Tualatin Subbasin TMDL

Chapter 2
pH and Chlorophyll a (Total Phosphorus) TMDL Amendment

August 2012

State of Oregon
Department of Environmental Quality

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2.1 Summary of TMDL Development and Approach

This Section provides a summary of the Total Maximum Daily Load elements in Table format.

Table 2-1. Tualatin River Subbasin pH and Chlorophyll *a* (Phosphorus) TMDL Components

WATERBODIES OAR 340-042-004(4)(A)	All stream segments within the Tualatin River Basin, 4th field HUC (hydrologic unit code) 17090010 as well as the Oswego Lake subbasin including tributaries to the Lake.
POLLUTANT IDENTIFICATION OAR 340-042-004(4)(B)	<u>*Pollutants*</u>*:* Human caused increases of instream phosphorus concentrations have been shown to contribute to exceedances of the pH criteria, chlorophyll *a* threshold values, and low dissolved oxygen following algal bloom conditions.
BENEFICIAL USES OAR 340-042-004(C) OAR 340-041	Salmon & Trout Rearing and migration, Salmon & Steelhead spawning use, and resident fish and aquatic life, water supply, water contact recreation, aesthetic quality.
TARGET IDENTIFICATION **(Applicable Water Quality Standards)** ***CWA §303(d)(1)*** ***OAR 340-041-0019*, Nuisance Algae;** ***OAR 340-041-021*** **Willamette Basin pH:** ***OAR 340-041-0345***	Contained in: The Nuisance Phytoplankton Growth Rule (OAR 340-041-0019 sections 1 – 3, this section requires an evaluation of the need for an algae management plan when riverine chlorophyll *a* exceeds 0.015 mg/L), and; The relevant text of OAR 340-041-0345 (for pH): *pH (hydrogen ion concentration): pH values shall not fall outside the ranges identified in paragraphs (a) of this subsection: All other basin waters (except Cascade lakes): 6.5 – 8.5* *OAR 340-041-0021 pH: The following exception applies: Waters impounded by dams existing on January 1, 1996, which have pHs that exceed the criteria shall not be considered in violation of the standard if DEQ determines that the exceedance would not occur without the impoundment and that all practicable measures have been taken to bring the pH in the impounded waters into compliance with the criteria:*
EXISTING SOURCES OAR 340-042-040(4)(F) CWA §303(D)(1)	Agriculture, Forestry, Rural Residential, Transportation, Urban, Waste Water Treatment Facilities
SEASONAL VARIATION OAR 340-042-040(4)(F) *CWA §303(D)(1)*	The potential for excessive algal growth and resulting pH criterion violations occurs predominately in the summer. Phosphorus control from point sources for algal growth is necessary from May through mid September, or later depending on water diversion to Oswego Lake. Phosphorus control from runoff into Oswego lake is necessary year-round.
TMDL **LOADING CAPACITY AND ALLOCATIONS** OAR-340-042-0040(4)(E) OAR 340-042-0040(G) OAR 340-042-0040(4)(H) 40 CFR 130.2(F) 40 CFR 130.2(G) 40 CFR 130.2(H)	<u>*Loading Capacity:*</u> Based on background phosphorus concentrations, phosphorus loading capacities listed in **Table 2.5** and **2.6** were developed for specific stream segments. <u>*Waste Load Allocations (Point Sources)*:</u> WLAs for point sources other than WWTPs are presented in **Tables 2.10, 2.11** and **2.12**. WLAs for the WWTPs are presented as phosphorus concentrations in **Table 2.13**. <u>*Load Allocations (Non-Point Sources)*:</u> LAs are presented as loads in **Tables 2.14, 2.15, 2.16,** and **2.17**.
MARGINS OF SAFETY OAR 340-042-0040(I) CWA §303(D)(1)	An Implicit Margin of Safety was demonstrated in critical condition assumptions and is inherent to methodology
WATER QUALITY STANDARD ATTAINMENT ANALYSIS CWA §303(D)(1)	Attainment of the pH standard is determined through the analysis of current and historical system response to phosphorus concentrations.

WATER QUALITY TRADING ORS 468B.555 40CFR122.4(I)	Phosphorus load trading is allowed between individual sources and sectors provided that all applicable water quality criteria are attained and sufficient legal or other mechanisms are put in place that ensure the trade will be implemented as designed.

2.2 Amending the 2001 Phosphorus TMDL

This Section describes the reasons for amending the existing Total Maximum Daily Load.

DEQ issued a Phosphorus TMDL order that was approved by EPA in August 7, 2001. The 2001 TMDL was a revision of a previous Phosphorus TMDL adopted in 1988. The initial Total Maximum Daily Load (TMDL) was developed to address the mainstem Tualatin River chlorophyll *a* and associated pH violations in 1988.[1] These impairments occurred in the lower Tualatin River, but phosphorus controls were necessary throughout the basin to improve conditions in the lower River. The purpose of this TMDL amendment is to update the 2001 TMDL to include waste load allocations for additional pollutant sources, to provide the daily load equivalents for the monthly 2001 TMDL targets in order to comply with current EPA requirements, and to modify the time periods that the TMDL applies to the waste water treatment facilities. Public comment was accepted only for the proposed amendments to the 2001 TMDL, and not to the already adopted allocations of the 2001 TMDL. However, previously adopted allocations have been included in this document to allow the reader to access all of the allocation values in a single document.

The 1988 TMDL identified total phosphorus concentrations using water quality models that would lower Chlorophyll *a* concentrations below the action level of 0.015 mg/L, and lower elevated pH values to between 6.5 and 8.5, the range allowed in OAR 340-41-0345. Based on subsequent water quality information, the 1988 TMDL target concentrations were found to be lower than estimates of background phosphorus concentrations in the basin. Due to this difficulty in achieving the 1988 TMDL targets, the 2001 TMDL revised the total phosphorus allocations commensurate with background phosphorus concentrations. Both TMDLs were developed to address elevated Chlorophyll *a*[2] concentrations and pH violations. The affected reaches are now included on Oregon's 303(d) list as having a TMDL approved for Chlorophyll *a*, phosphorus and pH. Water quality data from the lower Tualatin River show that total phosphorus concentrations meet the 2001 TMDL allocations, and violations of pH no longer occur in this reach.

This current TMDL amendment draws heavily on the success of the 2001 TMDL. The TMDL is being amended to include waste load allocations for new summertime discharge sources on the mainstem Tualatin River, to clarify the load allocations for applicable sites, and to allow trading of total Phosphorus allocations. The concentration-based allocations in the 2001 TMDL for Chlorophyll and pH are unchanged in this amendment. However, in addition to maintaining the seasonal median allocation values, this TMDL will also clarify the daily load equivalent for those allocations.

This TMDL amendment addressing excess chlorophyll *a* and high pH values relies heavily on the 2001 TMDL, maintaining the same in-stream target concentration, load and wasteload allocations for total phosphorus in the lower Tualatin River. This amendment adds waste load allocations for two additional waste water treatment plants run by Clean Water Services, one at Forest Grove, and one in Hillsboro. These two sites do not currently discharge during summer. In order to accommodate growth in the basin,

[1] The initial phosphorus TMDL was in the form of instream compliance concentrations, and originally adopted into rule. In 2001 these rules were rescinded, and the TMDL revision was adopted as an order from the Department of Environmental Quality. The1988 TMDL language can be found in Appendices to the 2001 TMDL (OAR 340-041-0470 [9][a], Appendix C-2 and mass load allocations TMDL Number 22M-02-004, Appendix C-3).

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

these two plants may begin discharging to the Tualatin River during the summer. Currently they divert summer discharges to the Rock Creek Plant for advanced treatment which is then discharged to the Tualatin River near the mouth of Rock Creek. This TMDL will also outline options for trading total phosphorus loads among three of the four Clean Water Services waste water treatment plants. In addition, the 2001 TMDL did not specify a load allocation for Wapato Creek, but instead included it by reference with all tributaries to the Tualatin River upstream of Dairy Creek. This load allocation will be clarified, and additional parties responsible for management at Wapato Lake will be identified in the Water Quality Management Plan, found in Chapter 4.

2.3 Geographic area and waterbodies addressed

This element describes the geographic area for which the TMDL is developed and applies to the following stream segments of the Willamette Basin

This phosphorus TMDL amendment to the 2001 Tualatin Phosphorus TMDL addresses all perennial and intermittent streams in the Tualatin Basin. The basin is identified in OAR 340-41-0340, Figures 340A and 340B, and is also known as the 4th field hydrologic unit code (HUC) 17090010. Therefore, it addresses the entire Tualatin Subbasin.

Oswego Lake watershed is adjacent to the Tualatin Basin to the southeast. Oswego Lake and Creek were historic Tualatin River channels, and drain into the Willamette north of the current mouth of the Tualatin River. Oswego Lake is 60 feet deep with a dam that is only 22 feet high. The more shallow Lakewood Bay, 35 acres of the 415 acre total, was originally a wetland. The lake was formed in the Missoula floods and was scoured to over 100 feet deep. The lake was enhanced by digging a canal from the modern-day Tualatin River, creating a diversion structure in the Tualatin River, and damming the outlet of Oswego Lake. The Lake Oswego Corporation manages Oswego Lake and holds a water right from the Tualatin for hydroelectric generation at the outlet of Oswego Lake. This shallow lake has historically received much of its water from the phosphorus-containing Tualatin River, and has long experienced water quality problems associated with algal blooms and aquatic weeds. This small basin, while not technically a part of the Tualatin Watershed Basin, is included in this Phosphorus TMDL because of the importance of Tualatin River water to the water quality of the lake. A map of Oswego Lake and its watershed is included in **Figure 2-1**, and **Table 2-3** below summarizes the water quality impairments that have been documented in Oswego Lake. Load and Waste Load Allocations for sources to Oswego Lake included in this TMDL apply to the entire Oswego Lake basin. TMDLs for temperature, bacteria and mercury for Oswego Lake are included in the Willamette Basin TMDL.

Water Quality Limited Streams in the Tualatin and Oswego Lake Basins that were identified in the 2004/2006 303(d) list are shown in **Figure 2-1** and **Tables 2-2** and **2-3.** The 2001 Tualatin Phosphorus TMDL has a more detailed discussion on phosphorus conditions in the Tualatin and its major tributaries (particularly Sections 4.4.3 Condition Assessment, and 4.4.4 Beneficial Use Impairment, of the 2001 TMDL), which is not repeated here.

Figure 2-1. 2004/2006 303(d) List for Phosphorus, pH or Chlorophyll *a* (Bolded Green Lines) in the Tualatin and Oswego Lake Subbasins

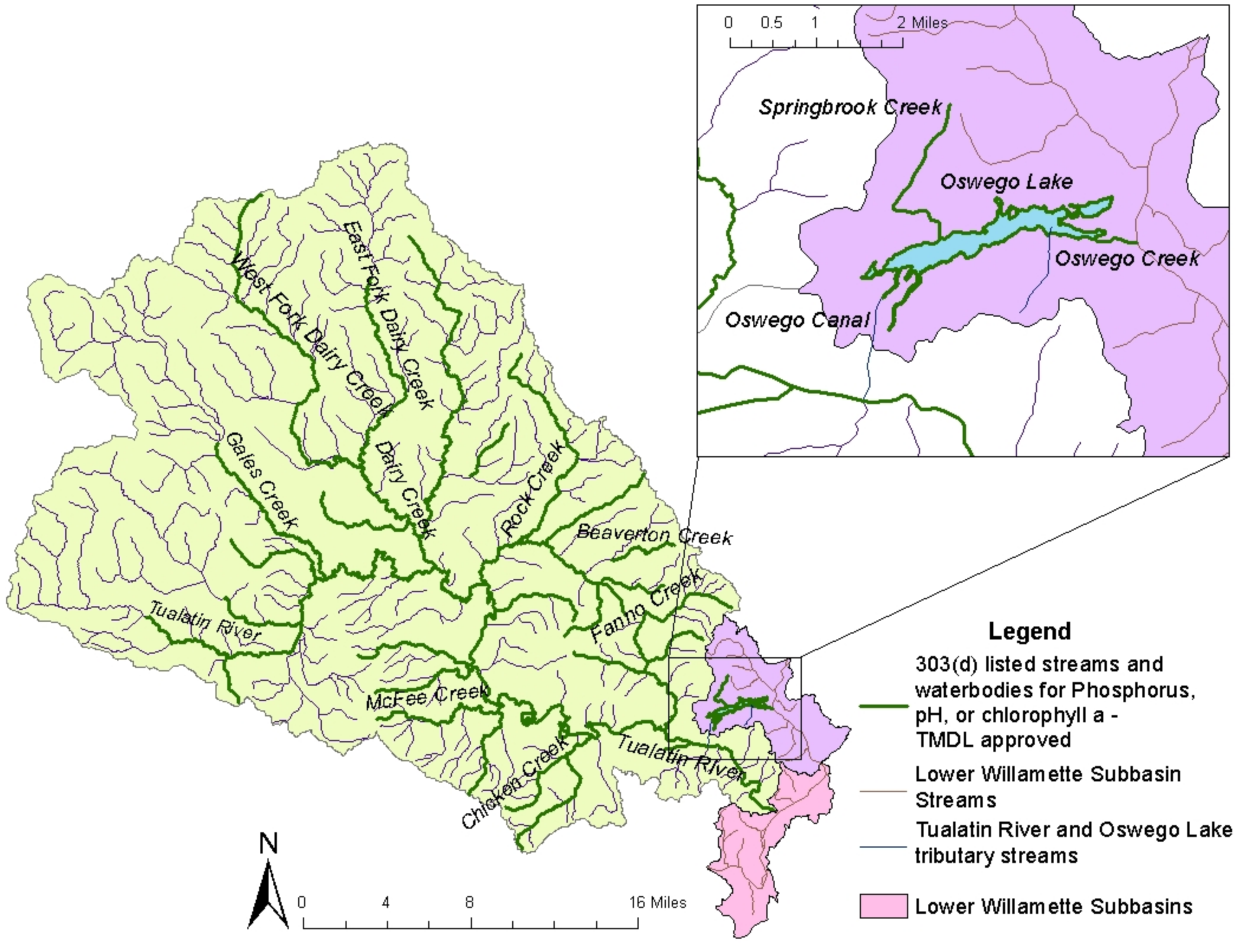


Table 2-2. Tualatin River Subbasin Stream Segments on the 2004/2006 303(d) List for Chlorophyll *a,* pH or Phosphorus

Stream Name	River Miles Listed	Parameter listed; TMDL Approved	Season
Ash Creek	0 - 3.7	Phosphorus	June 1-September 30
Beaverton Creek	0 - 9.8	Phosphorus	June 1-September 30
Bronson Creek	0 - 6.5	Chlorophyll *a*, Phosphorus	June 1-September 30
Burris Creek	0 - 6.0	Chlorophyll *a*, Phosphorus	June 1-September 30
Butternut Creek	0 - 5.3	Phosphorus	June 1-September 30
Carpenter Creek	0 - 6.3	Phosphorus	June 1-September 30
Cedar Creek	0 - 6.8	Chlorophyll *a*, Phosphorus	June 1-September 30
Chicken Creek	0 - 7.0	Phosphorus	June 1-September 30
Christensen Creek	0 – 6.4	Phosphorus	June 1-September 30
Council Creek	0 – 6.2	Phosphorus	June 1-September 30
Dairy Creek	0 – 10.1	Phosphorus	June 1-September 30
Dairy Creek, East Fork	0 – 13.5	pH, Phosphorus	June 1-September 30
Dairy Creek, West Fork	0 – 23.7	Phosphorus	June 1-September 30
Fanno Creek	0 – 13.9	Phosphorus	June 1-September 30

Stream Name	River Miles Listed	Parameter listed; TMDL Approved	Season
Gales Creek	0 – 11	Phosphorus	June 1-September 30
Heaton Creek	0 – 5.2	Phosphorus	June 1-September 30
Johnson Creek - North (Cedar Mill Creek)	0 – 3.7	Phosphorus	June 1-September 30
Johnson Creek - South (Beaverton Creek)	0 - 4	Phosphorus	June 1-September 30
McFee Creek	0 – 8.3	Phosphorus	June 1-September 30
McKay Creek	0 - 22.7	Phosphorus	June 1-September 30
Rock Creek	0 – 18.2	Chlorophyll *a*, Phosphorus	June 1-September 30
Summer Creek	0 - 4	Phosphorus	June 1-September 30
Tualatin River	0 – 44.7	Chlorophyll *a*	Fall/ Winter/ Spring
Tualatin River	0 – 69.9	Chlorophyll *a*, Phosphorus	June 1-September 30
Warble Creek	0 – 3.4	Phosphorus	June 1-September 30
Williams Canyon Creek	0 – 2.4	Phosphorus	June 1-September 30

Table 2-3. Oswego Lake Watershed. Subbasin Stream Segments on the 2004/2006 303(d) List for Aquatic Weeds, Dissolved oxygen, pH or Phosphorus

Stream Name	River Miles Listed	Parameter listed; TMDL Approved	Season
Oswego Creek/ Oswego Lake	0.7 – 3	Aquatic Weeds or Algae	Summer
Oswego Creek/Oswego Lake	0.7 – 3	Dissolved Oxygen	Summer
Oswego Creek/Oswego Lake	0.7 – 3	pH	May 1-October 31
Oswego Creek/Oswego Lake	0.7 – 3	Phosphorus	Spring/Summer/Fall
Spring Brook Creek	0 – 2.3	Phosphorus	May 1-October 31

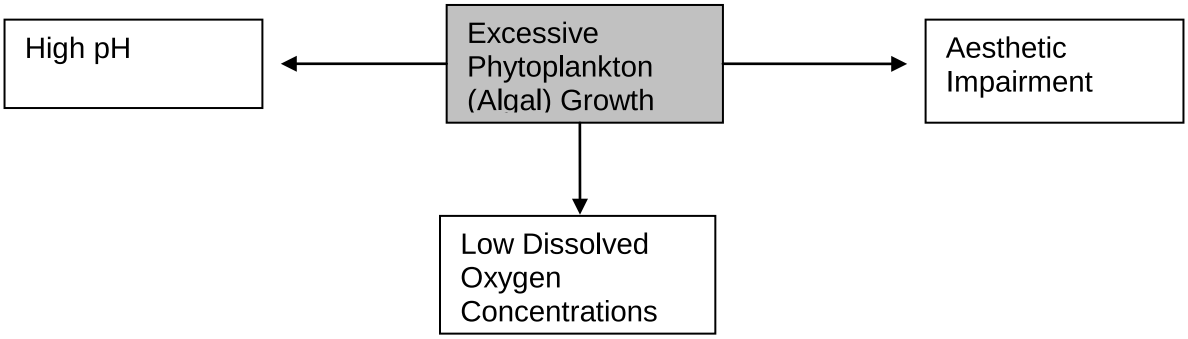
2.4 Pollutant Identification

This element identifies the pollutant causing the impairment of water quality addressed in this TMDL.

Historically, the Tualatin River was a common destination for summertime recreation. However, by the 1970’s and 80’s excessive algal growth had become common, and affected aesthetics, reduced water clarity, and restricted contact recreation. As described in more detail below, algal blooms can lead to high pH values and large daily swings in dissolved oxygen concentrations, both of which had also been observed in the lower river. In the Tualatin Basin, the TMDL for Total Phosphorus was adopted to address the pH violations, and the Dissolved Oxygen TMDL was adopted to address dissolved oxygen violations. Both of these 2001 TMDLs are amended here to provide waste load allocations for additional summer discharges. However loading capacities in the lower river are not amended by this TMDL, so the waste load allocations in the lower river where pH, chlorophyll and dissolved oxygen impairments have occurred historically are not being changed by this amendment. To some extent the Total Phosphorus TMDL contributes to improved dissolved oxygen conditions because nuisance algae blooms are controlled.

Figure 2-2 was presented in the 2001 TMDL (DEQ 2001), and presents a simplified schematic of the relationship between excessive algal growth and common related water quality impairments

Figure 2-2. Simplified Schematic of Possible Impacts of Excessive Algal Growth



Many streams experience excessive algal growth due to excessive solar radiation levels, high temperatures, high nutrient concentrations, and low flows. Excessive growth of algae and other autotrophs in natural waters can result in significant diel fluctuations in dissolved oxygen and pH which may adversely impact aquatic life. Autotrophs are organisms that obtain energy from sunlight and their materials from non-living sources (Allan, 1995). In streams, autotrophs include periphyton, phytoplankton, and macrophytes. Periphyton consists of algae and other small autotrophs that are attached to substrate, such as submerged rocks and vegetation. Phytoplankton are algae and other small autotrophs which are suspended in the water column. While they can dominate slow moving rivers and lakes, they generally are not present in significant quantities in fast flowing streams since their reproduction rates are low relative to retention times. Macrophytes include large vascular plants and bryophytes (mosses and liverworts).

Algae and other autotrophs impact pH and dissolved oxygen levels as they grow and respire. During the day, algae perform photosynthesis using sunlight and carbon dioxide to produce sugars, and release oxygen as a by-product. All algal cells respire, which is the process of using oxygen to utilize sugars for energy. Carbon dioxide is released as a by-product. Respiration occurs at a relatively constant rate both day and night, while photosynthesis occurs only under conditions of sufficient light. The net result is that during the day photosynthesis can occur at a greater rate than respiration, and increase water column concentrations of oxygen while decreasing carbon dioxide concentrations. At night respiration decreases oxygen concentrations and increases carbon dioxide concentrations.

Carbon dioxide, when introduced into an aqueous solution, combines with water to form carbonic acid (Chapra, 1997). The carbonic acid in turn dissociates into ionic form, releasing a hydrogen ion and consequently lowers the pH. Therefore, during the day as algae consume carbon dioxide pH increases, while at night algae produce carbon dioxide and pH decreases. Through this process algae can cause large diurnal fluctuations in both dissolved oxygen and pH which may result in water quality standards violations. Low oxygen levels can suffocate aquatic organisms, while excessively high or low pH levels can cause toxic effects ranging from growth and reproduction limitations to death.

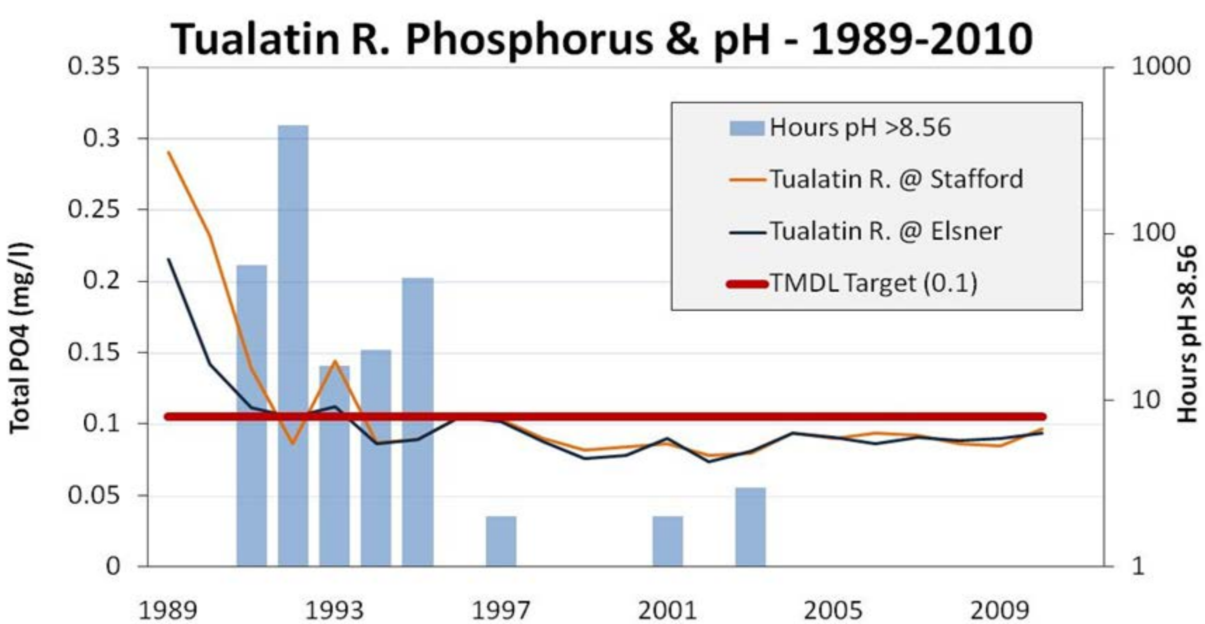
Algae can also impact DO when it dies, settles to the stream bottom, and decays. Consumption of oxygen by decaying algae can contribute to sediment oxygen demand (SOD), particularly in deep, quiescent zones prone to algal deposition. While this mechanism can have an impact on water quality, in the Tualatin River TMDLs, dissolved oxygen is addressed under a separate TMDL, found in Chapter 4 of the 2001 TMDL (DEQ 2001), and amended here in Chapter 3 of this document. Chapter 3 includes a short summary of current dissolved oxygen conditions in the lower Tualatin River.

Algal growth is commonly limited by the nutrients available to support growth. Extensive data collection and modeling for the 1988 TMDL demonstrated that total phosphorus levels had a large influence on algal populations, such that limiting total phosphorus concentrations in water should reduce the incidence and density of algal blooms. Using water quality models, DEQ identified total phosphorus limits for streams in the Tualatin Watershed for the 1988 TMDL. During the 1970's sewage was rerouted to new and updated treatment plants, and smaller plants in the basin were closed. In the 1980's and 1990's extensive efforts were made to decrease erosion as a main source of phosphorus from agricultural land, and changes were made to better manage stormwater across the basin.

During the 1990's, additional data were collected, and the USGS revised the water quality model, using a model that allowed further investigation of the relationship between phytoplankton growth and other factors. This modeling indicated that water temperature, travel time in the river, and incident solar radiation are the primary factors affecting the timing and extent of algal blooms on the river. The model predicts that substantial decreases in phosphorus concentrations would help limit the size of algal blooms (Rounds *et al*, 1999). However the additional data collected also showed that background concentrations of total phosphorus estimated from summer low flow seasons, when the main source of stream water is groundwater, were higher than the total phosphorus levels set in the 1988 TMDL (see Appendix C-2, DEQ 2001). Thus the 1988 TMDL targets for total phosphorus were lower than what could occur naturally during the critical summer season. The 2001 TMDL revised the total phosphorus TMDL targets upward to levels equal to the naturally occurring background concentrations.

Total phosphorus concentrations in Tualatin streams have declined since the adoption of the 1988 TMDL (**Figure 2-3**). The occurrence of pH violations has markedly declined in the same time period, and while the trend for chlorophyll has been more variable, it too has decreased in the Tualatin since 1989. While several factors influence bloom formation, both water quality models and experience to date indicate that maintaining lower total phosphorus concentrations does help control excess algal growth

Figure 2-3. Total Phosphorus concentrations at two sites in the Lower Tualatin, juxtaposed with the number of hours of pH violations each summer at the Lake Oswego Diversion Dam. The bar graph reflects zero hours of pH violations since 2004, not missing data. The Elsner and Stafford sites are at river miles 16.5 and 5.4 respectively.



Despite the improvements in the Tualatin River, a series of nuisance cyanophyte blooms (photosynthetic bacteria, previously known as blue green algae) were observed in Oswego Lake in 2004 from July through November. In-depth studies following these blooms (Gibbons and Welch, 2004) identified surface water concentrations of total phosphorus as a contributing factor to bloom formation, and collected samples that showed sediment release of phosphorus could be a significant source of phosphorus in the lake. Following the blooms and in-depth study, new management practices were established for Oswego Lake to limit phosphorus concentrations. Two major actions were adding alum in the canals and shallow lake sections to precipitate total phosphorus, and greatly limiting water withdrawals from the Tualatin River, both in volume and dates of intake. Historic diversion of Tualatin River water was as high as 57 cfs year round. Currently diversions of Tualatin River water are restricted to 5-7 cfs, beginning in July, and ending as late as mid-October in dry years, and as early as late-August in wet years. This practice limits the contribution of phosphorus to Oswego Lake form the Tualatin River.

A nuisance bloom of *Anabaena flos aquae* (Bonn, 2008) algae did occur in the lower Tualatin River in July of 2008, at sufficient density to cause the Department of Human Services to issue a health advisory to avoid contact with the bloom. This bloom, the first in many years, is thought to be related to management changes at Wapato Lake in the upper watershed. This is a wetland area that was modified with a dike and pump house to de-water the lake for summertime farming. Normally the area is dewatered by March, but a dike breach in December 2007 flooded the lake with volume much greater than usual, and prevented pumping the lake dry until nearby river waters receded below the elevation of the dike breach in July. Water discharged from the lake in July was rich in nutrients, algae, and zooplankton. The particular mix of species evolved as water travelled downstream, causing a bloom dominated by the cyanophyte *Anabaena flos aquae* in the lower river.

2.5 Applicable Water Quality Standards

This element identifies the beneficial uses in the basin and relevant water quality standards, including specific basin standards. The beneficial use that is most sensitive to impairment by the pollutant is specified.

Salmonid use, supporting aquatic life, and recreational use are the most sensitive beneficial uses affected by excessive algal populations in the Tualatin Basin. Recreational use may be impaired by decreased aesthetic quality from dense algae, as well as by skin irritation attributed directly to contact with algae. As noted above, dense algae blooms can result in excessive pH at levels that are harmful to fish and other aquatic life. Swimmers may also experience eye irritation from swimming in waters that have high pH levels. Fish and other aquatic life may be impaired by reduced dissolved oxygen levels that result from excessive algal blooms.

The water quality standards targeted by this TMDL are described thoroughly in the 2001 TMDL (DEQ 2001). **Table 2-4** summarizes the targets applicable to the Tualatin Basin, as well as providing citations to the rule language.

Table 2-4. Summary of Beneficial Uses and Water Quality Criteria in the Tualatin Basin Targeted by the TMDL for Total Phosphorus.

Standard:	***Quick Summary:***	***Citation:***
Beneficial Uses:	Salmonid Fish Spawning (Trout) Salmonid Fish Rearing (Trout) Resident Fish and Aquatic Life Anadromous Fish Passage Water Contact Recreation Aesthetic Quality	***Oregon Administrative Rule (OAR) 340-041-442, Table 6***
Chlorophyll a:	Action level of 0.015 mg/L Chlorophyll *a*: may trigger a study to determine the impacts to beneficial uses, the probable cause of those impacts, and a strategy to attain compliance	***OAR 340-041-0019***
pH	Values may not fall outside the range of 6.5 to 8.5	***OAR 340-041-0021***

Standard:	Quick Summary:	Citation:
Aesthetic Condition	Conditions offensive to the human senses of sight, taste, smell or touch may not be allowed	***OAR 340-041-007(15)***

Note that the limit for chlorophyll *a* is expressed as an action limit. Oregon water quality standards recognize that natural conditions may preclude meeting a specific criterion or action limit, and provide the following guidance regarding natural conditions for chlorophyll *a*: when it is determined that natural conditions are responsible for the exceedance of the chlorophyll a action level, the pertinent water quality standard states that the action level may be modified to an appropriate level:

> *Where natural conditions are responsible for exceedance of the values in section (1) of this rule or beneficial uses are not impaired, the values in section (1) of this rule may be modified to an appropriate value for the water body;* (from OAR 340-041-0150[2][a])

Thus, when naturally occurring phosphorus concentrations are high enough to cause elevated chlorophyll *a,* the chlorophyll *a* action limit may be increased accordingly. As noted in the 2001 TMDL, because background levels of total phosphorus exceed those necessary to meet the 0.015 mg/L chlorophyll *a* level, the chlorophyll a concentration that results when background levels of total phosphorus are achieved, will become the applicable threshold for support of the beneficial uses related to the Chlorophyll a action level.

2.6 Analytical Methods Overview

This Section summarizes the data collected and modeling that was completed to identify the loading capacity of surface water, and the affects of phosphorus loads on water quality in the system.

This TMDL amendment will add two additional sources of total phosphorus on the mainstem Tualatin River, located in the upper Tualatin River at Forest Grove and Hillsboro (river miles 53.8 and 43.3 respectively). Load and waste load allocations for existing sources from the 2001 TMDL will remain unchanged. Both the 1988 and 2001 TMDLs for Total Phosphorus targeted water quality impairment that occurred in the lower Tualatin River, mainly below river mile 9. In this TMDL amendment, the total phosphorus targets for the Tualatin River downstream of the Rock Creek Advanced Waste Water Treatment Plant at river mile 37.7 will remain unchanged.

The TMDL target for the Tualatin River downstream of the Rock Creek Advanced Waste Water Treatment Plant at river mile 37.7 will remain at 0.10 mg total P/L, and at 0.11 mg total P/L downstream of Elsner Road at river mile 16.2. Recent water quality monitoring data show that these phosphorus targets have been met since 1995 (**Figure 2-3 in Section 2.4** and in **Section 2.8, Table 2-7**). Chlorophyll *a* values have also decreased compared to historic levels, but are often higher than the 0.015 mg/L Chlorophyll action level set out in Oregon's water quality standard. Despite this level of algal growth, no pH violations have been observed, and dissolved oxygen concentrations have also improved. Empirical data show that these TMDL targets for total phosphorus are appropriate for meeting water quality standards and protecting the beneficial uses in the lower Tualatin River.

Two new sources will receive waste load allocations that may cause the phosphorus concentrations in the mid-Tualatin River, between river miles 53.8 and 37.7 to increase slightly. These new waste load allocations will be developed in such a way that the established TMDL targets downstream of Farmington Road at river mile 33.3 will still be met, so the water quality improvements attained by the 1988 and 2001 TMDLs will be maintained. The Tualatin River is a steeper, faster moving river upstream of river mile 37.7, which has historically not supported algal blooms and thus has not suffered the related water quality problems of high pH and chlorophyll concentrations. The upper Tualatin River has historically experienced high phosphorus concentrations; the reason for the lack of algae-related water quality issues in this reach has been attributed to its physical features, presumed to discourage the formation of algal blooms. The question posed by this TMDL modification is whether there is indeed evidence that increased loads of total phosphorus might contribute to water quality impairment between river miles 53.8 and 33.3.

Clean Water Services developed a modeling approach to identify how much total phosphorus could be added to the Tualatin River and still meet the TMDL concentration targets of 0.10 mg total P/L immediately downstream of the Rock Creek Advanced Waste Water Treatment Plant at river mile 37.7. This simple mass-balance approach assumed that all other phosphorus sources in the basin achieved their TMDL targets, and indicated that a total load of 66.1 pounds per day of phosphorus could be discharged in total from the Forest Grove, Hillsboro and Rock Creek Waste Water Treatment Plant discharges, and still meet the TMDL target. This water quality scenario was then modeled using the CE-QUAL-W2 model that has been developed for the upper river by the United States Geological Survey (Rounds et al 1999 and Rounds & Wood, 2001). The model results confirm the assumption that slightly increased P concentrations between river miles 53.8 and 37.7 do not cause measurable changes to water quality. The model scenarios confirm that TMDL targets downstream of Rock Creek are met, and that no measureable decreases in dissolved oxygen or increases in total chlorophyll *a* would be observed. The details for this modeling effort are presented in detail in Appendix 2-A, Tualatin River Total maximum Daily Loads: Total Phosphorus and Dissolved Oxygen Analyses for the Upper River.

Clean Water Services is also requesting that the time period during which the TMDL applies be shortened from the May 1-October 31 TMDL season that currently applies to May 1 through August 31 with this amendment. Clean Water Services uses two methods for removing phosphorus from waste water; biological removal and alum addition. During the TMDL period, biological removal is not sufficient to meet the TMDL allocation, so alum addition is also used. Shortening the TMDL season would result in the use of less alum to treat wastewater. Clean Water Services has presented an extensive analysis in support of this request that includes the interpretation of existing data, and water quality modeling results for the Lower River. This analysis described the effects on the lower Tualatin River, examining the historic conditions during algal blooms, as well as using the water quality model to predict future bloom events under current flow management scenarios. This analysis is presented in Appendix 2-B, Tualatin River TMDL for Total Phosphorus (4/20/2009). This request was considered, but the actual dates adopted in this TMDL revision were modified. The time periods during which this revised TMDL apply are presented in Section 2.9.

2.7 Loading Capacity

This element specifies the amount of a pollutant or pollutants that a water body can receive and still meet water quality standards. The TMDL will set allocations at a level that ensures the loading capacity is not exceeded.

Tualatin River and Tributaries:

Water quality models were used for the 1988 TMDL to quantify the loading capacity of phosphorus by identifying levels of total phosphorus that would limit chlorophyll *a* levels and thus limit excessive algal growth. Subsequent to the 1988 TMDL, water quality studies indicated that natural phosphorus loads from groundwater may constitute a significant portion of low flow (non-runoff period) tributary loads (Kelly *et al*, 1999 and Wilson *et al*, 1999), and that these levels, deemed to be from natural sources, exceeded the 1988 TMDL targets that were identified to meet the 0.015 mg/L action limit for chlorophyll *a.*

Data from monitoring sites in the lower Tualatin River demonstrate that these background phosphorus levels have been met since the late 1990's. Under these conditions, pH and dissolved oxygen violations are rare to non-existent. Chlorophyll *a* action levels are not consistently attained, but the nuisance character of blooms has declined. Water quality modeling has shown that chlorophyll *a* levels would exceed the 0.015 mg/L threshold value when the Tualatin River and its tributaries are at the natural background phosphorus concentrations, so the water quality target of 0.015 mg/L for chlorophyll *a* in the

Tualatin Basin would not be met at the natural background level of phosphorus, and can be exceeded without violation. It should be noted that at these higher chlorophyll *a* concentrations, the pH criteria is met, and the standard allows for higher chlorophyll *a* levels under these conditions.

The 2001 TMDL for total phosphorus identified dry-season summer medians of total phosphorus as the background conditions for streams in the Tualatin Basin. No changes to the area loading capacities are made by this TMDL. The loading capacities identified of Tualatin streams were identified in the 2001 TMDL, and are repeated here for convenience in **Table 2-5**.

Table 2-5. Tualatin River Subbasin Total Phosphorus Loading Capacities (Tualatin Subbasin Total Maximum Daily Load, DEQ, 2001)

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

Oswego Lake Watershed:

The 2001 TMDL determined that phosphorus loads that would achieve an "acceptable" trophic state are lower than the phosphorus background loading to the lake. Thus in the Oswego Lake watershed, phosphorus loading capacity of the lake was set at the estimated background of external loading, and not at a lower level that may result in more desirable chlorophyll levels but cannot be achieved. As detailed in the 2001 TMDL, meeting the 2001 TMDL targets would reduce phosphorus loads and were expected to have beneficial impacts for the lake. A quantitative analysis of those benefits was beyond the scope of that TMDL as well as this amendment. Load capacities from the 2001 Phosphorus TMDL for the surface-water inputs to Oswego Lake are repeated here. Phosphorus loads are presented in pounds delivered to the lake over a time period. Similar to the Tualatin River tributaries, they are based on background concentrations of total phosphorus in the watershed. Loads, not concentrations, are used for this subbasin because pollutant levels in the lake may remain for a long time period, contributing to water quality problems on a different time scale than that observed in the riverine environment.

Background concentrations of phosphorus for the tributary streams during summer in the Oswego Lake watershed (**Table 2-6**) were determined using the same methodology as was used for the Tualatin River Subbasin streams; dry season median concentrations. Because a substantial data set was only available for Springbrook Creek, these values were used to represent groundwater inputs for all tributaries to Oswego Lake. Springbrook is the largest tributary to Oswego Lake, and most of the streams in the watershed share similar geology and soils, so the dry-season phosphorus concentrations should represent groundwater background concentrations for all Oswego Lake basin tributaries.

Phosphorus loading to Oswego Lake occurs year round, and unlike river and stream environments where winter loads will be carried downstream and out of the watershed, winter loading to the lake will remain in the lake and affect summer bloom conditions. Springbrook Creek is in a highly urbanized system, where background levels are difficult to estimate. Therefore, background conditions for winter time loading were estimated from nearby Balch Creek. This system has a similar watershed, climate and geology, however, the land use in the watershed is considerably less impacted by urbanization, making it easier to estimate natural background conditions. Balch Creek watershed is primarily open space with some roads, parks and residential use. Based on these factors, Balch Creek was selected as a good reference site for estimating background wet weather concentrations of phosphorus for Springbrook Creek and the other Oswego Lake tributaries.

Table 2-6. Total Phosphorus Tributary Loading Capacity for Oswego Lake (Tualatin Subbasin Total Maximum Daily Load, DEQ, 2001)

May 1 through October 31 (summer)		
Storm Loads		169 lb. (77 Kg.) Total Phosphorus
Base Flow Loads	0.11 mg/L Total Phosphorus	242 lb. (110 Kg.) Total Phosphorus
November 1 through April 30 (Winter)		
Storm Loads	0.19 mg/L Total Phosphorus	1087 lb. (494 Kg.) Total Phosphorus
Base Flow Loads	0.08 mg/L Total Phosphorus	757 lb. (344 Kg.) Total Phosphorus

2.8 Excess Loads

This element evaluates the difference between current pollutant load in a waterbody and the loading capacity of the waterbody.

Tualatin River

The 1988 and 2001 TMDLs for total P have been very successful in the mainstem Tualatin River. TMDL targets have largely been met in the mainstem river since 1995 (**Table 2-7**). Excessive algal growth in the lower Tualatin River has become a rare event, and pH violations no longer occur. However, during July, 2008, a bloom of cyanobacteria also known as blue green algae, dominated by *Aphanezomenon sp.* formed in the Lower Tualatin River. Cell counts were sufficiently high to cause the Oregon Health Authority to issue an advisory against water contact for this reach, based on the potential for the bloom to produce cyanotoxins; toxins formed by bluegreen algae. Further upstream that same summer, the Joint Water Commission water providers experienced a prolonged taste and odor event. During this time period the Tualatin River drinking water source required additional treatment by filtration with activated carbon to remove an objectionable taste and odor caused by geosmin. Geosmin is a naturally occurring chemical that has a distinctive odor and can cause an undesirable taste in drinking water. Geosmin is found in soils, decaying organic matter, and can be produced by both green and bluegreen algae. As a result of these events, additional water quality data were collected in the basin by the Joint Water Commission and the USGS to identify the possible cause of these unusual conditions. High levels of organic carbon, total P, and dense zooplankton populations were found flowing from the Wapato Lake area near Gaston in the upper watershed. These factors contributed to the bluegreen bloom formation in the Lower Tualatin River. The large volume of water originating from the Wapato Lake area was uncommon, and due to a dike breach at that site in December of 2007. This event has drawn attention to the Wapato Lake area as a potential nutrient source, and resulted in the completion of a management plan for the lakebed to ensure that this source complies with the 2001 Phosphorus TMDL. In summary, the efforts set out to address the 1988 and 2001 TMDLs for total phosphorus in the Tualatin mainstem have been largely successful, but as demonstrated by the events of 2008, ongoing management is necessary to continue to meet the TMDL targets.

Table 2-7. TMDL Loading Capacity/Target concentrations and instream summer median concentrations at various Tualatin River sites in the Basin. Data were collected by Clean Water Services, and reported in the 2008 Annual Report of the Tualatin River Flow Management Technical Committee (Bonn, 2008).

Location	River Mile	2001 TMDL Target (mg/L as P)	Total Phosphorus (mg/L as P)						
			1990	1995	2000	2005	2006	2007	2008
Cherry Grove	71.5	0.04	--	0.01	0.01	0.01	0.01	0.01	0.01
Spring Hill	61.2	0.04	0.04	0.03	0.03	0.01	0.01	0.01	0.03
Golf Course Road	52.8	0.04	0.05	0.04	0.03	0.03	0.03	0.03	0.05
Highway 219	44.4	--	--	0.07	0.05	0.06	0.06	0.06	0.07
Rood Bridge Road	39.1	0.09	0.10	0.08	0.06	0.07	0.07	0.07	0.07
Farmington Road	33.3	0.10	0.43	0.08	0.09	--	0.08	0.08	0.09
Scholls Road	27.1	0.10	0.15	0.09	0.08	0.09	0.09	0.09	0.09
Elsner Road	16.5	0.11	0.14	0.09	0.08	0.09	0.09	0.09	0.09
Boones Ferry Road	8.7	0.11	0.23	0.09	0.08	0.09	0.09	0.10	0.09
Stafford Road	5.4	0.10	0.23	0.09	0.08	0.09	0.09	0.10	0.09
Weiss Bridge	0.2	0.10	0.22	0.09	0.08	0.09	0.08	0.08	0.08

Tualatin River Tributaries

Summertime phosphorus levels on the Tualatin River are heavily influenced by discharges from the Rock Creek and Durham Advanced Waste Water Treatment Plants, as well as flow augmentation from Hagg Lake and Barney Reservoir. Flow augmentation from the reservoirs provides "dilution water" at lower P levels, as well as by increasing flow rates in the lower river which in turn decreases residence time in the slower moving reaches. Phosphorus control in the tributaries is not as easily accomplished. Instead, management practices that decrease erosion and runoff must be implemented and maintained widely across the basin. Stream bank erosion is another source of instream phosphorus that originates from both natural and human-accelerated activities. In part because the control of non-point sources is difficult to accomplish, improvements on tributary streams take longer, and happen in smaller increments. The TMDL target concentrations and summer median stream concentrations are presented in **Table 2-8**. As in **Table 2-7**, these data were collected by Clean Water Services, and reported in the 2008 Annual Report of the Tualatin River Flow Management Technical Committee (Bonn, 2008).

Table 2-8. TMDL Loading Capacity/Target concentrations and instream summer median concentrations at various Tributary sites to the Tualatin River. Data were collected by Clean Water Services, and reported in the 2008 Annual Report of the Tualatin River Flow Management Technical Committee (Bonn, 2008).

Location	2001 TMDL Target (mg/L as P)	Total Phosphorus (mg/L as P)						
		1990	1995	2000	2005	2006	2007	2008
Scoggins Creek @ Highway 47	0.04	--	0.03	0.01	0.01	0.01	0.01	0.01
Gales Creek @ New Highway 47	0.04	0.06	0.05	0.04	0.04	0.04	0.04	0.04
Dairy Creek @ Highway 8	0.09	0.13	0.11	0.11	0.12	0.12	0.13	0.13

Location	2001 TMDL Target (mg/L as P)	Total Phosphorus (mg/L as P)						
		1990	1995	2000	2005	2006	2007	2008
Rock Creek @ Brookwood	0.19	0.21	0.21	0.18	0.19	0.24	0.20	0.20
Bronson Creek @ 205th	0.13	0.13	0.12	0.12	0.14	0.19	0.15	0.16
Chicken Creek @ Scholls-Sherwood	0.14	0.23	0.12	0.11	0.11	0.11	0.11	0.12
Nyberg Creek@ Brown's Ferry	0.14	--	--	0.17	0.20	0.19	0.20	0.18
Fanno Creek@ Durham Rd.	0.13	0.15	0.15	0.15	0.15	0.16	0.14	0.15

These data show that Scoggins Creek, Gales Creek and Chicken Creek generally meet the 2001 TMDL target, but that other creeks in the basin have summer median concentrations in excess of the 2001 TMDL targets. A simple trend analysis using summer monthly median values shows decreasing trends at Gales Creek (**Figure 2-4**), with relatively low variation in P values from month to month. Similar information for Dairy Creek shows a significant increase in P since 1990, but these data show a much larger variation among monthly values. Data at Rock and Fanno Creeks also show a large variation in values, and do not show significant changes over time. These data were collected and analyzed by Clean Water Services (Steve Anderson, personal communication).

Figure 2-4. Monthly median concentrations of total Phosphorus are plotted over time at four different tributary locations in the Tualatin River Basin. The decrease in Gales Creek and increase in Dairy Creek are significant at the 95% confidence level, using the Seasonal Kendal Tau trend test. No significant trends are present at the Rock Creek and Fanno Creek sites.

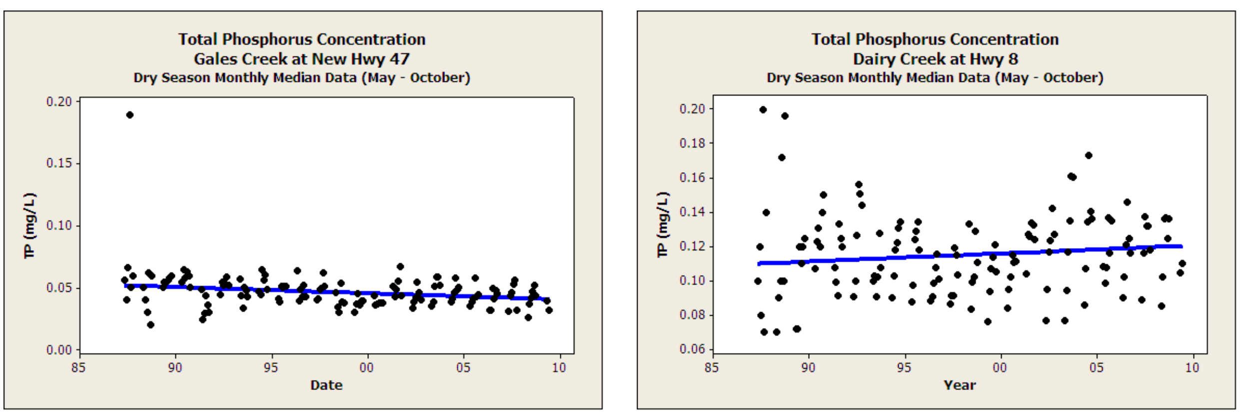
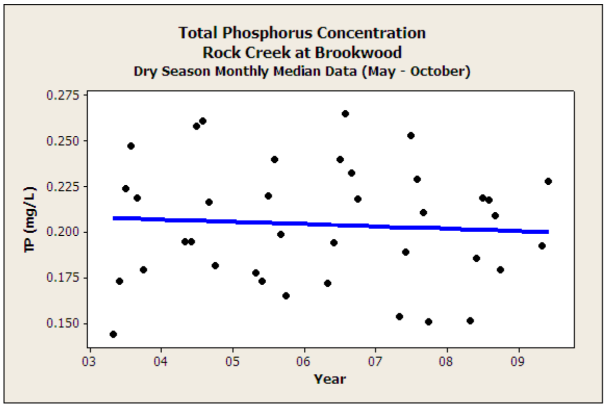
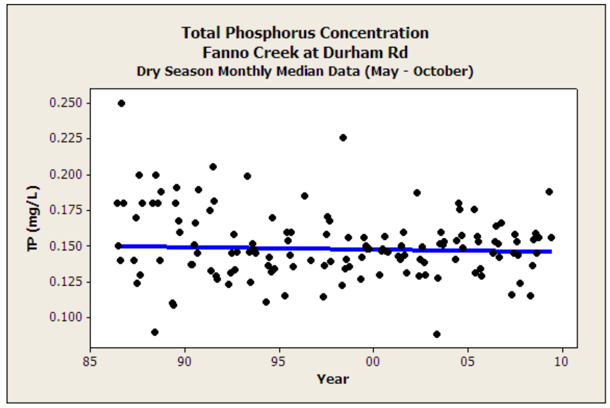


Figure 2-4, continued.



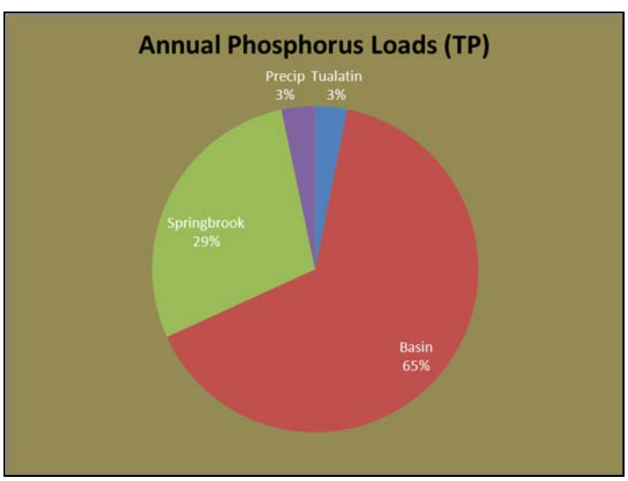


These data suggest that additional work could be done in tributary basins in order to achieve the TMDL targets.

Oswego Lake

At the time the 2001 TMDL was written, Oswego Canal, through its contributions from the Tualatin River, was estimated to contribute 58% of the total phosphorus loading to Oswego Lake that originated from external sources. In a phosphorus budget for 2009 (**Figure 2-5**), Tualatin River contributions are much smaller, and estimated at 3%. This is largely due to changes in both the volume and the dates that Tualatin River water is diverted into Oswego Lake. In 2004, a series of nuisance cyanophyte blooms triggered a study to look more closely at phosphorus sources to the Lake (Gibbons and Welch, 2004). This study identified significant loading sources from four sources: the Tualatin River, stormwater runoff, and phosphorus release from both deep and shallow sediments. As a result, the quantity and dates of diversions from the Tualatin River were greatly reduced. The Gibbons and Welch (2004) study also recommended more intensive monitoring of stormwater inputs to the lake. Lake Oswego Corporation continues to work with the City of Lake Oswego to improve the quality of runoff to the Lake. Since 2005, Lake Oswego Corporation has treated the Oswego Canal and shallow bays of the Lake with alum, to chemically bind the phosphorus to sediments, and decrease the release of phosphorus to the Lake. Despite these efforts, nuisance algae blooms still form in the Lake, indicating that additional work must be accomplished in this system.

Figure 2-5. Relative source contributions of the annual phosphorus loads to Oswego Lake, which totaled 1116 kg during the 2008-2009 water year. (personal communication, Mark Rosenkranz, Lake Oswego Corporation).



2.9 Seasonal Variation and Critical Conditions

This element accounts for seasonal variation and critical conditions in stream flow, sensitive beneficial uses, pollutant loading and water quality parameters so that water quality standards will be attained and maintained during all seasons of the year.

The TMDL for phosphorus is intended to control high chlorophyll *a* concentrations, and violations of the pH criteria. Historically, nuisance algal blooms have occurred seasonally during June, July and August. Nuisance blooms have also been limited geographically to the lower 33 miles, most commonly in the lower 9 miles of the Tualatin River, and in Oswego Lake. For the Tualatin basin proper, the 2001 TMDL allocations applied from May 1 through October 31. However, because of the increased sensitivity of Oswego Lake to phosphorus concentrations, phosphorus allocations apply year round in the Oswego Lake watershed, with different TMDL targets during the summer and winter time periods. One reason that Oswego Lake is more likely to exhibit nuisance blooms relates to the much longer retention time of water in the Lake than in the Lower Tualatin River. Thus water, and therefore phosphorus, diverted to Oswego Lake may influence algal growth over a longer season than phosphorus impacts the Lower Tualatin River. In addition to the dissolved phosphorus carried to the lake, phosphorus-laden sediment is likely to settle out in the slow moving lake water, and may release phosphorus to the water column at a later time.

Clean Water Services has requested that the time period during which the TMDL applies be shortened to May 1 through August 31. A detailed analysis of the water quality impacts resulting from such a change is included in Appendix 2-B. Water quality model results show that while algal blooms are influenced by phosphorus, other conditions such as sunlight, temperature and flow-governed residence time are also important factors in bloom formation. Years of monitoring data using a continuous monitor with hourly recording have shown no pH violations in the lower Tualatin River during October, despite high phosphorus levels in the river during some of the early TMDL years (see box plots in Appendix 2-B). The limited number of pH violations observed in September were all correlated with low river flows; levels that were much lower than occur under the current flow augmentation program. Indeed algal blooms in the lower river are less likely, and are much less sensitive to phosphorus concentrations in September and October than they are in mid-summer. Dry season flow augmentation has been implemented in the basin since Hagg Lake was constructed in the late 1970’s. However summer release strategies have changed over time. Starting in 1987, CWS (then United Sewerage Authority) targeted monthly average flows of 150 cfs at the Farmington gage. When the Watershed Permit was issued in 2005, CWS altered the flow augmentation program to release 35 cfs during July and August, and to target a flow of 180 cfs at the Farmington gage. Lake Oswego Corporation has a right to divert water from the Tualatin River. Diversions historically were about 57 cfs year round; in about 2005 these were reduced to less than 10 cfs during the summer months, leaving more flow in the lowest river reach in recent years.

In contrast, Oswego Lake has been shown to support nuisance algal blooms as late as November. In response to the extended series of blue-green algae blooms in Oswego Lake in 2004, Lake Oswego Corporation conducted a study to identify factors that contributed to the nuisance blooms, and subsequently changed their water diversion practices from the Tualatin River. Lake Oswego Corporation holds a water right that allows diversion of 57 cfs of Tualatin River water year-round for hydro-electric generation. Starting as early as 2003, Lake Oswego Corporation greatly decreased the volume of water diverted, as well as limiting those diversions to the summer time period. Roughly 5 cfs of water are now diverted from early July through August and into September, depending on the water year and the lake level. Diversions may continue until mid- October if the lake is particularly low. In addition to decreasing the phosphorus load to the lake by greatly limiting diversion from Tualatin River water, Lake Oswego Corporation has been adding alum to decrease the phosphorus concentration in water coming through the Oswego Canal from the Tualatin River, as well as reducing P release from sediments in other shallow locations of the lake. Alum is a commonly occurring mineral that when added to water will cause suspended particles to flocculate and precipitate. Phosphorus can be associated with suspended particles, and is also attracted to the flocculent. Thus alum treatment is used to remove phosphorus from water. This treatment is used during summer at the Clean Water Services Rock Creek and Durham Plants, and is used in natural waterbodies where phosphorus levels are too high and contribute to nuisance algal blooms.

Sunlight and river flow do play an important role controlling the formation of nuisance algal blooms in the Lower Tualatin River. If this were the only consideration for changing the season in which the phosphorus TMDL applies, it would appear reasonable to shorten the Phosphorus TMDL season to mid-September. Blooms in the Tualatin River have historically not occurred later than this time; light availability is lower, and with increased flow augmentation, river flow is likely to be sufficiently high to disrupt bloom formation. However nuisance blooms still occur in Oswego Lake, and have been attributed to high concentrations of phosphorus. Therefore, phosphorus concentrations should not be allowed to increase in the Tualatin River while river water is still being diverted into Oswego Lake.

When the Total Phosphorus TMDL applies, Clean Water Services discharge concentrations of phosphorus are limited to 0.1 mg total P/L. This is the background concentration of the lower river, although summertime river concentrations are slightly lower due to dilution from augmentation flow releases from the upper watershed (Hagg Lake or Barney Reservoir). Clean Water Services utilizes several treatment techniques to decrease phosphorus levels in their discharge, but summertime treatment with alum has been necessary in order to meet the low TMDL discharge limits. During late summer and early autumn, Tualatin River flow levels are sufficiently low that the phosphorus discharges from Clean Water Services Advanced Waste Water Treatment Plants at Rock Creek and Durham have a significant impact on phosphorus concentration levels in the Tualatin River. When Clean Water Services stops treating their discharge with alum at the end of October, phosphorus levels in the River rise quickly to as high as 0.4 mg P/L. These levels create a significant phosphorus source in water diverted to Oswego Lake. Therefore the TMDL should remain in place while water is diverted to Oswego Lake.

However, with an interest to lower the environmental impact of mining, transporting and adding alum to treat waste water, the dates for which the total phosphorus TMDL apply might still be modified. Clean Water Services two largest discharges are the two discharge points closest to the Oswego Lake diversion. The Rock Creek Advanced Waste Water Treatment Plant has the largest discharge to the Tualatin of 60 cfs at river mile 37.7. The Durham Advanced Waste Water Treatment Plant discharges 35 cfs at river mile 9.2. September travel times to the Oswego Lake Diversion, located at river mile 6.8 are approximately 12 days from Rock Creek, and less than 1 day from the Durham Plant. Therefore, in years when Oswego Lake diversions continue into October, discharges released from Rock Creek on October 1 will not arrive at the diversion point until October 12. Discharges from the Durham Plant have a much shorter travel time to the diversion point, so P levels in discharge from that plant should not be increased until diversions to Oswego Lake have ceased.

River flow in the lower river may also affect bloom formation in the lower Tualatin. **Figure 2-6** shows daily maximum pH values in September versus Tualatin River Flow. The data are plotted to show pH values during the TMDL transition phase of 1991-1993 when phosphorus values were higher, and 1994-2010, when waste water discharges met the TMDL allocation of 0.10 mg/L as total phosphorus (0.11 at Durham). September flows were generally about 100 cfs at the West Linn gauge from 1991-1993, and increased from about 115-150 cfs over the 1994-2010 time period. This figure shows that even with the higher phosphorus levels of 1991-1993, higher river flow is expected to decrease bloom formation and control pH levels in the lower river. The data here suggest that during September, with shorter days and lower temperatures, blooms are less likely to occur when river flows exceed 125 cfs at Farmington. Therefore, between September 15 and 30, if Oswego Lake Corporation has ceased diverting Tualatin River water, and the 7 day average flow is greater than 130 cfs at the Farmington gauge on the Tualatin River, the TMDL period for CWS four treatment plants may end. The TMDL season will be modified as shown in **Table 2-9.**

Figure 2-6. Daily maximum pH values in September at the Oswego Dam, collected between 1991 and 2010, versus daily average flow at the Farmington gage.

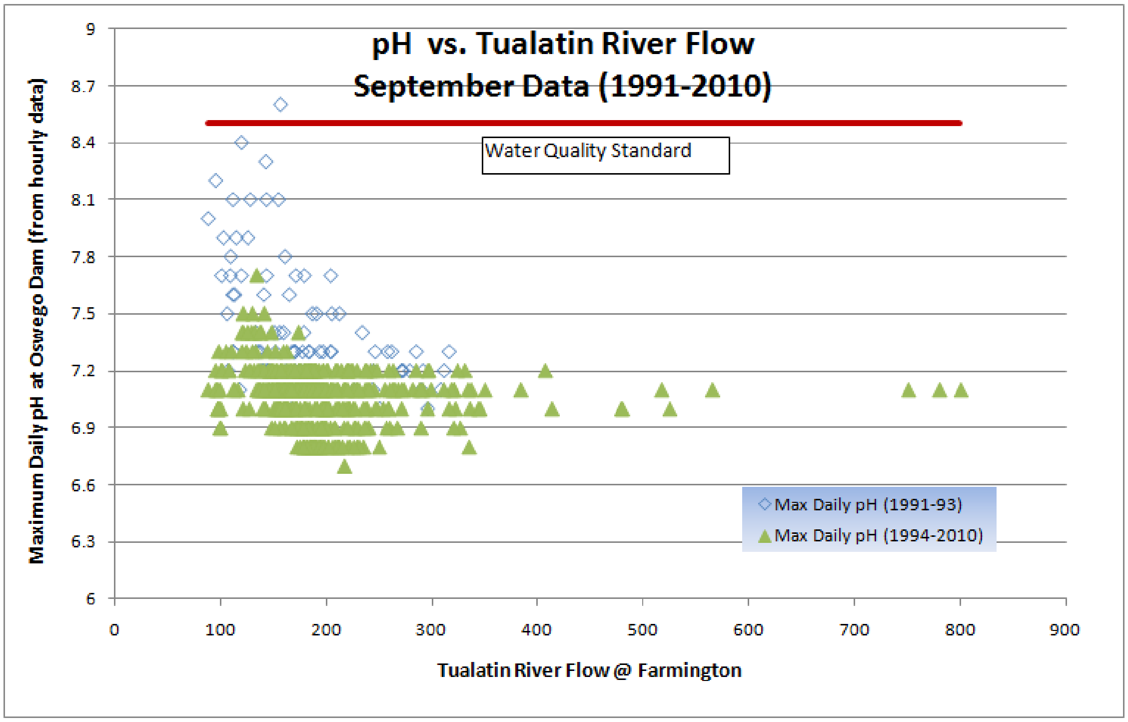


Table 2-9. Dates when the TMDL for Total Phosphorus applies to different sources in the Tualatin Basin.

Source	Dates TMDL Applies	Comments
Non-point Sources to Tualatin Basin	May 1-October 31	No change from 2001 TMDL
Clean Water Services Forest Grove and Hillsboro WWTP	May 1-September 30	Same seasonal and flow restrictions as Rock Creek Treatment Plant
Clean Water Services Rock Creek AWWTP	May 1-September 30	Phosphorus removal may decrease anytime after September 15 if diversions to Oswego Lake have stopped for the year and the 7 day average river flow at the Farmington Gauge is 130 cfs or greater
Clean Water Services Durham AWWTP	May 1-October 15	Phosphorus removal may decrease anytime after September 15 if diversions to Oswego Lake have stopped for the year and the 7 day average river flow at the Farmington Gauge is 130 cfs or greater
Runoff in Oswego Lake Watershed	Year-round	No change from 2001 TMDL

The TMDL dates are only modified for the Clean Water Services Discharges, and in no case will these be lifted earlier than September 16, to ensure that total P will not contribute to nuisance algal bloom formation in the lower Tualatin River in late summer.

The TMDL restrictions for watershed sources to Oswego Lake must remain in place year round in order to limit phosphorus loading to the lake, as annual phosphorus loadings influence the trophic state of lakes (SRI 1987). The dates for which the TMDL applies for load allocations governing non-point sources to the Tualatin River remain May 1 through October 31. These dates are not modified because management practices, not treatment processes are used to meet these targets. As such, they are not easy to change on short notice, and can easily remain in place throughout the season.

2.10 Existing Phosphorus Sources

This Section describes the pollutant sources within the basin.

Background Sources

The 2001 TMDL for pH and chlorophyll *a* provides a detailed description demonstrating that the main water quality parameter contributing to algal blooms and causing violations of the pH criterion and chlorophyll *a* action level was elevated levels of total phosphorus. Ambient light and travel time play a role as well; dense algal growth occurs in conditions of sufficient light, and is more likely to occur in low current, when populations are less physically dispersed and have greater contact time with favorable nutrient conditions.

Based on research in the local area (Kelly et al 1999 & Wilson et all 1999), the 2001 TMDL documented that background sources of phosphorus in the basin were elevated. Samples collected from tributaries at low summer flow were assumed to represent mainly groundwater inputs. These were analyzed for phosphorus concentrations and reported in the 2001 TMDL for pH and Chlorophyll *a*. The groundwater background concentrations were reported in the 2001 TMDL, and will not be repeated here. However, the median summer ‘dry weather’ levels formed the basis of the load allocations for tributaries, which are included here in Section 2.7 (Loading Capacity, see **Tables 2-5 and 2-6**). Dry weather surface water samples were selected to minimize the influence of surface water chemistry on the sample analyses; dry weather summer samples are assumed to be heavily dominated by, if not entirely composed of groundwater seepage. Background phosphorus concentrations were generally lower in the upper watershed (0.04 mg Total P/L), and higher toward the western portion of the basin (0.1 mg/L in the mainstem, with some tributaries as high as 0.19 mg total P/L).

Summer season inputs are more important to algal bloom formation in the riverine tributaries and Tualatin River itself than are winter contributions. However, year-round inputs to Oswego Lake are important because of the long retention time of water and sediment with the lake. Therefore wet-season sources to Oswego Lake are also described in this document. More detail about lake dynamics and sediment loading can be found in the original 2001 TMDL, which this chapter amends, but does not replace.

Point Sources

Wastewater Treatment Plants
Clean Water Services operates four wastewater treatment plants in the subbasin. Two of these plants Durham (RM 9.3) and Rock Creek (RM 38.1) currently discharge during the summer season. These plants discharge at concentrations below the allocations provided in the 2001 TMDL. The flow volumes from these two plants are expected to increase as the population of Washington County increases. In addition, to increase treatment volume, Clean Water Services proposes to modify summer treatment at the Forest Grove and Hillsboro Treatment Plants, and begin discharging during the summer at those sites. Before the discharge permit can be issued to allow those discharges, waste load allocations must be developed and a new TMDL order issued. Methods used to derive the new allocations are presented in Section 2.6 of this document, and the allocations themselves are included in Section 2.11

Other Permitted Point Sources

Permit conditions for individual and general industrial activity permits were reviewed to determine whether these discharges may be a source of phosphorus to Tualatin Basin waters. No permits included restrictions on phosphorus in their discharges, and no processes were deemed likely to discharge phosphorus, so these permitted sites are not considered to be sources of phosphorus.

Stormwater discharge is a source of phosphorus, and there are many sources of stormwater runoff in the Tualatin basin that hold NPDES permits. The character of these discharges is described below as runoff.

Runoff Sources
In addition to the groundwater sources of phosphorus, surface runoff is known to contribute total phosphorus loadings to both the mainstem Tualatin River and to the tributary streams. The amount of runoff and the concentration of phosphorus in the runoff will vary with precipitation and land use. What follows is a broad characterization of the contribution of runoff to total phosphorus loadings in the Tualatin River Subbasin. A more detailed discussion of the total phosphorus concentrations and loadings in runoff is included in Appendices C-6 and C-7 to the 2001 TMDL, (DEQ, 2001).

Urban Runoff
Urbanized land areas, with their high percentages of impervious surfaces and extensive drainage systems, have surface runoff even during relatively small rainfall events. The 2001 TMDL characterized phosphorus concentrations in urban runoff. The TMDL showed that concentrations in urban runoff commonly exceed background concentrations, so the TMDL provided load allocations for urban runoff sources.

Runoff from Rural, Agricultural and Forested Lands
While runoff from rural, agricultural and forested lands differs from runoff from urban areas; the main difference between the two broad source categories is that the volume of runoff for a given area from non-urbanized watersheds is generally lower, especially during the summer season. Data on total phosphorus concentrations for agricultural and forested land runoff in the subbasin is lacking, but general values for these concentrations indicate that non-urban runoff concentrations also exceed the background concentrations. Therefore the 2001 TMDL provided load allocations for non-urban runoff as well. (2001 TMDL, Appendix C-7 for a more detailed discussion of rural, agricultural and forested runoff in the subbasin, DEQ, 2001)

Other Sources

While the significant amounts of phosphorus loading to the Tualatin River and its tributaries comes from the wastewater treatment plants and urban and rural runoff including stormwater, there are other potential sources of phosphorus in the basin.

Unregulated (Unpermitted) Upland Sources
Potential upland sources aside from runoff and other permitted discharges include faulty septic and sewer systems, and illegal or illicit discharges. While these sources are not easily quantified, the phosphorus loads are expected to be relatively small due to the aggressive control programs that were established previously. It is important that these programs continue to be implemented and are updated based on new monitoring or other information.

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

The contribution of riparian bank erosion to water column and sediment phosphorus levels is also difficult to quantify. While the smaller instream flows during the summer season (when algal blooms are an issue) most likely result in only a small portion of the total bank erosion taking place, this remains a potential source of total phosphorus. Sediment deposited instream during winter-time erosion may still provide a significant source of phosphorus during summer months when in-stream dissolved oxygen levels are low.

Tile Drains
Tile drains, installed primarily in agricultural areas to drain shallow groundwater, are briefly examined in a USGS report on phosphorus sources in the Tualatin River Subbasin (Kelly *et al*, 1999). This report concluded that "(t)he data suggest that agricultural practices in the Tualatin River Subbasin did not significantly increase concentrations of phosphorus in water entering streams during the low-flow [non-runoff] period of this study". This is primarily referring to agricultural impacts on shallow groundwater and tile drains. While this study indicates that this source may be small, Department of Agriculture rules (OAR-603-095-0140(5)) require that irrigation occur at agronomic rates, and do not allow tile drain runoff to occur between May and October unless an approved monitoring plan for discharge water quality is in place.

Wapato Lake/Wapato Improvement District
Wapato Lake is located in Gaston, Oregon, in southwestern portion of the Tualatin River watershed. The Wapato Improvement District (WID) drained the lake in the 1930's to create farmland. This drainage project includes an elongated U-shaped dike, roughly 3,000 feet in length that protects the lakebed from winter flooding by the surrounding creeks. Irrigation canals were constructed both inside and outside the dike to deliver water to cropland.

During the rainy season the lakebed floods with a foot or two of water from rain and creeks that flow into the lake area. The flood water is pumped out of the lake in late winter or early spring, allowing the soil time to dry for spring and summer planting. Pipe turnouts penetrate the dike and allow for the controlled diversion of water from Wapato Creek into the lakebed canals to supply irrigation water during the summer. The turnouts discharge into drainage ditches inside the dike. Farmers pump this irrigation water out of the drainage ditches and apply it to their crops with either big gun travelling sprinklers, wheel-line sprinklers or hand-line sprinklers. Thus, the Wapato Lake drainage ditches provide two functions; drainage of the lakebed in the spring and transport of irrigation water in the summer.

Normally the lakebed is emptied and dried during the non-TMDL season between November and April. However, in recent years, both dike breaches and pump failures have resulted in the release of nutrient-rich water to Wapato Creek and the Tualatin River during the TMDL season. In 2008, this release led to a bloom of harmful algae in the lower Tualatin River, mentioned above in Section 2.4 and in greater detail in Bonn (2008). The U.S. Fish and Wildlife Service (USFWS) acquired most of the lake-bed property, along with the dikes and pumphouse between 2009 and 2012. In the near-term, the property will still be managed for seasonal farming, with annual draining of the lakebed. The USFWS is currently performing a study of the lakebed, and undergoing a comprehensive planning effort to determine how to restore the lakebed to a functioning wetland.

Oswego Lake Sources
Oswego Lake receives water both by diversion from the lower Tualatin River as well as its natural watershed. Gibbons and Welch, (2004) identified diverted Tualatin River water, stormwater runoff, and both shallow and deep lake sediment as significant sources of phosphorus to Oswego Lake. Additional sources include tributary flow, groundwater and precipitation. Phosphorus associates with soil particles more easily than it remains dissolved in the water column. Sediment tends to accumulate in lake-bottoms, as flow velocities decline in the slower or non-moving lake water. Water at depth has lower oxygen levels than surface water, and creates conditions where phosphorus associated with sediment particles is released to the water column. Lake Oswego Corporation, whose management activities for the lake include water quality, currently add alum to sediments in the lake and the diversion canal to control phosphorus levels and thus decrease algal bloom activity in the Lake. In addition, diversions of Tualatin River water are now limited in volume and season, further reducing phosphorus inputs to the

Lake. The current annual phosphorus budget (**Figure 2-5**) identifies Springbrook Creek as contributing 30% of the annual budget, with 65% generated in the lake basin itself. These numbers include both natural background as well as stormwater loading, and reflect the low volume of water currently diverted from the Tualatin River.

2.11 Waste Load Allocations

This element determines the portions of the receiving water's loading capacity that are allocated to existing point sources of pollution, including all point source discharges regulated under the federal Water Pollution Control Act Section 402 (33 USC Section 1342).This amendment to the 2001 TMDL provides new allocations for the Forest Grove and Hillsboro Clean Water Services discharge locations, and provides daily load equivalents for the monthly targets set out in the 2001 TMDL. Comments will only be accepted for the amended values.

Allocations

Total Maximum Daily Loads are described by a simple equation that defines the loading capacity of a system, and quantifies pollutant sources in the form of natural background sources, point sources from permitted discharges, and non-point sources. The TMDL is a legal document that places limits on point and non-point pollutant sources. The limits placed on point sources are referred to as Waste Load Allocations, and those placed on Non-Point Sources are referred to as Load Allocations. In the Tualatin Basin there are basically two types of point sources that contribute phosphorus; the waste water treatment plants, and the runoff originating from densely populated urban areas that require National Pollution Discharge Elimination Permits for Municipal Separate Storm Sewer Systems (MS4). Runoff from rural areas, and smaller urban areas that are not addressed by an MS4 permit are still subject to TMDL restrictions, but are provided with Load Allocations (see section 2.12), not Waste Load Allocations. DEQ oversees the implementation of wasteload allocations through National Pollution Discharge Elimination System permits that control point source discharges. DEQ allows pollutant trading programs to be used to meet waste load allocations; details about how trading can work are included in Section 4.4 of the Water Quality Management Plan that accompanies this TMDL revision.

The main purpose for this Total Phosphorus TMDL amendment is to provide Waste Load Allocations for two of the Clean Water Services municipal waste water treatment plants. These two facilities were online at the time of the 2001 TMDL, but they have not been discharging during the summer months. Instead, during the summer, raw wastewater from these treatments plants are piped down to the Rock Creek Advanced Waste Water Treatment Facility. As population in the Tualatin Basin increases, Clean Water Services proposes to increase their waste water treatment capacity by maintaining the current capacity at its' two downstream facilities, the Rock Creek and Durham plants, and by commencing summertime discharges at its' two upstream facilities at Forest Grove and Hillsboro. The two downstream plants at Rock Creek and Durham will increase capacity as needed once Forest Grove and Hillsboro are operating at full capacity during the summer.

Waste Load Allocations for Point Sources Other than Waste Water Treatment Plants

Waste Load Allocations for point sources other than the waste water treatment plants in the Tualatin Basin remain unchanged from the 2001 TMDL and are presented in **Table 2-10**. These sources are mainly those addressed in various Municipal Separate Stormwater Sewer System (MS4) National Pollution Discharge Elimination System Permits (NPDES). The summer median values are included in this document for convenience, so that the reader need not search out the 2001 TMDL for these values. These values are not part of the amendment to the 2001 TMDL, and therefore are not open for comment during this public comment period.

Table 2-10. Tualatin River Subbasin Total Phosphorus Wasteload Allocations for Point Sources (other than WWTPs). Summer median values are from the 2001 approved TMDL and are not included in the amendment.

Designated Management Agency/Source	Source Discharging to: (Subbasin)	Total Phosphorus Concentrations (Summer Median - mg/L)	Total Phosphorus Concentrations (Daily Maximum - mg/L)
City of Lake Oswego, City of Portland, City of West Linn, Clackamas Co., Oregon Dept. of Transportation, Multnomah Co., Clean Water Services, and Washington Co. (And other point sources other than WWTPs)	All Sources to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14	0.49
	All Sources to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04	0.14
	Bronson Creek @ Mouth (205th)	0.13	0.46
	Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.(all @ Mouth)	0.12	0.42
	Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr. (all @ Mouth)	0.14	0.49
	Dairy Creek @ Mouth	0.09	0.32
	Fanno Creek @ Mouth	0.13	0.46
	Gales Creek @ Mouth	0.04	0.14
	Rock Creek @ Mouth	0.19	0.67

Discharge concentrations are the applicable units for the waste load allocations presented in **Table 2-10** above. Equivalent allocations in the form of loads may be utilized instead as needed or desired. Loads are presented in units of weight per time period, such as pounds per day, or pounds per season. Allocations in the form of loads are calculated by multiplying the concentration in the discharge by the estimated discharge volume for the source. For point sources such as waste water treatment plants, discharge concentrations and volume are readily measured. Waste Load Allocations expressed as concentrations in **Table 2-10** above apply mainly to stormwater runoff, for which discharge volume is difficult to measure. Allocations in the form of loads for the sources in **Table 2-11** below have been calculated based on the mean seasonal precipitation. Discharge values were estimated for each source using a GIS analysis that included city and county boundaries, land use information, and boundaries for Clean Water Services' district, Oregon Department of Transportation Roads, and urban growth. The methods were outlined in detail in Appendix C-6 through C-8 of the 2001 TMDL (DEQ 2001).

The loading capacities identified in Section 2.7 were developed to address water quality issues specific to the lower mainstem Tualatin River. As such, the aggregate loading from all sources to the lower mainstem is the critical factor. Therefore, the allocations given to each DMA in **Table 2-11** may be met by addressing the aggregate of the 5th-field subbasin loadings for the DMA.

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

Equation 2-1.

$$\textbf{Allocation (lb. of Total Phosphorus/season)} = \textbf{Allocation (mg/L Total Phosphorus)} \times \textbf{Seasonal Discharge Volume } (ft^3/season) \times 6.24 \times 10^{-5}\ (lb.\text{–}L/ft^3\text{-}mg)$$

The resulting allocations are in the form of loads per unit time. The wasteload allocations (assigned to point sources) are given in units of pounds per season (May 1 – October 31). The concentrations listed in

Table 2-10 can be used to assist in the assessment of monitoring data and to provide targets for runoff quality. Loads **(Table 2-11)** can be used to guide management strategies that are designed to reduce the quantity and/or quality of runoff. DEQ encourages management strategies that optimize reduction of runoff quantity and improvement of quality.

The allocations in the form of loads for sources other than WWTPs are given below in **Table 2-11**. It should be noted that these values are designed to both meet the loading capacities of the receiving waters and to allocate loadings that allow for some human influence.

For each of the subbasins listed in **Tables 2-10** and **2-11**, one or more DMAs have jurisdiction over land and activities. Each DMA's implementation plan and responsibilities will address only the lands and activities within each identified stream segment to the extent of the DMA's authority.

Table 2-11. Waste Load Allocations for Runoff Expressed as Load in units of Pounds per Season (May 1- October 31). These allocations were established in the 2001 TMDL and are included here for reference only.

5th-Field Subbasin[1]	DMA (or Municipality – see note)[2]	Wasteload Allocation (Pounds per TMDL Season)	CWS Wasteload Allocations Subdivided by Municipality (Pounds per TMDL Season)[3]
Dairy	ODOT	3.7	
	CWS	213	
	Banks		0.1
	Cornelius		16.7
	Forest Grove		25.4
	Hillsboro		143.2
	North Plains		0.1
	Other		27.5
	Washington Co.	42.2	
Rock	ODOT	49.3	
	CWS	2974.5	
	Beaverton		629.7
	Hillsboro		796.2
	Other		1548.6
	Multnomah Co.	61.4	
	Washington Co.	14.9	
	Portland	100.8	
Lower Tualatin/Fanno Creek	ODOT	230.1	
	CWS	1271.6	
	Beaverton		217.5
	Rivergrove		3.4
	Sherwood		132.5
	Tigard		371.5
	Tualatin		279.1
	Durham		4.8
	King City		8.1
	Other		254.8
	Clackamas Co.	37.4	
	Multnomah Co.	1.5	
	Washington Co.	33.1	
	West Linn	26.4	
	Lake Oswego	73.0	

5th-Field Subbasin[1]	DMA (or Municipality – see note)[2]	Wasteload Allocation (Pounds per TMDL Season)	CWS Wasteload Allocations Subdivided by Municipality (Pounds per TMDL Season)[3]
	Portland	134.9	
Upper Tualatin	ODA	0	
	ODF	0	
	CWS	0.2	
	Gaston		0.2
	Washington Co.	0	
Middle Tualatin	ODOT	4.9	
	CWS	203.1	
	Cornelius		15.9
	Forest Grove		19.4
	Hillsboro		58.2
	Beaverton		3.5
	Other		106.0
	Washington Co.	26.9	
Gales	ODOT	1.3	
	Forestry	0	
	CWS	25.9	
	Forest Grove		25.4
	Other		0.5
	Washington Co.	0	

Notes:
[1]As explained in Section 2.11, the allocations given to each DMA may be met by addressing the aggregate 5th-field subbasin loadings for the DMA.
[2]The municipalities listed directly under CWS are not Designated Management Agencies; they are listed here with allocations corresponding to their jurisdictions for reference only. CWS is the designated management agency for these areas. “Other” under this heading refers to loads from areas outside of cities.
[3]The 2001 TMDL provided a calculation to derive daily load limits. In 2007, EPA provided guidance for calculating equivalent daily values. Using the EPA method, and assuming a coefficient of variation of 0.6, daily loads equivalent daily loads are calculated by multiplying the seasonal load by 3.51.

Oswego Lake Waste Load Allocations

The Load and Wasteload allocations combined for Oswego Lake were set equal to the background loadings as estimated in the 2001 TMDL. The wasteload allocations are for discharges from the City of Lake Oswego’s Municipal Separate Storm Sewer system (MS4). All other discharges and instream contributions (instream erosion, etc.) are included in the Load Allocation in Section 2.12. These allocations were developed in the 2001 TMDL, and are not changed by this TMDL amendment. The 2001 TMDL includes a detailed discussion regarding the development of these allocations (DEQ, 2001).

The summer stormwater background concentration (point source) is assigned a value of 0.09 mg/L total phosphorus (TP), with the corresponding load leading to an increase to 0.11 mg/L assigned to instream (non-point) sources. The winter stormwater target concentration (point source) is assigned a value of 0.15 mg/L TP, with the corresponding load leading to an increase to 0.19 mg/L assigned to instream (nonpoint) sources. Based on these values, the total phosphorus allocations for the City of Lake Oswego are given in **Table 2-12,** below. These values were established in the 2001 TMDL and are not being amended by this TMDL amendment.

Table 2-12. Total Phosphorus Allocations for the City of Lake Oswego, unchanged from the approved 2001 TMDL.

May 1 through October 31 (Summer)[1]	
Wasteload Allocations (Stormwater Discharges)	139 lb. (63 Kg.) Total Phosphorus
November 1 through April 30 (Winter)[1]	
Wasteload Allocations (Stormwater Discharges)	858 lb. (390 Kg.) Total Phosphorus

[1]Using the 2007 EPA method, and assuming a coefficient of variation of 0.6, daily loads equivalent daily loads can be calculated by multiplying the seasonal load by 3.51.

Waste Load Allocations for Clean Water Services Municipal Wastewater Treatment Plants

The main objective of the 2001 Phosphorus TMDL was to control the concentration of total phosphorus in the lower Tualatin River (Section 2.2) to reduce the incidence of nuisance algal blooms that led to increased pH and decreased dissolved oxygen concentrations. This objective remains unchanged in this TMDL amendment; waste load allocations for Clean Water Services Rock Creek and Durham Treatment Plants will remain the same as the 2001 TMDL (**Table 2-13**). These allocations provide each treatment plant with a maximum discharge concentration of total phosphorus, based on monthly median values. Due to the influence of these two discharges, combined with the flow augmentation program in CWS Watershed-Based NPDES Permit, the load allocations have been met in the Lower River for several years (**Figure 2-3**).

In November of 2006, EPA began to require TMDLs presented for time periods other than daily loads, as was the case for the 2001 TMDL for pH and Chlorophyll *a* (total phosphorus TMDL), to also include values for daily limits. The daily values have been added to **Tables 2-10, 2-13, 2-15, 2-16**, and **2-17**. Daily values were computed according to a June 2007 draft EPA document (EPA, 2007). The seasonal median values have been adjusted using multipliers from Table 18 in Appendix B of the EPA guidance. The multiplier utilizes an estimate of the variability of daily concentrations to calculate daily maximum concentrations that could occur and are still likely to meet a median monthly value. Little data are available to calculate the coefficient of variation for these TMDL concentration targets, so DEQ assumed a coefficient of variation of 0.6, as recommended in the Technical Support Document for Water Quality Based Toxics Control (EPA, 1991). Wasteload allocations in **Table 2-13** are based on monthly median values, so the daily load is computed by multiplying the monthly target by 2.39 (30 day time period with a coefficient of variance of 0.6). For the seasonal bubble allocation in **Table 2-13**, and seasonal allocations presented in **Tables 2-10, 2-11, 2-12, 2-15, 2-16** and **2-17**, the 2001 TMDL targets are based on meeting the target over a 6 month period. The multiplier for computing the daily load for these is 3.51 (180 days with a coefficient of variance of 0.6). Daily targets have been added as an additional column to most of the affected tables, and instructions for calculating daily limits are included on **Tables 2-11** and **2-12.**

The purpose for this TMDL amendment is to provide waste load allocations for Clean Water Services' Forest Grove and Hillsboro Waste Water Treatment Plants, to enable future summer discharges from these locations to accommodate population growth. Secondary treatment is currently utilized at both the Forest Grove and Hillsboro Waste Water Treatment Plants. Prior to summer discharge, Clean Water Services proposes to modify treatment at the Hillsboro facility to include Advanced Secondary treatment including nitrification, followed by nutrient polishing in a Natural (wetland) Treatment System (NTS). Future plans for Forest Grove include either a similar upgrade as Hillsboro (advanced secondary treatment with NTS), or advanced tertiary treatment to the levels currently provided at the Rock Creek Advanced Waste Water Treatment Plant, such that all NPDES requirements will be met.

In order to provide flexibility for future treatment systems, this TMDL provides a bubble allocation as a daily load for the three upstream discharge sites. A bubble load places a ceiling on the allowable discharge load from multiple sites combined; in this case the Forest Grove, Hillsboro, and Rock Creek treatment plants. Total Phosphorus discharged from these three sites combined must not exceed 66.1 pounds per day as a seasonal median value (the daily target is 232 pounds per day, and the average monthly limit is 81.6). (**Table 2-13**). The discharge concentration limit of 0.10 mg total P/ L must concurrently be met at the Rock Creek Advanced Waste Water Treatment Plant. Monthly limits can also be calculated for the bubble load, and may be of use for permitting, as permits require monthly performance reporting. This conversion must also take into account the number of discharge samples taken in a month. Using a value of 0.6 for the coefficient of variance, and 20 discharge samples taken per month during summer, the phosphorus bubble waste load allocation is 81.6 lbs/day as a monthly average (calculations were based on a method developed by US EPA Region 10). While equivalent daily targets have been added to this amendment, the renewed watershed NPDES permit will likely be based on the monthly or seasonal targets.

Table 2-13. Wasteload Allocations for Clean Water Services Municipal Sewerage Treatment Plants.

Bubble Allocation for CWS Forest Grove, Hillsboro and Rock Creek Wastewater Treatment Plant[1]		
Bubble Loads: ≤ 66.1 pounds per day as a seasonal median ≤232 pounds per day as a daily maximum load ≤ 81.6 pounds per day as an average monthly limit[1]	Dates TMDL applies	May 1- September 30[2]
CWS Rock Creek Wastewater Treatment Plant		
Wasteload Allocation Monthly Median Effluent Concentration 0.10 mg/L Daily maximum effluent concentration 0.24 mg/L	Dates TMDL applies	May 1- September 30[2]
CWS Durham Wastewater Treatment Plant		
Wasteload Allocation Monthly Median Effluent Concentration 0.11 mg/L Daily maximum effluent concentration 0.26 mg/L	Dates TMDL applies	May 1- October 15[2]

[1]The monthly median load will be calculated as follows: [(8.35 conversion factor)×(((Median monthly Forest Grove discharge concentration of total P mg/L)×(Actual median Forest Grove effluent volume MGD))+((Median monthly Hillsboro concentration of total P mg/L)×(Actual median Hillsboro effluent volume MGD)))] ≤[Monthly median load (81.6 pounds per day) - ((Monthly median Rock Creek discharge concentration of total P mg/L)×(Actual monthly median Rock Creek effluent volume MGD) ×(8.35 conversion factor))]
[2]See **Table 2-9** for details; TMDL Phosphorus restrictions may change as early as September 15 in years when Lake Oswego Corporation ceases Tualatin River withdrawals on or before September 15, and the weekly average flow at the Farmington gauge is at least 130 cfs. (see Section 2.9 for more detail)

Allocations for the new discharge locations are provided as a bubble allocation in an expansion of the pollutant trading program already established in the Tualatin Basin. The bubble allocation will provide Clean Water Services with the flexibility to adopt innovative treatment at one or both of the upstream treatment plants, knowing that minor variations in phosphorus treatment at the upstream plants can be offset by proven advance treatment technology already in place at the Rock Creek Plant. This type of trading, also called intramunicipal trading, is encouraged by EPA, and described in detail in EPA's Water Quality Trading Toolkit for Permit Writers (EPA 2007, pg 23). Intramunicipal trading allows the district to manage its multiple discharges as a system, apportioning a total load among multiple facilities. In this case, DEQ has already issued a watershed permit that includes all four discharges under a single permit order. Describing the total phosphorus allocation as a bubble load in this TMDL will enable the permit writer to incorporate intramunicipal trading in subsequent watershed permits for Clean Water Services. One requirement for this type of trade is a demonstration that localized impacts are not expected at any of the discharge locations. The modeling information in Appendix 2-A and the discussion below provide this demonstration.

The bubble wasteload allocation will allow a slight increase in river concentrations of total phosphorus between river mile 53.8 at the Forest Grove discharge and river mile 37.7 downstream of the Rock Creek Treatment Plant. However, the bubble allocation will restrict the concentration of the river to 0.10 mg/L downstream of Rood Road Bridge at river mile 39, maintaining the 2001 TMDL target.

Details that describe the modeling results and potential impacts for this change are located in Appendix 2-A. **Figure 2-7** shows that concentrations of total P will be maintained in the lower river, and increases only slightly between Forest Grove and Rock Creek. **Figure 2-8** shows the model prediction for chlorophyll *a* levels in that same river reach. Chlorophyll *a* levels are slightly lower with waste water treatment plants discharging, likely to due faster travel times, than when plants are not discharging.

Figure 2-7. Primary TP Mass Balance Results (Median TP Concentration, May through October, 2002-2007) Assumes TP Mass Load ≤ 66.1 lb/day, current flow augmentation levels, and tributaries meeting water quality standards.(See Appendix 2-A, Exhibit 2-10). Baseline Total P concentration (◊ light blue diamond) reflects current river concentrations, while the Concentration (◊, dark blue diamond) and load (∆ green triangle) are projected future conditions based on a future 66.1 lb./day load.

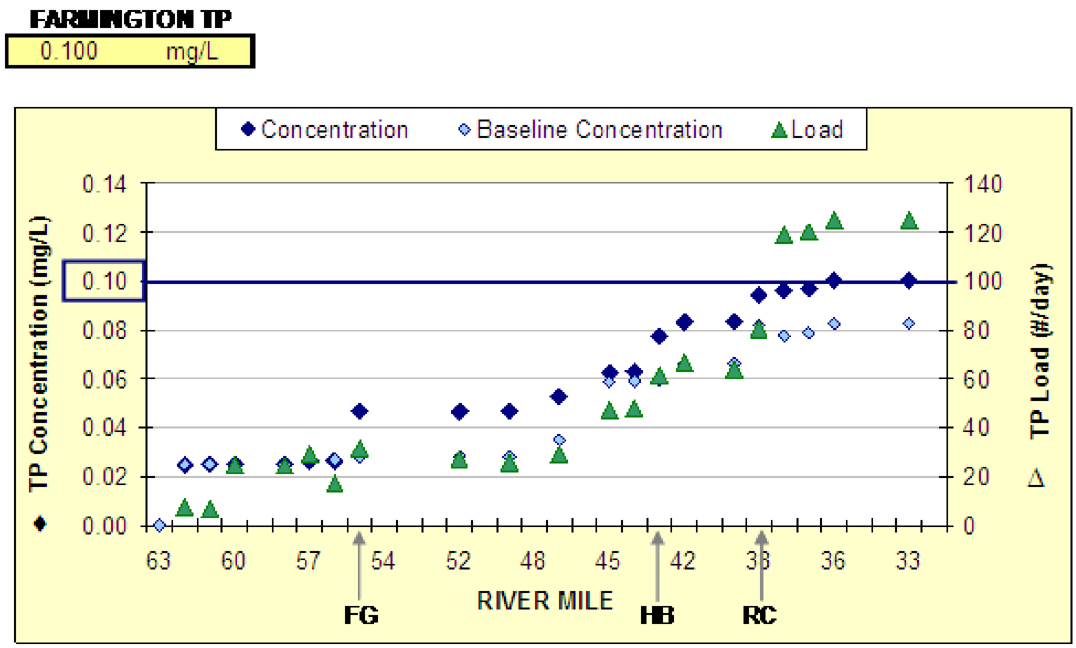
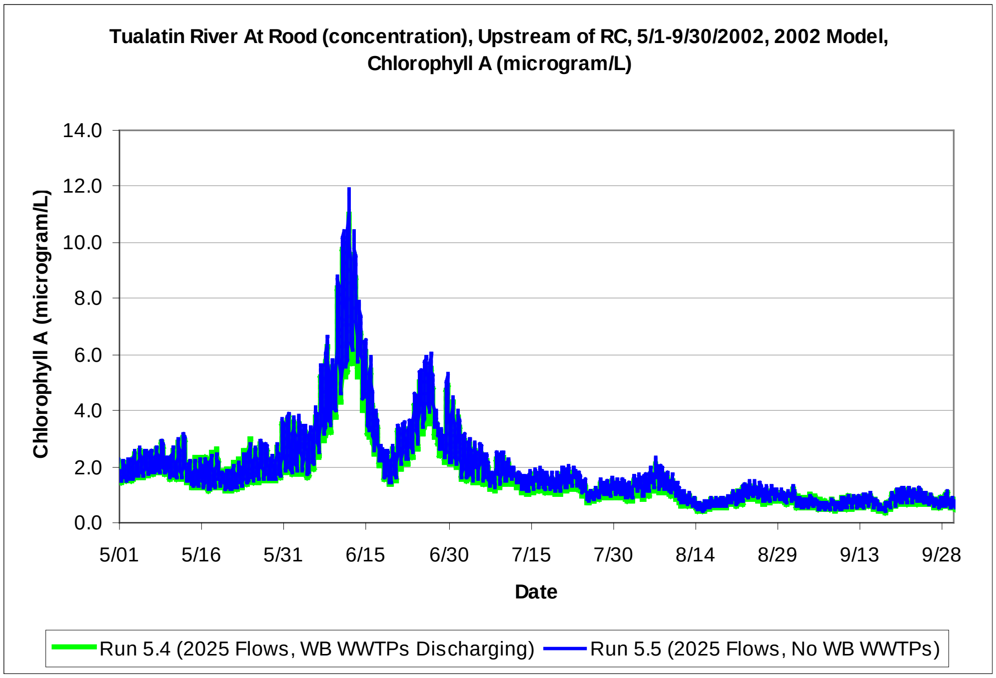


Figure 2-8. Model-predicted Chlorophyll *a* at Rood Road with and without Forest Grove and Hillsboro waste water treatment facility discharges, taken directly from the Total Phosphorus Modeling Report in Appendix 2-A.



Other Permitted Sources

Permitted sources other than the wastewater treatment plants and municipal separate storm sewer systems have been given allocations in the form of target concentrations. These target concentrations were assigned in the 2001 TMDL and are presented here in **Table 2-11 and 2-12** (above). These have been and will be incorporated into the sources' NPDES permits either directly as concentrations, or as loads based on these concentrations. If current discharge levels are below the WLA concentrations, the WLA to be given within the permit will be equivalent to "current performance".

Riparian Bank Erosion

Phosphorus loads from riparian bank erosion are estimated to be relatively small during the TMDL season, but they are still a potential source of pollutants. Due to limitations in the available data, it is not possible to develop a quantitative estimate of phosphorus from riparian bank erosion. Therefore, the load allocation for this source is narrative: No excessive riparian bank erosion may occur in the Tualatin River Subbasin during the TMDL season, or to the Oswego Lake Subbasin year-round. This issue is best addressed through the Tualatin River Subbasin (this document) and the Willamette Basin Temperature (DEQ, 2006) TMDLs, which will require system potential shading in the Tualatin and Oswego Lake Basins, respectively. It is reasonable to assume that the best management practices resulting in system potential shading will also result in bank stabilization and the elimination of excessive riparian bank erosion, especially during the TMDL season.

2.12 Load Allocations

This element determines the portion of the receiving water's loading capacity that is allocated to existing nonpoint sources of pollution or to background sources. Load allocations are best estimates of loading, and may range from reasonably accurate estimates to gross allotments depending on the availability of data and appropriate techniques for predicting loading. Whenever reasonably feasible, natural background and anthropogenic nonpoint source loads will be distinguished from each other. The Load Allocations here were adopted in the 2001 TMDL and are repeated for the reader's convenience.

Load allocations for tributaries and runoff in the Tualatin Basin remain unchanged from the 2001 TMDL. The allocations are repeated here, however the original 2001 TMDL includes more detail and discussion regarding these loads. These load allocations were presented as a combination of concentrations and loads based on meeting those median seasonal concentrations. Offering alternative units for the load allocations is considered appropriate since it both addresses the water quality standard and lends itself to the design of control measures. In addition to providing flexibility in the calculation of loads to ease full implementation of the TMDL allocations, DEQ allows water quality programs to be used to meet load and waste load allocations. Additional information about this process is included in Section 4.4 of the Water Quality Management Plan for these TMDL revisions, and in DEQs internal management directive for trading (DEQ, 2009).

Both mainstem and tributary background (groundwater) sources of total phosphorus are assigned load allocations in the form of concentrations in **Table 2-14**.

Table 2-14. Tualatin River Subbasin Total Phosphorus Load Allocations for Background (Groundwater) Sources.

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

Load allocations for runoff are provided in **Table 2-15** below. These loads are presented as median summer concentrations, and because they are based on maintaining background levels of total phosphorus, have the same values as the background concentrations in **Table 2-14** above. These values are repeated from the 2001 Tualatin TMDL. However, as now required by EPA, daily load equivalents for the monthly values included in the 2001 TMDL have been added to the tables below. These were computed in the same way as the waste load allocations and are described in Section 2.11.

Table 2-15. Tualatin River Subbasin Total Load Allocations for Nonpoint Sources

Designated Management Agency/Source	Source Discharging to: (Subbasin)	Total Phosphorus Concentrations (Summer Median - mg/L)	Total Phosphorus Concentrations (Daily Maximum - mg/L)
Clackamas Co., Oregon Dept. of Agriculture, Oregon Dept. of Forestry, Multnomah Co. and Washington Co., Wapato Improvement District (or future Wapato Lake Manager)	All Sources to the Mainstem Tualatin below Dairy Creek (Unless otherwise specified below)	0.14	0.49
	All Sources to the Mainstem Tualatin above Dairy Creek (Unless otherwise specified below)	.04	0.14
	Bronson Creek @ Mouth (205th)	0.13	0.46
	Burris Cr./ Baker Cr./ McFee Cr./Christensen Cr.(all @ Mouth)	0.12	0.42
	Cedar Cr./Chicken Cr./Rock Cr. (South)/ Nyberg Cr./Hedges Cr./Saum Cr. (all @ Mouth)	0.14	0.49
	Dairy Creek @ Mouth	0.09	0.32
	Fanno Creek @ Mouth	0.13	0.46
	Gales Creek @ Mouth	0.04	0.14
	Rock Creek @ Mouth	0.19	0.67

Wapato Creek, the outlet from Wapato Lake, discharges to the Tualatin River just upstream of Scoggins Creek near Tualatin River mile 60. Wapato Creek drains a mostly low-lying area, which includes the Wapato Lake area, an old wetland-shallow lake area characterized by unique organic, peaty soils. It is not clear whether background phosphorus concentrations here differ from the surrounding watersheds. Because there is not sufficient data to identify a different background contribution or load allocation for this system, the load allocation that applies to the upper watershed applies to Wapato Creek: 0.04 mg/L of total P, during the TMDL season.

Loads can be calculated using the same approach as described in Section 2.11 above for Waste Load Allocations using **Equation 2-1**. These are presented by source for average seasonal runoff in **Table 2-16** below.

Table 2-16. Tualatin River Subbasin Total Phosphorus Allocations for Runoff Sources

5th-Field Subbasin[1]	DMA	Load Allocation (Pounds per TMDL Season)	Load Allocation (daily maximum load in pounds
May 1 through October 31 (Summer)			
Dairy	ODOT	0	0
	CWS	0	0
	Washington Co.	1.1	3.86
Rock	ODOT	0	0
	CWS	0	0
	Multnomah Co.	0	0
	Washington Co.	0	0
	Portland	0	0
Lower Tualatin/Fanno Creek	ODOT	0	0
	CWS	0	0
	Clackamas Co.	0.8	2.8
	Multnomah Co.	0	0
	Washington Co.	0.2	.70
	West Linn	0	0
	Lake Oswego	0	0
	Portland	0	0
Upper Tualatin	ODA	26.4	92.7
	ODF	17.1	60.0
	CWS	0	0
	Washington Co.	8.6	30.2
Middle Tualatin	ODOT	0	0
	CWS	0	0
	Washington Co.	1.60	5.6
Gales	ODOT	0	0
	Forestry	0.1	.35
	CWS	0	0
	Washington Co.	0.1	.35

[1]As explained in Section 2.11, the allocations given to each DMA may be met by addressing the aggregate 5th-field subbasin loadings for the DMA.

Load Allocations for Oswego Lake

The Load Allocations and Wasteload Allocations combined were set equal to the background concentrations in the 2001 TMDL. These have been separated into load allocations for non-point sources and wasteload allocations for point sources. The wasteload allocations, presented in Section 2.12, are for discharges from the City of Lake Oswego's municipal separate storm sewer system (MS4). The Load Allocations in **Table 2.17** apply to all other discharges and for instream contributions (instream erosion, etc.) combined.

Table 2-17. Total Phosphorus Allocations for the City of Lake Oswego

	May 1 through October 31 (Summer)	Daily Maximum Load during Summer
Load Allocation (Base Flow and Instream Contributions)	272 lb. (124 Kg.) Total Phosphorus	955 lb. (435 kg)/day Total Phosphorus
	November 1 through April 30 (Winter)	Daily Maximum Load during Winter
Load Allocation (Base Flow and Instream Contributions)	986 lb. (448 Kg.)Total Phosphorus	3461 lb (1572 kg)/day Total Phosphorus

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

It can be seen that the estimated background loadings to the lake in the 2001 TMDL are higher than the allocations given in the original 1988 TMDL (which included total allocations of 1500 lb. of total phosphorus per year). These background loadings are also significantly lower than the estimated current loadings to the lake. In order to quantitatively estimate what water quality impacts would result from reducing the phosphorus loads from their current levels to background levels, a new diagnostic analysis for the lake would have to be undertaken. Qualitatively, however, as reported in the SRI report (SRI, 1987) a reduction in the annual phosphorus loading is predicted to result in decreased mean summer chlorophyll *a* values, increased mean summer secchi depths, and decreased hypolimnetic oxygen depletion rates. Estimating the significance of these reductions would be part of a full lake diagnostic analysis and would have to take into account other restoration efforts (e.g., artificial aeration, alum treatments, etc.).

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

2.13 Reserve Capacity

This element is an allocation for increases in pollutant loads for future growth and new and expanded sources. The TMDL may allocate no reserve capacity and explain that decision.

Reserve Capacity is a portion of the Loading Capacity that is set in reserve for future growth, so that new, expanded or unidentified sources can be accommodated. In the Tualatin River Basin, the loading capacity, waste load and load allocations are based on concentrations. As such, new sources may be added to the Tualatin Basin as long as they are able to meet the concentration-based allocations.

The Loading Capacity for the Oswego Lake subbasin is defined as a load, due to the lentic nature of lakes, and the relationship between annual loads of phosphorus to lake trophic level. No reserve Capacity has been set aside for phosphorus sources to Oswego Lake.

2.14 Margins of Safety

This element accounts for uncertainty related to the TMDL and, where feasible, quantifies uncertainties associated with estimating pollutant loads, modeling water quality and monitoring water quality.

Implicit Margins of Safety (MOS) were included in the Phosphorus TMDL for the Tualatin Subbasin. Conservative estimates of the background concentrations of phosphorus were used to identify the loading capacity for the Tualatin River and its tributaries. Since these background concentrations are the basis for the allocations, the allocations are also conservative. The details describing these estimations are presented in the 2001 TMDL (see Section 4.4.9 and Appendix C-8, DEQ, 2001). The climate changes predicted under global warming scenarios for the Tualatin Basin include a larger number of significant summertime storms, with increased summer time rainfall. The fact that groundwater, not storm inputs, are the main contributor of summertime phosphorus concentrations also provides a margin of safety that should protect Tualatin streams from high phosphorus levels in the future. High summer phosphorus from groundwater should be diluted under more frequent rainwater inputs. In addition, the establishment of system potential shade in riparian corridors will also act to filter phosphorus from runoff, reducing future storm-related phosphorus inputs.

New wasteload allocations are provided for new summertime discharges in this TMDL that were not included in the 2001 TMDL effort. Because these allocations are based on the 2001TMDL targets for the lower Tualatin River, the margins of safety from the 2001 TMDL are also partially applicable to these allocations. The new allocations are based on limiting a total phosphorus load to the lower river, in order to maintain the concentration based 2001 TMDL target downstream of Rock Creek and the Rock Creek Advanced Waste Water Treatment Plant on the Tualatin River. As a daily load, calculation of this bubble allocation was based on both discharge and phosphorus concentration. Flow data collected from 2002-2007 were used to estimate river and tributary flows; the bubble load was based on several years of variable flow regimes. The impact of the resulting phosphorus loads along the mid-reach of the Tualatin River was then determined using the CE-QUAL-W2 model, calibrated for the 2001-2002 low water years. Thus while the bubble load was estimated based on average flow, the potential impacts of the bubble load were modeled using low flow years, when the bubble allocation may have a larger impact.

The waste load allocation approach is also conservative in the assumptions made about treatment facilities, and because the allocation includes both a bubble allocation that provides some flexibility among three treatment plants, combined with a concentration-based effluent limit at the largest treatment plant. The conservative mass balance model used to calculate the total phosphorus load assumed that there would be no uptake of phosphorus as water travels down the Tualatin River. There is likely to be some uptake of phosphorus from the water column as the Tualatin River flows downstream, so the mass balance approach will somewhat overestimate the phosphorus reaching the lower river. These assumptions collectively over-estimate the contribution of phosphorus from the two upstream treatment plants. Discharge at the downstream Rock Creek Plant will be limited by the existing 2001 concentration based TMDL limit, so when the two upstream sources discharge at a rate lower than anticipated by the TMDL bubble allocation, the total phosphorus discharged to the Tualatin will remain low. Despite some flexibility for trading among plants, the phosphorus “savings” at the two upstream treatment plants cannot be transferred downstream to the Rock Creek Plant, because this location is limited by a concentration-based wasteload allocation as well as the bubble load. Finally, the mass balance model computed that a bubble load of 66.1 pounds of total P per day as a seasonal median value would meet the TMDL targets set as concentration levels in the downstream Tualatin River reaches.

Oswego Lake Allocation Margins of Safety

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

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