement of water, is the primary means of mass transfer of water in the downstream direction. Travel times are largely a function of stream velocity. Therefore the effect of stream velocity is considerable in the temperature response of a stream system. Not only does stream velocity help shape the wetted channel (and the surface areas

[16] 7Q10 low flow is the average seven day interval with a return period of 10 years. This condition has a 10% probability of occurring during any one year.

exposed to thermodynamic processes), but exposure times are also largely controlled by the rate of advective transfer of water downstream.

Figure 48. Wilson River Log Pearson Type III High Flow and Low Flow Analysis



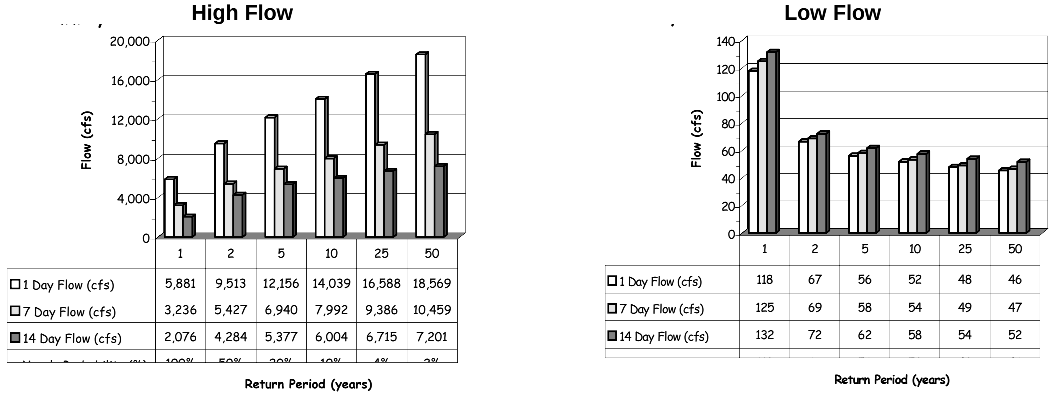
High Flow

Return Period (years)	1	2	5	10	25	50	100
1 Day Flow (cfs)	5,702	12,954	17,070	19,601	22,622	24,777	26,871
7 Day Flow (cfs)	3,835	6,878	8,807	10,088	11,722	12,953	14,203
14 Day Flow (cfs)	2,820	5,129	6,523	7,426	8,554	9,390	10,228

Low Flow

Return Period (years)	1	2	5	10	25	50	100
1 Day Flow (cfs)	113	63	52	47	42	39	37
7 Day Flow (cfs)	117	66	54	48	43	40	37
14 Day Flow (cfs)	133	69	56	51	45	42	40

Figure 49. Trask River Log Pearson Type III High Flow and Low Flow Analysis



High Flow

Return Period (years)	1	2	5	10	25	50
1 Day Flow (cfs)	5,881	9,513	12,156	14,039	16,588	18,569
7 Day Flow (cfs)	3,236	5,427	6,940	7,992	9,386	10,459
14 Day Flow (cfs)	2,076	4,284	5,377	6,004	6,715	7,201

Low Flow

Return Period (years)	1	2	5	10	25	50
1 Day Flow (cfs)	118	67	56	52	48	46
7 Day Flow (cfs)	125	69	58	54	49	47
14 Day Flow (cfs)	132	72	62	58	54	52

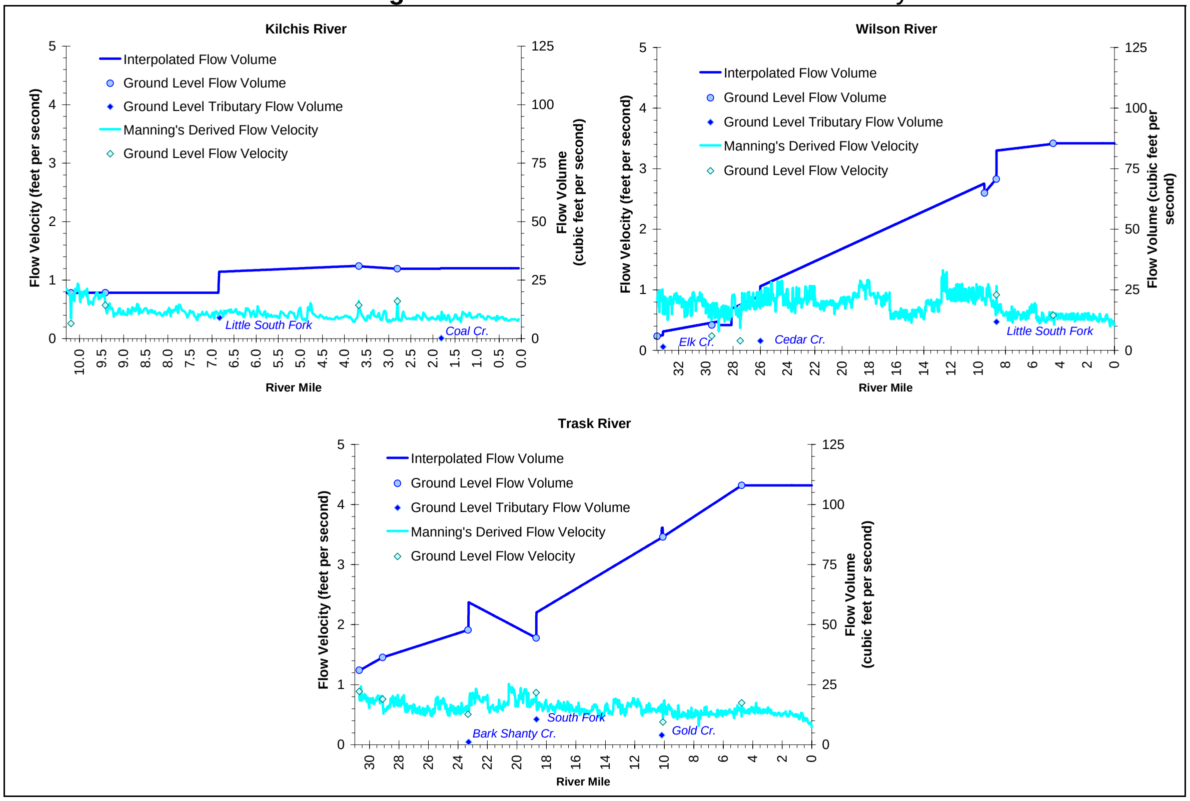
[1] Duration periods for which flows were averaged were 1 day, 7 days and 14 days. Return periods estimations were performed using the Log Pearson Type III distribution for the following *return periods*: 1 year, 2 years, 5 years, 10 years, 25 years, 50 years and 100 years. Average monthly flows were also calculated for many of the gages, depending on the length of the period of recorded flow values. Return flows are presented as *XQY*, where "*X"* represents the flow duration (days) and "*Y*" represents the return period (years). For example, a *7Q10* would represent the 7-day average flow that occurs on average once every 10 years. Therefore, the probability that seven-day duration 10-year *return period* flow (7Q10) conditions will occur during any year is 10%.

Groundwater Mixing

Groundwater inflow has a cooling effect on summertime stream temperatures. Subsurface water is insulated from surface heating processes. Groundwater temperatures fluctuate little and are cool (45^{o}F to 55^{o}F). Many land use activities that disturb riparian vegetation and associated flood plain areas may affect the surface water connectivity to groundwater sources. Groundwater inflow not only cools summertime stream temperatures, but also augments summertime flows. Reductions or elimination of groundwater inflow will have a compounding warming effect. The ability of riparian soils to capture, store and slowly release groundwater is largely a function of floodplain/riparian area health.

The effects of groundwater were not analyzed in the TMDL effort. The data required to assess the thermal effects of groundwater have not been collected in Tillamook Bay Watershed. Forward-looking infrared radiometry collected via remote sensing provides the best tool to identify and analyze groundwater and surface stream temperature interactions. DEQ recommends such data collection for future groundwater/stream analysis.

Figure 50. Stream Flow Volume and Velocity

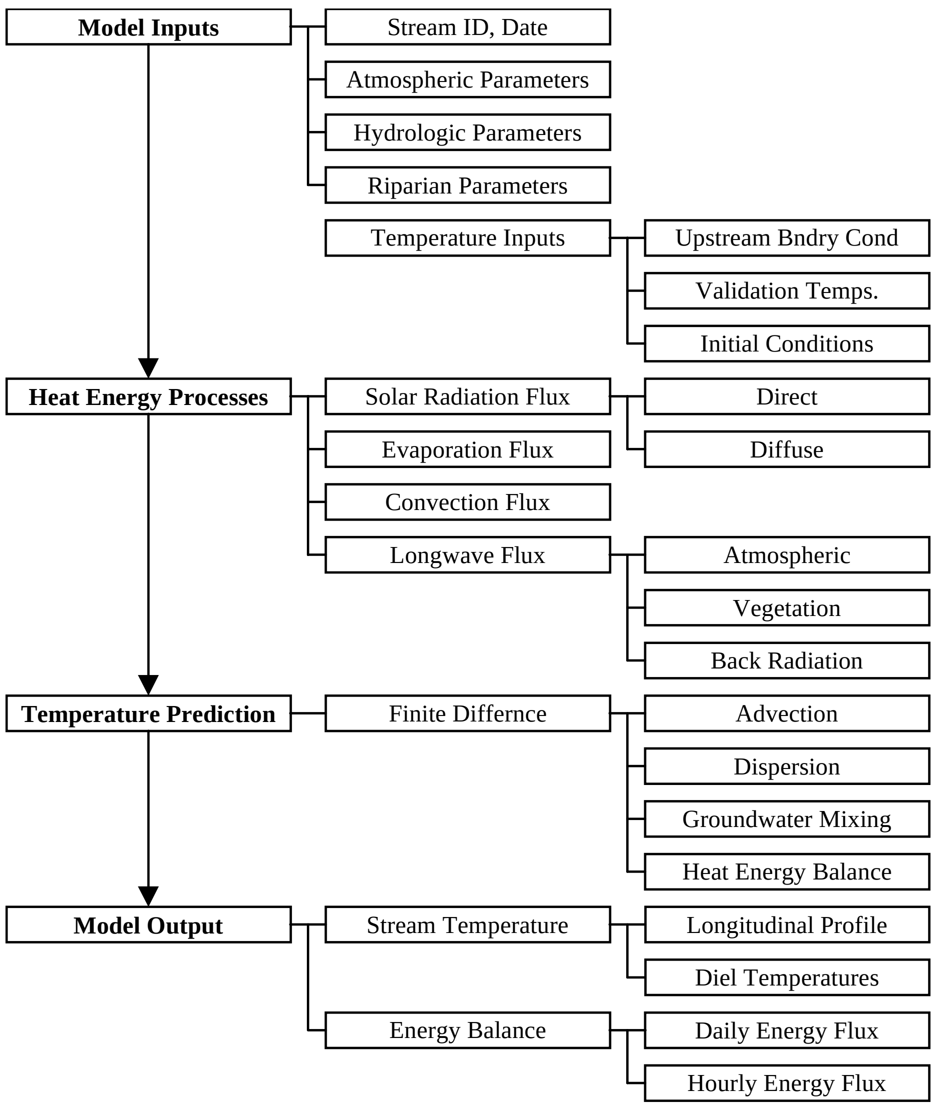


Analytical Framework

Conceptual Model

At any particular instant of time, a defined stream reach is capable of sustaining a particular water column temperature. Stream temperature change that results within a defined reach is explained rather simply. The temperature of a parcel of water traversing a stream/river reach enters the reach with a given temperature. If that temperature is greater than the energy balance is capable of supporting, the temperature will decrease. If that temperature is less than energy balance is capable of supporting, the temperature will increase. Stream temperature change within a defined reach, is induced by the energy balance between the parcel of water and the surrounding environment and transport of the parcel through the reach. The general progression of the model is outlined in the model flow chart, **Figure 51**.

Figure 51. Temperature Model Flow Chart



It takes time for the water parcel to traverse the longitudinal distance of the defined reach, during which the energy processes drive stream temperature change. At any particular instant of time, water that enters the upstream portion of the reach is never exactly the temperature that is supported by the defined reach. And, as the water is transferred downstream, heat energy and hydraulic process that are variable with time and space interact with the water parcel and induce water temperature change. The described modeling scenario is a simplification; however, understanding the basic processes in which stream temperatures change occurs over the course of a defined reach and period of time is essential.

Governing Equations

Heat Energy Processes

Water temperature change is a function of the total heat energy transfer in a discrete volume and may be described in terms of energy per unit volume. It follows that large volume streams are less responsive to temperature change, and conversely, low flow streams will exhibit greater temperature sensitivity.

Equation A-1. Heat Energy per Unit Volume,

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

Water has a relatively high heat capacity ($c_w = 10^3$ cal kg^{-1} K^{-1}) (Satterlund and Adams 1992). Conceptually, water is a heat sink. Heat energy that is gained by the stream is retained and only slowly released back to the surrounding environment, represented by the cooling flux ($_{cooling}$). Heating periods occur when the net energy flux ($_{total}$) is positive: ($_{heating}$ > $_{cooling}$).

Equation A-2. Heat Energy Continuity,

$$\Phi_{total} = \Phi_{heating} - \Phi_{cooling}$$

In general, the net energy flux experienced by all stream/river systems follows two cycles: a seasonal cycle and a diurnal cycle. In the Pacific Northwest, the seasonal net energy cycle experiences a maximum positive flux during summer months (July and August), while the minimum seasonal flux occurs in winter months (December and January). The diurnal net energy cycle experiences a daily maximum flux that occurs at or near the sun's zenith angle, while the daily minimum flux often occurs during the late night or the early morning. It should be noted, however, that meteorological conditions are variable. Cloud cover and precipitation seriously alter the energy relationship between the stream and its environment.

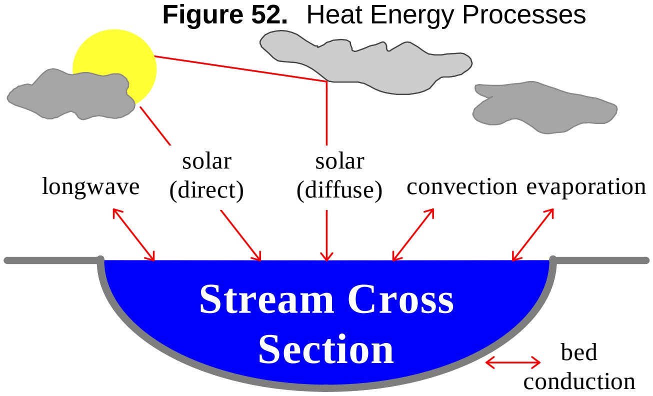
The net heat energy flux ($_{total}$) consists of several individual thermodynamic energy flux components, namely: solar radiation ($_{solar}$), long-wave radiation ($_{longwave}$), conduction ($_{conduction}$), groundwater exchange ($_{groundwater}$) and evaporation ($_{evaporation}$).

Equation A-3. Net Heat Energy Continuity,

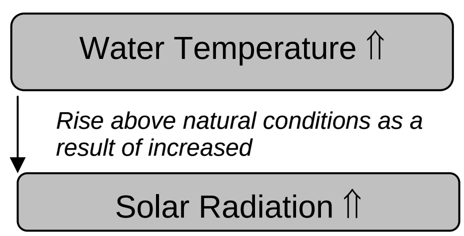
$$\Phi_{total} = \Phi_{solar} + \Phi_{longwave} + \Phi_{convection} + \Phi_{evaporation} + \Phi_{streambed} + \Phi_{groundwater}$$

Stream temperature is an expression of heat energy per unit volume, which in turn is an indication of the rate of heat exchange between a stream and its environment. The heat transfer processes that control stream temperature include solar radiation, longwave radiation, convection, evaporation and bed conduction (Wunderlich, 1972; Jobson and Keefer, 1979; Beschta and Weatherred, 1984; Sinokrot and Stefan, 1993; Boyd, 1996). With the exception of solar radiation, which only delivers heat energy, these processes are capable of both introducing and removing heat from a stream. **Figure A-21** displays heat energy processes that solely control heat energy transfer to/from a stream.

Figure 52. Heat Energy Processes



When a stream surface is exposed to midday solar radiation, large quantities of heat will be delivered to the stream system (Brown 1969, Beschta et al. 1987). Some of the incoming solar radiation will reflect off the stream surface, depending on the elevation of the sun. All solar radiation outside the visible spectrum (0.36µ to 0.76µ) is absorbed in the first meter below the stream surface and only visible light penetrates to greater depths (Wunderlich, 1972). Sellers (1965) reported that 50% of solar energy passing through the stream surface is absorbed in the first 10 cm of the water column. Removal of riparian vegetation, and the shade it provides, contributes to elevated stream temperatures (Rishel et al., 1982; Brown, 1983; Beschta et al., 1987). The principal source of heat energy delivered to the water column is solar energy striking the stream surface directly (Brown 1970). Exposure to direct solar radiation will often cause a dramatic increase in stream temperatures. The ability of riparian vegetation to shade the stream throughout the day depends on vegetation height, width, density and position relative to the stream, as well as stream aspect.



Both the atmosphere and vegetation along stream banks emit longwave radiation that can heat the stream surface. Water is nearly opaque to longwave radiation and complete absorption of all wavelengths greater than 1.2µ occurs in the first 5 cm below the surface (Wunderlich, 1972). Longwave radiation has a cooling influence when emitted from the stream surface. The net transfer of heat via longwave radiation usually balances so that the amount of heat entering is similar to the rate of heat leaving the stream (Beschta and Weatherred, 1984; Boyd, 1996).

Evaporation occurs in response to internal energy of the stream (molecular motion) that randomly expels water molecules into the overlying air mass. Evaporation is the most effective method of dissipating heat from water (Parker and Krenkel, 1969). As stream temperatures increase, so does the rate of evaporation. Air movement (wind) and low vapor pressures increase the rate of evaporation and accelerate stream cooling (Harbeck and Meyers, 1970).

Convection transfers heat between the stream and the air via molecular and turbulent conduction (Beschta and Weatherred, 1984). Heat is transferred in the direction of warmer to cooler. Air can have a warming influence on the stream when the stream is cooler. The opposite is also true. The amount of convective heat transfer between the stream and air is low (Parker and Krenkel, 1969; Brown, 1983). Nevertheless, this should not be interpretted to mean that air temperatures do not affect stream temperature.

Depending on streambed composition, shallow streams (less than 20 cm) may allow solar radiation to warm the streambed (Brown, 1969). Large cobble (> 25 cm diameter) dominated streambeds in shallow streams may store and conduct heat as long as the bed is warmer than the stream. Bed conduction may cause maximum stream temperatures to occur later in the day, possibly into the evening hours.

The instantaneous heat transfer rate experienced by the stream is the summation of the individual processes:

$$\Phi_{Total} = \Phi_{Solar} + \Phi_{Longwave} + \Phi_{Evaporation} + \Phi_{Convection} + \Phi_{Conduction}.$$

Solar Radiation (Φ_{Solar}) is a function of the solar angle, solar azimuth, atmosphere, topography, location and riparian vegetation. Simulation is based on methodologies developed by Ibqal (1983) and Beschta and Weatherred (1984). *Longwave Radiation* ($\Phi_{Longwave}$) is derived by the Stefan-Boltzmann Law and is a function of the emissivity of the body, the Stefan-Boltzmann constant and the temperature of the body (Wunderlich, 1972). *Evaporation* ($\Phi_{Evaporation}$) relies on a Dalton-type equation that utilizes an exchange coefficient, the latent heat of vaporization, wind speed, saturation vapor pressure and vapor pressure (Wunderlich, 1972). *Convection* ($\Phi_{Convection}$) is a function of the Bowen Ratio and terms include atmospheric pressure, and water and air temperatures. *Bed Conduction* ($\Phi_{Conduction}$) simulates the theoretical relationship ($\Phi_{Conduction} = K \cdot dT_b / dz$), where calculations are a function of thermal conductivity of the bed (K) and the temperature gradient of the bed (dT_b/dz) (Sinokrot and Stefan, 1993). Bed conduction is solved with empirical equations developed by Beschta and Weatherred (1984).

The ultimate source of heat energy is solar radiation both diffuse and direct. Secondary sources of heat energy include long-wave radiation, from the atmosphere and streamside vegetation, streambed conduction and in some cases, groundwater exchange at the water-stream bed interface. Several processes dissipate heat energy at the air-water interface, namely: evaporation, convection and back radiation. Heat energy is acquired by the stream system when the flux of heat energy entering the stream is greater than the flux of heat energy leaving. The net energy flux provides the rate at which energy is gained or lost per unit area and is represented as the instantaneous summation of all heat energy components.

Non-Uniform Heat Energy Transfer Equation

The rate change in stream temperature is driven by the heat energy flux($_i$). It is easily shown that a defined volume of water will attain a predictable rate change in temperature, provided an accurate prediction of the heat energy flux. The rate change in stream temperature (T) is calculated as shown in **Equation A-4**.

Equation A-4. Rate Change in Temperature Caused by Heat Energy Thermodynamics,

$$\frac{\partial T}{\partial t} = \left(\frac{Ax_i \cdot \Phi_i}{\rho \cdot c_p \cdot V_i} \right),$$

Which reduces to,

$$\frac{\partial T}{\partial t} = \left(\frac{\Phi_i}{\rho \cdot c_p \cdot D_i} \right).$$

Where,

Ax_i: cross-sectional area (m^2)

C_p:	specific heat of water (cal $kg^{-1} \cdot {}^oC^{-1}$)
D_i:	average stream depth (m)
t:	time (s)
T:	Temperature (${}^oC$)
V_i:	volume (m^3)
Φ_i:	total heat energy flux (cal $m^{-2} \cdot s^{-1}$)
ρ:	density of water (kg/m^3)

Advection (U_x) redistributes heat energy in the positive longitudinal direction. No heat energy is lost or gained by the system during advection, and instead, heat energy is transferred downstream as a function of flow velocity. In the case where flow is uniform, the rate change in temperature due to advection is expressed in the first order partial differential equation below.

Equation A-5. Rate Change in Temperature Caused by Advection,

$$\frac{\partial T}{\partial t} = -U_x \cdot \frac{\partial T}{\partial x}$$

Dispersion processes occur in both the upstream and downstream direction along the longitudinal axis. Heat energy contained in the system is conserved throughout dispersion, and similar to advection, heat energy is simply moved throughout the system. The rate change in temperature due to dispersion is expressed in the second order partial differential equation below.

Equation A-6. Rate Change in Temperature Caused by Dispersion,

$$\frac{\partial T}{\partial t} = D_L \cdot \frac{\partial^2 T}{\partial x^2}$$

The dispersion coefficient (D_L) may be calculated by stream dimensions, roughness and flow. In streams that exhibit high flow velocities and low longitudinal temperature gradients, it may be assumed that the system is advection dominated and the dispersion coefficient may be set to zero (Sinokrot and Stefan 1993). In the event that dispersion effects are considered significant, the appropriate value for the dispersion coefficient can be estimated with a practical approach developed and employed in the QUAL 2e model (Brown and Barnwell 1987). An advantage to this approach is that each parameter is easily measured, or in the case of Manning's coefficient (n) and the dispersion constant (K_d), estimated.

Equation A-7. Physical Dispersion Coefficient,

$$D_L = C \cdot K_d \cdot n \cdot U_x \cdot D^{\frac{5}{6}}$$

Where,

C:	Unit conversion C = 3.82 for English units C = 1.00 for Metric units
D:	Average stream depth (m)
D_L:	Dispersion coefficient (m^2/s)
K_d:	Dispersion constant
n:	Manning's coefficient
U_x:	Average flow velocity (m/s)

The simultaneous non-uniform one-dimensional transfer of heat energy is the summation of the rate change in temperature due to heat energy thermodynamics, advection and dispersion. Given that the stream is subject to steady flow conditions and is well mixed, transverse temperature gradients are negligible (Sinokrot and Stefan 1993). An assumption of non-uniform flow implies that cross-sectional area and flow velocity vary with respect to longitudinal position. The following second ordered parabolic partial differential equation describes the rate change in temperature for non-uniform flow.

Equation A-8. Non-Uniform One-dimensional Heat Energy Transfer,

$$\frac{\partial T}{\partial t} = -U_x \cdot \frac{\partial T}{\partial x} + D_L \cdot \frac{\partial^2 T}{\partial x^2} + \frac{\Phi}{c_p \cdot \rho \cdot D_i}$$

$$\text{Steady Flow: } \frac{\partial U_x}{\partial t} = 0$$

$$\text{Non-Uniform Flow: } \frac{\partial U_x}{\partial x} \neq 0$$

The solution to the *one-dimensional heat energy transfer equation* is essentially the summation of thermodynamic heat energy exchange between the stream system and the surrounding environment and physical processes that redistribute heat energy within the stream system. It is important to note that all heat energy introduced into the stream is conserved, with the net heat energy value reflected as stream temperature magnitude. Further, heat energy is transient within the stream system, due to longitudinal transfer of heat energy (i.e., advection and dispersion). The net heat energy flux ( ) is calculated at every distance step and time step based on physical and empirical formulations developed for each significant energy component. The dispersion coefficient (D_L) is assumed to equal zero.

Boundary Conditions and Initial Values

The temperatures at the upstream boundary (i_o) for all time steps (t_o ,$t_{1,}$,..., t_{M-1}, t_M) are supplied by the upstream temperature inputs. At the downstream boundary temperature at longitudinal position i_{n+1} is assumed to equals that of i_n with respect to time t. Initial values of the temperatures at each distance node (i_o ,$i_{1,}$,..., i_{N-1}, i_N) occurring at the starting time (t_o) can be input by the model user or assumed to equal the boundary condition at time t_o.

Spatial and Temporal Scale

The lengths of the defined reaches are 100 feet. The temperature model is designed to analyze and predict stream temperature for one day and is primarily concerned with daily prediction of the diurnal energy flux and resulting temperatures on August 12, 1998. Prediction time steps are limited by stability considerations for the finite difference solution method.

Input Parameters

Data collected during this TMDL effort has allowed the development of temperature simulation methodology that is both spatially continuous and spans full day lengths (diurnal). Detailed spatial data sets have been developed for the following parameters:

- ✓ River and Tributary Digital Mapping at 1:5,000 scale (**Figure A-22**),
- ✓ Riparian Vegetation Species, Size and Density Digital Mapping at 1:3,000 scale (**Figure A-23**),
- ✓ West, East and South Topographic Shade Angles calculations at 1:5,000 scale (**Figure A-24**),
- ✓ Stream Elevation and Gradient at 1:5,000 scale,
- ✓ Hydrology Developed from Field Data - Spatially Continuous Flow, Wetted Width, Velocity and Depth Profiles.

All input data is longitudinally referenced in the model allowing spatial and/or continuous inputs to apply to certain zones or specific river segments.

Spatial Input Parameters

Longitudinal Distance (meters): Defines the modeled reaches for which spatial input parameters reference. Model reaches are 100 feet each, are derived from DOQ 1:5000 river layer digitized from Digital Orthophoto Quarter Quads (DOQQs), and are measured in the downstream direction (**Figure A-22**).

Elevation (meters): Sampled for each model reach either from Digital Raster Graphic (DRG) or Digital Elevation Model (DEM).

Gradient (%): Is the difference between the upstream and downstream elevations divided by the reach length.

Bedrock (%): The percent of streambed material that has a diameter of 25 cm or greater. Values are derived from stream survey data or assumed where data is limited.

Aspect (decimal degrees from North): Calculated for each reach break (**see Figure A-22**) and represents the direction of stream flow.

Flow Volume (cubic meters per second): Measured by DEQ with standard USGS protocols with interpolation between flow measurement sites, while taking into account known water withdrawals and inputs.

Flow Velocity (meters per second): Derived from Manning's equation and Leopold power functions calibrated to measured flow velocity data.

Wetted Width (meters): Derived from Manning's equation and Leopold power functions calibrated to measured wetted width data.

Average Depth (meters): Derived from Manning's equation and Leopold power functions calibrated to measured average depth data. Calculated based on assuming rectangular channel.

Near-Stream Disturbance Zone Width (meters): Based upon ODEQ field measurements and USGS reported values.

Channel Incision (meters): Depth of the active channel below riparian terrace or floodplain. Measured by ODEQ and reported by USGS.

Riparian Height (meters): Obtained from WODIP satellite vegetation coverage and ODEQ field observations.

Canopy Density (%): Obtained from WODIP vegetation coverage and aerial photograph (DOQ) interpretation.

Riparian Overhang (meters): Distance of riparian vegetation intrusion over Near-Stream Disturbance Zone. Based on ODEQ field observations.

Topographic Shade Angle (decimal degrees): The angle made between the stream surface and the highest topographic features to the west, east and south as calculated from DEM at each stream reach (**Figure A-24**).

Continuous Input Parameters

Wind Speed (meters per second): Hourly values measured at Forest Grove and at Hillsboro Airport.

Relative Humidity (%): Hourly values measured at Forest Grove and at Hillsboro Airport.

Air Temperature (^{o}C): Hourly values measured at Forest Grove and at Hillsboro Airport.

Stream Temperature (^{o}C): Hourly values measured by ODEQ.

Tributary Temperature (^{o}C): Hourly values measured by ODEQ.

Tributary/Flow Volume (cubic meters per second): Measured flow volumes for all major tributaries.

Data Source Descriptions

Existing Vegetation:

1. WODIP satellite vegetation coverage that has been delineated into polygons according to vegetation species, size, and canopy density (BLM, 1999). The pixel size of this data is 25 meters. Tree sizes were presented as diameter at breast height (DBH) ranges. The mid-range DBH was used to calculate approximate heights for each species. All coverage was verified using Digital Orthophoto Quarter Quads (DOQQs) or Digital Orthophoto Quads (DOQs). (**Figure A-25**)
2. In agricultural areas, WODIP overlooked narrow riparian buffers. In these areas, ODEQ digitized the vegetation from DOQQs at a 1:3000 scale (**Figure A-22**). Canopy densities were assigned according to aerial photograph (DOQQ) interpretation, while heights were assigned based upon field measurements. Additionally, roads were digitized from the DOQQs for all areas.

Digital Elevation Models (DEM): 30-meter DEMs are available for the entire state of Oregon. These DEMs have a 30-meter pixels, each of which have an elevation associated with it.

Digital Orthophoto Quarter Quads (DOQQs): DOQQs for the Tillamook Bay Watershed are available from the United States Geologic Survey (the aerial photos were taken in 1997). USGS DOQQs correspond to the topographic map quarter quadrants.

APPENDIX B: BACTERIA

BACTERIA MODEL DESCRIPTION

DEQ used an event based, unit load model to evaluate bacteria loading in the Tillamook Bay Watershed. The model uses estimated peak flow, Event Mean Concentrations (EMC) for various land uses, and bacteria die off rates to predict total bacteria concentration and loads in the streams. Five major geographic data bases were used in this project: soils, land use, precipitation pattern, watersheds, and distance from the stream. These five data bases were overlaid in ArcView to create a composite GIS database, with over 12000 entries. This composite data set was used for estimating peak flow, travel time of overland flow in the watershed, the bacteria die-off rate as function of the travel time, and bacteria load. These parameters were modeled for all locations in the watershed. To calculate loading to the Bay, a bacteria die-off rate was incorporated for travel time instream to the Bay. Each of these parameters is discussed below.

Peak Flow

Peak runoff from a storm was estimated using the rational formula (Pilgrim and Cordery, 1993)as follows:

Peak rate of runoff (cfs) = Q_P = C i A

Where:

C = Land use runoff coefficient (unit-less)

i = Rainfall Intensity (inches/hour)

A = Area ($feet^2$)

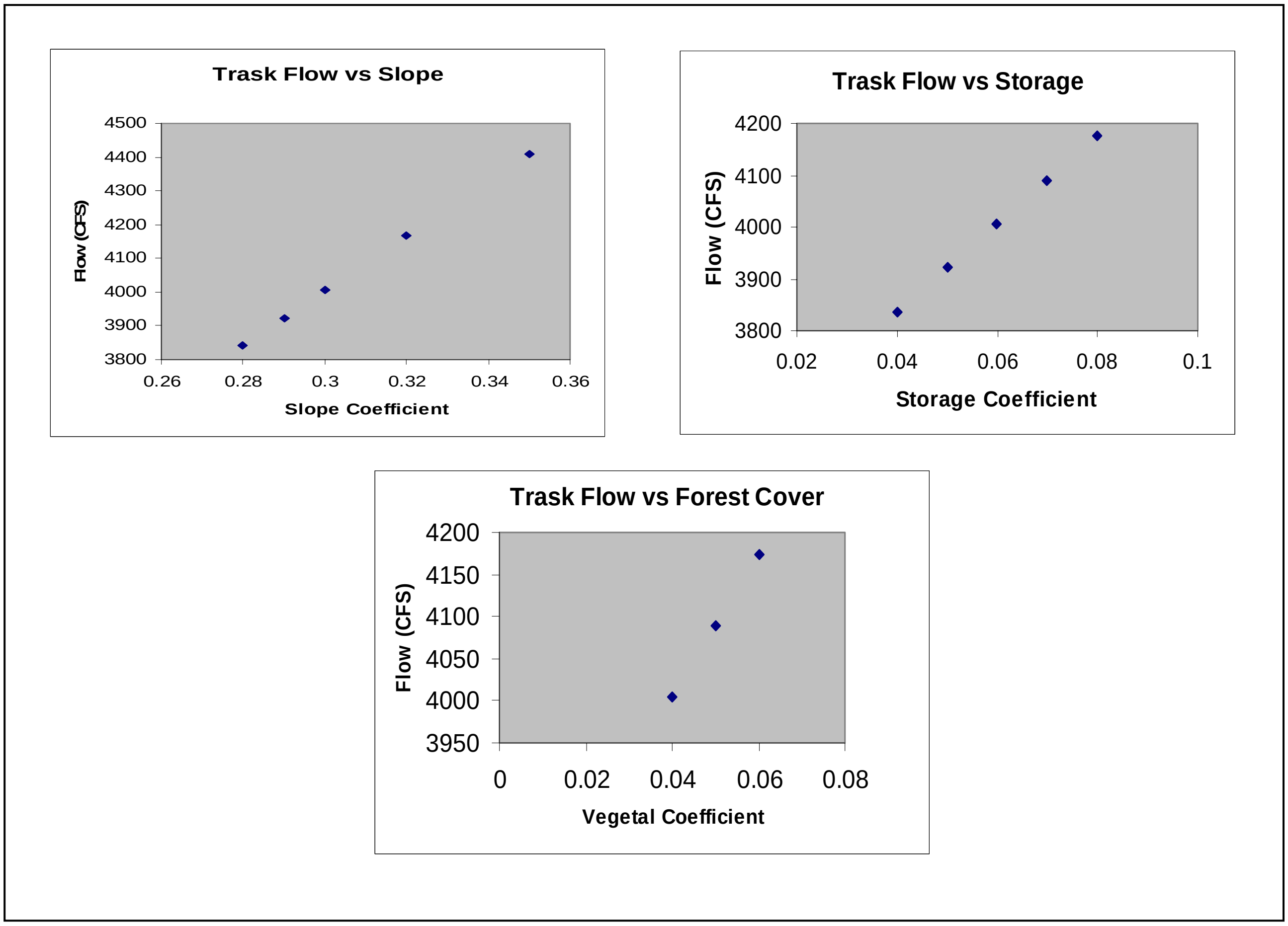
The runoff coefficient "C" represents the percent of water that will run off the ground surface during a storm. The remaining precipitation is lost to infiltration, transpiration, evaporation and surface storage. Infiltration is the movement of water into the soil. Transpiration is the uptake of water by plants. Evaporated water is lost to the atmosphere. Surface storage is the water that accumulates on the soil surface and fills small depressions (Dunn, ET al, 1978). Values for "C' may be determined for undeveloped areas by considering the four characteristics of relief, soil infiltration, vegetation cover and surface storage (Table 1). The soil characteristics were taken from the STATSGO database. This data is very generalized and revisions were made to the database based on comparisons with 30-meter Digital Elevation Model data.

A sensitivity analysis was performed on these input parameters. The slope (relief), storage and vegetation cover coefficients were varied within each category. For example, the slope was estimated as 0.3 for most of the watershed. According to Table 1, this value falls under the “extreme” relief category. Slopes were set at 0.28 to 0.35 in the model and the resulting affect on flow noted. Results of the sensitivity analysis for the Trask River are shown below in Figure 1.

Table 25. Runoff Coefficients for Undeveloped Land (California Highway Design Manual, 1995). The runoff coefficients for undeveloped land are calculated by adding the appropriate coefficient for each of the four characteristics.

	Extreme	High	Normal	Low
Relief	.28 -.35 Steep, rugged terrain with average slopes above 30%	.20 -.28 Hilly, with average slopes of 10 to 30%	.14 -.20 Rolling, with average slopes of 5 to 10%	.08 -.14 Relatively flat land, with average slopes of 0 to 5%
Soil Infiltration	.12 -.16 No effective soil cover, either rock or thin soil mantle of negligible infiltration capacity	.08 -.12 Slow to take up water, clay or shallow loam soils of low infiltration capacity, imperfectly or poorly drained	.06 -.08 Normal; well drained light or medium textured soils, sandy loams, silt and silt loams	.04 -.06 High; deep sand or other soil that takes up water readily, very light well drained soils
Vegetation Cover	.12 -.16 No effective plant cover, bare or very sparse cover	.08 -.12 Poor to fair; clean cultivation crops, or poor natural cover, less than 20% of drainage area over good cover	.06 -.08 Fair to good; about 50% of area in good grassland or woodland, not more than 50% of area in cultivated crops	.04 -.06 Good to excellent; about 90% of drainage area in good grassland, woodland or equivalent cover
Surface Storage	.10 -.12 Negligible surface depression: few and shallow; drainageways steep and small, no marshes	.08 -.10 Low; well defined system of small drainageways; no ponds or drainageways	06 -.08 Normal; considerable surface depression storage; lakes and pond marshes	.04 -.06 High surface storage; drainage system not sharply defined; large flood plain storage or large number of ponds or marshes

Figure 53. Effect of Slope Coefficient, Storage Coefficient, and Vegetation Coefficient on Trask River Flow



As shown by the sensitivity analysis, slope has a large effect on the river flow, increasing the flow by about 13% for a 20% change in slope. However, slope would be expected to remain constant during a storm event, so it is not adjusted in the flow calibration. Doubling the surface storage coefficient increases the flow by about 8%. Changing the vegetation cover coefficient by 33% increased the flow by about 4%.

The developed land use runoff coefficients (California Highway Design Manual, 1995) were calculated from major land uses in developed areas (Table 2). The land use data was constructed from a composite of the Tillamook Bay National Estuary Program (TBNEP) low elevation land use (from aerial photography) and USGS Land Cover.

Table 26. Runoff Coefficients Based on Land Use for Developed Areas

Type Of Drainage Area	Runoff Coefficient (C)
Business:	
Downtown areas	0.70 –0.95
Neighborhood areas	0.50-0.70
Residential:	
Single Family areas	0.30 –0.50
Multi Units –detached	0.40 –0.60
Multi Units – attached	0.60 –0.75
Industrial :	
Light Areas	0.50 –0.80
Heavy Areas	0.60 –0.90

The coefficients from Tables 26 and 27 were adjusted to calibrate to the measured flow. Five gages are maintained in the Tillamook Bay Watershed, with one in each major river basin. The selected coefficients are summarized below for each simulated storm event. Manning's n is a measure of friction, the higher the "n" the slower water moves. It is used to estimate time of concentration. Time of concentration is discussed under the *Bacteria Die Off* section.

Table 27. Coefficients Used in Modeling for October 1997 and March 1998 storms

Land Use	Manning's n	Vegetation Coefficient	Runoff Coefficient (developed land)
Agriculture w/ forest	0.08	0.08	
Agriculture	0.03	0.08	
Agriculture w/farm buildings	0.03	0.08	
Farm buildings			
Forest	0.12	0.04	
Rural Industrial	0.01		0.7
Rural Residential	0.01		0.7
Urban	0.01		0.75
Water	0.01		1.0

Table 28. Undeveloped Land Coefficients for October 1997 and March 1998 ( ) storms

STATSGO soil category	Slope	Surface Storage	Soil Infiltration
OR71	0.05	0.04	0.06
OR69	0.35	0.04	0.10
OR93	0.15	0.04	0.07
OR72	0.30	0.04	0.07
OR74	0.30	0.04	0.07
OR94	0.15	0.04	0.07
OR89	0.30	0.04	0.06
OR88	0.30	0.04	0.07

Flow Calibration

The rainfall distribution was estimated using spatial patterns of precipitation in the watershed from long term precipitation maps generated by the PRISM model, as seen in Figure 4 (Daly, et al. 1994, digital maps are available for Oregon).

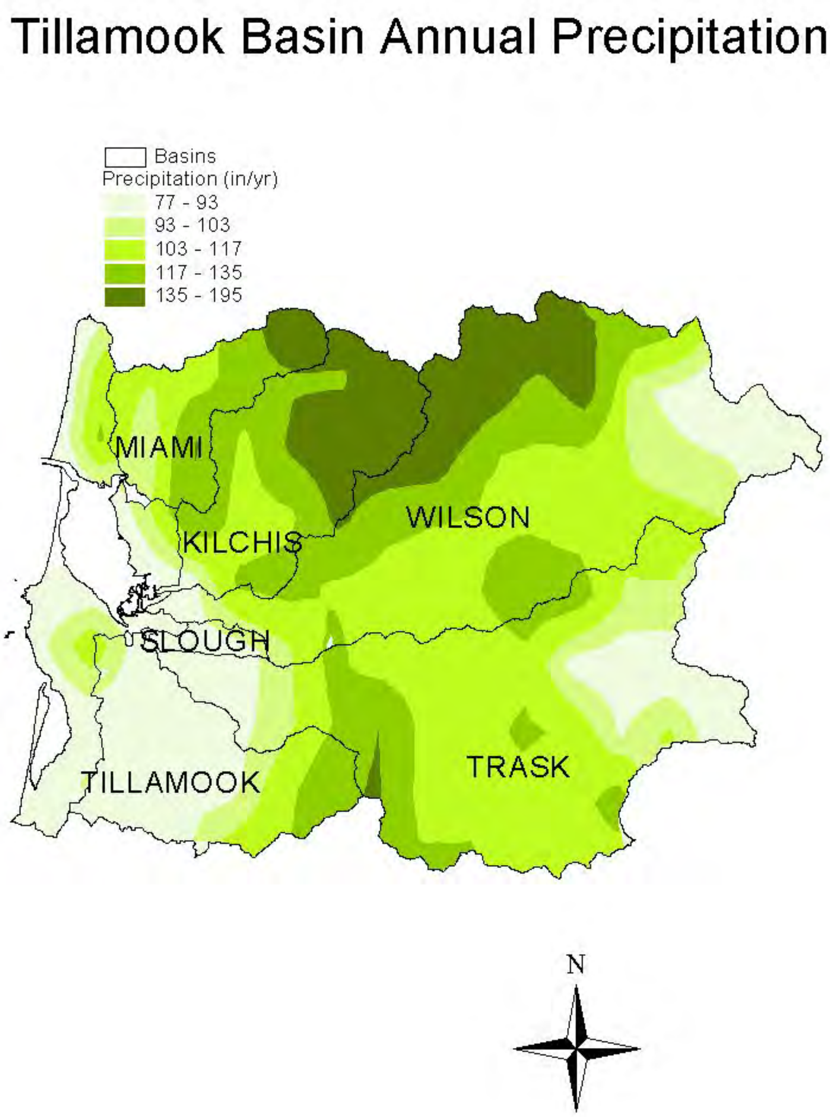


Figure 54. Annual Precipitation from PRISM model

The PRISM rainfall pattern and land uses were overlaid in ArcView. The resulting database generated the variables required for application of the rational formula. The annual precipitation estimates from PRISM were adjusted to generate peak runoff rates. Gages are maintained on each of the five rivers in Tillamook Bay basin (USGS, WRD). Because the gaged flow includes baseflow and storm flow, an estimate of baseflow was added to the peak runoff rates generated by the model. Estimates of baseflow were obtained by examination of three summer storm events for each of the rivers. The unit hydrograph method of separation was applied to divide the summer storm hydrographs into baseflow and storm runoff (Dunne and Leopold, 1978). The average of the summer storm baseflow was added to the modeled peak runoff.

The modeled peak flow (baseflow and peak runoff) was compared to the measured average flow for the peak flow day for five monitored watersheds in the Tillamook Bay Basin (Miami, Kilchis, Wilson, Trask and Tillamook rivers) over 2 storm events (October 1997 and March 1998). Agreement was calculated using a measure of the relative percent difference (RPD), the standard error of estimate (SEE) and the % error. Coefficients were adjusted until the flows with the lowest measures of error were attained. The error calculations are as follows:

$SEE = \sqrt{\sum (F_{0i} - F_{Si})}^2 / N - 1$ where F_o is the observed flow, F_s is the simulated flow, and N is the number of observations;

Total % error $= \sum (F_O - F_S)/F_O$;

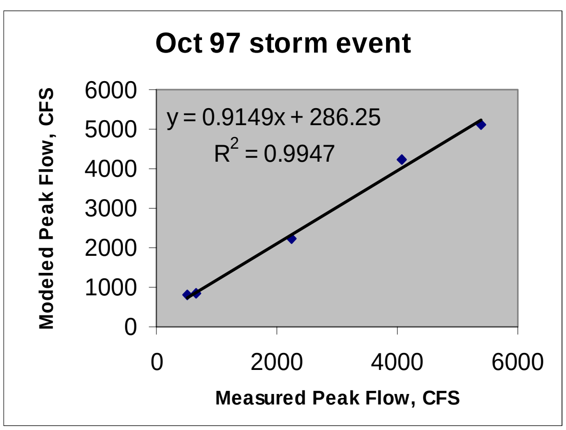
$$RPD_{total} = \sum \left(\frac{(F_{Oi} - F_{Si})}{(F_{Oi} + F_{Si})/2}\right) * 100$$

The calibrations with the lowest SEE, RPD and % error for the October 1997 and March 1998 storm events are listed in table 30 and shown graphically in Figures 55 and 56.

Table 29. Results of flow calibration error estimates

Storm event	SEE	Total % error	Total RPD
October 1997	243	-.918	81
March 1998	754	.737	30

Figure 55. Calibrated Flow for October 1997 storm event



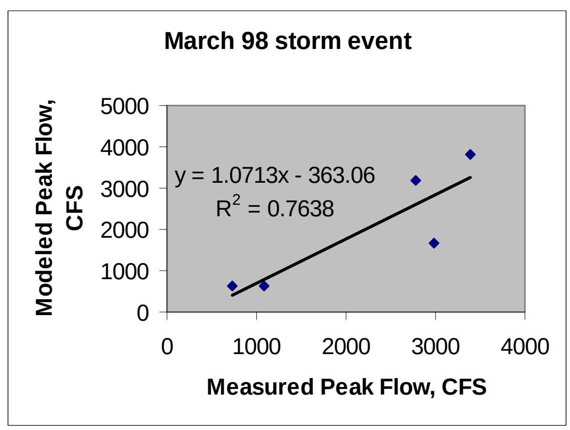


Figure 56. Calibrated Flow for March 1998 storm event

The PRISM rainfall pattern assumes a constant distribution across the basin. Rainfall from individual storm events may not follow the long term pattern represented by PRISM. The variability in the flow estimates is associated with the precipitation variability in individual storm events.

Land Use and Point Source Concentration

Event Mean Concentrations (EMC) are flow weighted average bacteria concentrations during a storm event. EMCs for bacteria were not readily available. Estimates of bacteria concentrations for each land use were taken from several sources (Table 31).

Table 30. Land Use Specific Fecal Coliform Concentrations

Forest Land Use: The forest land use concentration was estimated by review of the bacteria concentration measured at forested sites for each river. The median instream value at the sites was 10 counts/100 ml. The forest land use concentration was adjusted in the model to approximate this instream concentration. **Urban Land Use:** Estimates of bacteria concentrations from urban land uses were taken from the City of Portland MS4 permit application. An initial value of 60,000 counts/100 ml was used. This value represents the maximum mean concentration measured from mixed land uses. **Residential Land Use:** Estimates of bacteria concentrations from residential land uses were taken from the City of Portland MS4 permit application. An initial value of 9500 counts/100ml was used. This value represents the maximum mean measured from residential land uses. Additionally, DEQ monitored runoff from the City of Garibaldi. Fecal coliform concentrations ranged from 10 counts/100ml to 2000 counts/100ml. **Rural Industrial: Estimates** of bacteria concentrations from industrial land uses were taken from the City of Portland and Multnomah County MS4 permit application. An initial value of 3000 counts/100ml was used. This value represents the maximum concentration measured from industrial land uses. Additionally, DEQ monitored some industrial facilities in the Tillamook basin, and the maximum concentration was 1900 counts/100ml. This 1900 value is approximately the final concentration used in the calibration. **Agricultural Land Use:** This land use was assumed to include manure application on fields as well as animal grazing. Estimated of runoff concentrations were taken from two 319 project reports: Moore (May 1999) and Moore (August 1998). Initial pasture runoff concentration of 15000 counts/100ml was used. This value represents the mean of coliform measured 45 meters from the manure application site. **Agriculture/Farm Buildings and Farm Buildings Land Use:** This land use includes the fecal contribution from Confined Animal Feeding Operations (CAFOs). In a study conducted by DEQ in 1979 and 1980 (Jackson and Glendening, 1982) runoff from barnyards contributed to high instream fecal concentrations. At one site, DEQ measured the instream fecal concentration as 60,000 counts/100 ml downstream from a barnyard. This value was used as an initial estimate of the fecal coliform concentration from CAFOs. **Point Sources**: Concentrations and flow from the waste water point sources were taken from Discharge Monitoring Reports covering the period of November 1997 to December 1998. In the final calibration the flow and concentration from the Tillamook County Creamery Association were adjusted to meet the measured instream values. **Septic Systems:** The location of failing septic systems was obtained from the 1998 Shoreline Survey, conducted by the Tillamook County Health Division. According to this survey, 9 homes (out of 285 surveyed) in the river basins were identified as having systems that were not fully operational. This included systems that were marginal as well as directly failing to the surface. Additional systems were identified as marginal in the survey but were not located in the river basins. To account for failing systems in other areas of the basin, an estimate of overall failure rate was used. According to a review of previous sanitary surveys, approximately 6 to 7% of the septic systems in the basin are failing (Dennis Illingworth, DEQ memo, February 13, 1997). This failure rate was randomly applied to populated areas of the basin, not serviced by sanitary sewers. Using data from "ODEQ Final Report Oregon On site Experimental Systems Program, December 1982", the flow and concentration of septic tank effluent was estimated. It was assumed that 100% of the effluent flowed overland. The resulting load is calculated by the following equation:
(200 gallons/day)(20000 counts/100 ml)(3.7854 L/gallon)(1000ml/1 L) = 1.51 x 10^8 counts/day

Bacterial source concentrations used in the calibration for the October 1997 storm event are presented in Tables 31 and 32.

Table 31. Initial and Calibrated Fecal Coliform Concentrations for Land Uses

Land Use	Initial Fecal Coliform Concentrations (counts/100ml)	Oct 97 Calibrated Fecal Coliform Concentration (counts/100mL)
Agriculture/Forest	25	25
Agriculture	15000	10000
Agriculture/Farm Buildings	60000	100000
Farm Buildings	60000	100000
Forest	25	25
Rural Industrial	3000	1500
Rural Residential	9500	9000
Urban	60000	7000
Failing on site systems (per household)	20000	20000

Table 32. Initial and Calibrated Concentrations for Point Sources

Permittee	Initial Concentration (counts/100ml)	Oct 97 Calibrated Concentration (counts/100mL)	Flow (CFS)
Port of Tillamook Bay	62	62	1.7
City of Tillamook	2.6	2.6	1.7
Tillamook County Creamery Association[17] (TCCA)	5	100000	50

Land use concentrations used in the March 1998 calibration are presented in Table 34. The point source concentrations were the same as in the October 1997 calibration. Minimum measured concentrations from the City of Portland's storm water sampling (City of Portland, May 1993) and work by Moore (1998, 1999) were used as the initial concentrations. The concentrations were then adjusted to calibrate to the instream values.

Table 33. Land Use Concentrations for March 1998 Calibration

Land Use	Initial Fecal Coliform Concentrations (counts/100ml)	Mar 98 Calibrated Fecal Coliform Concentration (counts/100mL)
Agriculture/Forest	25	25
Agriculture	100	500
Agriculture/Farm Buildings	100	100
Farm Buildings	100	100
Forest	25	25
Rural Industrial	200	100
Rural Residential	800	100
Urban	100	20000
Failing on site systems (per household)	20000	20000

[17] TCCA data estimated from samples taken in mixing zone. DMRs measured at plant, not at outfall to river.

Bacteria Die Off

Overland Decay

The bacterial die off rate during overland flow was estimated based on the travel time of the water to the major streams. The travel time of water (hydrologic time of concentration) was estimated using a kinematic wave equation (Chow ET al, 1988):

Travel Time (minutes) = T = $(6.93L^{0.6}n^{0.6})/(i^{0.4} S^{0..3})$
Where:

L = Slope length (meters)
n = Manning's n
i = Rainfall Intensity (mm/hr)
S = Slope (m/m)

The generalized slopes derived from STATSGO were adjusted using the 30 meter Digital Elevation Model *(citation).* The Manning's n values were based on land uses (Chow ET al, 1988). To estimate the slope length, values within the GIS database were grouped together into concentric zones. The slope length was then the distance to major streams for each zone.

Decay is based on the first order decay equation. According to Moore (1982) there is a lack of data in the literature on correlation of other decay models to die-off in soil and water systems.

First order decay (Moore, 1982):

$$\frac{N_t}{N_o} = 10^{-kt}$$

Where:

N_t = number of bacteria at time t
N_o = number of bacteria at time o
t = time in days
k = first order or die-off rate constant

The first order decay rates can be adjusted in the model but typically ranges between 0.01 and 2.0 (Moore, 1982). A decay rate of 0.6 per day was used in the Tillamook basin.

Instream Decay

An additional die-off rate was incorporated into the stream to account for loss during travel time from each sampling point. The instream bacteria die-off was adjusted for temperature using the following equation (Tchobanoglous, 1985).:

$$(K)_T = (K)_{20}(\Theta)^{T-20}$$

Where:
Θ is the temperature coefficient
K_T = decay rate at temperature T
K_{20} = decay rate at 20°C
Using laboratory data (Moore 1982), the average Θ was 1.1. Theta (Θ) was then applied to a field determined K (from Moore 1982) using temperatures measured instream (Table 10).

Table 34. Average Instream Temperatures

River	June – September	October-May
Kilchis	15°C	9°C
Miami	14°C	9°C
Tillamook	16°C	9°C
Trask	17°C	9°C
Wilson	18°C	9°C
Average	**16°C**	**9°C**

The average temperatures were used to adjust the die off rate for the calibrations. Using a Θ value of 1.1 and a temperature of 9°C, a decay rate (K) of 3 was calculated for storms occurring in the period of October - May. For June- September storms, a decay rate (K) of 8 was calculated.

The instream travel time was estimated for each storm. Regressions of velocity and flow were developed for each of the rivers (USGS, WRD data). Because the Wilson River data followed a log normal distribution, this data was transformed for analysis. The regressions were then used to estimate the velocity under the storm flow conditions (Figures 57-59, all regressions are significant at $\propto = 0.05$).

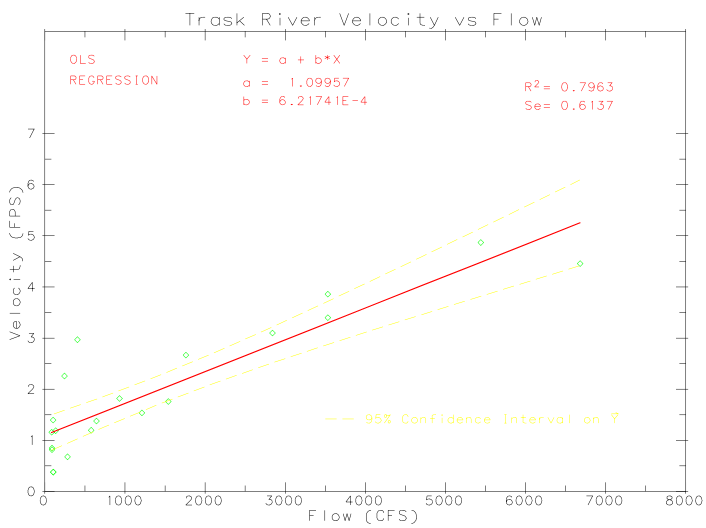


Figure 57. : Trask River Flow and Velocity, USGS gage 14302480

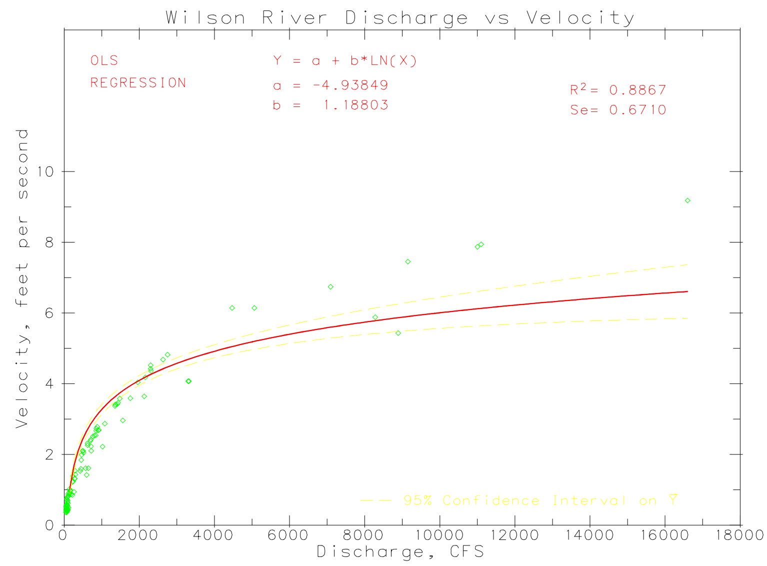


Figure 58. : Wilson River Flow and Velocity, USGS gage 14301500

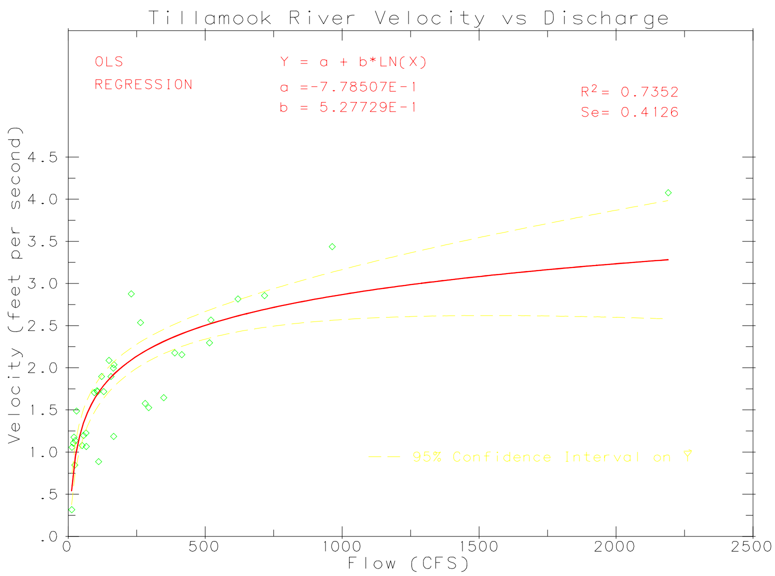
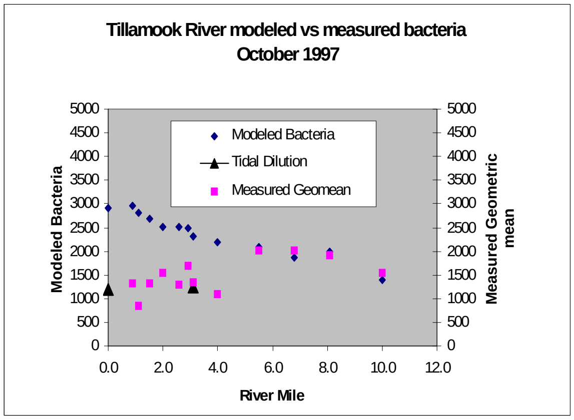


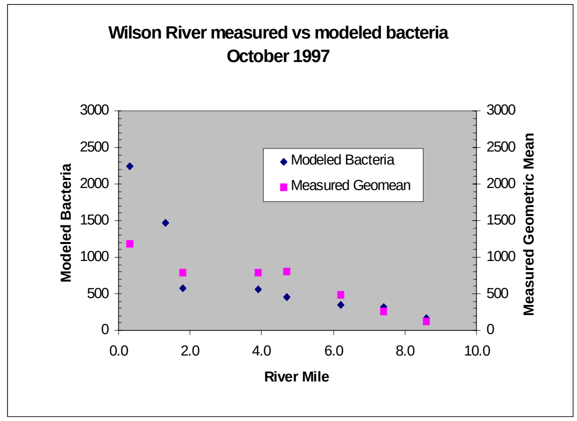
Figure 59. : Tillamook River Flow Vs Velocity, WRD Gage 14302700

BACTERIA CALIBRATION RESULTS

Modeled Concentrations

The total bacteria load was estimated by: the product of the flow, the source concentrations and the die-off rate. These bacteria loads for all the polygons in a watershed (where samples had been collected) were summed and divided by the flow volume to obtain an instream bacteria concentration. The results of the calibration for the October 1997 storm event for the Tillamook,





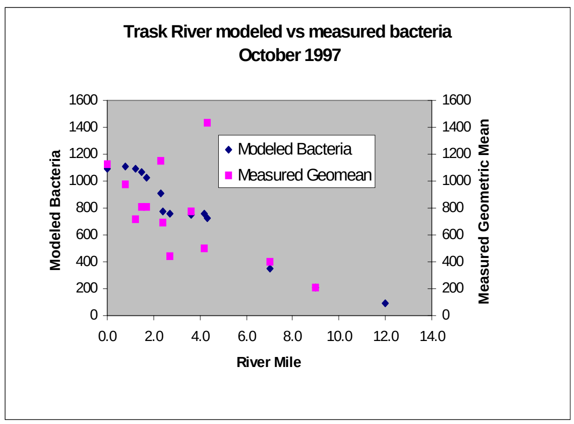


Figure 60. Tillamook, Wilson and Trask River Modeled versus observed Bacteria Concentrations, October 1997 Calibration. Black triangles in Tillamook River figure are modeled concentrations after accounting for tidal dilution with Bay Water.

Tidal Dilution

As seen in Figure 60, the calibration for the Tillamook River overestimated concentrations below river mile 4. This is apparently due to dilution from tidal input, which is not accounted for in the model. Estimates of the dilution due to tidal input were made by assuming the tide resulted in a tidal prism being formed in the Tillamook River from mile 4 to the mouth. The prism can be viewed as a completely mixed system and a mass balance can be used to calculate the average bacteria concentration in the prism over the tidal cycle. This is determined mathematically as follows:

$(C_{xp})(V_p) = (V_u)(C_u) + (V_d)(C_d)$

Where:

C_{xp} = average bacteria concentration in the tidal prism
V_p = volume of the tidal prism
V_u = upstream volume (of the Tillamook river)
C_u = upstream concentration (modeled for the Tillamook river)
V_d= downstream volume
C_d = downstream concentration

The tidal prism volume is calculated using the following dimensions:

Prism width =450 feet
Prism length = 21120 feet (4 miles)
Prism depth = 13 feet (over a tidal cycle)
V_P = volume of prism = W*D*L =123552000 ft^3

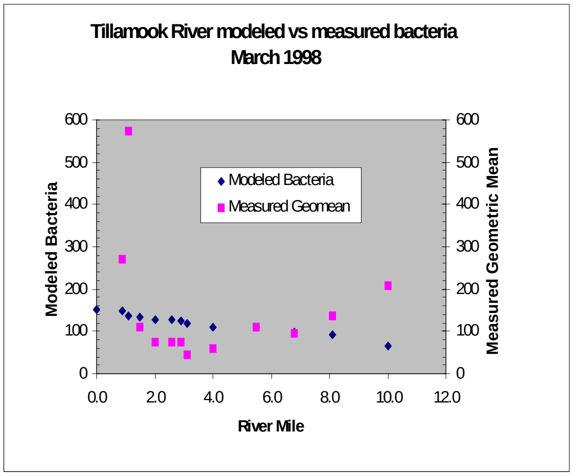
The upstream volume is represented by the flow in the Tillamook River, over 2 tidal cycles in a day:

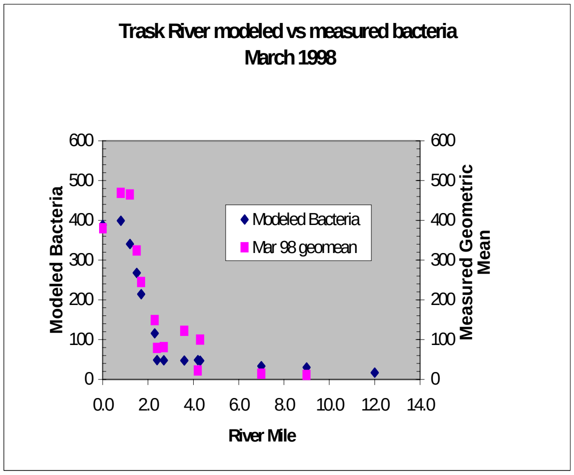
V_u = (700 cfs)(3600 seconds/hour)(24 hours/4 tidal cycles) = 15120000 ft^3/tidal cycle
C_u = upstream concentration = 1540 MPN/100ml (modeled concentration in the Tillamook River at river mile 6)
$V_d = (V_p – V_u) = 1.08 \times 10^8\ ft^3$
Cd = flow weighted average downstream concentration, with flow and bacteria concentrations from Tillamook, Trask and Wilson rivers = 1202 counts/100 ml

Solving the mass balance for C_{xp} yields a concentration in the tidal prism of 1240 counts/100ml. This value approximates the measured values in the Tillamook River from river mile 4 to the mouth. The tidal dilution is represented in Figure 57.

Instream concentrations were much lower for the March 1998 storm (Figure 51). Measured

Figure 61. Tillamook and Trask Rivers Modeled versus observed Bacteria Concentrations, March 1998





Calibration

results for the Wilson River are not available due to inadequate dilution of samples at the analytical laboratory. The Kilchis and Miami Rivers were also monitored in the March 1998 storm event, however, the sites selected by DEQ did not coincide with the watershed delineation. It is not possible to graph the modeled and measured results together.

TMDL CALCULATIONS

Loading Capacity:

The loading capacity is set to meet the shellfish consumption criterion in Tillamook Bay. The criterion is a median concentration of 14 counts/100 ml, with no more than 10% of the samples exceeding 43 counts/100 ml. The concentration at the mouth of each river to meet the bay concentration of 14 was calculated.

In order to calculate the dilution in Tillamook Bay due to freshwater inputs, a conservative tracer was used. Solving a mass balance using conductivity as the tracer yields:

Equation 1

$$Q_f C_f + Q_s C_s = C_b (Q_f + Q_s)$$

Where:

$$Q_f = \text{freshwater flow}$$

$$C_f = \text{freshwater conductivity} = 0$$

$$Q_s = \text{seawater flow}$$

$$C_s = \text{seawater conductivity} = 49000\ \mu\text{S/cm}$$

$$C_b = \text{bay conductivity} = \text{station - specific average}$$

$$Q_s C_s = C_b (Q_f + Q_s) - Q_f C_f$$

$$C_s = \frac{C_b (Q_f + Q_s) - Q_f C_f}{Q_s}$$

$$C_s = \frac{C_b Q_f}{Q_s} + \frac{C_b Q_s}{Q_s} - \frac{Q_f C_f}{Q_s}$$

$$C_S = C_b \frac{Q_f}{Q_s} + C_b - \frac{Q_f}{Q_s} C_f$$

$$C_s = C_b + \frac{Q_f}{Q_s}(C_b - C_f)$$

$$\frac{C_s - C_b}{C_b - C_f} = \frac{Q_f}{Q_s}$$

Where: $C_f = 0$

$$\frac{C_s - C_b}{C_b} = \frac{Q_f}{Q_s}$$

Equation 2

$$\frac{C_b}{C_s - C_b} = \frac{Q_s}{Q_f} = \frac{\text{bay conductivity}}{\text{seawater conductivity - bay conductivity}}$$

Solving a mass balance for bacteria in the Bay and assuming seawater has no bacteria:

Equation 3

$$\frac{C_f Q_f + C_s Q_s}{Q_s + Q_f} = C_b$$

Where:

$Q_f = \text{freshwater flow}$

$C_f = \text{concentration of bacteria in freshwater}$

$C_s = \text{concentration of bacteria in seawater} = 0$

$Q_s = \text{seawater flow}$

$C_b = \text{concentration of bacteria in the bay} = 14\ \text{CFU/100ml}$

$$\frac{C_f Q_f}{Q_s + Q_f} = C_b$$

$$C_f = C_b \frac{(Q_s + Q_f)}{Q_f}$$

$$\frac{C_f}{C_b} = \frac{Q_s + Q_f}{Q_f}$$

$$\frac{C_f}{C_b} = \frac{Q_s}{Q_f} + \frac{Q_f}{Q_f}$$

$$\frac{C_f}{C_b} = \frac{Q_s}{Q_f} + 1$$

$$C_f = \left\{ \left(\frac{Q_s}{Q_f} \right) + 1 \right\} * C_b$$

Substituting the dilution from equation 2:

Equation 4

$$C_f = \left\{ \frac{\text{bay cond.}}{\text{seawater cond. - bay cond.}} + 1 \right\} * C_b$$

As stated previously, the criteria concentration for bacteria in the bay is 14 counts/100 ml, expressed as a median. The average conductivity of the bay was calculated for each site under conditional approval for shellfish harvest by Oregon Department of Agriculture and some in the upper Bay as well. The conditionally approved sites are those that are open to shellfish harvesting under certain conditions. The conductivity of seawater for dilution was set at 49,000μS/cm based on a salinity outside the Bay of 32 ppt. Historical conductivity was used to calculate an average for each station.The results of this calculation are summarized in the following table.

Table 35. : Average Conductivity Ratios

STORET	Station	*Winter Dilution*	*Summer Dilution*
Conditionally Approved			
412011	Tillamook Bay at South Bay	2.39	3.88
412014	Tillamook Bay at Marker 19 (Hobsonville Pt.)	3.26	4.17
412234	Tillamook Bay at North Bay	4.08	4.49
412015	Tillamook Bay near Hobsonville Pt.	3.57	4.91
412013	Tillamook Bay at Northwest Bay	4.34	4.95
412016	Tillamook Bay at Northeast Bay	3.73	4.76
412012	Tillamook Bay at Southwest Bay	3.13	4.27
Average		**3.50**	**4.49**
Prohibited			
412007	Tillamook Bay at Middle Dolphin	1.55	1.97
412178	Garibaldi	2.41	4.20
412008	Tillamook Bay at South Dolphin	1.31	1.61
412009	Tillamook Bay at North End of Dick Pt. Dike	1.20	1.45
412153	Tillamook Bay at Gap in Dick Pt. Dike	1.08	1.34
412010	Tillamook Bay at Memaloose Pt.	1.15	1.28
Average		**1.45**	**1.97**
Restricted			
412006	Tillamook Bay at North Dolphin	2.14	2.58
412176	Tillamook Bay at Southeast Bay	1.59	2.79
Average		**1.87**	**2.68**

Using equation 4, we have adopted a dilution ratio of 3:1, resulting in an average allowable bacteria concentration in freshwater of 42 counts/100ml. This value is set as the loading capacity at the mouths of each of the five rivers. All non-point source runoff sources received an equal reduction rate that accumulated after application of overland and instream decay rates, and dilution by baseflow to meet the target of 42 COUNTS/100ml or less at the mouth of each of the rivers.

While the bay criterion is expressed as fecal coliform, the fresh water criterion is expressed as *E coli*. To determine the allowable fecal coliform concentration within the rivers, regressions between *E coli* and fecal coliform were calculated for each river. The regression line for the Kilchis River is shown in Figure 61; the regressions for the other rivers are in Appendix A. Substituting 126 *E coli*/100 ml for Y in the regressions yields the fecal coliform to be met instream (at any point above the mouth of the river).

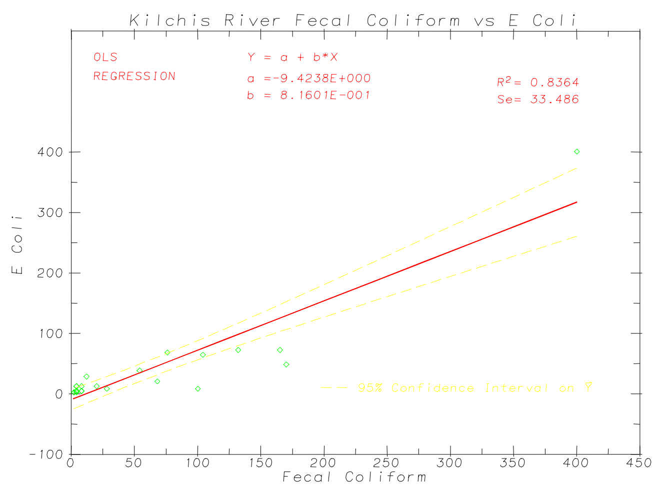
Kilchis River:
Y= -9.4238 + 0.81601(X)
Y =126 COUNTS/100 ml (*E coli*)
X = 166 COUNTS/100 ml (Fecal Coliform)

Miami River
Y = 35.693 + 0.55582(X)
For y = 126;
X = 163 COUNTS/100 ml (Fecal coliform)

Tillamook River
Y = -78.29 + 1.0305(X)
For y =126;
X = 198 COUNTS/100 ml (fecal coliform)

Trask River
Y = 5.3061 + 0.63871(X)
For y = 126;
X = 189 COUNTS/100 ml (fecal coliform)

Wilson River
Y = -14.57 + 0.5514(X)
For y = 126;
X = 255 COUNTS/100 ml (fecal coliform)



To summarize, at the mouths of the five rivers, the fecal coliform concentration must be 28 COUNTS/100ml. Upstream of the mouths, the *E coli* criteria apply, and the regressions are used to calculate the fecal coliform concentrations that will result in attainment of the *E coli* criteria. Details of the allocation strategies are found in the TMDL.

APPENDIX C: OREGON ADMINISTRATIVE RULES

[SELECTED] DEFINITIONS

340-04l-0006

(5) "Estuarine Waters" means all mixed fresh and oceanic waters in estuaries or bays from the point of oceanic water intrusion inland to a line connecting the outermost points of the headlands or protective jetties.

7) "Marine Waters" means all oceanic, offshore waters outside of estuaries or bays and within the territorial limits of the State of Oregon.

(9) "Pollution" means such contamination or other alteration of the physical, chemical, or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt, or odor of the waters, or such radioactive or other substance into any waters of the state which either by itself or in connection with any other substance present, will or can reasonably be expected to create a public nuisance or render such waters harmful, detrimental, or injurious to public health, safety, or welfare, or to domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses or to livestock, wildlife, fish or other aquatic life, or the habitat thereof.

(11) "Sewage" means the water-carried human or animal waste from residences, buildings, industrial establishments, or other places together with such groundwater infiltration and surface water as may be present. The admixture with sewage as herein defined of industrial wastes or wastes, as defined in sections (6) and (l3) of this rule, shall also be considered "sewage" within the meaning of this division.

14) "Waters of the State" include lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon, and all other bodies of surface or underground waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction.

(15) "Low Flow Period" means the flows in a stream resulting from primarily groundwater discharge or baseflows augmented from lakes and storage projects during the driest period of the year. The dry weather period varies across the state according to climate and topography. Wherever the low flow period is indicated in the Water Quality Management Plans, this period has been approximated by the inclusive months. Where applicable in a waste discharge permit, the low flow period may be further defined.

(17) "Non-point Sources" refers to diffuse or unconfined sources of pollution where wastes can either enter into -- or be conveyed by the movement of water to -- public waters.

(18) "Loading Capacity (LC)" -- The greatest amount of loading that a water can receive without violating water quality standards.

(19) "Load Allocation (LA)" -- The portion of a receiving water's loading capacity that is attributed either to one of its existing or future non-point sources of pollution or to natural background sources. Load allocations are best estimates of the loading which may range from reasonably accurate estimates to gross allotments, depending on the availability of data and appropriate techniques for predicting loading. Whenever possible, natural and non-point source loads should be distinguished.

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

(21) "Total Maximum Daily Load (TMDL)" -- The sum of the individual WLAs for point sources and LAs for non-point sources and background. If a receiving water has only one point source discharger, the TMDL is the sum of that point source WLA plus the LAs for any non-point sources of pollution and natural background sources, tributaries, or adjacent segments. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measure. If Best Management Practices (BMPs) or other non-point source pollution controls make more stringent load allocations practicable, then wasteload allocations can be made less stringent. Thus, the TMDL process provides for non-point source control tradeoffs.

30) "Water Quality Limited" can mean one of the following categories:
(a) A receiving stream which does not meet instream water quality standards during the entire year or defined season even after the implementation of standard technology;
(b) A receiving stream which achieves and is expected to continue to achieve instream water quality standard but utilizes higher than standard technology to protect beneficial uses;
(c) A receiving stream for which there is insufficient information to determine if water quality standards are being met with higher than standard treatment technology or where through professional judgment the receiving stream would not be expected to meet water quality standards during the entire year or defined season without higher than standard technology.
(31) "Reserve Capacity" means that portion of a receiving stream's loading capacity which has not been allocated to point sources or non-point sources and natural background as waste load allocations or load allocations, respectively. The reserve capacity includes that loading capacity which has been set aside for a safety margin and is otherwise unallocated.

40) "Critical Habitat" means those areas which support rare, threatened or endangered species, or serve as sensitive spawning and rearing areas for aquatic life.

(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.

54) "Numeric Temperature Criteria" are measured as the seven-day moving average of the daily maximum temperatures. If there is insufficient data to establish a seven-day average of maximum temperatures, the numeric criteria shall be applied as an instantaneous maximum. The measurements shall be made using a sampling protocol appropriate to indicate impact to the beneficial uses;
(55) "Measurable Temperature Increase" means an increase in stream temperature of more than 0.25°F;
(56) "Anthropogenic", when used to describe "sources" or "warming", means that which results from human activity;

[SELECTED] POLICIES AND GUIDELINES GENERALLY APPLICABLE TO ALL BASINS

340-04l-0026 Temperature

340-041-0026(3)(a)

(D) Effective July 1, 1996, in any waterbody identified by the Department as exceeding the relevant numeric temperature criteria specified for each individual water quality management basin identified in OAR 340-041-0205, OAR-340-041-0245, OAR-340-041-0285, OAR-340-041-0325, OAR-340-041-0365, OAR-340-041-0445, OAR-340-041-0485, OAR-340-041-0525, OAR-340-041-0565, OAR-340-041-0605, OAR-340-041-0645, OAR-340-041-0685, OAR-340-041-0725, OAR-340-041-0765, OAR-340-041-0805, OAR-340-041-0845, OAR-340-041-0885, OAR-340-041-0925, OAR-340-041-0965, and designated as water quality limited under Section 303(d) of the Clean Water Act, the following requirements shall apply to appropriate watersheds or stream segments in accordance with priorities established by the Department. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin based on the contribution of the segment(s) to the temperature problem:

(i) Anthropogenic sources are required to develop and implement a surface water temperature management plan which describes the best management practices, measures, and/or control technologies which will be used to reverse the warming trend of the basin, watershed, or stream segment identified as water quality limited for temperature;

(ii) Sources shall continue to maintain and improve, if necessary, the surface water temperature management plan in order to maintain the cooling trend until the numeric criterion is achieved or until the Department, in consultation with the Designated Management Agencies (DMAs), has determined that all feasible steps have been taken to meet the criterion and that the designated beneficial uses are not being adversely impacted. In this latter situation, the temperature achieved after all feasible steps have been taken will be the temperature criterion for the surface waters covered by the applicable management plan. 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;

(iii) Once the numeric criterion is achieved or the Department has determined that all feasible steps have been taken, sources shall continue to implement the practices or measures described in the surface water temperature management plan in order to continually achieve the temperature criterion;

(iv) For point sources, the surface water temperature management plan will be part of their National Pollutant Discharge Elimination System Permit (NPDES);

(v) For nonpoint sources, the surface water temperature management plan will be developed by designated management agencies (DMAs) which will identify the appropriate BMPs or measures;

(vi) A source (including but not limited to permitted point sources, individual landowners and land managers) in compliance with the Department or DMA (as appropriate) approved surface water temperature management plan shall not be deemed to be causing or contributing to a violation of the numeric criterion if the surface water temperature exceeds the criterion;

(E) Waters of the state exceeding the temperature criteria will be identified in the Clean Water Act (CWA), Section 303(d) list developed by the Department according to the schedule required by the Clean Water Act. This list will be prioritized in consul-tation with the DMAs to identify the order in which those waters will be addressed by the Department and the DMAs;
(
F) In basins determined by the Department to be exceeding the numeric temperature criteria, and which are required to develop surface water temperature management plans, new or increased discharge loads from point sources which require an NPDES permit under Section 402 of the Clean Water Act or hydro-power projects which require certification under Section 401 of the Clean Water Act are allowed a 1.0°F total cumulative increase in surface water temperatures as the surface water temperature management plan is being developed and implemented for the water quality limited basin if:

(i) In the best professional judgment of the Department, the new or increased discharge load, even with the resulting 1.0°F cumulative increase, will not conflict with or impair the ability of a surface water temperature management plan to achieve the numeric temperature criteria; and

(ii) A new or expanding source must demonstrate that it fits within the 1.0°F increase and that its activities will not result in a measurable impact on beneficial uses. This latter showing must be made by demonstrating to the Department that the temperature change due to its activities will be less than or equal to 0.25°F under a conservative approach or by demonstrating the same to the EQC with appropriate modeling.

(G) Any source may petition the Department for an exception to paragraph (F) of this subsection, provided:

(i) The discharge will result in less than 1.0°F increase at the edge of the mixing zone, and subparagraph
(ii) (ii) or (iii) of this paragraph applies;

(ii) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or

(iii) The source demonstrates that:

(I) It is implementing all reasonable management practices;

(II) Its activity will not significantly affect the beneficial uses; and

(III) The environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

(H) Any source or DMA may petition the Commission for an exception to paragraph (F) of this subsection, provided:

(i) The source or DMA provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or

(ii) The source or DMA demonstrates that:

(I) It is implementing all reasonable management practices;

(II) Its activity will not significantly affect the beneficial uses; and

(III) The environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.

340-041-0026(3)(a)(I) Bacteria

(I) In waterbodies designated by the Department as water-quality limited for bacteria, and in accordance with priorities established by the Department, development and implementation of a bacteria management plan shall be required of those sources that the Department determines to be contributing to the problem. The Department may determine that a plan is not necessary for a particular stream segment or segments within a water-quality limited basin 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.

OREGON ADMINISTRATIVE RULES – NORTH COAST BASIN

340-041-0205

Water Quality Standards Not to be Exceeded (To be Adopted Pursuant to ORS 468.735 and Enforceable Pursuant to ORS 468.720, 468.990 and 468.992)

(1) Notwithstanding the water quality standards contained below, the highest and best practicable treatment and/or control of wastes, activities, and flows shall in every case be provided so as to maintain dissolved oxygen and overall water quality at the highest possible levels and water temperatures, coliform bacteria concentrations, dissolved chemical substances, toxic materials, radioactivity, turbidities, color, odor, and other deleterious factors at the lowest possible levels.

(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 North Coast -- Lower Columbia River Basin:
b) Temperature: 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. The method for measuring the numeric temperature criteria specified in this rule is defined in OAR 340-041-0006(54):
(A) To accomplish the goals identified in OAR 340-041-0120(11), unless specifically allowed under a Department-approved surface water temperature management plan as required under OAR 340-041-0026(3)(a)(D), 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 64.0°F (17.8°C);
(ii) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface water temperatures exceed 68.0°F (20.0°C);
(iii) 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 55.0°F (12.8°C);

(iv) In waters determined by the Department to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);
(v) In waters determined by the Department to be ecologically significant cold-water refugia;
(vi) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;
(vii) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or sub-basin;
(viii) In natural lakes.
(B) An exceedance of the numeric criteria identified in subparagraphs (A)(i) through (iv) of this subsection will not be deemed a temperature standard violation if it occurs when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day average daily maximum air temperature calculated in a yearly series over the historic record. However, during such periods, the anthropogenic sources must still continue to comply with their surface water temperature management plans developed under OAR 340-041-0026(3)(a)(D);
(C) Any source may petition the Commission for an exception to subparagraphs (A)(i) through (viii) of this subsection for discharge above the identified criteria if:
(i) The source provides the necessary scientific information to describe how the designated beneficial uses would not be adversely impacted; or
(ii) A source is implementing all reasonable management practices or measures; its activity will not significantly affect the beneficial uses; and the environmental cost of treating the parameter to the level necessary to assure full protection would outweigh the risk to the resource.
(D) Marine and estuarine waters: No significant increase above natural background temperatures shall be allowed, and water temperatures shall not be altered to a degree which creates or can reasonably be expected to create an adverse effect on fish or other aquatic life.

340-041-0205(2)

(e) Bacteria standards:
(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:
(i) Freshwaters and Estuarine Waters Other than Shellfish Growing 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.
(ii) Marine Waters and Estuarine Shellfish Growing Waters: A fecal coliform median concentration of 14 organisms per 100 milliliters, with not more than ten percent of the samples exceeding 43 organisms per 100 ml.
(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 the Department or otherwise allowed by these rules;
(C) Animal Waste: Runoff contaminated with domesticated animal wastes shall be minimized and treated to the maximum extent practicable before it is allowed to enter waters of the State;
(D) Effluent Limitations and Water Quality Limited Waterbodies: Effluent limitations to implement the criteria in this rule are found in OAR 340-041-0120(12) through (16). Implementation of the criteria in this rule in water quality limited waterbodies is described in OAR 340-041-0026(3)(a)(I) and OAR 340-041-0120(17).
(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;

340-041-0120 Implementation Program Applicable to All Basins

(1) No waste treatment and disposal facilities shall be constructed or operated and no wastes shall be discharged to public waters without obtaining a permit from the Department as required by ORS 468.740.
(2) Plans for all sewage and industrial waste treatment, control, and disposal facilities shall be submitted to the Department for review and approval prior to construction as required by ORS 468.742.
(3) Minimum design criteria for waste treatment and control facilities prescribed under this plan and such other waste treatment and controls as may be necessary to insure compliance with the water quality standards contained in this plan shall be provided in accordance with specific permit conditions for those sources or activities for which permits are required and the following implementation program:
(a) For new or expanded waste loads or activities, fully approved treatment or control facilities, or both shall be provided prior to discharge of any wastes from the new or expanded facilities or conduct of the new or expanded activity;
(b) For existing waste loads or activities, additional treatment or control facilities necessary to correct specific unacceptable water quality conditions shall be provided in accordance with a specific program and timetable incorporated into the waste discharge permit for the individual discharger or activity. In developing treatment requirements and implementation schedules for existing installations or activities, consideration shall be given to the impact upon the overall environmental quality including air, water, land use, and aesthetics;
(c) Wherever minimum design criteria for waste treatment and control facilities set forth in this plan are more stringent than applicable federal standards and treatment levels currently being provided, upgrading to the more stringent requirements will be deferred until it is necessary to expand or otherwise modify or replace the existing treatment facilities. Such deferral will be acknowledged in the permit for the source;
(d) Where planning or design or construction of new or modified waste treatment and controls to meet prior applicable state or federal requirements is underway at the time this plan is adopted, such plans, design, or construction may be completed under the requirements in effect when the project was initiated. Timing for upgrading to meet more stringent future requirements will be as provided in section (3) of this rule.
(4) Confined animal feeding operations shall be regulated pursuant to OAR 340-041-0005 through 340-051-0080 in order to minimize potential adverse effect on water quality.
(5) Programs for control of pollution from nonpoint sources when developed by the Department, or by other agencies pursuant to Section 208 of Public Law 92-500 and approved by the Department, shall as applicable, be incorporated into this plan by amendment via the same process used to adopt the plan unless other procedures are established by law.
(6) Where minimum requirements of federal law or enforceable regulations are more stringent than specific provisions of this plan, the federal requirements shall prevail.
(7) Within framework of state-wide priority and available resources, the Department will monitor water quality within the basin for the purposes of evaluating conformance with the plan and developing information for future additions or updating.
(8) The EQC recognizes that the potential exists for conflicts between water quality management plans and the land use plans and resource management plans which local governments and other agencies must develop pursuant to law. In the event any such conflicts develop, it is the intent of the Department to meet with the local government or responsible agency to formulate proposed revisions to one or both so as to resolve the conflict. Revisions will be presented for adoption via the same process used to adopt the plan unless other specific procedures are established by law.
(9) The Department shall calculate and include effluent limits specified in pounds per day, which shall be the mass load limits for biochemical oxygen demand or carbonaceous biochemical oxygen demand and total suspended solids in National Pollutant Discharge Elimination System permits issued to all sewage treatment facilities. These limits shall be calculated as follows:

(a) Except as noted in paragraph (H) of this subsection, for existing facilities and for facilities receiving engineering plans and specifications approval from the Department for new treatment facilities or treatment facilities expanding the average dry weather treatment capacity, prior to June 30, 1992:
(A) During periods of low stream flows (approximately May 1 through October 31), the monthly average mass load expressed as pounds per day shall not exceed the applicable monthly concentration effluent limit times the design average dry weather flow expressed in million gallons per day times 8.34 pounds per gallons. The weekly average mass load expressed as pounds per day shall not exceed the monthly average mass load times 1.5. The daily mass load expressed in pounds per day shall not exceed the monthly average mass load times 2.0;
(B) During the period of high stream flows (approximately November 1 through April 30), the monthly average mass load expressed as pounds per day shall not exceed the monthly concentration effluent limit times the design average wet weather flow expressed in million gallons per day times 8.34 pounds per gallon. The weekly average mass load expressed as pounds per day shall not exceed the monthly average mass load times 1.5. The daily mass load expressed in pounds per day shall not exceed the monthly average mass load times 2.0;
(C) On any day that the daily flow to a sewage treatment facility exceeds the lesser hydraulic capacity of the secondary treatment portion of the facility or twice the design average dry weather flow, the daily mass load limit shall not apply. The permittee shall operate the treatment facility at highest and best practicable treatment and control;
(D) The design average wet weather flow used in calculating mass loads shall be approved by the Department in accordance with prudent engineering practice and shall be based on a facility plan approved by the Department, engineering plans and specifications approved by the Department, or an engineering evaluation. The permittee shall submit documentation describing and supporting the design average wet weather flow with the permit application, application for permit renewal, or modification request, or upon request by the Department. The design average wet weather flow is defined as the average flow between November 1 and April 30 when the sewage treatment facility is projected to be at design capacity for that portion of the year;
(E) Mass loads assigned as described in paragraphs (B) and (C) of this subsection will not be subject to OAR 340-041-0026(3);
(F) Mass loads as described in this rule will be included in permits upon renewal, or upon permit modification request;
(G) Within 180 days after permit renewal or modification, permittees receiving higher mass loads under this rule and having a separate sanitary sewer system shall submit to the Department for review and approval a proposed program and time schedule for identifying and reducing inflow. The program shall consist of the following:
(i) Identification of all overflow points and verification that sewer system overflows are not occurring up to a 24-hour, five-year storm event or equivalent;
(ii) Monitoring of all pump station overflow points; and
(iii) A program for identifying and removing all inflow sources into the permittees sewer system over which the permittee has legal control; and
(iv) For those permittees not having the necessary legal authority for all portions of the sewer system discharging into the permittee's sewer system or treatment facility, a program and schedule for gaining legal authority to require inflow reduction and a program and schedule for removing inflow sources.
(H) Within one year after the Department's approval of the program, the permittee shall begin implementation of the program.
(I) Paragraphs (A) through (G) of this subsection shall not apply to the cities of Athena, Elgin, Adair Village, Halsey, Harrisburg, Independence, Carlton and Sweet Home. Mass load limits have been individually assigned to these facilities.
(b) For new sewage treatment facilities or treatment facilities expanding the average dry weather treatment capacity, and receiving engineering plans and specifications approval from the Department after June 30, 1992, the mass load limits shall be calculated by the Department based on the proposed treatment facility capabilities and the highest and best practicable treatment to minimize the discharge of pollutants;

(c) Mass load limits as defined in this rule may be replaced by more stringent limits if required by waste load allocations established in accordance with a TMDL for treatment facilities discharging to water quality limited streams, or if required to prevent or eliminate violations of water quality standards;
(d) In the event that the design average wet weather flow or the hydraulic secondary treatment capacity is not known or has not been approved by the Department at the time of permit issuance, the permit shall include as interim mass load limits the mass load limits in the previous permit issued to the permittee for the treatment facility. The permit shall also include a requirement that the permittee shall submit to the Department the design average wet weather flow and hydraulic secondary treatment capacity within 12 months after permit issuance. Upon review and approval of the design flow information, the Department will modify the permit and include mass load limits as described in subsection (a) of this section;
(e) Each permittee with existing sewage treatment facilities otherwise subject to subsection (a) of this section may choose mass load limits calculated as follows:
(A) The monthly average mass load expressed as pounds per day shall not exceed the applicable monthly concentration effluent limit times the design average dry weather flow expressed in million gallons per day times 8.34 pounds per gallon;
(B) The weekly average mass load expressed as pounds per day shall not exceed the monthly average mass load times 1.5;
(C) The daily mass load expressed in pounds per day shall not exceed the monthly average mass load times 2.0. In the event that existing mass load limits are retained by the permittee, the terms and requirements of subsection (a) of this section shall not apply.
(f) The Commission may grant exceptions to subsection (a) of this section. In allowing increased discharged loads, the Commission shall make the findings specified in OAR 340-041-0026(3) for waste loads, and in addition shall make the following findings:
(A) That mass loads as calculated in subsection (a) of this section cannot be achieved with the existing treatment facilities operated at maximum efficiency at projected design flows; and
(B) That there are no practicable alternatives to achieving the mass loads as calculated in subsection (a) of this section.
(10) Agricultural water quality management plans to reduce agricultural non-point source pollution shall be developed and implemented by the Oregon Department of Agriculture (ODA) through a cooperative agreement with the Department of Environmental Quality (DEQ) to implement applicable provisions of ORS 568.900–933 and ORS 561.191. If DEQ has reason to believe that agricultural discharges or activities are contributing to water quality problems resulting in water quality standards violations, DEQ shall hold a consultation with the ODA. If water quality impacts are likely from agricultural sources, and DEQ determines that a water quality management plan is necessary, the Director of DEQ shall write a letter to the Director of the ODA requesting that such a management plan be prepared and implemented to reduce pollutant loads and achieve the water quality criteria.
(11) EQC policy on surface water temperature (as regulated in the basin standards found in OAR 340-041-0205, OAR-340-041-0245, OAR-340-041-0285, OAR-340-041-0325, OAR-340-041-0365, OAR-340-041-0445, OAR-340-041-0485, OAR-340-041-0525, OAR-340-041-0565, OAR-340-041-0605, OAR-340-041-0645, OAR-340-041-0685, OAR-340-041-0725, OAR-340-041-0765, OAR-340-041-0805, OAR-340-041-0845, OAR-340-041-0885, OAR-340-041-0925, OAR-340-041-0965:
(a) It is the policy of the Environmental Quality Commission (EQC) to protect aquatic ecosystems from adverse surface water warming caused by anthropogenic activities. The intent of the EQC is to minimize the risk to cold-water aquatic ecosystems from anthropogenic warming of surface waters, to encourage the restoration of critical aquatic habitat, to reverse surface water warming trends, to cool the waters of the State, and to control extremes in temperature fluctuations due to anthropogenic activities:
(A) The first element of this policy is to encourage the proactive development and implementation of best management practices or other measures and available temperature control technologies for non-point and point source activities to prevent thermal pollution of surface waters;
(B) The second element of this policy is to require the development and implementation of surface water temperature management plans for those basins exceeding the numeric

temperature criteria identified in the basin standards. The surface water temperature management plans will identify the best management practices (BMPs) or measures and approaches to be taken by non-point sources, and technologies to be implemented by point sources to limit or eliminate adverse anthropogenic warming of surface waters.
(b) Surface water temperatures in general are warming throughout the State. These water temperatures are influenced by natural physical factors including, but not limited to solar radiation, stream-side shade, ambient air temperatures, heated water discharges, cold-water discharges, channel morphology, and stream flow. Surface water temperatures may also be affected by anthropogenic activities that discharge heated water, widen streams, or reduce stream shading, flows, and depth. These anthropogenic activities, as well as others, increase water temperatures. Anthropogenic activities may also result in the discharge of cold water that decreases water temperatures and affects biological cycles of aquatic species;
(c) The temperature criteria in the basin standards establish numeric and narrative criteria to protect designated beneficial uses and to initiate actions to control anthropogenic sources that adversely increase or decrease stream temperatures. Natural surface water temperatures at times exceed the numeric criteria due to naturally high ambient air temperatures, naturally heated discharges, naturally low stream flows or other natural conditions. These exceedances are not water quality standards violations when the natural conditions themselves cause water temperatures to exceed the numeric criteria. In these situations, the natural surface water temperatures become the numeric criteria. In surface waters where both natural and anthropogenic factors cause exceedances of the numeric criteria, each anthropogenic source will be responsible for controlling, through implementation of a management plan, only that portion of the temperature increase caused by that anthropogenic source;
(d) The purpose of the numeric criteria in the basin standards is to protect designated beneficial uses; this includes specific life cycle stages during the time periods they are present in a surface water of the state. Surface water temperature measurements taken to determine compliance with the identified criteria will be taken using a sampling protocol appropriate to indicate impact to the beneficial use. The EQC, in establishing these criteria, recognizes that new information is constantly being developed on water temperatures and how water temperatures affect different beneficial uses. Therefore, continued reevaluation of temperature information is needed to refine and revise numeric criteria in the basin standards over time. The EQC also recognizes that the development and implementation of control technologies and best management practices or measures to reduce anthropogenic warming is evolving and the achievement of the numeric criteria will be an iterative process;
(e) Surface water temperature management plans will be required according to OAR 340-041-0026(3)(a)(D) when the relevant numeric temperature criteria are exceeded and the waterbody is designated as water-quality limited under Section 303(d) of the Clean Water Act. The plans will identify those steps, measures, technologies, and/or practices to be implemented by those sources determined by the Department to be contributing to the problem. The plan may be for an entire basin, a single watershed, a segment of a stream, single or multiple non-point source categories, single or multiple point sources or any combination of these, as deemed appropriate by the Department, to address the identified temperature problem:
(A) In the case of state and private forest lands, the practices identified in rules adopted pursuant to the State Forest Practices Act (FPA) will constitute the surface water temperature management plan for the activities covered by the act. Consequently, in those basins, watersheds or stream segments exceeding the relevant temperature criterion, and for those activities covered by the Forest Practices Act, the forestry component of the temperature management plan will be the practices required under the FPA. If the mandated practices need to be improved in specific basins, watersheds or stream segments to fully protect identified beneficial uses, the Departments of Forestry and Environmental Quality will follow the process described in ORS 527.765 to establish, implement, and improve practices in order to reduce thermal loads to achieve and maintain the surface water temperature criteria. Federal forest management agencies are required by the federal Clean Water Act to meet or exceed the substantive requirements of the state forestry non-point source program. The Department currently has Memoranda of Understanding with the U.S. Forest Service and Bureau of Land Management to

implement this aspect of the Clean Water Act. These memoranda will be used to identify the temperature management plan requirements for federal forest lands;
(B) The temperature management plan for agricultural non-point sources shall be developed and implemented in the manner described in section (10) of this rule;
(C) The Department will be responsible for determining the appropriate surface water temperature management plan for individual and general NPDES permitted sources. The requirement for a surface water temperature management plan and the content of the plan will be appropriate to the contribution the permitted source makes to the temperature problem, the technologies and practices available to reduce thermal loads, and the potential for trading or mitigating thermal loads;
(D) In urban areas, the Department will work with appropriate state, county, municipal, and special district agencies to develop surface water temperature management plans that reduce thermal loads in basins, watersheds, or stream segments associated with the temperature violations so that the surface water temperature criteria are achieved.
(f) The EQC encourages the release of stored water from reservoirs to cool surface water in order to achieve the identified numeric criteria in the basin standards as long as there is no significant adverse impact to downstream designated beneficial uses from the cooler water temperatures. If the Department determines that a significant adverse impact is resulting from the cold-water release, the Department shall, at its discretion, require the development of a management plan to address the adverse impact created by the cold-water release;
(g) Maintaining low stream temperatures to the maximum extent practicable in basins where surface water temperatures are below the specific criteria identified in this rule shall be accomplished by implementing technology based permits, best management practices or other measures. Any measurable increase in surface water temperature resulting from anthropogenic activities in these basins shall be in accordance with the antidegradation policy contained in OAR 340-041-0026.
(12) Effluent Limitations for Bacteria: Except as allowed in subsection (c) of this section, upon NPDES permit renewal or issuance, or upon request for a permit modification by the permittee at an earlier date, effluent discharges to freshwaters, and estuarine waters other than shellfish growing waters shall not exceed a monthly log mean of 126 E. coli organisms per 100 ml. No single sample shall exceed 406 E. coli organisms per 100 ml. However, no violation will be found, for an exceedance if the permittee takes at least five consecutive re-samples at four-hour intervals beginning as soon as practicable (preferably within 28 hours) after the original sample was taken and the log mean of the five re-samples is less than or equal to 126 E. coli. The following conditions apply:
(a) If the Department finds that re-sampling within the timeframe outlined in this section would pose an undue hardship on a treatment facility, a more convenient schedule may be negotiated in the permit, provided that the permittee demonstrates that the sampling delay will result in no increase in the risk to water contact recreation in waters affected by the discharge;
(b) The in-stream criterion for chlorine listed in **Table 20** shall be met at all times outside the assigned mixing zone;
(c) For sewage treatment plants that are authorized to use reclaimed water pursuant to OAR Chapter 340, Division 55, and which also use a storage pond as a means to dechlorinate their effluent prior to discharge to public waters, effluent limitations for bacteria shall, upon request by the permittee, be based upon appropriate total coliform, limits as required by OAR Chapter 340, Division 55: For Level II limitations, no two consecutive samples shall exceed 240 total coliform per 100 ml and for Level III and Level IV limitations, no single sample shall exceeds 23 total coliform per 100 ml. However, no violation will be found for an exceedance under this paragraph if the permittee takes at least five consecutive re-samples at four hour intervals beginning as soon as practicable (preferably within 28 hours) after the original sample(s) were taken; and in the case of Level II effluent, the log mean of the five re-samples is less than or equal to 23 total coliform per 100 ml or, in the case of Level III and IV effluent, if the log mean of the five re-samples is less than or equal to 2.2 total coliform per 100 ml.
(13) Sewer Overflows in Winter: Domestic waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of November 1 through May

21, except during a storm event greater than the one-in-five-year, 24-hour duration storm. However, the following exceptions apply:
(a) The Commission may on a case-by-case basis approve a bacteria control management plan to be prepared by the permittee, for a basin or specified geographic area which describes hydrologic conditions under which the numeric bacteria criteria would be waived. These plans will identify the specific hydrologic conditions, identify the public notification and education processes that will be followed to inform the public about an event and the plan, describe the water quality assessment conducted to determine bacteria sources and loads associated with the specified hydrologic conditions, and describe the bacteria control program that is being implemented in the basin or specified geographic area for the identified sources;
(b) Facilities with separate sanitary and storm sewers existing on January 10, 1996, and which currently experience sanitary sewer overflows due to inflow and infiltration problems, shall submit an acceptable plan to the Department at the first permit renewal, which describes actions that will be taken to assure compliance with the discharge prohibition by January 1, 2010. Where discharges occur to a receiving stream with sensitive beneficial uses, the Department may negotiate a more aggressive schedule for discharge elimination;
(c) On a case-by-case basis, the beginning of winter may be defined as October 15 if the permittee so requests and demonstrates to the Department's satisfaction that the risk to beneficial uses, including water contact recreation, will not be increased due to the date change.
(14) Sewer Overflows in Summer: Domestic waste collection and treatment facilities are prohibited from discharging raw sewage to waters of the State during the period of May 22 through October 31, except during a storm event greater than the one-in-ten-year, 24-hour duration storm. The following exceptions apply:
(a) For facilities with combined sanitary and storm sewers, the Commission may on a case-by-case basis approve a bacteria control management plan such as that described in subsection (13)(a) of this rule;
(b) On a case-by-case basis, the beginning of summer may be defined as June 1 if the permittee so requests and demonstrates to the Department's satisfaction that the risk to beneficial uses, including water contact recreation, will not be increased due to the date change;
(c) For discharge sources whose permit identifies the beginning of summer as any date from May 22 through May 31: If the permittee demonstrates to the Department's satisfaction that an exceedance occurred between May 21 and June 1 because of a sewer overflow, and that no increase in risk to beneficial uses, including water contact recreation, occurred because of the exceedance, no violation shall be triggered if the storm associated with the overflow was greater than the one-in-five-year, 24-hour duration storm.
(15) Storm Sewers Systems Subject to Municipal NPDES Storm Water Permits: Best management practices shall be implemented for permitted storm sewers to control bacteria to the maximum extent practicable. In addition, a collection-system evaluation shall be performed prior to permit issuance or renewal so that illicit and cross connections are identified. Such connections shall be removed upon identification. A collection system evaluation is not required where the Department determines that illicit and cross connections are unlikely to exist.
(16) Storm Sewers Systems Not Subject to Municipal NPDES Storm Water Permits: A collection system evaluation shall be performed of non-permitted storm sewers by January 1, 2005, unless the Department determines that an evaluation is not necessary because illicit and cross connections are unlikely to exist. Illicit and cross-connections shall be removed upon identification.
(17) Water Quality Limited for Bacteria: In those waterbodies, or segments of waterbodies identified by the Department as exceeding the relevant numeric criteria for bacteria in the basin standards and designated as water-quality limited under Section 303(d) of the Clean Water Act, the requirements specified in OAR 340-041-0026(3)(a)(I) and in section (10) of this rule shall apply.
[ED. NOTE: The Table(s) referenced in this rule is not printed in the OAR Compilation. Copies are available from the agency.]
Stat. Auth.: ORS 468B.030 & ORS 468B.048
Stats. Implemented: ORS 468B.048

Hist.: DEQ 128, f. & ef. 1-21-77; DEQ 16-1992, f. & cert. ef. 8-7-92; DEQ 5-1996, f. & cert. ef. 3-7-96; DEQ 11-1997, f. & cert. ef. 6-11-97

SELECTED OREGON REVISED STATUTES

Available on the internet at: http://landru.leg.state.or.us/ors/468b.html

468B.005. Definitions for water pollution control laws

(3) "Pollution" or "water pollution" means such alteration of the physical, chemical or biological properties of any waters of the state, including change in temperature, taste, color, turbidity, silt or odor of the waters, or such discharge of any liquid, gaseous, solid, radioactive or other substance into any waters of the state, which will or tends to, either by itself or in connection with any other substance, create a public nuisance or which will or tends to render such waters harmful, detrimental or injurious to public health, safety or welfare, or to domestic, commercial, industrial, agricultural, recreational or other legitimate beneficial uses or to livestock, wildlife, fish or other aquatic life or the habitat thereof.
….
(7) "Wastes" means sewage, industrial wastes, and all other liquid, gaseous, solid, radioactive or other substances which will or may cause pollution or tend to cause pollution of any waters of the state.
(8) "Water" or "the waters of the state" include lakes, bays, ponds, impounding reservoirs, springs, wells, rivers, streams, creeks, estuaries, marshes, inlets, canals, the Pacific Ocean within the territorial limits of the State of Oregon and all other bodies of surface or underground waters, natural or artificial, inland or coastal, fresh or salt, public or private (except those private waters which do not combine or effect a junction with natural surface or underground waters), which are wholly or partially within or bordering the state or within its jurisdiction. [Formerly 449.075 and then 468.700]

468B.015. Policy

Whereas pollution of the waters of the state constitutes a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life and impairs domestic, agricultural, industrial, recreational and other legitimate beneficial uses of water, and whereas the problem of water pollution in this state is closely related to the problem of water pollution in adjoining states, it is hereby declared to be the public policy of the state:
(1) To conserve the waters of the state;
(2) To protect, maintain and improve the quality of the waters of the state for public water supplies, for the propagation of wildlife, fish and aquatic life and for domestic, agricultural, industrial, municipal, recreational and other legitimate beneficial uses;
(3) To provide that no waste be discharged into any waters of this state without first receiving the necessary treatment or other corrective action to protect the legitimate beneficial uses of such waters;
(4) To provide for the prevention, abatement and control of new or existing water pollution; and
(5) To cooperate with other agencies of the state, agencies of other states and the Federal Government in carrying out these objectives. [Formerly 449.077 and then 468.710]

468B.020 Prevention of pollution.

(1) Pollution of any of the waters of the state is declared to be not a reasonable or natural use of such waters and to be contrary to the public policy of the State of Oregon, as set forth in ORS 468B.015.
(2) In order to carry out the public policy set forth in ORS 468B.015, the Department of Environmental Quality shall take such action as is necessary for the prevention of new pollution and the abatement of existing pollution by:
(a) Fostering and encouraging the cooperation of the people, industry, cities and counties, in order to prevent, control and reduce pollution of the waters of the state; and
(b) Requiring the use of all available and reasonable methods necessary to achieve the purposes of ORS 468B.015 and to conform to the standards of water quality and purity established under ORS 468B.048. [Formerly 449.095 and then 468.715]

468B.025 Prohibited activities.

(1) Except as provided in ORS 468B.050 or 468B.053, no person shall:
(a) Cause pollution of any waters of the state or place or cause to be placed any wastes in a location where such wastes are likely to escape or be carried into the waters of the state by any means.
(b) Discharge any wastes into the waters of the state if the discharge reduces the quality of such waters below the water quality standards established by rule for such waters by the Environmental Quality Commission.
(2) No person shall violate the conditions of any waste discharge permit issued under ORS 468B.050.
(3) Violation of subsection (1) or (2) of this section is a public nuisance. [Formerly 449.079 and then 468.720; 1997 c.286 s.5]

APPENDIX D: WATER QUALITY MANAGEMENT PLAN (WQMP)

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INTRODUCTION

Clean Water Act, 303(d) List, TMDLs, and Implementation Strategy

Section 303(d) of the 1972 federal Clean Water Act (CWA) as amended requires states to develop a list of rivers, streams and lakes that cannot meet water quality standards without application of additional pollution controls beyond the existing requirements on industrial sources and sewage treatment plants. Waters that need this additional help are referred to as "water quality limited". Water Quality Limited waterbodies must be identified by the Environmental Protection Agency (EPA) or by a state agency which has been delegated this responsibility by the EPA. In Oregon, this responsibility rests with the Oregon Department of Environmental Quality (DEQ). The DEQ updates the list of water quality limited waters every two years. The list is referred to as the 303(d) list. Section 303 of the CWA further requires that Total Maximum Daily Loads (TMDLs) be developed for all waters on the 303(d) list. A TMDL defines the amount of pollution that can be present in the waterbody without causing water quality standards to be violated. The total amount of allowable pollution is then allocated among the background sources, point sources, non-point sources and the amount needed as a measure of safety. The point sources are given wasteload allocations (WLAs) and the non-point sources are given load allocations (LAs).

Along with a TMDL, a water quality management plan (WQMP) is developed that describes a strategy to meet the allocations detailed in the TMDL. This strategy must include actions that will result in reductions in contributions from non-point sources to the level of the load allocations (LAs) and for reducing discharges from point sources to the level of the waste load allocations (WLAs) prescribed in the TMDL. The WQMP/Implementation Plan must include specific information to meet both State of Oregon statutes/rules and federal requirements.

TMDL Implementation Strategy Guidance

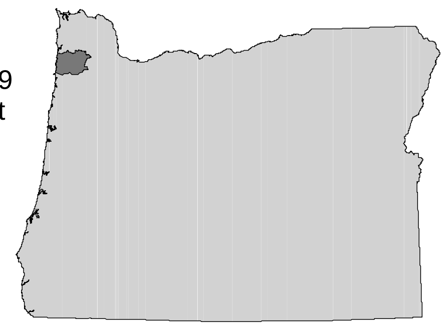
In November of 1997, DEQ issued a guidance document that described the basic elements needed in a TMDL Implementation Strategy. The elements are:

1. Condition Assessment
2. Goals and Objectives
3. Management Measures
4. Timeline for Implementation
5. Identification of Responsible Participants
6. Reasonable Assurance of Implementation
7. Monitoring and Evaluation
8. Public Involvement
9. Maintenance of Efforts over time
10. Costs and Funding
11. Legal Authorities to be Used
12. Estimate of the Time It Will Take to Meet Water Quality Standards
13. Milestones for Measuring Progress
14. Plans for Revising the TMDL if Progress is Not Being made

ELEMENT 1: CONDITION ASSESSMENT AND PROBLEM DESCRIPTION

Geographic Region of Interest

The Tillamook Bay Watershed is part of a coastal , temperate rainforest ecosystem west of Portland on the western slope of the Coast Range of Oregon. A typical year brings almost 90 inches (229 cm) of rainfall in the lower basin and close to 200 inches (510 cm) at higher elevations. The mean annual temperature is 50.4 °F (10.2 °C), with yearly mean maximum and mean minimum temperatures of 59.3 ° F (15.2 °C) and 41.6 °F (5.3 °C), respectively (reference). The soils are deep, fine textured, typically acid (pH 5.0 to 5.5), and high in organic matter (15-20%). Five rivers flow into Tillamook Bay. These rivers are the Tillamook, Trask, Wilson, Kilchis, and Miami. The five rivers drain a 560 square mile (1,450 square kilometer) watershed.



Location of Tillamook Bay Watershed. HUC 17100203.

The upper watershed originates in the high, steep ridges of the Coast Range at elevations reaching 3,500 feet (approximately 1100 m). The uplands support coniferous forests of douglas fir, true fir, spruce, cedar, and hemlock, and covering approximately 89% of the total area. Hardwood species such as alder and maple also grow throughout the region, especially as second growth in riparian areas. Understory vegetation is generally composed of a dense growth of shrubs, herbs, ferns, and cryptogams.

The lower watershed is composed of rich alluvial plains used primarily for dairy agriculture. The basin includes approximately 40 sq.miles (104 sq. km) of lowlands that support approximately 28,600 dairy cattle (TBNEP 1998). Once characterized by meandering rivers and networks of small channels that provided fish habitat, woody debris, and organic matter, the lowlands have been modified by dikes, levees, channels, tide gates, and riprap.

Tillamook Bay is a small, shallow estuary between the watershed and the Pacific Ocean. Approximately 6.2 miles (10 kilometers) long and 2.1 miles (3.4 kilometers) wide, the Bay averages only 6.6 feet (2 meters) in depth over a total area of 13 square miles (34 square kilometers), or 8,400 acres (3,400 hectares). At low tide, approximately 50% of the Estuary bottom is exposed as intertidal mud flats. Several deep channels, running roughly north to south, represent the geological signatures of river mouths drowned by the rising Pacific Ocean about 9,000 years ago.

The Bay receives fresh water input from five rivers and exchanges ocean water through a single channel in the Northwest corner. Despite large freshwater inflows, especially during the winter months, heavy tidal fluxes dominate the system; extreme diurnal tides can reach 13.5 feet (4.1 meters), with a mean tidal range of 5.6 feet (1.7 meters) and diurnal range of 7.5 feet (2.3 meters). Tidal effects extend various distances up the rivers, ranging from 0.4 miles (0.6 kilometers) for the Miami River, to 6.8 miles (11 kilometers) for the Tillamook River (Komar 1997). The Bay experiences the full range of estuarine circulation patterns, from well-stratified to well-mixed, depending on the season and variations in river discharge. During rainy winter months, November through March, researchers describe a stratified system, but during low-precipitation summer months, the Bay shifts to a well-mixed estuarine system (Camber 1997). Salinity ranges from approximately 32 ppt near the ocean entrance to 0 ppt at the upper (Southern) end of the Bay near the river mouths depending on location in the Bay, time of year, and rainfall conditions.

Water temperatures range from 47-66 °F (8-19 °C) over the year. The Estuary maintains relatively high levels of dissolved oxygen (DO) throughout the year, ranging from about 6.0 mg/L to 12.0 mg/L. Eutrophication and low DO concentrations do not appear to be problems for Tillamook Bay, although adjacent sloughs that are controlled by dikes and tide gates are poorly mixed. However, the Bay experiences high concentrations of bacteria, especially during and after storms that result in agricultural and urban runoff, and point source overflows. Most observers identify upland sediments as the primary source of current sediment load to the Bay. Forestry practices, road building, forest fires, and landslides are considered to be the major sediment contributors to the Bay. Smaller amounts of sediment come from lowland areas, mostly from eroding or unstable river banks (Komar 1997).

The estuary provides habitat for numerous fish, shellfish, crabs, birds, seals, and sea grasses. A 1973 survey identified 53 species of fish in the Bay at various times of the year. Five species of anadromous salmonids use the estuary at some point in their life cycle. A prolific benthic community includes rich clam beds, oyster beds, and dense areas of eelgrass. Oysters are harvested commercially, and dungeness crabs and clams provide an important recreational opportunity. Marine mammals also use the bay for resting, feeding, and pupping.

Oysters have been grown commercially in Tillamook Bay since the 1930s. Tillamook Bay has been one of the leading oyster producing bays in Oregon with an average annual production of about 21,200 shucked gallons during the 1970s and 1980s. Beginning in 1990, the level of production dropped off sharply and has remained low due to reduced production by several Oyster Companies. Problems with oyster production have been associated with business closures, bacterial contamination, flooding, siltation and burrowing shrimp.

Twelve species of bay clams are found in Tillamook Bay. Gaper, cockle, butter and native littleneck clams are the most important commercially and recreationally. The basin also supports a wide variety of water contact recreation that includes swimming, wading, fishing and boating. Both water contact recreation and shellfish harvesting are compromised by bacterial contamination of water.

Current Conditions

There are numerous assessment studies either completed or underway within the Tillamook Bay Watershed. These are: Tillamook Bay National Estuary Project, Comprehensive Conservation Management Plan (TBNEP 1999-complete); Kilchis River Assessment (TBNEP 1998-complete); Trask River Assessment (TBNEP 1998-complete); Miami and Wilson Rivers Assessments (TCPP-underway); and Tillamook Bay Basin Water Quality Technical Assessments for Temperature and Bacteria (DEQ 1999). The basin is commonly considered in three distinct zones; Upland, Lowland, and Estuarine habitats.

Upper Watershed Habitat

Tillamook County's forestlands have provided timber for wood products industries since the 1880s. By 1894, the timber industry was the most important industry in the County (Levesque 1985). Large-scale logging began in the 1900s with little or no effort to reforest cleared lands.

The Tillamook Burn forest fires from 1933-1951, profoundly affected the use of forestlands in the region. The fires killed most (approximately 200,000 acres) of the old-growth timber in the Trask and Wilson River Watersheds, burning some areas repeatedly. Roads were built for salvage logging, fire protection, and replanting (Levesque 1985). Reforestation of the burned acreage began in 1949. Since salvage logging ended in 1959, timber harvesting in the Tillamook Burn area, now the Tillamook State Forest, has been largely limited to commercial thinning. However, remaining private timberlands have been intensively cut (300 million board feet) in the past 10 years (Labhart. pers. com. 1997).

The Tillamook Burn forest fires contributed to a relatively high sediment load during the mid-20th Century. The fires likely increased surface erosion and were documented to have triggered many debris flows. Moreover, massive salvage logging after the fires left a legacy of poor quality logging roads and skid trails. These changed the frequency and composition of landslides, reducing the supply of large wood, and continue to supply excessive upland sediment. Many of these legacy forest roads have poorly designed culverts and road crossings, blocking fish passage (Mills 1997).

Lowland/floodplain Habitat

Agriculture and urban development in the lowland floodplains altered riparian and instream habitats vital to salmon and other aquatic species. Historically, bottomland forest and open grasslands covered a rich alluvial plain that regularly flooded in winter. Off-channel sloughs, oxbows, and wetlands in these lowland floodplain's provided ample habitat for rearing fish. A forest of mixed hardwoods and conifers supplied organic matter and insects to feed fish and support the aquatic food chain, Large log jams in the main rivers led to frequent seasonal flooding in floodplains, regularly depositing sediments to lowland areas and providing large areas of salmon habitat. Large wood deposition also created scour pools in the mainstream channels.

Early settlers cut down riparian trees to expedite log drives and cleared logjams in the main rivers to reduce flooding and improve navigation. In the early 1900s, loggers used splash dams to move logs downstream and subsequently damaged instream and riparian habitat in several river reaches. Prior to the early 1980s, ODFW policy was to clear streams and rivers of large wood to enhance fish passage. Such activities, as well as urban development, expansion of impervious surfaces, and other land changes, has caused changes in the hydrograph, sediment routing and disposition, and channel complexity.

The basin has lost most of its floodplain and lowland wetlands. Much of the landscape has been diked, ditched, filled, drained, and cleared, with poorly designed tide gates and culverts cutting off fish access to the remaining wetland habitat. Instream habitats have been channelized, straightened, riprapped, and mined for gravel. Most lowland riparian areas have been cleared of vegetation, except brush and grass. Livestock have direct access to streambanks and streams in some locations, resulting in crumbling streambanks, trampled vegetation, and disturbed streambeds. Livestock in and adjacent to streams also pollute the water with bacteria.

Estuarine Habitat

Fish and shellfish were historically plentiful in Tillamook Bay and early residents quickly established a commercial fishing industry. Commercial gillnet fishing in the Bay began in the late 1800s. Fish hatcheries were established in the early 1900s, with the Trask river hatchery in operation since 1914 (Coulton et al. 1996). Shellfish harvests before the 1960s were rarely documented, but Tillamook Bay has long been a major clam and oyster producer. Oysters are not native to the Bay, but were planted in the Bay in 1928. Tillamook Bay currently produces about 60% of Oregon's clam harvest.

Dredging and channel control, large wood removal, sedimentation, and the breach of Bayocean Spit have changed the Bay's bathymetry and reduced its complexity. Tidal sloughs were adversely impacted by adding tide gates, filling channels, and disrupting hydrologic connectivity in the floodplain and wetlands.

Existing Sources of Water Pollution

Parts of all the rivers that flow into Tillamook Bay and several tributaries are currently listed as impaired under section 303(d) of the Clean Water Act, resulting from excessive stream temperatures and elevated levels of bacteria.

Bacteria

Tillamook Bay has a long history of bacteria pollution problems (Blair and Michner 1962, Jackson and Glendening 1982, Musselman 1986, TBNEP 1998, DEQ 1994-1999). Bacteria concentrations in the Bay have historically been high during the wet seasons of the year: fall, winter, and early spring. Due to the Bay's unpredictable water quality, the proximity of five wastewater treatment plants, and many non-point sources of bacteria, oyster culture is allowed only in specified areas of the Bay, and harvesting is allowed only under conditions identified in the Shellfish Management Plan for Tillamook Bay (ODA 1991). Elevated bacterial concentrations or the assumption of high concentrations associated with high river flows often close harvesting in Tillamook Bay.

Elevated concentrations of bacteria are also found in all 5 major rivers and many streams throughout the Basin. Figure 62 displays the waters on the 303(d) list for elevated bacteria levels. Table 36 lists the water quality limited stream segments for bacteria. Major sources include dairy and other livestock operations, onsite septic systems for rural residential homes, runoff from industrial and municipal facilities, municipal and private wastewater treatment plants (Appendix B), urban storm runoff, and both domestic and wild animals.

Parameter	**Description**
Bacteria in Shellfish Waters Marine Waters and Estuarine Shellfish Growing Waters: OAR 340-41-205 (2)(e)(A)(ii) and OAR 603-100-0010:	A fecal coliform median concentration of 14 organisms per 100 ml, with not more than ten percent of the samples exceeding 43 organisms per 100 ml. Fecal coliform median or geometric mean MPN of the water sample results shall not exceed 14 per 100 ml, and not more than 10% of the samples shall exceed 43 colonies per 100 ml for a 5 tube decimal dilution test. A minimum of the most recent 15 samples collected under adverse pollution conditions from each sample station shall be used to calculate the median or geometric mean and percentage to determine compliance with this standard.
Recreational Contact in Water OAR 340-41-205 (2)(e)(A)(i):	Prior to March 1996: a geometric mean of five fecal coliform samples should not exceed 200 colonies per 100 ml, and no more than 10% should exceed 400 colonies per 100 ml. Effective March 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.

Temperature

Parts of all 5 major rivers and several of the tributaries are listed as impaired under the section 303(d) of the Clean Water Act resulting from excessive summer stream temperatures. Figure 7 displays the waters on the 303(d) list. Table 36 lists the water quality limited streams for temperature. These excessive temperatures directly affect the survival and reproduction of salmonid fish and may have a number of indirect impacts (e.g.,dissolved oxygen depression) that also affect fish.

Stream temperature is an expression of heat energy per unit volume. In the absence of a heated point source discharges, humans influence stream temperatures when land management activities cause in increase in the amount of solar radiation reaching and warming the stream. The pollutant source is solar energy. In general, many of the impairments in the basin are the result of the loss of riparian habitat. Healthy riparian areas provide direct shading from sun light, and maintain the integrity of the banks, reducing erosion that ultimately results in the widening and shallowing of streams.

Tillamook Bay Watershed Temperature Standard - OAR 340-041-202(2)(b)(A)(i-viii)

To accomplish the goals identified in OAR 340-041-120(11), unless specifically allowed under a DEQ-approved surface water temperature management plan as required under OAR 340-041-026(3)(a)(D), no measurable surface water temperature increase resulting from anthropogenic activities is allowed:

(ix) In a basin for which salmonid fish rearing is a designated beneficial use, and in which surface water temperatures exceed 64.0°F (17.8°C);
(x) In the Columbia River or its associated sloughs and channels from the mouth to river mile 309 when surface waters exceed 68.0°F (20.0°C);
(xi) In waters and periods of the year determined by DEQ to support native salmonid spawning, egg incubation, and fry emergence from the egg and from the gravels in a basin which exceeds 55.0°F (12.8°C);
(xii) In waters determined by DEQ to support or to be necessary to maintain the viability of native Oregon bull trout, when surface water temperatures exceed 50.0°F (10.0°C);
(xiii) In waters determined by DEQ to be ecologically significant cold-water refugia;
(xiv) In stream segments containing federally listed Threatened and Endangered species if the increase would impair the biological integrity of the Threatened and Endangered population;
(xv) In Oregon waters when the dissolved oxygen (DO) levels are within 0.5 mg/l or 10 percent saturation of the water column or intergravel DO criterion for a given stream reach or Basin; and
(xvi) In natural lakes.

Beneficial Uses, Water Quality Standards and Criteria, and 303(d) List

The Oregon DEQ's water quality program is designed to protect designated beneficial uses of the State's waters. The designated uses of the waters of the Tillamook Bay Watershed (Table 37) are identified in the Oregon Administrative Rules (OAR) at 340-41-202.

Table 36. Beneficial Uses Occurring in the Tillamook Basin *(OAR 340-41-202)*

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

Oregon's 1998 303(d) List of Water Quality Limited Waterbodies identifies temperature and bacteria as the two parameters most clearly related to water quality impairment in the Tillamook Bay Watershed. These impairments are documented throughout the Watershed. The beneficial uses most at risk in the Tillamook Bay Watershed are:

- fishing- bacteria in shellfish waters. (OAR 340-41-205(2)(e)(A)(ii);
- recreational contact in water. (OAR-340-41-205(2)(e)(A)(I), and;
- water temperature for salmonid spawning, migration, and rearing.(OAR-340-205-(2)(b)(A);

Fifteen river reaches in the basin are listed under Section 303(d) for bacterial impairment (Figure 62) and 12 are listed for temperature impairment (Figure 63). Table 36 lists the water quality limited streams for temperature and bacteria.

Figure 62. Tillamook Basin Land Ownership and 1998 303(d) Listings for Temperature

1998 303(d) Water Quality Limited Streams -Bacteria

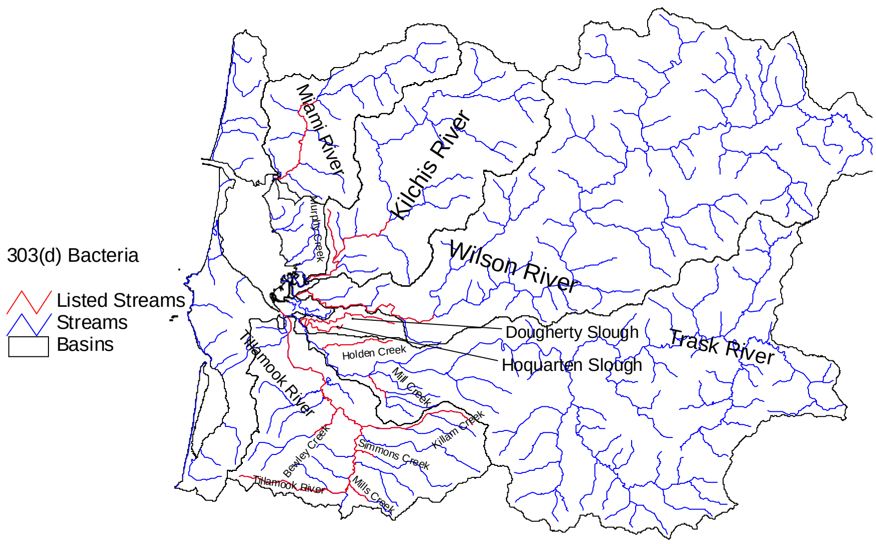


Figure 63. Tillamook Basin Land Ownership and 1998 303(d) Listings for Temperature

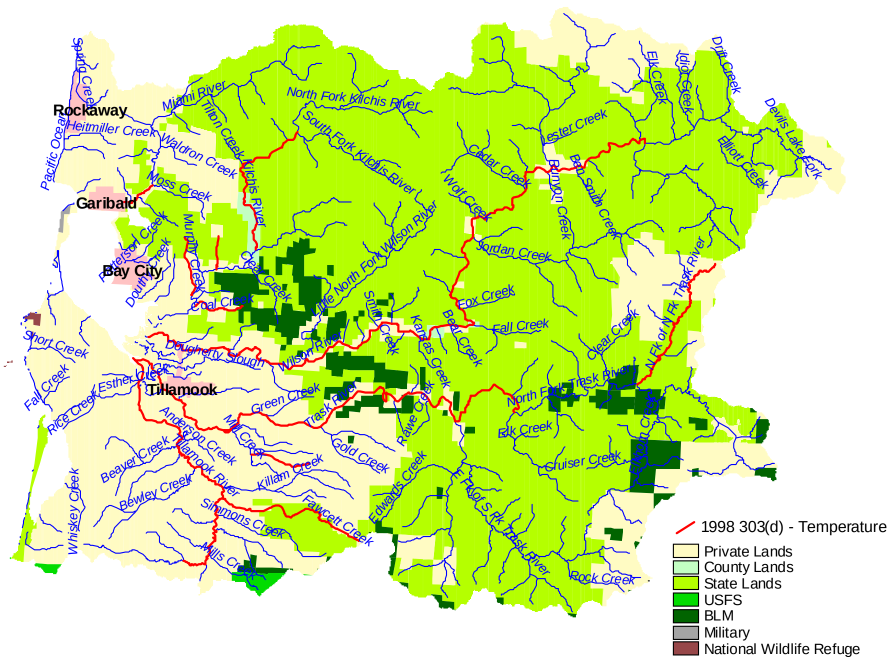


Table 37. 1998 303(d) Temperature and Bacteria Limited Waterbodies	
Parameter	**Stream Segment**
Temperature	• Kilchis River (Mouth to headwaters) • Miami River (Mouth to Moss Creek) • Tillamook River (Mouth to Yellow Fir) • Trask River (Mouth to S.F. Trask River) • Wilson River (Mouth to headwaters) • Coal Creek (Mouth to headwaters) • Fawcett Creek (Mouth to headwaters) • Mill Creek (Mouth to headwaters) • Murphy Creek (Mouth to headwaters) • Myrtle Creek (Mouth to headwaters) • Trask River, North Fork (Mouth to Bark Shanty Creek) • Trask River, North Fork of North Fork (Mouth to headwaters)
Time Period: **OAR 340-41-205(2)(b)(A)**	• Rearing: June 1 through September 30 • Spawning Through Fry Emergence: October 1 through May 31 or waterbody specified as identified by ODFW biologist.
Supporting Data:	• ODEQ (1997 – 1998) • NRCS (1992 – 1994)
Bacteria	• Bewley Creek: mouth to RM 2 • Dougherty Slough: mouth to headwaters • Holden Creek: mouth to headwaters • Hoquarton Slough: mouth to headwaters • Kilchis River: mouth to little South fork Kilchis River • Killam Creek: mouth to headwaters • Miami River: mouth to Stuart Creek • Mill Creek (Trask River tributary): Mouth to RM 3 • Mills Creek (mouth to USFS boundary)

	• Murphy Creek: mouth to headwaters • Simmons Creek: Mouth to 0.5 Mile above highway 101 • Tillamook Bay Main: marker No.19 to South Bay • Tillamook Bay Upper: Southeast Bay to Dick Point • Tillamook River: mouth to headwaters • Wilson River: mouth to Little North Fork Wilson River
Time Period: **OAR 340-41-205(2)(e)(A)**	• Year around in Bay • Fall-Winter-Spring; Summer for River Reaches
Supporting Data:	• ODEQ (1960 – 1998) • TBNEP (1997 – 1998)

ELEMENT 2: GOALS AND OBJECTIVES

The overall goal of the TMDL Implementation plan is to achieve compliance with water quality standards for each of the 303(d) listed parameters and streams in the Tillamook Bay Watershed. Sediment, though not identified on the 303(d) list, is also a parameter of concern. The specific goal of this implementation plan is to describe a strategy for reducing discharges from non-point sources to the level of the load allocations (LAs) and for reducing discharges from point sources to the level of the waste load allocations (WLAs) prescribed in the TMDL. This WQMP is designed to be adaptive as more information and knowledge is gained regarding the pollutants, allocations, management measures, and other related areas.

The goals and actions described are directly related to the Tillamook Bay National Estuary Project (TBNEP) Comprehensive Conservation Management Plan (CCMP) adopted in 1999. The CCMP was developed by the TBNEP Management Committee composed of representatives of local government, state and federal agencies, and individual citizens. Many actions discussed in this plan address sediment/erosion issues. Although streams in the basin are not listed for sediment/erosion, there are concerns about sediment loads and degraded streams from their effects.

Goal 1: **Promote Beneficial Uses of the Bay and Rivers**

Objectives: **Achieve water quality standards for bacteria in the rivers and Bay by 2010.**

Document at least a 25% reduction in bacteria loads to rivers, apparent trends by 2005.

Achieve at least a 25% reduction every four years in the number of days that the rivers are not in compliance with water quality standards for bacteria based on 1997-1998 monitoring results.

Achieve compliance with rules developed under SB1010 Agricultural Water Quality Management Area Plan by 2010.

Inspect all CAFOs by 2004. This objective has been achieved by ODA's CAFO Program.

Goal 2: **Reduce Instream Temperatures to Meet Salmonid Requirements**

Objectives: **Achieve instream temperatures that meet salmonid requirements by 2010.**

Goal 3: **Reduce Instream Sediment to Meet Salmonid Requirements**

Objectives: **Achieve instream sediment loads that meet salmonid requirements by 2010.**

ELEMENT 3: MANAGEMENT MEASURES

Management measures described here are those that will result in meeting the stated goals presented in Element 2. Some measures are mandatory and required as a condition of permits (e.g., wastewater discharges) or other legal requirements (e.g., Forest Practices Act). Others are measures that groups of Stakeholders in the Tillamook Basin have indicated are appropriate and feasible. Measures that were developed through a public process (TBNEP) with broad stakeholder participation are presented in detail in Appendix D-1.

A variety of state and federal laws and rules have been identified as critical in controlling discharge of pollutants to waters of the state and of the United States. These are:

- Clean Water Act section 303(d) as administered by the EPA/DEQ sets load allocations;
- NPDES and WPCF permit programs as administered by the DEQ addresses point source discharges;
- SB 1010 as administered by the ODA addresses agriculture practices;
- Oregon Forest Protection Act as administered by the ODF addresses forest practices; and
- Local zoning and ordinances to address urban activities.

Point Sources

Point sources of bacteria and heat originate with a variety of land uses, but are mostly associated with treated wastewater discharges operated by municipalities or industries, and with urban stormwater runoff. There are six NPDES-permitted wastewater discharges in the Watershed. The City of Tillamook and Port of Tillamook Bay each discharge treated effluent to the Trask River at river miles 1.9 and 5.2, respectively. The Tillamook County Creamery Association and Pacific Campground discharge treated effluent to the Wilson River at river mile 2. Bay City and the City of Garibaldi discharge treated effluent directly to Tillamook Bay. Bacterial contamination from these discharges will continue to be controlled through the conditions of the dischargers' permits. Depending on Wasteload Allocations developed and published in the TMDL, these permits will become more stringent upon renewal. These discharges are described more fully in **Appendix D-2**.

Current NPDES Discharge Limits for Point Sources in the Tillamook Bay Watershed

Facility Name	Discharge Point	Permit Limits
Port of Tillamook Bay	Trask River at RM 5.2	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
City of Tillamook	Trask River at RM 1.9	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
City of Bay City	Tillamook Bay	Monthly geometric mean of 80 /100 ml Weekly geometric mean of 160 /100 ml
City of Garibaldi	Tillamook Bay	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
Pacific Campground[18]	Smith Creek →Boquist Slough→Wilson River	Monthly geometric mean of 200 /100 ml Weekly geometric mean of 400 /100 ml
TCCA	Wilson River RM 1.7	Monthly geometric mean of 200 /100 ml No more than 10% of monthly samples > 400 /100 ml

There are also 15 permitted facilities that discharge stormwater or process waters to rivers or the Bay. Each of these facilities has one or more general permits covering the specific discharge activity. These include stormwater from facilities, gravel-mining operations, fish hatcheries, and seafood processing. There is some monitoring associated with these permits, which may be revised when the permits are renewed.

Permittee	Type of Operation	Permit Type
Tillamook Lumber Co.	Pulp and Paper	GEN12Z
Tillamook Co. Landfill	Miscellaneous	GEN17/GEN12Z
Northwest Hardwoods	Wood Products	GEN12Z
Merrill Auto Wrecking, Inc.	Miscellaneous	GEN12Z
Alice's Country House	Domestic Waste Treatment	GEN56
Pacific Coast Timber Co.	Gravel Mining/Processing	GEN12A
Coast Wide Ready Mix	Gravel Mining/Processing	GEN10
Pacific Coast Seafoods Co.	Seafood Processing	GEN09
East Fork Trask Pond – Hatchery	Fish Hatching and Rearing	GEN03
Trask River Hatchery	Fish Hatching and Rearing	GEN03
Tillamook Industrial Park	Domestic Waste Treatment Fac.	GEN12Z
Smith's Pacific Shrimp Co.	Seafood Processing	GEN09
Tillamook STP	Domestic Waste Treatment Fac.	Term.
Tillamook Creamery	Milk Products Processing	GEN12Z
S-C Paving Co.	Gravel Mining/Processing	GEN12A

[18] Model resolution not detailed enough to identify sources to mainstem.

The Department will work with county, municipal and special district agencies to develop surface water temperature management plans and to complete a storm sewer system evaluation by January 1, 2005. In addition, it will explore requiring municipalities that discharge urban runoff to rivers or the Bay to obtain permits. Although stormwater is diffuse in origin, it becomes a point source when it is conveyed and discharged to receiving streams. These permits may be for individual city and county facilities, or a regional permit may be issued if the individual governments can develop the necessary agreements on overall management strategies. General NPDES permits for stormwater require development of specific stormwater management plans. These plans must specify management practices that will be used to control the discharge of pollutants to the rivers and Bay and meet the Wasteload Allocations of the TMDL.

Individual permits for point sources requiring thermal load allocation permits will be modified or a new permit written within one year of the issuance of the TMDL. The permit will incorporate time schedules for implementation of the WLA through the Temperature Management Plans in the permit.

Individual permits for point sources requiring modification to bacterial limits will be modified or re-written within one year of the issuance of the TMDL. Permits must require compliance within the life of the permit, and the bacteria levels must be achieved as soon as possible. Interim compliance steps must not exceed: an evaluation and selection of strategies within three years of permit issuance; the engineering and design within four years, and compliance within five years.

For general permits, the Department will require, and will request by letter, bacteria and/or temperature monitoring from sources as needed to determine if there is reasonable potential for discharge to contribute to water quality standard violations within one year of the issuance of the TMDL. Additional monitoring required by this TMDL may occur for as long as three years after the issuance of the TMDL.

For stormwater sources, the bacteria allocation is the unit area concentration as defined in Table 15 of the TMDL. Stormwater sources may be required to update stormwater plans to assure the discharge does not contribute to water quality standard violations within three years of issuance of the TMDL and implement updated stormwater plans within four years of the issuance of the TMDLs.

Non stormwater sources with general permits that contribute pollutants to receiving streams must either demonstrate they have developed an implementation strategy to assure they do not contribute to standards violations within three years of the issuance of the TMDL, or applied for an individual permit within three years of the permit unless the Department develops basin specific general permits.

Management Measures

Additional management measures were developed by the TBNEP and were compiled in the Comprehensive Conservation and Management Plan (See Appendix D-1 for details).

Point Source Management Measures -- Bacteria

- ***Ensure adequate urban runoff treatment and retention***

- Effectively enforce laws and regulations
- Expand sewer network
- Develop system to ensure detection and elimination of illegal discharge activities
- Ensure that runoff from construction sites is contained

- Ensure that runoff from general road maintenance is contained

Point Source Management Measures -- Temperature

- Permit compliance will be the method of ensuring point sources meet Wasteload Allocations.
- Effectively Enforce Laws and Regulations

Non-Point Sources

Non-Point Sources of bacterial contamination and heating (temperature) are associated with large-scale land management practices. The sources include urban, rural residential , agricultural, and forestry uses. Elevated levels of bacteria are found in the Bay, all of the rivers flowing into the Bay, and many tributary streams throughout the basin. Major sources include dairy and other livestock operations, onsite septic systems for rural residential homes, runoff from industrial and municipal facilities, urban runoff, and both domestic and wild animals.
Instream temperature increase is associated with loss of riparian shade resulting from all of these land uses as well as forestry practices.

Agriculture

Many of the improvements in water quality are expected to occur as a result of implementation of the SB1010 Agricultural Water Quality Management Area Plan (AWQMAP) for the North Coast Basin. Generally the issues associated with agriculture are diffuse, or non-point sources rather than point sources. This plan (described more fully in Element 11) defines conditions that agricultural practices must allow to develop or are not allowed to cause. A regulatory backstop is provided by enforceable rules. The plan addresses riparian and streambank conditions, livestock access to surface waters, manure and nutrient management, among other issues.

One of the key elements of this planning process is the assumption that individual voluntary farm plans will be developed by a large percentage of the landowners in the watershed in concert with local agency (e.g., NRCS, SWCD) personnel. These farm plans would define the range of practices that individual landowners would use to ensure that their operations attain the proper conditions. Through development of the individual voluntary farm plans, landowners would use their personal experience, along with judgment of professionals in determining what practices will be most effective in limiting pollutant effects from their land.

Pollution Prevention and Control Measures for Agriculture (SB1010 – AWQMAP)

Bacteria --
- Healthy Riparian and Streambank Condition
- Livestock and Grazing Management
- Manure and Nutrient Management

Temperature
- Heathy Riparian and Streambank Condition
- Tidegates
- Livestock and Grazing Management

Other Management Measures Identified for Temperature and Bacteria (CCMP – Appendix A)
- Define, Implement, and Enforce Pollution Prevention and Control Measures on Agriculture Lands.
- Implement Voluntary Farm Management Plans.
- Implement Revised Confined Animal Feeding Operation (CAFO) Inspection Procedure
- Use Farm-Specific Agronomic Rates for Nutrient Management

- Provide Farm/Livestock Management Training Programs
- Identify Stream Segments Where Heating Occurs
- Assess and Map Riparian and Wetland Habitat
- Characterize riparian and Instream Habitat

- Increase Incentive Program Payments

- Encourage Protection and Enhancement on Private Lands
- Control Livestock Access to Streams
- Prioritize Floodplain/Lowland Protection and Enhancement Sites
- Protect and Enhance Lowland Riparian Areas
- Protect and Enhance Freshwater Wetland Habitat
- Revise Local Ordinances to Increase Protection of Riparian Areas,
- Wetlands, and Instream Habitat
- Remove or Modify Ineffective Tide Gates and Culverts
- Reconnect Sloughs and Rivers to Improve Water Flow

Forestry

Forestry practices are governed by the State of Oregon's Forest Practices Act (FPA). The FPA defines specific measures for protecting water quality and habitat during forestry operations. These measures include leaving trees within certain distances of streambanks depending on the type of stream and occurrence of fish. These trees and understory vegetation are intended to provide a buffer between logged areas and the stream, providing shade, woody debris, filtration of sediments from overland flow, and erosion control. The FPA is the governing law on all state forest and private land.

In addition to the FPA, the Tillamook State Forest (TSF) is developing a Habitat Conservation Plan (HCP) for management of its forests. A comparison of the FPA rules and proposed HCP practices is presented in Appendix C. The HCP is the mechanism used for protection of a variety of rare, threatened and endangered species that live in and on State Forest land. Although the HCP is being developed to protect habitat for endangered species, there will be direct benefits to water quality if it is implemented. Some of the principal improvements of the HCP relative to FPA regulations are:

- Increased widths of riparian vegetative buffers;
- Management for Mature Forest Condition in Streambank Zone;
- Increased density of trees within the Riparian Management Zones;
- Protection on non-fish-bearing streams as well as fish-bearing streams.

All of these measures will be effective in moderating temperature in forested areas where they are applied. Compliance with the HCP will be determined by ODF and will not be required outside the TSF. Logging within the TSF will follow HCP if it is approved by the Federal Government. Compliance by any private landowners will be on a voluntary basis.

Ordinances

Tillamook County and the cities of Tillamook, Bay City, and Garibaldi are responsible for the development of local ordinances designed to control NPS water quality pollution in urban and rural residential areas. Specific ordinances identified to date are:

- Riparian protection ordinance (existing and under review);
- Freshwater wetlands protection ordinance;
- Intertidal wetlands protection ordinance; and
- Stormwater abatement ordinance.

ELEMENT 4: TIMELINE FOR IMPLEMENTATION

The purpose of this element is to provide a chronological list of actions that will take place during the implementation of this plan. Each of these Action Items are discussed in detail in the Management Measures element. The table below lists the action to be completed and the completion date. Many actions are ongoing. They do not have completion dates but will continue to be implemented throughout the life of the plan.

Table 38. Goal I: Promote Beneficial Uses of the Bay and Rivers.

ACTION	Year of Completion										
Non-Point Sources	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Action 1: Define implement, Enforce pollution control measures on Agricultural land	■	■	■	■	■	■	■	■	■	■	■
Action 2: Implement Voluntary Farm Management Plans	■	■	■	■	■	■	■	■	■	■	■
Action 3: Implement Revised CAFO Inspection procedures.	**Accomplished in 2000**	■	■	■	■						
Action 4: Use Farm-Specific Agronomic Rates for Nutrient Management.	■	■	■	■	■	■					
Action 5:Provide Farm Management Training.	■	■	■	■							
Action 6: Control Livestock Access to stream	■	■	■	■	■	■	■	■	■	■	■
Action 7: Encourage Protection/Enhancement on Private Lands.	■	■									
Action 8: Characterize Riparian and Wetland Habitat.	■	■									
Action 9: Assess and Map Riparian and Wetland Habitats.	■	■									
Action 10: Prioritize Floodplain/Lowland.	■	■									
Action 11: Protect/Enhance Lowland Protection/Enhancement Sites.	■	■	■	■	■	■	■	■	■	■	■
Action 12: Protect/Enhance Freshwater Wetland Habitat.	■	■	■	■	■	■	■	■	■	■	■
Action 13: Revise Local Ordinances to Increase Protection of Riparian and Wetland Habitat.	■	■									
Action 14: Enforce Laws and Regulations.	■	■	■	■	■	■	■	■	■	■	■
Action 15: Characterize Estuarine and Tidal Habitat.	■	■									
Action 16: Prioritize Tidal Sites for Restorations.	■	■									
Action 17: Protect and Enhance Tidal Marsh.	■	■	■	■	■	■	■	■	■	■	■
Action 18: Remove/Modify Ineffective Tidegates.	■	■	■	■	■						
Action 19: Reconnect Sloughs and Rivers to Improve Water Flow.	■	■	■	■	■	■	■	■	■	■	■
Point Sources											
Action 1: Expand Sewer Network.	■	■	■	■	■						
Action 2: Ensure Adequate Urban Runoff Treatment and Retention.	■	■	■	■	■	■	■	■	■	■	■
Action 3: Ensure Properly Functioning On-Site Sewage Disposal Systems.	■	■	■	■	■	■	■	■	■	■	■

Goal II: Reduce Instream Temperatures to Meet Salmonid Requirements.

ACTION **Non-Point Sources**	**Year of Completion** **2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Action 1: Identify Stream Segments where heating occurs.	■	■									
Action 2: Analyze Instream Flows	■	■	■								
Action 3: Characterize Riparian Habitat	■	■									
Action 4: Assess and Map Riparian Habitat	■	■									
Action 5: Prioritize Upland Riparian Protection/Enhancement Sites	■	■									
Action 6: Protect/Enhance Upland Riparian Areas	■	■	■	■	■	■	■	■	■	■	■
Action 7: Protect/Enhance Lowland Riparian Areas	■	■	■	■	■	■	■	■	■	■	■
Action 8: Exclude Livestock Access to Streams.	■	■	■	■	■	■	■	■	■	■	■
Action 9: Encourage Protection/ Enhancement on Private Lands.	■	■									
Action 10: Ensure Minimum Streamflows.	■	■	■	■	■	■	■	■	■	■	■
Action 11: Remove Ineffective Tide Gates	■	■	■	■							
Action 12: Reconnect Sloughs and Rivers to Improve Water Flow	■	■	■	■	■	■	■	■	■	■	■

ELEMENT 5: IDENTIFICATION OF RESPONSIBLE PARTICIPANTS

The purpose of this element of the Tillamook Bay Watershed TMDL Implementation Strategy is to identify the lead organizations responsible for the implementation strategy and to list the major responsibilities of each organization. This list is restricted to governmental organizations, and as such does not reflect the important contributions of private organizations (e.g., Tillamook County Creamery Association) who, though they have no legal obligation, have contributed to restoration efforts in the basin.

Tillamook County:

Review/Revise/Adopt Relevant Ordinances;
Encourage Protection/Enhancement On Private Lands;
Assess and Map Riparian and Wetland Habitat;
Prioritize Floodplain/Lowland Protection/Enhancement Sites;
Reconnect Sloughs and Rivers to Improve Water Flow;
Expand Sewer Network;
Ensure Adequate Urban Runoff Treatment and Retention;
Ensure Properly Functioning On-Site Sewage Disposal Systems;
ProvideTechnical Assistance;
Provide Funding for Habitat Protection/Enhancement Projects.

Tillamook County Performance Partnerships:

Encourage Protection/Enhancement On Private Lands;
Characterize Riparian and Instream Habitat;
Prioritize Floodplain/Lowland Habitat;

Prioritize Floodplain/Lowland Protection/Enhancement Sites;
Protect and Enhance Freshwater Wetland Habitat;
Characterize Estuarine and Tidal Habitats;
Prioritize Estuarine and Tidal Protection/Enhancement Sites;
Protect and Enhance Tidal Habitat;
Remove or Modify Ineffective Tide Gates and Culverts;
Prioritize Upland Riparian Protection/Enhancement Sites;
Protect and Enhance Upland Riparian Sites;
Provide Technical Assistance;
Provide Funding for Habitat protection/Enhancement Projects.

Tillamook County Soil & Water Conservation District:
Nutrient Management Plans.
Livestock Management Training.
Exclude Livestock From Streams.
Encourage Protection/Enhancement on Private Lands.
Prioritize Floodplain/Lowland Protection/Enhancement Sites.
Protect and Enhance Freshwater Habitat.
Remove or Modify Ineffective Tide Gates and Culverts;
Provide technical Assistance.

Cities of Tillamook, Bay City, and Garibaldi:
Review/Revise/Adopt Relevant Ordinances;
Expand Sewer Network;
Ensure Adequate Urban Runoff Treatment and Retention;
Ensure Properly Functioning On-Site Sewage Disposal Systems;

Oregon Department of Agriculture:
Complete SB 1010 Plan.
Implement CAFO Implementation/Enforcement.
Nutrient Management Plans
Livestock Management Training.
Exclude Livestock From Streams
Encourage Protection/Enhancement On Private Lands
Prioritize Floodplain/Lowland Protection/Enhancement Sites.
Protect and Enhance Freshwater Habitat.
Effectively Enforce Laws and Regulations;
Provide technical Assistance;
Provide Funding for Habitat Protection/Restoration Projects;

Oregon Department of Environmental Quality:
Characterize Riparian and Wetland Habitat;
Prioritize Floodplain/Lowland Protection/Enhancement Sites;
Protect and Enhance Freshwater Riparian and Wetland Habitat;
Characterize Estuarine and Tidal habitat
Prioritize Tidal Habitat Protection/Enhancement Sites
Protect and Enhance Tidal Marsh;
Reconnect Sloughs and Rivers to Improve Water Flow;
Ensure Properly Functioning On-Site Sewage Disposal Systems;
Identify Stream Segments Where Rapid Heating Occurs;
Analyze Instream Flows;
Prioritize Upland Riparian Protection/Enhancement Sites;
Effectively Enforce Laws and Regulations;
NPDES Permitting and Enforcement
WPCF Permitting and Enforcement
Provide Technical Assistance;

Provide 319 Funding For Habitat Protection/Enhancement Projects

Oregon Department of Fish and Wildlife:
Characterize Riparian and Instream Habitat;
Prioritize Floodplain/Lowland Protection/Enhancement Sites;
Protect and Enhance Freshwater Riparian and Wetland Habitat;
Prioritize Tidal Habitat Protection/Enhancement Sites;
Protect and Enhance Tidal Marsh
Prioritize Upland Protection/Enhancement Sites
Protect and Enhance Upland Riparian Sites;
Effectively Enforce Laws and Regulations;
Provide Technical Assistance;
Provide Funding For Habitat Protection/Enhancement projects;

Oregon Department of State Lands:
Assess and Map Riparian and Wetland Habitat;
Characterize Riparian and Wetland Habitat;
Reconnect Sloughs and Rivers to Improve Water Flow;
Provide Technical Assistance;
Effectively Enforce Laws and Regulations;

Oregon Department of Forestry:
Characterize Riparian and Instream Habitat;
Prioritize Upland Riparian Protection/Enhancement Sites;
Protect and Enhance Upland Riparian Sites
Effectively Enforce Laws and Regulations;
Forest Practices Act Compliance
Provide Technical Assistance;
Provide Funding for Habitat Protection/Enhancement Projects;

Oregon State University Extension Service:
Nutrient Management Plans;
Livestock Management Training;
Provide technical Assistance;

Oregon State Police:
Effectively Enforce Laws and Regulations;

Oregon Watershed Enhancement Board:
Provide Funding for Habitat Protection/Enhancement Projects;

Oregon Wetlands Joint Venture:
Prioritize Wetlands Protection/Enhancement Sites;
Protect/Enhance Freshwater Wetlands Habitat;
Prioritize Estuarine and tidal Habitats;
Protect and Enhance Tidal Marsh;
Provide technical Assistance;
Provide Funding for Wetlands Protection/Enhancement Projects;

Oregon Water Resources Division:
Analyze Instream Flows;
Effectively Enforce Laws and Regulations;
Provide Technical Assistance;

U.S. Army Corps of Engineers:
Reconnect Sloughs and Rivers to Improve Water Flow;

Provide Technical Assistance;
Provide Funds for Habitat protection/Enhancement Projects;

U.S. Department of Agriculture Farm Service Agency:
Provide Technical Assistance;
Provide Funding for Habitat Protection/Enhancement Projects;

U.S. Environmental Protection Agency:
Provide technical Assistance;
Provide 319 Funding for Habitat Protection/Enhancement Projects;

U.S. Natural Resource Conservation Service:
Develop Voluntary Farm Plans**;**
Nutrient Management Plans;
Increase Incentive Program Payments;
Provide technical Assistance;
Provide Funding for Habitat Protection/Enhancement Projects;

ELEMENT 6: REASONABLE ASSURANCE OF IMPLEMENTATION

The Oregon Plan

The Oregon Plan for Salmon and Watersheds represents a major effort, unique to Oregon, to improve watersheds and restore endangered fish species. The Oregon plan is a major component of the demonstration of " reasonable assurance " that this TMDL Implementation Strategy will be implemented.

The Plan consists of four essential elements:

1. Coordinated Agency Programs:
Many state and federal agencies administer laws, policies, and management programs that have an impact on salmon and water quality. These agencies are responsible for fishery harvest management, production of hatchery fish, water quality, water quantity, and a wide variety of habitat protection, alteration, and restoration activities. Previously, agencies conducted business independently. Water quality and salmon suffered because they were affected by the actions of all the agencies, but no single agency was responsible for comprehensive, life-cycle management. Under the Oregon Plan, all government agencies that impact salmon are accountable for coordinated programs in a manner that is consistent with conservation and restoration efforts.

2. Community-Based Action:
Government alone, cannot conserve and restore salmon across the landscape. The Oregon Plan recognizes that actions to conserve and restore salmon must be worked out by communities and landowners, with local knowledge of problems and ownership in solutions. Watershed councils, soil and water conservation districts, and other grassroots efforts are vehicles for getting the work done. Government programs will provide regulatory and technical support to these efforts, but local people will do the bulk of the work to conserve and restore watersheds. Education is a fundamental part of the
community based action. People must understand the needs of salmon in order to make informed decisions about how to make changes to their way of life that will accommodate clean water and the needs of fish.

3. Monitoring:
The monitoring program combines an annual appraisal of work accomplished and results achieved. Work plans will be used to determine whether agencies meet their goals as promised. Biological and physical sampling will be conducted to determine whether water quality and salmon habitats and populations respond as expected to conservation and restoration efforts.

Direct monitoring of water quality parameters allocated in the TMDL (Temperature and bacteria) will be conducted in coordination between DEQ , ODA and local groups. This is described further in Element 7.

4. Appropriate Corrective Measures:
The Oregon Plan includes an explicit process for learning from experience, discussing alternative approaches, and making changes to current programs. The Plan emphasizes improving compliance with existing laws rather than arbitrarily establishing new protective laws. Compliance will be achieved through a combination of education and prioritized enforcement of laws that are expected to yield the greatest benefits for salmon.

Voluntary Measures

There are many voluntary, non-regulatory, watershed improvement programs.
that are in place and are addressing water quality concerns in the Tillamook Bay Watershed. Both technical expertise and partial funding are provided through these programs. Examples of actions promoted and accomplished through these programs include: planting of conifers, hardwoods, shrubs, grasses, and forbs along streams; fencing out livestock from riparian areas; protecting or enhancing wetlands; relocating and retiring legacy roads; and replacing tide gates and culverts. The programs addressing these problems include:

- **Tillamook Bay National Estuary Program (TBNEP);**
- **Tillamook County Performance Partnerships (TCPP).**

The TBNEP worked in close association with state and federal agencies, local governments, businesses, watershed councils, and landowners to develop a Tillamook Bay Watershed Comprehensive Conservation Management Plan (CCMP). The plan defines a litany of actions to be taken to protect or enhance water quality and fish habitat.

The TCPP was formed upon the completion of the CCMP to oversee implementation of the Plan. The TCPP is a partnership among local residents, state and federal agencies, local governments, and public interest groups concerned with the management of the Tillamook Bay Watershed. The central strategy of the TCPP approach is based upon the belief that a locally based effort to improve coordination, integration and implementation of existing local, state, and federal programs can be effectively protect, enhance, and restore a regional watershed area. The TCPP coordinates efforts to: characterize riparian and wetland habitats; prioritize riparian and wetland sites for protection/enhancement; develop specific project plans and design; provide funding; project implementation; and project monitoring.

The EPA provides funding for TCPP staff and provides oversight to ensure that CCMP goals, objectives, and action items are implemented. A majority of Management Measurers identified in this implementation strategy plan are identified as specific action items within the CCMP. This EPA oversight will add additional assurance of implementation.

Landowner Assistance Programs

A variety of grants and incentive programs are available to landowners in the Tillamook Bay Watershed. These incentive programs are aimed at improving the health of the watershed, particularly on private lands. They include technical and financial assistance, provided through a mix of state and federal funding. Local natural resource agencies administer this assistance, including the ODF, the ODFW, ODEQ, OWHB, and NRCS.

Field staff from the administrative agencies provide technical assistance and advice to individual landowners, watershed councils, local governments, and organizations interested in enhancing the Basin. These services include on-site evaluations, technical project design, stewardship/conservation plans, and referrals for funding as appropriate. This assistance and funding is further assurance of implementation of the TMDL Implementation Strategy.

NRCS has recently published a Watershed Plan/Environmental Assessment for the Lower Tillamook Bay Watershed (NRCS 2001) with sponsorship from the Tillamook Soil and Water Conservation District. The Plan is designed as an implementation measure for the Comprehensive Conservation and Management Plan developed by the TBNEP. This document describes the development of agricultural facilities, practices and restoration activities that will address TMDL-related water quality issues in the Tillamook Bay Watershed. In addition to description of these activities, the Plan identifies large-scale matching funding available through NRCS for its implementation. Modeling performed as part of the Environmental Assessment indicates significant improvements are possible through implementation of the Plan.

Regulatory/Structured Programs

There are a variety of structured programs that are either in place or will be put in place to help assure that this TMDL Implementation Strategy will be implemented. Some of these are traditional regulatory programs such as discharge permit programs for industry. In these cases the pollutants of concern will be considered and the regulation will be carried out as required by federal, state, or local law. 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.

1. NPDES and WPCF Permit Programs

The DEQ administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. These are: the National Pollutant Discharge Elimination System (NPDES) permits for waste discharge; and Water Pollution Control Facilities (WPCF) permits for waste disposal. The NPDES permit is also a Federal permit, which is required under the Clean Water act for discharge of waste into waters of the United States. DEQ has been delegated authority to issue NPDES permits by the EPA. The WPCF permit is unique to the State of Oregon. As the permits are renewed, they will be revised to insure that all 303(d) related issues are addressed in the permit. These permit activities assure that elements of the TMDL Implementation Strategy involving urban and industrial pollution problems will be implemented.

2. Municipal and Rural Residential

Tillamook County and the cities of Tillamook, Bay City, and Garibaldi have both ordinances and policies that are relevant to the implementation of the management practices discussed in the Management Measurers element of this Plan. These ordinances and policies will be reviewed and revised as described.

3. **Forestry**

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forest lands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describe BMPs for forest operations. These rules are implemented and enforced by ODF and monitored to assure their effectiveness. The Environmental Quality Commission, Board of Forestry, DEQ, and ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards. ODF provides on the ground field administration of the Forest Practices Act. For each administrative rule, guidance is provided to field administrators to insure proper, uniform and consistent application of the Statutes and Rules. The FPA requires penalties, both civil and criminal, for violation of Statutes and Rules. Additionally, whenever a violation occurs, the responsible party is obligated to repair the damage. For more information, refer to the Management Measures element of this Plan.

4. Agriculture

The Oregon Department of Agriculture (ODA) has primary responsibility for control of pollution from agriculture sources. This is done through the Agriculture Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010 adopted by the Oregon State Legislature in 1993. The AWQM Act directs ODA to work with local farmers and ranchers to develop water quality management area plans for specific watersheds that have been identified as violating water quality standards and having agriculture water pollution contributions. The agriculture water quality management area plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct those problems. These water quality management plans are developed at a local level, reviewed by the State Board of Agriculture, and then adopted into the Oregon Administrative Rules. It is the intent that these plans focus on education, technical assistance, and flexibility in addressing agriculture water quality issues. There may be, however, situations that require corrective action. In those cases when an operator refuses to take action, the law allows ODA to take enforcement action. For more information, refer to the Management Measurers element in this Plan.

ELEMENT 7. MONITORING AND EVALUATION

Purpose

Monitoring will provide information on progress being made toward achieving water quality standards. The information generated by each of the agencies/entities gathering data in the sub-basin will be pooled and used to determine whether management actions are having the desired effects or if changes in the management actions are needed. If progress is not occurring, then the appropriate management agency (ODA,ODF, TCSWCD, Cities, and Tillamook County) will be contacted with a request for action.

The objective of these monitoring efforts are to demonstrate long-term recovery, better understand natural variability, track implementation of projects and BMPs, and track effectiveness of TMDL Implementation. This monitoring and feedback mechanism is a major component of the “ reasonable assurance of implementation” for this Plan.

Tracking Implementation of the Plan

Implementation of the Plan will be tracked by accounting for the numbers, types, and locations of projects, BMPs, education activities, or other actions taken to improve or protect water quality.

This will be done on an annual basis by Tillamook Bay National Estuary Project/Tillamook County Performance Partnerships.

In 1999, the TBNEP completed the Tillamook Bay Comprehensive Conservation Management Plan (CCMP). Actions described in the CCMP represent a litany of BMPs designed to address water quality concerns, specifically bacteria and temperature problems. A component of the CCMP addresses monitoring. The Tillamook County Performance Partnerships was formed to implement the actions described in the CCMP, including monitoring. The Clean Water Act (CWA) section 320(b)(6) specifies that each Management Conference shall "… monitor the effectiveness of actions taken pursuant to the plan," with the following primary goals:

- measure the effectiveness of the management actions and programs implemented under the CCMP; and
- provide essential information that can be used to redirect and refocus the CCMP during implementation.

Implementation Monitoring

Programmatic implementation monitoring will help keep managers informed regarding the implementation status of various programs and the degree to which programs are not achieving their intended outcomes. With this information, managers can modify the Plan or actions as needed to achieve the desired outcomes outlined in the Plan.

Implementation, or programmatic monitoring is designed to answer such questions as: "is the CCMP being implemented at the level of commitment specified in the CCMP goals, targets, and measures of success?" "Are the actions in the Plan having the desired effects?" " Does the Plan need to be changed?" Many actions in the CCMP lend themselves to this type of administrative monitoring. Implementation monitoring established accountability on the part of the designated lead organizations for specific actions outline in the CCMP.

The TCPP will develop a real-time, web-based accountability system that will house all monitoring data at the Tillamook Coastal Watershed Resource Center (TCWRC). This system will track projects and costs. When appropriate, monitoring results will be entered into a monitoring database, then into a Geographical Information System (GIS) to display spatial data. The GIS system has been established by the TBNEP/TCPP and will be maintained by the TCWRC. The intent is that all data will be web-accessible.

Effectiveness Monitoring

Effectiveness monitoring answers broader ecological questions: "Is the ecological integrity of the Bay and watershed changing?" "Is water quality improving or getting worse, and by how much? Effectiveness monitoring lends itself more toward an assessment of success in obtaining CCMP goals and objectives than to the implementation of specific actions. This type of monitoring requires a statistically sound analysis of environmental data of known quality and confidence. For each CCMP Objective, associated monitoring parameters provide a measurement of success. For example, to monitor the CCMP Objective " Achieve at least a 25% reduction in bacteria loads to rivers", fecal coliform and E. coli bacteria concentrations will be measured at numerous sites in the Basin.

The environmental monitoring component of the Tillamook Bay Monitoring Program (TBMP) is designed to provide data that can be directly compared to the quantifiable objectives in each action item. It builds upon recently conducted characterization studies and existing monitoring efforts. It seeks to promote cooperation among agencies and stakeholders by incorporating and coordinating efforts into an integrated monitoring plan, increasing the scope and resolution of existing efforts, improving the timeliness of data analysis, and making the results available to a diverse group of agencies and stakeholders in a timely manner. This will minimize duplication of effort among agencies, reduce the cost of monitoring, and provide integrated results to the scientific, regulatory, and stakeholder communities in an efficient and timely manner.

Standardized sampling, analytical methods, and quality control (QA/QC) protocols will be adopted to ensure that monitoring information collected by the various partners in this effort are of high quality and are directly comparable.

Monitoring Workplans

Fifteen monitoring workplans are divided into three categories. Core monitoring workplans are those activities required to determine whether the stated CCMP environmental goals and objectives are being met. Research workplans are those activities developed to provide the additional information required to make sound management decisions as identified in specific action items. Citizen workplans builds upon ongoing efforts to support citizen involvement and development of bioindicators.

Core Monitoring Workplans:
Bacteria Monitoring;
Temperature Monitoring;
Total Suspended Solids Monitoring;
Riparian assessment;
Stream Channel and Habitat Assessments;
Tidal Wetland Assessments;
Submerged Aquatic Vegetation Survey;
Forest Road Surveys; and
Fish Monitoring (Rivers).

Research Monitoring Workplans:

Fish Use of the Estuary;
Benthic Invertebrate Inventory of the Bay;
Ecological Interactions Among Eelgrass, Oysters, and Burrowing Shrimp;
Nutrient Monitoring.

Citizen Monitoring Workplans:

Benthic Macroinvertebrate Monitoring (Rivers)
Plankton Monitoring.

Water Quality and Related Parameter Improvements

Bacteria Monitoring

The purpose of the bacteria monitoring program is to determine long-term trends in bacteria loading and short-term variations in bacteria concentrations in relation to DEQ water quality standards.

Major monitoring questions are: Is the concentration (flow-weighted average concentration) of fecal coliform bacteria (FCB) in the lower reaches of the Tillamook, Trask, and Wilson Rivers increasing or decreasing (and by how much) during typical storm events during the summer, fall, winter, and spring seasons over time scale of years to decades? Are the storm loads of FCB increasing or decreasing (and by how much) during typical seasonal storm events in the Tillamook, Trask, and Wilson Rivers over a scale of years to decades? How often and for what length of time does each of the five rivers violate DEQ's water quality criteria for E-coli bacteria? Are there trends in the frequency and/or duration of those water quality standard violations over time scales of years or decades?

The DEQ, ODA, and others have monitored the bacteria in Tillamook Bay and its watershed for many years. Major sampling efforts have included:

DEQ Ambient Water Quality Monitoring;
DEQ TMDL Development Sampling and Analysis;
ODA/DEQ National Shellfish Sanitation Program;
TBNEP/DEQ Storm Sampling;
Citizen Water Quality Compliance Monitoring; and
TBNEP Source and Transport Studies.

Temperature Monitoring

The purposes of temperature monitoring are: to determine the daily maximum temperatures of the rivers during summer months; To quantify changes in the number of days per year that daily maximum temperatures in the rivers exceed water quality criteria; and to determine the spatial extent of water temperature exceedences during summer months in the rivers.

Major monitoring questions are: What is the frequency and duration of temperature excursions above threshold values (expressed as daily maxima) in the rivers and what is the spatial extent of such excursions? Are there trends (increasing or decreasing) in the frequency, duration or extent of temperature excursions above the threshold values in the rivers over time scales of years or decades?

Temperatures in several rivers in the Tillamook Bay Watershed have been measured above 64°F, temperature conditions in the range that is stressful or lethal for salmonid fish. The monitoring program will measure temperature to more precisely quantify the frequency, duration, and extent of temperature excursions above threshold values in each of the rivers. Temperature monitoring by DEQ, and ODF, will continue with support from the Performance Partnership and Tillamook Bay Watershed Council.

Quality Assurance/Quality Control/Data Management

The TCPP, TCSWCD, local, state, and federal agencies, and academic institutions all use data collected in the Tillamook Bay Watershed. Data quality must be known to insure that it is of sufficient quality for its intended use.

In general, data will be gathered and handled in accordance with the Oregon Plan for Salmon and Watersheds " Water Quality Monitoring Guide Book", TBNEP CCMP Monitoring Program Guidelines, and standard DEQ field monitoring criteria. Special projects or other monitoring efforts will be done in accordance with specific quality assurance plans that identify the precision and accuracy of the data collected. Where this information is not available, the data will be identified as of unknown quality. For educational demonstrations, or screening efforts of lesser quality is sometime collected and still has value. Such data can be included in the data bases and data summaries but will be flagged and its quality identified.

Reporting/Revisions

The Tillamook Bay Watershed Resource Center (TBWRC), TCPP, and DEQ, will be responsible for collating and summarizing data and providing copies of data summaries to the other cooperators on an annual basis. The data will be maintained at the TBWRC and will be available to all interested parties. The TCPP will be responsible for convening a water quality advisory committee to discuss any needed revisions in monitoring strategies and coordinate the coming monitoring season activities.

On a biannual basis, the TCPP will produce a report on the status of water quality in the Tillamook Bay Watershed. This report will be developed in cooperation with the water quality advisory committee described above. The agencies involved in implementing this Plan will use this report to adjust the Water Quality Management Plan over time as indicated by monitoring results. Copies of the final report will be made available to the participating agencies, local media, and the general public.

ELEMENT 8: PUBLIC INVOLVEMENT

To be successful at improving water quality a TMDL Implementation Strategy must include a process to involve interested and affected stakeholders in both the development and the implementation of the Plan. This public involvement element of the Plan first describes on-going TCPP public involvement efforts within the Basin. The second section describes on-going efforts with the development of Basin TMDLs. The third section of this element describes a strategy by which the affected agencies/organizations will continue to involve and educate the public during the implementation of the Tillamook Bay Basin Implementation Strategy.

On-going Public Involvement Activities

As described earlier in Element 7, the Tillamook County Performance Partnerships has assumed the responsibility for the implementation of the TBNEP Comprehensive Conservation Management Plan (CCMP). The CCMP contains a majority of Action Items described in the Management Measurers element of this Plan.

To meet the goals and objectives of the CCMP, the TCPP will continue to foster citizen stewardship through public outreach and education. The program will provide staff, expertise and resources to the Tillamook Coastal Watershed Resource Center (TCWRC) and local watershed councils. It will produce an annual State of the Bay report, and continue to publish maps, brochures, signs, educational programs, and other materials to involve the public in project goals and objectives. The TCPP will continue to develop public outreach programs related to forestry, agriculture, shellfish industries, and urban and rural residential development. TCPP will also continue work to strengthen K-12 school watershed education programs and improve opportunities for adult education.

On-going activities include:

- Public presentations;
- Tillamook Bay Paddle;
- Fairs and exhibits;
- Issue forums;
- State of the Bay annual report;
- Signs and displays;
- TCPP web site;
- Videos;
- Newsletters.

TMDL Implementation Strategy Development

As a member of the Tillamook County Performance Partnerships, DEQ staff has periodically updated the partners on TMDL development efforts. The DEQ has also worked closely with TCPP and others to gather needed data. In January 2000, DEQ requested that a TCPP Task Force be established to work with DEQ in the development of the final TMDL and the associated TMDL Implementation Strategy. The Task Force has met twice with DEQ TMDL staff and will continue to work closely with DEQ to finalize and implement both the TMDL and Implementation Strategy.

Plan Implementation

As mentioned previously, public awareness and involvement will be crucial to the successful implementation of this plan and resulting improvements to water quality.
The following actions will take place during the implementation of this Plan:

Urban and Rural Residential

The primary message conveyed to citizens will be that everyone is a contributor to the water quality in the watershed and everyone needs to participate in the efforts to improve water quality. All citizens can participate by using less fertilizer and garden chemicals, washing vehicles on the lawn, keeping wastes of all kinds out of storm drains, drainage ditches, and similar measurers. Special emphasis will be given to protection of riparian vegetation, especially retention of trees along the rivers and urban streams. Additional efforts will be directed toward problems associated with new construction and development activities. Development should be designed to protect and retain vegetation, minimize impervious surfaces, and retain stormwater on-site to the extent possible.

Tillamook County and the Cities of Tillamook, Bay City, and Garibaldi will work with the TCPP and DEQ to develop programs and materials related to the Implementation Strategy action items that affect these areas. Actions that have been identified are:

City and County informational mailings;
Stormdrain stenciling;
Displays in public places;
Public service announcements;
Outreach to county planning departments; and
Outreach to city and county public works departments.

Forestry

The primary message conveyed to the forestry community will be that compliance with water quality standards and load allocations during commercial activities on non-federal forestlands will continue to be achieved through compliance with Best Management Practices (BMPs) established under the Forest Practices Act and forest practice rules. Consistent with the DEQ/ODF Memorandum of Understanding, the Act and BMPs may be modified in the future to better ensure water quality standard compliance. If and when such changes occur, forest landowners and operators will be expected to comply with those revised requirements as well.

The Department of Forestry in close association with the forest industry and small woodlot owners, will work with the TCPP and DEQ to accomplish the following objectives:

- To clearly explain and exchange information regarding the non-federal forestlands component of the Implementation Strategy in order to build understanding, acceptance, and support for the Plan;

- To clearly explain and exchange information on the other components of The Plan and how other users are affected.

- To exchange information and encourage cooperative monitoring efforts that can lead to further improvements in the non-federal forestland areas and/or the overall Plan in the future.

- To encourage forestry community involvement in future revisions of the non-federal forestland areas.

Agriculture

The primary message to agriculture landowners and operators will be that compliance with water quality standards and load allocations will be achieved through compliance with the provisions of SB 1010 and associated rules.

The Oregon Department of Agriculture (ODA) in association with the agriculture industry and landowners, will work with the TCPP to:

- Educate landowners and public about what SB 1010 is, and how it works;
- Raise awareness of what the prohibited conditions are;
- What the available solutions are; and
- Where financial and technical assistance is available.

Major public outreach efforts will include:

- Public meetings;
- Hearings;
- Direct mail;
- Newsletters;
- Newspaper articles;
- Workshops;
- Project tours;
- Public service announcements; and
- Presentations at community group meetings.

ELEMENT 9: MAINTENANCE OF EFFORT OVER TIME

The purpose of this element of the Implementation Strategy is to demonstrate efforts for maintaining the implementation of the Plan and resulting water quality improvements over the long-term.

To ensure the long-term implementation of the Plan the DEQ will work with the TCPP to oversee plan implementation, review plan priorities and practices, and encourage public education and involvement. The review group will be made up of private citizens and representatives of management agencies involved in the implementation of the Plan. At a minimum, the membership will include:

- Tillamook County government;
- City governments of Tillamook, Bay City, and Garibaldi;
- Tillamook Bay Watershed Council;
- Tillamook County Soil & Water Conservation District;
- Oregon Department of Agriculture
- Oregon Department of Forestry;
- Oregon Department of Fish & Wildlife;
- Oregon Department of Environmental Quality; and
- Private citizens.

The review group's major charge will be to periodically review the entire plan and revise as necessary. This will involve:

1. Review of the activities of the responsible agencies to determine if implementation is occurring as planned. If it is not, determine the reason and revise the plan timeline as necessary.

2. Promotion of ongoing communication and education among the public on the goals of the plan and on the availability of financial and technical assistance for implementing priority projects.

3. Continuing efforts to encourage adequate technical and financial assistance programs that are active in the Basin to help implement resource enhancement projects.

ELEMENT 10: COSTS AND FUNDING

The purpose of this element is to describe estimated costs and demonstrate there is sufficient funding available to begin implementation of the Implementation strategy. Another purpose is to identify potential future funding sources for project implementation. There are many natural resource enhancement efforts and projects occurring in the Basin which are relevant to the goals of the plan. These efforts, in addition to proposed future actions are described in the Management Measurers element of this Plan. The following table lists the action items described in the Management Measurers element and estimated costs.

Implementation Actions

Action Item	Description	Estimated Costs
Non-Point (Bacteria)		
Action 1:	Define, Implement, and Enforce Pollution Prevention and Control Measurers on Agriculture Lands.	$250,000/5 years
Action 2:	Implement Revised CAFO Inspection Procedure.	$80,000/year
Action 3:	Use Farm-Specific Agronomic Rates for Nutrient Management.	$30,000 (one year study) $5,000/year (soil testing)
Action 4:	Provide Farm/Livestock Management Training Programs	$12,500/year
Action 5:	Control Livestock Access to Streams.	$6,589,000-$8,823,000 (fencing, planting, water)
Action 6:	Encourage Protection and Enhancement on Private lands	$38,750 (one year study)
Action 7:	Prioritize Floodplain/Lowland Protection/Enhancement Sites.	$75,000 (one time study)
Action 8:	Protect and Enhance Lowland Riparian Areas.	Cost estimated in Action 5
Action 9:	Protect and Enhance Freshwater Wetland Habitat.	$10,000-75,000/project $15,000/year (materials)
Action 10:	Effectively Enforce Laws and Regulations.	$65,000/year
Action 11:	Characterize Estuarine and Tidal Habitats.	$250,00 (for 10 years)
Action 12:	Prioritize Tidal Sites For Protection.	$12,500
Action 13:	Protect and Enhance Tidal Marsh.	$3,000,000
Action 14:	Remove or Modify Ineffective Tide Gates and Culverts	$112,000 (16 tide gates)
Action 15:	Reconnect Sloughs and Rivers to Improve Water Flow.	$3,000,000 (COE study)

$2,000,000 $250,000-
(per project)

Point Sources (Bacteria)

Action 1: Expand Sewer Network ***$1,8000,000***

$25,000/year (staff)

Action 2: Ensure Adequate Urban Runoff Treatment and Retention. $35,000-
$150,000/project

$25,000/year for 5 years

Action 3: Ensure Properly Functioning On-Site Sewage Disposal Systems $30,000
(surveys)

$25,000 (ordinance)

$2,000-
$10,000/parcel

(sewer
annexations)

$50,000/year (floating head)

$250,000 for 10 years (staff)

Non-Point Sources (Temperature)

Action 1: Identify Instream Flows. $200,000 for 2
years (staff)

Action 2: Prioritize Upland Riparian Protection and Enhancement Sites $30,000

Action 3: Protect and Enhance Upland Riparian Areas. $3,372.000
(200 miles)

Action 4: Increase Incentive Program Payments. $50,000/year
(staff)

Monitoring

The water quality monitoring effort described in Element 7 is comprise of key actions identified by the agencies for documenting and understanding the long-term water quality trends in the Tillamook Bay Watershed. This monitoring is already underway and is expected to continue at this level. Cost estimates are identified below.

Monitoring Parameter	Estimated Costs
Bacteria	$45,000/year (storm monitoring) $8,000/year (compliance monitoring) $25,000/year (Bay monitoring) $25,000/year (river gages)
Temperature	$25,000/year (staff & equipment)
Total Annual Anticipated Costs	$128,000

Potential Sources of Project Funding

Funding is essential to implementing projects associated with this Implementation Strategy. There are many sources of local, state, and federal funds. The following is a partial list of assistance programs available in the Tillamook Bay Watershed.

Program	Agency/Source
OREGON PLAN FOR SALMON AND WATERSHEDS	**OWEB**
Environmental Quality Incentives Program	USDA-NRCS
Wetland Reserve Program	USDA-NRCS
Program	**Agency/Source**
Conservation Reserve Enhancement Program	USDA-NRCS
Stewardship Incentive Program	ODF
Access and Habitat Program	ODFW
Partners for Wildlife Program	USDI-FSA
Conservation Implementation Grants	ODA
Water Projects	WRD
Non-point Source Water Quality Control (EPA 319)	ODEQ-EPA
Riparian Restoration	TCCA
Riparian Protection/Enhancement	COE
forestlands Protection/Enhancement	NFF
Wetlands/Riparian Enhancement	NFWF

ELEMENT 11: LEGAL AUTHORITIES TO BE USED

Clean Water Act Section 303(d)

Section 303(d) of the federal Clean Water Act (CWA) as amended, requires states to develop a list of rivers, streams, and lakes that cannot meet water quality standards without application of additional pollution controls beyond the existing requirements on industrial sources and sewage treatment plants. Waters that need this additional help are referred to as "water quality limited" (WQL). Water quality limited waterbodies must be identified by the Environmental Protection Agency (EPA) or by a delegated state agency. In Oregon, this responsibility rests with the Department of Environmental Quality. The DEQ updates the list of water quality limited waters every two years. The list is referred to as the 303(d) list. The CWA section 303 further requites that Total Daily Maximum Loads (TMDLs) be developed for all waters on the 303(d) list. A TMDL defines the amount of pollution that can be present in the waterbody without causing water quality standards to be violated. A TMDL Implementation Strategy is developed to describe a strategy for reducing water pollution to the level of the TMDL, which will restore the water quality and result in compliance with the water quality standards.

NPDES and WPCF Permit Programs

The Oregon Department of Environmental Quality (DEQ) administers two different types of wastewater permits in implementing Oregon Revised Statute (ORS) 468B.050. These are: the National Pollution Discharge Elimination System (NPDES) permits for waste discharge; and Water Pollution Control Facilities (WPCF) permits for waste disposal. The NPDES permit is also a Federal permit and is required under the Clean Water Act. The WPCF permit is a state program. As permits are renewed they will be revised to insure that all 303(d) related issues are addressed in the permit.

Oregon Administrative Rules

Specific rules and authority regarding water quality and its management in the State of Oregon are contained in the Oregon Administrative Rules. A complete collection of the administrative rules relevant to listed waters in the Tillamook Bay Watershed are in Appendix C. Selected rules of interest are:

- Bacteria in Shellfish Waters OAR 340-41-205(2)(e)(A)(ii)
- Recreational Contact in Waters OAR 340-41-205(2)(e)(A)(I)
- Water Temperature OAR 340-41-205(2)(b)

Oregon Forest Practices Act

The Oregon Department of Forestry (ODF) is the designated management agency for regulation of water quality on non-federal forest lands. The Board of Forestry has adopted water protection rules, including but not limited to OAR Chapter 629, Divisions 635-660, which describes BMPs for forest operations. The Environmental Quality Commission (EQC), Board of Forestry, DEQ and

ODF have agreed that these pollution control measurers will be relied upon to result in achievement of state water quality standards.

Senate Bill 1010

The Oregon Department of Agriculture (ODA) has primary responsibility for control of pollution from agriculture sources. This is accomplished through the Agriculture Water Quality Management (AWQM) program authorities granted ODA under Senate Bill 1010
Adopted by the Oregon State Legislature in 1993. The AWQM Act directs the ODA to work with local farmers and ranchers to develop water quality management plans for specific watersheds that have been identified as violating water quality standards and have agriculture water pollution contributions. The agriculture water quality management plans are expected to identify problems in the watershed that need to be addressed and outline ways to correct the problems.

Ordinances

Tillamook County and the cities of Tillamook, Bay City, and Garibaldi are responsible for the development of local ordinances designed to control water quality pollution in urban and rural residential areas.

ELEMENT 12: ESTIMATE OF TIME TO MEET WATER QUALITY STANDARDS

Bacteria: Achieve water quality standards in the rivers and Bay by 2010.

Temperature: Achieve instream temperatures that meet salmonid requirements by 2010.
We do not expect instream temperatures that meet requirements of salmonids can be achieved by 2010. We do believe that significant decreases in temperature in smaller streams can accrue in this time frame with ongoing restoration projects currently underway in the Basin. The 2010 milepost will be a good point to look at the progress made and determine the benefits achieved while planning for further projects if appropriate. In general, language that was taken from the Tillamook Bay National Estuary Project Comprehensive Conservation and Management Plan will be left intact to guard against introducing confusion. Since these are the goals of this important implementation document, we accept them as a starting point and expect they will be modified as appropriate under an adaptive management approach.

ELEMENT 13: MILESTONES FOR MEASURING PROGRESS

Specific action items are described in Element 3, Management Measures section. Each action is described as a series of steps to be taken. Each step is identified and includes a specific timeline for completion. Element 4, Timeline for Implementation displays each action item and identifies a timeline for completing the action.

The TCPP will publish a yearly “State of the Bay” report. The report will identify specific actions taken during the year and determine if the implementation plan is moving forward on schedule.

ELEMENT 14: PLANS FOR REVISING THE TMDL

On an annual basis, the Tillamook County Performance Partnerships (TCPP) will produce a report on the “State of the Bay”. The report will discuss the status of water quality in the Basin. The TCPP/DEQ will convene a water quality advisory committee to discuss progress made toward implementation of the TMDLs. The agencies involved in implementing the TMDL Implementation Strategy will use the report and water quality advisory committee recommendations to adjust the Basin Implementation Plan over time as indicated by monitoring results.

WQMP APPENDICES

Appendix D-1 – Elements of the Comprehensive Conservation and Management Plan for Tillamook Bay

Management measures are described in terms of the pollutant they address and whether they are relevant to point- or non-point sources of pollution. These management measures are described in many of the elements of the Comprehensive Conservation and Management Plan and in other existing plans and Ordinances. The plans are presented in the context of the issue that they address. Some plans or plan elements will be discussed more than once, since they may address both bacterial and temperature pollution.

Some agricultural elements of the CCMP are not requirements of the SB1010 plan, and some are addressed by other statutes. Further, although the North Coast Basin Agricultural Water Quality Management Area Plan (NCB AWQMAP) does not require landowners to be the active means of restoration, many of the Pollution Control Measures require landowners to allow defined conditions to develop. The NCB AWQMAP will be implemented along with incentives for landowners to more effectively achieve the goals of the Plan

GOAL 1: Promote Beneficial Uses of the Bay and rivers.

Non-Point (Bacteria)

Objectives: Achieve water quality standards for bacteria in the rivers and Bay by 2010.

Document at least a 25% reduction in bacteria loads to rivers, with apparent trends by 2010.

Achieve at least a 25% reduction every four years in the number of days that the rivers are not in compliance with water quality standards for bacteria, based on 1997-1998 monitoring results.

Action 1: *Define, Implement, and Enforce Pollution Prevention and Control Measures on Agriculture Lands.*

Step 1: Complete the North Coast Basin 1010 Plan to ensure that landowners shall:

- restore/maintain riparian buffers on streams and potential fish-bearing areas to a healthy riparian condition (HRC);
- restore/maintain wetland areas to natural condition;
- Maintain adequate pasture growth near riparian areas to filter surface runoff;
- Control livestock access to streams, wetlands, and ditches and provide off-stream watering facilities;
- Refrain from/minimize stream channel modifications that adversely affect aquatic habitat
  (e.g., stream cleaning, diking, dredging, channelizing, or bank armoring);
- minimize the number and size of stream crossings;
- design and construct stream crossings to withstand 25-year flood events;

- design and operate irrigation systems to eliminate over-application;
- ensure that adequate manure storage facilities exist to provide flexibility in selecting dry periods for manure spreading;
- apply and store manure so that surface waters are not contaminated;
- keep records that indicate the quantity, location, and times of manure application;
- incorporate soil and manure testing into the record management system; and
- maintain tide gates in good operating condition.

Step 2: Enforce pollution prevention and control measures (PCMs) according to the provisions and civil penalties defined in Section 8 of SB 1010.
(ODA. Ongoing.)

Lead Agency ODA.

Other Partners Livestock operation managers, NRCS, TCCA, Oregon Dairy Farmers Association (ODFA), DEQ, TCPP.

Anticipated Costs 1.0 FTE ODA staff for five years @ $250,000
Local Advisory Committee – time voluntary

Action 2*: Implement Voluntary Farm Management Plans.*

Step 1: Develop, update, and implement voluntary farm management plans that meet the minimum standards for PCMs identified in Action 1 for all CAFOs and other farm and livestock owners or managers in the Basin by 2010.

- Update 20 CAFOs per year and 30 other operations per year, until all farms in the Basin have voluntary farm management plans by 2010.

(NRCS, ODA, TCSWCD. By 2010.)

Step 2: Support ODA, SWCD, and NRCS in their efforts to provide voluntary farm plans.

- Identify and secure cost-share opportunities to design and implement the plans.

Lead Agency **TCSWCD**

Other Partners NRCS, ODA, TCCA, ODFA, OSU Extension, OWRD, TCPP.

Anticipated Costs NRCS- 1 engineer and 3 farm plan writers @ $50,000each for 8 years (total $1.6 million) to write farm plans for 77 CAFO farms that currently do not meet SB 1010 requirements, plus 237 other farms.

Action 3*: Implement Revised Confined Animal Feeding Operation (CAFO) Inspection Procedure*

Step 1: Prioritize CAFO inspections to target areas with the highest concentrations of bacteria. (ODA by 2000.)

Step 2: Support ODA's CAFO technical review team by including local agriculture representative in the review process. (OSU Extension, NRCS. Ongoing.)

Step 3: Pursue additional funding for ODA's CAFO program to fund an additional CAFO inspector located in the Basin. **(ODA is currently inspecting 100% of permitted CAFOs)**.)

Step 4: Pursue achieving annual announced inspections of 100% of CAFOs. (ODA. By 2004.)

Step 5: Promote the following initiatives in revised CAFO inspection program. (TCPP. By 2000.):

- Conduct aerial surveys after storms twice annually;
- Conduct unannounced inspections at 10% of CAFOs annually. Prioritize based on aerial surveys and/or complaints.

Step 6: Respond to complaints and where necessary develop and insure implementation of correction plans in a timely manner. (ODA.Ongoing.)

Lead Agency ODA

Other Partners NRCS, TCSWCD, OSU Extension, livestock operation managers.

Anticipated Costs 1 additional CAFO inspector @ $50,000 per year.
OSU Extension Service – 0.25 FTE of dairy agent time
Cost of flyovers: $5,000 per year.

***Action 4**: Use Farm-Specific Agronomic Rates for Nutrient Management*

Step 1: Collect nutrient cycling data in the Basin to determine local agronomic rates, and demonstrate this process to operators and the general public. (NRCS, ODA, TCSWCD. By 2001.)

- Incorporate the new agronomic rate information into USDA NRCS Field Office Technical Guides and OSU Extension guidelines. (NRCS and OSU Extension by 2003)

Step 2: Include soil testing requirements in the voluntary farm management plan to monitor soil fertility and provide guidance for future manure and/or nutrient application timing, location , and rates so that agronomic capacity are not routinely exceeded. (NRCS by 2002)

Step 3: Promote documentation of management practices as a part of all voluntary farm management plans. (ODA, TCSWCD, and NRCS. By 2005.)

Step 4: Tie application of manure on all farms to agronomic capacity in order to improve nutrient use and effectively reduce bacteria transport to waterways. (already required by CAFOs, ODA. By 2003.)

Lead Agencies NRCS, ODA, TCSWC, OSU Extension Service

Other Partners Livestock operation managers, DEQ

Anticipated Costs Initial study $30,000.
Soil tests: $100 per test
Farm operator record keeping – voluntary

Action 5*:* *Provide Farm/Livestock Management Training Programs*

Step 1: Identify or design farm management curricula suitable for the Tillamook Bay Watershed.
* Conduct on-farm discussions about nutrient management.
* Offer farm management classes in Tillamook county.
* Document training for 50 farm managers per year.(OSU Ext. By 2000)

Step 2: Add certification requirements and financial incentives through independent organizations
To farm management education. (OSU Extension, ODFA. By 2000.)

Step 3: Increase recognition for farms whose managers and workers receive training. (TCSWCD. By 2001.)

Step 4: Pursue mandatory training as a part of the enforcement process for farm managers who violate water quality standards. (ODA. 2000.)
- Document a decreasing trend in permit violations over 10 years. (ODA. Ongoing.)

Lead Agencies OSU Extension Service

Other Partners ODA, NRCS, TCSWCD, TCCA, ODFA, TCPP.

Anticipated Costs **OSU Extension – 0.25 FTE @ $12,500 per year.**

Action 6*:* *Control Livestock Access to Streams*

Step 1: Continue/strengthen current riparian fencing and planting programs. (TCSWCD, NRCS, TCCA. Ongoing.)

Step 2: Continue education outreach on water quality to livestock owners. (OSU Extension Service and ODA. Ongoing)

Step 3: Identify and prioritize new sites for fencing, planting, and off-stream watering. (TCSWCD and TCPP. Ongoing.)

Step 4: Implement all appropriate measures to control livestock access to streams. Livestock access to streams controlled on at least *80% of priority riparian areas by 2010. (TCSWCD, NRCS, and TCCA. By 2010.)

Step 5: Monitor all fencing sites. Use photo-documentation to show changes. (TCSWCD,NRCS, and TCCA. Ongoing)

Lead Agencies TCSWCD, NRCS, ODA

Other Partners OSU Extension Service, TCCA, ODFW, DEQ, OWJV, Landowners.

Anticipated Costs Riparian fencing, planting, and off-stream watering: $6,589,000 - $8,823,000.

Action 7: *Encourage Protection and Enhancement on Private Lands*

Step 1: Summarize and synthesize relevant information to help landowners meet or exceed environmental standards. Include information on stream-crossing standards for fish passage, and the importance of protecting and restoring riparian and wetland habitat.

- Provide information on easements, tax incentives, cost-share programs, and grants.
- Develop and deliver a riparian seminar to landowners and discuss conservation options.(OSU Extension Service, ODF, and ODFW. 2000.)

Step 2: Partner with private timber companies, and Oregon Forestry Industries Council (OFIC) to accept and implement Core Area Voluntary Management Measures contained in the Oregon Plan. (ODF and OFIC. 2000.)

Step 3: Support and implement federal and state conservation programs (TCSWCD, NRCS, ODF, DSL, and ODFW. Ongoing.) including:

- Wetlands Reserve Program (USDA)
- Conservation Reserve Program (USDA)
- Wildlife Habitat Incentives Program (WHIP) (USDA)
- Environmental Quality Incentive Program (EQUIP) (State of Oregon, USDA)
- Partners for Wildlife (USFWS)
- Wetland Mitigation banking Revolving Fund (DSL)
- Forest Incentives Program (ODF)
- Landowner Stewardship Award (ODF)
- Riparian Tax Incentives Program (ODFW)
- Stewardship Incentives Program (ODF)

Step 4: Purchase conservation easements on lands included on the prioritized conservation/enhancement list. Transfer the management of the easements and any purchased lands to a land trust with sufficient funds for management. (TCPP and OWJV. Ongoing.)

Step 5: Review land taxes to consider tax incentives related to habitat protection and/or enhancement. (Tillamook County. 2000.)

Lead Agencies TCSWCD, ODF, ODFW, Tillamook County

Other Partners NRCS, ODFW, OSU Extension, OWJV, USFWS, OFIC, landowners.

Anticipated Costs 0.5 FTE TCPP staff time for one year @ $25,000.
Easements and land purchases.
Tax incentives.

***Action 8**: Characterize riparian and Instream Habitat*

Step 1: Identify priority stream reaches for ODFW Aquatic Inventory surveys. survey these reaches and update previous surveys in selected areas. (ODFW. 2000)

Step 2: Enter survey results in GIS database for use in analysis, site selection, and prioritization. (ODFW. 2000.)

Step 3: Use ODFW North Coast Stream Project Guide to Restoration Site Selection Phase II to identify and prioritize instream protection and enhancement sites and help identify upland riparian sites. (TCPP and ODFW. Annually.) Healthy Riparian Areas are characterized by the following conditions:

- **Structure and species composition.** The riparian area supports a diverse plant community in two or more layers (trees, shrubs/groundcover) dominated by native species suited to the particular site. Where conditions are suitable , native conifers are the dominant species.
- **Vegetative cover.** Vegetative cover within the riparian area is at least 90%, with no more than 10% in bare soil or impervious surface.
- **Width.** The width of the riparian area is sufficient to fulfill the purposes of management for Healthy Riparian Condition (HRC). Determination of the appropriate width will be made by qualified agency personnel in consultation with the land owner. Minimum widths will vary, depending on site-specific conditions and the requirements of applicable funding and regulatory programs.
- **Stream Shading.** The active channel is at least 80% shaded when deciduous trees have leaves.
- **Floodplain connectivity.** The stream and floodplain are actively connected, with bank overflows during a two and a half year flood event.
- **Bank stability.** Streambanks are stable during a two-year flow event without the use of riprap or other artificial structures. Streambanks show little or no change in bank gradient in 2-year events, or within two seasons of normal flow events.

Step 4: Complete watershed assessments or analysis for the Miami, Wilson, and Tillamook Rivers. Use the watershed assessment results from all five rivers to identify and prioritize floodplain/lowland and estuary sites. (TCPP. 2001)

Lead Agency ODFW for Aquatic Inventories
TCPP for watershed assessments

Other Partners BLM, USFWS, ODF, DEQ, private landowners

Anticipated Costs ODFW Aquatic Inventory surveys: $1,000 - $1,500 per mile X 200 miles = $200,000 - $300,00.
Data Analysis: $150 per mile X 200 miles = $30,000
Watershed Assessments: $25,00 - $40,000 per watershed. $90,000 total.

Action 9: *Assess and Map Riparian and Wetland Habitat*

Step 1: Gather existing sources of information on Tillamook Basin riparian areas and Wetlands including Federal National Wetland Inventory (NWI) maps and assessments completed by cities, TBNEP GIS layers, etc.. (DSL and Tillamook County. By 2000)

Step 2: Use the Oregon Freshwater Wetlands Assessment Manual protocol for areas that have not been surveyed and are known to contain wetlands. (DSL and NRCS. By 2002.)

Step 3: Construct GIS layers and associated data base files (DBF) of riparian and wetlands within the Basin. Add these layers to the Tillamook Coastal Watershed Resource Center for access by all interested parties. (TCWTC. By 2002.)

Lead Agencies DSL and Tillamook County.

Other Partners NRCS, ODFW, DLCD, EPA, DEQ, COE, USFS, BLM, local governments, watershed councils, and private landowners.

Anticipated Costs DSL: Crew of 2 and supervisor: $36,250 for 3-month project. Construction of GIS layers and DBF: $2,500.

Action 10: *Prioritize Floodplain/Lowland Protection and Enhancement Sites*

Step 1: Review and maintain current prioritization action list. (TCPP. 1999.)

Step 2: Apply an ecosystem approach such as the Bradbury Framework. (TCPP. 2000.) to:

- prioritize watersheds
- protect OPSW core areas and aquatic diversity areas; and
- enhance connectivity among existing habitats.

Step 3: Prioritize additional sites and river reaches. (ODFW. 2001.) Criteria for lowland site selection include:

- near existing high quality instream and/or riparian habitat;
- within or immediately adjacent to 303(d) listed stream reaches;
- provides habitat for federal or state listed sensitive species;
- potential habitat or existing core areas for salmonids;
- adjacent to functional instream habitat;
- established native riparian trees present;
- planned, active protection in place for adjacent upland areas;
- Beat Management Practices (BMPs) in use on adjacent farmlands;
- Landowner committed to riparian habitat improvement; and
- Multiple benefits for habitat, water quality, erosion, and flood protection.

Lead Agency TCPP

Other Partners ODFW, USFWS, ODF, NRCS, TCSWCD, DEQ, watershed councils, County.

Anticipated Costs $150 per mile for ODFW assessments X 500 miles = $75,000

***Action 11**: Protect and Enhance Lowland Riparian Areas*

Step 1: Identify existing and/or potential high-quality riparian areas in the floodplain. (ODFW and TCPP. By 2000)

Step 2: Protect high quality areas with voluntary agreements, easements, or outright purchase. (TCPP and OWJV. Ongoing)

Step 3: Deliver an educational program to landowners and interested members of the public.

- Assist with promoting the OPSW restoration guidelines.
- Develop maps and brochures about projects planned or implemented.
  (TCSWCD, NRCS, ODA. By 2000)

Step 4: Implement highest priority projects. Plantings should average 50 miles per year, with 500 miles of riparian habitat in the 0-500 ft elevation band completed by 2010. (TCSWCD, NRCS. By 2010.)

Step 5: Monitor the projects before and after planting. Use photo documentation. (TCSWCD, NRCS. Ongoing.)

Lead Agencies TCSWCD, NRCS, ODA

Other Partners DSL, ODFW, USFWS, ODF, DEQ, OWJV, County Planning Department, watershed councils.

Anticipated Costs Enhancement costs per foot of riparian area average: $1.45 for fencing, $0.35 - $0.60 for tree planting, $0.32 for water line and off-stream watering, $0.12 for design, and $0.256 - $0.852 for land costs. Costs depend on width of buffer: 15 ft buffer = a total of 900 acres; 50 ft buffer = 3,000 acres. Total costs $6,589,000 - $8,823,000.

***Action 12**: Protect and Enhance Freshwater Wetland Habitat*

Step 1: Protect any known high quality wetland through voluntary agreements, easements, or outright purchase.
(TCPP and Oregon Wetlands Joint Venture (OWJV). Ongoing)

Step 2: Update wetland inventory and identify high-priority projects for protection and enhancement. (DSL and Tillamook County. By 2000.)

Step 3: Develop riparian, wetland, and water quality seminars for landowners and the public.

- Develop maps and brochures that describe projects planned or implemented.
  (TCPP, By 2000)

Step 4: Implement selected wetland enhancement projects on relevant agriculture, forest, urban, and residential lands.
(TCPP, NRCS, TCSWCD, OWJV. Ongoing)

Step 5: Enhance 100 acres of freshwater wetland (TCPP and OWJV. By 2010.)

Lead Agency TCPP

Other Partners DSL, ODFW, USFWS, NRCS, TCSWCD, watershed councils, OWJV.

Anticipated Costs Created wetlands: engineering - $5,000 - $25,000 per project;
Construction - $5,000 - $50,000 per project
Land purchase/Easement – Variable Costs
Seminar Costs: $5,000
Maps and Brochures: $10,000

Action 13*: Revise Local Ordinances to Increase Protection of Riparian Areas, Wetlands, and Instream Habitat*

Step 1: Develop a draft riparian, instream, and wetlands protection ordinances for public review and input. (Tillamook County. 2000.)

Step 2: Adopt specific ordinances for protection of riparian resources, significant wetlands habitat, and in-stream habitat. (Tillamook County. 2000.)

Lead Agencies Tillamook County Board of Commissioners and city councils of the City of Tillamook, Bay City, and Garibaldi.

Other Partners TCPP, OSU Extension service

Anticipated Costs 0.5 FTE County staff time @ $25,000 per ordinance.
0.1 FTE staff time for each of the 3 cities.

Action 14*: Effectively Enforce Laws and Regulations*

Step 1: Organize a task force of enforcement agency representatives and citizens to review enforcement ,mandates, identify gaps, share information, and report suspected illegal actions.

- Develop an integrated enforcement network. (TCPP. 2000.)

Step 2: Pursue adding agency staff where enforcement gaps exist. (OSP,ODFW, ODA, DEQ, ODF, OWRD, DSL, NMFS. 2001.)

Step 3: Educate local judiciary and the public about the importance of laws affecting wetland, riparian, and instream areas, and the costs and consequences of habitat loss. (TCPP. 2000.)

Step 4: Develop a web page that outlines important land laws and regulations, the citizens complaint process, and contact people or offices. (TCPP. By 2001.)

Lead Agencies TCPP

Other Partners Tillamook County Board of Commissioners, County Department of Planning and Development, city councils of the City of

Tillamook, Bay City, and Garibaldi, OSP,ODA, ODF,BLM,USFS, DSL, ODFW, DEQ, NMFS.

Anticipated Costs 1.0 FTE agency staff costs for one year @ $50,000.
0.25 FTE TCPP staff for one year @ $12,500
Web page development (ODFW, TCWRC staff) @ $2,500.

Action 16*:* *Characterize Estuarine and Tidal Habitats*

Step 1: Maintain GIS database for:

- salmonid utilization of migration, spawning, and rearing habitats, especially tidal sloughs. (ODFW. By 2002.)
- water quality in Bay and sloughs. (DEQ, TCPP. Annually.)
- tidal wetlands. (Tillamook County. By 2000)
- tide gates and culverts. (TCPP. 2002.)

Step 2: Identify and map high priority protection and enhancement sites. (TCPP. Annually.)

Step 3: Integrate new habitat data from other studies. (TCPP. Annually.)

Lead Agencies TCPP

Other Partners ODFW, USFWS, ODA, NRCS, ODF, DEQ, DSL, Tillamook County.

Anticipated Costs Staff time. 0.5 FTE for 10 years = $250,000.

Action 17*:* *Prioritize Tidal sites for Protection and Enhancement*

Step 1: Assemble relevant data and maps. (ODFW and TCPP. Annually.)

Step 2: Convene task force to prioritize protection and enhancement opportunities. (DLCD and TCPP. By 2000.)

Step 3: Discuss protection and enhancement opportunities with landowners. (NRCS, TCSWCD, DLDC, OWJV, watershed council. Ongoing.)

Step 4: Submit task force recommendations to Stewardship Council. (TCPP. By 2000, Annually.)

Lead Agencies TCPP

Other Partners ODFW, USFWS, NMFS, ODA, DEQ, DSL, NRCS, Tillamook County.)

Anticipated Costs Staff time: 0.25 FTE @ $12,500

***Action 18**: Protect and Enhance Tidal Marsh*

Step 1: Protect existing saltmarsh and newly accreted saltmarsh through stronger County ordinances. (Tillamook County.)

Step 2: Prioritize a list of potential protection and enhancement sites. Initial site Selection criteria should include:

- **Wetland structure.** Length and complexity of historic and/or other existing channel;
- **Water Quality indicators.** Measures of bacteria and nonpoint source pollution.
- **Enhancement feasibility.** Competing human uses of the area.

Step 3: Contact landowners in optimal locations and determine interest in easements or land sale. (TCPP, TCSWCD, OWJV. Ongoing.)

Step 4: Purchase lands/easements and implement projects on high-priority sites. Enhance 750 acres of tidal marsh by 2010. (TCPP, OWJV. Ongoing.)

Step 5: Consider land trust options. Evaluate the feasibility of creating a local or Regional land trust and make recommendations. (TCPP. 2000.)

Step 6: Begin post-project monitoring plan. Work with citizen volunteers and use Photo documentation to show changes.
(Tillamook County, watershed councils, TCPP.)

Lead Agencies TCPP and OWJV

Other Partners ODFW, USFWS, DLDC, DSL, ODA, DEQ, NRCS, watershed councils.

Anticipated Costs $4,000 per acre for 750 acres = $3,000,000

***Action 19**: Remove or Modify Ineffective Tide Gates and Culverts*

Step 1: Maintain a GIS database of tide gates and culverts. Prioritize potential enhancement sites, based on habitat values and willing landowners.
(TCPP. Annually.)

Step 2: Survey culverts and tide gates and identify potential habitat values to be enhanced, by replacement or an upgrade.
(ODFW, DEQ, TCCC, TCPP. 2000.)

Step 3: Develop a seminar describing tide gate and culvert functions, locations, and fish and water quality benefits to be enhanced by replacement or upgrade.
(Tillamook Bay Watershed Council (TBWC). 2000.)

Step 4: Implement 16 tide gate upgrades or replacements.
(TCPP, TCSWCD. By 2002.)

Step 5: Monitor effectiveness of tidegate replacement/upgrade on water quality and fisheries habitat. Monitor fish presence/absence and water quality parameters to include dissolved oxygen, and pH.

Lead Agencies TCSWCD and TCPP

Other Partners ODA, DSL, ODFW, ODOT, DEQ, NRCS, COE, OWJV, OWEB, TCCA, TBWC, diking districts, landowners.

Anticipated Costs 16 tidegate replacements @ $7,000 per tidegate = $112,000.

***Action 20**: Reconnect Sloughs and Rivers to Improve Water Flow*

Step 1: Complete the COE feasibility study for flood control. Develop a hydrologic and hydraulic model for the watershed. Simulate alternative flows and changes to the floodplain in response to hydrologic modifications.
(COE. By 2002.)

Step 2: Select and conduct pilot projects to improve water movement and water column exchange on sloughs, which historically had natural connections to main rivers.
(FEMA and COE 2003.)

Step 3: Monitor changes in hydrology, DO, and other water quality parameters as identified by DEQ, in reconnected sloughs and adjacent streams.
(DEQ, TCPP.)

Step 4: Select and plan future projects, (Tillamook County, COE, DEQ. By 2004.)

Step 5: Reconnect, and/or otherwise modify 20 projects within two years following The adoption of the hydrodynamic model which:

- measurably reduce runoff rate in Basin uplands;
- improve drainage characteristics in Basin lowlands to reconnect sloughs to rivers;
- increase floodplain storage capacity in Basin lowlands; and
- improve the Basin's capacity to withstand or benefit from flood events.

Lead Agencies COE

Other Partners FEMA, DEQ, DSL, Tillamook County

Anticipated Costs Study cost: $3,000,000 for COE hydrologic model and feasibility study.
Implementation costs: $250,000 - $2,000,000 per project.

Point Sources (Bacteria)

***Action 1**: Expand Sewer Network*

Step 1: Developers near Tillamook now pay the costs of extending the sewer system to their site and work with the City to establish system development charge credits as a part of the capital project plan. The City and developers will develop a future ordinance that will form reimbursement districts to repay the developer when intermediate property owners connect to the system. (City of Tillamook, Developers. Ongoing)

Step 2: The City of Tillamook will procure funding to continue expansion of sewer service throughout the UGB, whenever and wherever possible as funding becomes available. (Tillamook City. By 2001.)

Step 3: Evaluate opportunities to expand sewer systems outside designated UGBs of the three incorporated cities in the Tillamook Basin. (City Governments. By 2003.)

Step 4: Where failing septic systems pose a health hazard, cities will require connections to sewer systems as per state law. Develop an appropriate ordinance, as allowed by ORS standards. (City Governments, DEQ. By 2001.)

Lead Agency Tillamook City Government

Other Partners Bay City and Garibaldi City Governments, Tillamook County Department of Community Development , DEQ, DLCD, developers.

Anticipated Costs Construction costs: $300,000 to sewer 1,500 linear feet.
$1,500,00 - $1,800,000 to sewer entire remaining Tillamook UGB.
Staff time: 0.5 FTE City Manager and Public Works Director

***Action 2**: Ensure Adequate Urban Runoff Treatment and Retention*

Step 1: Quantify the contribution of contaminants (TSS, bacteria, nutrients, temperature) from urban storm water discharge to surface waters. Urban areas include the City of Tillamook, Bay City, and Garibaldi. (DEQ. By 2002.)

Step 2: Identify natural landscape features that protect water quality . Prioritize areas for enhancement, protection, or possible acquisition. Update zoning maps. (County and City Governments. By 2001)

Step 3: Develop and enforce an ordinance that minimizes the use of impervious surfaces and favors onsite retention or treatment of storm water over downstream water treatment facilities. (Tillamook County and city governments. By 2002.)

Step 4: Develop and enforce an ordinance that sets protection of riparian, wetland,

and natural drainage functions as a priority for new construction.
(Tillamook County and city governments. By 2002.)

Step 5: Develop and implement sanitation standards, as well as erosion control Requirements for construction sites as defined in the CZARA Section 6217(g). (City of Tillamook, Bay City, and Garibaldi.)

Lead Agencies Tillamook County Board of Commissioners and city councils of Bay City, Garibaldi, and City of Tillamook.

Other Partners DEQ, DSL, landowners, developers.

Anticipated Costs Engineering studies: $25,000 - $50,000 each.
Construction: $10,000 - $100,000.
Municipal planning and ordinance development: 0.5 FTE.
Developers will be responsible for much of the cost.

***Action 3**: Ensure Properly Functioning On-site Sewage Disposal Systems*

Step 1: Maintain qualified County staff to administer DEQ on-site inspection program. (Tillamook County. Ongoing.)

Step 2: Conduct annual OSDS surveys using Shoreline Sanitation Survey Methods. Conduct comprehensive surveys on one sub-basin each year, inspecting each at least once every six years.
(Tillamook County. Complete new shoreline survey by 2005.)

Step 3: Coordinate education efforts with the surveys. Print brochures that explain the use, maintenance, and repair of OSDSs.
(Tillamook County. Begin 2000. Ongoing.)

Step 4: Implement CZARA 6217(g) Guidance Management Measures for OSDSs.
(Tillamook County. By 2002.)

Step 5: Institute an ordinance that requires OSDS inspection with sale of property in the County. (Tillamook County. By 2002.)

Step 6: Encourage all property owners within the City of Tillamook UGB to connect to a public sewer system. (TCPP. Ongoing.)

Step 7: Where appropriate, annex properties with failing OSDSs to the sewer system through ORS health hazard standards.(Tillamook County.Ongoing.)

Step 8: Reduce contamination from body wastes by installing a second floating head in Tillamook Bay during peak fishing season and reminding boaters to use the facility. (Port of Garibaldi. By 2001.)

Step 9: Require temporary restroom facilities on all construction sites where public facilities are not located nearby.
(Tillamook County and city governments. By 2001.)

Lead Agencies Tillamook County and TCPP.

Other Partners ODA, DEQ, Oregon Marine Board, city governments, Port of

Garibaldi, real estate sector, landowners.

Anticipated Costs Surveys: $30,000 each

Brochure development/updating: $1,000 per year.
Ordinance development: $25,000.
Sewer annexations: $2,000 - $10,000 per parcel.
Floating head: $50,000 per year.
0.5 FTE DEQ staff cost for 10 years = $250,000.

Goal 2: Reduce Instream Temperatures to Meet Water Quality Standards

Objective: Achieve instream temperatures to meet salmonid requirements by 2010.

Non-Point Sources (Temperature)

***Action 1**: Identify Stream Segments Where Heating Occurs*

Step 1: Using the TMDL process, identify those stream segments where rapid heating occurs, especially for salmonid rearing, spawning, and migration areas. (DEQ. 2000.)

***Action 2**: Analyze Instream Temperatures*

Step 1: Complete an analysis of instream flows on Tillamook Bay tributary streams to determine flow and temperature relationships. Develop a hydrodynamic models to demonstrate this relationship. (OWRD and DEQ. By 2002.)

Lead Agencies OWRD and DEQ.

Other Partners TCPP, ODFW

Anticipated Costs Instream study Costs: OWRD and ***ODFW, 1.0 FTE*** each = $200,000.

***Action 3**: Characterize Riparian and Instream Habitat*
(Refer to Non-point Source Bacteria Management Measures, Action ?.)

***Action 4**: Access and map Riparian and Wetland Habitat*
(Refer to Non-point Source Bacteria Management Measures, Action ?.)

***Action 5**: Prioritize Upland Riparian Protection and Enhancement Sites*

Step 1: Review current ODFW prioritization list based on “ North Coast Stream Project Guide to Restoration Site Selection Phase II (Thom and Moore, 1997). (TCPP. 1999. Ongoing)

Step 2: Prioritize watersheds, applying an ecosystem approach such as the Bradbury Framework. Protect intact aquatic ecosystems identified as aquatic diversity areas (Oregon American Fisheries Society [AFS}), key watersheds (Forest Ecosystem Management Team [FEMAT]), and/or core areas (ODFW). (TCPP. By 2000.)

Step 3: Prioritize additional river reaches sites. (ODFW. By 2001.) Parameters for prioritized site-selection should include:

- core areas
- close proximity to spawning, and rearing habitats;
- stream gradient (<5%);
- channel width (<12 meters);
- valley shape (moderate, not steep or V shaped);
- water quality (e.g. temperature) (See DEQ 303(d) list.);
- water supply (especially during summer months)
- good fish access (no barriers);
- debris torrent-impacted streams; and
- downstream and downslope of landslide-prone areas.

Lead Agencies TCPP
Other Partners ODFW, USFWS, NMFS, ODF, DEQ. BLM, USFS, NRCS, TCSWCD, Tillamook County, watershed councils, landowners.

Anticipated Costs 150 per mile x 200 miles = $30,000.

Action 1: Protect and Enhance Upland Riparian Areas

Step 1: Work to preserve riparian conifers in core areas. Follow guidelines described in the Oregon Plan (OPSW) vor voluntary measures in core areas. Assist with promoting the OPSW restoration guidelines. (ODF and private landowners. Ongoing.)

Step 2: Identify and protect existing high-quality riparian areas in the uplands through strengthened management practices during timber harvest operations, written agreements with landowners, or the purchase of easements. (ODF and private landowners. 2000.)

Step 3: Design and implement riparian enhancement projects on 200 miles of upland streams above 500 feet in elevation. Use ODF/ODFW approved methods. (ODF, TCPP, and private landowners. By 2010.)

Lead Agencies ODF and OFIC

Other Partners ODFW, NMFS, USFWS, DEQ, BLM, USFS, private timber Companies, small woodlot owners, watershed councils.

Anticipated Costs ***$16,860 per mile x 200 miles = $3,372,000.***

Action 2: Protect and Enhance Lowland Riparian Areas
(Refer to Bacteria Non-point Management Measures, Action 9.)

Action 3: Exclude Livestock Access to Streams
(Refer to Bacteria non-point Management Measures, Action ?.)

Action 4: Encourage Protection and enhancement on Private Lands
(Refer to Bacteria Non-point Management Measures, Action ?)

Action 5: Increase Incentive Program Payments

Step 1: Conduct an economic analysis of land use values, and costs. Quantify benefits and costs of riparian enhancement. Determine fair market value for easements and purchases. (NRCS. By 2000.)

Step 2: Communicate findings and recommendations to legislators, USDA and other program managers, and staff for agencies and industry groups. Align program payments with actual land values. (TCPP. By 2000.)

Step 3: Identify additional non-federal funds to supplement land conservation Payments. (TCPP. Ongoing.)

Step 4: Align conservation payments with actual land values and implement Relevant programs, including but not limited to:

- Conservation Reserve Enhancement Program (CREP);
- Conservation Reserve Program (CRP);
- Wildlife and Habitat Incentives Program (WHIP);
- Environmental Quality Incentive Program (EQUIP);
- Wetlands Reserve Program (WRP)
- Oregon Watershed Enhancement Board (OWEB);

Lead Agency NRCS, FSA.

Other Partners TCSWCD, OWEB, dairy farmers, small woodlot owners.

Anticipated Costs Cost to replace feed lost by taking pasture out of production: approximately $1,000/year/acre.
Woodlot costs: site-specific
Staff cost: NRCS 0.5 FTE + $25,000.

Action 6: Ensure Minimum Streamflows
(Refer to Bacteria Non-point Management Measures, Action 17.)

Action 7: Revise Local Ordinances to Increase Protection of Riparian Areas
(Refer to Bacteria Management Measures, Action 11.)

Action 8: Effectively Enforce Laws and Regulations
(Refer to Bacteria Management Measures, Action 12.)

Action 9: Remove or Modify Ineffective Tide Gates
(Refer to Bacteria Management Measures, Action 16.)

Action 10: Reconnect Sloughs and Rivers to Improve Water Flow
(Refer to Bacteria Management Measures, Action 17.)

Point Sources (Temperature)

Action 1: Identify Stream Segments Where Heating Occurs
(Refer to Non-point Source Temperature Management Measures, Action ?.)

Appendix D-2: Description of Permitted Point Sources Discharging to the Tillamook Bay Watershed

The Tillamook Bay Watershed has four domestic wastewater treatment plants (WWTP) which discharge directly to the bay or to streams that empty into the bay. Two sources discharge to the Trask River and two sources discharge directly to the bay:

PORT OF TILLAMOOK BAY:	**TRASK RIVER**	**RM 5.2**
City of Tillamook	Trask River	RM 1.9
City of Bay City	Tillamook Bay	
City of Garibaldi	Tillamook Bay	
Pacific Campground	Smith Creek →Boquist Slough → Wilson River	

(The Tillamook Creamery is a combined domestic and industrial source, which also discharges to the Tillamook Bay Watershed. This source discharges to the Wilson River. The compliance officer for this source is Elliot Zais.)

All five domestic sources disinfect with chlorine except for the City of Bay City who began using UV disinfection in October 1995. Chlorination and UV disinfection generally produce excellent bacteria kills. The WWTP's ability to remove and kill bacteria can be reduced when the hydraulic capacity of the plant is exceeded (during storm events), or when the plant has a temporary upset.

The permit limits for bacteria are based on a geometric mean. Bacteria limits under current permits are a monthly mean of 200 FC/100ml and a weekly mean of 400 FC/100ml except for the City of Bay City which has a monthly mean of 80 FC/100ml and a weekly mean of 160 FC/100ml. Review of the discharge monitoring reports (DMR) show that only the City of Tillamook has had a documented bacteria exceedance in the past five years. The City of Tillamook has had two excursions in the past five years. One was during extremely heavy rains when their plant was hydraulically overloaded, the other was a minor violation with no apparent cause for the bacteria excursion. The tables below summarized the DMR data for the WWTPs. The tables list the geometric mean and the maximum for each month. The City of Garibaldi was not summarized in a table because the maximum fecal count they reported was 4 FC/100ml. Most of their reported numbers were <1 FC/100ml.

All treatment plants appear to be performing their fecal tests properly. The Port of Tillamook is the only plant that has an outside lab perform their tests. The other three analyze their samples in their own labs. Both the City of Tillamook and the City of Garibaldi run positive plates (raw influent) at least once per week to check that their laboratory has the ability to produce positive counts of bacteria. The City of Bay City said they do not currently do this because they have never had troubles growing bacteria. They will begin to run a positive plate now at least once per

Bacteria Source Summary Tables

City of Tillamook		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	Mean	73	21	13	26	17	15	16	37	92	5	14	69
	Max	293	91	491	953	45	272	286	284	960	65	351	864
1995	Mean	9	4	11	8	12	17	31	26	11	14	75	44
	Max	40	39	54	176	106	238	550	303	278	101	452	315
1994	Mean	9	20	7	8	3	5	3	3	32	12	65	15
	Max	53	98	155	46	8	42	58	72	130	213	1000	76
1993	Mean			17	36	3	3	22	179	40	218	9	16
	Max			77	64	63	35	351	275	225	2400	14	53

month.

Port of Tillamook		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	Mean	3	5	3	7	28	3				29	4	
	Max	4	23	3	93	240	3				240	9	
1995	Mean	4	5	7	3	14						8	17
	Max	9	23	93	4	360						23	100
1994	Mean	3	5	6	6	3						3	4
	Max	3	43	35	43	4	0	0	0	0	0	4	9
1993	Mean	4	3	3	3	3							3
	Max	4	3	3	3	3							3
1992	Mean	3	3	3	3	3						3	20
	Max	3	3	3	3	3						3	20

City of Bay City		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1996	Mean	3	9	5	4	3	3	7	2	2	5	14	11
	Max	4	600	8	28	10	6	10	2	2	8	104	35
1995	Mean	4	4	3	3	3	6	20	3		4	4	8
	Max	4	4	3	3	3	6	20	3		9	15	14
1994	Mean	3	3	3	4				15	3	3	3	102
	Max	3	3	3	4				15	3	3	3	240
1993	Mean	39	23	9	9	23	3	3		93		31	7
	Max	39	23	9	9	23	3	3		93		240	7
1992	Mean	3	9	3	3	3				4	3	3	4
	Max	3	9	3	3	3				4	3	3	4

Only one of the four plants currently experience overflows which allow raw sewage to enter its receiving waters. The City of Garibaldi has one known sewer overflow/bypass point which allows raw sewage to be discharged into the bay. When flows exceed the hydraulic pumping capacity at the main pump station, excess flow backs up in the sewerlines and overflows at manhole #3025. A high water alarm is activated and plant personnel will go to the sight and open a bypass gate to avoid raw sewage backing up into nearby residents. Sewage enters into a storm water drainage culvert and eventually enters into the bay. Overflows generally occur when the rainfall exceeds 3-4 inches of rain in a 24-hour period.

The City of Tillamook has no known overflow points in their collection system or a bypass line at their plant, but during hydraulic overloading of their plant they can experience overflows of partially treated sewage into their parking lot. Until just recently, this overflow would drain into a storm drain which discharged to the Trask River. In December 1996, the City plugged this storm drain. Overflows now pool up in the parking lot until the WWTP personnel can clean up the area, alleviating any raw sewage from entering the Trask River.

The Port of Tillamook has a bypass line designed into their facility, but the current operator, who has been there for over eight years, says it has never been used while he has been working there. The City of Bay City has a surge pond which they bypass raw influent to when they are hydraulically overloaded. Then they pump this back into the plant during low flow periods. They have no known sewer overflow points in their collection system.

Summary of Current Facilities

City of Tillamook:

The City of Tillamook WWTP has a winter design flow of approximately 2 mgd. They exceed this regularly throughout the winter months due to excessive infiltration and inflow (I/I) problems. They frequently exceed TSS and BOD limits in their permit when flows exceed 2 mgd. They are currently working under an MAO to upgrade their plant. They are required to meet all permit limits, including chlorine, by May 31, 1998. Within the next year, the City will be upgrading the plant. They will be adding two primary clarifiers, each handling 2 mgd. The current primary clarifier has a design flow of 1.6 mgd. They will also be constructing a new headworks with grit removal, a new muffin monster, and an influent meter. The new clarifiers will alleviate overfows to the parking lot as long as flows remain below about 5.6 mgd. Flows above 5.6 mgd would only occur under severe storm conditions. Additional upgrades are planned after the above improvements can be evaluated. The City of Tillamook WWTP could infrequently exceed their fecal coliform limits in their permit. These exceedances would likely occur under storm conditions when the Trask River has high flows and high background bacteria concentrations resulting from runoff. They have alleviated any raw sewage overflows from reaching the Trask River. The facility would benefit greatly if they could allocate more resources to fixing their I/I problem. This would be an expensive effort.

The City of Garibaldi:

The City of Garibaldi has a average dry weather design flow of 0.5 mgd. Their average summer influent flow from 1993-1995 is approximately 0.2 mgd. In the winter they have peak flows reaching 0.9 mgd. The high winter flows are a result of serious infiltration and inflow (I/I) problems. During the winter they are treating extensive amounts of storm water. They are currently under an MAO to alleviate their I/I problems and to upgrade the facility. The City is currently performing an I/I study on their collection system. The City is ordered to have all I/I work complete by the fall of 1998. This I/I work includes the elimination of all overflows of untreated sewage, except during rain events as allowed under the OARs. This will eliminate the overflows that currently occur at manhole #3025 except under extreme rain events. This will also reduce excessive flows to their plant during the winter and will enhance their ability to treat sewage during the winter months. By the summer of 2001, they are ordered to comply with all permit requirements, state and federal regulations, and water quality standards.

The City of Bay City:

Their plant was built in 1995 and running smoothly with no apparent problems. Their influent averages around 0.2 mgd during the winter and their effluent averages around 0.4 mgd. During the summer the influent is around 0.1 mgd and the effluent is less than 0.1 mgd.

The Port of Tillamook:

Due to the age of the collection system and local shallow groundwater conditions, more than 95% of the wastestream is groundwater and surface runoff. Their treatment plant consists of two facultative lagoons. After the final lagoon, the effluent receives chlorine disinfection and then discharges to the Trask River. The Port of Tillamook is in the middle of a facilities upgrade to correct the current deficiencies in the system (particularly the I/I problem). They are currently operating under an SFO which requires wastewater system improvements to be completed by November 1, 1997. (STEP) system. They will have new pipes throughout the system which will alleviate their I/I problems.

Pacific Campground:

The wastewater system was built in the early 80's to replace a failing on-site system. The facility consists of a Bio-pure Batch Reactor (package plant) with chlorine disinfection and UV disinfection. It serves a 28-space RV park, campground and a single permanent residence. During the summer months the effluent is discharged to a drainfield and during the winter it is discharged to Smith Creek, which enters Boquist Slough which eventually drains to the Wilson River about one mile upstream from the bay. Average effluent flows reported on their monthly DMRs are about .0025mgd.

Appendix D-3 Acronym List

AWQM	Agriculture Water Quality Management (program or Act)
AWQMA	Agricultural Water Quality Management Area (plan)
BMP	Best Management Practice
CAFO	Confined Animal Feeding Operations
CCMP	Comprehensive Conservation Management Plan
CWA	Clean Water Act
DLCD	Department of Land Conservation and Development (state)
DMR	Discharge Monitoring Report
DO	Dissolved Oxygen
DOGAMI	Department of Geology and Mineral Industries (state)
DSL	Division of State Lands (state)
EIS	Environmental Impact Statement (federal)
LAC	Local Advisory Committee
LWD	Large Woody Debris
MAO	Mutual Agreement and Order
MOU	Memorandum of Understanding
NMFS	National Marine Fisheries Service (federal)
NOAA	National Oceanic and Atmospheric Administration (federal)
NPS	Nonpoint Source
NRCS	Natural Resource Conservation Service (federal)
ODOT	Oregon Department of Transportation (state)
OEDD	Oregon Economic Development Department (state)
OPSW	Oregon Plan for Salmon and Watersheds (state plan)
OSMB	Oregon State Marine Board (state)
OSP	Oregon State Police
OWEB	Oregon Watershed Enhancement Board
PLFN	Private Lands Forest Network
RHCAs	Riparian Habitat Conservation Areas
RMO	Riparian Management Objective
SWCD	Soil and Water Conservation District
TBNEP	Tillamook Bay National Estuary Project
TCPP	Tillamook County Performance Partnerships
TCWRC	Tillamook County Watershed resource Center
TCSWCD	Tillamook County Soil & Water Conservation District
TCCA	Tillamook County Creamery Association
USACOE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WPCF	Water Pollution Control Facility (permit)
WQL	Water Quality Limited
WQS	Water Quality Standards

APPENDIX E: TILLAMOOK MANAGEMENT PLAN FOR COMMERCIAL SHELLFISH HARVESTING

OREGON DEPARTMENT OF AGRICULTURE
Tillamook MANAGEMENT PLAN
FOR COMMERCIAL SHELLFISH HARVESTING
Revised 5/00

I. **Classification of Shellfish Growing Areas in Tillamook Bay (see map)**

A. All waters lying east and south of a line running from Boulder Point, through the northern most dolphin in the upper bay channel and going onto the shore at 400 yds north of the Bay City breakwater road are classified "Prohibited" and designated the **"Upper Bay Prohibited Area"**. This closed area encompasses the waters at the entrance of the Bay City breakwater and the northern most dolphin, in addition to the entire upper bay.

B. A triangular shaped area designated the **"Flower Pot Restricted Area"** is created by a line running south and west from the northern most dolphin in upper bay channel along the north side of the "Upper Bay Prohibited Area"; and bounded on the north and west by a line running from the east shore at 400 yds north of the Bay City breakwater road south and west to the turnaround on Bay Ocean Road at Flower Pot Slough on the west shore. Relay permits may be issued for this area after required verification studies.

C. The area immediately north and west of the "Flower Pot Restricted Area" is designated **"Cape Meares Conditionally Approved Area".** This area is bounded on the north and west side by a line running from Sandstone Point south and west to breakwater road to Kincheloe Point at 600' prior to the gate.

D. The area designated the **"Main Bay Conditionally Approved Area"** is north and west of the "Cape Meares Conditionally Approved Area" described above line and bounded on the north by a line that extends from the 1st dolphin 300 yards south of Hobsonville Point across the bay and **just north of** navigational marker "12" to the shore on Kincheloe Pt

E. **Within the "Main Bay Conditionally Approved Area" a special area designated the "West Bay Area" is described as the state leases lying north of a line drawn from the parking lot at the end of Bayocean Dike Rd directly across the Bay to Sandstone Point, AND west of the South Channel. Leases included are numbers 14, 7, 17,12, 11,16 and the NE corner plat of lease 1, see attached map.**

E. All waters north and west of a line drawn north of Kincheloe Point through navigational marker #10, to the opposite shore are designated the **"Lower Bay Conditionally Approved Area".**

F. All waters north and east of a line drawn from the 1st dolphin 300 yards south of Hobsonville Pt across the bay and **just to the north of** navigational marker "12" to the shore on Kincheloe Pt, excluding the Lower Bay area west of navigational marker "10" are classified as **"Lower Bay Prohibited Area".** This closed area is the buffer zone for discharges from the City of Garibaldi, marinas and urban runoff. This closed area is also required to allow harvester notification time in the event of a sewage spill.

II. **Tillamook Bay Closures for Predictable Conditions**

To comply with US Food and Drug Administration standards for shellfish growing waters Tillamook Bay will be closed when conditions can be predicted to cause fecal coliform counts over the standard in shellfish growing areas. Tillamook Bay will be temporarily closed by the following criteria:

A. When the Wilson River gauge rises to 7 feet (2500 CFS), all Main Bay, Lower Bay and Cape Meares conditionally approved areas shall be closed.

B. When there is more than 1.0" of rain within a 24-hour period the Cape Meares Conditionally Approved area shall be closed. The "Main Bay" conditionally approved area will remain open provided the Wilson River gauge does not rise and peak above 7 feet and there is not a sewage or toxic spill during the rainfall closure.

The National Weather Service (NWS) provides weather information 24 hours a day on FM 162.55. Reports give a 3-day forecast for Western Oregon rivers including the Wilson River. Oregon river information is also available at 1-503-249-0666 or on the NWS Hydrology web page. Rainfall is taken by KTIL Radio at 4 p.m. daily.

III. Tillamook Bay Closures Due to Sewage Spills, Toxic Material Spills, Marine Biotoxins or Catastrophic Events

The Department of Agriculture is the State agency responsible for closing bays to the commercial shellfish industry and advising recreational shellfish harvesters. Oregon Department of Fish and Wildlife,(ODF&W), administrative rules require the closure of recreational shellfishing whenever a state agency issues a health advisory. Bay closure procedures will be initiated when any one of the following conditions occur:

A. When a sewage spill of such magnitude to affect water quality and shellfish operations occurs, the Department will close the bay to commercial shellfish harvesting and will provide notice to recreational harvesters;

B. If there is a toxic material spill or contamination of a magnitude to affect shellfish or growing waters, the Department will close the growing area to commercial harvesting of shellfish and provide notice to recreational harvesters;

C. When flooding occurs which is determined to impair the adequate treatment of sewage from subsurface sewage treatment systems on the bay;

D. When marine biotoxins in the edible portion of shellfish are determined to be near or above the alert levels established by the US Food and Drug Administration (FDA).

IV. Closure Notification of Commercial Shellfish Dealers

A. The Department shall notify all commercial shellfish dealers operating in the area when the shellfish growing area is closed for a predictable (see II.) or non-predictable reason (see III.). Written confirmation will be sent to certified commercial shellfish growers, harvesters and distributors who are currently certified to operate and have designated Tillamook Bay as an area where they harvest or buy product.

B. All commercial shellfish harvesting of the shellfish growing area shall cease during closures. Any shellfish harvested during a closure shall be considered unfit for human food and shall be returned to the growing area, processed by an approved method to destroy harmful bacteria (such as canning or smoking) or subject to embargo, according to Oregon Revised Statutes (ORS) 622.

C. Certified dealers who have not informed the Department of their activity in a managed shellfish area and are therefore not contacted during closures may be subject to enforcement action if they harvest shellfish for human consumption during a commercial closure.

V. Length of Closures for Tillamook Bay

A. The length of closure for sewage, toxic materials spills, or flood events (see III.) is variable and will consider the time needed for water conditions to return within shellfish growing water standards based on such factors as: the volume of sewage or toxic material spilled; the location of the spill; tides; and rainfall. Water quality sample results may be used to determine if standards are met.

B. The length of closure for marine biotoxin contamination of shellfish is variable and will be based on testing and whether toxin levels have dropped below alert levels.

C. The length of closure for predictable conditions (see II.) under the Tillamook Bay Management plan will be based on water quality and shellfish meat samples taken after such a condition occurs. The length of closure for the predictable conditions in Tillamook Bay are:

1. The "Main Bay" and "Lower Bay" conditionally approved areas will be reopened 5 days after the peak of the Wilson River Flow. When there is a peak in river flow that exceeds the immediately previous peak in river flow, the reopening of the conditionally approved areas will be timed from that peak.

2. **The "West Bay" area of the "Main Bay" may be reopened 4 days after the peak of the Wilson River Flow provided the peak does not exceed 13', and the closure occurs after February 1 of the winter season.**

3. The "Cape Meares" conditionally approved area will be reopened 7 days after the peak of the Wilson River Flow or a rainfall event exceeding 1.0" in 24 hours, provided that rainfall during the 7 day period has been below 1.0" during any 24-hour period or until there is sufficient evidence to indicate that approved shellfish sanitation standards have been met.

VI. **Reopening the Tillamook Bay Following Closure**

A. Reopening of the shellfish growing areas for any closure initiated under this plan is the responsibility of the Department. The Department will notify: 1) state agencies; 2) local agencies; 3) commercial shellfish dealers and 4) local media (if applicable) when the shellfish growing areas are reopened. Written confirmation shall be sent.

B. If the river, rises over 2', after an initial closure peak, but does not exceed the first peak, the period of rise will be subtracted from the closure length. In no case can the area be reopened if the river remains above 7.05' feet.

VII. Authority for Tillamook Bay Management Plan

A. ORS 622 states the Department shall have authority to insure the sanitary production of shellfish. Oregon Administrative Rule's (OAR's) for shellfish sanitation give the Department the authority to classify and close commercial shellfish growing waters and control harvest of commercial shellfish when growing waters exceed standards. This plan sets a procedure to be followed by the Department and certified shellfish dealers when the growing waters exceeds those standards.

B. Any certified shellfish dealer who fails to follow the procedures of this plan shall be considered to have violated the above OAR's and will be subject to the penalties set forth in ORS 622.992.

VIII. Modifications to the Tillamook Bay Management Plan

A. Modifications to this plan may be presented to the Department by any party to the plan. Such proposals shall be reviewed by the Department. Local task forces and may review proposals and make recommendations. The Department has final authority over any plan changes. Contested issues shall be resolved according to ORS 183.

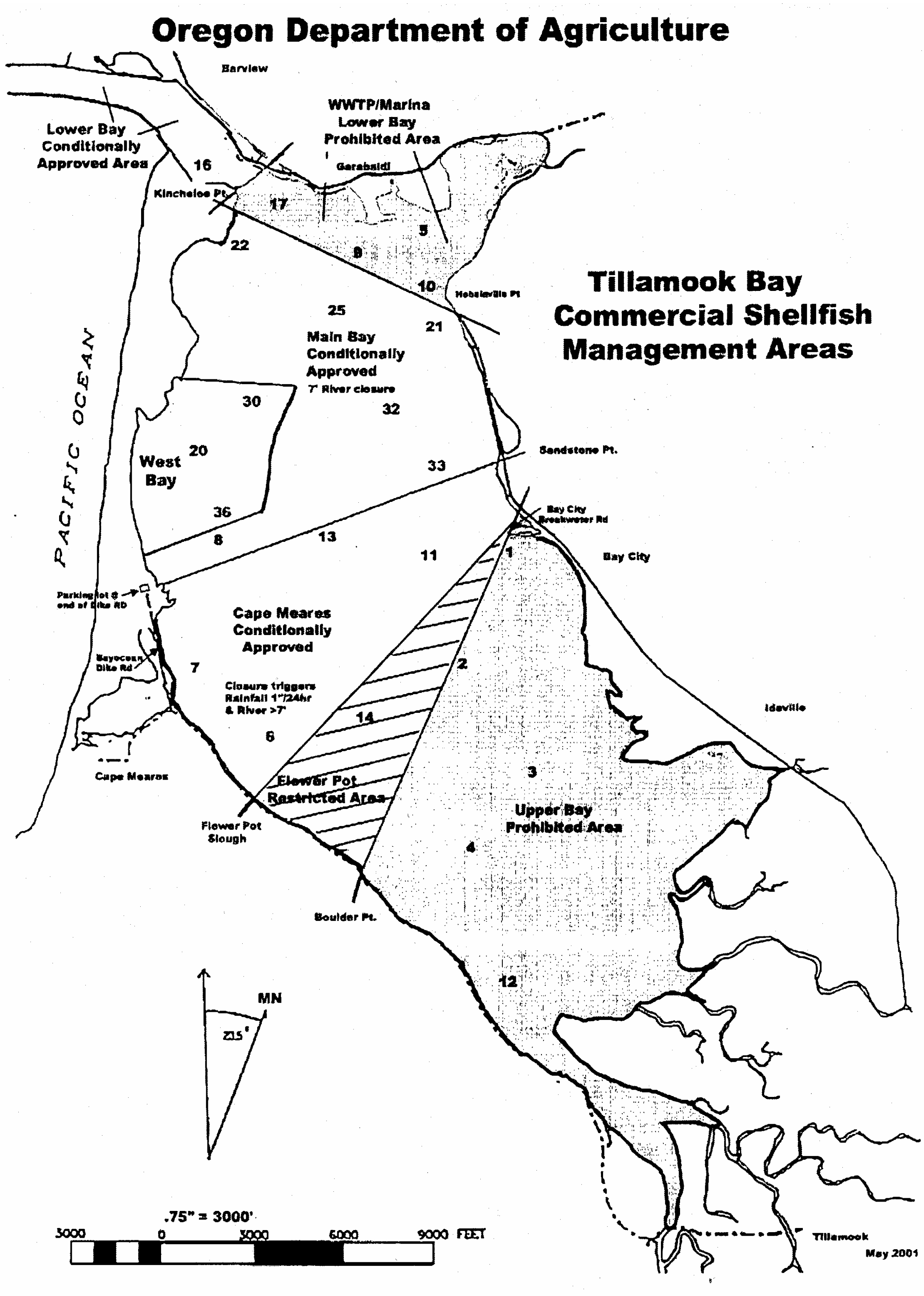
B. Reductions of pollution sources and improvement in Tillamook Bay shellfish growing water quality trends may lead to modifications of this plan.

IX. Tillamook Bay Notification List

A. When predictable closure conditions of the type written in this management plan occur the Shellfish Program Specialist shall implement the plan actions and notify: state, federal and local agencies and commercial shellfish dealers designating Tillamook Bay as an area of operation.

B. When a non-predictable closure condition occurs as described in this management plan (see III.), the shellfish program specialist will determine if a commercial closure is required and take actions to control harvest, including closure and recalls if needed.

C. If any event is determined to have an adverse effect on recreational shellfish harvest areas, thus posing a potential health hazard to recreational shellfish consumers, the shellfish program specialist shall notify recreational shellfish harvesters. Notification will be coordinated with Oregon Department of Fish and Wildlife and provided to local county health departments.


Oregon Department of Agriculture
Tillamook Bay
Commercial Shellfish
Management Areas
Barview
WWTP/Marina
Lower Bay
Prohibited Area
Garabaldi
Lower Bay
Conditionally
Approved Area
Kincheloe Pt.
Main Bay
Conditionally
Approved
7' River closure
Sandstone Pt.
West
Bay
Bay City
Breakwater Rd
Bay City
Cape Meares
Conditionally
Approved
Closure triggers
Rainfall 1"/24hr
& River >7'
Idaville
Cape Meares
Flower Pot
Restricted Area
Flower Pot
Slough
Upper Bay
Prohibited Area
Boulder Pt.
PACIFIC OCEAN
MN
.75" = 3000'
3000 0 3000 6000 9000 FEET
Tillamook
May 2001