Palouse River Dissolved Oxygen and pH Total Maximum Daily Load Study

Water Quality Study Design (Quality Assurance Project Plan)

August 2007

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Study Codes

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2004 303(d) Listings Addressed in this Study

Listing ID	Waterbody	New Waterbody ID	Old Waterbody ID
Dissolved Oxygen			
11133	Palouse River	NX00WG	WA-34-1030
8150	Rebel Flat Creek	MT96QP	WA-34-4010
pH			
16922	Palouse River	NX00WG	WA-34-1030
6732	Palouse River	NX00WG	WA-34-1030
42553	Palouse River	NX00WG	WA-34-1030

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Cover photo: Palouse River downstream of the city of Palouse.

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Abstract

Section 303(d) of the federal Clean Water Act requires the state of Washington to prepare a list of all surface waters in the state for which beneficial uses of the water are impaired by pollutants. Waterbodies placed on the 303(d) list require the preparation of a Total Maximum Daily Load (TMDL) study to identify and quantify sources of the impairments and to recommend implementation strategies for reducing point and nonpoint source loads.

The Palouse River and Cow and Rebel Flat Creeks have been listed by the state of Washington for non-attainment of Washington State dissolved oxygen and pH criteria. Additional 303(d) listings exist within the Palouse River watershed for temperature, fecal coliform bacteria, and ammonia.

EPA requires states to set priorities for cleaning up 303(d) listed waters and to establish a TMDL for each. A TMDL entails an analysis of how much of a pollutant load a waterbody can assimilate without violating water quality standards. The Palouse River TMDL study will address the 303(d) listings within the watershed with three separate Quality Assurance Project Plans: one for bacteria, one for temperature, and one for dissolved oxygen and pH.

This Quality Assurance Project Plan describes the technical study that will monitor dissolved oxygen and pH in the Palouse River watershed, and will form the basis for a proposal to allocate contaminant wasteloads to sources. The study will be conducted by the Department of Ecology's Environmental Assessment Program.

What is a Total Maximum Daily Load (TMDL)?

Federal Clean Water Act Requirements

The Clean Water Act established a process to identify and clean up polluted waters. Under the Clean Water Act, each state is required to have water quality standards designed to protect, restore, and preserve water quality. Water quality standards are set to protect designated uses such as cold water biota and drinking water supply. The TMDL is a watershed plan designed to improve water quality.

Every two years, states are required to prepare a list of waterbodies – lakes, rivers, streams, or marine waters – that do not meet water quality standards. This list is called the 303(d) list. To develop the list, Ecology compiles its own water quality data along with data submitted by local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the 303(d) list.

Water Quality Assessment/Categories 1-5

The 303(d) list is part of the larger Water Quality Assessment. The Water Quality Assessment is a list that tells a more complete story about the condition of Washington's water. This list divides waterbodies into five categories:

- Category 1 – Meets standards for parameter(s) for which it has been tested.
- Category 2 – Waters of concern.
- Category 3 – Waters with no data available.
- Category 4 – Polluted waters that do not require a TMDL because:
  - 4a – Has a TMDL approved and it is being implemented
  - 4b – Has a pollution control plan in place that should solve the problem
  - 4c – Is impaired by a non-pollutant such as low water flow, dams, culverts
- Category 5 – Polluted waters that require a TMDL – on the 303(d) list.

TMDL Process Overview

The Clean Water Act requires that a TMDL be developed for each of the waterbodies on the 303(d) list. The TMDL identifies pollution problems in the watershed and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Then Ecology works with the local community to develop an overall approach to control the pollution, called the Implementation Strategy, and a monitoring plan to assess effectiveness of the water quality improvement activities. Once the TMDL has been approved by EPA, a *Water Quality Implementation Plan* must be developed within one year. This Plan identifies specific tasks, responsible parties, and timelines for achieving clean water.

Elements Required in a TMDL

The goal of a TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of water quality problems and of the pollutant sources that cause the problem (the technical study) and an implementation plan based on the recommendations of the technical study. The TMDL determines the amount of a given pollutant that can be discharged to the waterbody and still meet standards (the loading capacity) and allocates that load among the various sources.

If the pollutant comes from a discrete (point) source such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a wasteload allocation. If it comes from a set of diffuse (nonpoint) sources such as general urban, residential, or farm runoff, the cumulative share is called a load allocation.

The TMDL must consider seasonal variations and system potential water temperatures. The TMDL must also include a margin of safety that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A reserve capacity for future loads from growth pressures is sometimes included as well. The sum of the wasteload and load allocations, the margin of safety, and any reserve capacity must be equal to or less than the loading capacity.

Total Maximum Daily Load Analyses: Loading Capacity

Identification of the contaminant loading capacity for a waterbody is an important step in developing a TMDL. The U.S. Environmental Protection Agency (EPA) defines the loading capacity as "the greatest amount of loading that a waterbody can receive without violating water quality standards" (EPA, 2001). The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a waterbody into compliance with standards. The portion of the receiving water's loading capacity assigned to a particular source is a load or wasteload allocation. By definition, a TMDL is the sum of the allocations, which must not exceed the loading capacity.

TMDL = Loading Capacity = sum of all Wasteload Allocations + sum of all Load Allocations + Margin of Safety

Why is Ecology Conducting a TMDL study in This Watershed?

The Washington State Department of Ecology (Ecology) is conducting a TMDL study in the Palouse River watershed because there are three reaches on the Palouse River exceeding the water pH standard. Furthermore, there is one reach on each the Palouse River and Rebel Flat Creek with dissolved oxygen (DO) levels below the DO standard.

There is high interest in water quality issues in this basin, demonstrated by the level of cooperative sampling and water management currently occurring. Ecology hopes to build on previous efforts and work cooperatively with all contributing entities to generate a better understanding of stream DO and pH in this watershed.

As part of this TMDL, Ecology will conduct field work during the summer of 2007 to characterize DO and pH processes in the Palouse River basin. The study will also establish load and wasteload allocations for nutrients, as necessary, to reduce algal productivity in order to moderate pH and DO levels to meet Washington State water quality pH and DO standards.

Overview

The Palouse River and its tributaries flow through Water Resource Inventory Area (WRIA) 34 in southeastern Washington. The upper part of the watershed extends into western Idaho beyond Potlatch. The Idaho Department of Environmental Quality (IDEQ) developed a TMDL for the upper tributaries in the Idaho part of the Palouse River watershed, but not the mainstem Palouse River.

This TMDL effort includes the portion of the watershed within Washington State, from the Idaho state border to the Snake River confluence. The study focuses on the mainstem Palouse River, including the section of river locally known as the North Fork, and associated tributaries near their confluence with the mainstem (Figure 1). The South Fork Palouse River was the subject of data collection during 2006 and 2007 for a related TMDL study. The South Fork Palouse River meets the mainstem Palouse River immediately downstream of Colfax at river mile 89.6.

This TMDL primarily addresses the 2004 303(d) listings for DO and pH in the Palouse River watershed (Category 5 dissolved oxygen and pH waterbody segments in Washington's Water Quality Assessment). Table 1 summarizes Category 5 listed waterbodies within WRIA 34, not including the South Fork Palouse River subbasin which was addressed in Carroll and Mathieu (2006).

Additionally, there are DO and pH listings on Cow Creek and Pleasant Valley Creek, respectively. Implementation activities which should address DO and pH impairments in Cow Creek have been ongoing. An evaluation of these efforts is underway to determine if these listings can be reclassified to Category 4B (addressed by a water pollution control plan). Pleasant Valley Creek has a pH listing but is outside the scope of the study area and will not be assessed.

This Quality Assurance (QA) Project Plan describes the technical study that will develop DO and pH TMDLs for the Palouse River and Rebel Flat Creek. These TMDLs will set water quality targets to meet DO and pH water quality standards, identify key reaches for source reduction, and allocate pollutant loads to point and nonpoint sources. The study will be conducted by Ecology's Environmental Assessment Program in cooperation with Ecology's Water Quality Program at the Eastern Regional Office, Adams Conservation District, and other local governments. The Idaho Department of Environmental Quality has completed a TMDL for several North Fork Palouse River tributaries. In 2005, Ecology completed a TMDL for fecal coliform in 2005 on the North Fork Palouse River based on monitoring conducted by the Palouse Conservation District and Ecology (Snouwaert and Ahmed, 2005).

Other listed parameters in the Palouse River for temperature and fecal coliform bacteria are addressed in separate QA Project Plans (Mathieu and Carroll, 2007; Kardouni et al., 2007).

Table 1. Reaches of the Palouse River with Clean Water Act Section 303(d) listings (2004 list) due to not meeting DO or pH water quality standards. These will be addressed in the Palouse River TMDL study for DO and pH.

Waterbody	Parameter	Township	Range	Section	2004 Listing ID
Palouse River	Dissolved Oxygen	16N	46E	06	11133
Rebel Flat Creek		17N	40E	29	8150
Palouse River	pH	14N	37E	31	16922
		15N	37E	26	6732
		16N	43E	11	42553

Project Objectives

Objectives of the proposed study are as follows:

- Characterize processes governing DO and pH in Rebel Flat Creek and the Palouse River including the influence of tributaries, nonpoint sources, point sources, and groundwater.
- Develop a model to simulate biochemical oxygen demand (BOD) and productivity in the Palouse River. Using critical conditions in the model, determine the capacity to assimilate BOD and nutrients.
- Use the calibrated model to evaluate future water quality management decisions in the Palouse River basin.

Watershed Description

The Palouse River basin is located primarily in Whitman County, Washington, and its headwaters are in Latah County, Idaho (Figure 1). The Palouse River flows along the border of Whitman, Adams, and Franklin Counties near its confluence with the Snake River. The Snake River flows into the Columbia River that flows into the Pacific Ocean at the Washington/Oregon state border. Palouse Falls (198 foot cliff) occurs six river miles upstream of the Palouse River's mouth. The 54-mile section of the river upstream of the South Fork Palouse River confluence is locally referred to as the North Fork Palouse River. Palouse River headwaters start within the Hoodoo Mountains in the St. Joe National Forest in Idaho.

The Palouse River is approximately 144 miles long, 120 miles of which is within Washington State. Its watershed area within Washington is approximately 3281 square miles (2,099,832 acres). The North Fork Palouse River basin area is approximately 495 square miles (316,799 acres) and contributes around 83% of the mean annual flow of the Palouse River at Colfax (Ahmed, 2004). The South Fork Palouse River basin area is approximately 344 square miles (219,943 acres) and joins the Palouse River at Colfax (Bilhimer et al., 2006).

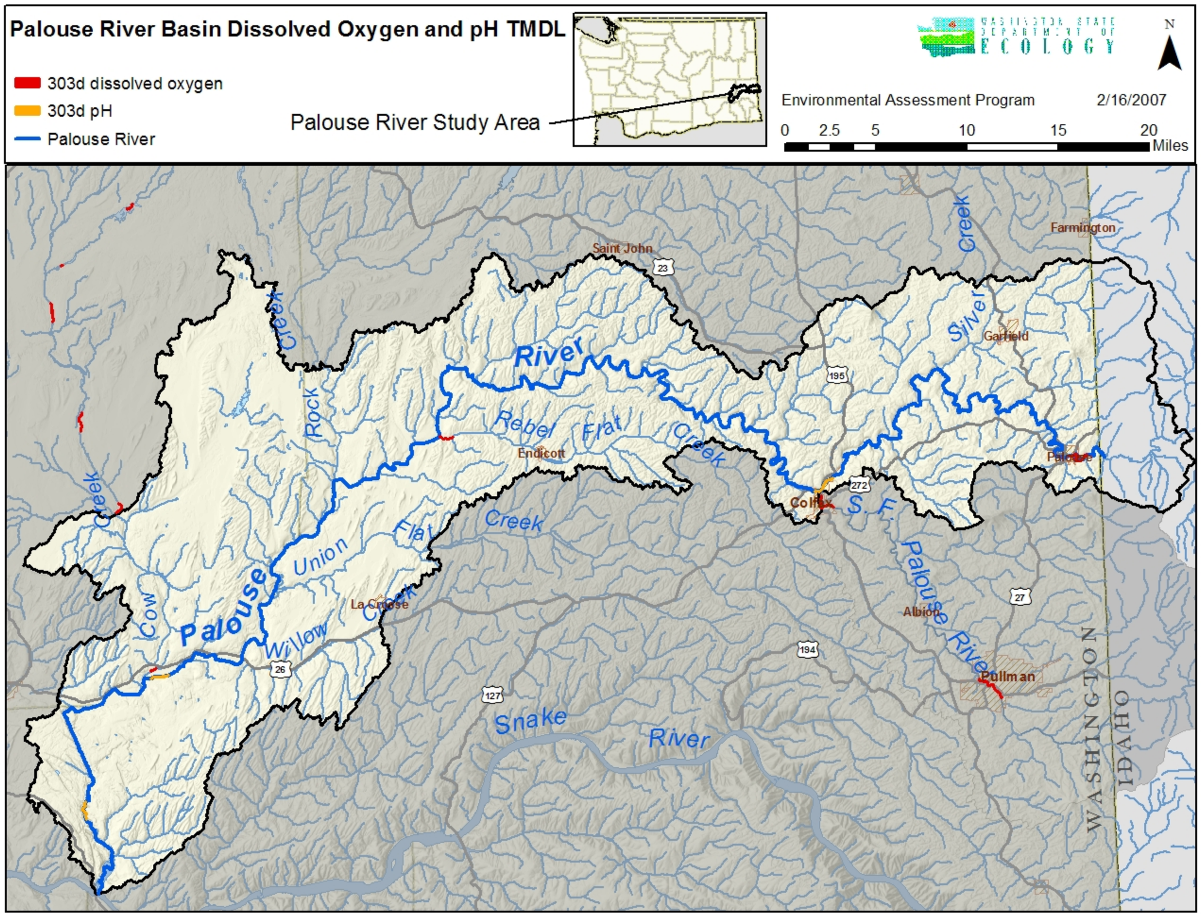

Figure 1. Study Area with 303(d) listed segments for dissolved oxygen and pH.

Hydrology

The Palouse River system includes over 398 miles of streams. Major tributaries and their relative percent contribution of drainage area are as follows:

- Cow Creek 22.4%
- Palouse River Mainstem 17.2%
- North Fork Palouse River 14.9%
- Rock Creek 12.1%
- Union Flat Creek 9.6%
- Pine Creek 10.8%
- South Fork Palouse River 8.9%
- Cottonwood Creek 4.2%

The United States Geological Survey (USGS) currently operates two streamflow gages on the Palouse River.

- USGS streamflow gage station #13351000 is located near Hooper, Washington, at river mile 19.6 downstream of the State Highway 26 bridge and 0.3 miles upstream of Cow Creek confluence. This gage station captures 2,500 square miles of the Palouse River watershed. It began recording in 1897, ceased during 1916, then started again in 1951 to present.
- USGS streamflow gage #13345000 is located near Potlatch, Idaho, at river mile 132.2 downstream of US Highway 95. This gage station near Potlatch captures 317 square miles of the Palouse watershed. It has recorded from 1914 to 1919, and 1966 to present.

Figures 2 and 3 depict the mean monthly flow of the Palouse River recorded at Hooper and Potlatch. Peak flows typically occur from January through March, and baseflows from August through September.

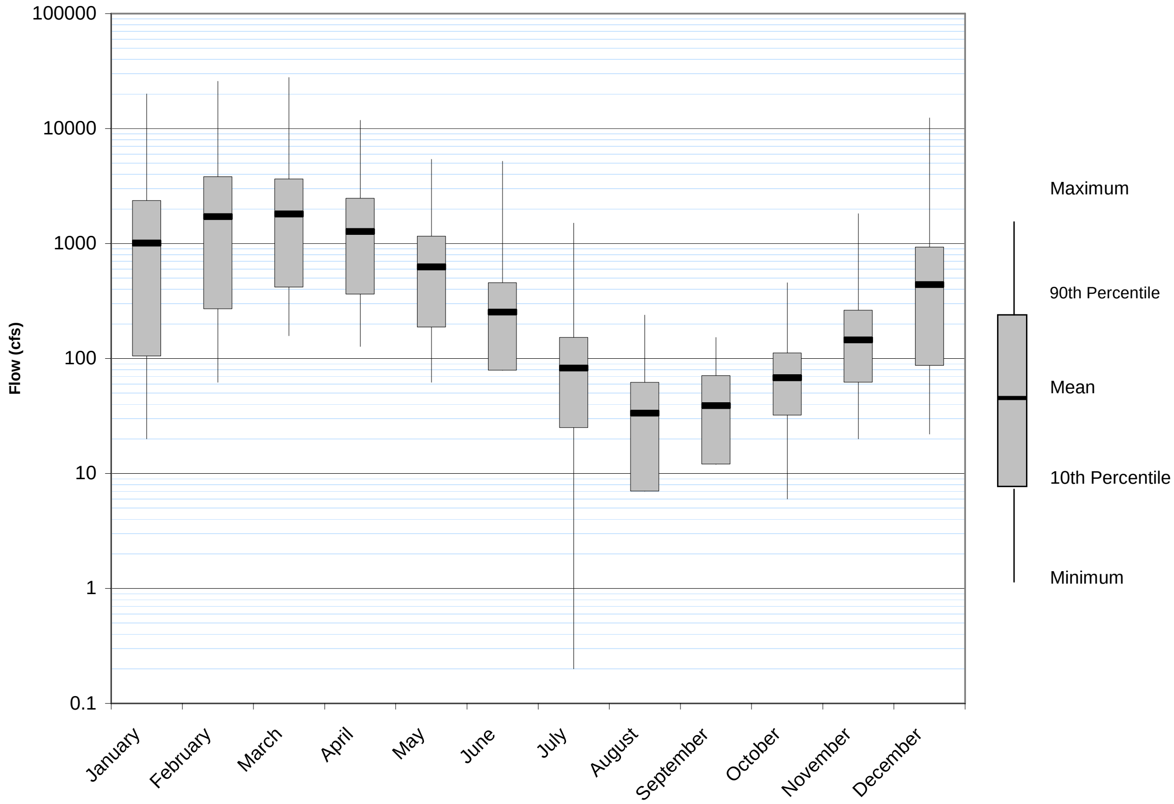

Figure 1: USGS stream gage mean monthly flows for the Palouse River near Hooper, WA.

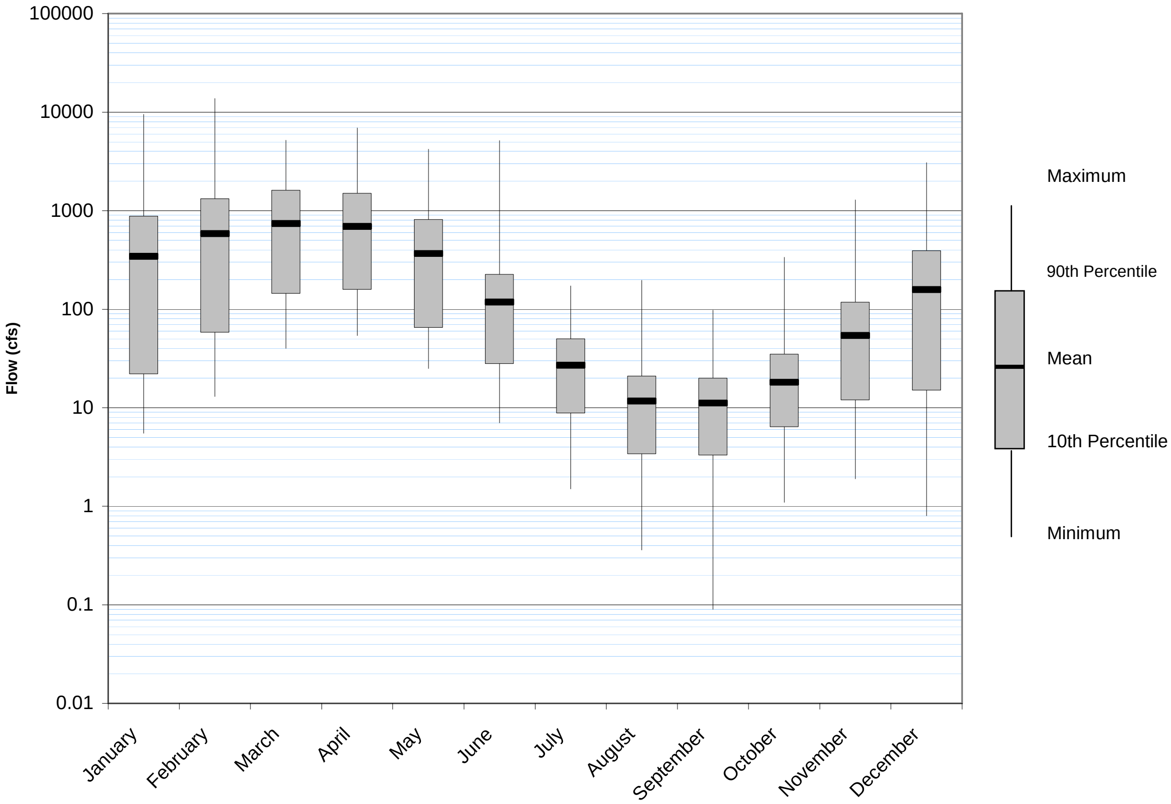

Figure 3: USGS stream gage mean monthly flows for the Palouse River near Potlatch, ID.

Land-use Patterns

Land use within the study area is dominated by agriculture and rangeland with small rural city populations. Colfax (population about 3,000) is the largest town within the Palouse watershed not including the South Fork Palouse subbasin. The next largest town is Palouse (population about 1,000), followed by Garfield (population 630). Smaller towns, with populations not exceeding 350, are located within the watershed as well (WA OFM, 2005). Agricultural use of water from the Palouse River is limited to adjacent land. Currently, slightly over 100 water rights exist that draw from the Palouse River. These surface water withdrawals are typically used for irrigation and stock. Rangeland mostly occurs in the scablands or the western region of the Palouse River watershed (Resource Planning Unlimited, Inc., 2004).

Vegetation

Historically the Palouse River watershed supported a variety of vegetation depending on sub-regional climate. For example, the eastern region of the watershed predominantly grew two types of perennial grass, Idaho fescue (*Festuca idahoensis*) and blue bunch wheatgrass (*Pseudoregneria spicata*). Shrubs included snowberry (*Symphoricarpos* spp.), black hawthorn (*Crataegus douglasii*), and rose (*Rosa* spp.) that grew often on the north aspect of the loess hills. Riparian areas in the eastern region commonly supported quaking aspen (*Populus tremuloides*) and cow parsnip (*Heracleum lanatum*) among other mentioned species herein.

Forest communities grew in the higher elevations of the eastern region. Such species included ponderosa pine (*Pinus ponderosa*), Douglas fir (*Pseudotsuga menziesii*), western red cedar (*Thuja plicata*), grand fir (*Abies grandis*), and western larch (*Larix occidentalis*), depending on aspect and available water. The forest understory included ocean spray (*Holodiscus discolor*), ninebark (*Physocarpus malvaceus*), serviceberry (*Amelanchier alnifolia*), snowberry, and wild rose.

Historically, wetlands existed across the watershed with the greatest amount in the northwest region. The highly diverse wetland vegetation was dominated by camas, forbs, sedges, rushes, and grasses.

The western region of the watershed was dominated by bluebunch wheatgrass. The western region riparian corridor also supported trees such as cottonwood (*Populus deltoides*), quaking aspen, mountain maple (*Acer glabrum*), and red alder (*Alnus rubra*). Currently, most of the Palouse Prairie has been converted to cropland (Resource Planning Unlimited, Inc., 2004).

Climate

The Palouse River watershed has a semi-arid climate. Annual precipitation in this watershed can range from 10 inches in the western region to 50 inches in the eastern region mountains of Idaho. Along the more mountainous eastern region, mean annual precipitation increases roughly seven inches with every 1,000 foot increase in elevation. Precipitation peaks during winter, and falls primarily as snow especially in the mountains (Resource Planning Unlimited, Inc., 2004). A drought was declared in 2001 and 2005. Summer daily maximum air temperatures can range from mid-70ºF to mid-90ºF (around 21ºC to 35ºC) and occasionally over 100ºF (37.8ºC).

Potential Sources of Biochemical Oxygen Demand and Nutrients

Point Sources

Wastewater treatment plants (WWTPs) are the primary point source contributors in the Palouse River watershed. Point source contributors relative to this TMDL study include sources that discharge either into an immediate tributary of the Palouse River, or directly into the Palouse River (Table 2).

Table 2. Point sources that discharge into the Palouse River or into an immediately associated tributary near its confluence with the Palouse River.

WWTP	Facility Type	Permit Type	City	Permit #	Discharges to	Year-round/ seasonal
COLFAX	Municipal	Minor	Colfax	WA0020613B	Palouse River	Year-round
ENDICOTT	Municipal	Minor	Endicott	WA0023981C	Rebel Flat Creek	Year-round
GARFIELD	Municipal	Minor	Garfield	WA0044822C	Silver Creek	Year-round
PALOUSE	Municipal	Minor	Palouse	WA0044806C	Palouse River	Year-round

Nonpoint Sources

Nonpoint sources and practices are dispersed and not readily controlled by discharge permits. BOD and nutrients from nonpoint sources are transported to the creeks by direct and indirect means. Several types of potential nonpoint sources are present in the study area including:

Runoff sources

- Manure that is spread over fields during certain times of the year can enter streams via surface runoff or fluctuating water levels.
- Manure is also deposited in the riparian area by range animals where fluctuating water levels, surface runoff, or constant trampling can bring the manure into the water.
- Pet waste concentrated in public parks or private residences can be a source of contamination, particularly in urban areas.
- Swales and flooding through pastures and near homes can carry BOD and nutrients from sources to waterways.
- Soil erosion of fertilized fields and lawns can also carry a considerable amount of particulate phosphate to streams.

Non-runoff sources

- Some residences may have wastewater piped directly to waterways or may have malfunctioning on-site septic systems where effluent seeps to nearby waterways.
- Often livestock have direct access to water.
- Tile drains, installed primarily in agricultural areas to drain shallow groundwater, may contribute nutrients.
- Naturally-occurring groundwater discharge to the Palouse River and its tributaries also affects DO levels and nutrient concentrations. Groundwater discharges to the river or creeks in some reaches, and is recharged by the stream in other reaches. In the Palouse River basin, background BOD/nutrient concentrations may be elevated due to upland practices such as agricultural field fertilizing and wastewater discharge to groundwater from on-site septic systems.

Wildlife and Background Sources

A wide variety of perching birds, upland game birds, raptors, and waterfowl are found within the Palouse River watershed. Birds, elk, deer, moose, beaver, muskrat, and other wildlife in rural areas are potential sources of nutrients. Open fields and riparian areas lacking vegetation are attractive feeding and roosting grounds for some birds whose presence can increase BOD and nutrients in runoff.

Usually these sources are dispersed and do not affect DO and pH in streams significantly enough to violate Washington State criteria. Sometimes birds and animals are locally concentrated, and such cases will be noted during sampling surveys.

Background concentrations of nutrients can also occur naturally from geologic sources.

Water Quality Standards and Beneficial Uses

In July 2003, the Washington State Department of Ecology (Ecology) made significant revisions to the state's surface water quality standards (Chapter 173-201A WAC). These changes included eliminating the classification system the state used for decades to designate uses (e.g., swimming, boating, fishing, aquatic life habitat, water supplies) for protection through the application of water quality criteria (e.g., temperature, dissolved oxygen, turbidity, bacteria). Ecology also revised the numeric temperature criteria assigned to waters to protect specific aquatic species and their use of streams during sensitive live stages.

Ecology submitted the revised water quality standards regulation to the U.S. Environmental Protection Agency (EPA) for federal approval. EPA was not satisfied that Ecology's 2003 standards met the requirements of the federal Clean Water Act and the federal Endangered Species Act. As a consequence, EPA formally disapproved portions of the revised standards. Ecology responded to the EPA disapproval by initiating a corrective state rule revision. The rulemaking addressed the changes EPA described as necessary in their disapproval. The state concluded its corrective rulemaking proceedings in October 2006, and expects to have approved state standards by October 2007. The result of the corrective state rulemaking will be that a number of streams and stream segments would receive more stringent temperature and dissolved oxygen criteria.

Ecology developed an implementation plan that describes when to use the new 2006 state standards while the state awaits formal EPA approval of those standards:

- TMDLs completed before December 2006, or whose fieldwork was largely completed before October 2006, will be based on the 1997 version of the state standards. These studies must also include:
    - A scenario evaluating what would be required to meet the 2006 standards where the existing data allows.
    - An implementation plan designed to assess compliance with the 2006 standards.
- TMDLs initiated after December 2006 will be based on meeting the new 2006 standards.

The revised water quality standards can be found online at Ecology's water quality standards website at www.ecy.wa.gov/programs/wq/swqs/index.html. Table 3 provides a general structure for understanding how the 1997 standards were revised in the 2006 rule revision including certain classifications that apply to the Palouse River watershed.

Table 3. Water Quality Standards and changes for temperature, dissolved oxygen, pH, and turbidity in former Class A and Class B waters.

1997 Standards Classification	Water Quality Parameter	1997 Criteria[2]	2003 Use Revision	2003/2007 Criteria[2]
Class A[1]	Temperature	18°C 1-Dmax[3]	Salmonid spawning, rearing, and migration	17.5°C 7-DADMax[4]
	Dissolved Oxygen	8.0 mg/L		8.0 mg/L[5]
	pH	6.5 to 8.5 units		6.5 to 8.5 units
Class B[1]	Temperature	21°C 1-Dmax[3]	Salmonid rearing and migration only	17.5°C 7-DADMax[4]
	Dissolved Oxygen	6.5 mg/L		6.5 mg/L[5]
	pH	6.5 to 8.5 units		6.5 to 8.5 units

1. Class A waters were subcategorized into "salmonid spawning, rearing, and migration" designated use types during the 2003 revision to the water quality standards regulation. Class B waters were subcategorized into "salmonid rearing and migration only" designated use types during the water quality standards revision.
2. Criteria have been established in the existing water quality standards for specific waterbodies that differ from the general criteria shown in the above table. These special conditions can be found in WAC 173-201A-130 of the 1997 version, and WAC 173-201A-602 of the 2003 version of the standards.
3. 1-DMax means the highest annual daily maximum temperature occurring in the waterbody.
4. 7-DADMax means the highest annual running 7-day average of daily maximum temperatures.
5. When a waterbody classified as "excellent quality" (formerly Class A) has a DO lower than 8.0 mg/L (or 6.5 mg/L for former Class B waters) and that condition is due to natural conditions, then cumulative human actions may not cause the DO to decrease more than 0.2 mg/L.

In the state water quality standards, aquatic life use categories are described using key species (salmon versus warm-water species) and life-stage conditions (spawning versus rearing) (WAC 173-201A-200; 2003 edition).

Table 4 describes the water quality standards and aquatic use for temperature, dissolved oxygen, and pH on the Palouse River. The Palouse River is an interstate waterbody. The federal Clean Water Act requires that the downstream receiving state's water quality standard be met at the state line.

Table 4. Water Quality Standards for temperature in the Palouse River.

Stream Name and Segment	1997 Classification	2003 Aquatic Life Use	2003/2007 Standards		
			Temperature	Dissolved Oxygen	pH
Palouse River from Palouse Falls to south fork (Colfax, river mile 89.6)	B	Salmonid Rearing and Migration Only	17.5 °C 7DADMax	6.5 mg/L	6.5 to 8.5 units
Palouse River mainstem from mouth to Palouse Falls	B	Salmonid Spawning, Rearing and Migration	17.5 °C 7DADMax	8.0 mg/L	6.5 to 8.5 units
Palouse River from south fork (Colfax, river mile 89.6) to Idaho border (river mile 123.4)[1]	A, Special condition[1]	Salmonid Spawning, Rearing, and Migration	20.0°C[1]	8.0 mg/L	6.5 to 8.5 units

1. Temperature shall not exceed a 1-DMax of 20.0°C due to human activities. When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t = 34/(T + 9).

Nitrogen and phosphorus are essential nutrients for plant growth and aquatic community health. However, when there is an overabundance of nutrients, aquatic plant growth can become over-stimulated—a process called eutrophication. If natural reaeration processes cannot compensate for plant respiration and production in areas affected by eutrophication, DO becomes under-saturated at night and over-saturated during the day; and hydronium ion (pH) concentrations become over-saturated at night and under-saturated during the day. These diel (i.e., day to night) swings can be harmful to macroinvertebrates and fish. Washington State water quality standards do not have numeric nutrient (nitrogen and phosphorus) criteria for streams. However, Chapter 173-201A contains a narrative criterion that applies to nitrogen and phosphorus:

"Toxic, radioactive, or deleterious material concentrations shall be below those which have the potential either singularly or cumulatively to adversely affect characteristic water uses, cause acute or chronic conditions to the most sensitive biota dependent upon those waters, or adversely affect public health, as determined by the department."

Natural Conditions

Water quality criteria are set at levels that fully protect designated uses. This ensures that these uses will be fully protected wherever doing so is an attainable condition. However, setting fully protective criteria means that for some water quality parameters, especially temperature and dissolved oxygen, some waterbodies will fail to meet the criteria even under natural conditions (absent any contributing human effects). To account for this condition, the standards contain both narrative provisions and numeric allowances for considering the effect of natural conditions.

A general narrative provision in the state standards is that when and where under natural conditions a waterbody would fail to meet the assigned numeric criteria, those measured or estimated natural conditions are used as alternate water quality criteria. In some cases, such as with the dissolved oxygen and temperature criteria, a small additional cumulative allowance for degradation beyond naturally poor conditions is provided for human activities (0.3° C for temperature and 0.2 mg/L for DO).

In assessing what is and is not natural, Ecology will use historic data and water quality modeling as appropriate to ascertain what the water quality conditions would be without human sources of degradation. Using this approach does not infer that Ecology believes that systems can or should be returned to pre-historic conditions. The water quality standards and the federal regulations governing those standards contain numerous provisions and tools for setting water quality-based limitations. These provisions, when followed, allow states to identify and protect the highest attainable uses.

Historical Data Review

USGS Water Quality Study

As part of the USGS National Water-Quality Assessment Program, the cumulative downstream effects from point and nonpoint discharges of nutrients were assessed during low-flow discharge in 1994 throughout the Palouse River basin (Greene et al., 1997).

Within the planned study area described in this Quality Assurance Project Plan, the USGS collected diel and instantaneous data at nine sites in the Palouse River basin. Additionally, six sites were assessed in the South Fork Palouse River basin. The USGS found that Washington State standards for minimum dissolved oxygen and maximum pH were not met at sites throughout the study area.

Growth of benthic algae in the Palouse River was found to be limited by inorganic nitrogen. The USGS found most of the inorganic nitrogen load in the Palouse River was removed before reaching the Palouse River, though the means remained unclear because algal and plant uptake could not explain all of the loss.

The USGS also found a decrease in orthophosphate concentrations downstream from Colfax that may have been caused by some combination of dilution by groundwater, uptake by plants and algae, and sorption to solids.

Washington State Department of Ecology Ambient Monitoring

Ecology has collected ambient monitoring data from the Palouse River at Palouse (Station 34A170) monthly since 1992, and from the Palouse River at Hooper since 1959 (Ecology, 2006). Data were collected sporadically from the Hooper station prior to October 1973.

Figures 4 and 5 show box plots of monthly instantaneous DO samples for the Palouse River at Palouse (above Palouse WWTP) and Hooper, respectively. The instantaneous DO measurements did not necessarily capture the daily minimum because they were made during daylight hours when photosynthesis is increasing water column DO. Monthly data from the Palouse site indicate DO levels are not in compliance with water quality standards during July through September. This season encompasses the growing season when light is more available and water temperatures are high in the Palouse River. Similarly, monthly data from the Hooper site indicated lowest DO levels in the summer months, though the lower DO standard of 6.5 mg/L was rarely violated during daylight hours of these months.

Figures 6 and 7 show box plots of monthly pH measurements for the Palouse River at Palouse and Hooper, respectively. Like the DO measurements, the instantaneous pH measurements did not necessarily capture the daily maximum or minimum because measurements were made at different times of the day. A clear season of higher pH levels occurred between May and November, though the Hooper site exceeded the upper pH criterion more often. This season encompasses the growing season when light is more available and water temperatures are warmer in the Palouse River. Diel high pH levels may result from periphyton growth (i.e., algae attached to the substrate consume inorganic carbon forms during productivity affecting the pH balance).

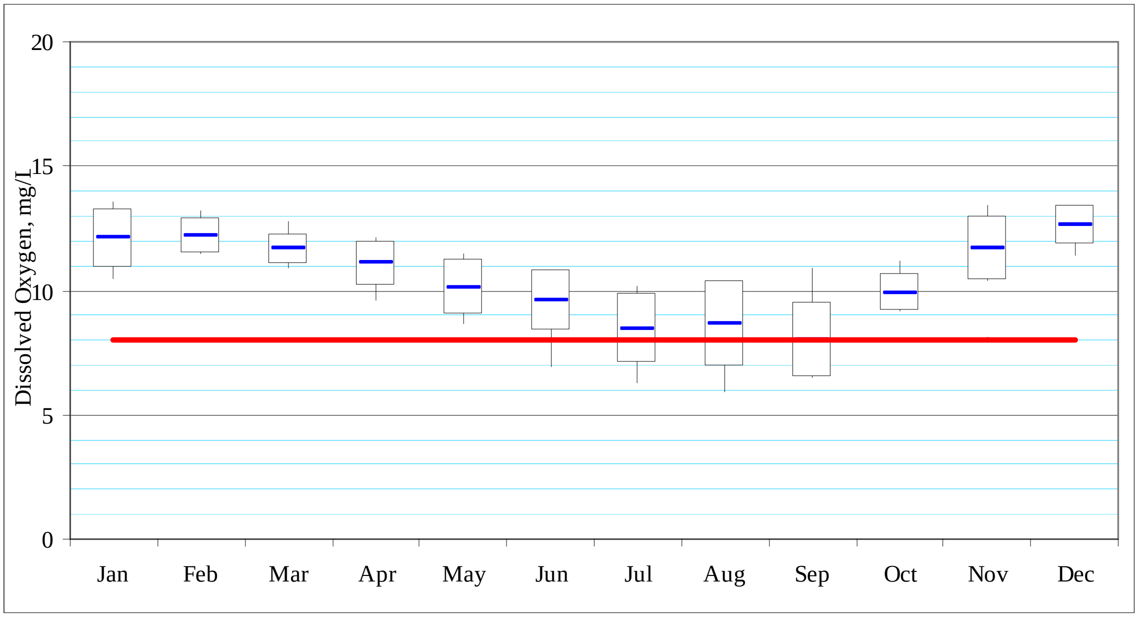

Figure 4. Distribution of monthly dissolved oxygen concentrations measured at the Palouse River at Palouse ambient monitoring station (34A170) from 1994 to 2004 (n=10-13 per month). Box plots represent the 90th percentile, mean, and 10th percentile of the measurements. Whiskers on boxes represent the maximum and minimum measurements. The red line represents the minimum instantaneous dissolved oxygen standard of 8 mg/L.

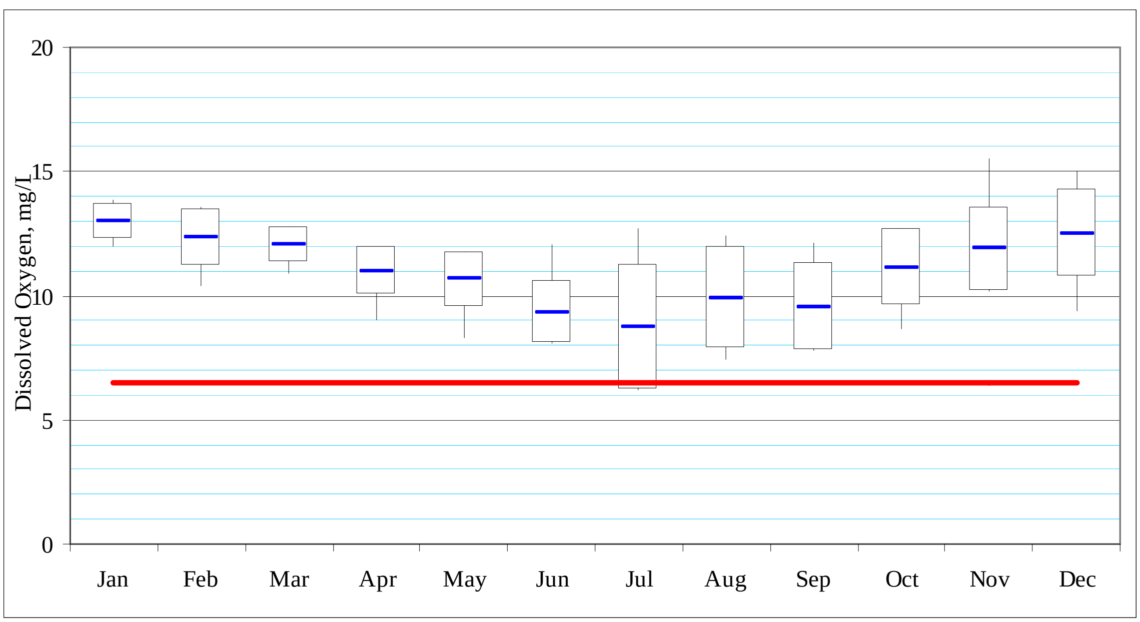

Figure 5. Distribution of monthly dissolved oxygen concentrations measured at the Palouse River at Hooper ambient monitoring station (34A070) from 1994 to 2004 (n=10-13 per month). Box plots represent the 90th percentile, mean, and 10th percentile of the measurements. Whiskers on boxes represent the maximum and minimum measurements. The red line represents the minimum instantaneous dissolved oxygen standard of 6.5 mg/L.

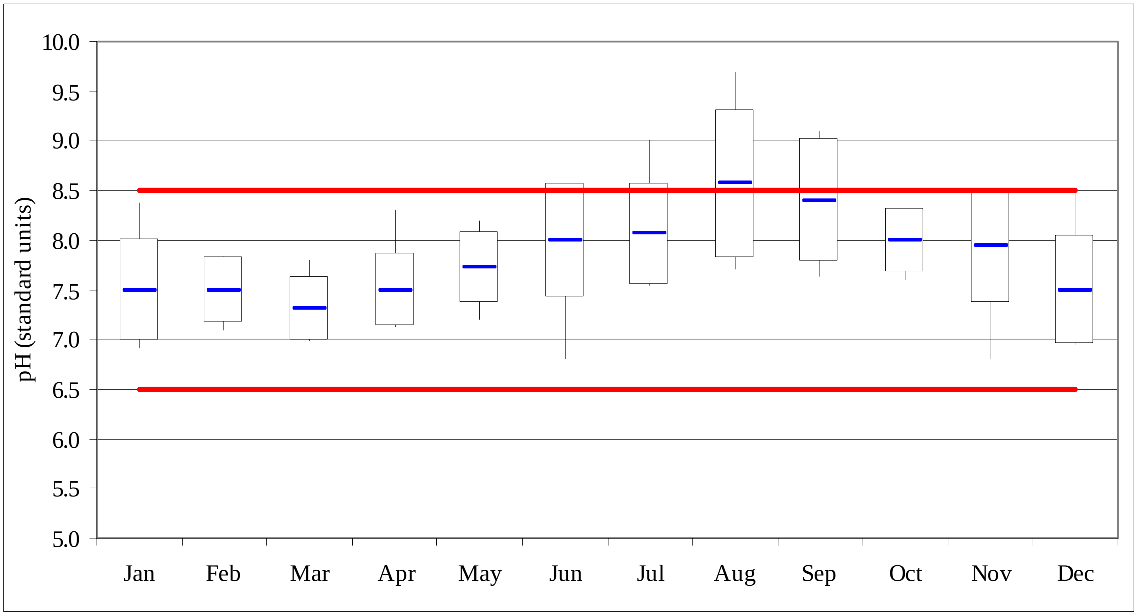

Figure 6. Distribution of monthly pH levels measured at the Palouse River at Palouse ambient monitoring station (34A170) from 1994 to 2004 (n= 10-13 per month). Box plots represent the 90th percentile, mean, and 10th percentile of the measurements. Whiskers on boxes represent the maximum and minimum measurements. Red lines denote the maximum and minimum pH water quality criteria of 8.5 and 6.5.

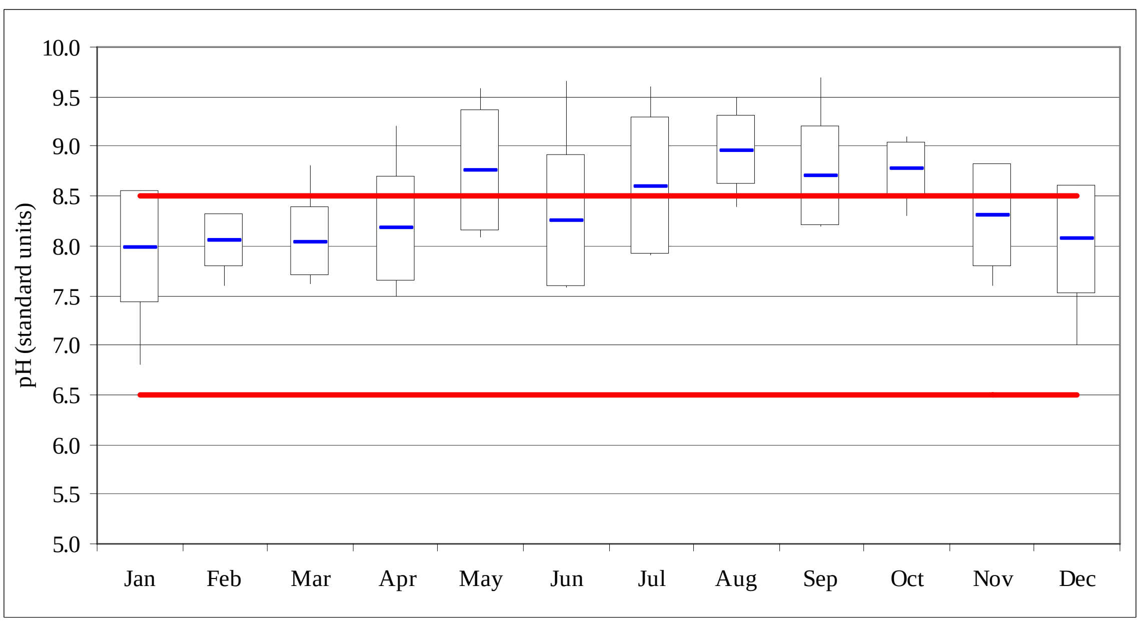

Figure 7. Distribution of monthly pH levels measured at the Palouse River at Hooper ambient monitoring station (34A070) from 1994 to 2004 (n= 10-13 per month). Box plots represent the 90th percentile, mean, and 10th percentile of the measurements. Whiskers on boxes represent the maximum and minimum measurements. Red lines denote the maximum and minimum pH water quality criteria of 8.5 and 6.5.

Project Description

Study Design

The project objectives will be met by developing a numerical water quality model for the Palouse River from the Washington-Idaho state line to the confluence of the Palouse River with the Snake River. The model will rely on data collected during the project by Ecology as well as existing data collected by Ecology, Adams Conservation District, USGS, and others.

The model will be calibrated to field data. The calibrated model will then be used to evaluate the water quality in the Palouse River in response to various alternative scenarios of pollutant loading. The loading capacity of the Palouse River will be evaluated and wasteload allocations for point sources and load allocations for nonpoint sources will be evaluated. The model will be used to determine how much nutrients and BOD need to be reduced to meet the DO and pH water quality standards.

Data will be collected for the Palouse River DO and pH TMDL from a fixed network of stations sampled synoptically (all stations sampled over a short period of time). Sampling at each station will be conducted twice daily. Synoptic surveys will be conducted at least two times throughout the course of the project to provide calibration and corroboration data sets. The fixed-network synoptic sampling will occur during the summer low-flow months (June to October 2007) to capture critical conditions. The locations of the fixed-network water quality stations are listed in Table 5 and can be seen in Figure 8. Major tributaries of the Palouse River will be sampled as close to their confluence with the mainstem as possible.

Synoptic sampling will include grab samples of chloride, total suspended solids, total non-volatile suspended solids, turbidity, ammonia, nitrite/nitrate, orthophosphate, total phosphorous, total persulfate nitrogen, dissolved and total organic carbon, and alkalinity. Ultimate carbonaceous biochemical oxygen demand sampling may be done on the WWTP final effluents.

Continuous diel monitoring for pH, DO, conductivity, and temperature will be conducted at several sites with Hydrolab DataSonde® (listed in Table 5). Phytoplankton and periphyton sampling will be conducted at the same sites to determine biomass and chlorophyll levels.

Staff gages may be installed at sites to develop discharge rating curves based on stage. Continuous streamflow data will be obtained from seven stream gaging stations:

- Palouse River at Potlatch, Idaho (USGS)
- Palouse River at Elberton, Washington (Ecology)
- Palouse River just above confluence with South Fork (Ecology)
- South Fork Palouse River just above confluence (Ecology)
- Palouse River at Shields Rd. bridge (Ecology)
- Palouse River at Winona (Ecology)
- Palouse River at Hooper (USGS)

Sites may be added or removed from the sampling plan depending upon access and new information provided during the Quality Assurance Project Plan review, field observations, and preliminary data analysis.

Table 5. Fixed-network stations for synoptic surveys in the Palouse River watershed.

Waterbody/ Source	Road Crossing or Access	Reason for Site	Datalogger Site
Palouse River at state line above Palouse	Off of North River Road	Boundary with Idaho	X
Palouse River at Palouse	Downtown bridge	Long-term monitoring site for Ecology	X
Palouse WWTP	WWTP effluent	WWTP effluent	X
Palouse River downstream of WWTP	Westicott Road	Access available to Palouse	X
Palouse River at Elberton	Elberton bridge	Upstream of tributary	X
Garfield WWTP	WWTP effluent	WWTP effluent	
Silver Creek	Mouth of creek	Mouth of tributary	
Palouse River above Colfax	USGS site	Access available to Palouse	X
Palouse River (North Fork)	W. Railroad Avenue (behind Subway)	North Fork boundary condition at Colfax	X
South Fork Palouse River	Railroad crossing at end of W. Railroad Avenue	South Fork boundary condition at Colfax	X
Colfax WWTP	Hwy 26 at Colfax	WWTP effluent	X
Palouse River	Below mixing zone of WWTP effluent	Below mixing zone below Colfax	X
Dry Creek	Near mouth at Manning Road	Mouth of tributary	
Palouse River	Above Dry Creek	Upstream of tributary	X
Palouse River	River mile 77.7 - Bridge crossing off Shields Road near Diamond	Access available to Palouse	X
Palouse River	Upstream of Little Valley Creek at Matlock Road bridge	Access available to Palouse	X
Little Valley Creek	Near the mouth at Jones Road	Mouth of tributary	
Palouse River	Kackman Road bridge crossing	Access available to Palouse	X
Downing Creek	At mouth near off bridge at Kackman Road	Mouth of tributary	
Palouse River	Upstream of Rebel Flat Creek at Benge-Winona Road.	Upstream of tributary	X
Rebel Flat Creek	Upstream of Endicott at Repp Road	Measure upstream influences	X
Rebel Flat Creek	Downtown Endicott at Endicott Road bridge	Measure upstream influences	X
Endicott WWTP	Downtown Endicott	WWTP effluent	X
Rebel Flat Creek	Downstream of Endicott at Swent Road	Measure WWTP influence	X
Rebel Flat Creek	At the mouth near Winona	Mouth of tributary	X
Palouse River	Upstream of Rock Creek off Troupe Road	Upstream of tributary	X
Rock Creek	At the mouth; Troupe Road crossing	Mouth of tributary	X
Palouse River	Upstream of Union Flat Creek	Upstream of tributary	X
Union Flat Creek	Near the mouth	Mouth of tributary	X
Palouse River	Upstream of Willow Creek	Upstream of tributary	X
Willow Creek	At the mouth near Gordon	Mouth of tributary	
Cow Creek	Near the mouth; Gray Road bridge crossing	Mouth of tributary	
Palouse River	At Hooper; existing ECY (34A070) and USGS station	Long-term monitoring site for Ecology	X
Palouse River	At West Hooper bridge	Access available to Palouse	X

WWTP - Wastewater Treatment Plant

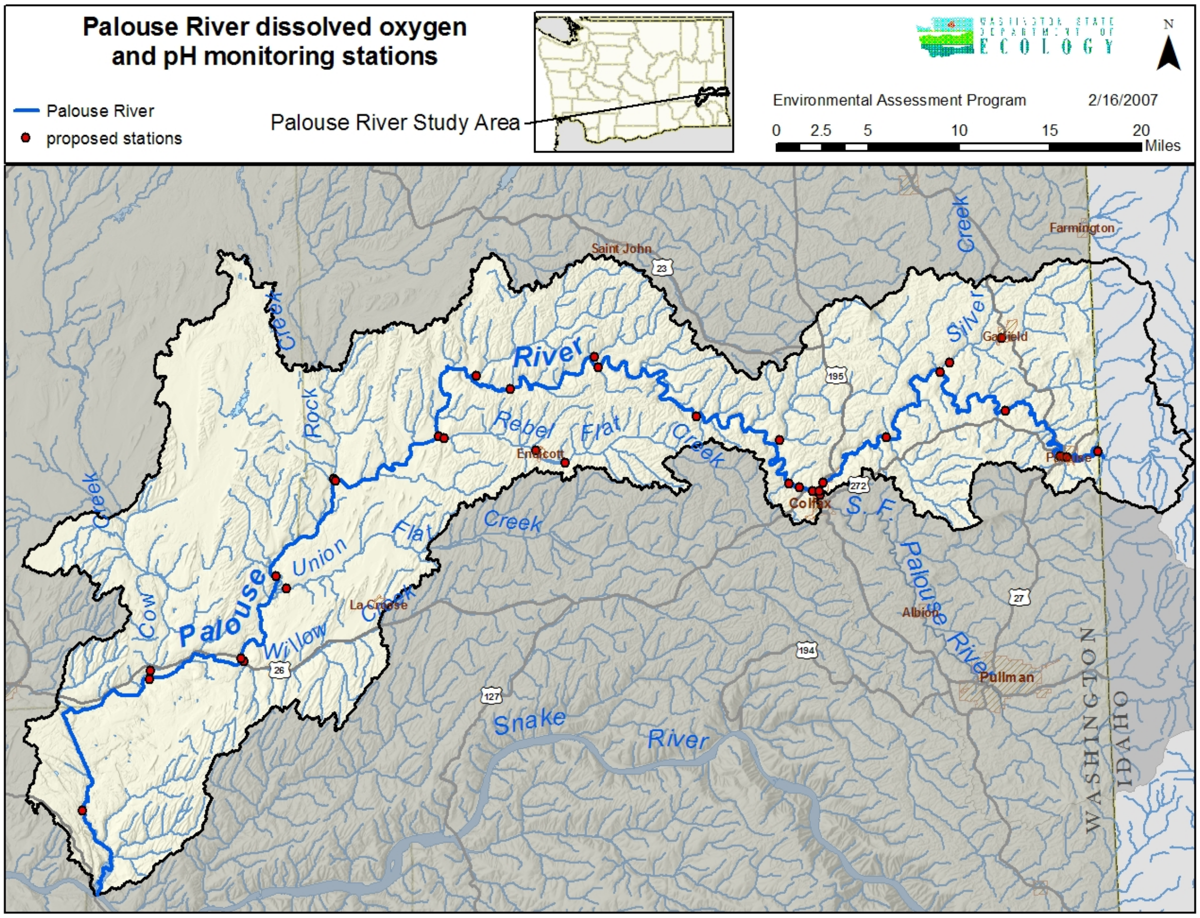

Figure 8. Map of the Palouse River watershed showing proposed TMDL sampling sites.

Groundwater monitoring

Geologic Setting

The Palouse River watershed lies near the eastern edge of the Columbia Plateau Aquifer System (Drost et al., 1990). The western three-quarters of the watershed is contained within Washington State and is underlain largely by Miocene age basalts and associated sediments of the Columbia River Basalt group. The Columbia River basalts, which contain the area's primary water supply aquifers, were extruded upon and overlie an assemblage of igneous intrusive and metasedimentary rocks of Cretaceous to Pre-Cambrian Age. These older rocks are widely distributed at land surface east of the Washington-Idaho border and locally within the Washington Palouse drainage, where they are not obscured beneath later basalt flows. The Washington Palouse uplands are typically mantled by thick accumulations of loess (wind-blown sand, silt, and clay). Where river and stream valleys bisect the uplands, the loess grades laterally into coarser deposits of alluvium and colluvium derived from reworked loess, basalt, and granatoid fragments (Bush et al., 1998).

Evaluation of Groundwater and Surface Water Interactions

For this study, groundwater and surface-water interactions will be assessed via a combination of common field techniques. Instream piezometers will be installed in June 2007 at selected points along the Palouse River to enable monitoring of surface water and groundwater head relationships, streambed water temperatures, and groundwater quality at discrete points along the river. The piezometers will be distributed to provide point measurements along the length of the river and, where possible, will be co-located with previously deployed instream thermistors.

The piezometers for this study will consist of a five-foot length of 1.5-inch diameter galvanized pipe, one end of which is crimped and slotted. The upper end of each piezometer will be fitted with a standard pipe coupler to provide a robust strike surface for piezometer installation and to enable the piezometers to be securely capped between sampling events. The piezometers will be driven into the streambed (within a few feet of the shoreline) to a maximum depth of approximately five feet. Following installation, the piezometers will be developed using standard surge and pump techniques to assure a good hydraulic connection with the streambed sediments.

Each piezometer will be instrumented with up to three thermistors for continuous monitoring of streambed water temperatures. In a typical installation, one thermistor will be located near the bottom of the piezometer, one will be located at a depth of approximately 0.5 feet below the streambed, and one will be located roughly equidistant between the upper and lower thermistors. The piezometers will be accessed monthly to download thermistors and to make spot measurements of stream and groundwater temperature for later comparison against and validation of the thermistor data. The monthly spot measurements will be made with properly maintained and calibrated field meters in accordance with standard Environmental Assessment Program methodology (Ecology, 1993).

During the monthly site visits, surface water stage and instream piezometer water levels will be measured using a calibrated electric well probe, a steel tape, or a manometer board (as appropriate) in accordance with standard USGS methodology (Stallman, 1983). The water level (head) difference between the internal piezometer water level and the external river stage provides an indication of the vertical hydraulic gradient and the direction of flow between the river and groundwater. When the piezometer head exceeds the river stage, groundwater discharge into the river is inferred. Similarly, when river stage exceeds the head in the piezometer, loss of water from the river to groundwater storage can be inferred.

To help define the potential nutrient load that discharging groundwater contributes to the river those piezometers that exhibit positive hydraulic gradients (groundwater discharge conditions) will be sampled in July and September 2007 for the following parameters: conductivity, temperature, pH, DO, alkalinity, chloride, dissolved nutrients (ammonia, nitrate-nitrite, total persulfate nitrogen, orthophosphate, and total phosphorus), dissolved organic carbon, iron, and fecal coliform. All water quality samples will be collected, processed, and transported to the laboratory in accordance with standard Environmental Assessment Program methodology.

To provide a secondary confirmation of the instream piezometer dataset, we will also attempt to arrange access to a tandem network of shallow off-stream domestic wells which will be used to monitor "regional" groundwater levels, temperatures, and groundwater quality. When selecting wells, preference will be given to shallow, properly documented wells in close proximity to the Palouse River. Wells selected for monitoring will be visited monthly between June and October, 2007, to measure groundwater levels. Where owner permission is granted and site conditions allow, recording thermistors and water level transducers will be deployed. A subset of the off-stream wells will be sampled in July and September 2007 for the above listed parameters.

In addition to the above work, we will make direct measurements of streambed sediment permeability using constant head injection tests. The field methods and analytical techniques are based on procedures outlined in Cardenas and Zlotnik (2003). The test results will be used to augment thermal profiling and gradient measurements for estimation of groundwater/surface water exchange.

Representativeness

The study was designed to have enough sampling sites and sufficient sampling frequency to adequately characterize water quality spatial and temporal patterns (during the synoptic survey) in the watershed. Representative sampling variability can be somewhat controlled by strictly following standard procedures and collecting quality control samples, but natural spatial and temporal variability can contribute greatly to the overall variability in a parameter value. Resources limit the number of samples that can be taken at one site spatially or over various intervals of time; however, an attempt will be made to take water quality grab samples at least twice at all stations during the synoptic survey, preferably one in the morning and one in the afternoon.

Comparability

Samples collected at the Palouse, Colfax, and Endicott Wastewater Treatment Plants (WWTPs) will be collected, when possible, in conjunction with the routine samples collected by the WWTP operators. Ecology results will be compared to the results from each WWTP.

Completeness

The U.S. Environmental Protection Agency (EPA) has defined completeness as a measure of the amount of valid data needed to be obtained from a measurement system (EPA, 2002). The goal for the Palouse River TMDL is to correctly collect and analyze 100% of the samples for each of the sites. However, problems occasionally arise during sample collection that cannot be controlled such as flooding, inadequate rain for storm sampling, or site access problems that can interfere with this goal. A lower limit of one grab sample per synoptic survey per site will be required for comparison to state criteria and model input. Investigatory samples may be collected at sites not included in this Quality Assurance Project Plan; or, if necessary, a site may be added to further characterize water quality problems in an area.

Laboratory Budget

The estimated laboratory budgets and laboratory sample loads are presented in Table 6.

Table 6. Projected sample loads and laboratory costs for nutrient sampling on the Palouse River.

Parameter	Cost/ Analysis (water only)	Number of Samples (including field QA)	Cost	Number of Surveys	Cost
Turbidity	10	53	530	2	1060
Total Suspended (TSS) + TNVSS	22	53	1166	2	2332
Alkalinity	16	99	1584	2	3168
Chloride	12	99	1188	2	2376
Chlorophyll	48	53	2544	2	5088
Total Persulfate Nitrogen (TPN)	16	99	1584	2	3168
Nutrients 5 (NH3, NO3, NO2, O-P, TP)	63	99	6237	2	12474
UBOD	426	0	0	2	0
Phytoplankton (biovolume, ID)	125	20	2500	1	2500
Dissolved Organic Carbon	34	99	3366	2	6732
Total Organic Carbon	29	99	2871	2	5742
Fecal Coliform	21	53	1113	2	2226
Additional samples (e.g., for unknown sources)					5000
				Total:	$51,866

Quality Assurance (QA) = replicates about 10% of the preceding column.

TNVSS = Total Nonvolatile Suspended Solids.

Nutrients = Ammonia (NH3), Nitrite/Nitrate (NO2/NO3), Orthophosphate (OP), Total Phosphorous (TP), and Total Persulfate Nitrogen (TPN).

UBOD = Biochemical Oxygen Demand (ultimate).

Projected lab costs include a 50% discount for services at Manchester Laboratory (the remaining 50% is paid through base funding).

Sampling Procedures

Field sampling and measurement protocols will follow those listed in an Environmental Assessment Program protocols manual (Ecology, 1993).

Grab samples will be collected directly into pre-cleaned containers supplied by Manchester Environmental Laboratory (MEL) and described in the MEL User's Manual (2005). Sample parameters, containers, volumes, preservation requirements, and holding times are listed in Table 7. All samples for laboratory analysis will be stored on ice and delivered to MEL within 24 hours of collection via Horizon Air and Ecology courier.

Ten-to-twenty percent of the samples will be duplicated in the field in a side-by-side manner to assess field and lab variability. Samples will be collected in the thalweg and just under the water's surface.

Periphyton field sampling protocols are adapted from the USGS protocols (Porter et al., 1993).

Table 7. Containers, preservation requirements, and holding times for samples collected during the Palouse River TMDL Study (MEL, 2005).

Parameter	Sample Matrix	Container	Preservative	Holding Time
Fecal Coliform	Surface water, WWTP effluent, & runoff	250 or 500 mL glass/poly autoclaved	Cool to 4ºC	24 hours
Chloride	Surface water, WWTP effluent, & runoff	500 mL poly	Cool to 4ºC	28 days
Total Suspended Solids; TNVSS	Surface water, WWTP effluent, & runoff	1000 mL poly	Cool to 4ºC	7 days
Turbidity	Surface water, WWTP effluent, & runoff	500 mL poly	Cool to 4ºC	48 hours
Alkalinity	Surface water, WWTP effluent, & runoff	500 mL poly – No Headspace	Cool to 4°C; Fill bottle *completely*; Don't agitate sample	14 days
Ammonia	Surface water, WWTP effluent, & runoff	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Dissolved Organic Carbon	Surface water, WWTP effluent, & runoff	60 mL poly with: Whatman Puradisc™ 25PP 0.45um pore size filters	Filter in field with 0.45um pore size filter; 1:1 HCl to pH<2; Cool to 4°C	28 days
Nitrate/Nitrite	Surface water, WWTP effluent, & runoff	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Total Persulfate Nitrogen	Surface water, WWTP effluent, & runoff	125 mL clear poly	H_2SO_4 to pH<2; Cool to 4ºC	28 days
Orthophosphate	Surface water, WWTP effluent, & runoff	125 mL amber poly w/ Whatman Puradisc™ 25PP 0.45um pore size filters	Filter in field with 0.45um pore size filter; Cool to 4°C	48 hours
Total Phosphorous	Surface water, WWTP effluent, & runoff	60 mL clear poly	1:1 HCl to pH<2; Cool to 4°C	28 days
Total Organic Carbon	Surface water, WWTP effluent, & runoff	60 mL clear poly	1:1 HCl to pH<2; Cool to 4°C	28 days
Biochemical Oxygen Demand (ultimate)	Surface water & WWTP effluent	1 gallon cubitainer	Cool to 4ºC in dark	48 hours
Chlorophyll a	Surface water & periphyton	1000 mL amber poly	Cool to 4ºC; 24 hrs to filtration	28 days after filtering

TNVSS = Total Nonvolatile Suspended Solids

WWTP = Wastewater Treatment Plant

Measurement Procedures

Field measurements in the Palouse River and its tributaries will include conductivity, temperature, pH, and DO using a calibrated Hydrolab DataSonde® or MiniSonde®. DO will also be collected and analyzed using the Winkler titration method (Ecology, 1993).

Estimation of instantaneous flow measurements will follow an Environmental Assessment Program protocols manual (Ecology, 2000). Flow volumes will be calculated from continuous stage height records and rating curves developed prior to, and during, the project. Stage height will be measured by pressure transducer and recorded by a data logger every 15 minutes. All data loggers will be downloaded monthly. Staff gages will be installed at other selected sites. During the field surveys, streamflow will be measured at selected stations and/or staff gage readings will be recorded. A flow rating curve will be developed for sites with a staff gage.

Measurement Quality Objectives

Field sampling procedures and laboratory analysis inherently have associated error. Measurement quality objectives state the allowable error for a project. Precision and bias are data quality criteria used to indicate conformance with measurement quality objectives.

Precision is defined as the measure of variability in the results of replicate measurements due to random error. Random error is imparted by the variation in concentrations of samples from the environment as well as other introduced sources of variation (e.g., field and laboratory procedures). Precision for replicates will be expressed as percent relative standard deviation (%RSD).

Bias is defined as the difference between the population mean and true value of the parameter being measured. Bias affecting measurement procedures can be inferred from the results of quality control procedures involving the use of blanks, check standards, and spiked samples. Bias in field measurements will be minimized by strictly following sampling and handling protocols, and will be assessed by submitting field blanks.

Analytical methods, expected precision of sample replicates, and method reporting limits, and resolution are given in Table 8. The targets for analytical precision of laboratory analyses are based on historical performance by MEL for environmental samples taken around the state by the Environmental Assessment Program (Mathieu, 2005). The reporting limits of the methods listed in the table are appropriate for the expected range of results and the required level of sensitivity to meet project objectives. The laboratory's measurement quality objectives and quality control procedures are documented in the Manchester Environmental Laboratory Lab Users Manual (MEL, 2005).

Table 8. Targets for precision and reporting limits for the measurement systems.

Analysis	Method	Duplicate Samples Relative Standard Deviation (RSD)	Method Reporting Limits and/or Resolution
Field Measurements			
Velocity[1]	Marsh McBirney Flow-Mate Flowmeter	0.1 ft/s	0.01 ft/s
Water Temperature[1]	Hydrolab MiniSonde®	+/- 0.1° C	0.01° C
Specific Conductivity[2]	Hydrolab MiniSonde®	+/- 0.5%	0.1 umhos/cm
pH[1]	Hydrolab MiniSonde®	0.05 SU	1 to 14 SU
Dissolved Oxygen[1]	Hydrolab MiniSonde®	5% RSD	0.1 - 15 mg/L
Dissolved Oxygen[1]	Winkler Titration	+/- 0.1 mg/L	0.01 mg/L
Laboratory Analyses			
Fecal Coliform – MF	SM 9222D	30% RSD[3]	1 cfu/100 mL
Chloride	EPA 300.0	5% RSD[4]	0.1 mg/L
Total Suspended Solids	SM 2540D	10% RSD[4]	1 mg/L
Turbidity	SM 2130	10% RSD[4]	1 NTU
Alkalinity	SM 2320	10% RSD[4]	10 mg/L
Ammonia	SM 4500-NH_3^-H	10% RSD[4]	0.01 mg/L
Dissolved Organic Carbon	EPA 415.1	10% RSD[4]	1 mg/L
Nitrate/Nitrite	4500-NO_3^- I	10% RSD[4]	0.01 mg/L
Total Persulfate Nitrogen	SM 4500-NO_3^-B	10% RSD[4]	0.025 mg/L
Orthophosphate	SM 4500-P G	10% RSD[4]	0.003 mg/L
Total Phosphorous	EPA 200.8 modified	10% RSD[4]	0.001 mg/L
Total Organic Carbon	EPA 415.1	10% RSD[4]	1 mg/L

[1] as units of measurement, not percentages.
[2] as percentage of reading, not RSD.
[3] replicate results with a mean of less than or equal 20 cfu/100 mL will be evaluated separately.
[4] replicate results with a mean of less than or equal to 5X the reporting limit will be evaluated separately.

SM = Standard Methods for the Examination of Water and Wastewater, 20th Edition (APHA, AWWA and WEF, 1998).
EPA = EPA Method Code.

Quality Control Procedures

Total variability for field sampling and laboratory procedures will be assessed by collecting replicate samples. Sample precision will be assessed by collecting replicates for 10-20% of samples in each survey. Manchester Environmental Laboratory (MEL) routinely performs duplicate sample analyses to measure bias in lab analytical methods. The difference between total variability and laboratory variability is an estimate of the error introduced by the sampling process.

All samples will be analyzed at MEL. The laboratory's measurement quality objectives and quality control procedures are documented in the MEL Lab Users Manual (MEL, 2005). MEL will follow standard quality control procedures (MEL, 2005). Field sampling and measurements will follow quality control protocols described in Ecology (1993). If any of these quality control criteria are not met, the associated results will be qualified and used with caution, or not used at all.

Data Management Procedures

Field measurement data will be entered into a field book with waterproof paper in the field and then entered into EXCEL® spreadsheets (Microsoft, 2001) as soon as practical after returning from the field. This database will be used for preliminary analysis and to create a table to upload data into Ecology's Environmental Information Management (EIM) System.

Sample result data received from MEL by Ecology's Laboratory Information Management System (LIMS) will be exported prior to entry into EIM and added to a cumulative spreadsheet for laboratory results. This spreadsheet will be used to informally review and analyze data during the course of the project.

An EIM user study (JICA0001) has been created for this TMDL study, and all monitoring data will be available via the internet once the project data has been validated. The URL address for this geospatial database is: www.ecy.wa.gov/eim/index.htm. All data will be uploaded to EIM by the EIM data engineer once the data has been reviewed for quality assurance and finalized.

All spreadsheet files, paper field notes, and GIS products created as part of the data analysis and model building will be kept with the project data files.

Audits and Reports

The project manager will be responsible for submitting quarterly reports and the final technical study report to Ecology's Water Quality Program TMDL coordinator for this project, according to the project schedule.

Data Verification

Laboratory-generated data reduction, review, and reporting will follow the procedures outlined in the MEL Lab Users Manual (MEL, 2005). Lab results will be checked for missing and/or improbable data. Variability in lab duplicates will be quantified using the procedures outlined in the MEL Lab Users Manual (MEL, 2005). Any estimated results will be qualified and their use restricted as appropriate. A standard case narrative of laboratory quality assurance/quality control (QA/QC) results will be sent to the project manager for each set of samples.

Field notebooks will be checked for missing or improbable measurements before leaving each site. The EXCEL® Workbook file containing field data will be labeled "DRAFT" until data verification and validity are completed. Data entry will be checked by the field assistant against the field notebook data for errors and omissions. Missing or unusual data will be brought to the attention of the project manager for consultation. Valid data will be moved to a separate file labeled "FINAL."

Data received from LIMS will be checked for omissions against the "Request for Analysis" forms by the field lead. Data can be in EXCEL® spreadsheets (Microsoft, 2001) or downloaded tables from EIM. These tables and spreadsheets will be located in a file labeled "DRAFT" until data validity is completed. Field replicate sample results will be compared to quality objectives in Table 7. Data requiring additional qualifiers will be reviewed by the project manager. After data validity and data entry tasks are completed, all field, laboratory, and flow data will be entered into a file labeled "FINAL," and then into the EIM system. EIM data will be independently reviewed by another Environmental Assessment Program field assistant for errors at an initial 10% frequency. If significant entry errors are discovered, a more intensive review will be undertaken. At the end of the field collection phase of the study, the data will be compiled in a data summary.

Data Analysis and Water Quality Modeling Procedures

Data analysis will include evaluation of data distribution characteristics and, if necessary, appropriate distribution of transformed data. Estimation of univariate statistical parameters and graphical presentation of the data (box plots, time series, and regressions) will be made using WQHYDRO (Aroner, 2003) and EXCEL® (Microsoft, 2001) software.

Means, maximums, minimums, and 90th percentiles will be determined from the raw data collected at each monitoring location. Estimates of groundwater inflow will be calculated by constructing a water mass balance from continuous and instantaneous streamflow data and piezometer studies.

A model will be developed for observed and critical conditions. Critical conditions for DO are characterized by a period of low-flow and high-water temperatures. Sensitivity analysis will be run to assess the variability of the model results. Model resolution and performance will be measured using the root-mean-square-error (RMSE), a commonly used measure of model variability (Reckhow, 1986). The RMSE is defined as the square root of the mean of the squared difference between the observed and simulated values.

Water quality modeling will be conducted using QUAL2Kw (Pelletier and Chapra, 2003) or a similar biogeochemical modeling framework. The specific modeling framework is expected to be QUAL2Kw, although an alternative framework may be used instead, depending on a review of available frameworks at the time when modeling tasks will be conducted. The water quality model will use kinetic formulations for simulating DO and pH in the water column similar to those shown in Figure 9 and Table 9.

QUAL2K, or a similar model (e.g., WASP EUTRO), will be used to analyze the fate and transport of water quality variables relating to nutrients, periphyton, DO, and pH interactions in the water column. The water quality model will be developed to simulate dynamic variations in water quality of the Palouse River. The water quality model will be calibrated and corroborated using data collected during the synoptic surveys, and historical data to the extent possible.

QUAL2K will be applied by assuming that flow remains constant (i.e., steady flows) for a given condition such as a 7-day or 1-day period (using daily average flows), but key variables other than flow will be allowed to vary with time over the course of a day. For QUAL2K temperature simulation, the solar radiation, air temperature, relative humidity, headwater temperature, and tributary water temperatures are specified or simulated as diurnally varying functions.

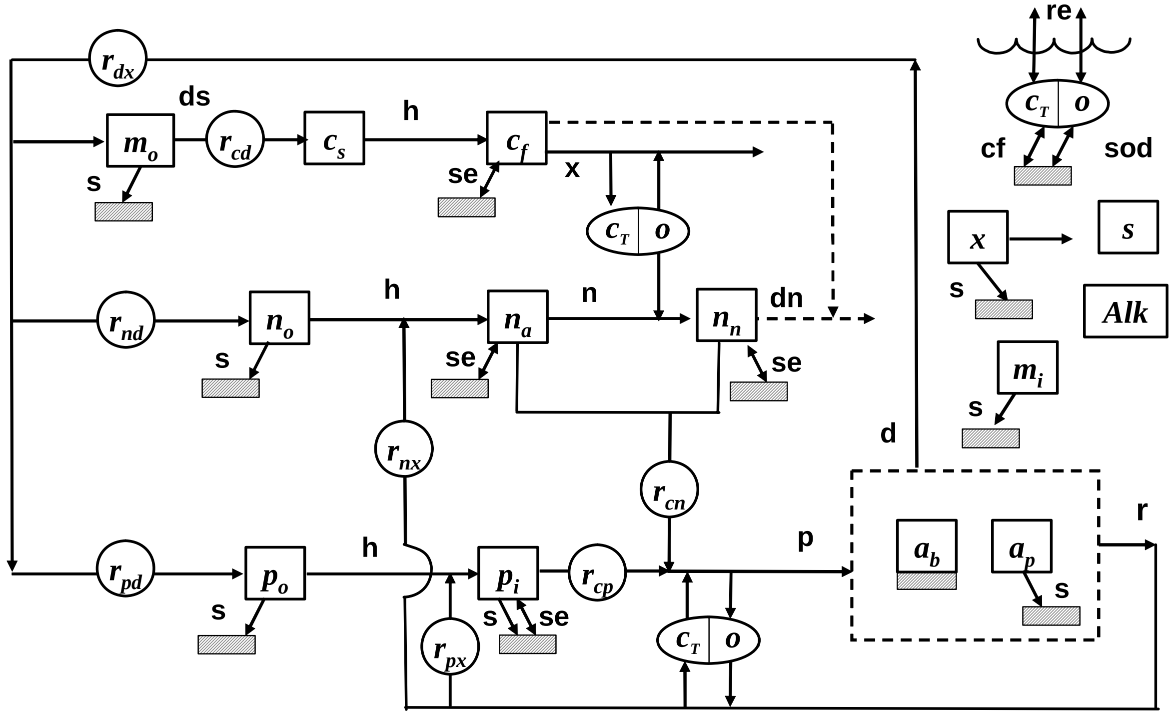

Figure 9. Model kinetics and mass transfer processes in QUAL2Kw. The state variables are defined in Table 9.

Kinetic processes are dissolution (ds), hydrolysis (h), oxidation (x), nitrification (n), denitrification (dn), photosynthesis (p), death (d), and respiration/excretion (r). Mass transfer processes are reaeration (re), settling (s), sediment oxygen demand (SOD), sediment exchange (se), and sediment inorganic carbon flux (cf).

Note that the subscript x for the stoichiometric conversions stands for chlorophyll a (a) and dry weight (d) for phytoplankton and bottom algae, respectively. For example: r_{px} and r_{nx} are the ratio of phosphorus and nitrogen to chlorophyll a for phytoplankton, or the ratio of phosphorus and nitrogen to dry weight for bottom algae; rdx is the ratio of dry weight to chlorophyll a for phytoplankton or unity for bottom algae; r_{nd}, r_{pd}, and r_{cd} are the ratios of nitrogen, phosphorus, and carbon to dry weight.

Table 9. Model state variables.

Variable	Symbol	Units*	Measured as
Conductivity	s	μmhos	COND
Inorganic suspended solids	m_i	mgD/L	TSS-VSS
Dissolved oxygen	o	mgO_2/L	DO
Slow-reacting CBOD	c_s	mgO_2/L	-
Fast-reacting CBOD	$c_{f,}$	mgO_2/L	r_{oc} * DOC or dissolved CBODU
Organic nitrogen	n_o	μgN/L	TN – NO3N NO2N– NH4N
Ammonia nitrogen	n_a	μgN/L	NH4N
Nitrate nitrogen	n_n	μgN/L	NO3N+NO2N
Organic phosphorus	p_o	μgP/L	TP - SRP
Inorganic phosphorus	p_i	μgP/L	SRP
Phytoplankton	a_p	μgA/L	CHLA
Detritus	m_o	mgD/L	r_{dc} (TOC – DOC)-r_{da}*CHLA
Alkalinity	*Alk*	$mgCaCO_3/L$	ALK
Total inorganic carbon	c_T	mole/L	Calculation from pH and alkalinity
Bottom algae biomass	a_b	gD/m^2	Periphyton biomass dry weight
Bottom algae nitrogen	IN_b	mgN/m^2	Periphyton biomass nitrogen
Bottom algae phosphorus	IP_b	mgP/m^2	Periphyton biomass phosphorus

* mg/L = $g/m^{3;}$ D = dry weight; A = chlorophyll a
r_{oc} = stoichiometric ratio of oxygen for hypothetical complete carbon oxidation (2.69)

The following are measurements that are needed for comparison with model output:

TEMP =	temperature (^oC)
TKN =	total kjeldahl nitrogen (μgN/L) or TN = total nitrogen (μgN/L)
NH4N =	ammonium nitrogen (μgN/L)
NO2N =	nitrite nitrogen (μgN/L)
NO3N =	nitrate nitrogen (μgN/L)
CHLA =	chlorophyll *a* (μgA/L)
TP =	total phosphorus (μgP/L)
SRP =	soluble reactive phosphorus (μgP/L)
TSS =	total suspended solids (mgD/L)
VSS =	volatile suspended solids (mgD/L)
TOC =	total organic carbon (mgC/L)
DOC =	dissolved organic carbon (mgC/L)
DO =	dissolved oxygen (mgO_2/L)
PH =	pH
ALK =	alkalinity ($mgCaCO_3/L$)
COND =	specific conductance (μmhos/cm)

The model state variables can then be related to these measurements as follows:

s = COND

m_i = TSS – VSS or TSS – r_{dc} (TOC – DOC)

o = DO

n_o = TKN – NH4 – r_{na} CHLA or n_o = TN – NO2 – NO3 – NH4 – r_{na} CHLA

n_a = NH4

n_n = NO2 + NO3

p_o = TP – SRP – r_{pa} CHLA

p_i = SRP

a_p = CHLA

m_o = VSS – r_{da} CHLA or r_{dc} (TOC – DOC) – r_{da} CHLA

pH = PH

Alk = ALK

Data Quality (Usability) Assessment

The field lead will verify that all measurement and data quality objectives have been met for each monitoring station. If the objectives have not been met (e.g., percent RSD for sample replicates exceeds the measurement quality objective or a Hydrolab was recording bad data), then the field lead and project manager will decide how to qualify the data and use it in the analysis or whether it should be rejected.

Project Organization

The roles and responsibilities of Ecology staff are as follows:

Environmental Assessment Program

- *Jim Carroll, Project Manager, Directed Studies Unit, Eastern Operations Section*: Responsible for overall project management. Defines project objectives, scope, and study design. Author of the Quality Assurance (QA) Project Plan for DO, pH, and nutrients. Develops the TMDLs for temperature, bacteria, and other conventional parameters, including model development and writing the technical report. Manages the data collection program. Coordinates field surveys with Eastern Regional Office staff. Collects data and conducts data quality review.

- *Brenda Nipp and Scott Tarbutton, Conventionals Field Investigators, Directed Studies Unit, Eastern Operations Section:* Coordinates and conducts field surveys. Responsible for data collection in the field, entering project data into the EIM system, and data quality review.

- *Mitch Wallace, Hydrogeologist, Freshwater Monitoring Unit, Eastern Operations Section*: Deploys and maintains continuous flow gages and staff gages. Produces records of streamflow data at sites selected for this study.

- *Gary Arnold, Section Manager, Eastern Operation Section*: Approves the QA Project Plan, the final TMDL report, and the project budget.

- *Stuart Magoon, Leon Weiks, and Pam Covey, Manchester Environmental Laboratory*: Provide laboratory staff and resources, sample processing, analytical results, laboratory contract services, and QA/QC data. Review sections of the QA Project Plan relating to laboratory analysis.

- *Bill Kammin, Ecology Quality Assurance Officer*: Reviews the QA Project Plan and all Ecology quality assurance programs. Provides technical assistance on QA/QC issues during the implementation and assessment of the project.

Water Quality Program

- *Elaine Snouwaert, Overall TMDL Coordinator, Water Quality Program, Eastern Regional Office*: Acts as point of contact between Ecology technical study staff and interested parties. Coordinates information exchange, technical advisory group formation, and organizes meetings. Supports, reviews, and comments on the QA Project Plan and technical report. Prepares the TMDL document for submittal to EPA.

- *Dave Knight, Watershed Unit Supervisor, Eastern Regional Officer*: Approves the TMDL submittal to EPA.

- *Jim Bellatty, Section Manager, Eastern Regional Officer*: Approves the TMDL submittal to EPA.

Project Schedule

Table 10. Project schedule for the Palouse River Total Maximum Daily Load study.

Environmental Information System (EIM) Data Set	
EIM Data Engineer	Nuri Mathieu
EIM User Study ID	JICA0001
EIM Study Name	Palouse River TMDL
EIM Completion Due	September 2008
Final Report	
Report Author Lead	Jim Carroll
Schedule:	
Draft to Supervisor	January 2009
Draft to Client/Peer	February 2009
External Draft	March 2009
Report Final Due (original)	June 2009

This project will be reported on quarterly, according to the schedule set up under an earlier Palouse River TMDL study QA Project Plan.

References

Ahmed, A., 2004. North Fork Palouse River Fecal Coliform Bacteria Total Maximum Daily Load Recommendations. Washington State Department of Ecology, Olympia, WA. Publication Number 04-03-022. www.ecy.wa.gov/biblio/0403022.html.

APHA, AWWA, and WEF, 1998. Standard Methods for the Examination of Water and Wastewater 20th Edition. American Public Health Association, Washington, D.C.

Aroner, E.R., 2003. WQHYDRO: Water Quality/Hydrology Graphics/Analysis System. Portland, OR.

Bilhimer, D., J. Carroll, K. Sinclair, 2006. Quality Assurance Project Plan: South Fork Palouse River Temperature Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication Number 06-03-104. www.ecy.wa.gov/biblio/0603104.html.

Bush, J.H. and Provant, A.P., 1998. Geologic Map of the Viola Quandrangle, Latah County, Idaho and Whitman County, Washington. Idaho Geological Survey, Geologic Map 25.

Cardenas, M.B. and V.A. Zlotnik, 2003. A Simple Constant-Head Injection Test for Streambed Hydraulic Conductivity Estimation, Ground Water, Vol. 41, Number 6, pages 867-871.

Carroll, J. and N. Mathieu, 2006. Quality Assurance Project Plan: South Fork Palouse River Dissolved Oxygen and pH TMDL. Washington State Department of Ecology, Olympia, WA. Publication Number 06-03-112. www.ecy.wa.gov/biblio/0603112.html

Drost, B.W., Whiteman, K.J., and Gonthier, J.B., 1990. Geologic Framework of the Columbia Plateau Aquifer System, Washington, Oregon, and Idaho. U.S. Geological Survey, Water-Resources Investigations Report 878-4238, 10 pages plus 10 plates.

Ecology, 1993. Field Sampling and Measurement Protocols for the Watershed Assessments Section. Washington State Department of Ecology, Olympia, WA. Publication Number 93-e04. www.ecy.wa.gov/biblio/93e04.html

Ecology, 2000. Determination of Instantaneous Flow Measurements of Rivers and Streams. Stream Hydrology Unit, Washington State Department of Ecology, Olympia, WA.

Ecology, 2006. Retrieval of Washington Department of Ecology Data Collected from River and Streams. Water Resource Inventory Area 34. www.ecy.wa.gov/programs/eap/fw_riv/rv_main.html.

EPA, 2001. Overview of Current Total Maximum Daily Load - TMDL - Program and Regulations. U.S. Environmental Protection Agency. www.epa.gov/owow/tmdl/overviewfs.html.

EPA, 2002. Guidance for Quality Assurance Project Plans. U.S. Environmental Protection Agency. Publication EPA QA/G-5. www.epa.gov/innovation/stategrants/g5-final.pdf.

Greene, K.E., M.D. Munn, and J.C. Ebbert, 1997. Nutrients, Benthic Algae, and Steam Quality During Low Streamflow in the Palouse River Basin, Washington and Idaho. Water Resources Investigations Report 96-4078. United States Geological Society, Tacoma, WA.

Kardouni, J., J. Carroll, and K. Sinclair, 2007. Quality Assurance Project Plan: Palouse River Temperature Total Maximum Daily Load Study. Washington State Department of Ecology, Olympia, WA. Publication Number 07-03-106. www.ecy.wa.gov/biblio/0703106.html.

Mathieu, N., 2005. Draft Memorandum: Summary of Replicate Precision for Twelve Total Maximum Daily Load (TMDL) Studies and Recommendations for Precision Measurement Quality Objectives for Bacteria and Conventional Water Quality Parameters. Environmental Assessment Program, Washington Sate Department of Ecology, Olympia, WA.

Mathieu, N., J. Carroll, and B. Nipp, 2007. Quality Assurance Project Plan: Palouse River Bacteria Total Maximum Daily Load. Washington State Department of Ecology, Olympia, WA. Publication Number 07-03-108. www.ecy.wa.gov/biblio/0703108.

MEL, 2005. Manchester Environmental Laboratory Lab Users Manual, Eighth Edition. Manchester Environmental Laboratory, Washington State Department of Ecology, Manchester, WA.

Microsoft, 2001. Microsoft Office XP Professional, Version 10.0. Microsoft Corporation.

Pelletier, G., and S. Chapra, 2003. QUAL2Kw: Documentation and User Manual for a Modeling Framework to Simulate River and Stream Water Quality. Draft Publication. Washington State Department of Ecology, Olympia, WA. www.ecy.wa.gov/programs/eap/models.html.

Porter, S.D., T.F. Cuffney, M.E. Gurtz, and M.R. Meador, 1993. Methods for Collecting Algal Samples as Part of the National Water-Quality Assessment Program; U.S. Geological Survey, Open-File Report 93-409, Denver, CO.

Recklow, K.H., 1986. Statistical Goodness-of-Fit Measures for Waste Load Allocation Models. Work Assignment Number 33, EPA Contract Number 68-01-6904.

Resource Planning Unlimited, Inc., 2004. Palouse Subbasin Management Plan. Sponsored by Palouse-Rock Lake Conservation District, St. John, WA.

Snouwaert, E. and A. Ahmed, 2005. North Fork Palouse River Fecal Coliform Total Maximum Daily Load: Submittal Report. Water Quality Program, Washington State Department of Ecology, Olympia WA. www.ecy.wa.gov/biblio/0410067.html.

Stallman, R.W., 1983. Aquifer-Test Design, Observation, and Data Analysis. Techniques of Water-Resources Investigations of the USGS, Book 3, Chapter B1. 26 pages

WAC 173-201A: Water Quality Standards for Surface Waters in the State of Washington
Washington State Department of Ecology. www.ecy.wa.gov/laws-rules/ecywac.html.

Appendix A

Response to Comments on the Draft Quality Assurance Project Plan for the Palouse River Dissolved Oxygen and pH Total Maximum Daily Load Study

The draft report, *Quality Assurance Project Plan for the Palouse River Dissolved Oxygen and pH TMDL Study*, was distributed to the Palouse River Technical Advisory Group (TAG) on July 3, 2007, for a two-week comment period. Comments were due by July 20, 2007. Ecology did not receive any written review comments; no changes were incorporated into the final QA Project Plan.