Annotated Bibliography – Tualatin River Basin Studies

This document contains the most comprehensive collection of Tualatin River basin research currently available. Annotation for each reference was copied almost entirely from the original document text, with some editing and reformatting to better represent: 1) project goals and 2) key findings. Material was copied from report abstract or executive summary; however, if abstract was not available, annotation was generated from materials included in the introduction, purpose and scope, and results.

Steven Sobieszczyk
2130 SW 5th Ave.
Portland, OR 97201
(503) 251-3208
ssobie@usgs.gov

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Tualatin River Reports

Abrams, M.M., and Jarrell, W.M., 1995, Soil processes and chemical transport – Soil phosphorus as a potential nonpoint source for elevated stream phosphorus levels: Journal of Environmental Quality, v. 24, p. 132-138

Eroded soils, as a potential nonpoint phosphorus source, have come under scrutiny, particularly in agricultural watersheds. Surface water and groundwater in the Tualatin River basin have maximum concentrations of 2.1 and 2.6 mg P/L, respectively. We hypothesized that soils are a major phosphorus source in the basin because of their high native soil phosphorus concentrations and soil phosphorus adsorption characteristics. We sampled eight soil series from both lowland and upland positions in the Tualatin River basin, with both andic and nonandic mineralogy. Findings include:

- All soils sampled had high total phosphorus concentrations (660-2304 mg P/kg soil).
- High average extractable phosphorus (Bray P1, 74 mg P/kg soil, and ammonium bicarbonate, 35.7 mg P/kg soil) concentrations were found primarily in lowland, nonandic soils.
- There was no significant difference between phosphorus sorption maxima; however, phosphorus affinity was significantly higher in upland soils (0.19 L/mg P) than in lowland soils (0.04 L/mg P).
- Upland, andic soils, due to their erosion potential and high total phosphorus levels (average of 1889 mg P/kg soils), could be a phosphorus source for surface waters.
- Lowland, nonandic soils, due to their high extractable phosphorus concentrations and lower phosphorus sorption affinity, could be a source for both surface and groundwater.
- Thus, all soils studied, comprising approximately 50% of basin soils, are potential nonpoint phosphorus sources in this watershed, indicating that native soil phosphorus is a potential source of nonpoint phosphorus pollution.

Keywords: phosphorus, soils

Locations: Tualatin River

Altman, Bob, Henson, C.M., and Waite, I.R., 1997, Summary of information on aquatic biota and their habitats in the Willamette basin, Oregon, through 1995: U.S. Geological Survey Water-Resources Investigations Report 97–4023, 174 p.

Report reviews and summarizes available information on aquatic biota of the Willamette River basin, including the status, distribution, and trends of aquatic biota, particularly algae, macroinvertebrates, and fish; the condition of aquatic and riparian habitat in which these biota reside; and the response of these biota to natural and human-associated impacts, such as level, type, and effect of contaminants. Findings from this study indicate:

- The Willamette River basin supports a diverse aquatic macroinvertebrate fauna. In the lower mainstem reaches, macroinvertebrate assemblages are dominated by pollution tolerant organisms and those adapted to low dissolved oxygen levels.
- Approximately 61 fish species occur in the basin, although nearly half are introduced. Species richness and distribution are highly correlated with elevation, stream gradient, and water temperature. High elevation, cold water, mountain streams are characterized by a few species

of salmonids, sculpins, suckers, and whitefish. Low elevation, mainstem reaches of major rivers and streams are dominated by warm water species, such as bass, catfish, and several species in the pan fish group. The only species of fish listed as threatened or endangered is the Oregon chub (Oregonichthys crameri).

- The effect of an expanding human presence in the Willamette River basin has altered aquatic and riparian habitats, and the biota that use or reside in these habitats.
- Aquatic toxicological investigations in the basin have focused primarily on fish. These studies have addressed chlorinated pesticides, polychlorinated biphenyls (PCBs), dioxins and furans, polycyclic aromatic hydrocarbons (PAHs), and trace elements in aquatic tissue, as well as fish health assessments, skeletal abnormalities, and aquatic toxicological responses.
- Several pesticides exceeded U.S. EPA and State water-quality criteria for the protection of aquatic life. Elevated PCB, dioxin, and furan concentrations were associated with point sources, such as pulp and paper mills. Elevated concentrations of mercury in aquatic tissue were associated with several reservoirs. Few investigations have examined aquatic toxicological responses, such as enzyme induction assays, growth assays, and biomarker studies.

Keywords: taxonomy, fish, biota, algae, macroinvertebrates, amphibians, reptiles, birds, mammals, introduced species, salmon, pollution, urbanization, pesticides, trace elements

Applicable Locations: Tualatin River, Rock Creek

Anderson, C. W., Rinella, F. A., and Rounds, S. A., 1996, Occurrence of selected trace elements and organic compounds and their relation to land use in the Willamette River basin, Oregon, 1992-94: U.S. Geological Survey Water-Resources Investigations Report 96-4234, 68 p.

Between 1992 and 1994, the USGS conducted a study of trace elements and organic compounds in the Willamette River basin. Low-level analyses were performed for trace elements, volatile organic compounds, organochlorine compounds, and pesticides. Overall, 94 water samples were collected from 40 sites, during predominantly high-flow conditions, representing urban, agricultural, mixed, and forested land uses. Findings from this study indicate:

- Few exceedances were observed of water-quality criteria for acute and chronic toxicity and for the protection of human health.
- Concentrations of chromium, copper, lead, and zinc in unfiltered water were well correlated with concentrations of suspended sediment.
- The highest trace-element concentrations generally were found at urban sites that receive a large portion of their runoff from industrial areas, particularly at high suspended-sediment concentrations. In contrast, concentrations of trace elements in some urban streams draining primarily residential areas appeared to approach a maximum as sediment concentrations increased.
- Eight organochlorine compounds were detected at 14 sites. Lindane, dieldrin, and DDT or its metabolites were each detected in about 30 percent of the samples, predominantly in samples collected from agricultural and urban areas. Polychlorinated biphenyl (PCB) compounds were detected in samples from two urban sites. For samples in which DDT and its metabolites were examined for partitioning, the largest proportion of the mass of DDT and its metabolites was associated with suspended sediment. In contrast, dieldrin and lindane were almost completely (greater than 99 percent) associated with the dissolved phase.

- Sixty-one of the 94 pesticides analyzed in filtered water were documented to have been used in the basin in 1987; 43 of these were detected at least once during 1992-94. An additional five were detected that were not documented in the 1987 estimates.
- Of the 25 most frequently detected pesticides, 3 were found primarily at urban sites, 6 were found primarily at agricultural sites, and 7 were found at all types of sites except forested.
- The four most commonly detected pesticides in the basin, observed at all except forested site types, were atrazine, metolachlor, simazine, and diuron.

Keywords: constituents, nutrients, bacteria, streamflow, nitrogen, phosphorus, E. coli, total solids, total suspended solids, total volatile suspended solids, turbidity

Locations: Fanno Creek

Anderson, C.W. and Rounds, S.A., 2003, Phosphorus and E. coli and their relation to selected constituents during storm runoff conditions in Fanno Creek, Oregon, 1998-99: U.S. Geological Survey Water-Resources Investigations Report 02-4232, 34 p.

This report characterizes water-quality conditions, including sources and transport of nutrients and bacteria, in Fanno Creek during three storm events between June 1998 and December 1999. Samples were collected over the discharge hydrograph at three locations during storm events in the summer, fall, and winter. Findings from this study indicate:

- Discharge was significantly correlated with total solids (TS), total suspended solids (TSS), total volatile suspended solids (TVSS), turbidity, and total phosphorus (TP).
- Of the different fractions of TS measured, TS was most directly correlated with TSS.
- Rising limbs of discharge hydrographs had higher concentrations of sediment and TP, possibly indicating that sources were nearby (resuspension of streambed, bank erosion, close upland sources) and that available supplies limited downstream transport.
- Concentrations of sediment (TS, TSS), TP, and bacteria (E. coli) were greatest and most variable at the most upstream site. Peak bacterial loads were similar at upstream and downstream sites, so additional sources were not evident, or downstream sources were offset by settling or losses of bacteria from upstream.
- Biochemical oxygen demand during storms was primarily associated with decomposable materials on particulate matter.
- E. coli concentrations exceeded the State of Oregon single-sample water-quality standard of 406 colonies/100 mL in almost all samples. E. coli concentrations measured during the summer storm were an order of magnitude greater than those measured during the fall or winter storms, primarily due to warmer water and less dilution during the summer storm.
- E. coli were correlated with suspended sediment (TSS and turbidity), indicating that they were either transported to streams attached to particles bound to resuspended streambed particles, or they had an affinity for particulate material in water.
- TP concentrations exceeded both the 1998 and 2001 Total Maximum Daily Load (TMDL) criterion concentrations in almost all samples.
- Soluble Reactive Phosphorus (SRP) in the stream may have originated primarily from ground-water discharge, whereas TP was mostly associated with particulates.

Keywords: constituents, nutrients, bacteria, streamflow, nitrogen, phosphorus, E. coli, total solids, total suspended solids, total volatile suspended solids, turbidity

Locations: Fanno Creek

Anderson, C.W., and Rounds, S.A., 2010, Use of continuous monitors and autosamplers to predict unmeasured water-quality constituents in tributaries of the Tualatin River, Oregon: U.S. Geological Survey Scientific Investigations Report 2010-5008, 76 p.

This report evaluates the feasibility of developing correlative regression models for predicting dependent variables, including concentrations of total suspended solids, total phosphorus, and E. coli bacteria in Fanno and Dairy Creeks. Results of this study indicate that the potential to develop predictive relations is good. These sorts of predictive regression equations may be used to quantify peak concentrations or annual loads of sediment or phosphorus moving through the system. This effort could provide a foundation for development of more detailed and accurate correlations. Correlations that can be used in near‑real time, potentially allowing evaluation of the efficacy of land use and other management decisions.

Keywords: TMDL, constituents, sediment, nutrients, bacteria, turbidity, streamflow, regression modeling, autosamplers, total suspended solids, total phosphorus, E. coli

Locations: Fanno Creek, Dairy Creek

Bautista, Mark, Geiger, Stan, and Riley, Kristen, 1992, 1991 report on monitoring of Jackson Bottom experimental wetland (JBEW) – Final report: Scientific Resources, Inc., Lake Oswego, Oregon, 46 p., plus Tables, Figures, and Appendices

This report provides a review of the third year's findings from the monitoring of the Unified Sewerage Agency's Jackson Bottom Experimental Wetland (JBEW). The JBEW was designed to treat secondary effluent during the period of May through October from the Hillsboro Wastewater Treatment Facility, which is located on the south side of Hillsboro, Oregon. Results from the study include:

- For 1991, a total of 237,665 m^3 of water entered the wetland. Of this total, 1.1% was from precipitation. Around 237,665 m^3 (46.5%) was pumped from the wetland. An apparent total of 96,927 m^3 (40.8%) flowed into the groundwater table, or laterally through berms as "leakage." Evapotranspiration accounted from 6.3% of water removed. Around 6.5% (15,379 m^3) remained in the wetland.
- For 1991, the measured mean total dissolved solids was 281 mg/L.
- During period of operation, water temperatures varied from 10.6 C to 23.7 C.
- Dissolved oxygen concentrations were low, with no apparent relation to temperature fluctuations.
- Chemical oxygen demands (COD) values for inflow averaged 39 mg/L, while effluent values ranged from 39 to 60 mg/L.
- Organic nitrogen values for inflow averaged 3.01 mg/L, while effluent was 1.31 mg/L.
- Average nitrite+nitrate+nitrogen inflow was 4.26 mg/L, while effluent was 0.015 mg/L (99.6% reduction).

- The anaerobic condition of the wetland during operation provided an environment for denitrification processes.
- Generally, outflow phosphorus concentrations were lower than inflow.
- The water-soluble fraction of phosphorus in surficial soil remained consistent, regardless of soil type, loading rate, or time of sampling.
- Canopy cover is variable.
- Vegetation abundance within the wetland is dynamic.
- The treatment wetland is producing algae.
- The linear relation between mass loading and removal indicates that for the range of loading rates used over the three year period, all biological, physical, and chemical mechanisms have yet to exceed their cumulative ability to remove these parameters (in particular, phosphorus).

Keywords: surface water, groundwater, water budget, water quality

Locations: Jackson Bottom Experimental Wetland (JBEW)

Berger, C.J., 1993, Water quality modeling of the Tualatin River, M.S. Thesis, Portland State University, Portland, Oregon, Technical Report EWR-001-94, 152 p.

Water quality problems related to excessive algal growth, high nutrient loading, and low flows have been occurring in the Tualatin River. An instream model was developed to analyze pollution control alternatives. The U.S. Army Corps of Engineer's CE-QUAL-W2 model, a two-dimensional, laterally averaged, dynamic model of hydrodynamics and water quality was applied to the Tualatin River. Calibration of the main pool model of the Tualatin River was from field data taken during June through August 1991. Verification of the model was performed from field data taken during the summer of 1990. After calibration and verification of the model, management alternatives were evaluated in order to achieve DEQ mandated water quality standards. Environmental performance criteria were determined to evaluate differences between model scenarios. Management alternatives focused on the reduction of point and nonpoint sources of pollution, flow augmentation, and structural changes in the river system, such as removal of the Lake Oswego Diversion Dam.

Keywords: model, CE-QUAL-W2, pollution, water quality, phosphorus

Locations: Tualatin River

Bonn, B.A., 1998, Dioxins and Furans in bed sediment and fish tissue of the Willamette basin, Oregon, 1992-95: U.S. Geological Survey Water-Resources Investigations Report 97-4082-D, 12 p.

An occurrence and distribution study of polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) in the Willamette Basin, Oregon, was done by the USGS between 1992 and 1995. Bed sediment samples were collected at 22 sites, and fish tissue samples were collected from 8 sites. Samples were analyzed for 10 tetra- through octa- congener class totals and for 17 individual 2,3,7,8-substituted congeners. Findings from this study indicate:

- Dioxins and furans were found in bed sediment and fish tissue throughout the Willamette River basin, including samples from the most remote sites.

- The highest concentrations in bed sediment were found at sites where industrial or urban inputs were most likely; potential toxicity at these sites (as measured by toxicity equivalents concentration) was high enough to be associated with increased risk to sensitive mammalian wildlife.
- From 30 to 60 percent of the toxicity equivalents concentration in bed sediment was due to hepta- and octa- congeners, not 2,3,7,8-TCDD (2,3,7,8-tetrachlorodibenzo-p-dioxin), which was detected at only 6 of 22 sites.
- Compared to bed sediment from the same site, fish tissue usually had lower total concentrations of dioxins and furans, but contained a higher proportion of the most toxic congeners, such as 2,3,7,8-TCDD and 2,3,7,8-TCDF (2,3,7,8-tetrachlorodibenzofuran).
- Concentrations of dioxins and furans in bed sediment at most sites in agricultural and forested areas were similar to those at reference sites worldwide and are probably background concentrations due to atmospheric deposition.

Keywords: dioxins, furans, toxicity, sediment, fish

Applicable Locations: Tualatin River, Fanno Creek

Bonn, B.A., 1998, Polychlorinated dibenzo-p-dioxin and dibenzofuran concentration profiles in sediment and fish tissue of the Willamette basin, Oregon: Environmental Science & Technology, v. 32, no. 6, p. 729-735

Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) are highly hydrophobic compounds that have been implicated as carcinogens and more recently, as estrogen disrupters. An occurrence and distribution study of these compounds in the Willamette Basin, Oregon was conducted by the USGS as part of the NAWQA Program. Bed sediment was collected from 22 sites; fish tissue was collected 8 sites. Findings from this study indicate:

- PCDD /Fs were found to be ubiquitous in Willamette River basin sediment. A distinct homolog profile, dominated by octachlorodibenzo-p-dioxin, was observed in sediment throughout the basin.
- The PCDD homolog profile was consistent at all sites, regardless of total PCDD/F concentration, presence of point sources, subbasin size, geographic location or land use.
- Principal components analysis revealed a gradient among the homolog profiles that showed increasing dominance of highly chlorinated congeners where human and industrial activity increased. Tissue and bed sediment obtained from the same site did not have similar PCDD/F concentrations or homolog profiles.
- Fish tissue showed enrichment in less chlorinated congeners and congeners with chlorine substitutions in the 2,3,7, and 8 positions.

Keywords: dioxins, furans, toxicity, sediment, fish

Applicable Locations: Tualatin River, Fanno Creek

Bonn, B.A., 1999, Selected elements and organic chemicals in bed sediment and fish tissue of the Tualatin River basin, Oregon, 1992-96: U.S. Geological Survey Water-Resources Investigations Report 99-4107, 61 p.

This report assesses the occurrence, magnitude, and relationship between contaminants in bed sediment and fish tissue that were collected from the Tualatin River basin between 1992 and 1996. Findings from this study indicate:

- Concentrations of trace elements in Tualatin River basin sediments and fish tissue were generally similar to those found in the Willamette River basin and were at the low end of national concentrations.
- There were no exceedances of U.S. Environmental Protection Agency (USEPA) Tier 1 sediment screening values for any trace element in the Tualatin River basin.
- Concentrations of chromium, copper, and nickel exceeded USEPA Tier 2 screening values at all sites. Copper and nickel concentrations were highest at the background sites and were probably related to basin geology.
- Polyaromatic hydrocarbons (PAHs) were detected more frequently in Tualatin River basin sediment than elsewhere (Willamette River basin or national), likely due to large number of urban sites in the basin.
- Few organochlorine pesticides were detected in bed sediment or fish tissue in the Tualatin River basin. Chlordanes and p,p'-DDE were commonly detected in both sediment and fish tissue. Dieldrin was commonly detected only in fish tissue.
- Contamination patterns that were consistent with urban sources-high concentrations of PAHs, lead, and some phthalates-were found at Ash Creek at Greenburg Road, Fanno Creek at Nicol Road, Fanno Creek at Denny Road, and McKay Creek at Hornecker Road.
- High levels of organochlorine pesticides in both sediment and fish tissue were found at two residential sites (Fanno Creek at Nicol Road and Fanno Creek at Denny Road). Concentrations of total chlordane, dieldrin, and p,p'-DDE in sediment at these sites exceeded USEPA Tier 2 screening values. Concentrations of total chlordane in fish tissue exceeded both the National Academy of Science/National Academy of Engineering (NAS/NAE) guidelines and the New York State criteria. Organochlorine concentrations were much lower downstream of these sites where the land use changed to light industrial; concentrations of trace elements, however, increased.
- The most contaminated bed sediment found in this study was collected from the most urban site (Beaverton Creek at Cedar Hills Boulevard). USEPA sediment screening values were exceeded for four organochlorine pesticides, six polyaromatic PAHs, two phthalates, p-cresol, and eight metals. Levels of polychlorinated biphenyls found in fish at this site exceeded NAS/NAE guidelines.

Keywords: trace elements, arsenic, chromium, copper, lead, mercury, nickel, selenium, zinc, Polyaromatic hydrocarbons, bed sediment, fish tissue, pesticides, chlordane, dieldrin, p,p'-DDE

Locations: Tualatin River, Fanno Creek, Ash Creek, McKay Creek, Dairy Creek, Bronson Creek, Cedar Mills Creek, Beaverton Creek, Chicken Creek, Gales Creek, Rock Creek

Bonn, B.A., and Rounds, S.A., 2010, Use of stable isotopes of carbon and nitrogen to identify sources of organic matter to bed sediments of the Tualatin River, Oregon: U.S. Geological Survey Scientific Investigations Report 2010-5154, 58 p.

This report describes the use of carbon and nitrogen stable isotope measurements and carbon/nitrogen (C/N) ratios to identify the likely sources of organic material to bed sediments in the Tualatin River. Samples of bed sediment, suspended sediment, and seston, as well as potential source materials, such as soil, plant litter, duckweed, and wastewater treatment facility effluent particulate were collected between 1998 and 2000. Findings from this study indicate:

- Based on the isotopic data, terrestrial plants and soils were determined to be the most likely sources of organic material to Tualatin River bed sediments.
- Phytoplankton probably was not a major source of organic matter to bed sediments.
- Although phytoplankton cannot be considered a major source of organic material to bed sediment, a few bed sediment samples in the lower reach of the river showed a small influence from phytoplankton as evidenced by lower δ13C values than in other bed sediment samples.
- Isotopic data and carbon/nitrogen ratios for bed sediments generally were similar throughout the basin, supporting the idea of a widespread source, such as terrestrial material.
- Strategies to improve oxygen conditions in the Tualatin River will be more successful if they target sources of soil, leaf litter, and other terrestrially derived organic materials to the river rather than the instream growth of algae.

Keywords: carbon, nitrogen, plants, phytoplankton, isotope, bed sediments, organic matter

Locations: Tualatin River, Fanno Creek, Rock Creek, Dairy Creek, Gales Creek, Henry Hagg Lake

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Bonn, B. A., Hinkle, S. R., Wentz, D. A., and Uhrich, M. A., 1995, Analysis of nutrient and ancillary water-quality data for surface and ground water of the Willamette basin, Oregon, 1980-90: U.S. Geological Survey Water-Resources Investigation Report 95-4036, 88 p.

This report reviews historical water-quality data for surface and groundwater collected in the Willamette and Sandy River Basins between 1980 and 1990. For surface water, most data were concentrated at sites on the Willamette River or near the mouths of major tributaries. All seasons were represented. Data for nitrogen and phosphorus species were readily available, but simultaneously collected discharge measurements frequently were not. Seven primary sites were used for a quantitative analysis of nutrient data in surface water. Findings from this study indicate:

- At six of the seven primary sites, median concentrations of nitrite plus nitrate and total phosphorus were less than 0.5 milligrams per liter (mg/L) as nitrogen (N) and 0.1 mg/L as phosphorus (P), respectively. These concentrations were lower than national median concentrations for basins with similar land uses.
- Forested sites had significantly lower water temperatures and nutrient concentrations than urban or agricultural sites. Evidence of diel variations in dissolved oxygen concentrations and pH values suggest that, at some sites, low dissolved oxygen concentrations may be a problem during early morning hours in the summer.

- Historical nutrient data for ground water were limited primarily to nitrate and nitrite-plus-nitrate determinations for wells completed in the basin-fill and alluvial aquifer. Nitrate and nitrite-plus-nitrate concentrations in this aquifer showed a weak inverse relationship with depth.

Keywords: streamflow, nutrients, NPDES, constituents, water temperature, pH, specific conductance, suspended sediment

Applicable Locations: Tualatin River

Bonn, B. A., Wentz, D. A., and Hinkle, S. R., 1996, Willamette basin, Oregon – Nitrogen in streams and ground water, 1980-90: U.S. Geological Survey Open-File Report 96-227, 4 p.

This report is a four-page fact sheet. Findings include:

- Large inputs of nitrogen to lakes and streams can cause eutrophication, or the excessive growth of aquatic plants, particularly algae.
- Shallow well depth increases susceptibility to contamination from activities at the land surface.
- Most nitrogen contamination arises from human and animal wastes, certain industrial wastes, and fertilizer use.
- The highest nitrate and total nitrogen concentrations were observed in the Calapooia, Pudding, and Tualatin Rivers.

Keywords: streamflow, nutrients, NPDES, constituents, water temperature, pH, specific conductance, suspended sediment

Applicable Locations: Tualatin River

Bureau of Reclamation, 2009, Biological assessment for Bureau of Reclamation future operations and maintenance in the Tualatin River subbasin – Tualatin Project: U.S. Department of the Interior, Bureau of Reclamation, Pacific Northwest Region, Columbia-Cascades Area Office, 156 p., plus Appendices

Biological assessment written by Bureau of Reclamation and submitted to U.S. Fish and Wildlife Service and NOAA's National Marine Fisheries Service, in compliance with Endangered Species Act (ESA), Magnuson-Stevens Fishery Conservation and Management Act (MSA), and Sustainable Fisheries Act of 1996. Analyses focus on ESA-listed species, designated critical habitat, and MSA-designated essential fish habitat, including aquatic and terrestrial environments. The biological assessment is submitted in response to Proposed Action by Reclamation, such as future operation and routine maintenance for the Tualatin Project, including projected uses of project water through the year 2020 and beyond. Findings from this study include:

- Proposed Action will have no effect on the following species: Northern Spotted Owl, Willamette daisy, Howellia, Bradshaw's lomatium, Kincaid's lupine, Nelson's checker-mallow, and golden paintbrush.
- Proposed Action is likely to adversely affect Upper Willamette River steelhead.

- Proposed Action is likely to adversely affect essential fish habitat for Chinook salmon (Oncorhynchus tshawytscha).
- Proposed Action will adversely affect essential fish habitat for coho salmon (Oncorhynchus kisutch).

Keywords: water quality, model, streamflow, Northern Spotted Owl, Willamette Daisy, Howellia, Bradshaw's Lomatium, Kincaid's Lupine, Nelson's Checker-mallow, Golden Paintbrush, salmon, steelhead, habitat

Locations: Tualatin River, Scoggins Creek, Henry Hagg Lake, Willamette River, Columbia River

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Carpenter, K. D., and Waite, I. R., 2000, Relations of habitat-specific algal assemblages to land use and water chemistry in the Willamette basin, Oregon: Environmental Monitoring and Assessment, vol. 64, no. 1, p. 247-257

In this article benthic algal assemblages, water chemistry, and habitat were characterized at 25 stream sites in the Willamette River basin in 1994 during low flow. Seventy-three algal samples yielded 420 taxa, including diatoms, blue-green algae, and green algae. Findings from this study indicate:

- Algal assemblages from depositional samples were strongly dominated by diatoms (76% mean relative abundance), whereas erosional samples were dominated by blue-green algae (68% mean relative abundance).
- Canonical correspondence analysis (CCA) of semiquantitative and qualitative (presence/absence) data sets identified four environmental variables (maximum specific conductance, % open canopy, pH, and drainage area) that were significant in describing patterns of algal taxa among sites.
- Based on CCA, four groups of sites were identified: streams in forested basins that supported oligotrophic taxa, such as Diatoma mesodon; small streams in agricultural and urban basins that contained a variety of eutrophic and nitrogen-heterotrophic algal taxa; larger rivers draining areas of mixed land use that supported planktonic, eutrophic, and nitrogen-heterotrophic algal taxa; and streams with severely degraded or absent riparian vegetation (> 75% open canopy) that were dominated by other planktonic, eutrophic, and nitrogen-heterotrophic algal taxa.
- Patterns in water chemistry were consistent with the algal autecological interpretations and clearly demonstrated relationships between land use, water quality, and algal distribution patterns.

Keywords: water chemistry, land use, benthic algae, habitat, CCA

Applicable Locations: Tualatin River

Carter, L.M., 1975, The effect of human activity on the middle course of the Tualatin River, Oregon: Ph.D., Portland State University, Portland, Oregon, 166 p.

A diurnal study of biological, chemical, and physical parameters was made on the middle course of the Tualatin River. This portion of the river lies along the transition between agricultural and urbanized land. Results from this study indicate:

- There is no nutrient loading from farming practices because there was no return of water from summer, sprinkler irrigation of commercial crops. However, irrigation significantly reduces the volume of water in the river in the summers.
- Effluents from sewage treatment plants cause of degraded water quality and algal biomass in the lower reaches of the river. The Tualatin River above the mouth of Rock Creek is relatively unpolluted, but downstream from Rock Creek the river is highly eutrophic and during the periods of low flow in the summer serves as a sewage oxidation channel. In this same portion of the river there is also evidence that nitrification occurs.
- Winter floods leach nitrate-nitrogen from the basin, but in the summer the possibility exists that nitrate-nitrogen may be a limiting nutrient for algal productivity in the river above Hillsboro.
- The principle source of poly-phosphates is from sewage treatment plant effluents, but concentrations of poly-phosphates in the middle reaches of the river indicate that there is a natural source of poly- and/or orthophosphates in the watershed. Removal of phosphorus compounds from the effluents probably would not affect the large algal blooms occurring in the river below Hillsboro.
- Trace metal analyses indicated that iron, potassium, nickel, zinc, lead, copper, cobalt, and chromium concentrations were higher during flooding. Turbidity readings suggest that these trace elements are deposited on the floodplain.
- Melted snow water, which caused one of the winter floods, contained concentrations of zinc, copper, and lead greater than those found in the river during the flood. Greater concentrations of arsenic and zinc came from farmland than from urban areas.
- Diversities of the net plankton, as measured by the Shannon-Weaver Index, did not change from season to season, nor with downstream flow. Species in the net plankton were benthic forms at the upper stations and planktonic forms downstream from Hillsboro, especially in the summer when the reduced flow caused the river to pond. The enriched effluents from Rock Creek did not affect the diversity of the organisms downstream, but supported a larger biomass. By rating the diversities with other studies, it was found that the middle course of the Tualatin River is eutrophic but not heavily polluted.
- A diurnal study was especially valuable from April to September, inclusive, when insolation and temperatures favored biological activities, such as photosynthesis and decomposition. From November to January little diurnal change in the water quality was found.
- Farming had its greatest impact in the quantity of water and municipalities had a more serious impact on the water quality in the middle course of the Tualatin River. Even with the reduced flow from agricultural irrigation, the river can maintain relatively good water quality, except when effluents from sewage plants caused highly eutrophic conditions.

Keywords: Shannon-Weaver Diversity Index, nutrients, plankton, wastewater treatment plant, land use, water quality, nitrogen, phosphorus, oxygen demand

Locations: Tualatin River

Cass, P.L., and Miner, J.R., 1993, The historical Tualatin River basin: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 7, 59 p.

Turning back the pages of history allows us to view the slow changing landscape of the Tualatin River and its floodplain. Every activity in the Tualatin River basin has contributed to the river we see today: the original floods; the Kalapuya field burning and animal drives; the beaver trapping; the draining of swamps; the introduction of cattle, sheep, and pigs; the conversion of belly-high grass to agriculture; the use of fertilizers and pesticides; the digging of wells and diversion of stream water; the felling of forests and the loss of understory brush; the straightening of channels and the removal of log jams and obstructions; the building of dams; the growing population; the production and treatment of sewage; even the transport of industrial wastes. Today, the water quality of the Tualatin River has deteriorated. Summer flows become but the merest trickle. Algal blooms are common, causing stretches of river unsuitable for boating, fishing, swimming, or even irrigation. Taste and odor issues affect drinking water quality. The grasses and trees that held the water and the soils in place no longer exist. Marshes and swamps that store winter rains have been reduced considerably. Harsh winter rains that once made rivers swell and pour out onto the floodplain, now are channelized and forced through the system. Winter water is no longer trapped by the trees, grasses, and marshes to slowly infiltrate the ground, store, and release back to the river in the summer. Today, the river rarely floods its banks. Today, the rains lap the soil where trees or crops have been harvested. The water picks up the sediments and fertilizers, travels through impervious urban areas and picks up more pollutants, rushes into the unobstructed river channel and washes out to the Willamette River, all within a single winter season. Little water remains stored in the soils awaiting summer.

Keywords: history, culture

Locations: Tualatin River

CH2MHill, 2006, Tualatin River basin water supply project – Water quality technical report: CH2MHill Technical Report, 89 p., plus Appendices

The primary objective of the Water Quality Technical Report (Technical Report) is to document the water quality modeling methodology, assumptions, and Tualatin River basin Water Supply Project (TBWSP) alternative effects on water quality in Hagg Lake, Scoggins Creek, and the mainstem Tualatin River. This Technical Report will also support the development of water quality analysis for the TBWSP Planning Report and Environmental Statement (PR/ES).

In this Technical Report, three alternatives are evaluated to illustrate their range of effects on water quality in comparison to baseline conditions. A more detailed description of the alternatives is presented in Chapter 2-Background. The three alternatives are as follows: 1) no action; 2) 40-foot Scoggins Dam raise and raw water pipeline (RWP) with pump-back; or 3) 25-foot Scoggins Dam raise and RWP with Pump-Back and Willamette River Water Treatment Plant (WTP) expansion with expansion of the Willamette River Pipeline. Findings from this study indicate:

- Hagg Lake model runs show that both Alternative 2 and 3 both would result in overall positive effects on key water quality metrics for the lake, including cooler average wholelake temperature and higher dissolved oxygen, longer periods of thermal stratification, shallower thermoclines, and fewer days of blue-green algae blooms and anoxia in comparison to Baseline and Alternative 1.
- For all of the alternatives, Hagg Lake would remain thermally stratified during the summer and early fall, with warmer surface water that exceeds temperature criteria for the designated use

of trout rearing and migration, and cooler bottom water that does not meet applicable dissolved oxygen criteria. These are conditions that are to be expected in stratified reservoirs and lakes and can be considered in compliance with water quality standards per the provisions of OAR 340-041-0061(15).

- Model runs from the Hagg Lake Model (at the outlet) indicate that both Alternative 2 and 3 will result in slightly higher annual average temperatures at the outlet of Scoggins Dam relative to Baseline and Alternative 1. However, this increase in annual temperature would be insignificant because the number of days in which the temperature standard is exceeded would be significantly reduced compared to Baseline and Alternative 1.
- Implementation of either Alternative 2 or 3 would improve the temperature of water in Scoggins Creek because of the use of selective withdrawal of cooler water. The Upper Tualatin River Model predicts that these overall temperature benefits would propagate to the mouth of Scoggins Creek.
- Dissolved oxygen would be lower than Baseline and Alternative 1 in the release of water at Scoggins Dam; however, because of the aeration that occurs at the dam outlet due to turbulence, dissolved oxygen concentrations in Scoggins Creek would be at or above saturation conditions for all the alternatives.
- Concentrations of ammonia, phosphorus, and algae in the releases from the dam would not significantly affect water quality conditions in Scoggins Creek under any of the alternatives.
- Water-quality effects of mainstem Tualatin River are summarized:
    - Alternative 1 (baseline) temperature criterion not met until October.
    - Alternative 1 (baseline) DO met at Forest Grove, however, never met downstream.
    - Alternative 1 (baseline) ammonia either not measureable or at permitted levels.
    - Alternative 1 (baseline) algae varies at location (not measureable, usually met, or often exceeded)
    - Alternative 2 and 3 would cause slightly warmer temperatures than Alternative 1.
    - Alternative 2 and 3 would typically higher August to November than Alternative 1.
    - Alternative 2 and 3 ammonia levels are lower than Alternative 1.
    - Alternative 2 and 3 algae levels generally lower than Alternative 1.

Keywords: TMDL, total phosphorus, temperature, dissolved oxygen, ammonia, chlorophyll a, orthophosphate, model, CE-QUAL-W2, wastewater treatment

Locations: Tualatin River, Scoggins Creek, Henry Hagg Lake, Forest Grove WWTP, Hillsboro WWTP, Rock Creek WWTP, Durham WWTP

Clean Water Services, 2011, WQL Sampling Information Summer 2011 Winter 2010-2011 [spreadsheet]: Clean Water Services, 1 p.

Spreadsheet listing sites, project, frequency, flow and temperature infrastructure, and water-quality parameters measured during sampling effort.

Keywords: time, depth, temperature, dissolved oxygen, DO%, pH, conductivity, turbidity, total solids, total dissolved solids, total suspended solids, nitrogen, ammonia, phosphorus, alkalinity, chloride, chlorophyll a, E. coli, BOD, priority pollutants, methyl mercury, mercury, hardness, metals, [NH3-N, TKN, T-PO4-P, NPOC for TOC, S-NPOC for SOC]

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, McKay Creek, Rock Creek, Beaverton Creek, Bronson Creek, Chicken Creek, Fanno Creek, Ash Creek, Dawson Creek

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Clean Water Services, 2011, Stormwater annual report: Clean Water Services, Hillsboro, Oregon, 102 p.

This annual report includes a summary of the activities and accomplishments for the period of July 1, 2010 through June 30, 2011, as outlined in the Clean Water Services (District) 2006 Stormwater Management Plan (SWMP), as modified in 2008 through adaptive management. The SWMP is incorporated by reference into the District's integrated, watershed-based National Pollutant Discharge Elimination System permit (Permit) which was originally issued on February 26, 2004. This report meets the reporting requirements of the Permit relating to the Municipal Separate Storm Sewer System (MS4). Highlights from the study include:

- Administered 13,439 erosion control inspections
- Cleaned over 400 miles of storm sewer pipelines
- Cleaned or inspected more than 36,700 catch basins
- Swept more than 38,000 miles of streets, removing over 7,500 cubic yards of material
- Performed 68 water quality investigations in response to reports of illicit discharges
- Performed 100 inspections of industrial stormwater 1200-Z permit facilities
- Reviewed five Industrial Stormwater Pollution Control Plans and provided comments to DEQ
- Presented Tualatin River Rangers program to over 3,700 elementary school students
- Marked more than 1,100 storm drains with "Dump No Waste, Drains to Stream"
- Obtained pledges from 27 dog owners to scoop up dog waste and toss it in the garbage as part of the Canines for Clean Water campaign
- Completed retrofit of six outfalls, with four additional sites in planning, design, or under construction phases – 118 acres of treatment were provided with outfall retrofit projects
- Completed retrofitting 124 manholes and catch basins with sumps to improve water quality

Keywords: habitat, riparian, water quality, macroinvertebrates, multimetric analyses, model, Marine Western Coastal Forest (MWCF), TMDL

Locations: Ash Creek, Beaverton Creek, Bronson Creek, Fanno Creek, Gales Creek, McFee Creek, McKay Creek, Rock Creek, Bannister Creek, Cedar Mill Creek, Chicken Creek, Christensen Creek, EF Dairy Creek

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Clean Water Services, 2011, Watershed monitoring plan – Update of November 2006 plan: Clean Water Services, Hillsboro, Oregon, 51 p.

This document provides the monitoring plan designed to document the above monitoring program. This monitoring plan provides a guide for why, how, when, and where to monitor and can be referred to throughout the course of program implementation to help maintain consistency and provide documentation to others. This plan is based upon the current understanding of the needs and requirements for information in the Tualatin Basin. These needs may change over time, so an adaptive management approach will be used to ensure that the plan continues to best satisfy future monitoring needs. It is anticipated that the basic plan will be reviewed on an annual basis to determine if any changes need to be made. Projects examined in this study include:

- Determine factors controlling dissolved oxygen in tributaries
- Tributary Flow Restoration Pilot Project
- Determine factors controlling dissolved oxygen in the Tualatin River
- Determine where stormwater facilities are needed and what types
- Evaluate the need to monitor current/ and emerging sources of pollution and other stressors
- Assess winter permit limits
- Determine how current and future projects (Water Supply Project, Reuse, etc) affect assimilative capacity
- Define river conditions under which WWTPs can currently discharge/trade ammonia
- Tributary Flow Restoration Pilot Project (Phase 1 complete, Phase 2 ongoing)
- Stormwater Screening – Completed
- Stormwater Low Impact Development BMPs – Completed
- Support development of water quality models – Ongoing
- Determine the impact of sanitary sewer overflows (SSOs) – Completed
- Define appropriate biological reference conditions for low gradient streams – Completed
- Define river conditions under which WWTPs can currently discharge/trade ammonia – Completed
- Determine where stormwater facilities are needed and what type
- Support the development of Use Attainability Analysis (UAA)/Site Specific Criteria (SSC)
- Hagg Lake Watershed Monitoring Program – Completed

Keywords: water quality, temperature, dissolved oxygen, DO%, pH, conductivity, turbidity, total solids, total dissolved solids, total suspended solids, nitrogen, ammonia, phosphorus, alkalinity, chloride, chlorophyll a, E. coli, BOD, priority pollutants, metals, [NH3-N, TKN, T-PO4-P, NPOC for TOC, S-NPOC for SOC]

Locations: Tualatin River, McKay Creek, Bannister Creek, Bronson Creek, Summer Creek, Beaverton Creek, Scoggins Creek, Gales Creek, Dairy Creek, Rock Creek, Dawson Creek, McFee Creek, Chicken Creek, Fanno Creek, Ash Creek, Nyberg Creek

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Cole, M.B., and Lemke, J.L., 2008, Biological assessment of wastewater outfall locations in the Tualatin River, Oregon – Final report: ABR, Inc. – Environmental Research & Services, Forest Grove, Oregon, 10 p.

This study was performed to determine whether treated effluent is measurably affecting benthic macroinvertebrate communities of the Tualatin River by comparing communities occurring below effluent outfall locations to those occurring above outfall locations. Four District-operated, wastewater treatment facilities were included in this study. Study reaches measuring 150 m were established both above and below each outfall location. One pair of study reaches was established at the Forest Grove, Rock Creek, and Durham facilities, while two pairs of reaches were established at the Hillsboro facility because the plant discharge through two outfalls separated by 0.4 miles. Each 150-m reach was subdivided and marked into five 30-m sampling belts. Five replicate macroinvertebrate samples, each consisting of a 0.75-m^2 composite sample, were collected from each above- and below-outfall study reach. Reach surveys included reach-wide visual assessments of instream physical and adjacent riparian zone conditions to support the biological sampling. Findings from the study include:

- Macroinvertebrate communities in all reaches were characterized by low taxonomic richness, a high collective community tolerance to organic-enrichment pollution, and were well represented by disturbance-tolerant and sediment-tolerant organisms.
- No significant differences were found between any of the above-below-outfall pairs for any of the community attributes tested.
- Ordination bi-plots resulting from non-metric multidimensional scaling (NMS) analyses showed considerable overlap between above and below-outfall replicate samples at each of the five outfall locations, further suggesting that community composition is similar between the above and below reach pairs.

Keywords: wastewater treatment, macroinvertebrates, outfall, riparian, habitat, metrics

Locations: Tualatin River

Cole, M.B., and Lemke, J.L., 2011, 2010-2011 Assessment of fish and macroinvertebrate communities of the Tualatin River basin, Oregon – Final report: ABR, Inc. – Environmental Research & Services, Forest Grove, Oregon, 68 p.

The objective of the study was to determine the current condition of biological communities in streams throughout the Tualatin River basin and ascertain long-term trends in these conditions using both current and historic data. This study represented the first effort to apply the DEQ's weighted average stressor models to Tualatin River basin macroinvertebrate data. These stressor tools, combined with the use of correlation analysis between environmental gradients and biological condition scores, allowed inferences to be made regarding site-specific effects of individual candidate stressors on biological condition. Findings from the study include:

- Water temperature is a stressor to biological communities in many valley-floor streams of the Tualatin River basin.
- Low dissolved oxygen stresses benthic communities in the majority of lower-gradient reaches.
- Among the high-gradient reaches included in the study, fine sediment was most frequently identified as a "likely stressor" based primarily on the high inferred fine sediment values produced by the model.
- Aquatic resources of the Tualatin River basin may benefit from a formalized effort to assess the status of freshwater mussels in the Tualatin River and its tributaries. Since 2001, mussel specimens have been collected during District macroinvertebrate survey efforts in only nine samples from seven waterbodies (more than 250 samples have been collected during this time). Five of those nine collections were made in 2001, while only four have been made in 2005, 2007, 2009, and 2010, combined.
- Fish assemblages of the Tualatin River basin have changed little since previous surveys in 1999–2001. Sculpin remain the most abundant and widely distributed species within the Tualatin River basin.
- Salmonids were present in the middle Gales Creek and upper Chicken Creek in both the fall and spring, while salmonids were present in the fall but not the spring in the middle Bronson Creek and lower Chicken Creek reaches. Juvenile cutthroat trout, rainbow trout, and coho salmon were all observed in the middle Gales Creek reach, highlighting the importance of this stream as rearing habitat for juvenile salmonids.

- Streams outside of the urban growth boundary (UGB) had higher IBI scores in comparison to those inside of the UGB in both the fall (unpaired t-test: $p = 0.0006$, $t = 4.740$, $df = 11$) and the spring (unpaired t-test: $p = 0.0005$, $t = 4.816$, $df = 11$).
- Streams outside of the UGB tended to have higher dissolved oxygen concentrations and lower afternoon water temperatures which are necessary to support sensitive species such as salmonids.
- As in 2005-2006, the results of 2010-2011 basin-wide assessments of fish and macroinvertebrate communities suggest little change in biological conditions since the last significant assessment of each community type. The results generally indicate little change occurring between 1999 and 2011, suggesting that ecological conditions have remained relatively stable over the last decade.

Keywords: stressor, fish, macroinvertebrates, channel stability, habitat, riparian, water chemistry, index of biological integrity (IBI), multimetric analyses, model, Marine Western Coastal Forest (MWCF)

Locations: Ash Creek, Beaverton Creek, Bergholzer Creek, Bronson Creek, Cedar Creek, Chicken Creek, Dawson Creek, Fanno Creek, Gales Creek, Hedges Creek, S Johnson Creek, McKay Creek, Rock Creek, Saum Creek, Scoggins Creek, WF Dairy Creek, Willow Creek, Christensen Creek, Summer Creek

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Cole, M.B., Lemke, J.L., and Currens, C.R., 2006, 2005-2006 Assessment of fish and macroinvertebrate communities of the Tualatin River basin, Oregon – Final report: ABR, Inc. – Environmental Research & Services, Forest Grove, Oregon, 68 p.

The objective of the study was to determine the current condition of biological communities in streams throughout the Tualatin River basin and ascertain long-term trends in these conditions using both current and historic data. This study represented the first effort to apply the DEQ's weighted average stressor models to Tualatin River basin macroinvertebrate data. These stressor tools, combined with the use of correlation analysis between environmental gradients and biological condition scores, allowed inferences to be made regarding site-specific effects of individual candidate stressors on biological condition. Findings from the study include:

- Macroinvertebrate community conditions ranged widely among high-gradient stream reaches as indicated by both RIVPACS O/E scores and DEQ multimetric scores.
- Upper Gales Creek received both the highest O/E and multimetric scores of 1.05 and 46, respectively. Three sites received "fair" O/E scores ranging from 0.779 to 0.877. These sites scored as slightly or moderately impaired according to multimetric scores. Fourteen high-gradient reaches received "poor" O/E scores; five of these sites also received severely impaired multimetric scores. These most impaired streams occurred in areas with higher urban and agricultural land use intensities.
- Multimetric scores and O/E scores were significantly correlated with a number of environmental variables, including percent urban land use, percent forested land use, effective impervious area, percent total urban and agricultural land use, water temperature, conductivity, and dissolved oxygen, and several measures of streambed substrate conditions.
- Across all high-gradient reaches, macroinvertebrate community conditions were similar to those reported in 2001 (Cole 2002).
- Biological integrity of macroinvertebrate communities varied less among low-gradient reaches and generally scored lower than in high-gradient reaches.

- A total of 112 fish-community IBI scores were calculated from reaches surveyed during fall, 2005 and spring, 2006. The upper Tualatin River reach was the only site to score as in acceptable condition in each season.
- Collectively, our results suggest that biological conditions largely remain the same as those measured between 1999 and 2001.

Keywords: stressor, fish, macroinvertebrates, channel stability, habitat, riparian, water chemistry, index of biological integrity (IBI), multimetric analyses, model, Marine Western Coastal Forest (MWCF)

Locations: Ash Creek, Beaverton Creek, Bergholzer Creek, Bronson Creek, Cedar Creek, Chicken Creek, Dawson Creek, Fanno Creek, Gales Creek, Hedges Creek, S Johnson Creek, McKay Creek, Rock Creek, Saum Creek, Scoggins Creek, WF Dairy Creek, Willow Creek, Christensen Creek, Summer Creek

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Cole, M.B., Lemke, J.L., and Harris, A.P., 2011, Characterization of macroinvertebrate communities in valley-floor stream reaches of the Tualatin River basin – Final report: ABR, Inc. – Environmental Research & Services, Forest Grove, Oregon, 25 p.

This study was performed to identify least-disturbed stream conditions among low-gradient Tualatin Valley floor streams and develop a bioassessment tool more appropriate for glide-dominated reaches lacking coarse sediment within the Tualatin River basin. The objectives of this study were to 1) assist Clean Water Services with identifying locations of least disturbed low-gradient valley floor streams, 2) characterize benthic macroinvertebrate community conditions in these locations, and 3) develop a bioassessment tool calibrated for valley floor streams in the Tualatin River basin. Macroinvertebrate communities, physical habitat, and water chemistry were sampled at 13 survey reaches between September 14, 2009, and October 28, 2009. Macroinvertebrate data were analyzed using existing multimetric (western Oregon index) and predictive-model techniques (Marine Western Coastal Forest [MWCF] model). In addition, a new bioassessment model named the Tualatin Valley Floor Null (TVFN) model was developed to more accurately classify biological conditions in Tualatin Valley floor streams. The results (O/E scores and condition classes) from the TVFN model were compared to those initially produced by the MWCF model. Findings from this study include:

- Application of the existing MWCF model to the macroinvertebrate data collected from glides resulted exclusively in “poor” condition classifications for all 13 sites. TVFN O/E scores from the three proposed reference sites averaged 0.998 with a standard deviation of 0.132. The six reaches with moderate upstream land-use intensity (50-90% forested) received an average TVFN O/E score of 0.574 (+ 0.183 SD), while the four reaches with high upstream land-use intensity (<50% forested) averaged 0.359 (+ 0.091 SD).
- TVFN O/E scores of the 13 study reaches were highly correlated with percent developed upstream area, suggesting the potential utility of this null model at discriminating among macroinvertebrate community condition classes in Tualatin Valley floor streams.
- TVFN O/E scores were significantly correlated with the MWCF scores ($r = 0.9185$, $p < 0.0001$).
- For best results, the TVFN model should be used alongside existing biomonitoring tools to evaluate biological conditions of Tualatin Valley floor streams. As opportunities allow, the TVFN model should be further developed and tested to include a larger number of locations and to ensure the model represents least disturbed conditions.

- Unlike the MWCF model, the TVFN model uses benthic condition information from least-disturbed stream reaches that are representative of Tualatin Valley floor streams, and, therefore, derives a more meaningful estimate of biotic condition for this stream type.
- Assessment of Tualatin River basin macroinvertebrate communities collected from reaches containing coarse substrates and riffle habitat should continue to be assessed using the MWCF model.

Keywords: habitat, pool, riffle, glide (run), rapid, riparian, water chemistry, macroinvertebrates, multimetric index, model, Marine Western Coastal Forest (MWCF), Tualatin Valley floor null (TVFN), land use, benthic

Locations: McKay Creek, Bergholzer Creek, WF Dairy Creek, Gales Creek, McFee Creek, Heaton Creek, Baker Creek, Cedar Creek, Chicken Creek, Bronson Creek, Summer Creek

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Cole, M.B., Lemke, J.L., and Harris, A.P., 2011, Comparison of macroinvertebrate communities collected from riffles and glides in Tualatin River basin stream reaches – Final report: ABR, Inc. – Environmental Research & Services, Forest Grove, Oregon, 21 p.

The purpose of this study was to characterize and quantify differences in benthic assemblages between riffle and glide habitat types, as determined by multimetric scores and Marine Western Coastal Forest (MWCF) model scores and their resulting community condition classifications. This study also examined how stream characteristics (namely substrate composition) and land-use intensity affected the relative difference in community conditions between riffles and glides. To address these questions, macroinvertebrates were sampled from both riffles and glides in 17 stream reaches in the Tualatin River basin in the fall of 2009. Findings from this study indicate:

- Both MWCF model scores and multimetric scores were significantly higher in riffles than in glides, but glide scores were marginally higher in several reaches.
- Differences in multimetric scores or MWCF model scores were not significantly affected by land-use intensity class (low/moderate versus high). However, graphic analysis suggests that the largest differences in scores between riffles and glides occurred in drainages with the lowest amount of development.
- EPT richness was higher in riffles than in glides, and the size of the difference was significantly higher in the low/moderate land-use intensity class than in the high land-use intensity class.
- Differences in multimetric or MWCF model scores between riffles and glides were not correlated with the amount of coarse substrate present in glides or with the extent to which riffles were embedded with fine substrate.
- Collectively, these results suggest a need for consistency in selecting habitats for benthic macroinvertebrate sampling, and avoiding comparing results derived from samples collected in riffles to those from glides when comparing conditions across waterbodies or within a waterbody over time.
- Clean Water Services and ABR are developing a new model referred to as the Tualatin Valley Floor Null model, for use with glide samples collected from Tualatin River basin valley-floor streams, which should allow for more accurate assessments of benthic conditions in low-gradient streams of the Tualatin River valley where riffles are absent or sparse.

Keywords: habitat, pool, riffle, glide (run), rapid, riparian, water chemistry, macroinvertebrates, multimetric index, model, Marine Western Coastal Forest (MWCF), land use, benthic

Locations: McKay Creek, WF Dairy Creek, Roaring Creek, Gales Creek, EF Dairy Creek, Scoggins Creek, Bergholzer Creek, McFee Creek, Fanno Creek, Bronson Creek, Willow Creek, Summer Creek, Cedar Creek, Cedar Mill Creek, Ash Creek

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Courter, Ian, Duery, Shadia, Vaughn, Jay, Watry, Clark, and Morasch, Mark, 2011, Steelhead radio telemetry, fish assemblage, and salmonid fry monitoring at Spring Hill pumping plant, Tualatin River, Oregon: Cramer Fish Sciences, Gresham, Oregon, 12 p.

The primary objectives of this study were to characterize fish species composition in the Spring Hill Pumping Plant (SHPP) intake channel, describe relative abundance of each species found within the intake channel, estimate mortality of steelhead smolts diverted into the intake channel, and determine whether steelhead fry are present in the intake channel during pumping operations. Findings from this study indicate:

- Since only one Oncorhynchus Mykiss (resident or anadromous) was captured at 190 mm it is likely that steelhead fry are not present in the intake channel in appreciable numbers.
- The smallest salmonid captured, a coho salmon, was 55 mm. It is much more likely that coho fry would utilize the intake channel as rearing habitat because coho are often found in offchannel habitats with fine sediment substrates, while steelhead tend to prefer areas with gravel or cobble substrates.
- Coho were the most abundant salmonid species observed.
- Habitat adjacent to the SHPP is not ideal habitat for spawning and rearing steelhead.
- Velocities within the SHPP intake channel do not appear to be a significant threat to migrating steelhead smolts in the Tualatin River. In spite of being released within 10 meters of the SHPP, none of the 95 radio tagged smolts were last detected by the underwater antennas along the face of the plant. Since we did not observe any entrainment of radio tagged steelhead smolts during this study it is not clear whether increased residence time caused by increasing water withdrawals poses a latent mortality risk for juvenile steelhead, or whether the level of effect attributable to SHPP withdrawals is even of concern. We would postulate that it is not because the effect of withdrawals on residence time was small and there is a low probability that a naturally produced winter steelhead smolt would wander into the SHPP intake channel. Unfortunately, empirically testing the hypothesis that minor migration delays are not effecting smolt survival cannot be achieved with data from this study.
- None of the radio tagged steelhead were detected at the receiver site near the mouth of the Tualatin River, so differential survival rates between release groups could not be estimated.
- None of the 95 radio tagged steelhead were detected at the mouth of the Tualatin River. This may be because low survival of radio tagged smolts or insufficient radio tag battery life (~33 days).
- Five of the radio tagged fish were never detected downstream of the SHPP intake channel; this may be the result of insufficient tag battery life for fish that remained in the intake channel for a prolonged period predation or other sources of mortality.

Keywords: pump station, fish, salmonid, steelhead, coho, smolt

Locations: Tualatin River, Spring Hill Pumping Plant

Cross, T.L., and Wood, Mary, 1995, Estimated costs of reducing nonpoint phosphorus loads from agricultural land in the Tualatin basin, Oregon: Oregon Water Resources Institute, Tualatin River Basin Water Resources Management Report Number 9, 31 p.

About one-third of the Tualatin River basin is used for agricultural production. The variety of crops produced includes grains, specialty seeds, vegetables, fruits, berries, and nursery corps. Cattle and hog enterprises are the most prevalent livestock operations in the area, with small numbers of dairy and sheep operations also present. Agricultural production can be a nonpoint source of phosphorus pollution. One alternative in helping to meet Total Maximum Daily Load (TMDL) limits for phosphorus in the Tualatin River is to decrease the loading of phosphorus from agricultural sources. Potential sources of agricultural phosphorus pollution are from applications of phosphorus fertilizers and livestock wastes through surface runoff on sediments and groundwater interflows. A range of best management practices (BMPs) has been identified to address these sources; most are technically feasible to implement. Documented reductions in pollution due to adoption of these practices are generally not available, but most experts agree that the practices would result in decreased levels of phosphorus loads from agriculture. This report describes a set of management practices that have been suggested to reduce agricultural nonpoint source pollution and estimates the economic impacts of adopting these practices. Best management practices include:

- For phosphorus: applying phosphorus at plant utilization rates based on crop nutrient requirements and realistic yield goals; applying phosphorus fertilizers at optimal times of the year; incorporating broadcast applications of phosphorus into the soil; and banding phosphorus whenever possible.
- For runoff: using vegetative filter strips and fencing around riparian areas appear most promising for improving runoff control on crop and livestock farms.
- For erosion: using conservation tillage, permanent and annual cover crops and mulches, filter strips, and improved irrigation management.

Keywords: phosphorus, land use, best management practices, runoff, nonpoint source, sediment

Locations: Tualatin River

Davis, Stu, Britch, Mike, and Dummer, John, 2011, Intake and pump station preliminary design: Tualatin Basin Water Supply Project, Aquatic Working Group Pre-Meeting Information, 12 p.

Over the last 13 months, the Tualatin Basin Water Supply Project (TBWSP) Partners have further analyzed the six alternatives that were established for the Intake and Pump Station as part of the preliminary design. Based on cost, constructability, operations and maintenance, environmental/permitting, and property acquisition requirements, the Partners recently identified two preferred alternatives for consideration as the design process progresses. The first choice is Riverbank F - modified vee screen located near the existing Spring Hill Pumping Plant (SHPP). The second choice is River B – flat plate on-bank screen located on the riverbank near the existing SHPP. These preferred alternatives represent the best fit for the necessary facilities at this site.

Keywords: pump station

Locations: Tualatin River

Doyle, M.C. and Caldwell, J.M., 1996, Water-quality, streamflow, and meteorological data for the Tualatin River Basin, Oregon, 1991-93: U.S. Geological Survey Open-File Report 96-173, 49 p., CD-ROM

This report documents the sampling sites, field measurement techniques, sampling techniques, laboratory-analysis techniques, and the results of an ongoing quality-assurance program. The report also contains field measurements and analytical and quality-control data from mainstem Tualatin River sites, major tributary sites, groundwater sites, and wastewater-treatment facilities between 1991 and 1993. No interpretation or analysis was completed.

Keywords: water quality, streamflow, meteorology, TMDL, surface water, ground water

Locations: Tualatin River, Scoggins Creek, Carpenter Creek, Gales Creek, Dairy Creek, Jackson Slough, Rock Creek, Butternut Creek, Christensen Creek, Burris Creek, McFee Creek, Baker Creek, Chicken Creek, Rock Creek, Fanno Creek, Nyberg Creek

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Doyle, M.C. and Rounds, S.A., 2003, The effect of chamber mixing velocity on bias in measurement of sediment oxygen demand rates in the Tualatin River Basin, Oregon: U.S. Geological Survey Water-Resources Investigations Report 03-4097, 16 p.

This report describes experiments used to quantify the variability of sediment oxygen demand (SOD) measurements, as a function of chamber circulation velocity, at a typical depositional area in the lower Tualatin River. Specifically, this report describes the effect of water velocity on SOD as the velocity in the chamber is changed over the same parcel of bottom sediment. Findings from this study indicate:

- Measured river and chamber velocities were similar, indicating that results from the chambers were representative of instream effects.
- At low to moderate chamber circulation velocities (less than about 7.5 centimeters per second), the measured SOD rate appeared to be only slightly affected by the circulation velocity, indicating that the measured rates reflect the rate of oxygen utilization by chemical and biological reactions in the sediment rather than the rate of physical transport of oxygen to the sediment-water interface.
- At high chamber circulation velocities the measured oxygen depletion rate was affected by the circulation velocity, as sufficient energy was generated within the chamber to resuspend bottom sediment.
- The resuspension effect in the Tualatin River causes increased turbidity and increased oxygen demand, resulting in lower instream dissolved oxygen concentrations.

Keywords: sediment oxygen demand, dissolved oxygen, velocity, turbidity

Locations: Tualatin River

Dupuis, Tom, 2009, Comparison of water quality effects for pre-project, existing operations, and dam scenarios: CH2MHill 12 p.

This technical memorandum describes and compares water quality effects for several scenarios: 1) Pre-project conditions; 2) Existing operations; 3) 40 foot dam raise with pump back and fixed point (low-level) outlet to Scoggins Creek; and 4) 40 foot dam raise with pump back and multi-level outlet to Scoggins Creek. For this memorandum, the analyses focuses on DO, temperature, and algae in Henry Hagg Lake, Scoggins Creek, and the Tualatin River (from Scoggins to Rood Road). Findings from this study indicate:

- Dam raise alternatives increase the concentration of algae during the spring bloom compared to existing operations. There is no difference in the magnitude or duration of this spring bloom between the low-level and multi-level scenarios. For all of the scenarios, the spring and summer blooms do not extend deep enough into the water column to be drawn into the outlet to Scoggins Creek.
- Temperature differences between the various scenarios are striking and consistent with the modeling presented in the water quality technical report comparing the existing dam with fully contracted deliveries to a 40 foot raise with pump back and multi-level outlet because the latter was modeled such that the multi-level outlet released water to Scoggins Creek to closely approximate natural temperatures.
- Differences in DO are primarily due to temperature differences. Higher temperatures have lower DO saturation concentrations, and for all scenarios it was assumed that DO would be fully saturated because of the high reaeration that occurs at the dam outlet to the creek and in the creek itself.
- For steamflow, water temperature, and DO, the most striking differences between scenarios are a decrease just downstream of Scoggins Creek. This diminishment is largely because the operational flow releases from Hagg Lake are mostly withdrawn at the Springhill Pump Plant, except for the releases by Clean Water Services for flow augmentation that remain in the upper and lower river reaches.

Keywords: chlorophyll a, algae, water quality, dissolved oxygen, streamflow

Locations: Henry Hagg Lake, Scoggins Creek, Tualatin River

Ervin, D.E., 1995, Analysis of pollution control strategies for the Tualatin River: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 11, 52 p.

The objective of this report was to describe the cost effectiveness of alternative strategies at reducing the excessive summertime growth of algae and associated water-quality problems in the Tualatin River. Thus, the evaluation required two steps. First, estimate the probable environmental impacts of the alternative strategies using the load delivery model Hydrologic Simulation Program FORTRAN (HSPF) and the instream water-quality model CE-QUAL-W2. Second, estimate the likely economic impacts of these strategies based on available cost and foregone benefit information. For the economic assessment, both private and public costs were assessed across urban and agricultural lands. Because of the uncertainties associated with many data and scientific processes, the sensitivities of the environmental and economic estimates were examined if the uncertainty was large and/or the variable was thought to play a key role. The economic estimates should be interpreted as short-run effects and therefore are likely the largest impacts, because socioeconomic and technological processes tend to diminish adjustment costs over time. Findings from the study indicate:

- The four categories of strategies identified to improve Tualatin River water quality were: 1) Augment summertime flow; 2) decrease phosphorus load; 3) modify stream corridors; and 4) change instream processes.
- At least three "best management practices" (BMPs) could reduce phosphorus load deliveries to the Tualatin River: 1) Increase infiltration through land use planning by maximizing contact of runoff with pervious areas; 2) construct stormwater detention and "wet" ponds for flood peak reduction, sedimentation and phosphorus removal; and 3)reduce loads through public education and physical means.
- Application of the following measures can reduce surface runoff and erosion from forestry activities: 1) Limit fire use and intensity; 2) limit widespread yarding and slash piling/scarification; 3) modify road design and drainage maintenance; 4) modify silvicultural systems; and 5) reduce harvesting of riparian areas.
- Three measures would enhance stream function and aquatic health: 1) Lower the Lake Oswego Dam to restore natural hydrology; 2) restore riparian zones; and 3) restore and develop wetlands.
- Phosphorus concentrations, streamflow levels, and water temperature continue to promote algal growth. These conditions can be improved by removing or lowering the flaps on the Lake Oswego Dam, which will lower the river depth, increase water velocity, promote better mixing, and reduce stratification in deeper pools.
- Another approach to dealing with the water-quality problems in the Tualatin River basin is to continue to pursue present pollution load reduction strategies. This approach has limited costs and has been successful in avoiding a water-quality problem of drastic proportions that would otherwise have occurred.

Keywords: model, CE-QUAL-W2, TMDL, Hydrologic Simulation Program FORTRAN (HSPF), algae, pH, dissolved oxygen, chlorophyll a, economic impacts, streamflow

Locations: Tualatin River, Henry Hagg Lake, Scoggins Creek, Gales Creek, Barney Reservoir, WF Diary, EF Dairy, McKay Creek, Rock Creek, Fanno Creek, Chicken Creek

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Ervin, D.E., Gregory, S.V., Klingeman, P.C., Koch, Roy, Li, Judith, Miner, J.R., Nelson, P.O., Warkentin, B.P., and Wells, S.A., 1993, A project to collect scientific data and provide evaluation and recommendations for alternative pollution control strategies for the Tualatin River basin: Oregon Water Resources Research Institute, Oregon State University, Corvallis, Oregon, 45 p.

The goal of this project was to analyze water quality in the Tualatin River basin and to present it in a form that would be useful to decision-makers. The report lists alternative actions that can be taken to improve water quality in the basin, but does not include any further research into amounts of nonpoint source phosphorus entering the river or the dynamics of phosphorus supply for algal growth. Increasing health of the Tualatin River is not simply a matter of meeting TMDLs for phosphorus but is a comprehensive restoration of health of the watershed. This includes the biota and decisions, such as whether the Tualatin River should be managed for warm water fish or cold water fish. It will include restoration of riparian functions, with vegetated riparian areas and more areas of wetlands to enhance river functions of quantity and water quality. There has been no systematic study of biota in the basin; this is needed as a baseline for planning the restoration of biological functions of the river. Similarly, systematic studies of trace amounts of organic and inorganic potentially toxic pollutants need to be carried out to evaluate the potential chronic effects on river health. Recommendations include:

- Algal growth can be decreased by increasing water flows during the summer, with estimated requirements of at least an extra 100 cubic feet per second during the months of July and August. These extra flow will dilute phosphorus concentrations, decrease temperature, and decrease residence time in the Tualatin River pool area.
- It is difficult to decrease nonpoint phosphorus inputs 50%, a level that would be required to decrease growth of algae.
- Urban nonpoint sources are significant and control is possible through management of stormwater and treatment on land.
- Instream processes can be modified through mechanical means, such as aeration, which would increase dissolved oxygen and prevent thermal stratification.
- Stream corridor management includes restoration of riparian vegetation to trap sediments and to remove nutrients from surface and subsurface flow.
- Recommended long term actions include restoration of riparian vegetation, restoration of water storage in the landscape, such as wetlands, and source reduction through changed management of land in urban and agricultural areas .

Keywords: Total Maximum Daily Load (TMDL), biota, toxics, algae, sediments, restoration, phosphorus

Locations: Tualatin River

Ervin, D.E., Gregory, S.V., Klingeman, P.C., Koch, Roy, Li, Judith, Miner, J.R., Nelson, P.O., Warkentin, B.P., and Wells, S.A., 1995, Evaluation of alternative pollution control strategies for the Tualatin River basin, Oregon: Oregon Water Resources Research Institute, Oregon State University, Corvallis, Oregon, 50 p.

The goal of this project was to analyze water quality in the Tualatin River basin and to present it in a form that would be useful to decision-makers. The report lists alternative actions that can be taken to improve water quality in the basin, but does not include any further research into amounts of nonpoint source phosphorus entering the river or the dynamics of phosphorus supply for algal growth. Two models were used to evaluate the different alternative actions. First, the Hydrologic Simulation Program FORTRAN (HSPF) model was used to simulate land processes affecting water quality. Next, the river model CE-QUAL-W2 was applied to the Tualatin River to predict changes in the river as a result of different loadings, such as streamflow and temperature. Based on this study recommended actions include:

- Provide supplemental streamflow, continue aggressive implementation of nonpoint source management programs, and continue public engagement in long-term planning.
- Restore riparian vegetation, water storage in wetland landscapes, and reduce source pollution through effective management of urban and agricultural lands.

Keywords: model, Hydrologic Simulation Program FORTRAN (HSPF), CE-QUAL-W2, water quality, phosphorus, algae, streamflow, riparian, strategies

Locations: Tualatin River

Franczyk, Jon, and Chang, Heejun, 2009, The effects of climate change and urbanization on the runoff of the Rock Creek basin in the Portland metropolitan area, Oregon, USA: Hydrological Processes, v. 23, p. 805-815

Climate changes brought on by increasing greenhouse gases in the atmosphere are expected to have a significant effect on the Pacific Northwest hydrology during the 21st century. Many climate model simulations project higher mean annual temperatures and temporal redistribution of precipitation. This is of particular concern for highly urbanized basins where runoff changes are more vulnerable to changes in climate. The Rock Creek basin, located in the Portland metropolitan area, has been experiencing rapid urban growth throughout the last 30 years, making it an ideal study area for assessing the effect of climate and land cover changes on runoff. A combination of climate change and land cover change scenarios for 2040 with the semi-distributed AVSWAT (ArcView Soil and Water Assessment Tool) hydrological model was used to determine changes in mean runoff depths in the 2040s (2030–2059) from the baseline period (1973–2002) at the monthly, seasonal, and annual scales. Findings from this study indicate:

- Statistically downscaled climate change simulation results from the ECHAM5 general circulation model (GCM) found that the region would experience an increase of 1.2 °C in the average annual temperature and a 2% increase in average annual precipitation from the baseline period.
- AVSWAT simulation shows a 2.7% increase in mean annual runoff but a 1.6% decrease in summer runoff.
- Projected climate change plus low-density, sprawled urban development for 2040 produced the greatest change to mean annual runoff depth (+5.5%), while climate change plus higher-density urban development for 2040 resulted in the smallest change (+5.2%), when compared with the climate and land cover of the baseline period. This has significant implications for water resource managers attempting to implement adaptive water resource policies to future changes resulting from climate and urbanization.

Keywords: climate change, urbanization, runoff, model, SWAT, land-use scenario

Locations: Rock Creek

Goldman, J.H., Rounds, S.A., and Needoba, J.A., 2012, Applications of fluorescence spectroscopy for predicting percent wastewater in an urban stream: Environmental Science and Technology, v. 46, no. 8, p. 4374-4381 [**DOI: 10.1021/es2041114]**

Dissolved organic carbon (DOC) is a significant reservoir of carbon in many ecosystems, and its characteristics and sources determine many aspects of ecosystem health and water quality. Fluorescence spectroscopy methods can quantify and characterize the subset of the DOC pool that can absorb and reemit electromagnetic energy as fluorescence and, thus, provide a rapid technique for environmental monitoring of DOC in lakes and rivers. Using high-resolution fluorescence techniques, we characterized DOC in the Tualatin River watershed near Portland, Oregon, and identified fluorescence parameters associated with effluent from two wastewater treatment plants and samples from sites within and outside the urban region. Using a variety of statistical approaches, we developed and

validated a multivariate linear regression model to predict the amount of wastewater in the river as a function of the relative abundance of specific fluorescence excitation/emission pairs. The model was tested with independent data and predicts the percentage of wastewater in a sample within 80% confidence. Model results can be used to develop *in situ* instrumentation, inform monitoring programs, and develop additional water-quality indicators for aquatic systems.

Keywords: fluorescence, spectroscopy, wastewater, organic carbon, DOC, biogeochemistry, model

Locations: Tualatin River

Hansen, P.J., 1998, Scoggins Dam, Washington County, Northwestern Oregon: *in* Burns, S.F., edt., Environmental, Groundwater and Engineering Geology–Applications from Oregon, Star Publishing Company, Belmont, CA, p. 155-159

Scoggins Dam is a U.S. Bureau of Reclamation dam built by Peter Kiewit Sons Company between 1972 and 1975 to impound water from Scoggins Creek to form Henry Hagg Lake. The dam is a feature of the Tualatin Project and is located five miles southwest of Forest Grove, Oregon. The embankment is a zoned earthfill structure with a crest length of 2,700 feet and a structural height of 151 feet. The dam is founded on Eocene-age Spencer Formation sandstone and Holocene-age valley alluvial deposits. Foundation preparation included excavation of upstream and downstream trenches beneath the embankment to bedrock. Drainage pipe was placed in the downstream trench and covered with gravel to provide a cutoff toe drain. Trenches and drains were excavated in the abutments to bedrock on the right side and in valley alluvial deposits on the left side. These trenches and drains were connected to the upstream embankment trenches.

- No major problems relating to geology have become apparent during the 20+ years of post-construction operation.
- Landslides along the reservoir rim are a concern, and several slide areas are currently being monitored. The ancient landslides occurred in the Yamhill Formation and are related to the dipslope in the units. The modern landslides are related to road cuts and fills. Reclamation has participated with state and local agencies in the remediation of some of the landslides.
- A minor amount of seepage has been monitored at five locations downstream of the dam. Facilities, including instrumentation and a new toe drain trench excavated into bedrock on the left side of the dam, have been constructed through the years to contain, control, and more effectively monitor the seepage flows.

Keywords: dam, geology, landslides, seepage, engineering

Locations: Scoggins Creek, Henry Hagg Lake

Harrison, H. E., Anderson, C. W., Rinella, F. A., Gasser, T. M., and Pogue, T. R., Jr., 1995, Analytical data from phases I and II of the Willamette River basin water quality study, Oregon, 1992-94: U.S. Geological Survey Open-File Report 95-373, 171 p.

This report presents trace-element, organic-compound (pesticides, volatile and semivolatile organic compounds, and dioxin and furan compounds), and nutrient concentration data from the analyses of water column, suspended-sediment, and bed-sediment samples collected by the U.S. Geological Survey

as part of Phases I and II of the comprehensive Willamette River basin Water Quality Study in western Oregon. The overall study was designed by the Oregon Department of Environmental Quality to acquire the technical and regulatory knowledge necessary to protect and enhance water quality in the Willamette River basin. The data were collected at 50 sites, representing runoff from agricultural, forested, and urbanized subbasins. In Phase I, water samples were collected during high and low flows in 1992 and 1993 to represent a wide range of hydrologic conditions. Bed-sediment samples were collected during low flows in 1993. In Phase II, water samples were collected in the spring of 1994 after the first high-flow event following the application of agricultural fertilizers and pesticides and in the fall during the first high-flow events following the conclusion of the agricultural season. This was a data report and does not contain any interpretation or analyses.

Keywords: water chemistry, land use, organic compounds, trace elements, water quality, DOC, VOC, SOC

Applicable Locations: Tualatin River, Dairy Creek, Beaverton Creek, Bronson Creek, Fanno Creek

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Hart, D.H., and Newcomb, R.C., 1965, Geology and ground water of the Tualatin Valley, Oregon: U.S. Geological Survey Water-Supply Paper 1697, 172 p., plus maps

The Tualatin River valley consists of broad valley plains, ranging in altitude from 100 to 300 feet, and lower valley foothills of the coastal range. The valley is almost entirely farmed. Its population is increasing rapidly, partly because the expansion of metropolitan Portland. Structurally, the bedrock of the basin is a saucer-shaped syncline almost bisected lengthwise by a ridge. The bedrock basin has been partly filled by alluvium, which underlies the valley plains. Groundwater occurs in the Columbia River basalt, a lava unit that forms the top several hundred feet of the bedrock, and also in the zones of fine sand in the upper part of the alluvial fill. It occurs under unconfined, confined, and perched conditions. Findings from this study indicate:

- Observed water levels in wells show that the groundwater is replenished each year by precipitation.
- The amount and time of recharge vary in different aquifers and for different modes of groundwater occurrence.
- Shallow alluvial aquifers are refilled each year to a level where further infiltration recharge is retarded and water drains away as surface runoff.
- No occurrences of undue depletion of the groundwater by pumping are known.
- There is a great quantity of additional water available for future development.
- The groundwater in the basalt and the valley fill is in general of good quality, only slightly or moderately hard and of low salinity.
- Saline and mineralized water is present in the rocks of Tertiary age below the Columbia River basalt.
- Under certain structural and stratigraphic conditions this water is poor quality contaminates the freshwater aquifers.

Keywords: geology, ground water

Locations: Tualatin River

Hawksworth, J.T., 2000, Upper Tualatin-Scoggins watershed analysis, Washington County Soil and Water Conservation District and Bureau of Land Management, Salem District Office, Tillamook Resource Area, Tillamook, Oregon, 222 p.

This watershed analysis is a combination of current inventory data provided by a BLM interdisciplinary team and information compiled by the Washington County SWCD. The purpose of this watershed analysis is to provide reference information used in project planning. The information in this document is considered the most current data available. This document is comprehensive and covers a wide range of watershed information ranging from basin setting to core topics and key questions.

Keywords: watershed, ecology, environment, hydrology, geology

Locations: Tualatin River, Scoggins Creek

Hinkle, S.R., 1997, Quality of shallow ground water in alluvial aquifers of the Willamette basin, Oregon, 1993-95: U.S. Geological Survey Water-Resources Investigations Report 97-4082-B, 48 p.

This report describes shallow (generally, <25 meters below land surface) groundwater quality in Willamette River basin alluvium between 1993 and 1995. Data were collected during two surveys: a study unit survey (regional assessment of shallow groundwater) with 70 domestic wells between June and August 1993, and an urban land use study with 10 monitoring wells installed in areas of residential land use during July 1995. Findings from the study indicate:

- Concentrations of nitrite plus nitrate ranged from <0.05 to 26 mg N/L (milligrams nitrogen per liter) in groundwater from study unit survey wells
- Nine percent of study unit survey samples exceeded the U.S. Environmental Protection Agency (USEPA) Maximum Contaminant Level.
- Relationships were observed between nitrate concentrations and dissolved-oxygen concentrations, the amount of clay present within and overlying aquifers, overlying geology, and upgradient land use.
- Tritium (^3H) data indicate that 21 percent of study unit survey samples represented water recharged prior to 1953. Nitrogen-fertilizer application rates in the basin have increased greatly over the past several decades. Thus, some observed nitrate concentrations may reflect nitrogen loading rates that were smaller than those presently applied in the basin.
- Concentrations of phosphorus ranged from <0.01 to 2.2 mg/L in study unit survey wells and exceeded USEPA Maximum Contaminant Level in 60 percent of samples.
- Phosphorus and nitrate concentrations were inversely correlated.
- From one to five pesticides and pesticide degradation products were detected in groundwater from each of 23 study unit survey wells (33 percent of 69 wells sampled for pesticides) for a total of 51 pesticide detections.
- Thirteen different pesticides were detected.
- Atrazine was the most frequently encountered pesticide. Although detections were widespread and concentrations were low (generally <1,000 ng/L [nanograms per liter]).
- One detection (dinoseb, at 7,900 ng/L) exceeded a USEPA Maximum Contaminant Level.
- Relationships were observed between the occurrence of pesticides and the amount of clay present within and overlying aquifers, overlying geology, and land use.

- Between one and five volatile organic compounds (VOCs) were detected at each of seven study unit survey sites (11 percent of 65 sites evaluated), for a total of 14 VOC detections.
- One detection (tetrachloroethylene, at 29 mg/L) exceeded a USEPA MCL. Other detections were at low concentrations (0.2 to 2.0 mg/L).
- VOC detections generally were from sites associated with urban land use.
- Concentrations of arsenic ranged from <1 to 13 mg/L in 70 study unit survey wells. Concentrations in 16 percent of samples exceeded the USEPA Risk-Specific-Dose Health Advisory of 2 mg/L.
- Radon concentrations ranged from 200 to 1,200 pCi/L (picocuries per liter) in 51 study unit survey wells. All samples exceeded the USEPA Risk-Specific-Dose Health Advisory of 150 pCi/L.
- All urban land use study samples were well oxygenated; thus, nitrate reduction probably did not affect these samples. Urban Land use study nitrate concentrations were similar to those of the well-oxygenated, agricultural subset of the study unit survey samples.
- Pesticides were detected in samples from three urban land use study sites, but concentrations were low (1 to 5 ng/L). In contrast, VOCs were detected in groundwater from 80 percent of urban land use study wells; concentrations ranged up to 7.6 mg/L.
- Trace-element concentrations in the urban land use study samples were low. Median concentrations consistently were <10 mg/L and frequently were <1 mg/L.

Keywords: pesticides, volatile organic compounds (VOC), phosphorus, organic carbon, hydrogeology, land use, trace elements, radon

Applicable Locations: Tualatin River

Hinkle, S. R., 1997, Regional distribution of nitrite plus nitrate in shallow groundwater from alluvial deposits of the Willamette basin, Oregon: In Laenen, Antonius, and Dunnette, D. A., eds., River Quality -- Dynamics and Restoration, CRC Press, New York, p. 141-149

Keywords: nutrients, nitrogen, groundwater

Applicable Locations: Tualatin River, Willamette River

Hughes, M.L., and Leader, K.A., 2000, Distribution of fish and crayfish, and measurement of available habitat in the Tualatin River basin: Columbia River Investigations Program, Oregon Department of Fish and Wildlife, Clackamas, Oregon, 39 p.

We conducted fish, habitat, and water-quality surveys on seven tributaries of the lower Tualatin River as part of an effort to assess the biotic health of the watershed. We surveyed lower, middle, and upper reaches of most streams. Habitat surveys were conducted in summer 1999, whereas fish and water-quality surveys were conducted in summer, spring, fall, and winter 1999 through 2000. This project is a follow up to a similar one conducted from 1993 through 1995. Industrial and residential developments, as well as efforts to restore water quality and riparian habitat, have continued since the 1993 through 1995 surveys; therefore, periodic monitoring is needed to ensure that important habitat and existing populations of native fish are protected. Results from this study indicate:

- The number of species collected increased from 21 to 22 in the seven streams; additionally, the number of introduced species increased from 10 to 11.

- The native reticulate sculpin (Cottus perplexus) remains the most abundant and widely distributed species.
- Introduced species contributed 6.4% of the total catch.
- Native and introduced species tolerant of habitat degradation accounted for 17.7% of the total catch, whereas native species sensitive to habitat degradation accounted for only 6.7% of the catch.
- The majority of the catch (75.5%) consisted of species considered intermediate in their response to habitat degradation.
- Habitat changed little from previous surveys. Glides were the most common habitat type, and soil was the most common substrate. Little woody debris was found in any stream

Keywords: fish, habitat, water quality, tolerance

Locations: Hedges Creek, Fanno Creek, South Rock Creek, Chicken Creek, Butternut Creek, North Rock Creek, Dairy Creek

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Johnston, M.W., and Williams, J.S., 2006, Field comparison of optical and Clark cell dissolved oxygen sensors in the Tualatin River, Oregon, 2005: U.S. Geological Survey Open-File Report 2006-1047, 11 p.

This report compares two Clark cell type dissolved oxygen sensors with three optical sensors in the Tualatin River. Findings from this study indicate:

- Optical sensors were less prone to fouling drift and calibration drift. During two cleanings and calibrations over the 3-week study, the Clark cells exhibited fouling drifts ranging from 0.17 to 0.37 mg/L (milligrams per liter) and calibration drifts ranging from –0.22 to 0.03 mg/L. The optical sensors had fouling drifts ranging from 0 to 0.02 mg/L and calibration drifts ranging from –0.09 to 0.02 mg/L after 2–3 weeks of deployment.
- Measurements by the Clark cell and optical sensors compared favorably to each other, as well as to point measurements of oxygen concentration using the Winkler method. Therefore, the optical sensors were as accurate as the Clark cell sensors under the study conditions.

Keywords: dissolved oxygen, optical sensors, fouling

Locations: Tualatin River

Jung, B.W., and Chang, Heejun, 2011, Climate change impacts on spatial patterns in drought risk in the Willamette River basin, Oregon, USA: Theoretical Applied Climatology [DOI 10.1007/s00704-011-0531-8]

Climate change is likely to lead more frequent droughts in the Pacific Northwest. Rising air temperature will reduce winter snowfall and increase earlier snowmelt, subsequently reducing summer flows. Longer crop-growing season caused by higher temperatures will lead to increases in evapotranspiration and irrigation water demand, which could exacerbate drought damage. However, the impacts of climate change on drought risk will vary over space and time. Thus, spatially explicit drought assessment can help water resource managers and planners to better cope with risk. This study seeks to identify possible drought-vulnerable regions in the Willamette River basin of the Pacific Northwest. In order to

estimate drought risk in a spatially explicit way, relative Standardized Precipitation Index (rSPI) and relative Standardized Runoff Index (rSRI) were employed. Statistically downscaled climate simulations forcing two greenhouse gas emission scenarios, A1B and B1, were used to investigate the possible changes in drought frequency with 3-, 6-, 12-, and 24-month time scales. Findings from this study include:

- The results of rSPI and rSRI showed an increase in the short-term frequency of drought due to decreases in summer precipitation and snowmelt. However, long-term drought showed no change or a slight decreasing pattern due to increases in winter precipitation and runoff.
- According to the local index of spatial autocorrelation analysis, the Willamette Valley region was more vulnerable (hot spot) to drought risk than the mountainous regions of the Western Cascades and the High Cascades (cold spot). Although the hydrology of the Western Cascades and the High Cascades will be affected by climate change, these regions will remain relatively water-rich. This suggests that improving the water transfer system could be a reasonable climate adaptation option.
- Additionally, these results showed that the spatial patterns of drought risk change were affected by drought indices, such that appropriate drought index selection will be important in future studies of climate impacts on spatial drought risk.

Keywords: climate change, drought, model

Locations: Willamette River, Tualatin River

Kalscheur, K.N., Penskar, R.R., Daley, A.D., Pechauer, S.M., Kelly, J.J., Peterson, C.G., and Gray, K.A., 2012, Effects of anthropogenic inputs on the organic quality of urbanized streams: Water Research, v. 46, p. 2515-2524

Due to arid conditions, population growth, and anthropogenic impacts from agricultural and urban development, wastewater effluent makes up an increasingly large percentage of surface water supplies. Therefore, concerns have grown about the potential ecological and human health effects that are associated with the organic quality of surface waters receiving treated wastewater discharge. Anthropogenic inputs that alter the quality and quantity of organic carbon also can affect the ability of aquatic ecosystems to retain or transform carbon and other nutrients. In this paper, we use pyrolysis-GC/MS (Py-GC/MS) as a tool to examine whether the dissolved organic carbon (DOC) in suburban streams influenced by anthropogenic inputs displays an organic signature that is structurally different from natural organic material (NOM). Findings from this study indicate:

- Py-GC/MS was able to differentiate among stream sites that received discharge from upstream wastewater treatment plants.
- Py-GC/MS was also able to distinguish stream sites influenced significantly by stormwater.
- Distinct organic signatures were evident in streams with wastewater treatment plant discharge.
- Organic signatures prevailed regardless of the distance from effluent discharge, indicative of the persistent nature of effluent-derived organic material (EfOM).

- The pyrolysis fragments of 3-methyl-pyridine, 2-methyl-pyridine, pyrrole, and acetamide were identified as indicators of EfOM, supporting previous research that has suggested that protein and aminosugar derivitives are possible wastewater markers.
- Pyrolysis fragments associated with soil polycarboxylic acids correlated highly with stream sites having the least anthropogenic influences.

Keywords: effluent, wastewater, organic material, model

Locations: N/A

Kavanagh, K.B., 2007, Henry Hagg Lake – Technical Memorandum, Evaluation of Monitoring Data from 1999-2005: Flow Science Incorporated, 9 p., plus Appendices

This memorandum presents the results of a brief evaluation of the monitoring data collected at Henry Hagg Lake (Hagg Lake) from 1999 through 2005. The monitoring plan was developed and implemented by the Tualatin River Flow Management Technical Committee. The purpose of this evaluation is to identify: 1) major trends in the data, 2) baseline reservoir conditions, and 3) gaps in the monitoring program. More specifically, the data have been reviewed to assess the magnitude and duration of thermal stratification, seasonal variations in temperature, mixing, and stratification, and the distribution of chemical and biological parameters as a function of depth and time (e.g., dissolved oxygen depletion in the hypolimnion). Nutrient data have also been evaluated with respect to their distribution in the water column and relative to observed patterns of algal growth. The data have been evaluated to identify any interactions between thermal stratification and biochemical processes. Findings from the study include:

- Thermal stratification occurs annually in Hagg Lake from April to November and impacts mixing, DO and nutrient concentrations, and algae growth.
- The largest inflows to the lake occur during the winter and spring. During this time, the inflows and the nutrients they carry are mixed completely over depth and are available to support algae growth.
- Algae growth declines during the late spring and summer (May-Aug) due to a reduction of nutrients in the epilimnion and probably also due to a shift in environmental conditions (e.g., light levels and water temperature) that no longer favor the species that bloomed after the storm inflows in the spring. During this period of stratification, the inflows are generally confined to the epilimnion. Since the summer inflow rates are much smaller than in winter, the nutrient inputs are lower. Also, stratification prevents the mixing of any nutrients from the hypolimnion into the epilimnion during this time.
- Thermal stratification impacts DO concentrations by isolating the hypolimnion from the atmosphere and preventing reaeration. Subsequently, the decomposition of organic materials by bacteria (e.g., sediment oxygen demand and biological oxygen demand) consumes oxygen and causes the DO concentrations to gradually decrease below the thermocline.
- Anoxic conditions result in the hypolimnion for about two months of every year (usually September/October). In 2004, anoxia occurred for four months. These anoxic conditions cause the release of nutrients from the sediments.
- Recommendations are included in text.

Keywords: meteorological, water temperature, water quality, dissolved oxygen, total phosphorus, E. coli, total nitrogen, chlorophyll a, nutrients

Locations: Henry Hagg Lake, Sain Creek, Scoggins Creek, Tanner Creek

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Kelly, V.J., 1997, Dissolved oxygen in the Tualatin River, Oregon, during winter flow conditions, 1991 and 1992: U.S. Geological Survey Water-Supply Paper 2465-A, 68 p.

The purpose of this report is to provide an understanding of the capacity of the Tualatin River to assimilate oxygen-demanding material during the winter season, and to provide a basis for evaluating the relative significance of the various factors that affect oxygen concentrations in the Tualatin River during this period. Findings from this study indicate:

- Under "natural" conditions the temperature of the Tualatin River would exceed the State standard of 17.8 degrees Celsius at many locations during the low-flow season.
- Current operation of wastewater-treatment plants increases the temperature of the river downstream of the plants under low-flow conditions.
- River temperature is affected by riparian shade variations along the tributaries and mainstem.
- Flow releases during the low-flow season from Henry Hagg Lake decrease the river temperature in the upper basin.
- Removal of a low diversion dam at RM 3.4 would slightly decrease temperatures below RM 10.0.

Keywords: channel morphology, wastewater treatment, effluent, streamflow, dissolved oxygen, total suspended solids, ammonia, biochemical oxygen demand

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, Rock Creek, Fanno Creek

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Kelly, V.J., 1997, Dissolved oxygen in the Tualatin River, Oregon, under winter low-flow conditions, November, 1992, in Laenen, A. and Dunnette, D.A., eds., River Quality - Dynamics and restoration: New York, CRC Press, p. 151-162

Keywords: dissolved oxygen

Locations: Tualatin River

Kelly, V.J., Lynch, D.D., and Rounds, S.A., 1999, Sources and transport of phosphorus and nitrogen during low-flow conditions in the Tualatin River, Oregon, 1991-1993: U.S. Geological Survey Water-Supply Paper 2465-C, 94 p.

This report characterizes the sources and transport of phosphorus and major forms of nitrogen in the Tualatin River during the low-flow periods of summer 1991-1993. Since the report focuses on nutrients in the Tualatin River, inputs from tributaries and tile drains, groundwater, and wastewater treatment plant effluent, and losses from withdrawals are discussed primarily as sources or sinks of nutrients to the mainstem river. Findings from this study indicate:

- Because large natural supplies of highly mobile phosphorus exist in the upper 500 feet of valley-fill sediments throughout the Tualatin River basin, groundwater in the basin is naturally enriched with phosphorus.
- Even with improvements to wastewater treatment and land management, phosphorus concentrations still exceed TMDL criterion concentrations.
- Underlying geology drives phosphorus in basin.
- Efficient wastewater treatment is effective for controlling ammonia concentrations in the Tualatin River.

Keywords: algae, pH, phosphorus, ammonia, nitrogen, groundwater, wastewater treatment, dissolved oxygen, streamflow, chlorophyll a

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, Jackson Slough, Rock Creek, Butternut Creek, Christensen Creek, Burris Creek, McFee Creek, Baker Creek, Chicken Creek, Rock Creek, Fanno Creek, Nyberg Creek

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Khaodhiar, Sutha, and Nelson, P.O., 1995, Summary and assessment of toxics data for the Tualatin River: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 14, 87 p.

The Tualatin River is a major water resource for Washington County. In its course, the river drains forestlands, farmlands, and urban areas receiving toxic materials from nonpoint source runoff. Wastewater treatment plant effluents from municipalities and industries also contribute toxic materials to the river. Many materials discharged into the river system can be toxic to human health and aquatic organisms if present above critical concentrations. These materials include heavy metals and organic compounds, such as insecticides, polychlorinated biphenyls, herbicides, and certain industrial organics. Considerable information on the presence and concentration of potentially toxic materials is available from measurements by different agencies with varying program objectives. This project collected and assembled existing data to evaluate the adequacy of the toxics data record and to assess possible toxicity problems in the Tualatin River. Findings from the study indicate:

- The concentrations of potentially toxic materials in the Tualatin River are low compared to water quality standards.
- The major sources of metals in the river appear to be the four municipal wastewater treatment plants and urban runoff.
- Based on sediment data, Fanno Creek and Beaverton Creek supply a significant amount of industrial toxics from either point sources or urban runoff. However, the parameters measured, the sampling locations, and the sampling frequency, are limited.
- A more comprehensive sampling program coupled with specific focused studies is required to provide a more complete understanding of the possible toxic effects in the river.

Keywords: toxics, pollutants, metals, wastewater treatment, total organics, sediment, fish tissue

Locations: Tualatin River, Scoggins Creek, Carpenter Creek, Gales Creek, Mcfee Creek, Baker Creek, Dairy Creek, Mckay Creek, WF Dairy Creek, EF Dairy Creek, Rock Creek, Beaverton Creek, Butternut Creek, Cedar Mill Creek, Johnson Creek, Hall Creek, Christensen Creek, Burris Creek, Chicken Creek, Nyberg Creek, Fanno Creek, Ash Creek

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Knoder, Erik, 1995, Benefits and costs of riparian habitat improvement in the Tualatin River basin: Oregon Water Resources Institute, Tualatin River Basin Water Resources Management Report Number 10, 52 p.

The Oregon Department of Environmental Quality (DEQ) has designated the Tualatin River as "water quality limited"; therefore, management agencies are pursuing tasks, such as restoration and enhancement of riparian areas, to improve water quality. This paper examines some of the potential costs and benefits of undertaking riparian restoration and enhancement on two tributaries (Gales and Dairy Creeks) of the Tualatin River. In general, the potential costs are likely to be more identifiable and have market prices associated with them. The potential benefits of riparian restoration are often public or non-exclusive in nature. Measuring and estimating prices for benefits was found to be more difficult. Although costs of restoration depend on the standards adopted, the costs for the two study areas were found to be approximately $6,000 per stream mile at Gales Creek and $21,000 per stream mile at Dairy Creek. The cost of retiring agricultural land from production was a major influence on the total costs and was significant in explaining the cost difference between the two sites.

Keywords: habitat, land use, cost, water quality, riparian, restoration

Locations: Gales Creek, Dairy Creek

Knutson, M.T., 1993, Modeling of flow and water quality on Henry Hagg Lake near Forest Grove, Oregon: M.S. Thesis, Portland State University, Portland, Oregon, Technical Report EWR-4-93, 146 p.

This thesis represents the application of the CE-QUAL-W2 model to Henry Hagg Lake. The Hagg Lake Model is a submodel of a Tualatin River model, which has been created as a working tool for use by scientists and engineers evaluating the Tualatin River system. Findings from this study include:

- With the limited data set available, the Hagg Lake model produced results of varying accuracy.
- The Hagg Lake model was observed to be most sensitive to initial summer season conditions.
- No water quality problems appear to exist at Henry Hagg Lake. When compared to water in the lower reaches of the Tualatin River, it could be said that the lake has excellent water quality.
- The Hagg Lake model was used to determine the effects on water quality if additional outflow were allowed during the withdrawal season. An additional 100 cfs was added to the outflow from Hagg Lake from June 15, 1990 through September 15, 1990. The results of this analysis showed that water quality would not be drastically effected.

Keywords: model CE-QUAL-W2, bathymetry, water quality, water temperature, sedimentation

Locations: Tualatin River, Henry Hagg Lake

Laenen, Antonius, and Bencala, K.E., 2001, Transient storage assessments of dye-tracer injections in rivers of the Willamette basin, Oregon: Journal of the American Water Resources Association, vol. 37, no. 2, p. 367-377

Rhodamine WF dye-tracer injections in tributaries of the Willamette River basin yield concentration-time curves with characteristically long recession times suggestive of active transient storage processes. The scale of drainage areas contributing to the streams studied in the basin ranges from 10 to 12,000

km^2. A transient storage assessment of the tracer studies has been completed using the U.S. Geological Survey's One-dimensional Transport with Inflow and Storage (OTIS) model, which incorporates storage exchange and decay functions along with the traditional dispersion and advection transport equation. Findings from this study indicate:

- First-order decay coefficients are on the order of 105/sec for the nonconservative Rhodamine WT. On an individual subreach basis, the first-order decay is slower (typically by an order of magnitude) than the transient storage process, indicating that nonconservative tracers may be used to evaluate transient storage in rivers. In the transient storage analysis, a dimensionless parameter (A5/A) expresses the spatial extent of storage zone area relative to stream cross section.
- In certain reaches of Willamette River basin pool-and-rime, gravel-bed rivers, A5/A was as large as 0.5.
- A measure of the storage exchange flux was calculated for each stream in the simulation analysis. This storage exchange was shown to be higher at higher stream discharges.
- Hyporheic linkage between streams and subsurface flows are the probable physical mechanism contributing to a significant part of this inferred active transient storage. Hyporheic linkages are further suggested by detailed measurements of river discharge with an Acoustic Doppler Current Profiler system delineating zones in two large rivers where water alternately enters and leaves the surface channels through graveland-cobble riverbeds.
- Measurements show patterns of hyporheic exchange that are highly variable in time and space.

Keywords: transient storage, hyporheic zone, OTIS model, solute transport estimation, dye tracer, Rhodamine WT

Applicable Locations: Tualatin River

Leader, K.A., 2001, Distribution and abundance of fish, and measurement of available habitat in the Tualatin River basin outside of the urban growth boundary: Columbia River Investigations Program, Oregon Department of Fish and Wildlife, Clackamas, Oregon, 11 p.

Fish, habitat, and water quality surveys were conducted on ten tributaries of the Tualatin River and two reaches of the upper Tualatin River as part of an effort to assess the biotic health of the watershed. Samples were collected for lower, middle, and upper reaches of most streams. Habitat surveys were conducted in the summers of 1999-2000, whereas fish and water-quality surveys were conducted in summer, fall, winter, and spring 1999-2001. Findings from this study include:

- Fish surveys identified 16 fish species from seven families during seasonal sampling.
- The native reticulate sculpin (Cottus perplexus) was the most abundant and widely distributed species. Sculpins accounted for 62.6% of the total catch and were found in all stream reaches sampled.
- Largemouth bass were the only introduced species found, contributing 0.1% of the total catch.
- Native and introduced species moderately or very tolerant of habitat degradation made up 83.7% of the total catch, whereas native species sensitive to habitat degradation accounted for only 16.3% of the catch.
- Glides were the most common habitat type, and soil was the most common substrate. Little woody debris was found in any stream.

- A seasonal index of biotic integrity (IBI) scores was calculated for each stream reach using the collected fish assemblage data. Biotic integrity scores were used to evaluate the need for restoration and enhancement within Tualatin tributaries.
- Of the 86 biotic integrity scores calculated, none were found to be considered acceptable, twelve were marginally impaired, and the remaining scores were considered severely impaired..

Keywords: fish, habitat, water quality, index of biotic integrity (IBI)

Locations: Tualatin River, Roaring Creek, Gales Creek, WF Dairy Creek, McKay Creek, Christensen Creek, Burris Creek, Ayers Creek, McFee Creek, Heaton Creek, Baker Creek

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Leader, K.A., and Ward, D.L., 2000, Effect of Spring Hill pumping plant on juvenile salmonids in the Tualatin River: Columbia River Investigations Program, Oregon Department of Fish and Wildlife, Clackamas, Oregon, 11 p.

As part of U.S. Bureau of Reclamation's (Reclamation) Tualatin River fish passage improvement program, Reclamation recognized they lacked data on the distribution, movement, and abundance of juvenile salmonids near Spring Hill Pumping plant. Reclamation entered into a contract with the Oregon Department of Fish and Wildlife (ODFW) to collect biological data to determine the effects of the Spring Hill pumping plant on juvenile salmonids. Currently, the fate and abundance of downstream-migrating fish diverted into the canal is unknown. Therefore, the objectives of this study are to determine the fate and abundance of juvenile salmonids that enter the canal at the Spring Hill Pumping Plant. Radio-tagged juvenile steelhead (Oncorhynchus mykiss) released upstream from the facility were monitored as they migrated downstream. In addition, predation rates were estimated for the juvenile salmonids that entered the canal at the Spring Hill Pumping Plant. Findings from the study include:

- Of the 89 radio-tagged juvenile steelhead released upstream from the intake canal, 70 were confirmed to have migrated past the canal.
- Passage time for the radio-tagged fish to reach the intake canal was negatively correlated with streamflow ($r=-0.84$, $P=0.04$).
- Small numbers of predators collected precluded meaningful population estimates.
- The small number of predatory fish examined and the small number of digestive tracts containing food precluded meaningful estimates of consumption.
- Although all of the fish released above and in the canal eventually exited the canal, it is possible that any passage delay caused by entering the canal could increase the chances of mortality due to predation.

Keywords: fish, streamflow, pumping station, salmonids

Locations: Tualatin River, Spring Hill Pumping Plant

Lee, K. K., 1995, Stream velocity and dispersion characteristics determined by dye-tracer studies on selected stream reaches in the Willamette River basin, Oregon: U.S. Geological Survey Water-Resources Investigations Report 95-4078, 39 p.

Dye-tracer analyses were done from April 1992 to July 1993 in the Willamette River and nine tributaries to determine velocity and dispersion conditions. These analyses helped answer questions regarding time

of arrival, peak concentrations, and persistence of constituents dissolved in the flow for various streamflows. The time of travel of the peak, leading, and trailing edge of the dye cloud was determined for each stream segment studied, and was related to streamflow at an index location for each stream. An equation was developed, based on the dye-tracer measurements, to estimate the velocity of the peak of a solute cloud for unmeasured streams. The results of the dye-tracer study on the Willamette River were compared with results from a previous study of the same river reach. Results indicated the velocity regime in the low and medium flow range has not changed since 1968. To identify the dispersion characteristics of a conservative solute in each stream segment, a relation was developed between the elapsed time from injection to the peak concentration measured at each sampling location. A general equation was developed to estimate the unit-peak concentration for a given elapsed time after a solute was introduced to the stream.

Keywords: Rhodamine WT, streamflow, velocity, dye tracer

Applicable Locations: Tualatin River

Lemke, J.L., and Cole, M.B., 2008, 2007 Assessment of macroinvertebrate communities of the Tualatin River basin, Oregon – Final report: ABR, Inc. – Environmental Research & Services, Forest Grove, Oregon, 17 p.

In 2007, Clean Water Services (CWS) began performing bi-annual macroinvertebrate assessments at approximately 20 monitoring stations. This monitoring is in support of the CWS 's efforts to track long-term trends in benthic community conditions in more than 60 stream and river reaches that have been monitored since 2001. The objective of the present study was to determine the current condition of macroinvertebrate communities in 20 stream reaches within the Tualatin River basin and compare these present conditions to those measured in previous investigations of these reaches. Study sites included 12 low-gradient reaches and eight high-gradient reaches. Findings from the study include:

- Macroinvertebrate community conditions ranged widely among high-gradient Tualatin River basin stream reaches, as indicated by both O/E scores and DEQ multimetric scores. O/E scores from high-gradient reaches ranged from 0.43 to 0.81 and averaged 0.68, while 2005 O/E scores from these sites ranged from 0.34 to 0.83 and averaged 0.65. Using updated O/E condition thresholds, 2007 O/E scores occur exclusively in the "most disturbed" range. Using condition thresholds that were used in the 2005 assessment, but that have since been superseded, 3 of the 8 high-gradient reaches scored as "fair" rather than "poor". Multimetric scores ranged from 18 to 40 and averaged 27.3, while in 2005, the range of scores was 20 to 38 and averaged 25.7. Impairment classes in 2007 derived from MMS scores ranged from unimpaired (1 site) to severe impairment (1 site); most sites were slightly (3 sites) to moderately impaired (3 sites). In comparison, 2005 multimetric scores indicated that 2 sites were slightly impaired and 5 sites were moderately impaired (one high gradient reach, BAM1 not sampled in 2005). Only Christensen Creek (CHM1) received an unimpaired multimetric score in 2007, while Bronson Creek (BRM1), Gales Creek (GSM2), and McKay Creek (MKM4) received slightly impaired classifications based on multimetric scores.
- O/E scores from 12 low-gradient reaches ranged from 0.195 to 0.488 and averaged 0.344. Using biological condition thresholds adjusted for valley-floor streams, these 12 reaches scored exclusively in the "more impacted" range. Individual metrics calculated from macroinvertebrate assemblages collected in low-gradient reaches varied among reaches. Taxa richness ranged from

11 to 22 taxa and averaged 16 taxa. EPT richness ranged from zerio to seven and averaged one taxon. No EPT taxa were sampled from 6 of the 12 sites, including lower Ash Creek (ASM2), lower Beaverton Creek (BCM1), upper Fanno Creek (FUM2), lower McFee Creek (MFM2), lower McKay Creek (MKM3), and middle Rock Creek (RMM1). These reaches generally exhibited low taxa richness, high dominance by one or a few tolerant taxa, and a high community-wide tolerance to disturbance.

- In three sampling years (2001, 2005, and 2007), less variation was observed in both multimetric and O/E scores at the lower end of the range of scores (i.e. with sites with moderate to severe levels of impairment or those with "most impacted" community condition). Conversely, at the higher end of the range of scores, more variability was noted in both multimetric and O/E scores over the three years in which macroinvertebrate communities were sampled. Low-gradient reaches generally supported fewer taxa, fewer sensitive taxa, far fewer EPT taxa, and larger numbers of tolerant organisms than did the higher-gradient reaches. While these differences between low and high-gradient streams are likely exacerbated by human activities on the valley floor, bioassessment activities are currently unable to separate human-induced changes to valley floor macroinvertebrate assemblages from naturally occurring differences in community composition.
- O/E and multimetric scores were highly correlated, but there was little agreement in biological condition classes between the two approaches. The MWCF model consistently produced lower (or equal) condition classes than did the multimetric tool. Importantly, DEQ uses the MWCF model to assess biological conditions in wadeable streams, so assessments should include the use of this tool.
- Collectively, our results suggest that biological conditions in reaches that have previously been classified as moderately to severely-impaired sites have largely remained unchanged. Conversely, sites that have previously scored within the upper range of multimetric and O/E scores tend to have more annual variation in community condition. In order to better quantify community conditions in these streams that exhibit wider temporal variability, we recommend collecting triplicate samples at these sites to produce statistical measures of confidence in estimates of average condition. Such estimates will better inform these monitoring efforts to detect trends in community conditions over time in relation to land use changes, water resource management programs, and restoration activities occurring in the Tualatin River basin.

Keywords: habitat, riparian, water quality, macroinvertebrates, multimetric analyses, model, Marine Western Coastal Forest (MWCF)

Locations: Ash Creek, Beaverton Creek, Bronson Creek, Fanno Creek, Gales Creek, McFee Creek, McKay Creek, Rock Creek, Bannister Creek, Cedar Mill Creek, Chicken Creek, Christensen Creek, EF Dairy Creek

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Li, Judith, and Gregory, S.V., 1993, Issues surrounding the biota of the Tualatin River basin: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 8, 37 p.

This report assesses the patterns of physical and biological processes across the Tualatin River basin, including a review of the available information on biota, suggestions for acquiring missing biological data, and identification of potential problems for biological integrity in the watershed. Findings from the study indicate:

- Attention must be paid to geomorphic, chemical, and biological components of both aquatic and terrestrial domains.
- Introduction of non-native plants and animals, chemical treatments to the landscape and within the waterways, and discharge and channel alterations have had dramatic effects on biological communities within the basin.
- Seasonal monitoring of all trophic levels, from primary producers such as algae, to ultimate consumers in the food chain, such as warmwater game fish and raptorial birds, are necessary to understand anthropogenic and biological processes operating in the Tualatin River basin.
- Keys to recovery should focus on landscape and watershed-level phenomena. A landscape perspective recognizes the stream and terrestrial environments as continua within the basin. Therefore, any floodplain recovery plan must address concerns from all parts of the basin, both natural and human-derived.

Keywords: biota, vegetation, riparian, benthic invertebrates, fish, ecosystem, zooplankton, phytoplankton, periphyton, nutrients, geomorphology, hydrology

Locations: Tualatin River

Luzier Hydrosciences, 1991, Geohydrology and distribution of phosphorus, Jackson Bottom experimental wetland, Hillsboro, Oregon: Scientific Resources, Inc., Lake Oswego, Oregon, 24 p., plus figures

Jackson Bottom Wetlands is the site of an experimental study to determine the practicality of using wetlands to help polish secondary wastewater effluent. Luzier Hydrosciences was retained by Scientific Resources, Inc. in April 1989, to characterize the groundwater hydrology at the wetland site and to evaluate the subsurface distribution and transport of phosphorus and other dissolved substances related to surface application of wastewater. Findings from this study include:

- Jackson Bottom Wetland is natural floodplain wetland in hydraulic continuity with nearby Tualatin River.
- Recharge to the upper most aquifer consists of regional-derived groundwater influx, rainfall, leakage from wastewater ponds, wastewater irrigation, and periodic flooding from Tualatin River.
- The experimental wetland caused minor physical changes to local groundwater flow regime, such as slight mounding, increased groundwater gradients, and localized changes to groundwater flow direction.
- It is not possible to clearly define short-term impacts of wastewater leakage.
- Groundwater near wetlands is good quality and meets inorganic and organic standards for drinking water.
- Iron, manganese and hydrogen sulfide are present in groundwater at nuisance levels.
- Orthophosphate concentrations are unusually high for natural groundwater conditions, however, appear to have been present prior to wetland study.
- Phosphorus-rich aquifer discharges into Tualatin River and helps maintain river flow during dry periods.
- Weak correlation between chloride concentrations and dissolved orthophosphate.
- Average groundwater travel times are about 120 feet/year.

- Estimated influx of groundwater to Tualatin River near Hillsboro may be roughly 200 gallon/minute per linear mile of stream.

Keywords: groundwater, orthophosphate, heavy metals, streamflow

Locations: Jackson Bottom Experimental Wetland (JBEW)

Mayer, T.D., and Jarrell, W.M., 1995, Assessing colloidal forms of phosphorus and iron in the Tualatin River basin: Journal of Environmental Quality, v. 24, n. 6, p. 1117-1124

Although colloids can affect the transport and chemistry of trace constituents in some aquatic systems, there are few estimates of the mass of given constituents in colloidal forms. The existence, variability, and origin of colloidal iron (Fe) oxide, and its effect on phosphorus (P) chemistry, was evaluated in the Tualatin River basin. Watershed streams were regularly sampled during 1992 and 1993. The concentrations of P and Fe in the colloidal size class (0.05-1.0 am) were determined by filtration. Elemental composition of the suspended material was assessed using scanning electron microscopy/energy-dispersive spectroscopy (SEM/EDS). Results include:

- Colloidal P and Fe ranged from 0% to 48% and 2% to 77% of the total P and total Fe, respectively. Since filtration underestimates colloidal concentrations, these are conservative estimates.
- Concentrations of P and Fe in colloidal form were correlated ($r^2 = 0.83$; $P < 0.001$) but total P, total Fe, and total suspended sediments were not correlated.
- SEM/EDS analysis showed that in addition to P and Fe, the colloids contained Si, Al, and Ca. The colloids were enriched with P and Fe relative to Al and Si.
- The colloidal P and Fe particles form as groundwater or sediment-released Fe(II), which is oxidized to Fe(III) and associated with P, either as coatings on the surface of colloidal clays and organics, or as homogeneous particles.

Keywords: iron, phosphorus, scanning electron microscopy (SEM), colloids

Locations: Tualatin River

Mayer, T.D., and Jarrell, W.M., 1996, Formation and stability of iron(II) oxidation products under natural concentrations of dissolved silica: Water Resources, v. 30, n. 5, p. 1208-1214

Model solutions were used to evaluate the effect of dissolved silica on the mineralogy and stability of Fe(II) oxidation products. Mineralogy was evaluated with scanning electron microscopy (SEM) and X-ray diffraction. Stability was evaluated by measuring the decrease in turbidity of colloidal suspensions with time. Findings from this study include:

- At Si/Fe molar ratios of 0.1 or less, oxidation of Fe(II) produced lepidocrocite, a moderately crystalline oxide that settled rapidly out of solution.
- At Si/FE molar ratios of 0.36 or higher, ferrihydrite formed from the oxidation of Fe(II). The ferrihydrite consisted of 0.1 µm spherical particles that were poorly crystalline and increasingly stable with higher Si/Fe molar ratios.

- The ferrihydrite was similar in structure and composition to Fe oxide colloids isolated from two natural samples: 1) a reduced groundwater sample that was allowed to oxidize in the laboratory and 2) the colloidal particles in the < 1.0 µm size class of surface water samples from the Tualatin River.
- The similarity of the natural and synthetic colloids is evidence that Fe oxide colloids in natural waters can result from the oxidation of Fe(II) and that dissolved silica may contribute to the stability of the colloids.

Keywords: iron, pH, silica, scanning electron microscopy (SEM)

Locations: Tualatin River

McCarthy, K.A., 2000, Phosphorus and E. coli in the Fanno and Bronson Creek subbasins of the Tualatin River basin, Oregon, during summer low-flow conditions, 1996: U.S. Geological Survey Water-Resources Investigations Report 00-4062, 31 p.

This report details the data collection and sampling efforts of the Fanno and Bronson Creek subbasins during September 1996. The investigation focused on summer base-flow phosphorus and E. coli concentrations in the two subbasins and their potential impact on water-quality conditions in the Tualatin River. Findings from this study indicate:

- Concentrations of total phosphorus from samples in both Fanno and Bronson Creek subbasin indicate that groundwater discharge could account for the phosphorus measured at most sites in this subbasin.
- A few sites in the Fanno Creek subbasin had phosphorus concentrations above background levels, indicating a source other than groundwater. Some of these sites were probably affected by the decomposition of avian waste materials and the release of phosphorus from bottom sediments in nearby ponds.
- Concentrations of E. coli exceeded the current single-sample criterion for recreational contact in freshwater (406 organisms/100 mL [organisms per 100 milliliters]) at 70% of the sites sampled in the Fanno Creek subbasin.
- Concentrations of E. coli in the Bronson Creek subbasin exceeded the single-sample criterion at one-third of the sites sampled.
- Most occurrences of elevated E. coli levels were probably due to sources such as domestic pet and wildlife waste, failing septic systems, or improperly managed hobby farms. The data did not indicate any large breaks in sewer lines or other large-scale sources of bacterial contamination to surface water in either subbasin during this low-flow period.

Keywords: phosphorus, E. coli, streamflow, groundwater, dissolved orthophosphate

Locations: Fanno Creek, Bronson Creek, Pendleton Creek

Miner, J.R., 1995, An analysis of water quality data in Tualatin River tributaries with three different land uses: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 12, 35 p., plus Appendices

This document contains the authors responses to a series of comments that were received in response to "A Project to Collect Scientific Data and Provide Evaluation and Recommendations for Alternative Pollution Control Strategies for the Tualatin River Basin," submitted to the Oregon Department of Environmental Quality (DEQ) on March 1, 1993. The authors are deeply indebted to the various people who commented on the report. Their comments have brought additional insights to the challenge of restoring water quality in the Tualatin River. It is the future to which these interested citizens, administrators, and scientists have contributed. The comments listed in the document were received from three sources:

- comments that were shared during the March 15, 1993 public hearing
- written comments submitted in response to the DEQ invitation
- comments submitted by nonpoint water quality specialists.

Keywords: public opinion

Locations: Tualatin River

Miner, J.R., Nelson, P.O., and Vedanayagam, Samuel, 1993, Late winter 1992 sampling for water quality in three stream segments of the Tualatin River basin, Oregon: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 4, 36 p.

The Tualatin River basin has been identified by the Oregon Department of Environmental Quality (DEQ) as "Water Quality Limited. " Algal blooms have become commonplace in the lower reaches of the river during summer months. Phosphorus has been identified as the nutrient upon which to base allowable Total Maximum Daily Loads (TMDL). Water quality data have been collected from the Tualatin River and its tributaries for the period of May through October for each of the past several years. Samples from the Tualatin River have also been collected during the winter months on a less frequent basis. There are very few data, however, from the tributaries for the winter months. This study was planned to collect water samples from three of the Tualatin River tributaries during the months of March and April, 1992. These tributaries were selected to represent the three major land uses within the basin: urban, agricultural, and forest. Weekly samples were taken from Dairy, McKay, and Fanno Creeks . Multiple samples were collected on each sampling dates to establish the extent to which short term variability would affect interpretation of the results. Results include:

- Total phosphours (TP) and orthophosphate (OP) concentrations on East and West Fork Dairy Creek were constant over time and location, averaging 0.05 and 0.02 mg/L, respectively.
- McKay Creek samples contained 0.01 mg/L OP, with TP increasing from 0.02 to 0.045 mg/L downstream. The values did not change with time.
- Dairy Creek samples contained 0.025 mg/L OP and 0.065 mg/L TP.
- Fanno Creek had average values of 0.035 mg/L OP and 0.09 mg/L TP, which increased with time, but were constant across sampling locations.
- Total solids and suspended solids were highest in Fanno Creek and lowest in McKay Creek. Suspended solids decreased downstream in Fanno Creek, and total solids increased for McKay Creek.
- Streamflow responded to rainfall, but no erosion events were recorded during this sampling period.

Keywords: water quality, total solids (TS), total suspended solids (TSS), soluble ortho-phosphorus (OP), total phosphorus (TP), streamflow, precipitation, pH

Locations: McKey Creek, Fanno Creek, Dairy Creek

Miner, J.R., and Scott, E.F., 1992, An analysis of water quality data in Tualatin River tributaries with three different land uses: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 2, 68 p.

Water quality and stream flow data for three representative land uses in the Tualatin River basin were evaluated to determine the comparative levels of various pollutants. In addition, the data were used in an effort to identify the extent to which observed concentrations of total and ortho phosphorus could be attributed to nonpoint surface runoff, to groundwater inflow or to extraction from previously deposited phosphorus bearing sediment. Findings from the study indicate:

- Surface runoff was not identified as a factor in determining water quality at any of the weekly dry season samplings in the streams flowing through agricultural and forested areas.
- Five incidents were identified in the urban area in which surface runoff was contributing to the quality of water in the streams.
- The data confirm that summer and fall runoff have minimal impact on stream quality.
- The data do not distinguish between the groundwater inflow or re-suspension of previously deposited sediments as being the major contributor to elevated phosphorus concentrations .

Keywords: pollution, precipitation, chloride, phosphorus, nitrogen, nutrients, water quality, total suspended solids, streamflow

Locations: Tualatin River, McKey Creek, EF Dairy Creek, Gales Creek, Fanno Creek, Dairy Creek

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Miner, J.R., and Scott, E.F., 1995, Data analysis – Water quality of Dairy Creek and major tributaries: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 5, 50 p.

Dairy Creek, located in Washington County, Oregon, has a drainage area of approximately 230 square miles, and includes West Fork, East Fork, and McKay Creek drainages. Dairy Creek is a major tributary of the Tualatin River, which experiences algal problems during the late summer when streamflows decrease and water temperatures increase. The upper reaches of Dairy Creek are forested land, while the lower reaches are devoted to intensively irrigated agricultural production. It has been proposed that excessive algae blooms are associated with elevated nutrient concentrations during summer low-flow conditions. The objective of this project was to evaluate nutrient loading to the Tualatin River from the Dairy Creek watershed. Water-quality parameters were selected to examine relationships between precipitation, streamflow, total solids and nutrient constituents. The following conclusions were reached:

- Surface runoff and erosion processes did not appear to occur and hence had little impact on water quality during the months of July through October during 1990 and 1991.
- Groundwater moving to the stream appears to drive streamflow and has significant influence on water quality during summer low-flow conditions.

- Nutrient concentrations are greatest during the summer. This may be a consequence of increased solubility and greater contact time between soils and groundwater moving toward the creek. An alternative is the winter sediment deposition. Most of loading for nutrient and total solids occurs during the winter and early spring at times of highest streamflows.

Keywords: streamflow, total solids, nutrients, precipitation, total dissolved solids, T-PO4-P, S-OPO4-P, phosphate, nitrogen

Locations: Dairy Creek, EF Dairy Creek, WF Dairy Creek, McKay Creek

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Nilsen, E.B., Rosenbauer, R.R., Furlong, E.T., Burkhardt, M.R., Werner, S.L., Greaser, L., and Noriega, M., 2007, Pharmaceuticals, personal care products and anthropogenic waste indicators detected in streambed sediments of the lower Columbia River and selected tributaries: Costa Mesa, CA, 6th International Conference on Pharmaceuticals and Endocrine Disrupting Chemicals in Water, National Ground Water Association, Paper 4483, p. 15.

One by-product of advances in modern chemistry is the accumulation of synthetic chemicals in the natural environment. These compounds include "pharmaceuticals and personal care products" (PPCPs) and "anthropogenic waste indicators" (AWIs), some of which are endocrine-disrupting compounds (EDCs) that can have detrimental reproductive effects in wildlife and in humans. Methods have been developed to screen for large suites of PPCPs and AWIs in aqueous media, but the role of sediments in exposure of aquatic organisms to these chemicals is less well understood. The first methods capable of analyzing a large suite of these compounds in solid media were published in 2005. Here we present an application of these methods to a small-scale reconnaissance of PPCPs and AWIs in natural bed sediments of the lower Columbia River Basin. Surficial bed sediment samples were collected from the Columbia River, the Willamette River, the Tualatin River, and several small urban creeks in Oregon. Results from this study show:

- Forty-nine compounds were detected at concentrations ranging from <1 to >1000 ng [g sediment]-1 dry weight basis (<1 to >10 µg [g OC]-1).
- Concentrations and frequency of detection were higher in tributaries and small urban creeks than in the Columbia River.
- There is a higher risk of toxicity to juvenile salmonids and other aquatic life in lower order streams.
- Thirteen known or suspected EDCs were detected during the study. At least one EDC was detected at 22 of 23 sites sampled; several EDCs were relatively widespread among the sites.

Keywords: chemistry, pharmaceuticals, wastewater, endocrine distruption, toxics, food web

Locations: Tualatin River

Oregon Department of Agriculture, Tualatin Soil and Water Conservation District, and Tualatin River Subbasin Local Advisory Committee, 2010, Tualatin River subbasin agricultural water quality management area plan: Oregon Department of Agriculture, Salem, Oregon, 37 p.

This Agricultural Water-Quality Management Area Plan provides guidance for addressing agricultural water-quality issues in the Tualatin River subbasin management area. The purpose of this plan is to

identify strategies to reduce water pollution from agricultural lands through a combination of educational programs, suggested land treatments, management activities, and monitoring. The provisions of this plan do not establish legal requirements or prohibitions. The Oregon Department of Agriculture will exercise its enforcement authority for the prevention and control of water pollution from agricultural activities under administrative rules for the Tualatin Subbasin and Oregon Administrative Rules (OARs) 603-090-0120 through 603-090-0180. Issues that need to be addressed include:

- The quality of the Tualatin River has been found to be limited due to water quality standards violations for temperature, dissolved oxygen, pH, bacteria, biological criteria, and chlorophyll a, resulting in impairment of beneficial uses.
- Achievement of the Area Plan's mission, goals, and objectives is expected to contribute, along with similar efforts by other DMAs with responsibilities in the subbasin, to the restoration of the Tualatin's waters to a level of quality that will preserve and protect its beneficial uses.
- The primary strategies to reduce amounts of pollution from agricultural and rural lands lie in the reduction of pollutants in runoff, the establishment of riparian vegetation, and the reduction of erosion through a combination of educational programs, land treatment, implementation of conservation practices and installation of structural measures.
- Streamside landowners are strongly advised and encouraged to plant and maintain trees and shrubs near streams.
- In order to make maximum use of available resources in addressing the natural resource issues of greatest concern in priority order, educational and technical assistance implementation activities must be carried out in stages.

Keywords: erosion, surface water, irrigation, nutrients, pesticides, Permitted Confined Animal Feeding Operations (CAFOs), riparian, wetlands

Locations: Tualatin River

Palmer, R.N., VanRheenen, N.T., Clancy, Erin, and Wiley, M.W., 2005, The impacts of climate change on the Tualatin River basin water supply – An investigation into projected hydrologic and management impacts: Department of Civil and Environmental Engineering, University of Washington, 72 p., plus Appendices

This report addresses the potential future impacts of climate change on the Tualatin River basin and the region's ability to meet current and future water demands. Although there is a growing preponderance of evidence that the earth's climate is changing, the exact type and magnitude of change that will occur in the future in relatively small river basins is not easily estimated. To address this issue, the report presents the results of a series of loosely-integrated models that track the impacts of climate change on precipitation and temperature, streamflow, and water management. Findings from this study indicate:

- Using the average output of six General Circulation Models of global climate, it is estimated that average monthly temperatures will increase by as much as 2°F by 2040 and as much as 4°F by 2080. The increase in temperatures will be the most dramatic during the winter and summer months.

- The changes in precipitation and temperature will significantly influence annual streamflow patterns. By 2040, the watershed's average annual runoff will be less than its historic average. In particular, summer streamflows will decrease by between 10 and 20%.
- During future decades, climate change will consistently and significantly impact on the yield of the water supply system. The yield of the current system is expected to erode by approximately 1.2% per decade during the next sixty years. This is particularly important as system demands are expected to increase in the future, and will surpass the system yield.
- Two alternatives were evaluated for increasing system yield: raising the height of Scoggins Dam by 20 feet and raising it 40 feet. If climate change is not considered, these expansions increase the 97% reliable yield from 63,784 acre-feet per year to 97,135 acre-feet (20-foot expansion) or 109,017 acre-feet (40-foot expansion). Using climate change projections for 2060, expansions will increase reliable yield from 59,198 acre-feet per year to 87,714 acre-feet and 107,307 acre-feet, respectively.
- If it is desirable to provide sufficient storage to meet future demands, expansion will be necessary. Without considering climate impacts, and using the 97% reliable yield as a standard, it will be necessary to expand the system by 20 feet by 2012 and to 40 feet by 2025. By 2035, the safe yield of the 40-foot expansion dam will be exceeded by demand. If the impacts of climate change are considered and an equal level of reliability is desired, the 20-foot expansion is needed by 2011 and the 40-foot expansion is needed by 2034.
- As the impacts of climate change are felt and as the system capacity is increased to meet larger demands, the Tualatin basin will encounter dramatically different types of droughts and reservoir operations. Currently, the system refills almost every year, with drawdown periods longer than a year being unusual. If the system attempts to meet increased demands in the future by significantly increasing its capacity, it is anticipated that system refill will become far less likely on an annual basis, multi-year draw-downs will be common, and the impacts of extended droughts may be much more significant.

Keywords: climate change, water temperature, streamflow, water supply

Locations: Tualatin River

Parker, Jr., E.D., Forbes. V.E., Nielsen, S.L., Ritter, C., Barata, C., Baird, D.J., Admiraal, W., Levin, L., Loeschke, V., Lyytikäinen-Saarenmaa, P., Høgh-Jensen, H., Calow, P., Ripley, B.J., 1999, Stress in ecological systems: Oikos, vol. 86, no. 1, 179-184, Accessed 1/18/2012 at http://www.jstor.org/stable/3546584

The impact of environmental extremes on the organization and function of biological systems is a dominant concern not only to biologists, environmental scientists, and global economists, but also to society in general. Perturbations ranging from the local release of toxic pollutants to acyclical weather shifts and longer-term climatic changes have dramatic effects on ecosystems that influence not only biodiversity and community organization, but also the sustainable development of natural resources. One of the crucial goals from a scientific point of view should be to develop experimental and monitoring procedures that will allow accurate predictions concerning the impacts of environmental perturbations on all levels of biological organization, particularly how effects at different levels of organization (i.e., gene, individual, population, community, ecosystem, and economic/political) interact.

Our purpose in this forum is to elucidate analogies and points of contact among the different subdisciplines that we represent (population and quantitative genetics, ecotoxicology, community and population ecology, and agriculture) that could provide new insights to understanding and predicting the effects of stress on ecological systems by summarizing major areas of concern from these different viewpoints. Thus, this article does not represent a consensus of opinion as much as an enumeration of the questions or criticisms of particular approaches to the study of stress that can be raised by workers in other disciplines. Our hope is that comparison of the paradigms and methods of the diverse programs in stress research can help in interpreting current work and in guiding future research on both anthropogenic and natural stress effects in ecological systems.

Keywords: ecology, stressors

Locations: n/a

Praskievicz, Sarah, and Chang, Heejun, 2011, Impacts of climate change and urban development on water resources in the Tualatin River basin, Oregon: Annals of the Association of American Geographers, v. 101, no. 2, p. 249-271

This study investigates the importance of future climate change and land use change in determining the quantity and quality of freshwater resources in the Tualatin River basin. Climate and land use change scenarios were modeled using the U.S. Environmental Protection Agency's (EPA) Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) modeling system. Models were calibrated and validated using historic flow and water-quality data between 1990 and 2006. The goodness of fit for the calibrated models was high, with coefficients of determination ranging from 0.72 to 0.93 in the calibration period. The calibrated models were run under a range of eight statistically downscaled climate change, two regional land use change, and four combined scenarios. Findings from this study indicate:

- Modeled changes in climate caused average increases in winter flows of 10%, decreases in summer flows of 37%, and increases in fifth-percentile flows of up to 80%.
- Modeled land use changes increased annual flows 21% for the development-oriented scenario and decreased 16% for the conservation-oriented scenario.
- For combined scenarios of high climate change and high urban development, there is a projected increase in winter flows of up to 71% and decrease in summer flows of up to 48%.
- Climate change scenarios were more significant than urban development scenarios in determining basin hydrological response.
- The results are relevant to regional planners interested in the long-term response of water resources to climate change and land use change at the basin scale.

Keywords: model, Better Assessment Science Integrating Point and Nonpoint Sources (BASINS), Windows-based Hydrologic Simulation Program-Fortran (WinHSPF), climate change, land use, urban development, streamflow, hydrology

Locations: Tualatin River

Rinella, F. A., and Janet, M. L., 1998, Seasonal and spatial variability of nutrients and pesticides in streams of the Willamette basin, Oregon, 1993-95: U.S. Geological Survey Water-Resources Investigations Report 97-4082-C, 59 p.

From April 1993 to September 1995, the U.S. Geological Survey conducted a study of the occurrence and distribution of nutrients and pesticides in surface water of the Willamette and Sandy River basins. About 260 samples were collected at 51 sites during the study; of these, more than 60% of the pesticide samples and more than 70% of the nutrient samples were collected at seven sites in a fixed-station network (primary sites). These sites were used to characterize seasonal water-quality variability related to a variety of land-use activities. Samples collected at the remaining 44 sites were used primarily to characterize spatial water- quality variability in agricultural river subbasins located throughout the study area.

This report describes concentrations of four nutrient species (total nitrogen, filtered nitrite plus nitrate, total phosphorus, and soluble reactive phosphorus) and 86 pesticides and pesticide degradation products in streams, during high- and low-flow conditions, receiving runoff from urban, agricultural, forested, and mixed-use lands. Findings from this study indicated:

- Although most nutrient and pesticide concentrations were relatively low, some concentrations exceeded maximum contaminant levels for drinking water and water-quality criteria for chronic toxicity established for the protection of freshwater aquatic life.
- The largest number of exceedances generally occurred at sites receiving predominantly agricultural inputs.
- Total nitrogen, filtered nitrite plus nitrate, total phosphorus, and soluble reactive phosphorus concentrations were detected in 89 to 98% of the samples
- Atrazine, simazine, metolachlor, and desethylatrazine were detected in 72 to 94% of the samples.
- Fifty different pesticides and degradation products was detected during the 2.5 year study.
- Seasonally, peak nutrient and pesticide concentrations at the seven primary sites were observed during winter and spring rains. With the exception of soluble reactive phosphorus, peak nutrient concentrations were recorded at agricultural sites during winter rains, whereas peak pesticide concentrations occurred at agricultural sites during spring rains.
- Spatially, nutrients were detected slightly more often in samples from the northern Willamette River basin relative to the southern basin. Concentration distributions in the two areas were similar. About 75% more pesticides were detected in the northern basin; however, two-thirds of the pesticide detections in the southern basin were larger in concentration than for the same pesticides detected in the northern basin.
- Nutrient and pesticide concentrations were associated with percent of upstream drainage area in forest, urbanization, and agriculture. Nutrient concentrations at forested sites were among the smallest observed at any of the sites sampled. In addition, only one pesticide and one pesticide degradation product were detected at forested sites, at concentrations near the method detection limits.
- The highest nutrient concentrations were observed at agricultural sites. The largest numbers of different pesticides detected were at agricultural sites, at concentrations generally larger than at most other land-use sites.
- Three pesticides (dichlobenil, prometon, and tebuthiuron) were detected more frequently at a site receiving predominantly urban inputs.

Keywords: nutrients, pesticides, phosphates, point source, water quality, water chemistry, land use

Applicable Locations: Tualatin River, Gales Creek, Fanno Creek, Mill Creek

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Risley, J.C., 1997, Relations of Tualatin River water temperatures to natural and human-caused factors: U.S. Geological Survey Water-Resources Investigations Report 97-4071, 143 p.

This report describes how two dynamic-flow heat-transport models, DAFLOW-BLTM and CE-QUAL-W2, were used to quantify the temporal and spatial patterns of water temperature in the Tualatin River and its major tributaries. Included in this modeling effort were an examination of the relation of water temperature in the Tualatin River and its major tributaries to climatic conditions, seasonal and daily variations, and human-caused factors, and an assessment of the effects of various flow-management practices on water temperature during the low-flow season. Results from the first 10 scenarios for 1994 were published here. Findings from this study indicate:

- Under "natural" conditions the temperature of the river would exceed the State standard of 17.8 degrees Celsius at many locations during the low-flow season.
- Current operation of wastewater-treatment plants increases the temperature of the river downstream of the plants under low-flow conditions.
- Water temperature is significantly affected by riparian shade variations along both the Tualatin River and its tributaries.
- Flow releases during the low-flow season from the Henry Hagg Lake reservoir decrease the water temperature in the upper Tualatin River.
- Removal of a low diversion dam at RM 3.4 would slightly decrease temperatures below RM 10.0.

Keywords: streamflow, water temperature, riparian shading, heat transport, Stream Network Temperature (SNTEMP), Diffusion Analogy Flow (DAFLOW), Branched Lagrangian Transport Model (BLTM), CE-QUAL-W2

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, Rock Creek, Fanno Creek, Oswego Canal

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Risley, J.C., 2000, Effects of hypothetical management scenarios on water temperatures in the Tualatin River, Oregon: U.S. Geological Survey Water-Resources Investigations Report 00-4071 (supplement to Water-Resources Investigations Report 97-4071), 110 p.

This report describes how two dynamic-flow heat-transport models, DAFLOW-BLTM and CE-QUAL-W2, were used to quantify the temporal and spatial patterns of water temperature in the Tualatin River and its major tributaries. Included in this modeling effort were an examination of the relation of water temperature in the Tualatin River and its major tributaries to climatic conditions, seasonal and daily variations, and human-caused factors, and an assessment of the effects of various flow-management practices on water temperature during the low-flow season. This report presents the results of 16 scenarios for both 1994 and 1995 conditions. In all scenarios, the State's temperature standard was exceeded in much of the lower reaches of the Tualatin River during the warmer months in both years. Findings from this study indicate:

- The effect of diverting 1.33 cfs (cubic feet per second) of Rock Creek Wastewater Treatment Plant (WWTP) effluent for irrigation was evaluated. Temperatures downstream of that facility for most months decreased about 0.05 degrees Celsius, or less. Farther downstream the effect was almost negligible. The effect of the diversion is slightly more apparent in the 1994 simulation than in the 1995 simulation. In a similar follow-up scenario, a constant flow of 1.33 cfs was withdrawn from the river at RM 37.3 and an additional constant flow of 2.0 cfs was released from Henry Hagg Lake to compensate. The effect of this diversion/augmentation on the river system was also fairly minimal for both 1994 and 1995. Temperatures generally decreased from RM 60.0 to RM 3.4 by about 0.05 to 0.1 degrees Celsius. For most months, the overall cooling resulting from this scenario was slightly greater than the cooling resulting from the former scenario.
- In another set of scenarios, the effect of piping and then releasing Rock Creek WWTP effluent at two upstream locations was evaluated. A constant flow of 5 Mgal/d (million gallons per day) was released at each upstream location, in addition to a constant release of either 10, 20, or 30 Mgal/d of effluent at RM 38.1. Temperatures increased between RM 55.2 and RM 38.1 by about 1.0 degree C, or less, but were still within compliance with the water-quality standard. Downstream of RM 38.1 the river temperature decreased (0.6 degrees C, or less) if the release from Rock Creek WWTP was only 10 Mgal/d. If the release from Rock Creek WWTP was 20 or 30 Mgal/d, temperatures downstream of RM 38.1 generally increased. However, the magnitude of the increase was generally less than 1.0 C.
- The temperature effect resulting from constant 25, 45, or 65 Mgal/d effluent releases from the Rock Creek and Durham WWTPs was evaluated. Temperatures throughout the reach downstream of Rock Creek WWTP and, to a lesser extent downstream of Durham WWTP, increased proportionately. The magnitude of the increases was as much as 0.6, 1.5, and 2.2 degrees C for the three scenarios, respectively.
- In another scenario, a cooler water-temperature data set, representing more shaded "natural" background conditions, was used as input to the model upper boundary at Gaston. Water temperatures decreased substantially between RM 63.9 and the confluence with Scoggins Creek (RM 60.0) by as much as 4.0 degrees C. In a follow-up scenario, the same model upper boundary condition was used in conjunction with the "natural" background conditions scenario from an earlier study. Water temperatures again decreased substantially between RM 63.9 and the confluence with Scoggins Creek. However, between Scoggins Creek and the Dairy Creek confluence, water temperatures gradually increased because the unnaturally cool water released from Henry Hagg Lake was not present. Almost all of the reach above Rood Bridge (RM 38.4) was still in compliance with the water-quality standard. Below RM 38.4 temperatures increased (1.0 degree C, or less) for July and August and decreased for other months.
- The effect of setting the temperature of effluent released at RM 38.1 and RM 9.3 equal to the temperature of the river was evaluated. Temperatures downstream of RM 38.1 decreased by as much as 2.4 degrees C. The reduction then tapered off to 0.5 degrees C upstream of RM 9.3. Downstream of RM 9.3, temperatures decreased by as much as 1.2 degrees C.
- Another scenario was used to evaluate the effect of releasing a purchased allotment of Scoggins Dam flow (up to, but not exceeding 10 Mgal/d) at RM 38.1 instead of into Scoggins Creek. Observed Scoggins Dam temperature data were used for the allotted flow. Temperatures increased for all months except October from RM 60.0 to RM 38.1 by as much as 0.6 degrees C. However, downstream of RM 38.1, temperatures decreased from as much as 0.7 degrees C for all months except October. However, the effect of the supplemental release became less pronounced farther downstream.

- The effect of constant effluent releases of 20, 25, 45, and 65 Mgal/d at two WWTPs (RM 38.1 and RM 9.3) was evaluated. The 1994 and 1995 measured effluent temperature data from the WWTPs were used, except that the temperatures were not permitted to be greater than 17.8 degrees C. For most months, the temperature in the reach downstream of both WWTPs decreased in all four scenarios. From RM 38.1 to RM 9.3, the temperature decrease was less than 1.0 degrees C. Downstream of the Durham WWTP (RM 9.3), temperatures decreased almost by 2.0 degrees C.

Keywords: model, water temperature, riparian shading, Stream Network Temperature (SNTEMP), Diffusion Analogy Flow (DAFLOW), Branched Lagrangian Transport Model (BLTM), CE-QUAL-W2

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, Rock Creek, Fanno Creek, Oswego Canal

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Risley, J.C. and Doyle, M.C., 1997, Water-temperature, specific-conductance, and meteorological data for the Tualatin River Basin, Oregon, 1994-95: U.S. Geological Survey Open-File Report 96-315, 124 p.

This report describes methodology for data collection used to quantify the temporal and spatial patterns of water temperature in the Tualatin River and its major tributaries. Included in this data collection effort were an examination of the relation of water temperature in the Tualatin River and its major tributaries to climatic conditions, seasonal and daily variations, and human-caused factors, and an assessment of the effects of various flow-management practices on water temperature during the low-flow season. Data were collected at 14 fixed-station continuous monitoring sites on the Tualatin River or its tributaries. Data were collected for water temperature, specific conductance, wind speed, and solar radiation. Surveys were conducted during the low-flow period from August to October of 1994 and August to September 1995. During each survey, up to six water temperature probes were positioned at locations upstream and downstream of wastewater-treatment plant effluent outlets. No interpretation or analysis was completed.

Keywords: water temperature, specific conductance, wind speed, solar radiation

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, Rock Creek, Fanno Creek, Oswego Canal

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Rounds, S.A., 1999, Investigations of water quality in the Tualatin River basin, Oregon, and their role in the TMDL process, in Proceedings of the Seventh Biennial Watershed Management Conference, C.W. Slaughter, Ed., Water Resources Center Report No. 98, University of California, Davis, p. 7-19

The U.S. Geological Survey (USGS) has studied eutrophication processes in the Tualatin River for most of the past decade. Prior to 1988, high concentrations of ammonia (> 20 mg/L) and phosphorus (> 2 mg/L) were discharged into the river from two large wastewater-treatment plants (WWTPs) operated by the Unified Sewerage Agency (USA). These loads of ammonia and phosphorus led to low dissolved oxygen concentrations and large phytoplankton blooms in the river during the warm, low-flow months between May and October. In response, Total Maximum Daily Loads (TMDLs) of ammonia nitrogen and total phosphorus were set in 1988. In 1990, after upgrades to the WWTPs were under way, the USGS and USA initiated an investigation of water quality in the Tualatin River. This investigation quantified the sources

and sinks of water, nitrogen, and phosphorus in the main stem of the river. Findings from this study indicate:

- Groundwater is a natural source of phosphorus.
- Photosynthetic production is the largest instream source of dissolved oxygen.
- Sediment oxygen demand (SOD) is the most important sink.
- The model CE-QUAL-W2 was successful at simulating streamflow, water temperature, nutrients, phytoplankton, and dissolved oxygen in the lower Tualatin River, proving beneficial for future river management.

Keywords: CE-QUAL-W2, model, phosphorus, dissolved oxygen, algal bloom, ammonia

Locations: Tualatin River

Rounds, S.A., 2001, Modeling water quality in the Tualatin River: Achievements and limitations, in AWRA Annual Spring Specialty Conference Proceedings, "Water Quality Monitoring and Modeling," Warwick, John J. (ed.), American Water Resources Association, Middleburg, Virginia, TPS-01-1, p. 115-120

Many of today's water-quality models are adequate for the simulation of basic transport processes and simple chemical and biological reactions. Hence, they are good tools for helping us understand and quantify water-quality processes. However, at some level of complexity these tools will inevitability fail. Successes and failures from such efforts can be illustrated by a modeling water quality in the Tualatin River. Findings from this study indicate:

- The model CE-QUAL-W2 successfully assesses the sources and transport of phosphorus, quantifies the river's ammonia assimilative capacity, determines the relative importance of the sources and sinks of dissolved oxygen, quantifies the factors that affect phytoplankton growth, and tests the effects of potential management strategies.
- The model CE-QUAL-W2 fails to adequately predict pH or assess long-term sediment diagenesis.
- Improved models are needed for simulating sediment transport and periphyton growth. These are some of the issues that must be addressed by the next generation of water-quality models.

Keywords: water quality, model, CE-QUAL-W2, successes, limitations

Locations: Tualatin River

Rounds, S.A., 2002, Development of a neural network model for dissolved oxygen in the Tualatin River, Oregon, in Proceedings of the Second Federal Interagency Hydrologic Modeling Conference, July 29 - August 1, 2002, Las Vegas, NV: Subcommittee on Hydrology of the Interagency Advisory Committee on Water Information

Many of the processes that affect dissolved oxygen concentrations in the Tualatin River, including solubility, sediment oxygen demand, photosynthesis, respiration, biochemical oxygen demand, and reaeration, are controlled by physical and meteorological factors, such as streamflow, air temperature, and solar radiation. To test the extent of that control, an artificial neural network model was constructed to predict dissolved oxygen concentrations in the Tualatin River using only air temperature,

solar radiation, rainfall, and streamflow as inputs. Two neural network models were constructed in series: the first model simulated daily mean dissolved oxygen concentrations, while the second superimposed any daily periodic signals. Findings from this study indicate:

- The neural network models predicted the dissolved oxygen concentration with acceptable accuracy, producing high correlations between measured and predicted values (correlation coefficient of 0.83, mean absolute error less than 0.9 milligrams per liter).
- By some measures, neural network model performance was better than that of a calibrated, mechanistic model of dissolved oxygen in the Tualatin River.
- Dissolved oxygen concentrations from non-physical and non-meteorological factors, such as large point-source ammonia releases, were not predicted well by the neural network model.
- The neural network model demonstrated potential for use as a river management and forecasting tool to predict the effects of flow augmentation and near-term weather conditions on Tualatin River dissolved oxygen concentrations.

Keywords: dissolved oxygen, artificial neural network, solar radiation, air temperature, streamflow, wastewater treatment

Locations: Tualatin River

Rounds, S.A. and Doyle, M.C., 1997, Sediment oxygen demand in the Tualatin River basin, Oregon, 1992-1996: U.S. Geological Survey Water-Resources Investigations Report 97-4103, 19 p.

Sediment oxygen demand (SOD) rates were measured by U.S. Geological Survey (USGS) personnel at 20 stream sites in the Tualatin River Basin from 1992 through 1996 as part of an investigation into the sources and sinks of dissolved oxygen in the Tualatin River. All SOD rates were measured with in-situ benthic chambers designed to monitor the loss of dissolved oxygen in a known volume of water circulating above a known area of minimally disturbed stream sediment. Results from this study include:

- The observed SOD rate for the Tualatin River ranged from 0.6 to 4.4 grams of oxygen per square meter per day (g/m 2 d) with a median of 2.3 g/m 2 d.
- The observed SOD rate for tributaries ranged from 0.2 to 10.9 with a median of 3.6 g/m 2 d.
- Statistical comparisons show that the SOD rates measured at tributary sites are significantly larger than those measured in the Tualatin River.
- Within the Tualatin River, SOD rates measured at sites in meanders were not significantly different from those measured in the reservoirs.
- No difference was found between sites with phytoplankton bloom and die-off compared to those unaffected by phytoplankton.
- Only the site on the Tualatin River at RM 5.5 was found to have an SOD rate that was significantly higher than that found at the other mainstem sites. Algal detritus or the rate of sediment accumulation may have contributed to the elevated rate at that site.

Keywords: sediment oxygen demand, dissolved oxygen, Chlorophyll a, phytoplankton

Locations: Tualatin River, Beaverton Creek, Bronson Creek, Cedar Mill Creek, Dairy Creek, Fanno Creek, Gales Creek, Rock Creek, Willow Creek

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Rounds, S.A., Doyle, M.C., Edwards, P.M., and Furlong, E.T., 2009, Reconnaissance of pharmaceutical chemicals in urban streams of the Tualatin River basin, Oregon, 2002: U.S. Geological Survey Scientific Investigations Report 2009-5119, 22 p.

Prior to this study, few data existed to quantify the occurrence or concentration of pharmaceutical chemicals in streams of the Tualatin River basin. This report eliminates the data gap as a step toward determining whether this class of compounds affects ecosystem health. A reconnaissance of pharmaceutical chemicals in urban streams of the Tualatin River basin was conducted in July 2002 in an effort to better understand the occurrence and distribution of such compounds, and to determine whether they might be useful indicators of human-related stream contamination. Findings from this study indicate:

- Fifteen pharmaceutical chemicals or metabolites were detected in wastewater treatment facility influent, with concentrations far exceeding those measured in streams.
- Only five of compounds (carbamazepine, cotinine, ibuprofen, metformin, and sulfamethoxazole) were detected in the treated effluent and most of those were at concentrations less than 0.2 microgram per liter.
- The target pharmaceutical chemicals and metabolites show limited potential for use as tracers of specific types of human-related contamination in Tualatin River basin streams because of widespread sources (caffeine, for example) or extremely low concentrations.
- Caffeine and cotinine are likely to be good indicators of sources that can occur in urban areas, such as sewage spills or leaks or the widespread use and careless disposal of tobacco products and caffeine-containing beverages. Neither compound, however, is likely to be a good tracer for a specific source unless that source is large.
- The presence of 1,7-dimethylxanthine (a caffeine metabolite) concurrently with caffeine might indicate the presence of untreated wastewater; in contrast, the absence of the metabolite might help rule out that source.
- Acetaminophen might make a good tracer for untreated wastewater because of its common usage, high concentration in raw wastewater, and effective removal via treatment.
- Carbamazepine and sulfamethoxazole have the potential to be good indicators of treated wastewater because of their incomplete removal in treatment facilities.

Keywords: pharmaceuticals, chemical compounds, wastewater treatment, contamination, caffeine, acetaminophen, codeine

Locations: Tualatin River, Fanno Creek, Summer Creek, Gales Creek, Dairy Creek

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Rounds, S.A. and Sullivan, A.B., 2006, Development and use of new routines in CE-QUAL-W2 to blend water from multiple reservoir outlets to meet downstream temperature targets, in Proceedings of the Third Federal Interagency Hydrologic Modeling Conference, April 2-6, 2006, Reno, NV: Subcommittee on Hydrology of the Interagency Advisory Committee on Water Information, ISBN 0-9779007-0-3

In this work, version 3.12 of CEQUAL-W2 was modified to enable it to automatically blend water from multiple reservoir outlets and to select optimum depths for sliding-gate (adjustable-elevation) outlets to meet downstream temperature targets. Previous applications of CE-QUAL-W2 were forced to make such operational adjustments outside of the model in an iterative manner, a process that typically required many model runs. These tasks are now accomplished in a single model run because the necessary

operational adjustments are done internally. These changes were tested in an application of CE-QUAL-W2 to a proposed 40-foot raise of Scoggins Dam in northwestern Oregon. Downstream temperature targets were generated by smoothing measured temperatures upstream of the reservoir. Various combinations of fixed- and adjustable-elevation outlets were tested. Findings from this study indicate:

- Results showed that downstream temperature criteria could be met, though the reservoir sometimes ran out of cold water in the fall.
- The outlet combinations that were best able to meet downstream temperature targets were those that accessed both cold water near the bottom of the lake and warm water near the surface.
- The greatest operational flexibility typically was provided by adjustable-elevation outlets because they could be moved to access cold or warm water, as necessary. These tests demonstrated the utility of the model modifications, which worked well and saved the model user considerable time.

Keywords: CEQUAL-W2, model, water temperature

Locations: Scoggins Creek, Henry Hagg Lake, Tualatin River

Rounds, S.A. and Wood, T.M., 1998, Using CE-QUAL-W2 to assess the ammonia assimilative capacity of the Tualatin River, Oregon, in Proceedings of the First Federal Interagency Hydrologic Modeling Conference, Las Vegas, Nevada, April 19-23, 1998: U.S. Geological Survey, p. 2-133 - 2-140

A modified version of the U.S. Army Corps of Engineers model CE-QUAL-W2 was used to simulate streamflow, water temperature, and water quality in the lower reaches of the Tualatin River. Simulated water-quality constituents included nutrients (nitrogen and phosphorus), phytoplankton, and dissolved oxygen. Findings from this study indicate:

- CE-QUAL-W2 successfully quantifies the river's ability to assimilate ammonia wasteloads from the basin's two largest wastewater treatment plants without causing violations of the State of Oregon minimum dissolved oxygen standard. This assimilative capacity increases with increasing river discharge and solar insolation, and decreases with increasing water temperature.
- CE-QUAL-W2 model simulations were used to determine that the 30-day mean dissolved oxygen concentration would decrease by only about 0.2 milligrams per liter under the most sensitive observed conditions when each of the wastewater-treatment plants releases a constant load of 100 pounds per day of ammonia nitrogen.

Keywords: CE-QUAL-W2, model, dissolved oxygen, ammonia, streamflow, water temperature, solar insulation

Locations: Tualatin River

Rounds, S.A. and Wood, T.M., 2001, Modeling water quality in the Tualatin River, Oregon, 1991-1997: U.S. Geological Survey Water-Resources Investigations Report 01-4041, 53 p.

This report documents the performance of the USGS Tualatin River model for the summers of 1991–1997, as well as the minor changes made to the model since the conclusion of the original study. This report builds on the original report by Rounds and others (1999). Findings from this study indicate:

- The model CE-QUAL-W2 provides a good fit to the measured data for streamflow, water temperature, and water-quality constituents, such as chloride, ammonia, nitrate, total phosphorus, orthophosphate, phytoplankton, and dissolved oxygen.
- CE-QUAL-W2 successfully simulates ammonia concentrations and the effects of instream ammonia nitrification, which is critical to ongoing efforts to revise ammonia regulations for the Tualatin River.
- CE-QUAL-W2 simulates the timing, duration, and relative size of algal blooms with sufficient accuracy to provide important insights for regulators and managers of this river.
- Efforts to limit the size of algal blooms through phosphorus control measures are apparent in the model simulations, which show this limitation on algal growth. Such measures are largely responsible for avoiding violations of the State of Oregon maximum pH standard of 8.5 in recent years, but they have not yet reduced algal biomass levels below the State of Oregon nuisance phytoplankton growth guideline of 15 µg/L chlorophyll-a.
- CE-QUAL-W2 captures most of the dynamics of the instream dissolved oxygen concentrations. About half of the error in the simulated dissolved oxygen concentrations is directly attributable to error in the size of the simulated phytoplankton population. To achieve greater accuracy in simulating dissolved oxygen, therefore, it will be necessary to increase accuracy in the simulation of Tualatin River phytoplankton.

Keywords: CE-QUAL-W2, model, water temperature, streamflow, zooplankton, ammonia, chloride, nutrients, algae, dissolve oxygen, nitrate, phosphorus, orthophosphate, wastewater treatment

Locations: Tualatin River

Rounds, S.A., Wood, T.M., and Lynch, D.D., 1999, Modeling discharge, temperature, and water quality in the Tualatin River, Oregon: U.S. Geological Survey Water-Supply Paper 2465-B, 121 p.

This report describes CE-QUAL-W2 modeling for the lower Tualatin River between 1991 and 1993. Nine hypothetical scenarios were tested with the model to provide insight for river managers and regulators. Findings from this study indicate:

- Few of the scenarios tested for this report had significant effects upon simulated dissolved oxygen conditions in the Tualatin River.
- During September and October, the most significant improvements in dissolved oxygen (as much as 1 milligram per liter) were obtained only through a large amount of flow augmentation (minimum flow of 200 cfs at RM 38.4) or through a lesser amount of flow augmentation (minimum flow of 150 cfs at RM 38.4) combined with a reduction in the loads of carbonaceous biochemical oxygen demand (CBOD) from the boundaries.
- For the period May through August, several scenarios showed some ability to limit algal growth during large blooms. When these scenarios failed to reduce the impact of the background oxygen demands (SOD, CBOD), however, dissolved oxygen concentrations between algal blooms still showed a tendency to decrease nearly to problem levels.

- Phosphorus reduction scenarios showed that if the total phosphorus total maximum daily load (TMDL) is achieved at the boundaries to the Tualatin River and the wastewater-treatment plants are efficiently removing phosphorus from their effluent and meeting their wasteload allocations, then the river will be in compliance with the TMDL. Even if the TMDL is achieved, however, the predicted effect on dissolved oxygen concentrations is unclear. If particulate and organic phosphorus is removed rather than soluble orthophosphate, then dissolved oxygen conditions will improve, especially in October, primarily because CBOD will be removed. If soluble phosphorus is removed instead, then dissolved oxygen conditions may actually worsen because of reduced photosynthetic production of oxygen without the loss of CBOD at the boundaries.
- Scenarios that provided the most improvement in dissolved oxygen conditions, include both a decrease in residence time through flow augmentation and a decrease in the background oxygen demands (CBOD and SOD).

Keywords: CE-QUAL-W2, model, water quality, carbon, dissolved oxygen, phosphorus, nitrogen, total suspended solids, dissolved solids, pH, streamflow, meterology, biochemical oxygen demand, water temperature

Locations: Tualatin River

Scott, E.F., Wood, Mary, Warkentin, B.P., 1995, Agricultural land use in the Tualatin Basin: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 15, 35 p.

This report presents estimates of land uses, concentrating on agricultural land, in the Tualatin River basin. Acreage was estimated for different crop groups, agricultural water use, and distribution in the watershed. The total amounts were calculated for nitrogen and phosphate applied to agricultural land and the average loading of nutrients per acre in each subbasin. Findings include:

- Over 60 different crops and a variety of livestock are produced commercially in the Tualatin River basin.
- There are between 90,000 and 110,000 harvested acres in Washington County.
- The Tualatin watershed has three major land uses: forest, agriculture, and urban.
- Most of the forested land is located in the northwestern part of the watershed
- Urban land is clustered primarily in the southeastern corner of the watershed, in the lower reaches of the Tualatin River.
- Agricultural land is located in the central part of the watershed.
- The approximately 63,000 acres of pasture land in the Tualatin River basin includes 47,000 acres for non-dairy cattle, 15,000 acres for horses, and 1,100 acres for sheep.

Keywords: agriculture, land use

Locations: Tualatin River

Shively, D.D., 1993, Landscape change in the Tualatin basin following Euro-American settlement: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 6, 19 p.

The Tualatin River basin landscape has undergone extensive change since the initiation of Euro-American settlement, with important consequences for basin hydrology and water quality. Changes include the isolation of the Tualatin River from its floodplain areas, losses of important wetlands and riparian areas, and urbanization associated with population growth in the basin. The anthropogenic changes have produced a landscape that is functionally different from the pre-contact landscape. These changes, though they have occurred gradually over a 130-year period, began to become important in the late 19th and early 20th centuries, when timber production and agricultural activities began to dominate. Any effective watershed management plan developed for the Tualatin River basin must address these landscape changes and the loss of important landscape features, such as wetlands and riparian areas.

Keywords: hydrology, nutrient dynamics, biota, wetlands, history, land use

Locations: Tualatin River

Simon, Andrew, Bankhead, Natasha, Klimetz, Lauren, and Thomas, R.E., 2011, Evaluation of bed and bank stability along selected stream reaches within the Tualatin River basin: U.S. Department of Agriculture, Agricultural Research Service, National Sedimentation Laboratory Technical Report 75, 179 p., plus Appendices

This report documents results of the study to quantify erosion resistance and potential frequency of erosion for many areas in the Tualatin River Basin between 2000 and 2009. Although erosion resistance was found to be variable, as is typical with cohesive deposits, the central 50% of reaches tested erode at rates comparable to gravel-sized sediment. Results from this study include:

- Rapid Geomorphic Assessments (RGAs) conducted throughout the watershed verified that most of the channels have been incised. Incision may be an important, ongoing process and system-wide adjustment in some tributary basins is evident.
- Numerous knickpoints were observed throughout the basin, with the greatest concentration in the southeastern part of the watershed.
- Channel instabilities are the result of both localized and system-wide disturbances.
- Analysis of flow series validated initial concerns about using a short data set characterized by generally lower flows than long-term averages. When compared to long-term gage records, flows for the 2000-2009 period were generally about 20% lower across the range of flow frequencies.
- Critical shear stresses of both streambed and bank materials were measured in situ with two jet-test devices and cohesive strength meter (CSM). While the two jet devices provided consistent estimates of critical shear stresses, the CSM produced estimates that were much smaller.
- Critical shear stresses obtained from individual jet tests of the streambeds covered a broad range, as is typical of cohesive deposits. These critical shear stresses equate to those of non-cohesive particles with diameters in the sand- to gravel- and cobble-size ranges. The modal class was in the medium-gravel range (16 mm).
- Root strength/root diameter relation developed from testing of six riparian species in the Tualatin River watershed compared closely with those of other riparian species sampled by the USDA-ARS across the United States. Vegetation appeared to play an important role in moderating mass wasting at some of the study sites.

- The role of vegetation on hydraulic simulations within BSTEM-Dynamic proved to be very significant. The hydraulic roughness provided riparian vegetation significantly reduces the effective stress acting on the bank surface, and moderates the stress distribution on the streambed.
- Based on simulations with BSTEM-Dynamic, about 25% of sites did not show any erosion over the study period. However, some sites modeled that showed no erosion did in fact erode.
- The greatest erosion amounts were found in the lower Tualatin River, although Fanno Creek also had areas of particularly high erosion amounts.
- The variability in the erosion-resistance of the boundary materials precluded the identification of a single threshold discharge above which erosion would occur at all sites.
- The relative resistance of the channel boundary, expressed as "equivalent particle diameter" ranged from 1.7 to 66.6 mm, and 0.6 to 66.1 mm for beds and bank toes, respectively. The central 50% of these distributions represent particles in the gravel-size range.
- A hydro-modification ratio was defined as half the 2-year discharge divided by the critical discharge. Based on simulations of the 37 "intensive" sites, two categories of the hydro-modification ratio were highlighted as conditions that deserve consideration for hydro-modification.

Keywords: channel stability, shear strength, erosion, streamflow, mass movement, landslide, Bank-Stability and Toe-Erosion Model (BSTEM)

Locations: Tualatin River, Fanno Creek, McKay Creek, Beaverton Creek, Rock Creek, Butternut Creek, Dairy Creek, Gales Creek

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Sullivan, A.B. and Rounds, S.A., 2005, Modeling hydrodynamics, temperature and water quality in Henry Hagg Lake, Oregon, 2000-2003: U.S. Geological Survey Scientific Investigations Report 2004-5261, 38 p.

In this report CE-QUAL-W2 was used to simulate hydrodynamics, water temperature, and water quality in Henry Hagg Lake, Oregon, for the years 2000 through 2003. The model initially was calibrated with data from 2000 to 2001 and tested with data from 2002 to 2003. Sensitivity tests were performed to examine the response of the model to specific parameters and coefficients, including the light-extinction coefficient, wind speed, tributary inflows of phosphorus, nitrogen and organic matter, sediment oxygen demand, algal growth rates, and zooplankton feeding preference factors. Findings from this study include:

- Lake levels were highest in late spring and early summer and decreased through the summer and fall as downstream users required water for irrigation, drinking water, flow augmentation, and municipal uses. Lake levels were lowest in November. The annual cycle in lake level was an important factor that affected lake temperature and water quality.
- Spatial and temporal patterns in water temperature in Henry Hagg Lake were similar in all four years modeled. A thermocline developed each year by early summer. Withdrawals from the lake tended to draw the thermocline down to the lake's outlet structure by mid-summer. Hagg Lake typically turned over in November and remained uniformly mixed and isothermal until early March. Meteorological factors and reservoir operations influence the lake's water temperature.
- During normal years, dissolved oxygen became depleted in the hypolimnion by late September; during the drought year, this occurred earlier, by late August. Colder temperatures and lake

turnover in November reoxygenated the water column and ended hypolimnetic anoxia in each year. Dissolved oxygen levels in Henry Hagg Lake were controlled mainly by water temperature, sediment oxygen demand, and by algal photosynthesis and respiration.

- Ammonia concentrations generally were low throughout Henry Hagg Lake and accumulation of ammonia in the hypolimnion only occurred after dissolved oxygen was depleted.
- Algae were separated into two groups in the model: blue-green algae and all other algae. The general algae group had its highest abundance in the spring, due in part to inputs of algae from tributaries and possible resuspension of algal cells during storms. The blue-green algae group tended to bloom in late summer . Orthophosphate concentrations,zooplankton grazing, water temperature, and light all controlled the levels and timing of algal blooms in the model. Concentrations of bioavailable phosphorus appeared to limit the size of the annual blue-green algae bloom.
- While a community of zooplankton was found in Henry Hagg Lake, its interactions with other zooplankton and with the lake's algal communities appears to be significantly more complex than what was represented in the model.
- The model captured the dominant processes affecting water quality, including water temperature, dissolved oxygen, nutrients, and algae in Henry Hagg Lake and simulated the lake's water-quality dynamics with sufficient accuracy for the planned purposes of the model.

Keywords: CE-QUAL-W2, dam, outflow, streamflow, reservoir, bathymetry, water temperature, orthophosphate, total phosphorus, ammonia, nitrate, algae, biomass, Chlorophyll a, zooplankton, dissolved oxygen

Locations: Henry Hagg Lake, Scoggins Creek, Tualatin River

Sullivan, A.B. and Rounds, S.A., 2006, Modeling water-quality effects of structural and operational changes to Scoggins Dam and Henry Hagg Lake, Oregon: U.S. Geological Survey Scientific Investigations Report 2006-5060, 36 p.

This report presents CE-QUAL-W2 modeled scenarios of Henry Hagg Lake that could predict changes in hydrodynamics, water temperature, and water quality that could result from a set of proposed modifications to the dam and lake. Most model scenarios were run with the calibrated model for 2002, a typical water year; a few scenarios were run for 2001, a drought year. Findings from this study indicate:

- The proposed dam raise and associated changes to the lake's inflows and releases are likely to produce important and measurable changes in water quality, both in the lake and in the water released downstream to Scoggins Creek.
- Compared with the baseline conditions, most modifications considered in these scenarios would lead to cooler annual average water temperatures, less hypolimnetic anoxia, and lower annual average concentrations of ammonia and chlorophyll a.
- The amount of water withdrawn from Henry Hagg Lake has water-quality implications. Model scenarios with low water levels produced warmer lake temperatures, earlier turnover, and higher ammonia concentrations in the hypolimnion compared with scenarios having higher water levels. In the outflow, low lake levels led to more frequent exceedance of downstream temperature criteria in the absence of outlet modifications.
- Either diverting upper Tualatin River water through a Sain Creek tunnel or pumping back downstream Tualatin River water would fill an enlarged Hagg Lake [7.6 meter (25 foot) and 12.2

meter (40 foot) dam raises] in 2002. In a drought year such as 2001, however, pump-back would not necessarily fill the enlarged lake, as water levels would be low at the start of the year, and drought conditions would reduce the availability of water in the Tualatin River downstream.

- Simulations of the wintertime transfer of water into Hagg Lake from the Tualatin River via pump-back resulted in increased phosphorus concentrations in the lake, especially in 2002 due in part to high concentrations of orthophosphate in the pump-back water that year.
- Water temperature criteria in Scoggins Creek downstream of Scoggins Dam will likely not be met without modifications, such as the construction of additional lake outlets to allow the blending of warm and cold water from various depths in the lake.
- Model predictions indicate that blending water from near the lake's surface (typically warm in the summer) with water from near the lake bottom (typically cold) would be sufficient to meet downstream temperature criteria and restore a more natural seasonal temperature pattern in Scoggins Creek below the dam. A selective withdrawal tower with sliding gates or multiple fixed outlets would offer dam operators the necessary flexibility for blending.
- The use of multiple lake outlets and various operational strategies has important effects on water quality in the lake. Hypolimnetic anoxia and the subsequent buildup of hypolimnetic ammonia can be minimized or avoided. Lake surface temperature maxima can be decreased, which may help to minimize blooms of the blue-green algae Anabaena planctonica.

Keywords: CE-QUAL-W2, dam, outflow, streamflow, reservoir

Locations: Henry Hagg Lake, Scoggins Creek, Tualatin River

Swift III, C.H., 1971, Appraisal of streamflow in the Tualatin River basin, Washington County, Oregon: U.S. Geological Survey Open-File Report…1972, 38 p., plus 1 plate

This report describes the within-year time distribution of streamflow; the magnitude and frequency of annual minimum, mean, and maximum flows; and the within-year storage required to sustain selected flows in the Tualatin River basin. The report does not include an appraisal of instantaneous peak discharges in the basin. Data were derived by statistical methods and are adequate for general water-development planning. A duration hydrograph provides a general description of the within-year time distribution of streamflow. Generalized equations based on a sample of gage flows are presented for estimating magnitude and frequency of flows at ungagged sites. Generalized storage relations are included for estimating storage requirements at gaged and ungagged sites.

Keywords: precipitation, streamflow

Locations: Tualatin River

Tang, Fei, 1993, Calibration and verification of HSPF model for Tualatin River Basin Water Quality: M.S. Thesis, Portland State University, Portland, Oregon, Technical Report EWR-003-93, 76 p., plus Appendices

The Tualatin River basin is located in the Washington County, Oregon. The river was detected having high chlorophyll a concentration and low dissolved oxygen concentration during summer time, which violated DEQ water quality standards. A mathematical model (HSPF) was used to simulate physical, chemical, and biological processes in the river and to evaluate the effect of the 'best management

practice' (BMP) strategy used to improve water quality in the basin. Calibration of the model focused on water temperature, total suspended solids, dissolved oxygen, dissolved ammonia, dissolved nitrate, dissolved phosphate, and chlorophyll a. Comparison against observed data (1990) showed that the model predictions were representative for most of the constituents. After verification, the model was used to evaluate the effectiveness of the BMP on the agricultural land in the Gales Creek subbasin. The results showed that the effect of the BMP on nutrient loading is not significant.

Keywords: model, HSPF, nutrients, water quality, water temperature, total suspended solids, dissolved oxygen, dissolved ammonia, dissolved nitrate, dissolved phosphate, and chlorophyll a

Locations: Tualatin River, Gales Creek

Taylor, G.H., Klingeman, P.C., and Miner, J.R., 1995, Estimating the frequency and quantity of surface runoff within the Tualatin River basin: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 16, 27 p.

The purpose of this analysis is to determine the frequency of surface runoff from various land areas within the Tualatin River basin during the various months of the year. Several variables determine whether precipitation in the basin will cause runoff in the Tualatin River or its tributaries. This analysis assumes that the two most important variables are land use and soil moisture holding capacity. Various studies have been conducted in the past to explore these topics. The purpose of this paper is to organize that thinking and apply it to the Tualatin River basin. Finding from this study include:

- During the months of May through October, runoff from agricultural and forested lands is unlikely.
- Runoff from urban and otherwise impermeable land is greater but still less than once per month, on average.
- During high rainfall winter months, when evapotranspiration is lowest, runoff from all of the Tualatin River basin land uses is frequent.
- Although this analysis is helpful in evaluating' the impact of runoff-carried phosphorus from the agricultural and forested areas on the phosphorus concentrations in the Tualatin River, the question of amounts remains unresolved.
- Changing land uses from agricultural and forestry to urban and other less permeable uses increases the frequency of runoff, and hence, changes both the hydrology and nutrient concentration of the river.

Keywords: precipitation, runoff

Locations: Tualatin River

Uhrich, M. A., and Wentz, D. A., 1999, Environmental setting of the Willamette basin, Oregon: U.S. Geological Survey, Water-Resources Investigations Report 97-4082-A, 20 p.

The Willamette River basin is one of more than 50 large river basins and aquifer systems (referred to as study units) across the United States where the status and trends of water quality and the factors controlling water quality are being studied by the National Water-Quality Assessment Program of the U.S. Geological Survey. The 12,000-square-mile Willamette River basin study unit consists of the

Willamette and Sandy River basins, which are tributaries to the Columbia River. The Willamette River is the 13th largest in the conterminous United States in terms of discharge and is the largest of all major United States rivers in terms of discharge per square mile of drainage area. The environmental setting of a study unit includes all natural and human-related, land-based factors that have the potential to influence the physical, chemical, and biological quality of its surface water and groundwater resources. For the Willamette River basin, these include primarily ecoregions, hydrogeology, climate, hydrology, land use/land cover, and crop types.

Keywords: history, population growth, environmental setting, ecoregions, hydrogeology, climate, hydrology, land use, agriculture

Applicable Locations: Tualatin River, Fanno Creek, Beaverton Creek

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Ulrich, E.M., Foreman, W.T., Van Metre, P.C., Wilson, J.T., and Rounds, S.A., 2009, Enantiomer fractions of chlordane components in sediment from U.S. Geological Survey sites in lakes and rivers: Sci. Tot. Environ., v. 407, no. 22, 5884-5893, doi: 10.1016/j.scitotenv.2009.08.023

Spatial, temporal, and sediment-type trends in enantiomer signatures were evaluated for cis- and trans-chlordane (CC, TC) in archived core, suspended, and surficial-sediment samples from six lake, reservoir, and river sites across the United States. Findings from this study indicate:

- The enantiomer fractions (EFs) measured in these samples are in good agreement with those reported for sediment, soil, and air samples in previous studies.
- The chlordane EFs were generally close to the racemic value of 0.5, with CC values ranging from 0.493 to 0.527 (usually >0.5) and TC values from 0.463 to 0.53 (usually <0.5).
- EF changes with core depth were detected for TC and CC in some cores, with the most non-racemic values near the top of the core.
- Surficial and suspended sediments generally have EF values similar to the top core layers but are often more non-racemic, indicating that enantioselective degradation is occurring before soils are eroded and deposited into bottom sediments.
- Rapid losses (desorption or degradation) from suspended sediments of the more bioavailable chlordane fraction during transport and initial deposition cause the apparent shift to more racemic EF values in surficial and top core sediments.
- Near racemic CC and TC in the core profiles suggest minimal alteration of chlordane from biotic degradation, unless it is via non-enantioselective processes.
- EF values for the heptachlor degradate, heptachlor epoxide (HEPX), determined in surficial sediments from one location only were always non-racemic (EF ≈ 0.66), were indicative of substantial biotic processing, and followed reported EF trends.

Keywords: core, suspended, surficial, organochlorine pesticide, chiral separation

Locations: Beaverton Creek, Fanno Creek

Unified Sewerage Agency, 1992, Flow augmentation in the Tualatin River for water quality enhancement – A status report: Planning Division, Unified Sewerage Agency, Hillsboro, Oregon, 27 p.

There is a continued need to achieve water quality enhancement of the Tualatin River. Many local, state, and federal agencies, including the Unified Sewerage Agency (USA), effect the water quality through their mandated decisions and activities. USA's mission statement and strategies are focused on the management of storm, sanitary, and surface water systems to protect the water quality for the users in the Tualatin River. This report reviews the current activities of USA to achieve water quality in the river with a focus on current and potential future flow augmentation decisions and activities. The report puts forth definitions and assumptions used by USA to base its water management decisions. Results include:

- The strategy is achieving improved water quality in the river. The wastewater treatment activities, recycling of the solids and liquids from the treatment process, releases of water from Hagg Lake, reductions in the amounts of unwanted rainwater in the sewage collection system, and implementation of certain elements of the surface water management program are working and should continue.
- Flow augmentation costs to achieve the required chlorophyll a response are approximately 6% of the cost of nonpoint source phosphorus control.
- Modeling of flow augmentation scenarios revealed that water from Hagg Lake should be released more in the fall, that USA should obtain additional water from Hagg Lake, and that it would be beneficial to expand Barney Reservoir to obtain even more waterl.
- Modeling also showed potential benefits of removing the Lake Oswego diversion dam. However, removal of the dam would have serious other side effects that must be evaluated against the benefits.
- USA has no further need to pursue the development of an additional dam and reservoir on the Tualatin River for water-quality compliance. Existing activities and plans will achieve the desired water quality effects without building a new dam.
- It is recommended that USA should continue the existing elements in the Wastewater Facilities and Surface Water Management Plans.
- Achieve additional beneficial effects from flow augmentation through:
    - Additional water from Hagg Lake and discharge those flows in the late summer
    - Expand Barney reservoir and use water designated for pollution abatement in the late summer
    - Obtain additional water rights out of the Barney Reservoir expansion project.
- The Tualatin River water-quality conditions are improving. Data suggest USA's pollution control efforts are achieving the desired benefits. However, further flow augmentation of the river's flows must also be implemented to insure continued improving trends.

Keywords: streamflow, chlorophyll a, phosphorus, nutrients, dam

Locations: Tualatin River, Henry Hagg Lake

[Unknown Author], 2005, Clean Water Services DNA fingerprinting of bacteria sources in the Tualatin sub-basin: [Unknown Publisher], 33 p.

This study had two goals: 1) determine sources of bacteria in the stormwater and receiving streams; 2) determine if bacteria from human waste was present in stormwater outfall at the Durham wastewater treatment plant. Findings from this study include:

- Most of the bacteria identified in stormwater and receiving streams are from avian sources, with rodents and canines being the second and third largest sources.
- Human sources are not a dominant source of bacteria in stormwater and receiving streams; therefore, their reduction alone will not result in streams meeting their bacteria criterion.
- Activities that humans participate in (e.g., waterfowl feeding and dog waste management) do have an impact on the bacteria levels in both stormwater and the receiving streams.
- There is too much variability in the bacteria values and the percentages of sources to accurately predict what combination of actions will achieve the wasteload allocations.
- The results from Durham wastewater treatment plant are very different from the general sites. There is a much higher percentage of bacteria from human sources and fewer types of isolates. There were only about half as many rodents and no canine isolates at this site. Now that isolates from human sources have been identified at this site, options for reducing or eliminating this source are being evaluated by the treatment plant staff.

Keywords: bacteria, wastewater treatment

Locations: Tualatin River, Fanno Creek, Ash Creek, Summer Creek, Dawson Creek, Rock Creek

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[Unknown Author], 2011, Tualatin basin water supply project – Intake and pump station preliminary design: Tualatin Basin Water Supply Project, 11 p.

This report consists of aerial photographs and engineering diagrams of pump station design.

Keywords: pump station

Locations: Tualatin River

[Unknown Author], [unknown date], Basin characteristics and their correlation with the Richards-Baker flashiness index in tributaries of the Tualatin River: [Unknown Publisher], 33 p.

The goal of the initial analysis was to determine which of the streamflow statistics (Annual 7-day Low Flow [Qmin], Fraction of year annual mean discharge was exceeded [TQmean], and Richards-Baker Flashiness Index [R-B Index]) are most associated with basin characteristics that are known to be related to urbanization (e.g., percent impervious area). This was accomplished by calculating the three streamflow statistics using flow data from nine monitoring sites on tributaries of the Tualatin River and correlating the average values of these measures with basin characteristics for these sites. The Richards-Baker Flashiness Index was selected as the statistic that is most associated with basin characteristics; it was then correlated with basin characteristics for the original nine sites and an additional 14 tributary flow monitoring sites. Findings from this study include:

- Results of the preliminary analysis indicate that the R-B Index is correlated with 14 of the basin characteristics, compared with eight basin characteristics for Qmin and two basin characteristics for TQmean.
- The R-B Index was the only flow statistic to be significantly correlated with the basin characteristics that are associated with measures of hydrological alteration (impervious area/urban land cover).

- The two basin characteristics that were found to be most highly correlated with the R-B index were the NOAA percent impervious area and percent urban land cover (r = 0.843 and r = 0.829, respectively).
- Another basin characteristic related to land use (NLDC percent impervious area) was also highly correlated with the R-B Index, but the calculated correlation coefficient (r = 0.715) was lower than the correlations with NOAA percent impervious area and percent urban land cover.
- The correlation of R-B Index with percent forest cover, also related to land use, was also significant (r = -0.437, p = 0.037).

Keywords: Richards-Baker Flashiness Index (R-B Index), basin characteristics, streamflow, land use, impervious

Locations: Gales Creek, Dairy Creek, Rock Creek, Cedar Mill Creek, Bronson Creek, Chicken Creek, Fanno Creek, Sain Creek, Waible Creek, McKay Creek, Beaverton Creek, Willow Creek, Johnson Creek, Sylvan Creek, Hedges Creek, Summer Creek, Ash Creek, Dawson Creek

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U.S. Fish and Wildlife Service, 2010, Tualatin River basin water supply project feasibility study at Scoggins Dam, Washington County, Oregon: U.S. Department of Interior Fish and Wildlife Service, Oregon Fish and Wildlife Office, Portland, Oregon, 124 p.

The Fish and Wildlife Service (Service) has prepared this report pursuant to the Fish and Wildlife Coordination Act. It covers fish and wildlife resources in the Henry Hagg Lake area and projected changes to those resources in the future (raise Scoggins Dam height) both with and without the various project alternatives. Most of the information included in this report was taken from the Draft Planning Report/Environmental Impact Statement (PR/EIS), which expanded on the information gathered from the Water Supply Feasibility Study (WSFS). The purpose of the Draft PR/EIS is to comply with the National Environmental Policy Act (NEPA) by evaluating a range of alternatives, including a no action alternative, and assessing the potential environmental impacts to those alternatives. Findings from this study indicate:

- Alterations in the aquatic character of the expanded pool will affect the hydrology and water quality of Scoggins Creek and the entire Tualatin River downstream of the dam. There are several concerns that are addressed in this report including potentially adverse hydrological impacts to two known National Wildlife Refuge units in the Tualatin Basin, especially with regard to their role in providing habitat for migratory birds and other potentially impacted species. The Raw Water Pipeline and Willamette Pipeline are linear corridors that also expand the project area through local rural and developing urban areas.
- It was determined that the two action alternatives would result in severe impacts to fish and wildlife resources. The proposed no action alternative would have the least impact on fish and wildlife; however, it would not meet future water demands. While the action alternatives would have the most impacts on fish and wildlife resources, several actions, including the application of best management practices during project construction to minimize development impacts, and appropriate mitigation actions taken to either avoid or minimize impacts. Both the action alternatives would have permanent impacts to occupied habitats due to the increase in normal full pool elevation of the reservoir. Impacts caused by the RWP and the Willamette Pipeline would be largely temporary. RWP impacts for both action alternatives would be nearly equal, and mitigation would be provided at both on-site and off-site locations.

Keywords: pump station

Locations: Tualatin River

Vedanayagam, Samuel, and Nelson, P.O., 1995, Mass balance analysis of suspended solids in the Tualatin River: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 13, 61 p.

The purpose of this study was to develop a mass-balance model for total suspended solids in the Tualatin River to better understand turbidity in the river. Major sources and sinks of suspended solids in the river were identified, and seasonal effects were explored. The study also examined relationships between suspended solids and transparency, turbidity, and chlorophyll a in an attempt to better understand processes occurring in the river and its watershed. To perform the mass balance, the river was divided into 12 sections based on the monitoring stations of the Unified Sewerage Agency (USA). Tributaries were treated as point sources flowing into one of these sections. The water quality and flow data of USA formed the basis of the mass balance, with additional flow data provided by the Oregon Water Resources Department, Tualatin Valley Irrigation District, and U.S. Geological Survey, and additional water quality data from Oregon Department of Environmental Quality. Findings from this study include:

- Tributaries were found to be the major contributors of suspended.
- The largest contributors were Dairy Creek, Fanno Creek, Gales Creek, Rock Creek, and Scoggins Creek. In 1992, they contributed 90% of the average suspended solids mass loading during the non-summer period and 79% during the summer season. Gales Creek is the major contributor to suspended solids mass loading during the non-summer season. Scoggins Creek, which receives the discharge of Henry Hagg Lake, is the major contributor of suspended solids to the river in the summer period (more than 50% of the combined loading of the five major tributary creeks). The tributaries also accounted for 63% of the flow (including withdrawals) in the river during the summer of 1992 and for 84% during the 1992 non-summer season.
- The seasonal variation of the suspended solids loading in the river differed by as much as a factor of ten, the loading being lower in summer when suspended solids concentrations averaged about 50% of non-summer values . Water clarity was found to be higher in summer, during which time chlorophyll a concentrations were also higher. Suspended solids concentration was inversely correlated with transparency (water clarity) and directly correlated with turbidity but found to be unrelated to chlorophyll a concentration, indicating the algae were not a primary constituent of the total solids.
- Increased chlorophyll a concentrations were not found to relate to any one particular factor but were found to be related as a combination of air temperature, and total phosphorus concentrations. This indicates that the cause of algal blooms are due to a combination of factors, especially nutrient levels, water temperature, and the residence time of water in pool areas.

Keywords: turbidity, suspended solids, chlorophyll a, mass balance

Locations: Tualatin River, Scoggins Creek, Gales Creek, Dairy Creek, Fanno Creek, Rock Creek, Henry Hagg Lake

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Waite, I. R., and Carpenter, K. D., 2000, Associations among fish assemblage structure and environmental variables in Willamette basin streams, Oregon: Transactions of the American Fisheries Society, v. 129, no. 3, p. 754-770.

As part of the U.S. Geological Survey's National Water-Quality Assessment Program, fish were collected from 24 selected stream sites in the Willamette River basin between 1993 and 1995 to determine the composition of the fish assemblages and their relation to the chemical and physical environment. Variance in fish relative abundance was greater among all sites than among spatially distinct reaches within a site (spatial variation) or among multiple sampled years at a site (temporal variation). Therefore, data from a single reach in an individual year was considered to be a reliable estimator of the fish assemblage structure at a site when the data were normalized by percent relative abundance. Multivariate classification and ordination were used to examine patterns in environmental variables and fish relative abundance over differing spatial scales (among versus within ecoregions). Across all ecoregions (all sites), fish assemblages were primarily structured along environmental gradients of water temperature and stream gradient (coldwater, high-gradient forested sites versus warmwater, low-gradient Willamette Valley sites); this pattern superseded patterns that were ecoregion specific. Water temperature, dissolved oxygen, and physical habitat (e.g., riparian canopy and percent riffles) were associated with patterns of fish assemblages across all ecoregions; however, pesticide and total phosphorus concentrations were more important than physical habitat within the Willamette Valley ecoregion. Consideration of stream site stratification (e.g., stream size, ecoregion, and stream gradient), identification of fish to species level (particularly the sculpin family), and detailed measurement of habitat, diurnal dissolved oxygen, and water temperature were critical in evaluating the composition of fish assemblages in relation to land use. In general, these low-gradient valley streams typical of other agricultural regions had poor riparian systems and showed increases in water temperature, nutrients, and fine grain sediments that were associated with degradation in the native fish assemblages. There was an association of high abundances of introduced species and high percent external abnormalities in medium-sized river sites of mixed land use and high abundances of tolerant species in small streams of predominantly agricultural land use.

Keywords: fish, riparian, water quality

Applicable Locations: Tualatin River

Waite, I.R., Sobieszczyk, Steven, Carpenter, K.D., Arnsberg, A.J., Johnson, H.M., Hughes, C.A., Sarantou, M.J., and Rinella, F.A., 2008, Effects of urbanization on stream ecosystems in the Willamette River basin and surrounding area, Oregon and Washington: U.S. Geological Survey Scientific Investigations Report 2006-5101-D, 62 p.

This report describes the effects of urbanization on physical, chemical, and biological characteristics of stream ecosystems in 28 watersheds along a gradient of urbanization in the Willamette River basin and surrounding area, Oregon and Washington, from 2003 through 2005. The study that generated the report is one of several urban-effects studies completed nationally by the U.S. Geological Survey National Water-Quality Assessment Program. Watersheds were selected to minimize natural variability caused by factors such as geology, elevation, and climate, and to maximize coverage of different stages of urban development. Because land use or population density, alone, often are not a complete measure of urbanization, a combination of land use, land cover, infrastructure, and socioeconomic

variables were integrated into a multimetric urban intensity index (UII) to represent the degree of urban development in each watershed. Physical characteristics studied include stream hydrology, stream temperature, and habitat; chemical characteristics studied include sulfate, chloride, nutrients, pesticides, dissolved and particulate organic and inorganic carbon, and suspended sediment; and biological characteristics studied include algal, macroinvertebrate, and fish assemblages. Semipermeable membrane devices, passive samplers that concentrate trace levels of hydrophobic organic contaminants such as polycyclic aromatic hydrocarbons and polychlorinated biphenyls, also were used. The objectives of the study were to 1) examine physical, chemical, and biological responses along the gradient of urbanization and 2) determine the major physical, chemical, and landscape variables affecting the structure of aquatic communities. Findings from this study indicate:

- Common effects documented in the literature of urbanization on instream physical, chemical, and biological characteristics, such as increased contaminants, increased streamflow flashiness, increased concentrations of chemicals, and changes in aquatic community structure toward a more tolerant community associated with organically enriched conditions, generally were observed in this study.
- The strongest correlations to the UII and to many of the algal, macroinvertebrate, and fish assemblage metrics and community ordination involved water-chemistry metrics including the total pesticide concentration, toxic equivalents (extract assay from semipermeable membrane devices), and dissolved oxygen.
- Hydrologic variability metrics, such as flashiness, that normally are considered to be one of the main processes of urban disturbance had a strong association to the algal and fish assemblages in this study; however, the hydrologic variables for macroinvertebrates were secondary to the water-chemistry metrics mentioned above.
- Generally, the high urban intensity sites had high abundances of eutrophic and lower dissolved oxygen-indicating diatoms, high abundances of noninsects and tolerant insects, and high abundances of nonnative fish species. On the other hand, the low urban intensity sites had higher abundances of pollution sensitive diatoms, larger numbers of the sensitive macroinvertebrate EPT taxa (Ephemeroptera, Plecoptera and Trichoptera Orders), and fish assemblages with higher abundances of sensitive salmonids.
- The percent salmonid and macroinvertebrate EPT richness metrics plotted against the UII indicated a possible threshold response at about 25 on the UII, which is equivalent to an impervious surface value of about 5 percent. However, due to the added agricultural land use at sites within the 25 to 60 UII range, this possible threshold probably is not solely due to urbanization, but a combination of urban and agricultural land use.
- The effects of agricultural and urban land use could not be distinguished from each other, yet combined they provide a good assessment of overall watershed disturbance.

Keywords: water chemistry, land use, ecology, fish, macroinvertebrates, algae, nutrients, urbanization, impervious surfaces, hydrology

Applicable Locations: Beaverton Creek, Rock Creek, Fanno Creek, EF Dairy Creek, Chicken Creek

Wells, S.A., Berger, C.J., and Knutson, M.T., 1992, Modeling the Tualatin River system, including Scoggins Creek and Hagg Lake – Model description, geometry, and forcing data: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 3, 90 p.

The modeling project included the following elements: 1) obtaining data for setting up an instream water quality model of the Tualatin River, 2) setting up the model for the Tualatin River with a link to HSPF for the tributary flows and pollutant loadings, and 3) evaluating alternative management strategies for improving water quality in the Tualatin River system. The alternatives analysis will be the responsibility of Oregon State University (OSU) with assistance from the Portland State University (PSU) modeling team. A list of project alternatives to be modeled will be assembled and screened by the OSU team. The next step in this modeling project will be the calibration of the model to field data taken during the summer of 1990, and validated from field data taken during the summer of 1991 and 1992. If data from wet periods are available, the model will be validated during those time periods, as well. After calibration and validation, alternatives analyses will be completed. Model may be used later by the USGS by incorporating additional field data into the calibration/validation process.

Keywords: model, CE-QUAL-W2, HSPF, meteorological data

Locations: Tualatin River, Scoggins Creek, Henry Hagg Lake

Wentz, D. A., Bonn, B. A., Carpenter, K. D., Hinkle, S. R., Janet, M. L., Rinella, F. A., Uhrich, M. A., Waite, I. R., Laenen, Antonius, and Bencala, K. E., 1998, Water quality in the Willamette basin, Oregon, 1991-95: U.S. Geological Survey Circular 1161, 34 p.

SUMMARY OF MAJOR ISSUES AND FINDINGS IN THE WILLAMETTE BASIN.

- Pollution sensitive native fish, such as cutthroat trout and torrent sculpin, were found predominantly in forested streams with large riffle areas, high quality riparian habitat, and low water temperatures. No external anomalies were found on fish from these streams.
- Pollution tolerant introduced fish, such as carp and bullheads, were collected primarily from streams with few riffles, poor quality riparian habitat, and high water temperatures. External anomalies were most abundant on fish from these streams.
- Relative abundances of fish generally were not highly correlated with water chemistry; however, pollution tolerant native fish, including minnows and reticulate sculpin, were found mostly in agricultural and urban streams with the highest nutrient and pesticide concentrations. External anomalies were moderately high on fish from these streams.
- Suspended sediment transport has remained unchanged downstream from 10 dams since their construction, but average particle size of the transported sediment has decreased. These facts indicate that erosion has increased downstream from the dams to compensate for the sediment trapped by the reservoirs.
- Erosion of stream channels and/or recently developed land could account for much of the sediment presently transported downstream from the dams.
- Dye injection studies and streamflow measurements demonstrate the widespread occurrence of significant ground water/surface water interactions in large, gravel-bed rivers.

- Interchange of water between streams and adjacent aquifers can result in changes to associated nutrient and pesticide concentrations.
- In 45 percent of streams sampled, total phosphorus concentrations exceeded 0.1 mg/L (milligram per liter), which is the maximum value cited by the U.S. Environmental Protection Agency (USEPA) as a goal for prevention of nuisance plant growth.
- Sixty-eight percent of streams where total phosphorus concentrations exceeded 0.1 mg/L drained predominantly agricultural land.
- Guidelines do not exist for evaluating the effects of nitrate concentrations on algal growth, but nitrate concentrations in only 2 of 51 of streams exceeded the 10 mg/L maximum contaminant level (MCL) established by the USEPA for drinking water. Neither stream was used as a source for drinking water.
- In streams of the Pudding Basin, nitrate and soluble reactive phosphorus concentrations during spring runoff increased as the percent of drainage area in agriculture increased.
- Nitrate concentrations in ground water exceeded the USEPA MCL in 6 of 70 shallow domestic wells drawing water from the alluvial aquifer of the Willamette Valley.
- Nitrate concentrations were higher downgradient from irrigated agricultural areas than from nonirrigated agricultural areas.
- Nitrate concentrations in ground water are likely to increase in the future because water sampled as part of the present study entered the ground water system when nitrogen fertilizer application rates were lower than in subsequent years.
- Fifty pesticides were detected in streams, and 10 pesticides exceeded criteria established by the USEPA for the protection of freshwater aquatic life from chronic toxicity.
- Atrazine exceeded the drinking water MCL of 3 mg/L (micrograms per liter) in one sample, and simazine exceeded the MCL of 4 mg/L in a different sample from the same stream; however, the stream was not used as a source of drinking water.
- Atrazine, simazine, metolachlor, deethylatrazine, diuron, and diazinon were detected in more than one-half of stream samples. Their concentrations varied seasonally in response to runoff and application rates.
- Forty-nine pesticides were detected in streams draining predominantly agricultural land, whereas 25 pesticides were detected in streams draining mostly urban areas. The highest pesticide concentrations generally occurred in streams draining predominantly agricultural land.
- In streams of the Pudding Basin, concentrations of atrazine, simazine, and metolachlor during spring runoff increased as the percent of drainage area in agriculture increased.
- Dinoseb (an herbicide) exceeded the MCL of 7 mg/L in ground water from one shallow domestic well, and tetrachloroethene (a VOC) exceeded the MCL of 5 mg/L in a second well. These were the only organic compounds detected at concentrations greater than USEPA drinking water MCLs in domestic wells.
- Pesticides were detected in water from about one-third of the shallow alluvial wells sampled, but concentrations typically were low. A greater variety of pesticides was found at higher concentrations in agricultural areas than in urban areas.

- VOCs were detected in water from about 20 percent of the shallow alluvial wells sampled. VOCs were found more frequently in urban areas than in agricultural areas.
- Concentrations of total dioxins and furans in bed sediment from streams and lakes exceeded the USEPA guideline for risks to fish at 2 of 22 sites; both sites were downstream from industrial areas. Concentrations in fish tissue did not exceed the threshold for risks to predator fish at any of the 8 sites where fish were collected.
- Dioxin and furan concentrations in bed sediment from forested and agricultural basins are similar to those found in other areas of the United States where atmospheric deposition is the presumed source.
- Concentrations in bed sediment exceeded USEPA guidelines for protection of aquatic life at 10 of 47 sites. Chlordane and its component compounds, and DDT and its degradation products accounted for most guideline exceedances.
- Concentrations in fish at 17 sites did not exceed National Academy of Sciences and National Academy of Engineering criteria for protection of fish-eating wildlife.
- The most commonly detected organochlorine compound both in bed sediment and aquatic biota was p,p'-DDE, a degradation product of DDT.
- Chromium and nickel, which are relatively abundant in Willamette Basin rocks, commonly exceeded guidelines.
- The highest concentrations of cadmium, lead, silver, and zinc in bed sediment were in urban streams.
- The highest mercury concentrations in bed sediment were downstream from an abandoned mercury mine. High mercury concentrations in fish have prompted the Oregon Health Division to issue advisories warning of health risks from consumption of fish taken from some streams and reservoirs.

Keywords: fish, groundwater, surface water, nutrients, water quality, pesticides, volatile organic compounds (VOC), dioxins, trace elements

Applicable Locations: Willamette River valley, Tualatin River

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Wentz, D. A., Waite, I. R., and Rinella, F. A., 1998, Comparison of streambed sediment and aquatic biota as media for characterizing trace elements and organochlorine compounds in the Willamette basin, Oregon: Environmental Monitoring and Assessment, v. 51, no. 3, p. 673-693

Between 1992 and 1993, 27 organochlorine compounds (pesticides plus total PCB) and 17 trace elements were analyzed in bed sediment and aquatic biota from 20 stream sites in the Willamette River basin as part of the U.S. Geological Survey's National Water-Quality Assessment Program. Data from each medium were compared to evaluate their relative effectiveness for assessing occurrence of these constituents. Findings included:

- Except for Cd, Hg, Se, and Ag, trace element concentrations generally were higher in bed sediment than in biota. Conversely, although frequencies of detection for organochlorine compounds in biota were only slightly greater than in bed sediment, actual concentrations in

biota (normalized to lipid) were as much as 19 times those in sediment (normalized to organic carbon).

- Sculpin (Cottus spp.) and Asiatic clams (Corbicula fluminea), found at 14 and seve sites, respectively, were the most widespread taxa collected during the study.
- Concentrations of trace elements, particularly As and Cu, were typically greater in Asiatic clams than in sculpin. In contrast, almost half of the organochlorine compounds analyzed were found in sculpin, but only DDT and its degradation products were detected in Asiatic clams; this may be related to the lipid content of sculpin, which was about three times higher than for clams.
- The medium of choice for assessing occurrence depends largely on the constituent(s) of interest.

Keywords: aquatic biota, NAWQA, organochlorine compound, streambed sediment, trace element

Applicable Locations: Tualatin River

Wilson, D.C., 2003, Hydrogeology and water resource potential of neogene sediments in the Tualatin basin and comparison with the neighboring Portland basin, Northwest Oregon: Environmental and Engineering Geoscience, v. 9, no. 4, p. 327-338

Hydrogeologic properties of the Neogene Hillsboro Formation and Willamette Silt in the Tualatin basin are evaluated to provide a foundation for future groundwater use in the Portland, Oregon, metropolitan area, and are then compared to hydrogeological conditions in the neighboring Portland basin. Catastrophic flood deposits of the Willamette Silt in the Tualatin Valley have low hydraulic conductivities and well yields below 7 gpm (26.5 lpm). Fluvial sand aquifers within the Hillsboro Formation compose only 20 percent of the 1,400-ft (450-m) thick unit and most contain a significant quantity of silt and clay, with hydraulic conductivities on the order of 2–30 ft/day (0.6–6 m/day). Water quality is good, yet low well yields (6–100 gpm; 23–380 lpm), a low hydraulic gradient within the basin, and geochemical data point to residence times of tens to hundreds of years and slow recharge to the system. A numerical simulation verifies slow groundwater velocities and the presence of local and regional flow regimes. Aquifers of the Hillsboro Formation are limited to domestic use, and model simulations of hypothetical well fields show that these aquifers would not support large-scale withdrawals. High-yield aquifers of the coarse-grained Troutdale Formation in the Portland basin contrast sharply with those of the Hillsboro Formation and Willamette Silt in that they can be separated into multiple hydrogeologic units, have high hydraulic conductivities, and can be used for municipal purposes. Such drastic differences in hydrogeologic characteristics within a metropolitan area require different strategies involving groundwater use or remediation.

Keywords: groundwater, sediment, chemistry, model, geology

Locations: Tualatin River

Wilson, D.C., Burns, S.F., Jarrell, Wesley, Lester, Alan, and Larson, Edwin, 1999, Natural ground-water discharge of orthphosphate in the Tualatin basin, Northwest Oregon: Environmental and Engineering Geoscience, v. 5, no. 2, p. 189-197

Orthophosphate concentrations in the Tualatin River of northwest Oregon have historically been high enough for the formation of seasonal algal blooms in the lower slow moving stretches of the river. Past

work to decrease phosphate levels concentrated on limiting agricultural runoff and reducing effluent from water treatment plants, yet phosphate levels have remained high. Close examination of the Willamette Silt and underlying Hillsboro Formation in the Tualatin Valley has revealed that phosphate is leaching from the substrata into the overlying drainage system through ground-water discharge. Hillsboro Formation samples from sub-surface borings as deep as 330 m contain up to 3.17 mg/1 orthophosphate as measured by saturated pastes. Three distinct zones of phosphate concentrations are recognized in the HBD-1 core drilled at the Hillsboro airport; the top 65 m average 0.3 mg/1 orthophosphate, the next 60 m average 1.22 mg/1, and the bottom 138 m average 0.1 mg/1. Reductions in orthophosphate concentrations below a depth of 150 m correspond with the presence of small vivianite nodules and crystals, and increased abundances of magnetite, both which persist to the base of the Hillsboro Formation. Changing redox conditions with depth along with phosphate complex adsorption onto iron oxides in the shallow zone best explain the observed relationships between phosphate, vivianite, and magnetite concentrations in the sediments. Observations in other borings from the central and western Tualatin Basin support the above hypothesis. Naturally large phosphate concentrations leaching from the Hillsboro Formation and into the Tualatin River drainage system will always keep the river at risk of accelerated seasonal algal growth.

Keywords: groundwater, orthophosphate, algae, geology, phosphorus

Locations: Tualatin River

Wolf, D.W., 1992, Land use and nonpoint phosphorus pollution in the Tualatin basin, Oregon – A literature review: Oregon Water Resources Research Institute, Tualatin River Basin Water Resources Management Report Number 1, Special Paper 898, 63 p.

Human activities may contribute to the eutrophication of surface waters by providing nutrients to aquatic ecosystems. Phosphorus is frequently identified as a nutrient that is limiting in most aquatic ecosystems under natural conditions. Sources of phosphorus contributing to eutrophic conditions often include nonpoint sources that are dispersed across the landscape. In the Tualatin River basin, nonpoint sources have been identified as contributing to phosphorus levels in the Tualatin River that exceed legislated limits. This paper provides a review of relevant literature to explore possible connections between land use and the sources and transport of nonpoint source phosphorus in the Tualatin River basin. Additionally, where these connections exist, methods to alter existing land use practices to reduce phosphorus contributions are identified.

Keywords: land use, pollution, phosphorus

Locations: Tualatin River

Wolf, D.W., 1993, Land use and nonpoint source phosphorus pollution in the Dairy-McKay hydrologic unit area of the Tualatin River Basin, Oregon: M.S. Thesis, Oregon State University, Corvallis, Oregon, 166 p.

Human-related activities can contribute to the eutrophication of surface waters by providing nutrients to aquatic ecosystems. Phosphorus is frequently identified as a nutrient that is limiting to most aquatic ecosystems under natural conditions. Sources of phosphorus often include nonpoint sources dispersed across the landscape. Nonpoint sources have been identified as contributing to phosphorus levels in the

Tualatin River that exceed limits established by water quality regulations. This paper provides a review of literature that explores connections between land use and the sources and transport of nonpoint source phosphorus into the Tualatin River. As one of the most obvious and influential connections, phosphorus-laden sediment is examined both for its influence to the total phosphorus content of streams, and for evidence that it may become more influential as it is transported downstream. Data sets are also examined for seasonal effects and for interactions between phosphorus and other sampled water quality parameters. In addition, this report examines relevant social issues connected to nonpoint source phosphorus issues in the realization that any solution must be not only technically achievable, but also socially acceptable. Lastly, aspects of adaptive management are discussed, including addressing the problems of establishing regulatory control and resolving issues surrounding which segments of society are responsible for paying for control.

Keywords: phosphorus, land use, pollution

Locations: Dairy Creek, McKay Creek

Wood, T.M. and Rounds, S.A., 1998, Using CE-QUAL-W2 to assess the effect of reduced phosphorus loads on chlorophyll-a and dissolved oxygen in the Tualatin River, Oregon, in Proceedings of the First Federal Interagency Hydrologic Modeling Conference, Las Vegas, Nevada, April 19-23, 1998: U.S. Geological Survey, p. 2-149 - 2-156

A modified version of CE-QUAL-W2 was used to simulate streamflow, water temperature, and water quality in the Tualatin River from 1991 to 1993. Findings from this study indicate:

- For the period May through August, phosphorus-reduction scenarios showed some ability to limit algal growth during large blooms. When these scenarios failed to simultaneously reduce the background oxygen demands (carbonaceous biochemical oxygen demand [CBOD] and sediment oxygen demand), however, DO concentrations between algal blooms still decreased to near-problem levels.
- Phosphorus reduction scenarios showed that if the total phosphorus TMDL was achieved in the tributaries and in the main stem at RM 38.4, the predicted effect on DO was unclear. If detrital phosphorus were removed preferentially, then DO conditions would improve, especially in October, because CBOD would be removed. If soluble orthophosphate were removed instead, then DO conditions actually would deteriorate due to reduced photosynthetic production of oxygen without a simultaneous loss of CBOD.
- During September and October, the most significant improvements in DO were obtained only through a large amount of flow augmentation, or through a lesser amount of flow augmentation combined with a reduction in the loads of CBOD from the boundaries.
- The model results indicate that the goals of limiting algal growth and reducing DO violations can be, at times, incompatible. (However, excursions to high pH values are also of concern, and reducing the number of pH violations is dependent on limiting algal growth.)

Keywords: chlorophyll a, dissolved oxygen, pH, total phosphorus, orthophosphate, model, CE-QUAL-W2

Locations: Tualatin River
