Quality Assurance Project Plan

South Fork Palouse River Temperature Total Maximum Daily Load Study

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This plan was prepared by a licensed hydrogeologist.
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303(d) Listings Addressed in this Study

Listing ID	Waterbody description	New Waterbody ID	Old Waterbody ID #
3724	Palouse River, S.F.	ZX82FM	WA-34-1020
8130	Palouse River, S.F.	ZX82FM	WA-34-1020

Project Tracker Code: 05-008-02

Approvals

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Glossary of Acronyms

7DADMax, 7-day average of the daily maximum temperature
7DADMin, 7-day average of the daily minimum temperature
DAve, Daily average temperature
DMax, Daily maximum temperature
DMin, Daily minimum temperature
EIM, Environmental Information Management (system)
EPA, US Environmental Protection Agency
IDEQ, Idaho Department of Environmental Quality
NFPR, North Fork Palouse River (a.k.a. Palouse River from Idaho border to Colfax)
NIST, National Institute of Standards and Technology
NPDES, National Pollutant Discharge Elimination System
ODEQ, Oregon Department of Environmental Quality
PCD, Palouse Conservation District
PST, Pacific Standard Time
PDT, Pacific Daylight Savings Time
SFPR, South Fork Palouse River
TI, Temperature Instrument
TIR, Thermal Infra-red remote sensing
TMDL, Total Maximum Daily Load
USGS, US Geological Survey
WES, Watershed Ecology Section, EA Program, Washington Department of Ecology
WSDOT, Washington State Department of Transportation
WRIA, Watershed Resource Inventory Area
WSU, Washington State University
WWTP, Wastewater Treatment Plant

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 study to identify and quantify sources of the impairments and to recommend implementation strategies for reducing point and nonpoint source loads.

The South Fork Palouse River is listed on the 303(d) list of impaired waterbodies for high instream temperatures. This Quality Assurance Project Plan describes the technical study that will evaluate instream temperatures in those impaired waterbodies and build on previous data collection efforts conducted by a variety of governmental and private organizations. The study will be conducted by the Washington State Department of Ecology Environmental Assessment Program. The South Fork Palouse River will be intensively monitored during 2006; the other temperature listings in the Palouse River Watershed Resource Inventory Area 34 will be addressed in a subsequent study in 2007.

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 Federal 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.

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, the Washington State Department of Ecology (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 one of 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 its being implemented.
  - 4b – Has a pollution control plan in place that should solve the problem.
  - 4c – Impaired by a non-pollutant such as low water flow, dams, culverts.
- Category 5 – Polluted waters that require a TMDL – or the 303d list.

TMDL Process Overview

The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be developed for each of the waterbodies on the 303(d) list. A TMDL identifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology works with the local community to develop a strategy to control the pollution and a monitoring plan to assess effectiveness of the water quality improvement activities.

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, 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 source (referred to as a 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 sources (referred to as a nonpoint source) 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. 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 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.

Introduction

The South Fork Palouse River (SFPR) and its tributaries form a sub-watershed within WRIA 34 in southeastern Washington. The upper part of the watershed extends into western Idaho. The Idaho Department of Environmental Quality (IDEQ) is developing a TMDL for the upper part of the SFPR watershed and has developed one for the Idaho portion of Paradise Creek. This TMDL effort will focus on the portion of the watershed within Whitman County, Washington State, from the state border to the town of Colfax (Figure 1). The SFPR flows into the mainstem Palouse River immediately downstream of Colfax. The study area includes two waterbody segments impaired by temperature as listed in the 2004 Clean Water Act Section 303(d) list (Category 5). An additional three sites are listed as water's of concern (Category 2) on Washington's 2004 Water Quality Assessment (Table 1).

Table 1. WRIA 34 Temperature 303(d) Listings and Waters of Concern.

Listing ID	Category	Waterbody description	New Waterbody ID	Old Waterbody ID #	Listing Cycle
3724	5	Palouse River, S.F.	ZX82FM	WA-34-1020	2004
8130	5	Palouse River, S.F.	ZX82FM	WA-34-1020	2004
8129	2	Palouse River, S.F.	ZX82FM	WA-34-1020	2004
8131	2	Palouse River, S.F.	ZX82FM	WA-34-1020	2004
8143	2	Paradise Creek	YO22BZ	WA-34-1025	2004

Project Objectives

1. Characterize stream temperatures and processes governing the thermal regime in the SFPR including the influence of tributaries, point sources, and groundwater/surface water interactions on the heat budget.
2. Develop a predictive temperature model for the SFPR. Using critical conditions in the model, determine the SFPR's capacity to assimilate heat. Evaluate the system potential temperature (approximated natural temperature conditions) for the SFPR. The calibrated temperature model will be used to evaluate future water quality management decisions in the SFPR basin.

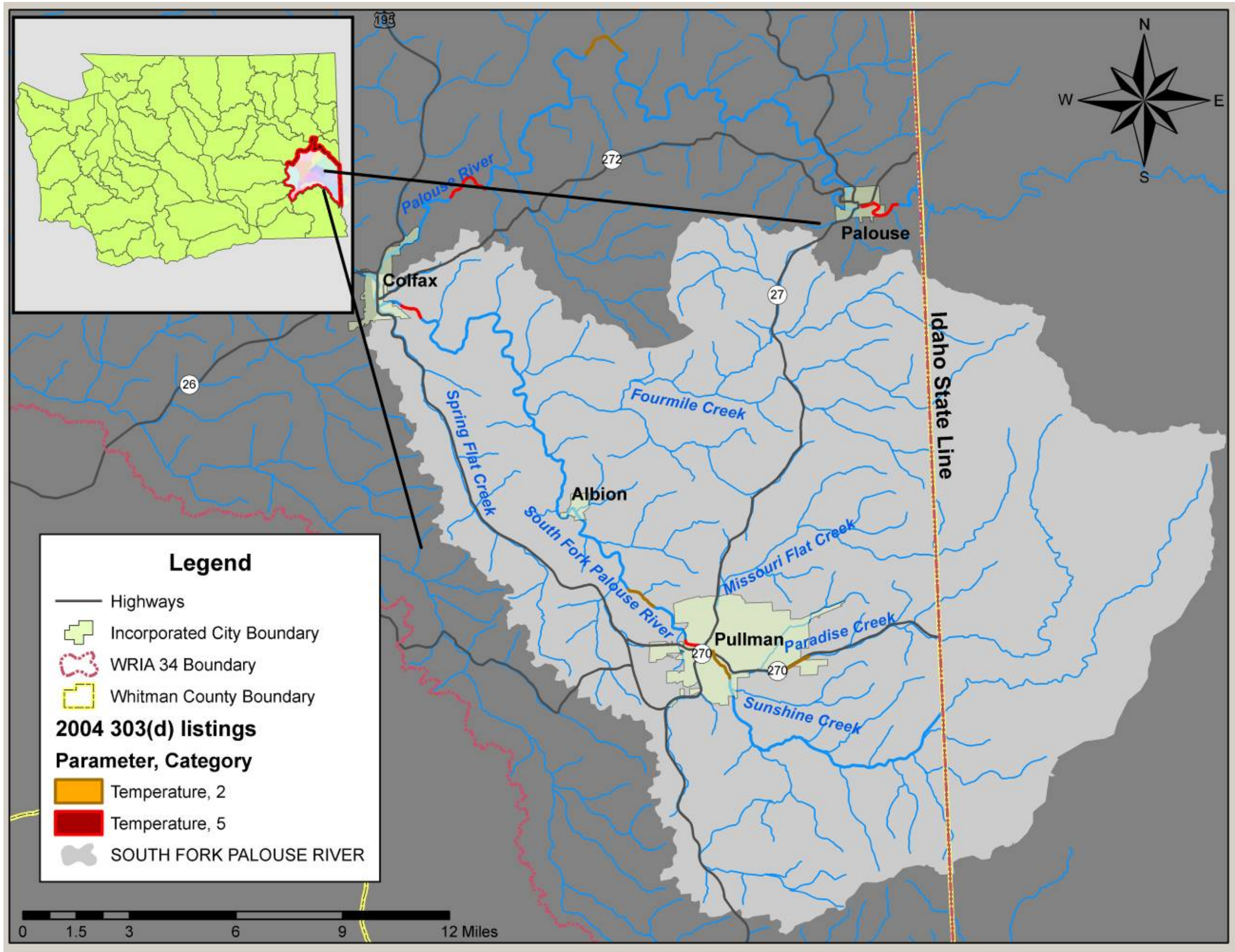

Figure 1. South Fork Palouse River Watershed.

Water Quality Standards and Beneficial Uses

1997 Temperature Water Quality Standards for Freshwater

Under the 1997 Washington Administrative Code (WAC) 173-201A-130, the SFPR is classified as Class A. WAC 173-201A-030 (1997) defines the characteristics of Class A waters as follows:

(2) Class A (excellent).

> *(a) General characteristic. Water quality of this class shall meet or exceed the requirements for all or substantially all uses.*
> *(b) Characteristic uses. Characteristic uses shall include, but not be limited to, the following:*
>
> > *(i) Water supply (domestic, industrial, agricultural).*
> > *(ii) Stock watering.*
> > *(iii) Fish and shellfish.*
> > *(iv) Wildlife habitat.*

(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment).

(vi) Commerce and navigation.

WAC 173-201A-030 (2)(c)(iv) defines the water quality standard as:

(iv) Temperature shall not exceed 18.0°C (freshwater) due to human activities. When natural conditions exceed 18.0°C (freshwater), no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C. Incremental temperature increases resulting from point source activities shall not, at any time, exceed t=28/(T+7) (freshwater). Incremental temperature increases resulting from nonpoint source activities shall not exceed 2.8°C.

For purposes hereof, "t" represents the maximum permissible temperature increase measured at a mixing zone boundary; and "T" represents the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.

2003 Proposed Temperature Water Quality Standards for Freshwater

In July 2003, 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 had used for decades to designate uses to be protected by water quality criteria (e.g., temperature, dissolved oxygen, turbidity, bacteria). Ecology also revised the numeric temperature criteria that were to be assigned to waters to protect specific types of aquatic life uses (e.g., native char, trout, and salmon spawning and rearing in warm water fish habitat).

The revised water quality standards regulation was submitted to 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. Their main concerns were over the temperature criteria applied to waters that support endangered fish species (e.g., bull trout, salmon, and steelhead). As a consequence, EPA has formally disapproved portions of the revised standards.

Ecology has agreed to initiate state rule revision proceedings that will consider making the changes EPA has highlighted as necessary. 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.

The state expects to conclude its corrective rulemaking proceedings in October 2006 and have approved state standards in early 2007. Until that time, TMDLs must be based on the 1997 version of the state water quality standards, rather than the 2003 version that was disapproved by EPA.

TMDLs will be designed during this uncertain transition period with formal allocations that meet the existing (1997) approved standards. In all TMDL technical studies completed during this transition period, the analysis must include a scenario evaluating what would be required to meet the EPA required standards in the corrective rule.

Proposed revisions to the existing standards can be found online at Ecology's water quality standards website www.ecy.wa.gov/programs/wq/swqs. Table 2 provides a general structure for understanding the expected changes for Class A waters including the South Fork Palouse River.

Table 2. Expected Water Quality Standard Changes for Temperature in Class A 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[4]	"Non-core" Salmon/Trout	17.5°C 7-DADMax[3, 5]

1. Class A waters were subcategorized into *native char* and *salmon/trout non-core rearing* designated use types during the 2003 revision to the water quality standards regulation.
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. The 2007 corrected water quality standards rule will contain supplemental spawning and incubation temperature criteria (13°C for salmon and trout, and 9°C for native char) that will be applied to specific portions of many of these waters.
4. 1-DMax means the highest annual daily maximum temperature occurring in the waterbody.
5. 7-DADMax means the highest annual running 7-day average of daily maximum temperatures.

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, even under natural conditions (absent any contributing human effects). some waterbodies will fail to meet the criteria. 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.

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. Some sources of human degradation cannot be remedied due to both technical and/or social (legal) limitations. 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. Thus, while an assessment of natural conditions may demonstrate what was once attainable, it may not represent what can be attained given the changes that have occurred over more than a century.

Background

Study Area

The SFPR basin is located primarily in Whitman County, Washington, and its headwaters are in Latah County, Idaho. The SFPR is approximately 47.2 miles long, 33.9 miles of which is within Washington State. There are three towns along the SFPR: Pullman (population 24,675 with 14,122 persons in college), Albion (population 616), and Colfax (population 2,844) (WAOFM, 2005). In Pullman, the Washington State University (WSU) campus incurs a significant increase on the town population during the school year (2005 enrollment in Pullman is approximately 18,690 students) resulting in an increase of intake volumes at the waste-water treatment plant (WWTP) from mid-August to early-May. The SFPR meets the mainstem Palouse River less than a mile downstream of the town of Colfax. The SFPR watershed area is approximately 11.5% (219,943 acres) (see Table 3 for more detail) of the total WRIA 34 area (1,908,776 acres).

Table 3. South Fork Palouse River Watershed Area Totals.

Watershed Name	Subwatershed Name	Area (Acres)*
South Fork Palouse River	Kamiak Butte (Upper Fourmile Cr)	45,715
	Lower Fourmile Creek	15,721
	Lower South Fork Palouse River	11,824
	Middle South Fork Palouse River	19,183
	Missouri Flat Creek	17,447
	Paradise Creek	22,549
	Spring Flat Creek	12,980
	Sunshine Creek	21,777
	Upper Fourmile Creek	15,152
	Upper South Fork Palouse River	37,593
South Fork Palouse River Total Acreage		219,943

*Data Reference: HUC_6th_field.lyr published by US Department of Agriculture, Natural Resources Conservation Service, Regional Ecosystem Office, Portland, Oregon. 2002. 1:24,000 scale.

Paradise Creek drains about 35 square miles from its headwaters at Moscow Mountain in Idaho to its confluence with the SFPR near the eastern Pullman city limits. The creek serves as the receiving waters for the Moscow WWTP, located approximately 0.5 miles east of the state line. During low-flow periods (June to October), the WWTP discharge can account for up to 87% of the flow in Paradise Creek at the state line (Hallock, 1993).

Missouri Flat Creek originates north of Moscow in Idaho and flows west across the state border where it bends south, travels through Pullman along Highway 27/Grand Avenue, and converges with the SFPR near downtown Pullman. The 27 square mile drainage area is influenced primarily by nonpoint agricultural runoff; however, the stretch of the creek within the Pullman city limits receives residential and commercial runoff from 26 separate storm drains.

Hydrology

The US Geological Survey (USGS) currently operates one streamflow gage on the SFPR in the town of Pullman (#13348000) with a 34-year record (see Figure 2). The gage has not been in continuous operation, but has data for the years 1934-1942, 1960-1981, and 2001-present. This gage is downstream of Paradise Creek at the State Street crossing of the SFPR. Peak flows typically occur from January through March and baseflows from August through September. For the objectives of the temperature study, monthly average streamflows for the critical period from June through September are important to focus on (Table 4). The two 7Q10 values were calculated using the longest continuous period of record (1960-1981) and for the entire discontinuous period of record (1934-2004).

Table 4. USGS Streamflow Gage #13348000 (SFPR at Pullman) Average Monthly \Streamflow Calculated from the Entire Period of Record. The 7Q10 Value is Calculated using the 'Log-Pearson Type III Frequency Factor Method.

Monthly Average Streamflow (cfs)				July - Sept 1960-1981	July - Sept Entire Period of Record
June	July	August	September	7Q10	7Q10
10.29	3.68	3.06	3.36	1.62	0.76

There were six historical streamflow gages located on the SFPR and major tributaries, and the monthly average of the daily average streamflow can be found in Appendix A. Two of these historical stations are the most relevant to this study: SFPR at Colfax (#13349200) and Paradise Creek (#13347000); all six were discontinued. The original location of the USGS gage at Colfax is the last appropriate stream gaging opportunity at the downstream end of the study area because of the flood control channel running through town. Continuous stream gaging on Paradise Creek and the SFPR will be important to this project to help understand the daily flow fluctuation (during low-flow periods) resulting from WWTP discharges.

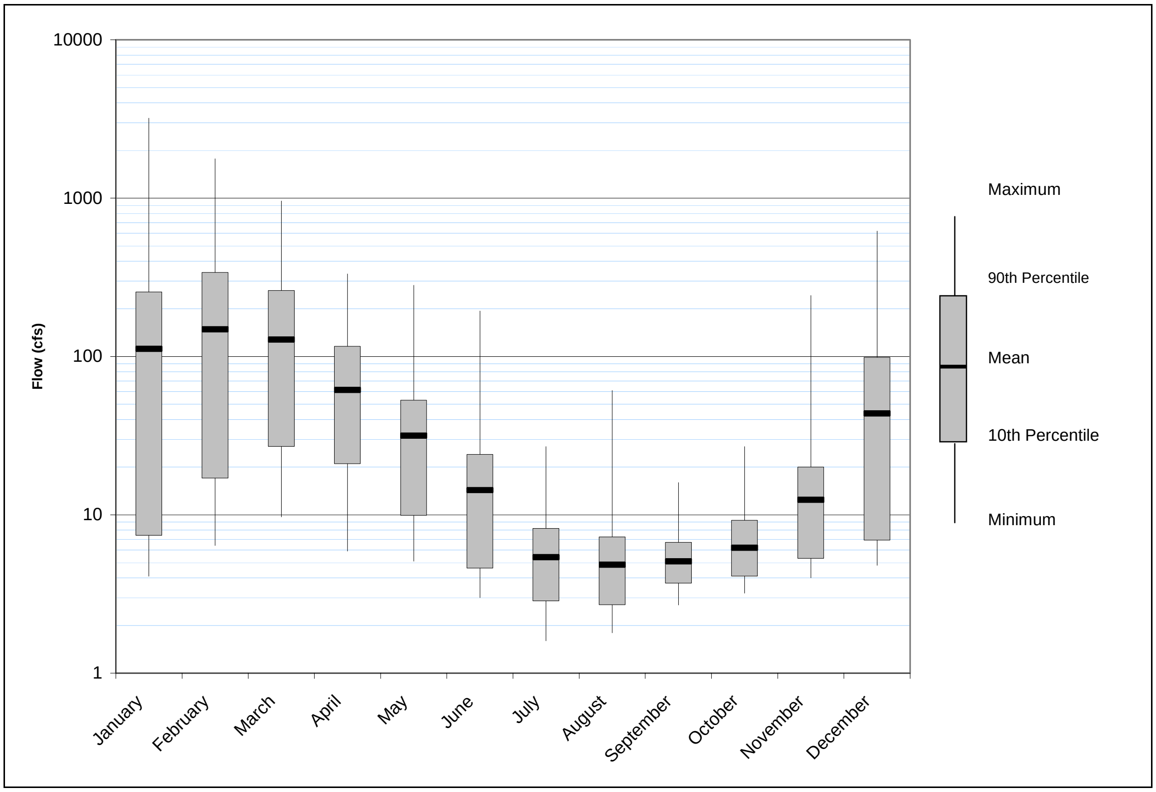

Figure 2. USGS Stream Gage Mean Monthly Flows for the SFPR at Pullman from 1970 - 2004.

The magnitude of the Pullman WWTP discharge can be greatly affected by the WSU school schedule. Norm Glenn (1992) examined two weekly influent flow charts from the Pullman WWTP as part of a Class II inspection and found that the difference in peak influent flow (approximately 2.5 mgd) between a week in July and a week in early October was attributed to the large increase in the number of students living in town once school was in session in October compared to the summer break time when few students remain in town. The two weekly influent flow charts exhibit a bimodal pattern in daily inflow volumes as the result of patterns of human water consumption; the pattern is stronger for the October data compared to the July data. The dual, daily-peak patterns in the streamflow gage record at Colfax (see Figure 3) suggest that daily fluctuations are influenced by patterns of household wastewater discharged from the WWTP to the river.

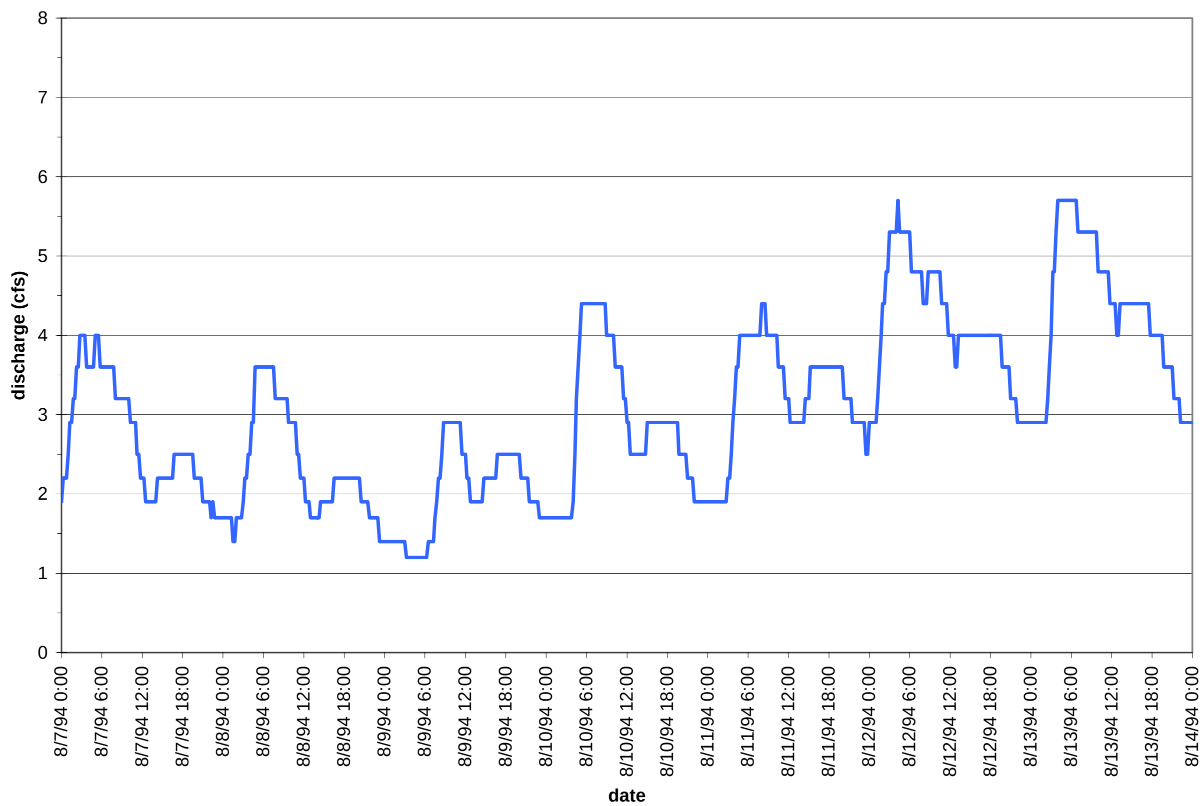

Figure 3. A Closer Look at a One Week Continuous Streamflow Record for the SFPR Gage at Colfax (#13349200) Showing the Daily Fluctuation in Stream Stage Resulting from Upstream Point Discharges.

Land-Use Patterns

Land use within the study area is dominated by dryland agriculture (Table 5) and interspersed with several clusters of urban population. The majority of population is concentrated around WSU in the city of Pullman and the University of Idaho in Moscow. Smaller communities include the towns of Colfax (at the mouth of the SFPR) and Albion, located along the SFPR between Pullman and Colfax. Major crops include spring and winter wheat, barley, peas, and lentils. These crops are produced without irrigation, thus the term *dryland agriculture* (RPU, Inc., 2002).

Table 5. Land Use in SFPR Watershed (RPU, Inc., 2002).

Land Use	Acres	% of Watershed
Cropland	154,764	82%
Urban Use (Including Roadways)	15,100	8%
Forestland	11,324	6%
Rangeland	3,774	2%
Riparian/Wetland	3,774	2%
Total	**188,736 acres**	

Geology

The SFPR watershed lies near the eastern edge of the Columbia Plateau Aquifer System (Drost et al., 1990). The western two-thirds 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 areas 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 Palouse uplands in Washington State are generally mantled by thick accumulations of loess (wind blown sand, silt, and clay). Where stream valleys bisect the uplands, the loess typically grades laterally into coarser deposits of alluvium and colluvium derived from reworked loess, basalt, and granatoid fragments (Bush et al., 1998).

Vegetation

Past vegetation assessments of the Palouse bioregion (Weaver, 1917; Daubenmire, 1942; and Black et al., 2005) describe the region as dominated by bunchgrasses on the original prairies prior to 1900. Riparian areas in the Palouse were limited to supporting *a narrow gallery forest of plains cottonwood (Populus deltoids), quaking aspen (P. tremuloides), mountain maple (Acer glabrum), and red alder (Alnus rubra)* (Black et al, 2005). Gilmore (2005) describes the SFPR system potential riparian vegetation to include: grasses and sedges, hawthorn, snowberry, ninebark, rose, willow, alder, birch and the occasional Ponderosa pine and Douglas fir.

Climate

Annual precipitation in this watershed can range from 15-25 inches of rain per year. A drought was declared in 2001 and 2005. Summer daily maximum air temperatures can range from mid-80ºF to mid-90ºF (around 29ºC to 35ºC) and occasionally over 100ºF (37.8ºC). There is a weather monitoring station at the Pullman/Moscow regional airport collecting data on: air and dewpoint temperatures, wind speed and direction, barometric pressure, and weather observations (see Appendix A for a summary of the 2005 weather station data).

Sources of Pollution

Point Sources

The major point-source discharger to SFPR is the Pullman WWTP with its outlet at the outskirts of the Pullman municipal boundary downstream of the town. Figure 4 shows the temperature of the effluent discharged to the SFPR by the Pullman WWTP. Effluent temperature grab samples are recorded at the same time every morning. Pullman WWTP also records instream temperatures three times daily on the SFPR, both above and below their point of discharge, using an Onset temperature datalogger, and they use a continuous flow recorder for their discharge to the SFPR.

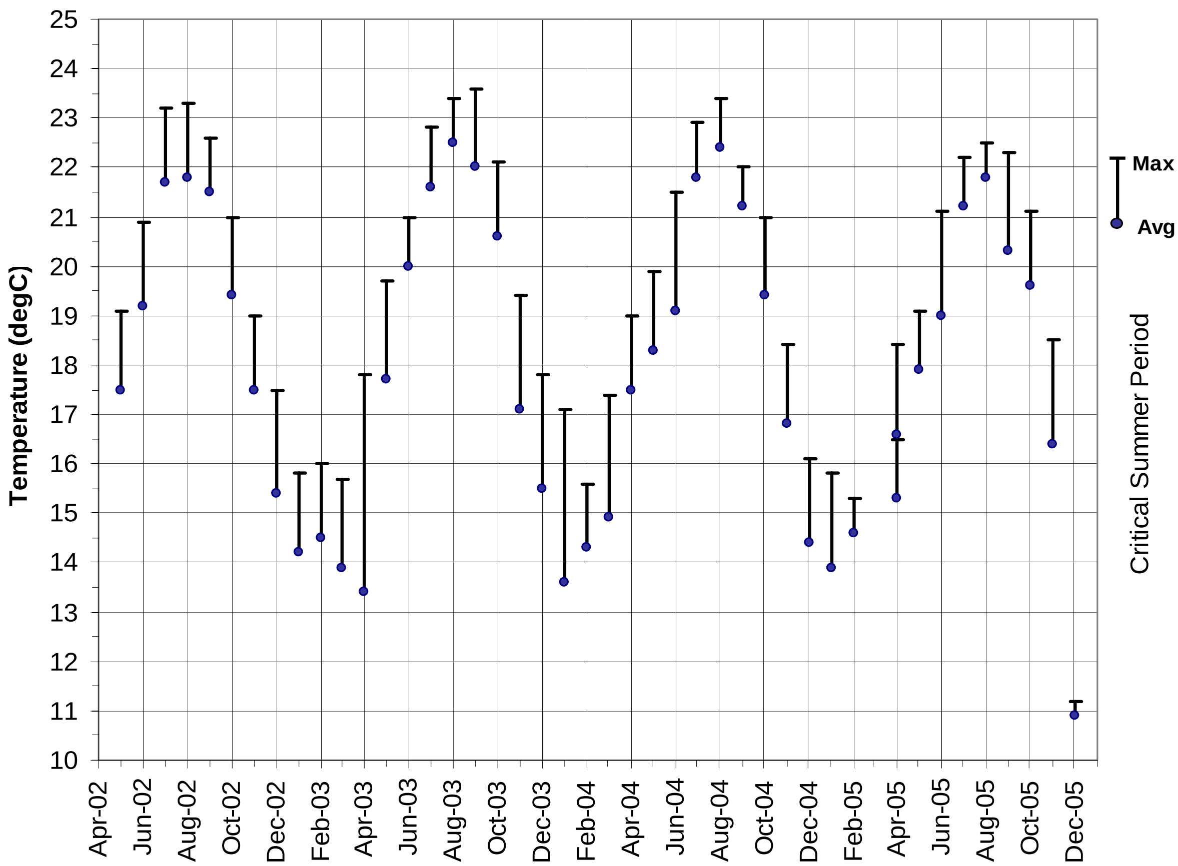

Figure 4. Summary of Pullman WWTP Discharge Grab Sample Temperature for each Month from May 2002 to December 2005. Average and Maximum Temperatures are Computed as the Average and Maximum of all Measurements Made During Each Month.

Paradise Creek, a tributary to the SFPR, also receives a major point-source discharge from the Moscow WWTP. The City of Moscow WWTP uses continuous temperature and flow monitoring for their effluent that enters Paradise Creek. They also use continuous instream temperature monitoring equipment on Paradise Creek above and below their point of discharge. A portion of the facility's discharge goes to a beneficial reuse program operated at the University of Idaho, where it is land applied. The WWTP discharge constitutes the majority of the streamflow in Paradise Creek during summer baseflow conditions.

Non-Point Sources

Non-point sources are pollutant loads that cannot be attributed to a single point of discharge, but they are the diffuse accumulation of pollutant loads over a given area. Contributing factors to stream heating loads include:

1. Riparian vegetation disturbance and loss of shade due to:
   - Removal of trees and shrubs for pasture, crops, timber harvest, roads, or buildings.
   - Heavy grazing by livestock and wild animals.
   - Conversion of forest to pasture land.
2. Channel morphology impacts resulting from:
   - Increased sediment loading from agriculture and roads.
   - Channel constraint/diking for agriculture, flood control, and roads.
   - Bank instability/erosion and sedimentation from removal of established riparian vegetation and high stream velocities from past channel straightening projects and other land-use practices in the watershed.
   - Increases in channel width and corresponding decrease in depth due to incision or aggradation.
3. Hydrologic changes influenced by:
   - Extraction of groundwater for irrigation, household, or other purposes.
   - Global climate change and its regional effects on overall water quantity (snow pack) as well as the timing and magnitude of the spring freshet.

The role of riparian vegetation in maintaining a healthy stream condition and water quality is well documented and accepted in the scientific literature. Summer stream temperature increases due to the removal of riparian vegetation are well documented (for example Lynch et al., 1984; Swift and Messer, 1971; and Brown et al., 1971). These studies generally support the findings of Brown and Krygier (1970) that loss of riparian vegetation results in larger daily temperature variations and elevated monthly and annual temperatures. Adams and Sullivan (1989) also concluded that daily maximum temperatures are strongly influenced by the removal of riparian vegetation because of the effect of diurnal fluctuation in solar heat flux.

Rates of heating to the stream surface can be dramatically reduced when high levels of shade are present and heat flux from solar radiation is minimized. There is a natural maximum level of shade that a given stream is capable of attaining, which is a function of species composition, soils, climate, and stream morphology.

The distinction between reduced heating of streams and actual cooling is important. Shade can significantly reduce the amount of heat flux that enters a stream. Whether there is a reduction in the amount of warming of the stream, maintenance of inflowing temperatures, or cooling of a stream as it flows downstream depends on the balance of all of the heat exchange and mass transfer processes in the stream.

Historical Data

Data relevant to this TMDL study have been collected for the last several years under the direction of the Palouse Watershed Planning Unit. On-going monitoring of stream temperatures has been conducted by the Palouse Conservation District and Ecology's ambient monitoring stations in the WRIA. Studies used to develop this study plan include:

- *Golder & Associates 2005 Data Collection for GW/SW Study and Vegetation*
  The flow and temperature monitoring project conducted by Golder & Associates (DeFrancesco, 2005) helped to identify the importance of the timing of streamflow measurements and how the complexity of the dynamic hydrology in the system can make it difficult to quantify groundwater net gains and losses. Point-source discharges from the Pullman and Moscow WWTPs provide most of the instream flow to the SFPR during baseflow conditions. Municipal water consumption patterns and the resultant WWTP discharges can fluctuate widely within a 24-hour period resulting in a daily rise and fall in stream stage as the discharge volume moves downstream through the system.

  A system potential vegetation study was also completed by Golder & Associates that identified native riparian vegetation types that have the potential to establish riparian corridors along SFPR (Gilmore, 2005). Many different sources of historical information and current surveys of soil types and reference conditions (the Rose Creek preserve and existing vegetation along SFPR) were evaluated. These data will be used to guide development of the stream model for system potential shade inputs.

- *Airborne TIR Survey*
  An airborne Thermal Infra-Red (TIR) survey was conducted on July 30 and 31, 2005, on the South Fork Palouse River, North Fork Palouse River, and Paradise Creek. Data products from the TIR survey included geo-referenced and ortho-rectified full-color and thermal infrared images of the study streams, and longitudinal profiles of median stream temperatures derived from the TIR data. The TIR imagery will help guide investigation of probable groundwater seeps and the full-color imagery will facilitate the mapping of existing vegetation along the SFPR riparian corridor.

- *Ecology Ambient Water quality Monitoring Stations*
  Ecology's ambient monitoring program for Washington State includes three monitoring stations in the SFPR subbasin. Continuous temperature data from station 34B110 (SFPR at Pullman) was the basis for 303(d) listing #3724 showing a 7-day average of daily maximum values (7DADMax) of 22.2°C (71.96ºF) for July 13, 2001. Three stations collected continuous temperature measurements (30 minute intervals) in 2005 (see Figure 5). Table 6 details the monthly average of the daily maximum temperature, standard deviation, and maximum 7DADMax for these four stations.

Table 6. 2005 Monthly Summary for Ambient Monitoring Stations.

Station ID	July (°C)				August (°C)			
	Avg. DMax	Stdev	Max 7DADMax	Date of 7DADMax	Avg. DMax	Stdev	Max 7DADMax	Date of 7DADMax
34C100 (Paradise Cr)	21.31	0.74	21.67	7/30/2005	20.64	0.95	21.33	8/1/2005
34B110 (SFPR at Pullman)	20.03	0.67	20.39	7/15/2005	17.83	1.64	20.1	8/1/2005
34B130 (SFPR blw Sunshine)	21.57	1.13	22.51	7/4/2005	17.62	1.59	20.57	8/1/2005

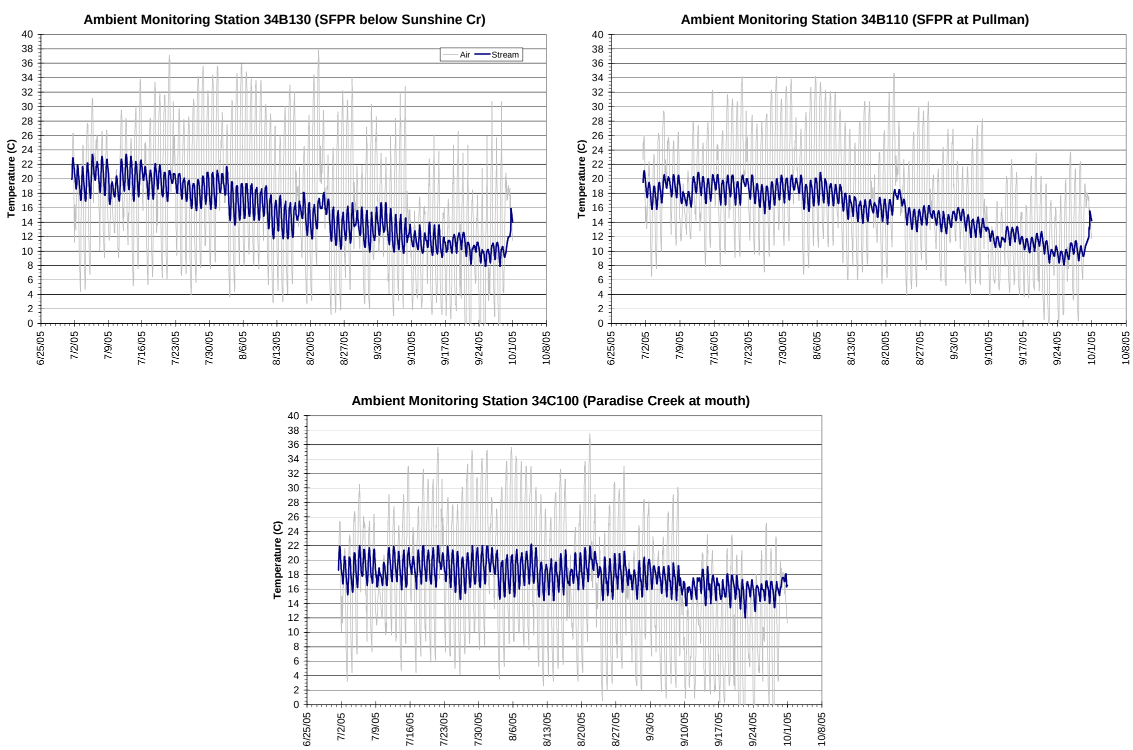

Figure 5. Continuous Monitoring Data for 2005 at Ecology's Ambient Monitoring Program.

Project Description

Study Approach

The South Fork Palouse River temperature TMDL will be developed for heat (i.e., incoming solar radiation). Heat is considered a pollutant under Section 502(6) of the Clean Water Act. The transport and fate of heat in natural waters has been the subject of extensive study. Edinger et al. (1974) provide an excellent and comprehensive report of this research. Thomann and Mueller (1987) and Chapra (1997) have summarized the fundamental approach to the analysis of heat budgets and temperature in natural waters that will be used in this TMDL. Figure 6 shows the major heat energy processes or fluxes across the water surface and streambed. Adams and Sullivan (1989) reported that the following environmental variables are the most important drivers of water temperature:

- **Stream Depth**
  Stream depth affects both the magnitude of the stream temperature fluctuations and the response time of the stream to changes in environmental conditions.

- **Solar Radiation and Riparian Vegetation**
  The daily maximum temperatures in a stream are strongly influenced by removal of riparian vegetation because it blocks and/or reduces the amount of radiation reaching the stream and establishes a micro-climate along the stream that may be cooler than that experienced without the vegetation. Daily average temperatures are less affected by removal of riparian vegetation.

- **Groundwater**
  Inflows of groundwater can have an important cooling effect on stream temperature. This effect will depend on the rate of groundwater inflow relative to the flow in the stream and the difference in temperatures between the groundwater and the stream.

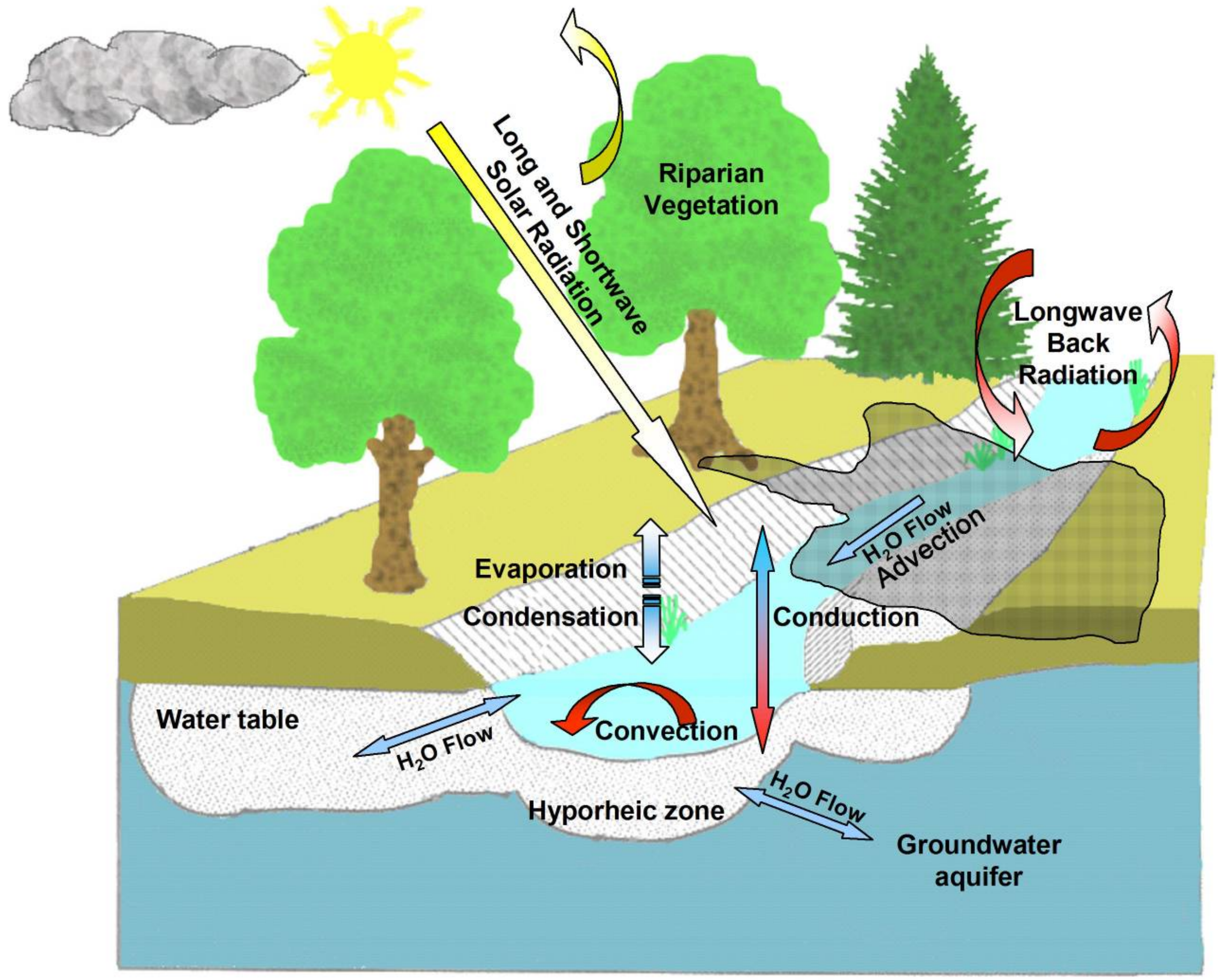

Figure 6. Surface Heat Transfer Processes that Affect Water Temperature.

The heat exchange processes with the greatest magnitude are as follows (Edinger et al., 1974):

- **Short Wave Solar Radiation**
  Short wave solar radiation is the radiant energy that passes directly from the sun to the earth. It constitutes the major thermal input to an unshaded body of water during the day when the sky is clear.

- **Long Wave Atmospheric Radiation**
  Long wave atmospheric radiation depends primarily on air temperature and humidity and increases as both of those increase. It constitutes the major thermal input to a body of water at night and on warm cloudy days.

- **Long Wave Back Radiation from the Water to the Atmosphere**
  Water radiates heat energy back to the atmosphere in the form of long wave radiation. Back radiation accounts for a major portion of the heat loss from a body of water. Back radiation increases as water temperature increases.

Rates of heating to the stream surface can be dramatically reduced when high levels of shade are produced and heat flux from solar radiation is minimized. There is a natural maximum level of shade that a given stream is capable of attaining, which is a function of species composition, soils, climate, and stream morphology.

The distinction between reduced heating of streams and actual cooling is important. Shade can significantly reduce the amount of heat flux that enters a stream. A reduction in the amount of warming or cooling of a stream as it flows depends on the balance of all of the heat exchange and mass transfer processes in the stream.

Mass transfer processes refer to the downstream transport and mixing of water throughout a stream system and inflows of surface water and groundwater. The downstream transport of dissolved/suspended substances and heat associated with flowing water is called advection. Dispersion results from turbulent diffusion that mixes the water column. Due to dispersion, flowing water is usually well-mixed vertically. Stream water mixing with inflows from surface tributaries and subsurface groundwater sources also redistributes heat within the stream system. These processes (advection, dispersion, and mixing of surface and subsurface waters) redistribute the heat of a stream system via mass transfer. Tributaries and groundwater inflows can change the temperature of a stream segment when the inflow temperature is different from the receiving water.

Data Needs

Since temperature is a measure of heat content, the TMDL will be developed for heat. Temperature is an indication of heat content of the material. If heat accumulates in the waterbody due to the processes discussed above, there will be a net increase in temperature of the water column and vice versa.

Stream temperatures will be modeled using a stream water quality model such as QUAL2K (Chapra, 2003) or GEMSS (Edinger and Buchak 1980, 1995). QUAL2Kw is a one dimensional (completely-mixed vertically and laterally) model with steady-state hydraulics and diurnal water quality simulation capabilities. GEMSS is a one dimensional model with dynamic hydraulics and water quality simulation.

Effective shade produced by current riparian vegetation will be estimated using Ecology's Shade-model (Ecology, 2003a). The shade model is a spreadsheet model that calculates effective shade by using the HeatSource model developed by Oregon Department of Environmental Quality (ODEQ, 2003). Data needs for temperature modeling are listed in Table 7.

Table 7. Temperature Data Requirements.

	Parameter	Model Requirement		Data Source		
		Shade	Temperature Model	Ecology Field Studies	Other Data Contributor	GIS Analysis
Flow	discharge - tributary		x	x		
	discharge (upstream & downstream)		x	x		
	flow velocity		x	x		
	groundwater inflow rate/discharge		x	x		
	travel time		x	x		
General	calendar day/date	x	x	x		
	elevation - downstream	x	x			x
	elevation - upstream	x	x			x
	elevation/altitude	x	x			x
	latitude	x	x	x		x
	longitude	x	x	x		x
Physical	channel azimuth/stream aspect	x	x			x
	cross-sectional area	x	x	x		
	Manning's n value	x	x	x		
	reach length	x	x			x
	width - bankfull	x		x		
	width - stream	x	x	x		
Temperature	temperature - groundwater		x	x		
	temperature - tributaries		x	x		
	temperature - water downstream		x	x		
	temperature - water upstream		x	x		
	temperature - air		x	x		
	temperature – point sources			x	x	
Vegetation	% riparian cover on each side	x		x	x	x
	canopy-shading coefficient/veg density	x			x	
	diameter of shade-tree crowns	x				x
	distance to shading vegetation	x		x		x
	topographic shade angle	x				x
	vegetation height	x		x	x	
	vegetation shade angle	x				x
	vegetation width	x		x	x	x
Weather	dewpoint temperature		x	x	x	
	% possible sun/cloud cover		x		x	
	wind speed and direction		x	x	x	
	barometric pressure			x	x	
	precipitation			x		
	solar radiation		x	x		
	temperature- air		x	x		
	wind speed/direction		x	x		

Study Design

The TMDL technical assessment for the SFPR will use effective shade as a surrogate measure of heat flux to fulfill the requirements of Section 303(d) of the Clean Water Act. Effective shade is defined as the fraction of the potential solar short wave radiation that is blocked by vegetation and topography before it reaches the stream surface. Effective shade accounts for the interception of solar radiation by vegetation and topography.

Heat loads to the stream will be calculated in the TMDL using a heat budget that accounts for surface heat flux and mass transfer processes. Heat loads are of limited value in guiding management activities needed to solve identified water quality problems. Shade will be used as a surrogate to thermal load as allowed under EPA regulations (defined as *other appropriate measure* in 40 CFR § 130.2(i)). A decrease in shade due to inadequate riparian vegetation causes an increase in solar radiation and thermal load upon the affected stream section. Other factors influencing the distribution of the solar heat load also will be assessed, including increases in streamflow and groundwater interactions.

Representativeness and Completeness

Representativeness of the data is achieved by a sampling scheme that accounts for land practices, flow contribution of tributaries and point sources, and seasonal variation of instream flow and temperatures in the watershed. Stream temperature measurements will be made in the well-mixed portion of the streamflow where there is no thermal stratification and no direct influence from standing water in pools or the stream margins. Five types of field studies will be conducted to measure physical processes in the river system: 1) temperature monitoring network, 2) groundwater/surface water interactions, 3) stream gauge and flow, 4) stream velocity, and 5) riparian habitat and channel geometry.

Establish a temperature monitoring network

Continuously recording temperature instruments (TI) will be deployed at approximately 36 key locations along the mainstem SFPR and at the mouths of perennial tributaries. Each TI will measure temperature at 30-minute intervals. Monitoring locations will typically consist of an air TI (measuring air temperature near the edge of the stream) and an instream TI. Instream TIs are deployed in the thalweg of a stream such that they are suspended off the stream bottom and in a well-mixed portion of the stream, typically in riffles or swift glides.

Our analysis of the 2005 TIR data and field data from instream temperature recorders suggests that, during baseflow conditions, stream channel morphology and low-stream velocities may contribute to localized vertical stratification of temperatures. It is possible during days of extreme high temperature and extreme low flow to have a vertical gradient of very warm water temperature at the surface that decreases in temperature 1-3°C with 1.5 to 2 feet of depth. Stream temperature stations will be thoroughly checked for vertical stratification during field checks. The intent is to avoid measurement bias from vertical and horizontal temperature stratification.

Instream TIs will be co-located with the core piezometers and will also be deployed at the mouths of perennial tributaries to the SFPR and at key locations on the mainstem SFPR to account for: land-use changes, stream morphology changes, temperature mixing zones, tributary confluences, and point sources. Air TIs will be co-located with all instream TIs to provide a quality check for the instream data and a comparison with weather station air temperature data. Figure 7 is an example of a possible monitoring network. Final placement will depend on site access considerations such as having landowner permission and/or using public right-of-way access at road crossings.

A weather station will be temporarily installed in the lower watershed near Colfax. This station will collect the following climate data: air temperature, relative humidity, barometric pressure, total solar radiation, wind speed and direction, precipitation, and soil temperature (at a depth of 2-3 ft.). This station will complement the data collected by the Moscow/Pullman Regional Airport in the upper part of the SFPR watershed to account for regional differences in weather phenomena.

Both Moscow and Pullman WWTPs have agreed to provide temperature monitoring data sampled at 30 minute intervals for their effluent discharge and any surface water monitoring they perform on their respective receiving waters. Ecology will coordinate quality assurance efforts with both facilities to ensure that all data quality objectives are met including: calibration of temperature dataloggers as well as documentation of calibration and instrument deployment. Ecology may also monitor temperatures at the same stream locations for data redundancy in case continuous temperature data is lost for unforeseen circumstances.

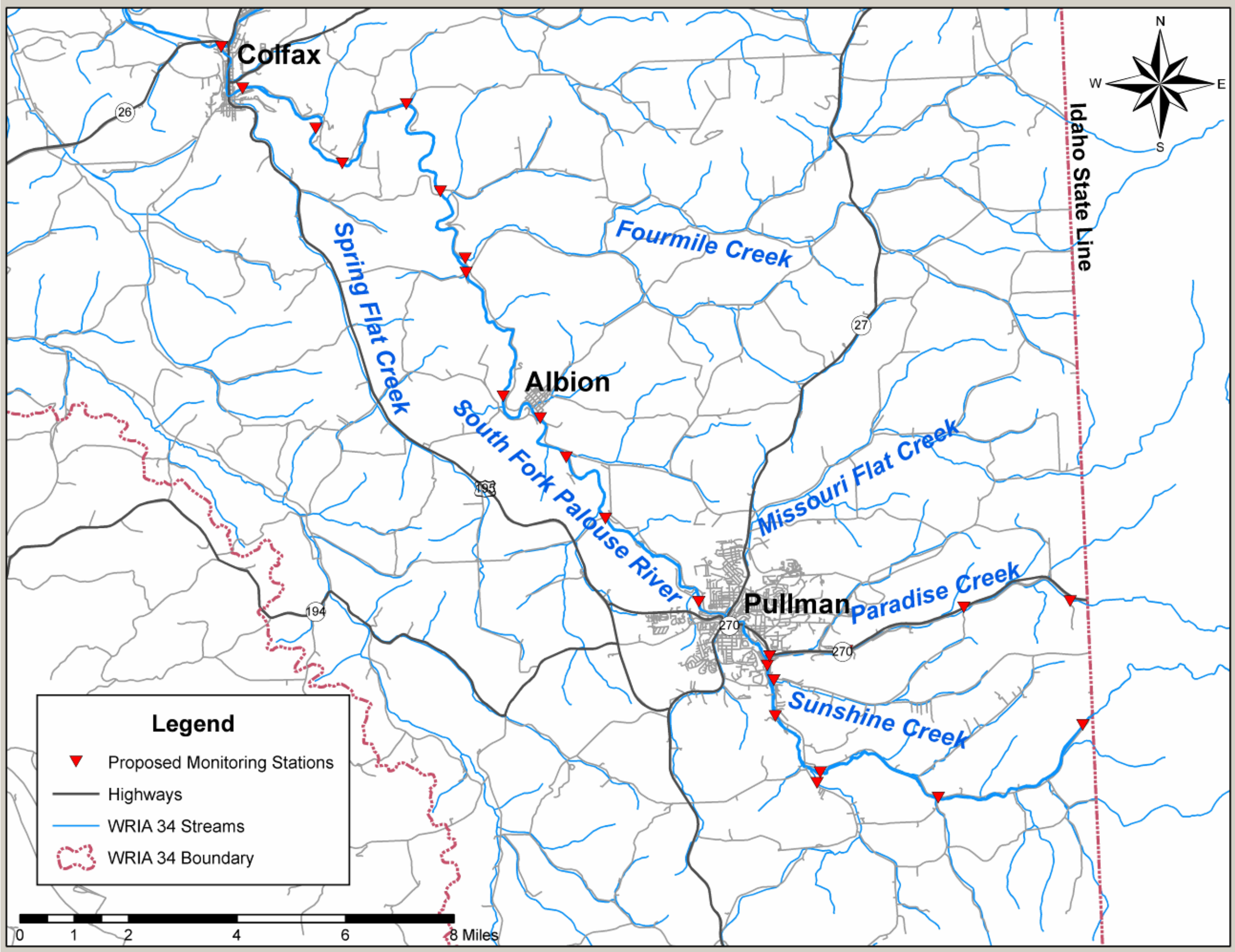

Figure 7. An Example of a Possible Stream Temperature Monitoring Network on the South Fork Palouse River and its Major Tributaries.

In addition to this project's focus on monitoring the SFPR, data collected in other streams in WRIA 34 by other entities will help to guide TMDL technical study development to address the other 303(d) listings outside of the SFPR sub-watershed. Ecology will attempt to coordinate with these other entities including: Ecology's ambient monitoring stations and Adams County Conservation District to make sure their field methods and the resulting data will meet the data quality control guidelines for using the data as part of the future TMDL study. Stream temperature data collected by the Conservation District in the Palouse River basin that will help augment data collection in other parts of WRIA 34 include the following streams to be monitored:

- Mainstem Palouse River.
- Cow Creek.
- Union Flat Creek.
- Rock Creek.
- Rebel Flat Creek.

Identify and Quantify GW/SW Interactions with an Instream Piezometer Network

For this study, groundwater and surface water interactions will be assessed via a combination of common field techniques. In-stream piezometers will be installed beginning in May 2006 at selected points along the SFPR 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 stream bed (within a few feet of the shoreline) to a maximum depth of approximately 5 feet. Keeping the top of the piezometer underwater and as close to the streambed as possible will reduce the influence of heat conductance from the exposed portion of the pipe. Following installation, the piezometers will be developed using standard surge and pump techniques to assure a good hydraulic connection with the streambed sediments.

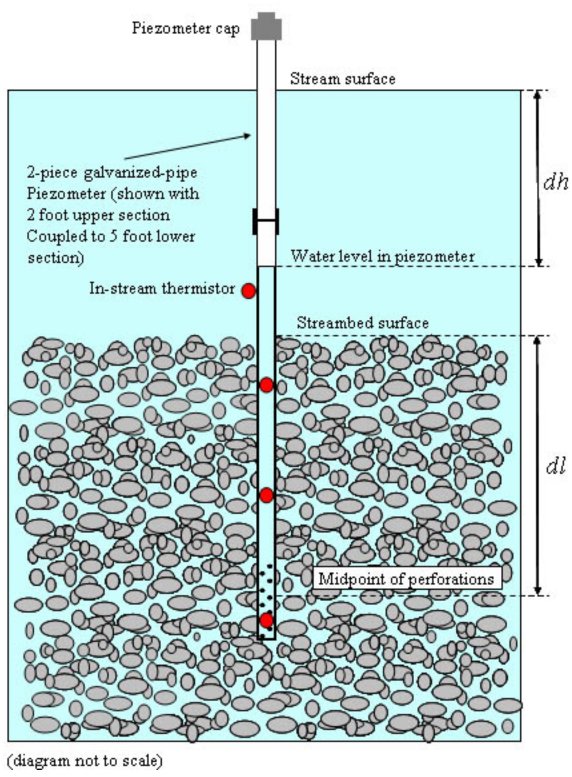

Figure 8. Instream Piezometer Conceptual Diagram.

Each piezometer will be instrumented with up to three thermistors for continuous monitoring of streambed water temperatures (Figure 8). 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 Watershed Ecology Section methodology.

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 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 SFPR. Wells selected for monitoring will be visited monthly between May and November 2006 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 August 2006 for the above listed parameters.

The Washington Department of Transportation (WSDOT) installed and monitored a network of approximately 50 shallow wells along the Paradise Creek corridor as part of their Highway 270 realignment project. We hope to use water level and geologic data collected from these wells to better understand local groundwater flow conditions and to guide our own instream piezometer placements along Paradise Creek. We will coordinate quality assurance efforts with WSDOT to ensure that the data quality objectives for this project are met.

In addition to the above work Ecology is currently evaluating a method for the direct measurement 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). To support the development of this procedure for future Environmental Assessment Program studies, injection tests are proposed for a subset of the piezometers installed during this study. If successful, the test results will be used to augment thermal profiling and gradient measurements for estimation of groundwater/surface water exchange.

Establish a Continuously Recording Stream Gage Network and Measure Streamflows

During low flow and baseflow conditions, point source discharges can affect timing and streamflow volumes on a daily cycle along the SFPR and Paradise Creek. These dynamic flows are difficult to track using instantaneous streamflow measurements only. A network of six continuously recording stream gages, installed and operated by Ecology's Stream Hydrology Unit and the USGS, will give us the ability to quantify the dynamic streamflow conditions on the SFPR. Piezometers instrumented with water level loggers may be co-located with the stream gages to facilitate the development of continuous vertical hydraulic gradient profiles for each location.

Continuously recorded streamflow data, instantaneous streamflow measurements conducted during baseflow conditions, piezometer vertical hydraulic gradient measurements, and the resulting flow mass balance will be used to determine streamflow lost or gained to groundwater. Surface water inputs to the SFPR will be instantaneously measured including the mouths of tributaries and point discharges including storm drains within the city of Pullman. Surface water withdrawals will be estimated based on water right certificates and claims or by surveying those users to determine how much water they are withdrawing during the flow monitoring periods.

Time of Travel Studies to Determine Average Stream Velocities

Time of travel studies will use a fluorescent dye (20% Rhodamine WT) that will be used to trace the movement of a dye cloud from an upstream point to a downstream point to calculate the average velocity of that body of water. Rhodamine WT dye is commonly used by Ecology, the US Geological Survey, and others to safely and effectively measure time of travel. The methods and protocols used in this survey will follow those prescribed by Kilpatrick and Wilson Jr. (1982).

Field measurements of dye concentration in the stream will be made using a Hydrolab© datasonde equipped with a rhodamine fluorometer recording measurements every five-to-ten minutes at key locations downstream from the initial point of dye release. These studies will occur at several different flow regimes to determine how stream velocity varies with point-source discharge patterns during baseflow conditions.

Ecology will notify local and state emergency contacts before any dye is put into the water so unnecessary emergency actions will not expend valuable resources in the event a spills' complaint is submitted (i.e., somebody calls the sheriff or the Ecology spills hotline because the river just turned red).

Riparian Habitat and Channel Geometry Surveys

Effective shade inputs to the QUAL2k model require an estimate of the areal density of vegetation shading the stream. A hemispherical lens and digital camera will be used to take 360° pictures of the sky and shading vegetation at the center of the stream. Digital photographs will be taken at stream TI locations and in reference reaches with existing riparian vegetation (possibly Rose Creek and SFPR). The digital images will be processed and analyzed using the Hemiview© software program.

Ecology stream temperature survey methods will be followed for the collection of data during thermal reach surveys. The surveys will be conducted July to September 2006 at mainstem temperature sites established by Ecology. Depending on stream access, field measurements will either be taken at six-to-ten transects per each temperature station. Stream channel measurements will include: bankfull width and depth, wetted width and depth, channel incision, width of the near stream disturbance zone (defined here as the distance from the bankfull edge to the edge of the major riparian vegetation), tree heights, and riparian vegetation composition.

Measurement Procedures

Measurement of relative head conditions between the piezometer and the river stage will be accomplished by direct comparison measurements using standard procedures for calibrated electric well probes (Stallman, 1983, and as described on pg 29). Direct measurements of relative heads will also serve as reference points for the interpretation of the continuous water level logger data.

Temperature monitoring stations and piezometers will be checked monthly to make field measurements and to clear accumulated debris away from the instruments. Documentation of the temperature monitoring stations will include:

- GPS coordinates and a sketch of the site (during installation only).
- Depth of the instream TI under the water surface and height off stream bottom.
- Stream temperature.
- Serial number of each instrument and the action taken with the instrument (i.e. downloaded data, replaced TI, or noting any movement of the TI location to keep it submerged in the stream).
- The date and time before the data loggers are installed or downloaded and the date and time after they have been returned to their location. All timepieces and PC clocks should be synchronized to the atomic clock using Pacific Daylight Savings Time (PDT). Pacific Standard Time (PST) will be reported if instruments are still in place during the time change.

Estimation of instantaneous flow measurements will follow the SHU 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 a 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 or other stream depth reference point so that gage readings can be converted to a discharge value.

Measurement Quality Objectives

The most important detail for using continuously recording data loggers is to ensure that they are all synchronized to the same time. There is an official U.S. time that is a public service cooperatively provided by the two time agencies of the United States: a Department of Commerce agency; the National Institute of Standards and Technology (NIST); and its military counterpart, the U. S. Naval Observatory (USNO). The official time can be found at: www.time.gov/timezone.cgi?Pacific/d/-8/java. All date and time stamps will be recorded in Pacific Daylight Savings Time (PDT).

Table 8 summarizes the accuracy and reporting limits of the equipment that will be utilized for this study. Certain instruments are used exclusively for water temperature and others for air, as noted in the table. A WTW 340i multi-meter will be used to measure water conductivity and temperature.

Table 8. Summary of Measurement Quality Objectives and Manufacturer Measurement Limits of Field Equipment.

Measurement/Instrument Type	Accuracy (% Deviation from True Value)	Required Reporting Limits
Stream Velocity Marsh McBirney Flo-Mate model 2000	±2% of reading; 0.1 ft/s 5%-8% measurement error	0.05 ft/s
Continuous Temperature Hobo Water Temp Pro	±0.2°C at 0 to 50°C (± 0.36°F at 32° to 122°F)	0.2°C for water temperature
Continuous Temperature StowAway Tidbits -5°C to +37°C model	±0.4°F (±0.2°C) at +70°F	0.2°C for water temperature
Continuous Temperature StowAway Tidbits -20°C to +50°C model	±0.8°F (±0.4°C) at +70°F	0.4°C for air temperature
Continuous Water Levels Hobo Water Level Logger U-20-001-01	±2.1 cm (0.07 ft) and ±0.37°C at 20°C (0.67°F at 68°F);	0.01 ft
Instantaneous Conductivity and Temperature TetraCon 325C probe and WTW 340i multi-meter	±1% of value (conductivity) 0.2°C (temperature)	0.2°C (temperature)
Hobo Pro Relative Humidity	±3% RH	n/a
Hobo Wind speed/direction smart sensor	±0.5 m/s (±1.1 mph) for <17 m/s (<38 mph) ±3% for 17 to 30 m/s (38 to 67 mph) ±4% for 30 to 44 m/s (67 to 99 mph)	n/a
Hobo Barometric Pressure smart sensor	±1.5 mbar (0.044 inHg) over full pressure range at +25°C (+77°F)	n/a
Hobo Rain Gage smart sensor	±1.0% at up to 20 mm or 1" per hour	n/a
Hobo Silicon Pyranometer smart sensor	±10 W/m2 or ±5%, whichever is greater in sunlight. Additional temperature induced error ±0.38 W/m^2 /°C from 25°C (0.21 W/m^2/°F from 77°F)	n/a

Quality Control Procedures

Field

The Onset StowAway Tidbits©, Hobo Water Temp Pro©, and Hobo Water Level Logger© instruments will be calibrated pre- and post-study in accordance with Ecology Temperature Monitoring protocols (Ward, 2003) to document instrument bias and performance at representative temperatures. A NIST certified reference thermometer will be use for the calibration. At the completion of the monitoring, the raw data will be adjusted, based on the pre- and post-study calibration results, if the temperature for the instrument differs from the NIST certified thermometer by more than the manufacturer stated accuracy of the instrument (i.e. by more than ±0.2°C or ±0.4°C). The mean difference of the pre- and post-study calibration values from the NIST thermometer reading will be used for calculating the adjusted temperature.

Variation for field sampling of instream temperatures and potential thermal stratification will be addressed with a field check of stream temperature at all monitoring sites upon deployment, during regular site visits, and during instrument retrieval at the end of the study period. Air temperature data and instream temperature data for each site will be compared to determine if the instream TI was exposed to the air due to stream stage falling below the installed depth of the stream TI.

The Onset Hobo Water Level Logger© pressure transducers will also be checked for measurement accuracy both pre- and post-study by comparing each instrument to a graduated vertical water column and comparing the accuracy of the water level instrument over the range of expected depths and developing a calibration curve if the instrument does not meet manufacturer specified accuracy of measurement (i.e. ±0.07ft). Water levels both in the piezometer and at the stream stage reference point will be measured in the field with an e-tape and steel engineers tape. Barometric pressure will be recorded at representative stations to compensate for atmospheric pressure effects on the water level loggers.

Conductivity meters will be calibrated in the field using a conductivity standard according to the manufacturer's specifications each day before data collection begins.

Data Management Procedures

All continuous data will be stored in a project database that includes station location information and data quality assurance information. This database will facilitate summarization and graphical analysis of the temperature data and create a data table to upload temperature data to Ecology's statewide Environmental Information Management System (EIM) geospatial database.

An EIM user study (JICA0000) 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/. EIM will accept the daily maximum, daily minimum, and daily average temperature summary from a continuous temperature data set as well as instantaneous streamflow measurement results. All temperature and streamflow data will be uploaded to EIM by the temperature field investigator once all data has been reviewed for quality assurance and finalized.

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

Data Analysis and Temperature Modeling Procedures

From the raw data collected at each monitoring location for temperature, the maximum, minimum, and daily average will be determined. The data will be used to characterize the water temperature regime of the basin and to determine periods when the water temperatures are above the state numeric water quality standard. Estimates of groundwater inflow will be calculated by constructing a water mass balance from continuous and instantaneous stream flow data and piezometer studies.

A model will be developed for observed and critical conditions. Critical conditions for temperature are characterized by a period of low-flow and high-water temperatures. The model will be used to evaluate the system potential temperature in the river. Sensitivity analysis will be run to assess the variability of the model results. The model will be used to evaluate various heat budget scenarios for future water quality management decisions in the SFPR basin.

GIS coverage of riparian vegetation in the study area will be created from information collected during the 2006 temperature field study and the system potential riparian vegetation study (Gilmore, 2005). Riparian vegetation coverage will be created by qualifying four attributes: vegetation height, general species type and/or combinations of species, percent vegetation overhang, and the average canopy density of the riparian vegetation.

Data collected during this TMDL effort will allow the development of a temperature simulation methodology that is both spatially continuous and which spans full-day lengths. The model will be calibrated to current (2005) conditions measured by this study design. The GIS and modeling analysis will be conducted using specialized software tools.

- Ecology's Ttools extension for Arcview will be used to sample and process GIS data for input to the shade and temperature models.

- Ecology's shade calculator (Ecology, 2003a) will be used to estimate effective shade along the mainstem SFPR. Effective shade will be calculated at 50 to 100-meter intervals along the streams and then averaged over 500- to 1000-meter intervals for input to the temperature model.

- The QUAL2Kw model (Chapra and Pelletier, 2004; Ecology, 2003b) or GEMMS model (Edinger and Buchak, 1995) will be used to calculate the components of the heat budget and simulate water temperatures. Both temperature models simulate diurnal variations in stream temperature using the kinetic formulations for the components of the surface water heat budget that are described in Chapra (1997).

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.

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. If model resolution using QUAL2K is too high (measured as RMSE greater than 1.5°C), then GEMSS will be applied using variable flow over the course of a day (i.e., unsteady flow).

Audits and Reports

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

Data Verification and Validation

Data for instream temperature monitoring stations will be verified against the corresponding air temperature station to ensure the stream temperature record represents water temperatures and not temperatures recorded during a time the instream TI is dewatered. Measurement accuracy of individual TIs is verified using a NIST certified reference thermometer and field measurements of stream temperature at each TI location several times during the study period.

All manually-entered data products in spreadsheets will receive a 100% quality check assessment by another technician other than the person who entered the data to ensure accuracy in transcription from field notes to the electronic files. The database will be checked to make sure the data records and serial numbers match the field records.

Data Quality (Usability) Assessment

The temperature field investigator will verify that all measurement and data quality objectives have been met for each monitoring station. If the objectives have not been met (such as a TI operating outside of its specifications or recording bad data) and the field investigator will decide how to qualify the data and how it should be used in the analysis or whether it should be rejected. Part of this analysis includes graphically comparing each instream TI record to its paired air TI record to see if any of the water data reflects a time when the instrument was dewatered. The field investigator will produce a Station quality assurance report that will include: Site descriptions, data quality assurance notes, and graphs of all continuous data.

Organization and Schedule

The roles and responsibilities of Ecology project staff are as follows:

Environmental Assessment Program

- *Jim Carroll, Water Quality Studies Unit, Project Manager*: Responsible for overall project management of the study. Responsible for development of TMDLs for temperature and conventional parameters, including model development and writing the technical report.
- *Dustin Bilhimer, Nonpoint Studies Unit, Temperature Field Investigator:* Responsible for the development of the temperature study, writing the QA Project Plan, temperature field data collection, analysis and data entry to EIM, project database management, and writing sections of the technical report related to temperature data collection and data quality review.
- *Kirk Sinclair, Nonpoint Studies Unit, Hydrogeologist:* Provides hydrogeologic assistance with study design including interpretation of historical geology and groundwater data in the basin, groundwater data collection, data analysis, and report writing.
- *Chuck Springer, Stream Hydrology Unit, Hydrologist*: Responsible for deploying and maintaining continuous flow gages and staff gages. Responsible for producing records of streamflow data at sites selected for this study.
- *Darrel Anderson, Nonpoint Studies Unit, Unit Supervisor*: Reviews the QA Project Plan and TMDL report.
- *Karol Erickson, Water Quality Studies Unit, Unit Supervisor*: Reviews the QA Project Plan and TMDL report.
- *Will Kendra, Watershed Ecology Section, Section Manager*: Responsible for approval of the QA Project Plan and final TMDL report.
- *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, Eastern Regional Office, TMDL Project Lead*: Acts as point of contact between Ecology technical study staff and interested parties and coordinates information exchange and meetings. Supports, reviews, and comments on the QA Project Plan and technical report. Responsible for implementation, planning, and preparation of the TMDL submittal document for EPA.
- *Dave Knight, Eastern Regional Office, Watershed Unit Supervisor*: Responsible for approval of TMDL submittal to EPA.
- *Jim Bellatty, Eastern Regional Office, Section Manager*: Responsible for approval of the TMDL submittal to EPA.

Schedule

Each general study activity and their expected completion dates are listed in Table 9. Acquiring landowner permissions for accessing the river in some locations may affect the starting date for monitoring activities.

Table 9: Proposed TMDL Schedule.

Document or Activity	Completion Date
Final QA Project Plan	April 2006
Monitoring Activities Begin	May 2006 through October 2006
Analyses, Modeling, and Report Writing	October 2006 to February 2008
Environmental Information System (EIM) Data Set	
EIM Data Engineer	Dustin Bilhimer
EIM User Study ID	JICA0000
EIM Study Name	South Fork Palouse River Temperature TMDL
EIM Completion Due	March 2007
Final Report	
Report Author Lead	Jim Carroll
Schedule	
Report Supervisor Draft Due	September 2007
Report Client/Peer Draft Due	October 2007
Report External Draft Due	November 2007
Report Final Due (Original)	February 2008

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Appendices

Appendix A

USGS Streamflow Gage Summary of the Monthly Average of Daily Average Flows

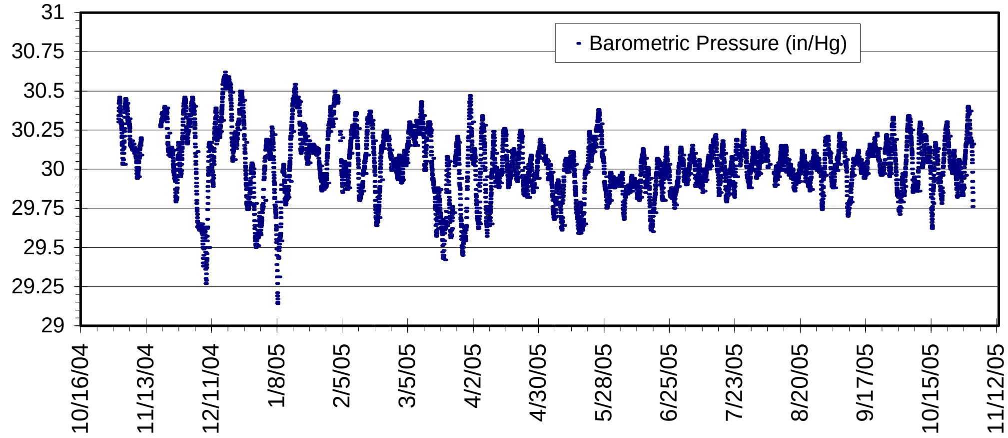
Station Description	USGS Station ID #	Period of Record	January		February		March		April		May		June	
			Avg. Q	stdev	Avg. Q	stdev	Avg. Q	stdev	Avg. Q	stdev	Avg. Q	stdev	Avg. Q	stdev
Palouse below SFPR	13349210	1963-1995	562.33	428.70	894.81	676.96	1006.64	637.89	736.09	471.91	364.62	231.76	154.41	165.25
SFPR at Colfax	13349200	1993-1995	115.87	108.89	186.68	234.66	125.79	131.27	93.55	66.39	66.23	68.31	17.16	5.28
Missouri Flat Cr	13348500	1934-1979	21.56	23.22	27.97	25.11	29.17	21.91	9.16	6.95	2.42	2.16	1.03	1.74
Paradise Cr	13347000	1934-1938	17.32	14.94	17.01	12.85	42.70	10.98	25.18	14.51	2.80	0.79	1.47	0.58
SFPR above Paradise Cr	13346500	1934-1940	20.41	22.65	32.90	15.68	86.02	29.80	42.99	25.05	8.39	3.73	1.94	1.07
SFPR at Pullman	13348000	1934-2004*	82.85	88.65	111.70	86.80	117.60	76.22	57.46	36.01	23.47	14.43	10.29	7.60
Fourmile Cr at Shawnee	13349000	1934-1940	23.80	28.54	37.38	19.99	78.84	27.48	27.09	21.89	2.67	1.43	1.01	0.76
			July		August		September		October		November		December	
Palouse below SFPR	13349210	1963-1995	39.31	18.91	20.03	9.82	25.22	15.37	32.83	10.76	81.44	45.86	241.92	274.35
SFPR at Colfax	13349200	1993-1995	11.38	8.48	8.85	3.55	10.25	3.28	11.16	0.72	20.13	9.48	61.48	58.03
Missouri Flat Cr	13348500	1934-1979	0.37	0.33	0.41	0.50	0.25	0.18	0.36	0.29	1.23	1.80	7.53	10.97
Paradise Cr	13347000	1934-1938	0.69	0.14	0.49	0.11	0.67	0.05	0.93	0.21	1.10	0.27	3.70	2.86
SFPR above Paradise Cr	13346500	1934-1940	0.28	0.18	0.01	0.02	0.05	0.07	0.63	0.50	1.14	0.83	4.41	4.90
SFPR at Pullman	13348000	1934-2004*	3.68	2.07	3.06	2.10	3.36	1.85	4.39	2.10	9.14	7.48	34.49	43.08
Fourmile Cr at Shawnee	13349000	1934-1940	0.03	0.03	0.00	0.00	0.00	0.00	0.06	0.15	0.38	0.50	4.89	5.98

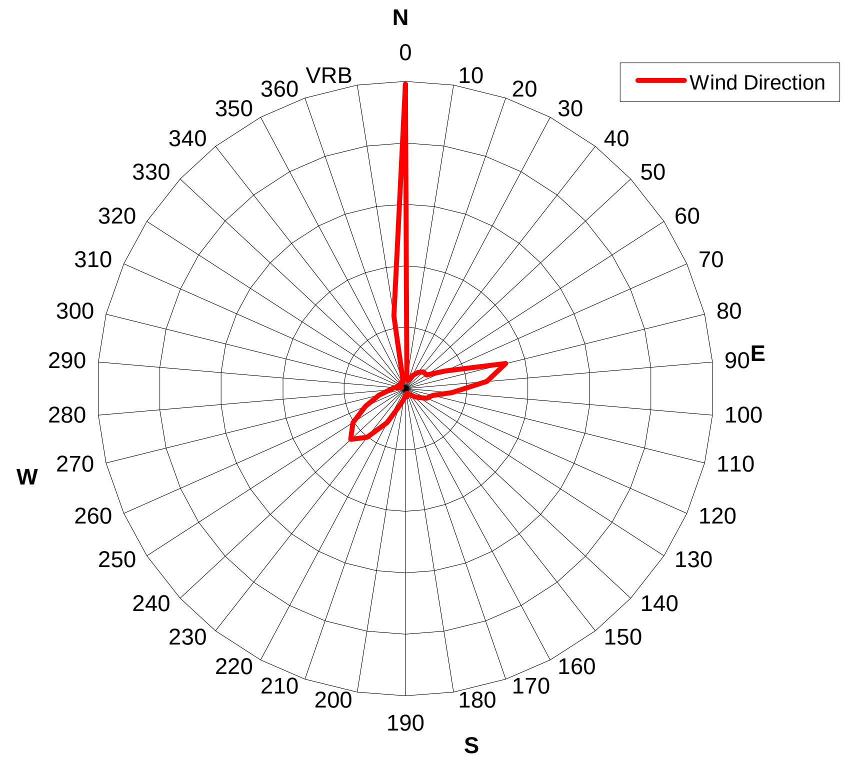
*This gage is presently under operation, but summary statistics for this station are based on the period of record from 1934-2004 only.

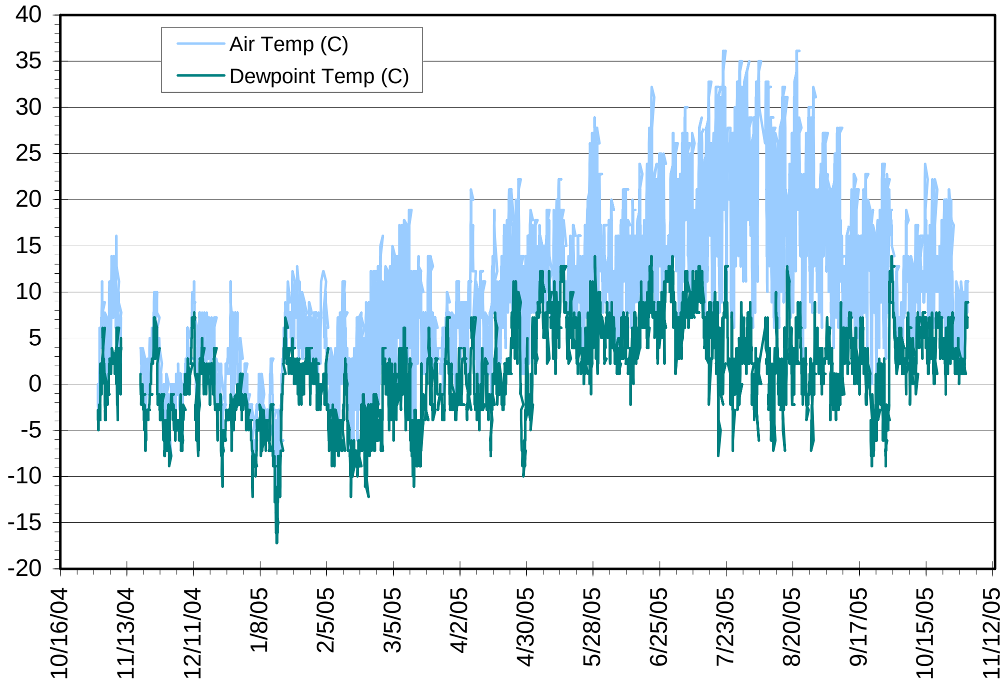
Monthly Average of Daily Average Streamflows for USGS Streamflow Gage #13348000 (SFPR at Pullman)

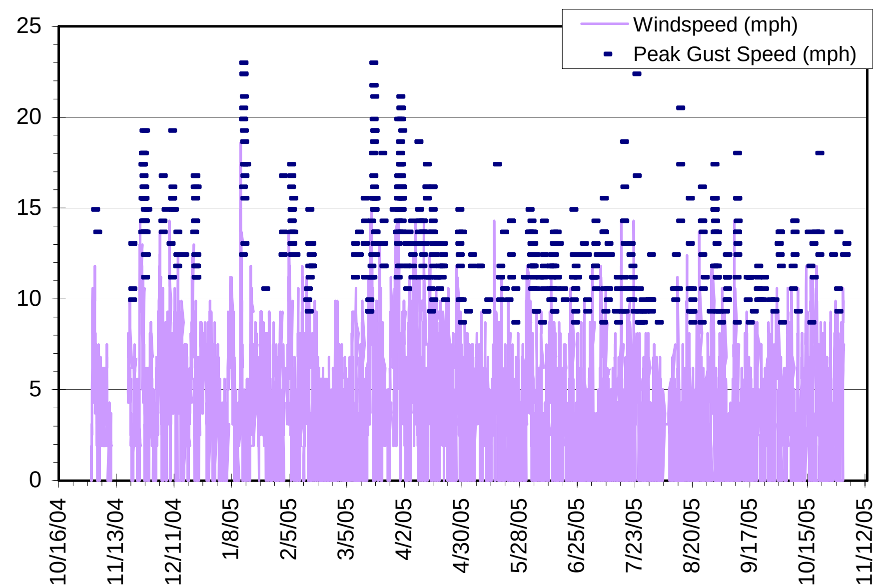
Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1934		44.39	94.23	25.07	5.75	7.28	1.80	1.10	1.11	2.93	4.32	23.41
1935	108.97	63.57	92.06	123.87	17.80	3.99	1.56	0.75	0.81	1.39	2.04	4.31
1936	49.64	52.61	140.32	35.40	12.13	3.46	0.90	0.54	1.09	1.30	1.56	2.70
1937	1.77	13.84	176.58	122.23	15.17	6.75	1.62	0.73	0.83	1.73	3.43	16.71
1938	51.70	88.71	134.55	54.73	11.26	3.06	1.30	0.61	0.79	2.25	2.83	4.05
1939	6.57	47.16	217.81	26.17	5.95	2.21	1.19	0.53	0.68	1.08	1.44	3.04
1940	7.01	87.23	90.48	42.30	6.86	1.52	0.86	0.50	1.24	3.70	19.51	69.98
1941	114.58	61.32	36.06	41.82	26.85	18.54	4.29	1.10	1.62	2.19	6.94	64.82
1942	39.92	88.64	62.48	20.87	17.88	8.30	1.94	0.58	0.49			
1960	19.83	99.69	90.74	53.50	19.65	6.43	1.80	2.13	1.88	3.11	15.70	17.65
1961	49.66	288.36	163.42	44.70	25.81	8.40	2.24	2.03	2.27	3.25	7.76	28.05
1962	30.03	36.55	110.19	45.50	19.25	6.47	2.45	2.07	2.81	4.81	5.30	12.22
1963	7.08	127.38	21.68	34.77	9.99	4.98	2.25	1.78	2.13	2.52	4.97	8.86
1964	29.68	49.45	149.26	75.77	27.74	12.54	3.94	2.55	2.66	3.00	6.79	113.21
1965	246.68	158.39	56.23	71.97	18.98	8.86	3.21	2.43	2.58	2.85	4.43	4.13
1966	40.52	40.32	70.39	20.13	7.03	4.38	2.65	2.22	1.97	2.84	5.46	16.23
1967	74.77	37.43	40.42	41.30	41.61	12.48	2.72	2.18	2.49	3.87	3.41	47.55
1968	17.94	100.71	21.68	13.85	6.04	3.27	2.00	2.69	4.60	5.22	16.82	44.58
1969	160.45	90.96	313.13	137.47	35.68	8.23	3.73	3.10	4.20	5.58	5.53	11.03
1970	168.33	148.89	102.71	39.20	23.13	8.98	5.77	2.65	4.06	5.41	10.15	13.29
1971	151.71	80.39	121.81	44.67	21.52	40.50	7.58	4.56	5.30	7.14	13.87	40.00
1972	267.77	360.28	304.77	69.67	52.81	16.32	6.75	8.89	6.03	6.94	9.00	64.87
1973	84.90	32.50	36.87	21.33	10.00	4.38	3.23	3.57	4.60	4.64	40.92	219.06
1974	400.90	298.46	183.58	122.57	38.10	22.93	6.71	3.58	4.20	5.18	7.98	13.89
1975	86.98	114.89	233.94	95.47	58.42	15.46	7.81	7.47	5.71	9.43	14.71	84.87
1976	165.23	133.34	187.00	136.00	39.71	19.30	7.28	7.41	5.38	6.74	7.81	8.80
1977	11.71	10.47	13.95	8.20	8.13	4.33	2.97	4.36	5.33	5.33	15.71	54.77
1978	80.97	128.36	73.45	62.77	25.19	7.69	5.66	5.00	5.25	4.65	6.98	15.98
1979	6.91	332.41	160.77	67.10	57.26	9.30	4.48	4.34	4.28	6.29	7.83	16.83
1980	46.23	102.59	72.13	27.93	27.68	17.35	6.35	4.43	5.71	5.33	9.12	22.90
1981	20.63	122.83	41.90	65.17	22.52	17.67	5.80	3.35	5.17			
2001					12.29	9.58	5.18	3.90	4.37	8.62	12.80	31.90
2002	83.52	115.96	150.97	76.97	30.71	13.35	4.60	4.07	4.87	5.15	6.77	9.04
2003	47.29	135.54	168.00	56.97	30.23	8.19	3.08	4.16	5.42	5.93	10.45	14.97
2004	54.00	104.07	64.74	28.37	32.42	13.82	3.22	5.58	5.58			

Pullman/Moscow Regional Airport
Continuous Recorded Data
from November 2004 - November 2005









Appendix B

Response to Comments on the Draft Quality Assurance Project Plan for the South Fork Palouse River Temperature Total Maximum Daily Load Study

The draft report, *Quality Assurance (QA) Project Plan for the South Fork Palouse River TMDL Study*, was distributed to the SFPR Technical Advisory Group (TAG) on April 26, 2006, for a two-week comment period. Comments were due by May 10, 2006. Written review comments were received from the cities of Pullman, Moscow, Colfax and Albion; Washington State University; and Jan Boll of the University of Idaho. Ecology appreciates all comments received. Minor editorial and grammatical comments were incorporated into the final QA Project Plan. The remaining comments were summarized below (as italicized text) with our response or action following each comment. Changes will be incorporated into the final QA Project Plan.

1. Several comments submitted noted that the Temperature QA Project Plan did not address an allocation plan or inquire how the modeling would be used to establish allocations:

Tom Dupuis, CH2M Hill

> *My overall observation is that the QAPPs do a thorough job of defining the kinds of field studies that will be done, and the QA/QC procedures that will be followed for that particular field work. These field studies are very comprehensive and the data they provide should be defensible for the TMDL process. My comments below are more reflective of the need to evaluate how the data ultimately will be used in the TMDL allocations. Perhaps the QAPPs were not intended for this purpose, although the stated objectives and some of the information provided suggest that that is the intent. In addition, it is not possible to fully evaluate if the studies being proposed will provide all of the information actually needed without answers to the questions I raise below. In particular, there is not enough discussion in the temperature QAPP to understand at this point how system potential (natural) conditions will be defined and quantified.*
>
> *For example, the bacteria QAPP not only identifies field methods, but also the way in which the data will be used to develop allocations (statistical roll-back method), similar to other bacteria TMDLs such as the N.F. Palouse River bacteria TMDL. Those other TMDLs can be reviewed to get a good sense of how the data will ultimately be used. In the case of this TMDL, it appears that data collection will be sufficient to support that methodology.*
>
> *The temperature QAPP, on the other hand, other than identifying options for which model may be used, does not define specifically how the field data and modeling will be used to develop allocations. It seems that this kind of information should be included given that the objective is to determine assimilative capacity and system potential (approximate natural) conditions.*

Response: The SFPR Temperature TMDL QA Project Plan restricted the objectives of this year's effort to:

Characterize stream temperatures and processes governing the thermal regime in the South Fork Palouse River including the influence of tributaries, point sources, and groundwater/surface water interactions on the heat budget.

Develop a predictive temperature model for the South Fork Palouse River. Using critical conditions in the model, determine the South Fork Palouse River's capacity to assimilate heat.

Evaluate the system potential temperature (approximated natural temperature conditions) for the South Fork Palouse River. The calibrated temperature model will be used to evaluate future water quality management decisions in the SFPR basin.

This year, model development will be completed for Paradise Creek and the SFPR only. Ecology understands that the SFPR has challenging issues concerning establishing a temperature TMDL, particularly because the SFPR is effluent-dominated during critical low-flow conditions. For this reason, Ecology is proposing to delay establishing WLAs or LAs for temperature until a thorough understanding of the science is completed. After a calibrated model is developed for the SFPR, the model will be used to evaluate future water quality management decisions in the SFPR basin.

2. Several comments were submitted inquiring how Ecology planned to establish what the natural conditions were in the SFPR watershed.

Kevin Gardes, City of Pullman

Under the "Natural Conditions" section it states "Using this approach does not infer that Ecology believes that systems can or should be returned to pre-historic conditions" and "Thus while an assessment of natural conditions may demonstrate what was once attainable, it may not represent what can be attained given the changes that have occurred over more than a century." While I find it encouraging that these sentences are in the QAPP, my question is how will the above statements be incorporated into the analysis of determining the natural and appropriate temperature condition and related canopy/shade cover? This will be very important in explaining to decision makers in the future the need for improvements, if that is what the TMDL concludes.

I am still not clear how tributaries will be modeled with respect to shade and natural conditions, which seems important in the analysis.

As the QAPP points out regarding the TIR flight completed last summer, it seemed to indicate that the South Fork was characterized by a repeating regime of deeper pools (slower moving and heat collecting near surface) and then shallower, faster moving sections giving the impression that the water temperature was fluctuating significantly. Since it ties in with channel morphology (are we accepting the current channel morphology as natural conditions?), how will natural temperature conditions be determined with respect to morphology and vegetation, since these two issues are connected?

Tom Dupuis, CH2M Hill

The way in which natural conditions will be determined has also not been defined completely in the QAPP. It states that the system potential riparian shade has been developed in a study by Golder, but the method for estimating the natural flow regime has not been defined. The flows will be a very critical component of the natural condition, perhaps even more so than shade. Given that the Moscow and Pullman WWTFs are the source of virtually all of the flow in the river during non-storm periods, determining what the natural flows would be without the WWTFs during the critical dry periods in summer will be a major challenge. The QAPP does not identify how diversions, if there are any, will be identified and their flows quantified. Although extensive

piezometer data will help characterize existing groundwater inputs, the natural groundwater flows also will need to be quantified. The QAPP does not address this issue at all. Is there an existing groundwater model of the area that will be used to estimate groundwater/surface interactions in the absence of groundwater pumping? If not, how will natural baseflows in the river be estimated? Another important component of natural conditions is the natural stream/river morphology. The QAPP does not discuss if an attempt will be made to evaluate what a more natural condition would be. This is often a difficult thing to do, but if the plan is to use existing morphology, then there needs to be some discussion about how the existing and system potential riparian conditions are compromised or altered by man-made morphological changes.
Finally, the QAPP does not indicate if any of the tributary streams will be directly modeled, or if they will be simple inputs to a mainstem model. If the latter, how will the natural temperature conditions be determined?

Tom Scallorn, City of Moscow

Is there sufficient data to determine the natural background and if not how is it to be collected?

Response: In modeling system potential temperatures in the SFPR, Ecology cannot completely mimic the conditions prior to white settlement on the SFPR (i.e. natural conditions). By all accounts, the SFPR watershed has been so drastically altered by land use in the last century that there is no reference condition to infer the myriad of components that the original natural landscape might have had such as stream flow; groundwater flow (natural base-flow); channel morphology; tributary flow; tributary water temperatures; and to some extent, the riparian vegetation. Ecology believes it is important to evaluate what is currently attainable in the SFPR watershed. Primarily, the temperature TMDL will rely on establishing what effective shade can be supported given the current conditions. Various flow regimes will be simulated to test their effect on system potential temperature. System potential temperature in the SFPR will be affected by the design flow chosen to represent an attainable condition.

3. Several comments submitted noted that the Temperature TMDL will likely have to address the new water quality standards:

Tom Scallorn, City of Moscow

Which streams will have more stringent requirements for temperature and D.O.? When the new rules are approved will the TMDL be updated to reflect the new criteria?

Tom Dupuis, CH2M Hill

The temperature QAPP identifies the two criteria that are in play because of EPA's disapproval of the 2003 temperature rule, and notes that Ecology is currently working on revising the rule and expects to have an approved rule in place by 2007. Thus, it would seem that the revised rule will be the governing one by the time this TMDL is completed. It would seem that this would be an opportune time to consider if the carry-over use designations from the old Class A system are appropriate for the S.F. Palouse. The Washington Department of Fish and Wildlife management plan for the river is for a mixed fishery (put-and-take rainbow trout, brown trout, brook trout, largemouth bass and smallmouth bass). The river does not contain native char (bull trout would be *the char of concern), nor is it designated as critical habitat for bull trout, nor are there any management goals for bull trout; thus the "native char" use designation seems incorrect. Existing summer temperatures are warmer than the numeric criteria for both the native char (12^oC 7-DADMax) and salmon/trout (17.5^oC 7-DADMax), and thus it is possible that the ultimately applicable temperature criterion for this river will be the natural condition, but it is also possible that natural conditions would be cooler than the salmon/trout numeric criterion (in which case the numeric criterion for salmon/trout would apply), but warmer than the char criterion (in which case the natural conditions criteria would apply). Thus, a colder temperature would have to be used in the TMDL to protect a char that does not and will not ever exist in the river. If it is assumed that the allocation approach for point sources will include a thermal load to offset requirement (similar to Oregon temperature TMDLs), then the use of an unnecessarily low criterion can lead to a very substantial increase in the amount of WWTF heat load that would have to be mitigated via augmentation, riparian shade planting, and/or reuse. In addition, the QAPP should identify the details of how a thermal load to offset would be calculated, if that is approach is contemplated.*

Response: The currently disapproved 2003 water quality standards will likely be revised and approved during the SFPR TMDL timeline. In order to expedite the approval of the new standards, new rulemaking leading to the approval of the new standards will only address EPA's challenges to specific designated uses. (Currently, the only use-changes EPA has requested for the Palouse River watershed are below the falls at the mouth of the Palouse River at the Snake River.) Ecology encourages communities to bring forward their concerns about the designated uses of their waters during the triennial review process which will review specific designated uses. The triennial review will begin after the approval of the new water quality standards.

The SFPR is not an assigned water to support a native char fishery. References to char numeric temperature criteria will be deleted from the QA Project Plan.

An allocation approach for the SFPR temperature TMDL will not be addressed at this time (see above #1).

4. Several comments were submitted inquiring about what water quality temperature model Ecology planned to use.

Tom Dupuis, CH2M Hill

I was also curious as to why the QUAL2K and GEMMS models are being considered. If Oregon's Heat Source (version 7) model would be used, it would not only do the same things for shade as Ecology's shade model, but would also be able to do multiple days (up to 21) of hydrodynamic (time variable flows) simulation, all in one modeling package. Because the temperature criterion is 7-days, it seems that a model with at least 7 days run capability will be needed.

Kevin Gardes, City of Pullman

I think that Tom's comments above related to choosing the appropriate temperature model are very relevant. We seem to be going in the direction that the South Fork is a very complex and dynamic system, especially during the period of concern – low summer flows. Deciding up front what the appropriate model is will ensure that the necessary data is collected.

<u>Response</u>: The QUAL2K model is capable of evaluating 7-day maximum temperatures, either by using 7-day average boundary conditions (most often done) or by running seven concurrent day scenarios and averaging the temperature output. Ecology will attempt to use QUAL2K using daily or 7-day average flow conditions. QUAL2K simulates steady-state flow conditions only. GEMSS is a fully hydrodynamic, time-variable water quality model which is being considered because of the unsteady flows in the SFPR during low flow.

<u>5. Several comments were submitted inquiring about the flow balance and water withdrawals in the SFPR.</u>

<u>Kevin Gardes, City of Pullman</u>

> *It would be helpful to know (map) where the six (6) continuously recording stream gages will be located. How will the frequency of instantaneous stream flow and storm drain measurements be determined? For the time of travel studies it seems to me that you will need a minimum of three for comparison purposes. As you suggest they should be done at different flow regimes.*
>
> *I am still not clear how tributaries will be modeled with respect to shade and natural conditions, which seems important in the analysis.*
>
> *It was not clear to me if surface water withdrawals will be accounted for. There are a number of surface water rights on the South Fork below the Pullman WWTP outfall. If a majority of the water rights were in use the impact would be significant during low flow periods.*

<u>Jan Boll, University of Idaho</u>

> *Establishing rating curves will require visits on an event-basis so high flow events are captured.*

<u>Marty O'Malley, Washington State University</u>

> *I think it would be better to include monitoring stations up the tributaries of the SFPR because they drain a significant portion of the watershed and this may help identify areas of concern. Lastly, I am not a hydrologist but the focus of the study is to do a heat balance in the watershed and to do that you need to have flow data. My concern is that the study proposes ~ 36 temperature stations but only 6 flow measurement stations. I wonder if more would not be better.*

<u>Tom Scallorn, City of Moscow</u>

> *Estimates of groundwater inflow will be calculated via water mass balance, is this accurate or a guess?*

<u>Response</u>: The six continuous flow gages will be:

1. **Paradise Creek at the State Line.**

2. **Paradise Creek at Mouth.**

3. **SFPR at State St. (USGS).**

4. SFPR at Albion.

5. SFPR at Parvin.

6. SFPR above Colfax.

Instantaneous flows will be taken either monthly or twice a month at all sites until a rating curve is established. Tributaries, or other surface water inflows, will be measured twice a month. Most tributaries will not be running during the summer low-flow period. Most of the flow in the SFPR will be from the WWTPs. WWTPs will conduct continuous flow monitoring. Surface water withdrawals will be estimated based on water right certificates and claims or by surveying those users to determine how much water they are withdrawing during the flow monitoring periods. The temperature TMDL is primarily concerned with flow during the summer months when high flow events will most likely not occur. A water balance will be used to calculate groundwater gains and losses. Reaches of groundwater gains and losses will be confirmed with head gradient measurements.

6. Several comments were submitted inquiring about system potential vegetation in the SFPR.

Kevin Gardes, City of Pullman

> *If the system potential riparian shade that has been developed in a draft study by Golder is to be used, how will the conclusions of the report be distributed throughout the South Fork subbasin? The draft report issued by Golder to WRIA 34 was fairly general in nature with respect to the percentages of different vegetative cover that historically existed along the South Fork. Will the proposed canopy cover be distributed by soil type? Will the main stem be treated differently then the tributaries? How will the TMDL estimate aerial cover across the stream reaches?*

Tom Scallorn, City of Moscow

> *How will current projects that are in progress to increase stream shading be evaluated and will this be considered in the TMDL? SFPR will use riparian shade as a surrogate measure of heat flux. What is this really saying and is it accurate or a wild guess?*

Response: Effective shade produced by riparian vegetation will be estimated using Ecology's shade-model. The shade-model is a spreadsheet model that calculates effective shade by using the HeatSource model developed by Oregon Department of Environmental Quality. The shade-model estimates effective shade using vegetation attributes like vegetation height, general species type and/or combinations of species, percent vegetation overhang, and the average canopy density of the riparian vegetation.

Current vegetation effective shade will be evaluated using field data and digitized aerial photos. In addition, the data summarized by Golder will be used to evaluate system potential vegetation. Spatial distribution of the vegetation classifications established by Golder will be developed from the USDA SCS Soils Survey. Riparian vegetation attributes will be assigned to each of Golder's vegetation classifications for use in the shade-model. Only the SFPR and Paradise Creek will be modeled.

7. Several comments were submitted inquiring about protocols.

Kevin Gardes, City of Pullman

> *There is a discussion about calibration of the temperature data loggers per Ecology protocols. Will there be a protocol followed for selecting locations for deployment and orientation with respect to sun/shade, etc. It seems to me the probes deployed in the thalweg should be positioned to determine average temperature in the stratification zone. Based on past experience, monthly checks of temperature data loggers may not be frequent enough to avoid loss of data due to animals, aquatic vegetation disrupting the probe location, or other factors.*

Jan Boll, University of Idaho

> *It is important to know that the Hobo reader needs to stay at about room temperature to give accurate results.*

Tom Scallorn, City of Moscow

> *The reference to standard procedures for the calibration of electric well probes seems rather opened ended and undefined. How current are the certificates for the certified thermometers?*

Response: Ecology has many years of experience conducting field work and developing temperature TMDLs. Ecology will take all precautions to ensure the collection of reliable and credible data in the SFPR. The NIST thermometer was last certified on January 6, 2005.