South Prairie Creek Bacteria and Temperature Total Maximum Daily Load (Water Cleanup Plan)

Detailed Implementation Plan

June 2006
Publication Number 06-10-018

South Prairie Creek Bacteria and Temperature Total Maximum Daily Load (Water Cleanup Plan)

Detailed Implementation Plan

Prepared by:

Dave Seabrook
Puyallup River Watershed Council

Kim McKee
Washington State Department of Ecology
Water Quality Program

Cindy James
Washington State Department of Ecology
Water Quality Program

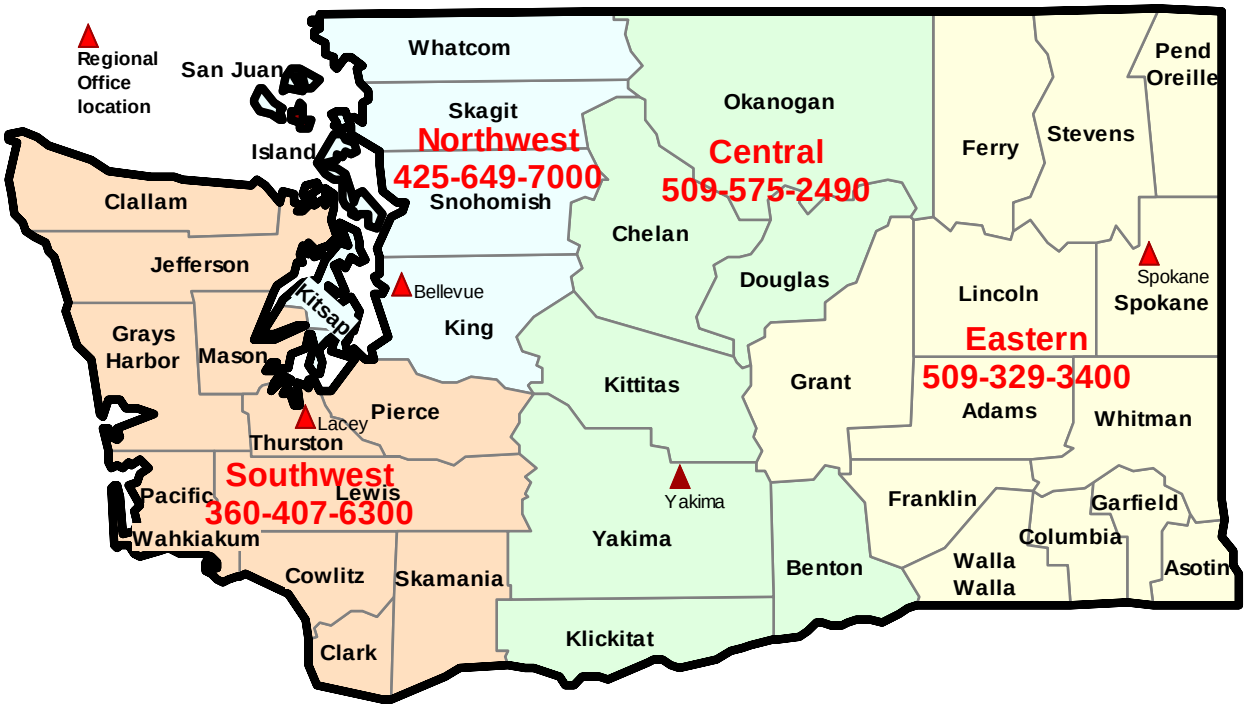
June 2006
Publication Number 06-10-018

You can print or download this document from our Web site at:
http://www.ecy.wa.gov/biblio/0610018.html

For more information contact:

Department of Ecology
Water Quality Program
Southwest Regional Office
P.O. Box 47775
Olympia, WA 98504-7775
Telephone: 360-407-6270

Headquarters (Lacey) 360-407-6000



Persons with a hearing loss can call 711 for Washington Relay Service.
Persons with a speech disability can call 877-833-6341.

If you need this publication in an alternate format, please contact us a 360-407-6270. If you are a person with a speech or hearing impairment, call 711 for relay service or 800-833-6341 for TTY.

Table of Contents

List of Tables

List of Figures

Executive Summary

In 2000 Ecology initiated a Total Maximum Daily Load (TMDL) process to address temperature and fecal coliform bacteria impairments in South Prairie Creek, a tributary of the Carbon River in Pierce County, Washington. A technical assessment and loading evaluation was completed three years later and results indicated that bacterial reductions were needed for South Prairie Creek ranging from 32 to 71 percent for the growing season (May through October) and reductions of 7 to 77 percent were needed for the non-growing season (November to April). Temperature impairments were also identified and recommendations for improvements in effective shade for South Prairie Creek ranged from 64 to 79 percent.

An advisory committee was formed of interested tribal, state agency, local watershed planning, and governmental entities to help direct development of this Detailed Implementation Plan. The committee used the TMDL submittal report as the basis for exploring possible implementation actions. A three-phased implementation approach was established and actions were proposed for 12 groups and governmental entities. The first phase of implementation started in 2006 and the final phase is scheduled to start in calendar year 2014.

Interim reduction targets were established for both fecal coliform bacteria and temperature. An interim target date of June 2008 was established for a 50 percent reduction of growing season and non-growing season bacterial loads. Bacteria waster quality standards are anticipated to be fully met by June 2011. An interim target of calendar year 2008 was established for completion of a riparian inventory to identify watershed locations where riparian plantings are needed. A second interim target of calendar year 2020 was established for revegetating 50 percent of the area identified in the inventory and where voluntary cooperation of streamside landowners has been received. Temperature water quality standard are anticipated to be met by calendar year 2089.

Introduction

Fecal coliform pollution and high stream water temperatures were found in the South Prairie Creek basin during studies conducted by the Washington State Department of Ecology (Ecology), and the Muckleshoot Indian Tribe in the early 1990s.

Under the Clean Water Act, each state develops standards designed to protect, restore and preserve water quality. Water quality standards address designated uses, such as cold water biota or stream water supply, and criteria, such as a maximum of 18 ˚C stream temperatures or 100 fecal coliform colonies per 100 ml sample of drinking water, which are safety limits for those uses. When a lake, river, or stream fails to meet water quality standards after application of required technology-based controls, the Clean Water Act requires the state to place the water body on a list of "impaired" water bodies (referred to as the 303(d) list after the Clean Water Act section number). South Prairie Creek was first placed on the 303(d) list in 1996 (Figure 1).

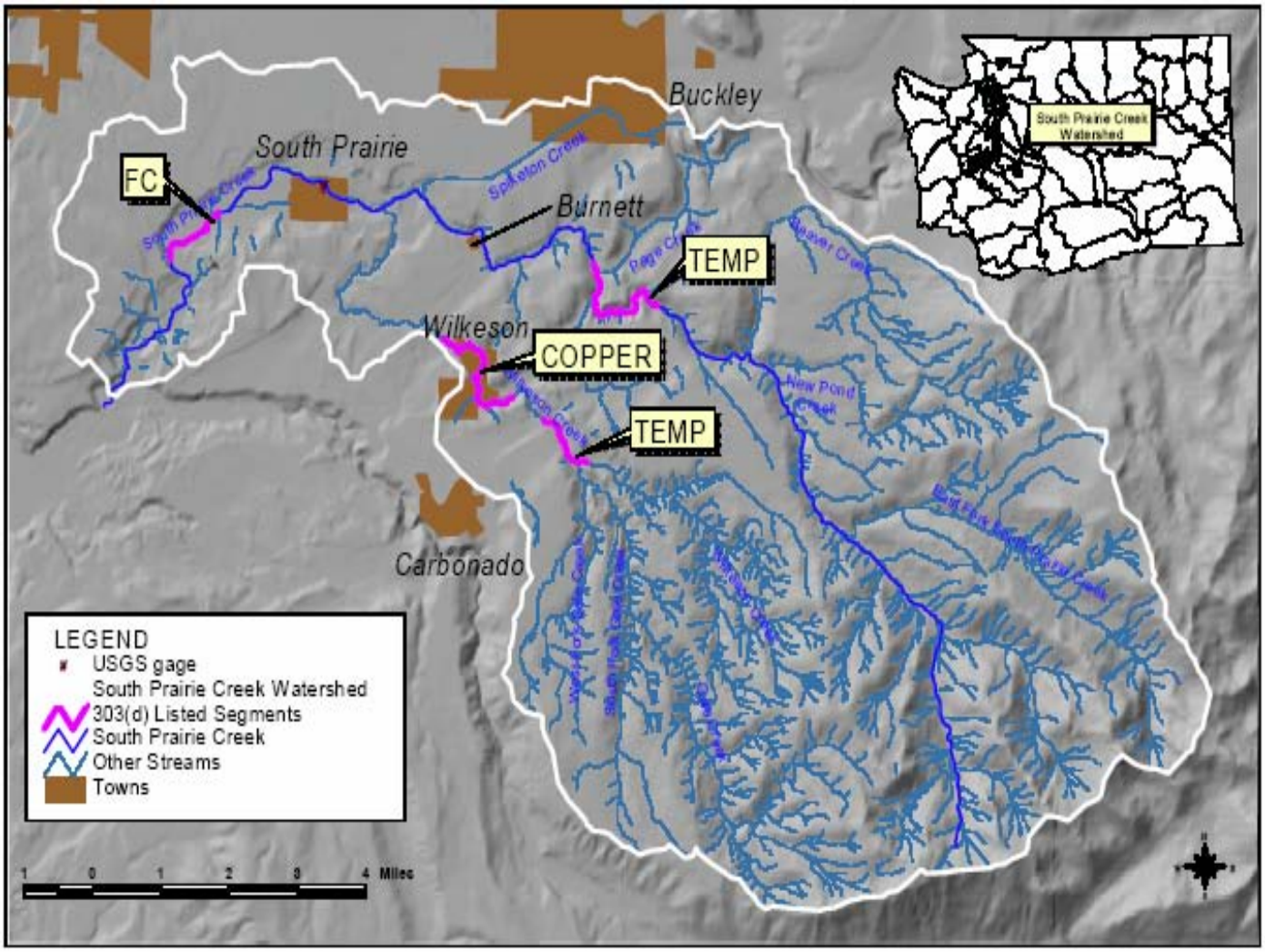


Figure 1. South Prairie Creek Watershed with 303(d) Listings

The temperature standard for South Prairie Creek as stated in state regulations is as follows:

"Temperature shall not exceed 18.0°C … due to human activities. When natural conditions exceed 18.0°C … no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C." [WAC 173-201A-030 (2)(c)(iv)]

The fecal coliform bacteria standard for South Prairie Creek as stated in state regulations is as follows:

"…fecal coliform organism levels shall both not exceed a geometric mean value of 100 colonies/100 mL, and not have more than 10 percent of all samples obtained for calculating the geometric mean value exceeding 200 colonies/100 mL." [WAC 173-201A-030 (2)(c)(i)(A)]

An outcome of placing a water body on the 303(d) list is that a Water Cleanup Plan, also known as a Total Maximum Daily Load (TMDL), must be developed for the impaired water body. Ecology completed an analysis for South Prairie Creek in 2003 which included a preliminary identification of the source and nature of the "impairments" and assigned pollutant limits for temperature and bacterial sources in the watershed. The technical information along with load and wasteload allocations, a summary implementation strategy (SIS), and summation of public input to the development of the TMDL, was compiled into a TMDL submittal. The submittal was conveyed to the U.S. Environmental Protection Agency on June 19, 2003 and subsequent approval was given on August 5, 2003.

Water quality monitoring stations used in development of the TMDL are shown in Figure 2 and Figure 3. Temperature profiles for selected locations in South Prairie Creek, and Spiketon Creek are shown in Figure 4.

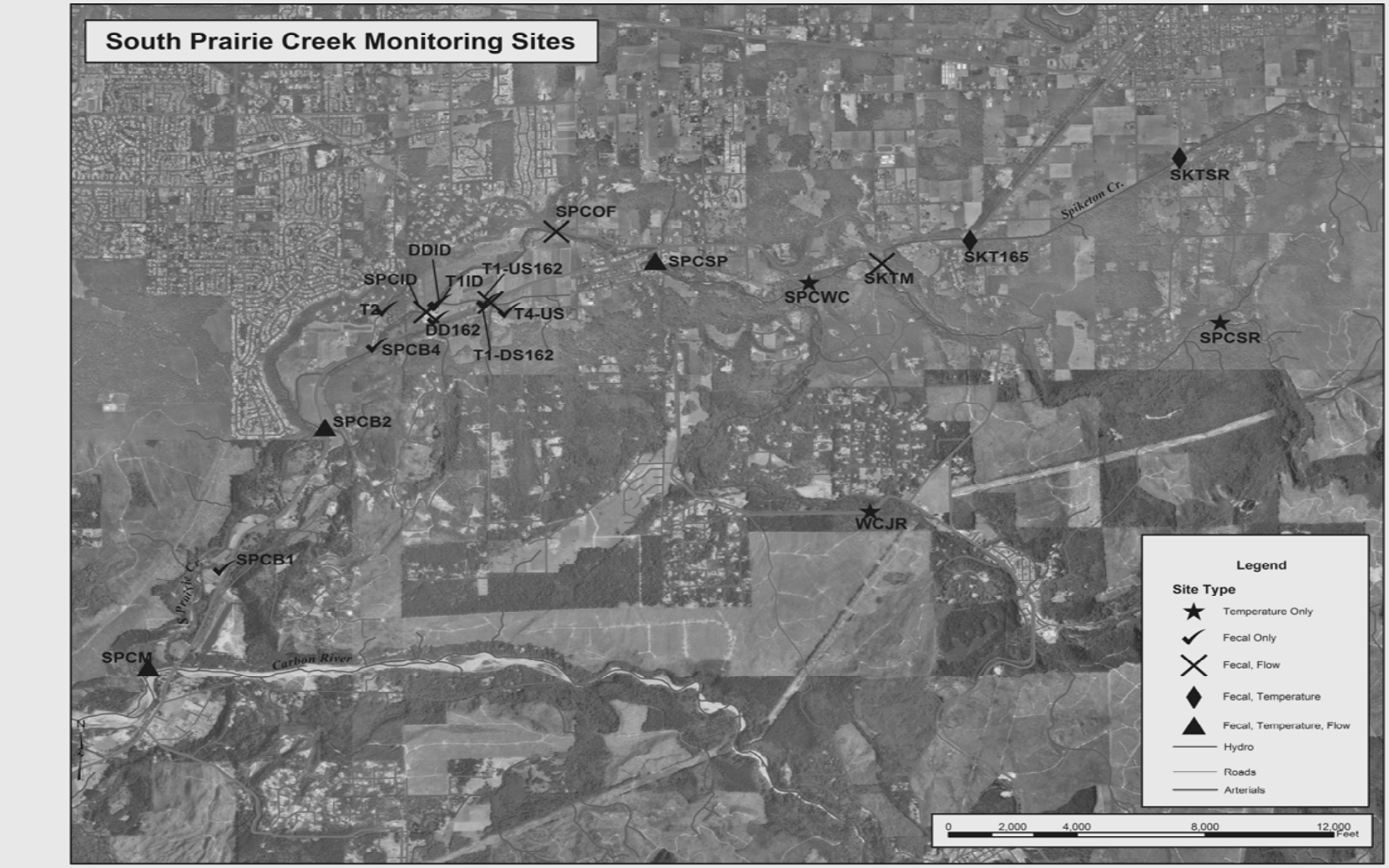


Figure 2. 2001 Monitoring Stations for South Prairie Creek (Barreca and Roberts, 2003

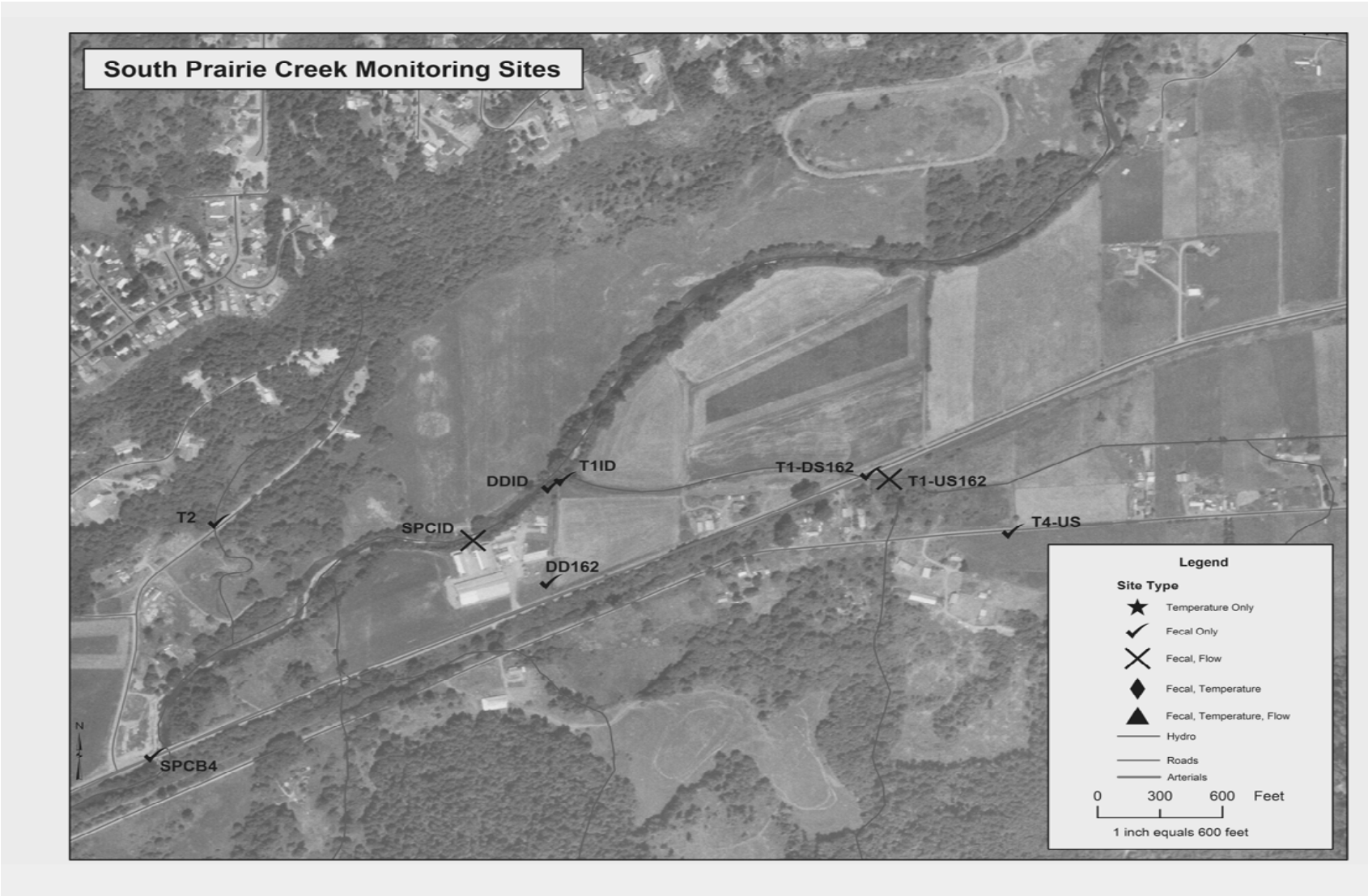


Figure 3. 2001 Monitoring Stations for Tributary 1 South Prairie Creek (Barreca and Roberts, 2003)

The following nine graphs indicate the results of temperature sensing during the development of the TMDL (Roberts, 2005). In some cases data for both years is on the same chart, and in other cases, data was collected for only one season at a particular location.

Legend: <><><><>< Cross-hatch = Temperature Standard
---------- Dashed Line = Temp. Results for 2000
_____ Solid Line = Temp. Results for 2001

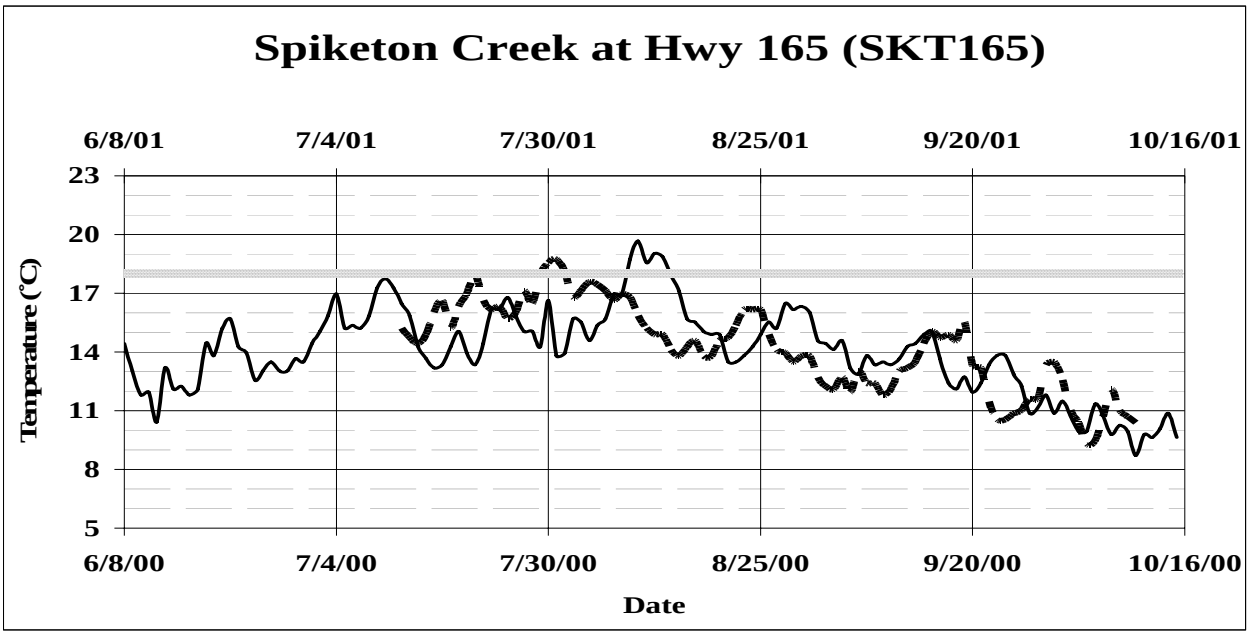


Figure 4-A. Temperature Profiles at Selected Sampling Sites in South Prairie Creek and Spiketon Creek during 2000 and 2001. Graph 1

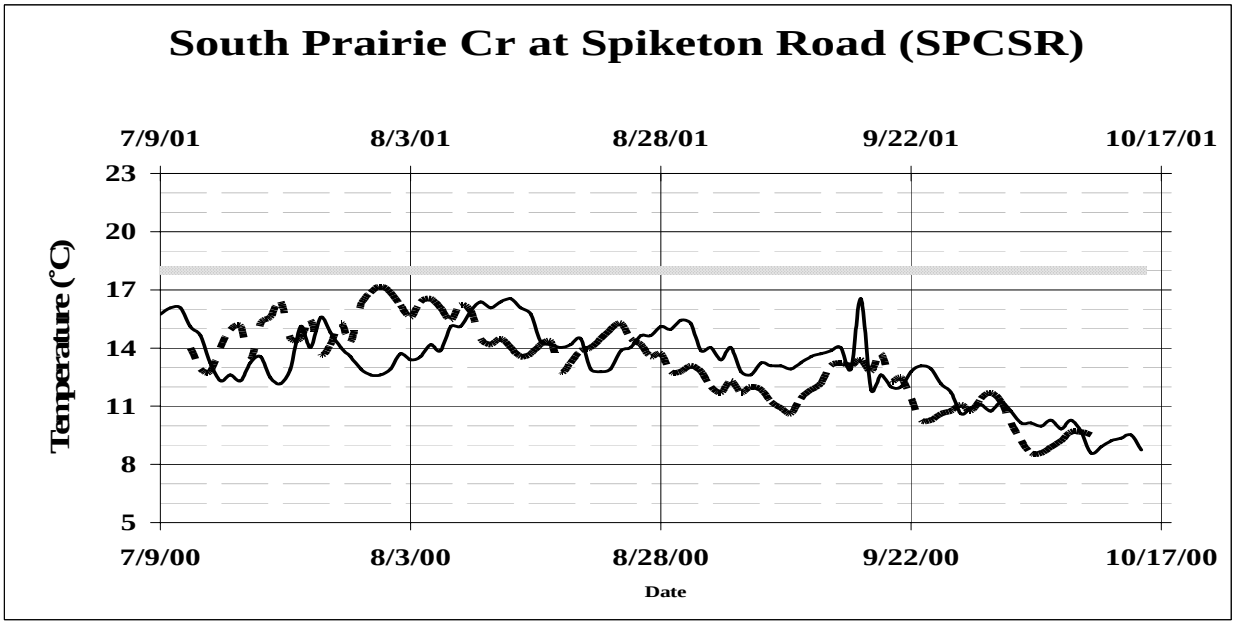


Figure 4-B Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 2

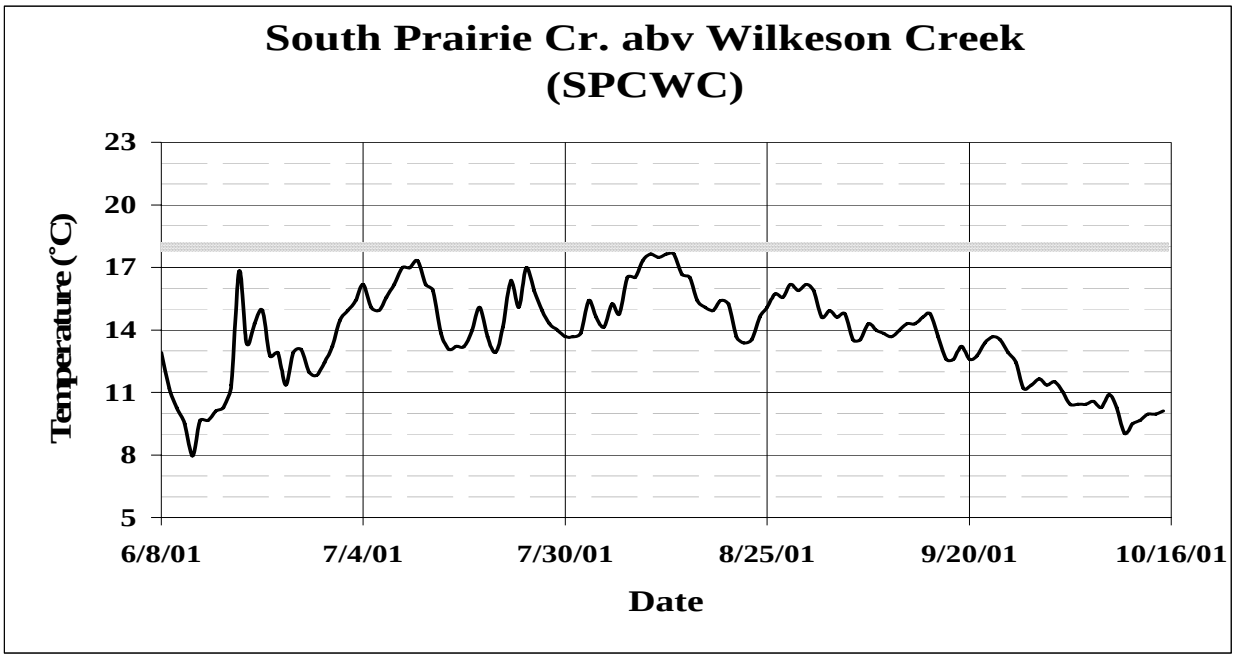


Figure 4-C. Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 3

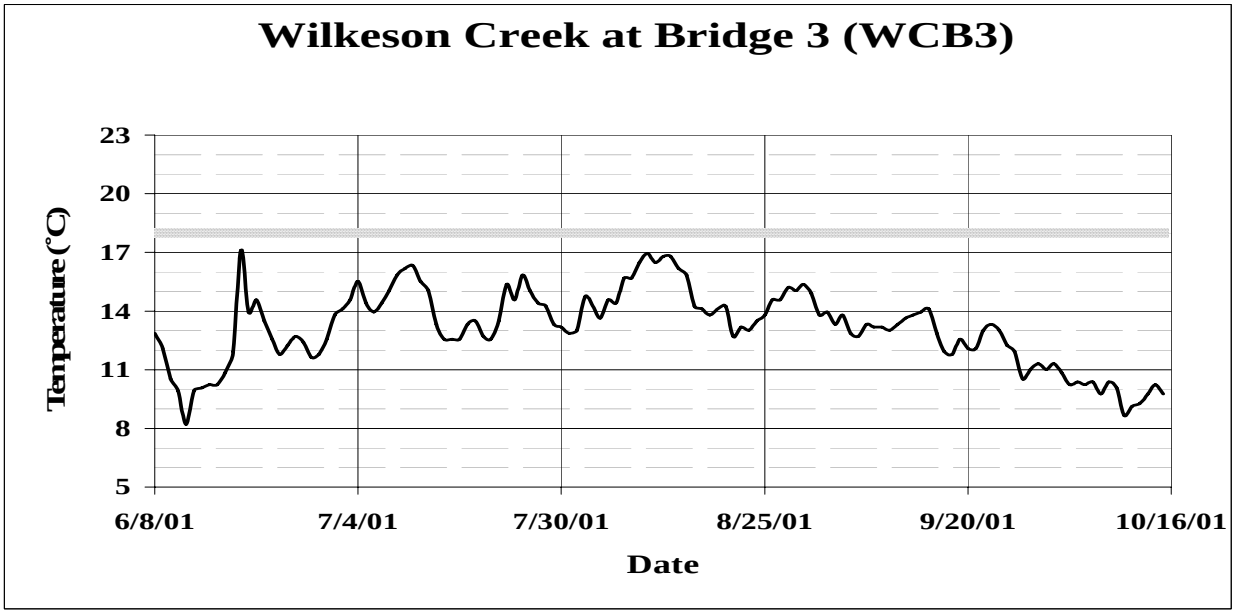


Figure 4-D. Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 4

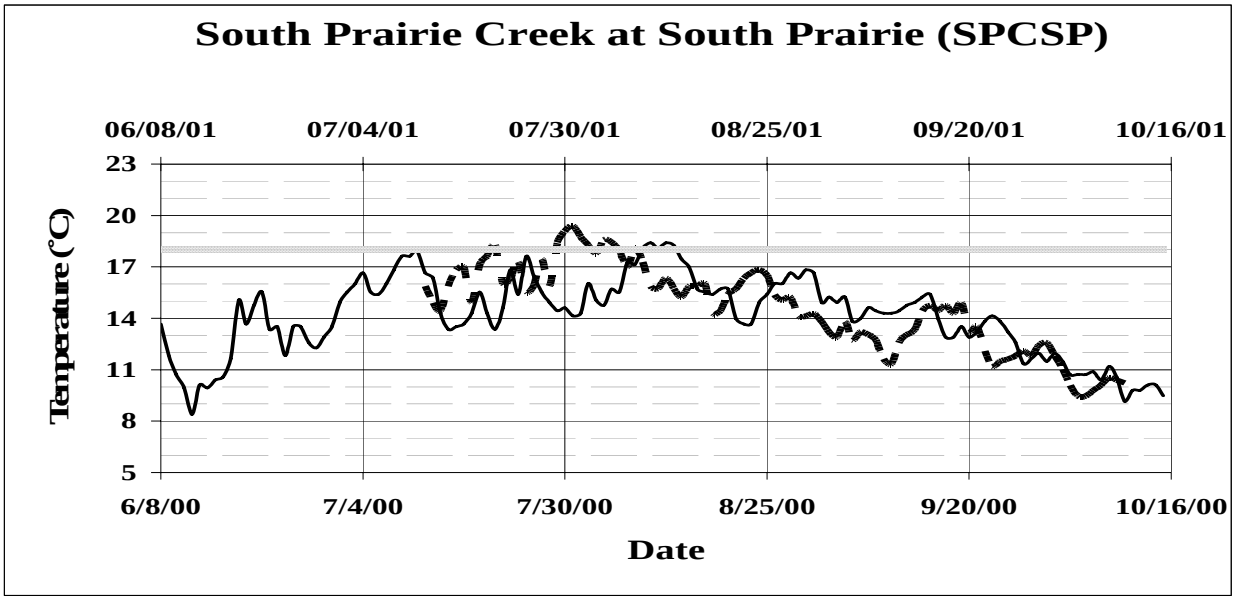


Figure 4-E. Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 5

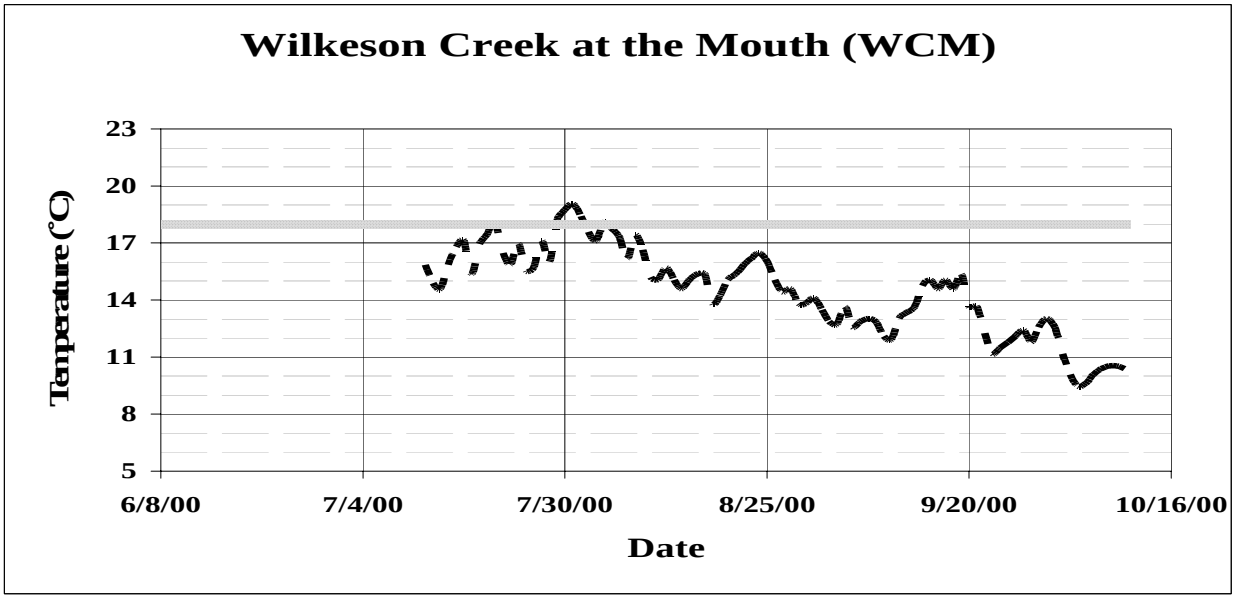


Figure 4-F. Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 6

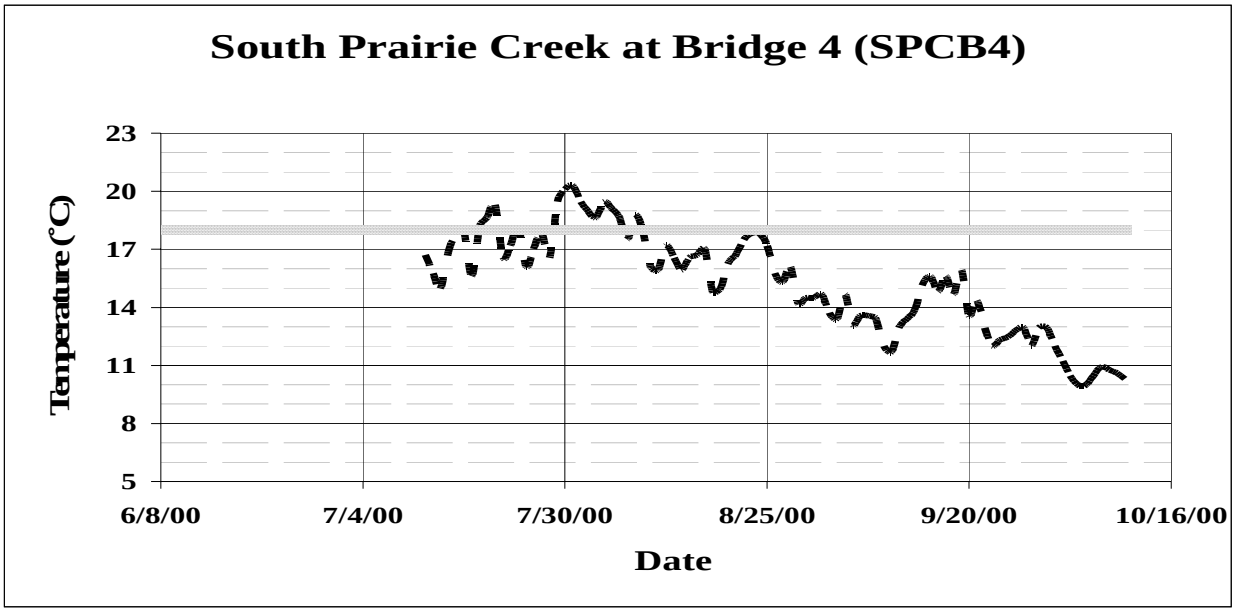


Figure 4-G. Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 7

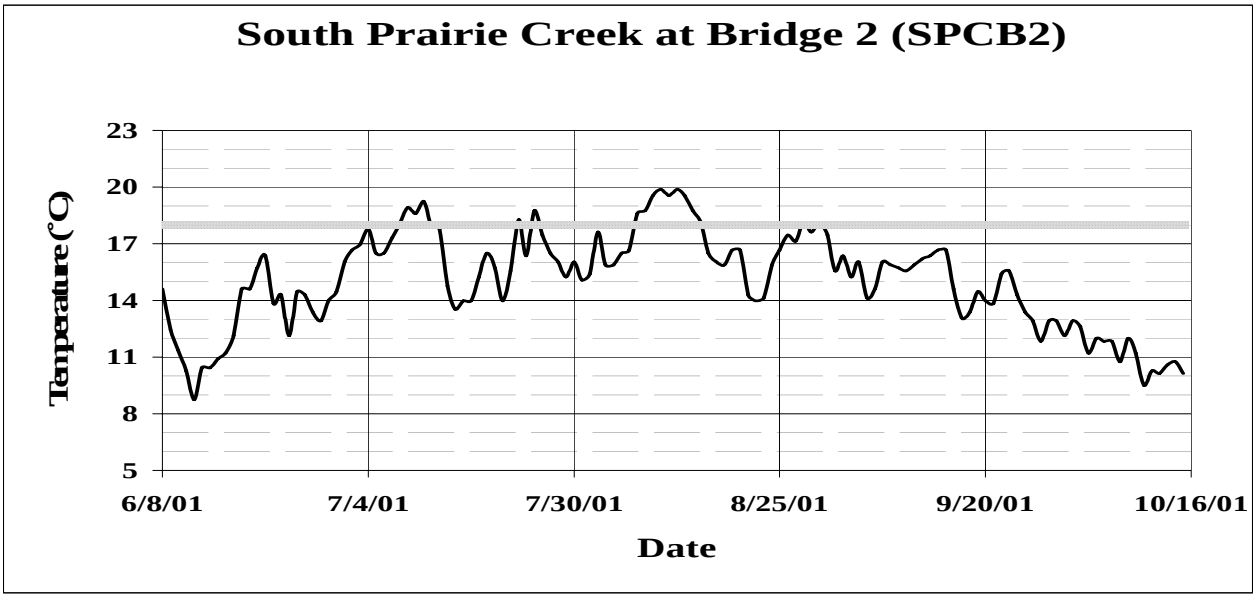


Figure 4-H. Temperature Profiles at Selected Sampling sites in South Prairie Creek. Graph 8

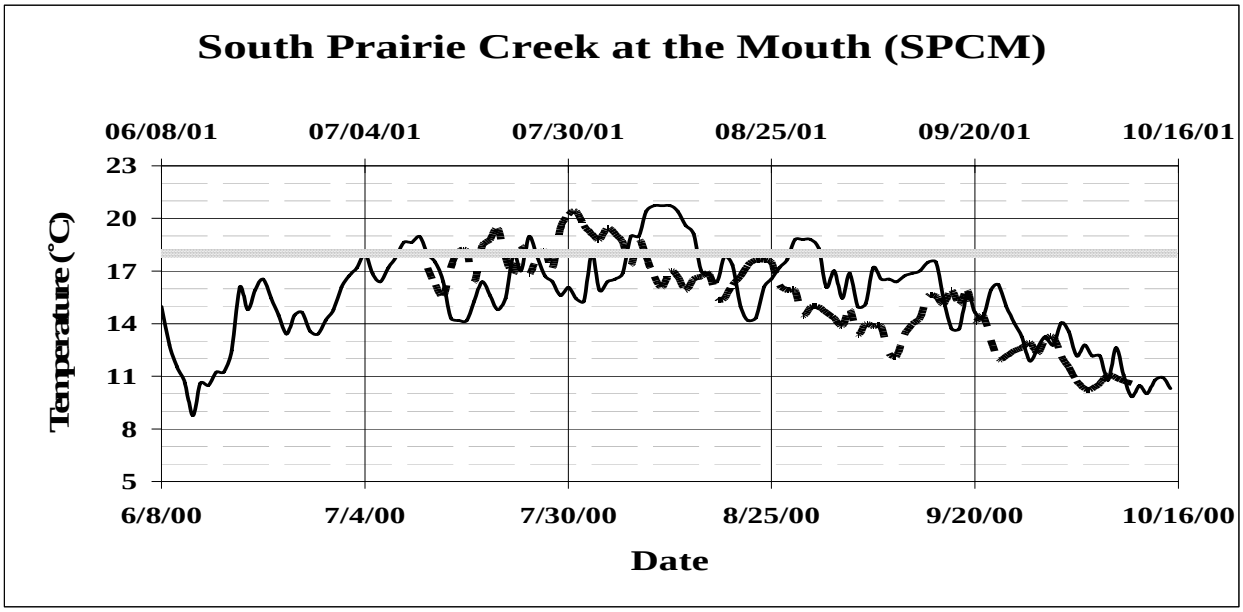


Figure 4-I. Temperature Profiles at Selected Sampling sites in South Prairie Creek Graph 9

The goal of any TMDL is to ensure the impaired water will attain water quality standards. A TMDL includes a written, quantitative assessment of both water quality problems and sources of the problems, the loading capacity, of the water body (the water body's capacity to remain within standards when loaded with a given pollutant), load allocations for nonpoint pollution sources (diffuse sources), wasteload allocations for point source pollution (discrete sources), and a summary of public involvement. The TMDL must also consider seasonal variations and include a margin of safety that takes into account any lack of knowledge regarding the causes of the water quality problem or a water body's loading capacity. The sum of the load and wasteload allocations and the margin of safety must be equal to or less than the loading capacity of the system.

The water bodies addressed in this TMDL DIP are shown in Table 1. Implementation efforts will be prioritized to address the timing for implementation related to these streams and tributaries to South Prairie Creek.

Table 1: Streams Addressed in the Fecal Coliform Bacteria and Temperature TMDL (Barreca and Roberts, 2003)

Name	Parameter	Old ID	New ID	1996 303(d) list	1998 303(d) list	Impaired but not listed
South Prairie Creek	Temperature and fecal coliform bacteria	WA-10-1085	VC19MO	Yes	Yes	Yes
Spiketon Creek	Temperature and fecal coliform bacteria	(none)	(none)	No	No	Yes
Wilkeson Creek	Temperature and fecal coliform bacteria	WA-10-1087	NX07HW	Yes	Yes	Yes
[Unnamed] Tributary One	Fecal coliform bacteria	(none)	(none)	No	No	Yes

The 1996 and 1998 303(d) lists identify South Prairie Creek or its tributaries as impaired by fecal coliform bacteria, temperature, and copper. The fecal coliform bacteria listing were based on historical ambient monitoring conducted by Ecology. The original temperature listings on South Prairie Creek and its tributaries were based on data collected by the Muckleshoot Tribe. Subsequent monitoring by Ecology conducted under the present study indicates that much of the lower watershed exceeds the temperature standard. Finally, the copper listing for Wilkeson Creek, originally based on estimates rather than field data, was reevaluated in 2001. Golding and Johnson (2001) concluded that the creek remains in compliance with water quality standards during critical conditions and recommended that Ecology not list Wilkeson Creek for copper. Therefore, Ecology did not conduct a copper TMDL.

Background

The South Prairie Creek watershed covers 235 km^2 and ranges in elevation from 1800 m at Pitcher Mountain to 87 m above mean sea level (Mastin, 1998), spanning the Puget Lowlands and Cascades eco-regions. The river flows 34.8 km from its headwaters within the Mt. Baker-Snoqualmie National Forest near the northwest corner of Mt. Rainier National Park to its confluence with the Carbon River, itself a tributary of the Puyallup River. The South Prairie Creek watershed includes several tributaries, of which Wilkeson Creek is the largest, with a watershed of 73 km^2. Spiketon Creek, (also known as Spiketon Ditch), flows to South Prairie Creek upstream of the Wilkeson Creek confluence and has a watershed area of 8.2 km^2). A small, unnamed tributary to South Prairie Creek (referred to as Tributary 1) with a watershed of 1.8 km^2 originates in the town of South Prairie and discharges to South Prairie Creek downstream of the town. Tributary 1 also has a tributary, referred to here as Tributary 4, which drains the hillside west of the town and enters Tributary 1 upstream of Washington State Highway 162 (SR162). Climate in the basin follows patterns typical of the Puget Lowlands and Cascades eco-regions, with wet, mild winters and dry, cool summers. Mean annual average precipitation in the watershed varies from 2.2 m/yr at the higher elevations to 1.0 m/yr at the mouth (DNR, 1995; Miller et al., 1973). Most of the average annual precipitation occurs between November and April. Winter precipitation falls as rain in the lowlands and a mix of rain and snow at higher elevations.

Streamflow also varies seasonally. Highest flows occur between November and February, while the lowest flows occur in August and September, based on the U.S. Geological Survey (USGS) gage located at the town of South Prairie. Average discharge for the water years 1988 to 2001 is 223 cfs. Minimum 7-day average flows have ranged from 25 to 42 cfs.

The watershed is composed of well-compacted glacial till and stratified drift deposits. Steeper gradients occur in the upper watershed, but the local channel slope in the lowlands study area varies from 0.03 to 0.003. The Osceola mudflow spilled into the South Prairie Creek valley near the confluence of South Prairie Creek and Spiketon Creek. The low-permeability valley bottom includes the developed areas of South Prairie, Wilkeson, Buckley and Burnett (USDA SCS, 1979).

Current land use includes forestry operations in the higher elevations. The Mount Baker-Snoqualmie National Forest, administered by the White River Ranger District, includes 70 km^2 of the headwaters of South Prairie Creek (Mastin, 1998). The area is not included in the present modeling analysis, since no impairment has been identified. In addition, the U.S. Forest Service is required to develop forest plans under the National Forest Management Act. Private timber companies, including Plum Creek, own land within the South Prairie Creek watershed. The area falls under the jurisdiction of the Timber Fish and Wildlife (TFW) Agreement. The 1987 agreement and the subsequent Forests and Fish Report, presented to the Forest Practices Board of Washington of the Department of Natural Resources and the Governor's Salmon Recovery Office in 1999, establish the following goals: provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands, restore and maintain riparian habitat to support a harvestable fish supply, meet the requirements of the Clean Water Act, and keep the timber industry economically viable.

Two dairy facilities and one livestock feeding operation are located near the town of South Prairie. One dairy is owned by the Soler family and it continues to operate, although the herd size has been reduced. The Solers have also given a conservation easement to the Pierce Conservation District for riparian activities. A second dairy (owned by the Inglin family and renamed as the South Prairie Creek Preserve) was operating at the time of the TMDL investigation and has since been purchased by Pierce County, the Pierce Conservation District, and others. A small livestock feeding operation is located along South Prairie Creek downstream of the dairies and small, non-commercial farms can be found at many locations in the lower watershed.

Residential land use includes both small urban centers and rural residential parcels. Wilkeson is the largest town in the watershed, with a population of 395, based on the 2000 census. Local springs provide drinking water. The town owns and operates a wastewater treatment plant that discharges to Wilkeson Creek. South Prairie is the next largest town with a population of 332, based on the 2000 census. The town relies on local wells for drinking water and operates a wastewater treatment plant that discharges to South Prairie Creek. The community of Burnett is the site of a large on-site wastewater demonstration project that relies on various emerging technologies (Creveling, 2002). The project eliminated direct wastewater discharges to the creek

The city of Buckley has a water right for 2 cfs (0.057 m^3/s) and diverts a portion of upper South Prairie Creek for its water supply but did not gage the volume during the study period. The Department of Social and Health Services (DSHS) shares the diversion and has a water right for 3.5 cfs to serve the Rainier State School and Washington State University Dairy Forage Facility. The combined diversion passes through a sand filter as part of Buckley's drinking water supply infrastructure. When the infiltration capacity of the filters is exceeded, the overflow is diverted back to South Prairie Creek via Spiketon Creek. However, the portion used by Buckley for drinking water is transferred out of the watershed, since the city discharges wastewater to the adjacent White River watershed.

The Burnett Water System currently holds surface water rights in the form of a presumed pre-code vesting water right. Water on the site has been in continuous use prior to the establishment of the surface water code. Current water use appears to amount to 180 gallons per minute, 0.4 cubic feet per second from the Burnett Springs, 16 acre-feet per year. The period of use has been year-round. The water requirement for the homes and stores in the Burnett community should not exceed an average of 400 gallons per day per home. For the current 35 units this amounts to approximately 16 acre-feet per year. The claim may ultimately be adjudicated and an adjudicated certificate awarded in a different quantity.

Other scattered residential developments throughout the lower watershed rely on private wells and septic systems.

In the process of developing action items for this DIP, questions were raised about why Pierce County was the only responsible entity identified in the TMDL with a bacteria load allocation in Tributary 1. A likely answer is that this tributary system was considered to be a municipal stormwater system operated by Pierce County and thus a load allocation for bacteria would be needed.

Further investigation of this tributary system suggests however, that Tributary 1 is likely a natural stream (and thus waters of the state) that has been straightened and channeled to conform to

landowner needs or to improve drainage capabilities. This stream originates from a hillside area south of the town of South Prairie and flows through animal pastures, under roadways (both county and Washington State Highway 162 (SR162)), and through the South Prairie Creek Preserve before discharging to South Prairie Creek. The town of South Prairie collects stormwater through a conveyance system that discharges to Tributary 1 at several locations. In addition, both Pierce County and the Washington State Department of Transportation (DOT) also have stormwater drainage systems that flow into Tributary 1.

In addition to direct flows from roadway surfaces, the Pierce County and DOT stormwater systems receive surface sheet flows from properties adjacent to the drainage systems. Although Pierce County and DOT are not generating this runoff, because it ends up in their stormwater drainage systems, they are still responsible for any water quality impacts resulting from the combined flows in their stormwater systems.

Tributary 1 is also likely impacted by ground water in the area. The TMDL submittal report acknowledges that soils in this area are not suitable for septic systems (Barreca and Roberts, 2003). The Tacoma-Pierce County Health Department (TPCHD) has jurisdictional responsibility over on-site sewage systems in the county. Shallow ground water impacts to Tributary 1 from septic systems will require further investigation as any inputs from these sources likely contribute to the bacteria loading.

To address the bacterial loading in Tributary 1, the current load allocation should be shared by DOT, the town of South Prairie, Pierce County, and the TPCHD. Determining who is responsible for what portion of the load allocation requires additional data collection and evaluation efforts. Source verification and assessment should be performed at locations in Tributary 1 to determine bacterial contributions. Corrective actions should be identified and implemented as soon as possible. Once addressed, a determination of whether additional measures are needed should become part of the adaptive management process.

Pierce County has taken a considerable step toward implementing this TMDL by joining with the Cascade Land Conservancy, the Boeing Company, and the Pierce Conservation District in the acquisition of the 107 acre South Prairie Creek Preserve adjacent to South Prairie Creek and through which Tributary 1 passes. The county has provided in excess of $400,000 toward the $950,000 purchase price, and the acquisition became final in early 2005. This acquisition will undoubtedly be the single most important implementation action to affect the bacterial quality of South Prairie Creek and eliminates direct livestock access to South Prairie Creek. Fecal coliform inputs and loading between the Tributary 1 and Tributary 1-Inglin Dairy sampling locations will be significantly reduced as dairy livestock will no longer be grazing in the pastured area through which Tributary 1 flows.

It is assumed that the vast majority of fecal coliform pollution in South Prairie Creek will be eliminated by the removal of the dairy herd from the former Inglin dairy (September 2003), and that the creek, downstream of the former dairy may now be meeting water quality standards for fecal coliform. Monthly fecal coliform monitoring beginning in May, 2005, will evaluate this assumption (Ragland and Roberts, 2004). It is not expected that Tributary 1 at Hwy 162 (T1)

will meet water quality standards for fecal coliform since there have been no changes to account for a load reduction at this time. It is assumed that Tributary 1, between Hwy 162 and its mouth, will not experience an increase in fecal coliform pollution because the dairy herd has been removed.

Currently, the Pierce Conservation District is conducting a monitoring program (Ragland and Roberts, 2004) that will locate contamination sources and guide remedial work or point to further source identification. Wildlife contributions were not quantified explicitly in the TMDL study. However, it is possible that smaller "duck ponds" discharging into Tributary 1 or Spiketon Creek could elevate bacterial concentrations in these smaller streams. The district's monitoring may provide information to answer this question.

Wildlife contributions were not quantified explicitly in the TMDL study. However, using literature values for gull contributions of 0.1 billion fecal coliform/day 2,500 gulls would be necessary to contribute the differential fecal coliform load between South Prairie Creek at the town of South Prairie and South Prairie Creek at the fourth highway bridge north of the Carbon River on SR162 (Barreca and Roberts, 2003). There is no evidence that wildlife frequent this reach more than other reaches. Due to the level of development, wildlife are likely less prevalent between these locations.

Approach

The TMDL submittal report presented the TMDL analysis and made recommendations for reductions of fecal coliform bacteria and improvements for temperature in South Prairie Creek and its tributaries. The next step in the TMDL process is the development of a detailed implementation plan.

Using the submittal report as the basis for recommended implementation actions, an advisory committee was formed of interested tribal, state agency, and local governments. Participants in the advisory committee included representatives of:

- Pierce Conservation District
- Pierce County Public Works and Utilities
- Puyallup River Watershed Council
- Puyallup Tribe
- Tacoma-Pierce County Health Department
- Town of South Prairie
- Town of Wilkeson
- Washington State Department of Agriculture
- Washington State Department of Ecology
- Washington State Department of Natural Resources
- Washington State Department of Transportation

The advisory committee met monthly between August 2003 and April 2005 at the town of South Prairie Fire Department Community Room. Dave Seabrook of the Puyallup River Watershed Council scheduled and facilitated advisory committee meetings, sent out agendas, kept meeting notes, and organized public outreach events.

The approach to cleanup will be varied, flexible, and adaptive. Cleanup will first address those activities identified by the advisory committee using the priorities established in Table 4 and 5. The relative priority of the implementation actions should direct efforts and resources. There is no expectation that actions must follow this approach as the key to address fecal coliform bacteria and temperature loadings is getting implementation to happen. Deviations of priority to take advantage of funding opportunities or citizen interests is very acceptable from this DIP planning perspective.

Pollution Sources and Organizational Responsibilities

Agriculture Sources
Based on land use, agricultural practices are likely the primary source of bacteria in the area of most concern. Livestock manure enters waterways when animals have direct access to streams, and when water running off the surface of the land carries feces into the water. Agricultural practices that are most critical to preventing bacterial pollution are:

- Fencing to exclude animals from waterways.
- Maintaining streamside vegetation.
- Land application of manure at times and rates that prevent excess from being carried into waterways.
- Storing manure so that it's not accessible to rain or flood waters.
- Maintaining pastures and animal-keeping areas to minimize run-off.

The Pierce Conservation District will offer technical assistance to landowners to develop farm plans, and suggest and design best management practices including livestock access to waterways. The Pierce County Stream Team will also work with groups and individuals to educate them about water quality and non-point pollution issues as they relate to fecal coliform bacteria. Through these educational efforts, stream team's educational outreach takes many forms, including water quality trainings and presentations on a variety of subjects to classrooms, teachers, and other groups.

Septic System Sources
Although exceptions do exist, soil conditions in the South Prairie Creek Valley are generally marginal to unsuitable for the siting and proper function of septic systems. The septic systems serving residential development were constructed prior to current permitting requirements and have the potential to introduce bacterial pollution. The Pierce Conservation District and the Tacoma-Pierce County Health Department will cooperate in identifying and addressing such problems.

Roadway Sources
Roadways and their associated drainage can also be sources of bacterial pollution. Washington SR162 and SR165 have drainage ditches that empty into Spiketon Creek, Tributary 1, South Prairie Creek and Wilkeson Creek. City, town, county, and private roads also provide drainage into Tributary 1 and Spiketon, Wilkeson and South Prairie Creeks. The Pierce Conservation District is conducting monitoring efforts on Tributary 1 and Spiketon Creek to assess the levels and sources of these potential bacteria sources. Source control measures and public outreach/landowner education efforts are warranted to curtail and minimize bacteria loading from the roadway and ditch system.

Wildlife Sources
However, it is possible that smaller "duck ponds" discharging into Tributary 1 or Spiketon Creek could elevate bacterial concentrations in these smaller streams. The Pierce Conservation District is conducting monitoring efforts on these streams to answer these questions.

Reduction Targets

Fecal Coliform Bacteria
Efforts to address fecal coliform bacteria are separated into two general areas - wasteload allocations and load allocations. Wasteload allocations address reductions needed from point source (confined) discharges while load allocations address pollution contributed from non-point (diffuse) sources.

Table 2 reflects the target reductions of fecal coliform bacteria concentrations for South Prairie Creek, Tributary 1, and Spiketon Creek.

Table 2: Fecal Coliform Bacteria load reduction necessary to meet water quality standards (Barreca and Roberts, 2003).

Station	Meets standard?	Geometric mean for growing season (cfu per 100mL)	90th Percentile for growing season (cfu per 100mL)	$f_{reduction}$ (to meet standard for growing season - %)	Target Geometric Mean for growing season (cfu per 100mL)	Geometric mean for non-growing season (cfu per 100mL)	90th Percentile for non-growing season (cfu per 100mL)	$f_{reduction}$ (to meet standard for non-growing season - %)	Target Geometric Mean for non-growing season (cfu per 100mL)
		Growing Season				Non- growing Season			
South Prairie Creek Mainstem									
SPCSR	YES	6	24	NA		2	7		
SPCLB	YES	12	54	NA		2	9		
SPCSP	YES	25	49	NA		13	58		
SPCOF	NO	54	234	14%	**46**	16	110		
SPCID	NO	80	280	28%	**57**	46	259	77%	36
SPCB4	NO	92	340	41%	**54**	74	865	23%	17
SPCB2	NO	58	138	NA		52	439	46%	24
SPCB1	NO	64	142	NA		55	413	48%	27
SPCM	NO	84	192	NA		83	851	23%	19
South Prairie Creek Tributaries									
SKT165	NO	200	1234	84%	**32**	68	420	48%	33
WCM	YES	52	145	NA		7	22		
WCOF	YES	6	72	NA		22	149		
T1	NO	192	542	63%	**71**	270	2809	7%	19
WCOF	YES	6	72	NA		22	149		
T1ID	NO	583	1916	90%	**61**	637	2649	8%	48

Legend:

SPCSR	South Prairie Creek at Spiketon Road, south of Buckley.
SPCLB	South Prairie Creek at Lower Burnett Road, downstream of State Route 165 bridge.
SPCSP	South Prairie Creek at the Town of South Prairie, near the fire station.
SPCOF	South Prairie Creek at the Town of South Prairie wastewater treatment plant outfall
SPCID	South Prairie Creek at South Prairie Creek Preserve bridge.
SPCB4	South Prairie Creek at State Route 162, fourth bridge north of the Carbon River.

SPCB2	South Prairie Creek at State Route 162, second bridge north of the Carbon River.
SPCB1	South Prairie Creek at State Route 162, first bridge north of the Carbon River.
SPCM	South Prairie Creek at mouth.
SKT165	Spiketon Creek at State Route 165.
WCM	Wilkeson Creek at mouth.
WCOF	Wilkeson Creek at the Town of Wilkeson WWTP outfall.
T1	Unnamed tributary at State Route 162 culvert.
T1ID	Unnamed tributary at confluence with South Prairie Creek.

Temperature

South Prairie Creek water temperatures are affected by many different physical processes in the watershed. Some of the factors affecting stream temperatures are 1) ambient air temperature, 2) stream flow rate, depth, and volume of water, 3) solar heating, 4) how much shade is available to block sunlight, and 5) influence of adjacent groundwater. All of these factors are important in the watershed and implementation actions need to address some, if not all. Temperature reduction targets are shown in Appendix E.

The purpose of streambank revegetation projects is to develop or enhance riparian cover along streams. A good cover of native plants with a mix of conifers, deciduous trees, and groundcover will result in more food, shelter, and cover for salmon, benthic macroinvertebrates, and other wildlife. Using native plants to help eradicate week species such as reed canary grass, blackberries, and Japanese knotweed results in better stream flow, greater numbers and diversity of native wildlife, increased woody debris in the stream from mature plantings, and the cooling of stream temperatures for salmonids.

Trees and shrubs used at each planting are chosen on a site–specific basis, and revegetation projects along streams must be maintained for a minimum of three years to increase the chances of the planting's success. Maintenance may include the use of tree protectors around the base of the trees and shrubs, weeding and invasive plant removal, and prohibiting animal browse.

The Pierce County Stream Team continues to support riparian planting and many volunteers have donated their time to help plant riparian areas in Pierce County. Stream team often requires the help of volunteers to return to previous planting sites to do maintenance. This includes pulling invasive species to reduce competition, checking for animal damage, and placing tree protectors around the plant stems.

Efforts to address temperature loadings are separated into two general areas - wasteload allocations and load allocations. Wasteload allocations address reductions needed from point source (confined) discharges while load allocations address pollution contributed from non-point (diffuse) sources.

Participating Organizations for Implementation Actions

Fecal Coliform Bacteria

Pierce Conservation District
Pierce Conservation District, under authority of Ch. 89.08 RCW, Conservation Districts, provides education and technical assistance to residents, develops conservation plans for farms, and assists with design and installation of best management practices. When developing conservation plans, the district uses guidance and specifications from the U.S. Natural Resources Conservation Service. Farmers receiving a Notice of Correction from Ecology will normally be referred to Pierce Conservation District for assistance.

In 2002, the district requested, and was granted, fee funding from the Pierce County Council, in accordance with Chapter 89.08.400 RCW. This provided a stable source of funding and allowed an increase in services.

Pierce County Water Programs and the cities of Tacoma, Bonney Lake, Fife, and Sumner, as well as monies collected from the Conservation Assessment Fee (from unincorporated Pierce County and the cities of Tacoma, Lakewood, Puyallup, Sumner, University Place, Fircrest, Steilacoom, and Milton) support the Pierce Stream Team. The stream team is a coalition of volunteers whose goal is to improve the quality of streams in Pierce County for the benefit of fish, wildlife, and people through public education and action projects. Stream team offers opportunities for volunteers to participate in water quality monitoring, streamside revegetation with native plants, stormdrain stenciling, and stream clean-up projects. Stream team members educate the public through participation in educational displays about streams and related issues at a variety of events, including the Puyallup Fair. In addition, the stream team program offers workshops and tours dealing with stream improvement and habitat enhancement for salmon and other wildlife living in and along streams.

Pierce County Planning and Land Services
Pierce County Planning and Land Services have responsibility for making decisions regarding land use actions in the unincorporated areas of the county. This is accomplished through evaluating land use proposals for compliance with existing county regulations and through compliance with a Critical Areas Ordinance (Ch. 18E.60.050), developed in accordance with Washington State's Growth Management Act, Ch. 36.70A. Planning and Land Use Services has enforcement authority for improper land use actions.

Pierce County Public Works and Utilities, Water Programs Division
In addition to other responsibilities, the Water Programs Division of Pierce County's Public Works and Utilities Department is responsible for managing water quality and flooding through basin-specific basin planning efforts, ensuring compliance with the stormwater quality management requirements of the Clean Water Act, and for gathering existing water quality data performing physical surveys, water quality monitoring, and coordinating public input for water programs division initiatives.

Under federal regulations CFR Title 40 122.26., Pierce County manages a stormwater system with 24 known outfalls to South Prairie Creek. The unincorporated areas of the county are covered under a Phase I municipal stormwater National Pollutant Discharge Elimination System (NPDES) permit. The county has oversight on the requirements of this permit and has developed both a storm water manual and a best management practices manual for potential dischargers to this system.

Chapter 11.05 of the Pierce County Code, Illicit Stormwater Discharges (Ordinance No. 96-47), makes it unlawful for any person to discharge any pollutants into municipal drainage facilities. The county usually addresses nonpoint source pollution entering drainage ditches through education and technical assistance, but can require immediate cessation of discharges and implementation of best management practices.

Ecology is currently in the development stage for re-issuing the Phase I Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) permit for Pierce County. The municipal stormwater permits require the implementation of a stormwater management program. The stormwater management program is a plan for the term of the permit to reduce the discharge of pollutants, reduce impacts to receiving waters, eliminate illicit discharges, and make progress towards compliance with surface water, ground water, and sediment standards.

The Phase I Municipal Stormwater NPDES permit will incorporate action items identified in this DIP for the county to perform along with action items from other applicable TMDLs completed by the time of permit issuance. Ecology anticipates that the Phase I permit will be drafted by mid-May 2005, and a final permit will be issued by March 2006. Permit coverage extends for five years.

Puyallup Tribe of Indians
The Puyallup Tribe has been collecting bacteria data in the South Prairie Creek watershed since 1998. The tribe continues to perform water quality monitoring, especially for temperature.

Town of South Prairie
The South Prairie wastewater treatment plant (NPDES Permit No. WA0040479, expires June 30, 2010) discharges to an impaired section of South Prairie Creek. Although nonpoint sources contribute the vast majority of the bacteria load to South Prairie Creek, the point source contribution from the wastewater treatment plant could increase the concentration at the edge of the mixing zone by 0 to 5 cfu/100 mL, depending on the background contribution. The recently issued NPDES permit limits remain at 200 cfu/100 mL for a monthly geometric mean and 400 cfu/100 mL for a weekly geometric mean. This is the recommended wasteload allocation for the South Prairie wastewater treatment plant.

If monitoring shows that the creek downstream of the treatment plant is still not meeting water quality standards by 2010, then the South Prairie wastewater treatment plant should receive water quality-based permit limits of 100cfu/100 mL for a monthly geometric mean and 200cfu/100 mL for a weekly geometric mean.

The town also manages wastewater and stormwater from the city, and controls development standards, i.e., density, placement, and sewering requirements for new developments. The town has a stormwater collection system that drains to Tributary 1 at several locations. New develop-

ment within the town must meet specifications of the Pierce County Stormwater Manual. The town shares responsibilities with the Department of Transportation and Pierce County for Tributary 1 load allocations.

Tacoma-Pierce County Health Department
TPCHD regulates on-site septic systems in Pierce County in accordance with Ch. 246-272 WAC, and has an on-site operations and maintenance program. High-volume business systems, and complex systems, both business and residential, are required to perform yearly inspections. Other residential systems must be inspected at time of sale. Sanitary surveys or other investigative work are usual compliant or problem-driven, and usually must be grant funded. Outreach, including providing educational DVDs, presentations, and "as-built" information, is a primary tool for technical assistance and education.

Although exceptions do exist, soil conditions in the South Prairie Creek Valley are generally marginal or unsuitable for the siting and proper function of septic systems. The septic systems serving residential development were constructed prior to current permitting requirements and have the potential to introduce bacterial pollution. The Pierce Conservation District and the Tacoma-Pierce County Health Department will cooperate in identifying and addressing such problems.

Washington State Department of Ecology
Washington State Department of Ecology has been delegated authority under the federal Clean Water Act by the U.S. Environmental Protection Agency to establish water quality standards; coordinate water cleanup projects (TMDLs) on water bodies that fail to meet water quality standards, and enforce water quality regulations under the Water Pollution Control Act, Chapter 90.48 RCW. In addition to this regulatory role, Ecology provides financial assistance to local governments, tribes, conservation districts, and citizens groups for water quality projects. Projects that implement water cleanup plans for TMDLs are a high priority for funding.

For non-dairy agricultural problems, if Ecology confirms that poor farm management practices are likely to be polluting surface waters, farmers are typically referred to conservation districts for technical assistance. If necessary, Ecology can require specific actions under Chapter 90.48 RCW, such as implementation of an approved farm plan, to correct the problem.

Ecology issues NPDES permits to address point source and stormwater pollution. Ecology also conducts nonpoint source inspections on nonpoint source activities.

Washington State Department of Transportation
The Washington State Department of Transportation (DOT) has responsibility for all state roadways and adjacent stormwater drainage systems. Ecology is currently in the development stage for re-issuing the Phase I Municipal Stormwater National Pollutant Discharge Elimination System (NPDES) permit for DOT. (The public entities that are covered under Phase I Municipal Stormwater NPDES permits include: King County, Pierce County, Snohomish County, Clark County, city of Seattle, city of Tacoma, and the Washington State Department of Transportation.)

The municipal stormwater permits require the implementation of a stormwater management program. The stormwater management program is a plan for the term of the permit to reduce the discharge of pollutants, reduce impacts to receiving waters, eliminate illicit discharges, and make progress towards compliance with surface water, ground water, and sediment standards. Ecology anticipates that the final Phase I permit will be issued in 2006. Permit coverage extends for five years.

Roadway runoff from SR 162 and the adjacent highway ditch system contribute to the fecal coliform bacteria loading to Tributary 1 and roadway runoff from SR 165 and the adjacent ditch system contribute to the fecal coliform bacteria loading to Spiketon Creek. Materials deposited on the roadway surface, surface discharges from properties adjacent to the ditch system, and wildlife/waterfowl utilizing of the roadway ditch system for habitat all can be sources of bacterial contamination. The Department of Transportation shares responsibilities with Pierce County, and the Town of South Prairie for Tributary 1 load allocations.

Town of Wilkeson
Wilkeson Creek met the fecal coliform bacteria water quality standard therefore, the Wilkeson wastewater treatment plant (NPDES Permit No. WA0023281, expires June 30, 2010), wasteload limits should remain at the current level of 200 cfu/100 mL for a monthly geometric mean and 400cfu/100 mL for a weekly geometric mean. No reduction in wasteload allocation is recommended, since the plant contributes <1 percent of the load increase in the system.

Temperature

Streamside Property Owners
Riparian vegetation has been reduced due to land conversions and residential development pressure. Forestry practices and livestock access have also contributed to the loss of riparian cover. Voluntary cooperation by streamside property owners with conservation and revegetation efforts is critical for temperature improvements.

Town of South Prairie
The South Prairie wastewater treatment plant discharges to South Prairie Creek under NPDES permit number WA0040479. The permit does not have an effluent limit for temperature. Because South Prairie Creek currently exceeds the 18°C standard near the discharge, discharges must then meet the second element of the water quality standards which stipulates that *"…no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."*

Town of Wilkeson
The Wilkeson wastewater treatment plant discharges to Wilkeson Creek under NPDES permit number WA0023281. The permit does not have an effluent limit for temperature. Wilkeson Creek currently meets the 18°C standard near the discharge, based on the monitored conditions of 2000 and 2001, but exceeds the standard at the mouth. Discharges must then meet the second element of the water quality standards stipulate that *"…no temperature increases will be allowed which will raise the receiving water temperature by greater than 0.3°C."*

Management Roles, Activities, and Schedules

This section describes general responsibilities of organizations involved in fecal coliform bacteria and temperature improvements. It is assumed that the vast majority of fecal coliform pollution in South Prairie Creek was eliminated by the removal of the dairy herd and decommissioning the Inglin Dairy in September of 2003, and that the stream now meets water quality standards for fecal coliform. Monthly fecal coliform monitoring beginning in May, 2005, and will evaluate this assumption (Ragland and Roberts, 2004).

Implementation actions need to focus in the following areas:

Tributary 1
Tributary 1 at Hwy 162 is not expected to meet water quality standards for fecal coliform without additional source identification effort since there have been no specific problems identified upstream to account for a load reduction. It is assumed that there will not be an increase in fecal coliform pollution in Tributary 1, between SR 162 and its mouth, because the dairy herd has been removed.

Pierce Conservation District is conducting a monitoring program designed to discriminate among several potential sources that would impact fecal coliform levels in Tributary 1 (Ragland and Roberts, 2004). The possible sources include roads and highways, livestock areas, wildlife ponds, and septic systems. Pierce County and the Washington State Department of Transportation will be responsible for roadways. The Pierce Conservation District, will work with local farms to implement BMPs, and the Tacoma-Pierce County Health Department will work to solve identified septic failures.

Spiketon Creek
It is not expected that Spiketon Creek will meet water quality standards for fecal coliform without additional source identification effort since, as in the case of Tributary 1 above SR 162, there have not been any specific problems identified to account for a reduction in loading at this time.

The Pierce Conservation District is conducting a monitoring program (Ragland and Roberts, 2004) that will localize contamination sources and guide remedial work or point to further source identification. The possible sources include roads and highways, livestock areas, and septic systems. Pierce County and the Washington State Department of Transportation will be responsible for roadways, while the Pierce Conservation District will work with local farms to implement BMPs and the Tacoma-Pierce County Health Department will work to solve identified septic failures.

Implementation Actions and Phased Priority
Implementation actions have been identified for the responsible entities to complete. Table 3 indicates the implementation phase, timeline, entity, and targeted pollutant. Actions have been phased to acknowledge actions taken to date and other actions needed by entities which need to participate in order to achieve the necessary reductions by the established calendar year targets (Refer to Performance Measures and Targets Section). While bacterial concentrations in the lower mainstem South Prairie Creek may have significantly changed through the acquisition of

the South Prairie Preserve, additional reductions are still needed at other locations (Tributary 1 and Spiketon Creek) in order to meet the established calendar targets.

Table 3: Fecal Coliform and Temperature Implementation Actions

Focused Implementation	
	Phase I – Year 2006-2009
Entity	Action
All	
	Fecal Coliform and Temperature
	Participate in annual adaptive management meetings beginning in 2007 to discuss progress and identify alternatives if needed.
City of Buckley	
	Fecal Coliform
	In cooperation with the Pierce Conservation District, investigate Spiketon Creek bacterial sources impacting the city's stormwater drainage system adjacent to Spiketon Creek while it remains out of compliance with clean water standards. If necessary, identify activities impacting surface discharges to the drainage system and perform sampling to verify bacterial sources, determine the relative contributions of bacteria from these activities, and the combined contribution from the stormwater drainage system at their outfalls to Spiketon Creek.
	Assess current roadway maintenance practices adjacent to the city's stormwater drainage system along Spiketon Road. Determine the type, frequency, and schedule of maintenance activity and identify those which indirectly support bacterial contributions. Revise or modify maintenance activities to minimize bacterial contributions.
Cascade Land Conservancy	
	Fecal Coliform
	Participate in land acquisition for riparian restoration in the South Prairie Creek Watershed.
	Temperature
	Participate in land acquisitions for riparian restoration in the South Prairie Creek Watershed.
Pierce Conservation District	
	Fecal Coliform
	Conduct basin-wide inventory of livestock bearing properties.
	Promote and/or administer financial assistance programs for implementing riparian livestock exclusion fencing and plantings.
	Assist in the development and implementation of farm plans and water quality BMPs.

Phase I – Year 2006-2009	
Entity	Action
Pierce Conservation District (cont)	Conduct at least three small farm land management workshops to inform livestock. owners about water quality BMPs.
	Conduct riparian conditions inventory of Spiketon Creek.
	Conduct at least five native plant workshops to introduce land owners to the environmental benefits of native riparian vegetation.
	Conduct monitoring to assess the response of South Prairie Creek to the measures detailed in this plan.
	Temperature
	Conduct continuous temperature monitoring to further assess baseline conditions for South Prairie Creek and Spiketon Creek.
	Conduct riparian conditions inventory in TMDL study area and develop planning for riparian restoration on public and private lands.
	Provide assistance to private landowners for riparian improvements.
Pierce County	Fecal Coliform
	Enforce Critical Areas Ordinance and other Pierce County land use regulations. (Planning and Land Services)
	Increase review requirements and inspection frequency for permitted land conversions (clearing/grading/grubbing) and other land use actions where potential sediment loading to South Prairie Creek or tributaries could occur. (Planning and Land Services)
Puyallup Indian Tribe	
	Fecal Coliform
	Conduct fecal coliform bacteria monitoring.
	Temperature
	Conduct continuous temperature monitoring in the summer at select locations.
	Inventory existing water rights and pursue acquisition to preserve instream flows.
Town of South Prairie	
	Fecal Coliform
	Manage and maintain the town's sewage treatment plant and collection system in compliance with current NPDES permit requirements.

	Phase I – Year 2006-2009
Entity	Action
	Fecal Coliform
Town of South Prairie (cont)	Manage stormwater quality and related discharges to South Prairie Creek and Tributary 1 in compliance with current stormwater regulations and Ecology's Western Washington Stormwater Manual.
	Update every seven years and enforce Critical Areas Ordinances and other land use regulations.
	Temperature
	Update every seven years and enforce Critical Areas Ordinances and other land use regulations.
	Compliance with NPDES permit limits.
Tacoma-Pierce County Health Department	
	Fecal Coliform
	The On-site Sewage Operation and Maintenance Program will provide education materials through its On-Site Sewage Operation and Maintenance Program. Materials will be provided through an initial mailing to property owners. The effectiveness of the mailings will be assessed to determine the focus of future septic system operation and maintenance efforts. The Tacoma-Pierce County Health Department will continue to require on-site sewage system operation evaluations as the time of sale and provide enforcement activities to correct confirmed on-site sewage system failures.
	Coordinate with Pierce County for low income on-site sewage system repair loans.
	Perform dye testing of those systems suspected of failing of where lateral movement is suspected.
Washington State Department of Agriculture	
	Fecal Coliform
	Enforce the Dairy Nutrient Management Act (Ch. 90.64 RCW). This act requires dairy farmers to have approved dairy waste management plans through an NPDES permit.
	Work with Pierce Conservation District to encourage small and hobby farms to implement BMPs.

	Phase I – Year 2006-2009
Entity	Action
Washington State Department of Ecology	
	Fecal Coliform
	When requested, assist in the review of QAPP plans for non-Ecology water quality monitoring efforts.
	Conduct TMDL effectiveness monitoring.
	Include the Puyallup Tribe of Indians in the review and comment of permits that are developed addressing this TMDL.
	Enforce the Water Pollution Control Act (Ch. 90.48 RCW) requirements.
	Perform inspections of construction stormwater sites and other permitted facilities.
	Respond to non-dairy agriculture complaints.
	Temperature
	Provide funding opportunities and track successful applications through facilitation of annual funding cycles for: Centennial Clean Water Fund, Washington State Water Pollution Control Revolving Fund, Clean Water Act. Section 319 Nonpoint Source Fund.
	Include the Puyallup Tribe of Indians in the review and comment of permits that are developed addressing this TMDL.
Washington State Department of Natural Resources	
	Temperature
	Enforce Forest Practices Act (Ch 76.09 RCW and WAC 222). Review applications for timber harvesting or land conversions to minimize impacts to South Prairie Creek. Require adequate riparian buffers, when applicable.
Washington State Department of Transportation	
	Fecal Coliform
	Investigate Tributary 1 bacterial sources impacting DOT's stormwater drainage system along SR162. Identify activities impacting surface discharges to the drainage system and perform sampling to verify bacterial sources. Determine the contributions from the drainage system at the outfall to Tributary 1 for both the growing season (May through October) and the non-growing season (November through April) periods.

Phase I – Year 2006-2009	
Entity	Action
Washington State Department of Transportation (cont.)	Investigate bacterial sources impacting DOT's stormwater drainage system along SR165. Identify activities impacting surface discharges to the drainage system and perform sampling to verify bacterial sources. Determine the contributions from the drainage system at their outfalls to Spiketon Creek for both the growing season (May through October) and the non-growing season (November through April) periods.
	Assess current roadway maintenance practices adjacent to DOT's stormwater drainage systems along SR162 and SR165. Determine the type, frequency, and schedule of maintenance activities and identify those which indirectly support bacterial contributions. Revise or modify roadway maintenance activities to minimize bacterial contributions. Implement the most current highway runoff manual if more stringent reductions can be realized.
	Provide $19,584 to support for two years of water quality monitoring to determine relative contributions of bacteria from the roadway corridor and ditch systems for both the growing season (May through October) and non-growing season (November through April) periods. Determine the relationship of DOT loads to non-DOT loads to Tributary 1.
	Develop and distribute educational materials on stormwater source controls/best management practices to landowners adjacent to SR162 and SR165 stormwater drainage systems.
	Refer landowners to the Pierce Conservation District for technical assistance where agricultural or livestock impacts contribute direct flows or sheet flows to DOT's stormwater drainage system along SR162 or SR165.
	Temperature
	Consider land acquisitions to preserve floodplain, water quality functions, and riparian habitat in the South Prairie Creek Watershed.
	Promote civic and local landowner efforts to restore native vegetation in riparian areas.

	Phase II – Year 2010-2013
Entity	Action
All	
	Fecal Coliform and Temperature
	Participate in adaptive management meeting to discuss progress and identify alternatives if needed.
Pierce Conservation District	
	Fecal Coliform
	Restore land at the South Prairie Creek Preserve to native plant conditions, provide riparian enhancement, and put 50 percent of water rights into trust.
	Assist in the development and implementation of farm plans and water quality BMPs.
	Conduct monitoring to assess the response of South Prairie Creek to the measures detailed in this plan.
	Temperature
	Conduct continuous temperature monitoring to further assess baseline conditions for South Prairie Creek and Spiketon Creek.
	Provide assistance to private landowners for riparian improvements.
Pierce County	
	Fecal Coliform
	Investigate Tributary 1 bacterial sources impacting the county's stormwater drainage system upstream of SR162. Identify activities impacting surface discharges to the drainage system and perform sampling to verify bacterial sources. Determine the contributions from the drainage system at their outfalls to Tributary 1 for both the growing season (May through October) and the non-growing season (November through April) periods.
	Investigate bacterial sources impacting the county's stormwater drainage system upstream of SR165 along Spiketon Road, Mundy Loss Road, and Spiketon Ditch Road. Identify activities impacting surface discharges to the drainage system and perform sampling to verify bacterial sources. Determine the contributions from the drainage system at their outfalls to Spiketon Creek for both the growing season (May through October) and the non-growing season (November through April) periods.
	Assess current roadway maintenance practices adjacent to the county's stormwater drainage system upstream of SR162. Determine the type, frequency, and schedule of maintenance activities and identify those which indirectly support bacterial contributions. Revise or modify roadway maintenance activities to minimize bacterial contributions.

	Phase II – Year 2010-2013
	Distribute educational materials on stormwater source controls/best management practices to landowners adjacent to the county's stormwater drainage system.
	Refer landowners to the Pierce Conservation District for technical assistance where agricultural or livestock impacts contribute direct flows or sheet flows to the county stormwater drainage system upstream of SR162 or along Spiketon Ditch Road.
	Enforce Critical Areas Ordinance and other Pierce County land use regulations. (Planning and Land Services)
	Increase review requirements and inspection frequency for permitted land conversions (clearing/grading/grubbing) and other land use actions where potential sediment loading to South Prairie Creek or tributaries could occur. (Planning and Land Services)
	<u>Temperature</u>
	Complete county-led basin planning efforts for the Carbon River Basin which includes the South Prairie Creek Watershed. Identify and propose projects for the South Prairie Creek Watershed.
	Consider land acquisitions to preserve floodplain, water quality functions, and riparian habitat in the South Prairie Creek Watershed.
	Promote civic and local landowner efforts to restore native vegetation in riparian areas.
Tacoma-Pierce County Health Department	
	<u>Fecal Coliform</u>
	The Tacoma-Pierce County Health Department will evaluate and track suspected on-site sewage system failures and areas where other sources of contamination have been ruled out, and provide enforcement activities to correct confirmed on-site sewage system failures.

Phase II – Year 2010-2013	
Entity	Action
Tacoma-Pierce County Health Department Cont.	Fecal Coliform
	Perform dye testing of those systems suspected of failing of where lateral movement is suspected.
Washington State Department of Agriculture	Fecal Coliform
	Enforce the Dairy Nutrient Management Act (Ch. 90.64 RCW). This act requires dairy farmers to have approved dairy waste management plans through an NPDES permit.
Washington State Department of Ecology	
	Fecal Coliform and Temperature
	Conduct TMDL effectiveness monitoring after sufficient implementation has occurred.
	Enforce the Water Pollution Control Act (Ch 90.48 RCW) requirements.
Washington State Department of Natural Resources	
	Temperature
	Enforce Forest Practices Act (Ch 76.09 RCW and WAC 222) requirements.
Town of Wilkeson	
	Fecal Coliform
	Manage and maintain the town's sewage treatment plant and collection system in compliance with current NPDES permit requirements.
	Manage stormwater quality and related discharges to Wilkeson Creek in compliance with current stormwater regulations and Ecology's Western Washington Stormwater Manual.
	Update every seven years and enforce Critical Areas Ordinances and other land use regulations.
	Temperature
	Adopt and enforce Critical Areas Ordinance and other land use regulations.
	Compliance with NPDES permit limits.

Ongoing Implementation – Year 2014+	
Entity	Action
All	
	Fecal Coliform and Temperature
	Participate in adaptive management meeting to discuss progress and identify alternatives if needed.
Pierce Conservation District	
	Fecal Coliform and Temperature
	Conduct monitoring to assess the response of South Prairie Creek to the measures detailed in this plan.
Pierce County	
	Enforce Critical Areas Ordinance and other Pierce County land use regulations. (Planning and Land Services)
	Increase review requirements and inspection frequency for permitted land conversions (clearing/grading/grubbing) and other land use actions where potential sediment loading to South Prairie Creek or tributaries could occur. (Planning and Land Services)
Washington State Department of Agriculture	
	Fecal Coliform
	Enforce the Dairy Nutrient Management Act (Ch. 90.64 RCW). This act requires dairy.
Washington State Department of Ecology	
	Fecal Coliform
	Enforce the Water Pollution Control Act (Ch 90.48 RCW) requirements.
Washington State Department of Natural Resources	
	Temperature
	Enforce Forest Practices Act (Ch 76.09 RCW and WAC 222) requirements.

Performance Measures and Targets

The ultimate goal performance measure of this plan is to achieve healthy water quality in the freshwater areas of the South Prairie Creek Watershed. Water will be considered "healthy" when it meets state water quality standards. The TMDL established a target date of calendar year 2089 for meeting temperature standards and calendar year 2008 for meeting fecal coliform bacteria standards. The detailed implementation plan advisory committee has reviewed these dates and while the temperature target remains as originally indicated, the fecal coliform bacteria target has been revised to calendar year 2011.

Efforts to meet the fecal coliform bacteria target are well on the way. With the removal of livestock and acquisition of the South Prairie Creek Preserve, a significant source of bacterial contamination to South Prairie Creek has been addressed. While mainstem concentrations are the current focus, attention is still needed for Tributary 1 and Spiketon Creek. An interim target date of June 2008 is anticipated for a 50 percent reduction of growing season and non-growing season bacterial loads (Table 2). Bacteria water quality standards are anticipated to be met by June 2011.

Achieving the temperature target depends on establishing healthy riparian buffers where they do not exist and protecting and enhancing existing buffers (Appendix E). To achieve the temperature target by calendar year 2089, an interim target of calendar year 2008 has been established for completion of an inventory to identify sites in the watershed where riparian plantings are needed. Priority areas will be established and a second interim target of calendar year 2020 has been established for revegetating 50 percent of the area in need of plantings and where voluntary cooperation has been received from streamside landowners. It should be noted that the Pierce Conservation District is on track to complete plantings at the South Prairie Preserve by April 2007.

Measuring Progress towards Goals

The implementation committee will review new fecal coliform data annually for the first three years following the adoption of this document, and on a schedule to be determined after three years. Failure of South Prairie Creek, Tributary 1 or Spiketon Creek to meet water quality standards for fecal coliform will require the development of additional controls and source identification procedures.

Failure of South Prairie Creek to meet water quality standards for temperature will require the development of additional controls and source identification procedures. Monitoring for the effectiveness of shade will not occur until potential shade levels are reached. Adaptive management for both temperature and fecal coliform will be facilitated by the Puyallup River Watershed Council.

The Puyallup Tribe of Indians is currently in the process of establishing water quality standards for tribal lands. Proposed standards for temperature are lower than current state water standards and bacterial indicator species are proposed to be Eschericia coli rather than the current fecal coliform standard. At the time of DIP completion, the tribal standards were not in effect and the

timing for implementation of the new standards had yet to be resolved. Detailed implementation plan actions will also need to be reviewed as part of the adaptive management process when the tribal standards go into effect.

Implementation Monitoring

The Pierce Conservation District is conducting a monitoring program (Ragland and Roberts, 2004) that will localize contamination sources and guide remedial work or point to further source identification. The possible sources include roads and highways, livestock areas, and septic systems. Pierce County and the Washington State Department of Transportation will be responsible for roadways, while the Pierce Conservation District will work with local farms to implement BMPs and the Tacoma-Pierce County Health Department will work to solve identified septic failures.

Effectiveness Monitoring Plan

When it appears that TMDL allocation levels have been achieved, an effectiveness monitoring program will begin. Effectiveness monitoring refers to conducting a rigorous monitoring effort to confirm that the TMDL goals have been achieved. Ecology is ultimately responsible for effectiveness monitoring, and must oversee the process. However, actual data collection may be accomplished in several ways including:

- As part of county or other local monitoring efforts.
- As part of tribal monitoring.
- As a special project requested by Ecology's Southwest Regional Office and performed by Ecology's Environmental Assessment Program.

Effectiveness monitoring will begin when the advisory committee believes TMDL reductions have been achieved. The choice of which of the monitoring options to employ will be determined based on resources available at the time when effectiveness monitoring is needed. Once TMDL reductions are achieved, Ecology intends to monitor every five years.

In order to be thorough in accomplishing this task, monitoring personnel will consult with the original TMDL modeler to determine critical parts of the implementation plan and to verify critical locations. All monitoring will be performed in accordance with an approved Ecology quality assurance/project plans. Data will be evaluated to determine water quality status, and an advisory memorandum will be followed by a technical report.

Adaptive Management

Adaptive management describes those actions which will be followed in the unlikely event that implementation actions are not performed or if the water quality of South Prairie Creek does not respond as anticipated after implementation actions are put into place. The Puyallup River Wa-

tershed Council is the logical entity to facilitate implementation activities and to facilitate necessary adaptive management actions.

As described in the approach section, basic tools for pollution source identification will be used. Upon identification of known or potential sources of pollution, technical assistance and education will be provided and control measures will be implemented. Over time, it is expected that this simple approach will result in reduced pollution levels. An adaptive management approach to this water cleanup plan would begin at the point where monitoring results indicate that control measures are not producing the anticipated pollution reductions. In that event, further analysis of monitoring data and pollution sources would likely identify additional controls that could be implemented to gain the desired pollution reductions. Data gaps will be identified which, when filled, may lead to new information about other potential pollution sources. Further source identification activities and control measures will follow the course described in this DIP. While adaptive management primarily focuses on necessary adjustments or revisions to implementation actions, it will also be used to draw attention to and/or enhance measures that are working and achieving the desired results.

Should water quality standards be achieved before the load allocations are achieved, then the TMDL will be considered to be satisfied.

The advisory committee will meeting annually for the first three years following the adoption of this document to review results of implementation efforts. Failure of Tributary 1 to meet water quality standards for fecal coliform will require the development of additional control and source identification procedures.

Enforcement

The Water Pollution Control Act (Chapter 90.48 RCW) provides broad authority to issue permits and regulations, and prohibits all unregulated discharges to water. The act clearly states that it is the policy of the state to maintain the highest possible standards to ensure the purity of all waters of the state, and to require the use of all known, available, and reasonable means to prevent and control water pollution. Ecology is authorized under this act to control and prevent pollution, and to make and enforce rules, including water quality standards. The act also designates Ecology as the state water pollution control agency for all the purposes of the federal Clean Water Act.

Reasonable Assurances

The U.S. EPA requires some assurances that TMDL implementation measures will actually occur. To that end, responsible parties, regulatory authorities, detailed implementation measures and schedules, and funding mechanisms must be identified. To provide this assurance, this DIP specifically details the people, actions, timelines, and funding to accomplish the stated goals. While it must be acknowledged that Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with state water quality standards, it is the goal of all participants in the South Prairie Creek TMDL process to achieve clean water through voluntary control actions.

Commitment to addressing the bacteria and temperature in the South Prairie Creek Watershed has been well demonstrated over the last few years. Interested and responsible organizations have worked together as demonstrated by the following:

- The TPCHD is providing technical assistance to property owners with on site sewage systems and is implementing provisions of their On Site Sewage System Program (OSS). When OSS failures are identified, owners will be referred to TPCHD.
- The Pierce County Public Works and Utilities, Water Programs Division will continue to implement their storm water program as required by their Phase 1 Storm Water Permit under NPDES.

- The Pierce Conservation District is working with landowners on agricultural best management practices and conducts water related workshops. The district is involved with on-going education, technical assistance, and cost-share programs and continues to pursue grant and loan funding opportunities.

- The Pierce Conservation District has initiated stream restoration measures including tree planting and outreach/public education to streamside landowners.

- The Pierce Conservation District is conducting a monitoring program supported by an Ecology Centennial Clean Water Fund grant (G0500118; South Prairie Creek Restoration Monitoring Project). The project purpose, as stated in the grant agreement, is to "produce highly trained volunteers for the purpose of monitoring the recovery of South Prairie Creek from fecal coliform and temperature contaminants, and providing a data set for use in adaptive management decisions for recovery as recommended by the South Prairie Creek TMDL submittal report."

- The Puyallup Tribe of Indians continues to perform continuous temperature monitoring as part of their water quality monitoring program.

Public Involvement

Communication with the public along with providing an opportunity for public awareness and input to the detailed implementation plan was accomplished by the following approaches:

- An advisory committee (referenced in the approach section) was formed to provide feedback at major decision points in the development of this document. The advisory committee met nine times (August 26, 2003, March 8, 2004, April 5, 2004, May 3, 2004, June 7, 2004, August 2, 2004, September 8, 2004, December 13, 2004, and January 13, 2005) and was instrumental in providing a forum and sounding board for the implementation actions proposed.

- On June 15, 2004, an open house was held in the town of South Prairie to allow interested parties to hear about the DIP process and receive answers to any questions they may have. Advisory committee members were present at the open house to provide information about their organizations involvement with the TMDL. Ecology assisted

with advertising the meeting and answered questions from the public about the TMDL process. Anticipated implementation actions were also discussed at this time. The meeting was held at the South Prairie Community Center starting at 4:00 p.m. and 15 citizens attended.

- On April 14, 2005, a second open house regarding the project was held at the South Prairie Creek Preserve. The formal acquisition of the property had recently been completed and this provided an opportunity to engage the public about the project at a location that had been identified as a significant source of bacterial contamination. An added benefit for this meeting is that the South Prairie Creek Preserve is adjacent to the creek. The meeting started at 3:30 p.m. and 22 citizens attended.
- Ecology released a draft DIP for public comment. A thirty-day comment period was established, beginning on March 17, 2006, and extending through April 18, 2006. Notification of document availability was made through Ecology's Internet and advisory committee members were provided with a draft document. Printed copies of the draft document were provided to the Pierce County Library System for placement at the Puyallup South Hill Library, Orting Library, and Buckley Library. Copies were also placed in the town halls of the communities of South Prairie and Wilkeson. Extra copies of the draft DIP were provided to the Pierce Conservation District and copies were available through Ecology's publications.
- Because the DIP identified actions for the Washington State Department of Transportation to perform, recognition of this obligation was provided via electronic mail notification.
- A final public meeting was held on March 28, 2006 at 6:30 p.m. in the South Prairie Community Center. A presentation was made on the history of the TMDL and the process followed for developing the DIP. Identification of final recommended actions was made along with a discussion of the phasing of implementation actions and proposed implementation schedule. Six citizens attended.
- No comments to the draft DIP document were received during the public comment period.

Funding Opportunities

The following is a list of commonly available funding sources at the time of this document. These represent potential sources for grants and other financial incentives, however, there are other sources of funds through federal programs, Indian Tribes, and conservation groups that will or may provide assistance with the implementation of this plan. While these are generally stable sources of funding, funding sources change over time. New initiates, political interest, and legislation may create funding sources not available at this time. As new or additional sources become available, they will be pursued to accomplish the water quality goals in South Prairie Creek.

Centennial Clean Water Fund/Clean Water Act Section 319 Nonpoint Source Fund/Washington State Water Pollution Control Revolving Loan Fund. These three funding sources are managed by Ecology through one combined application program. Funds are

available to public entities and some not-for-profit organizations (Section 319 only) as grants or low-interest loans. Grants require a 25 percent local match and they may be used for education/outreach, technical assistance, specific water quality projects, or as seed money to establish various kinds of water quality related programs or program components. Grants may not be used for capital improvements to private property without an easement being given; but riparian fencing, riparian re-vegetation, and alternative stock water projects can be eligible for funding consideration.

Low-interest loans are available to public entities for all the above uses. They have also been used as "pass-through money" to provide low-interest loans to homeowners for septic system repair or agricultural best management practice implementation. Loan money can also be used for a wide range of improvements to private property.

Conservation Reserve Enhancement Program. This federal program provides incentives to restore and improve salmon and steelhead habitat on private land. This is a voluntary program to establish forested buffers along streams where streamside habitat is a significant limiting factor for salmonids. In addition to providing habitat, the buffers improve water quality and increase stream stability. Land enrolled in CREP is removed from production and grazing under 10-15 year contracts. In return, landowners receive annual rental, incentive, maintenance and cost share payments. The annual payments can equal twice the weighted average soil rental rate (incentive is 110 percent in areas designated by the Growth Management Act). The Pierce County Conservation District administers this program in conjunction with the U.S. Department of Agriculture, Natural Resource Conservation Service.

Conservation Reserve Program. This is a voluntary program that offers annual rental payments, incentive payments for certain activities, and cost-share assistance to establish approved cover on eligible cropland. Assistance is available in an amount equal to not more than 50 percent of the participant's costs in establishing approved practices; contract duration is between 10-15 years. The Pierce County Conservation District administers this program in conjunction with the U.S. Department of Agriculture, Natural Resource Conservation Service.

Emergency Watershed Protection. The U.S Department of Agriculture, Natural Resource Conservation Service may purchase easements on floodplain lands and the right to conduct restoration activities, in exchange for limited future use by the landowner.

Environmental Quality Incentives Program. This federally funded program is also administered by the Pierce County Conservation District in conjunction with the U.S. Department of Agriculture, Natural Resource Conservation Service. It provides technical assistance, cost share payments, and incentive payments to assist crop and livestock producers with environmental and conservation improvements on the farm. This funding source proves 75 percent cost-share but allows 90 percent if a producer is a limited resource or beginning farmer or rancher. Program funding is divided up between livestock-related practices (60%) and crop land needs (40%). Contracts are for one to ten years.

Forestry Riparian Easement Program. This voluntary program, administered through the Washington State Department of Natural Resources Small Forest Landowner Office, acknowledges the importance of small landowners and their contribution to protect wildlife habitat. The intent of the program is to help small forest landowners keep their land in forestry. The Forestry

Riparian Easement Program partially compensates landowners for not cutting or removing qualifying timber under a 50-year easement. The landowner still owns property and retains full access, but has "leased" the trees and their associated riparian function to the state.

Riparian Open Space Program. This is a voluntary program administered by the Washington State Department of Natural Resources (DNR) to acquire (through purchase or donation) an interest in lands within unconfined avulsing channel migration zones (CMZs). The DNR may acquire the fee interest of the CMZ land or a permanent conservation easement over such lands.

Rural Housing Repair and Rehabilitation Program. This program is administered by the U. S. Department of Agriculture and provides loans to low-income rural residents who own and occupy a dwelling in need of repairs. Funds are available for repairs to improve or modernize a home or to remove health and safety hazards. One percent loans are given for up to 20 years.

Salmon Recovery Funding. In 1999, the Washington State Legislature created the Salmon Recovery Funding Board (SRFB) composed of five citizens appointed by the Governor and five state agency directors. The board provides grant funds to protect or restore salmon habitat by funding habitat protection and restoration projects and supports related programs and activities that produce sustainable and measurable benefits for fish and their habitat. It works closely with local watershed groups known as lead entities. SRFB has helped finance over 500 projects. To be considered for funding assistance, the grant programs require that the proposed project will be operated and maintained in perpetuity for the purposes for which funding is sought. All projects require lead entity approval and must be a high priority in the lead entity strategy. Grants are awarded by the board based on a public, competitive process that weighs the merits of proposed projects against established program criteria.

Literature Cited

Barreca, J. and M. Roberts. 2003. *South Prairie Creek Bacteria and Temperature Total Maximum Daily Load (Water Cleanup Plan) Submittal Report*. Washington State Department of Ecology. Publication No. 03-10-055.

Creveling. 2002. Tacoma/Pierce County Health Department. Personal communication.

EPA. 1991. *Guidance for Water Quality-Based Decisions: The TMDL Process*. U.S. Environmental Protection Agency. EPA 440/4-91-001.

Golding and Johnson. 2001. *Re-Evaluation of Copper Impact from Wilkeson Wastewater Treatment Plant on Wilkeson Creek.* Environmental Assessment Program, Washington State Department of Ecology. Olympia, WA. Publication No. 01-03-021.

Mastin, M.C. 1998. *Flood Potential of South Prairie Creek, Pierce County, Washington. Water-Resources Investigations Report 98-4009.* Prepared in cooperation with Pierce County Department of Public Works. Tacoma, WA.

Miller, et al. 1973. *Precipitation-Frequency Atlas of the Western United States, Volume IX, Washington*. National Oceanographic and Atmospheric Administration, U.S. Department of Commerce.

Milne, M. 2005. Fecal Coliform Load from Inglin Dairy. Brown and Caldwell. Pierce County Work Order # D053-001-1. BC Project No. 25986.

Pieritz, G. 2002. Ecology Water Quality Program, Southwest Regional Office. Personal communication.

Ragland, I and M. Roberts. 2004. *Quality Assurance Project Plan For South Prairie Creek Restoration Monitoring.* Pierce Conservation District. Centennial Clean Water Grant No. G0500118.

Roberts, M. 2005. Personal communication. Excel files of temperature data from 2000 and 2001 TMDL investigations.

United States Department of Agriculture, Soil Conservation Service. 1979. *Soil Survey of Pierce County Area, Washington.*

Washington Department of Natural Resources. 1995. Statewide precipitation isohyetals GIS data layer, digitized from 1:2,000,000 source documents Forest Practices Division.

Appendix A - Response to Comments

Ecology received no formal written comments during the 30-day public review and comment period.

Appendix B - Schedules

Table B-1: Assistance to Landowners for Riparian Plantings (Pierce Conservation District)

Year	Assistance Visits		Percent Achievement
	Goal	Result	
2006	3		
2007	3		
2008	3		
2009	3		
2010	3		
2011	3		
2012	3		
2013	3		
2014	3		
2015	3		
2016	3		
2017	3		
2018	3		
2019	3		
2020	3		

Table B-2. South Prairie Creek Recovery Monitoring Data Review (Pierce County, Puyallup Tribe, Washington Department of Transportation)

Year	Monitoring Reports Reviewed		Percent Achievement
	Goal	Result	
2006*	1		
2007*	1		
2008*	1		
2009	1		
2010	1		
2011	1		
2013	1		
2015	1		

Data from Ecology Grant G0500118.

Table B-3. TMDL Effectiveness Monitoring (Ecology)

Year	Monitoring Performed		Percent Achievement
	Goal	Result	
2011	1		
2016	1		
2021	1		

Table B-4. Stream Team Projects (Pierce County)

Year	Projects Performed		Percent Achievement
	Goal	Result	
2006	2		
2007	2		
2008	2		
2009	2		
2010	2		
2011	2		

Table B-5. Adaptive Management Meetings (Puyallup River Watershed Council and All)

Year	Meetings Held		Percent Achievement
	Goal	Result	
2007	1		
2008	1		
2009	1		
2010	1		
2011	1		
2012	1		
2014	1		
2016	1		
2018	1		
2020	1		

Table B-6. Small Farm Workshops (Pierce Conservation District).

Year	Meetings Held		Percent Achievement
	Goal	Result	
2006	3		
2007	3		
2008	3		
2009	3		
2010	3		
2011	3		

Appendix C - Source Identification Monitoring Quality Assurance Project Plan

Quality Assurance Project Plan

For

South Prairie Creek Recovery Monitoring

Funded by Centennial Clean Water Grant # FP05090

Mindy Roberts, Technical Lead, EAP, Ecology — Date: 10/29/04

Cindy James, Project Manager, Ecology — Date: 10-4-04

Monty Mahan, District Manager, Pierce CD — Date: 10/25/04

Isabel Ragland, Stream Team, Pierce CD — Date: 10/25/04

Dave Seabrook, Supervisor, Pierce CD — Date: 10/26/04

Quality Assurance Project Plan
For
South Prairie Creek Recovery Monitoring

Funded by Centennial Clean Water Grant # FP05090

Introduction

Located in the South Puget Sound region, South Prairie Creek is a tributary of the Carbon River, which is a tributary of the Puyallup River. The watershed includes all or portions of the towns of Wilkeson, Buckley, South Prairie, and Burnett. Lower South Prairie Creek is the most important salmonid spawning area in the Puyallup River basin, with runs of fall chinook, pink, coho, chum, and winter steelhead. A TMDL analysis and recommendations were completed for fecal coliform bacteria and temperature in South Prairie Creek and its tributaries (Barreca and Roberts, 2003)

South Prairie Creek exceeds water quality standards for fecal coliform bacteria and temperature according to Barreca and Roberts, 2003. A detailed implementation plan is being developed for the clean up of South Prairie Creek that this monitoring effort will support. The purpose of this monitoring plan (funded by CCW grant # FP05090) is to measure the effectiveness of clean-up actions taken, to further isolate the fecal coliform sources, and to enhance the temperature modeling of the stream in preparation for evaluating management actions.

South Prairie Creek is a 35 km tributary of the Carbon River in the western foothills of the Cascade Range with a drainage area of 235 km^2. It is forested in its upper reaches and rural (agricultural and residential) in its lower reaches. In the study area, it has one large tributary, Wilkeson Creek. Spiketon Creek is a smaller tributary which drains the prairie south of Buckley and there are other small, unnamed tributaries that originate from groundwater sources on the valley sides. One of these, referred to by Barreca and Roberts (2003) as Tributary 1, is west of the town of South Prairie. Other small tributaries, which will be monitored in this effort, will be referred to as tributaries 2, 3 and 4. Tributaries 2 and 3 merge with South Prairie Creek on the left bank upstream of bridge 4 (see map) and Tributary 4 is a branch of Tributary 1. A U.S. Geological Survey (USGS) gage at South Prairie (drainage area about 206 km^2) has recorded an average annual daily discharge of ~6.7 m^3/s during 35 years of record since 1950.

Fecal coliform bacteria are used by the state of Washington as indicators of pathogens associated with fecal contamination. Fecal pathogens are microorganisms capable of causing disease through ingestion or skin contact. Fecal pathogens may be harmful to humans if ingested. Sources of fecal coliforms include failing septic systems and agricultural wastes from improperly managed commercial and non-commercial farms. The influence of pets and wildlife is not currently considered a contributing factor. Fecal pathogens can enter the waterway by runoff from the adjacent stream banks or from unrestricted animal access to streams.

Temperatures above a threshold level can reduce fish survival rates. Higher temperatures can lead to a decreased supply of oxygen, disrupted metabolism, increased susceptibility to toxins, increased vulnerability to disease, reduced ability to avoid predators, and reduced food supply. Water temperatures are elevated along South Prairie Creek due in large part to inadequate streamside vegetation.

Volunteers will be recruited and trained to monitor fecal coliform and temperature levels in South Prairie Creek to provide a data set which will reflect the response of South Prairie Creek to the clean-up actions detailed in the summary implementation strategy (SIS) and the detailed implementation plan (DIP) currently under development. The SIS is included in the TMDL submittal report (Barreca and Roberts, 2003) and the detailed implementation plan is expected to be completed by December 2004.

Basin Characteristics

Climate in the basin follows patterns typical of the Puget Lowlands and Cascades eco-regions, with wet, mild winters and dry, cool summers. Mean annual average precipitation in the watershed varies from 2.2 m/yr at the higher elevations to 1.0 m/yr at the mouth (DNR, 1995; Miller et al., 1973). Most of the average annual precipitation occurs between November and April. Winter precipitation falls as rain in the lowlands and a mix of rain and snow at higher elevations.

Streamflow also varies seasonally. Highest flows occur between November and February, while the lowest flows occur in August and September, based on the USGS gage located at the town of South Prairie. Average discharge for the water years 1988 to 2001 is 223 cfs. Minimum 7-day average flows have ranged from 25 to 42 cfs.

The watershed is composed of well-compacted glacial till and stratified drift deposits. Steeper gradients occur in the upper watershed, but the local channel slope in the lowlands study area varies from 0.03 to 0.003. The Osceola mudflow spilled into the South Prairie Creek valley near the confluence of Spiketon Creek. The low-permeability valley bottom includes the developed areas of South Prairie, Wilkeson, Buckley and Burnett (USDA SCS, 1979).

Current land use includes forestry operations in the higher elevations. The Mount Baker-Snoqualmie National Forest, administered by the White River Ranger District, includes 70 km^2 of the headwaters of South Prairie Creek (Mastin, 1998). The area is not included in the present modeling analysis, since no impairment has been identified. In addition, the U.S. Forest Service is required to develop forest plans under the National Forest Management Act. Private timber companies, including Plum Creek, own land within the South Prairie Creek watershed.

Previous forest practices impacted South Prairie Creek (Schuett-Hames, 1994). The area falls under the jurisdiction of the Timber Fish and Wildlife (TFW) Agreement. The 1987 agreement and the subsequent Forests and Fish Report, presented to the Forest Practices Board of Washington of the Department of Natural Resources and the Governor's Salmon Recovery Office in 1999, establish the following goals: provide compliance with the Endangered Species Act for aquatic and riparian-dependent species on non-federal forest lands, restore and maintain riparian habitat to support a harvestable fish supply, meet the requirements of the Clean Water Act, and keep the timber industry economically viable.

A dairy facility located near the town of South Prairie is the only commercial agricultural operation in the watershed. However, small non-commercial farms occur throughout the lower watershed. A second dairy, Inglin's, which was operating at the time of the TMDL investigation before 2004, has since ceased operations but retains a right to divert 160 acre-ft. per year from South Prairie Creek.

Residential land use includes both small urban centers and rural residential parcels.

Wilkeson is the largest town in the watershed with a population of 395, based on the 2000 census. Local springs provide drinking water. The town owns and operates a wastewater treatment plant that discharges to Wilkeson Creek.

South Prairie is the next largest town with a population of 332, based on the 2000 census. The town relies on local wells for drinking water and operates a wastewater treatment plant that discharges to South Prairie Creek.

The community of Burnett is the site of a large on-site wastewater demonstration project that relies on various emerging technologies (Creveling, 2002). The project replaced direct wastewater discharges to the creek.

The city of Buckley has a water right for 2 cfs (0.057 m3/s) and diverts a portion of upper South Prairie Creek for its water supply but did not gage the volume during the study period. The Department of Social and Health Services (DSHS) shares the diversion and has a water right for 3.5 cfs to serve the Rainier State School and Washington State University Dairy Forage Facility[1]. The combined diversion passes through a sand filter as part of Buckley's drinking water supply infrastructure. When the infiltration capacity of the filters is exceeded, the overflow is diverted to South Prairie Creek via Spiketon Creek. However, the portion used by Buckley for drinking water is transferred out of the watershed, since the city discharges wastewater to the adjacent White River watershed.

Other scattered residential developments throughout the lower watershed rely on private wells and septic systems. One septic system serving a residential property near the South Prairie wastewater treatment plant failed during the February 28, 2001, Nisqually earthquake (Barreca and Roberts, 2003). The system has been repaired. The Tacoma/Pierce County Health Department has determined that some soils in the area are unsuitable for septic systems.

Wilkeson was a mining center, and coal waste products have been reported (Lund, 1994). An unconfirmed report presented in Lund (1994) describes 100% coho salmon fry mortality due to sulfur-laden water from the Wilkeson coal mines. However, salmon have been sighted spawning in active mine seeps, and pH is not believed to be a problem (Roberts, 2001).

Project Description

The goal of this project is to provide a set of monitoring data that will be used to determine effectiveness of best management practices implemented to address fecal coliform bacteria and temperature contamination. Additionally, temperature will be monitored to enhance understanding of the temperature behavior of the stream and guide adaptive management strategies.

The objectives of this monitoring program include:

1. Characterize and quantify the impact of clean-up actions identified in the submittal report (Barreca and Roberts, 2003) and the detailed implementation plan (DIP) (under development) on the recovery of South Prairie Creek to required water quality standards for fecal coliforms from September 2004 through September 2007.

    a. Continue to isolate and quantify fecal coliform sources on a finer scale as the larger impacts are managed, e.g. highways and roads, and small tributaries near livestock areas, following the clean-up of agricultural operations, etc.

[1] The WSU facility ceased dairy operations as of July 2000 but continues farming operations.

b. Discharge measurements will be made where possible to determine loads. Where discharge measurement is not possible, discharge will be estimated based on previously identified relationships between the USGS gage at South Prairie and downstream flows.

2. Continue to develop temperature data from South Prairie Creek to provide an increasingly robust model of temperature behavior. Collection of continuous records from temperature data loggers beginning in September 2004 and continuing through September 2007 will enhance temperature modeling of South Prairie Creek in preparation for evaluating management strategies.

Data and measurements collected from monthly fecal coliform sampling and wading discharge measurements will be used to calculate instantaneous loads. Temperature data will be downloaded monthly from temperature data loggers and the daily minimum, maximum, and average temperatures will be computed.
Volunteers will be recruited and trained on field data collection protocols including:

1. Fecal coliform sample collection and handling.
2. Fecal sample transport to lab.
3. Stream flow measurement using approved USGS methods.
4. Temperature data logger programming and offloading procedures.
5. Stream safety procedures.

Table 1 presents the schedule for major tasks in the South Prairie Creek TMDL monitoring project.

Table 1. South Prairie Creek TMDL Monitoring Schedule

Task	**Date**
Volunteer Recruitment	August, September 2004, ongoing
Volunteer Training	September 2004, ongoing
Monitoring Site Selection	August 2004
Temperature Data Loggers Installation	September 2004
Sample & Data Collection – Fecal & Temperature	Monthly September 2004 – Sept. 2007
Stream Flow Measurements	Monthly September 2004 – September 2007
Data Entry	September 2004 – September 2007
Semi-annual Reports	April 2005 and ongoing until project end

Data Quality Objectives
Sample collection and handling protocols are based on published protocols and are noted in the section titled Field Sampling Protocols and Analytical Procedures on page 9. Standardized procedures will be followed closely for sample collection, handling and transportation to the laboratory to minimize bias.

A two-part, 12-month test program to reduce sampling procedure bias for fecal coliform will be conducted. First, for four sites on the mainstem of South Prairie Creek, three samples will be collected across the sampling section at 1/6, ½, and 5/6, of the horizontal distance to identify lateral variation and produce a weighted mean concentration. Second, for two of the small tributary sites, three samples will be collected at five-minute intervals. At the end of the test program, the results will be evaluated for effectiveness in controlling sample bias. Wading discharge measurements will be taken at the same time as the fecal sampling and in the same cross-section and will be used for instantaneous load calculations from five locations in South Prairie Creek. To compensate for instrument bias, successive discharge measurements will use alternate current meters.

Table 2: Data Quality Objectives

Parameter	Accuracy (2*precision + bias)	Precision (%)	Bias (%)	Lowest level of interest
Discharge for South Prairie Cr.	Less than 6%	$1.22^{2}+1.41^{3}=2.63$ (RPD)[4]	-	-
Discharge for Tributaries	10%	5*	-	-
Temperature (discrete)	0.5 ˚C	0.18 (RPD)	-	0 ˚C
Temperature (continuous)	0.5 ˚C	0.15 (RPD)	.73**	0 ˚C
Fecal Coliform Bacteria	66%	28 (%RSD)[5]	10^{5}	10/100 mL[5]

*estimate

**estimate based on ± 1 ˚C because of placement

Sampling Design

The South Prairie Creek Recovery Monitoring project includes continuous, year-round temperature monitoring and year-round monthly sample collection for lab analysis of fecal coliform bacteria. Discharge measurements will also be taken at the time of fecal sample collection to determine instantaneous loads. Table 3 presents the monitoring locations, and Table 4 presents the parameters to be monitored at each location. Monitoring sites were chosen based on the results presented in Barreca and Roberts, 2003.

[2] Hubbard, E. F., et. al. 1999

[3] ± 1% depth measurement

[4] Relative percent difference: Calculated for a pair of results, x_1 and x_2, as $200*(x_1 - x_2) / (x_1 + x_2) = 100*(x_1 - x_2) / (\text{avg } [x_1 \text{ and } x_2])$.

[5] Roberts, 2001. Calculated for a pair of results, x_1 and x_2, as $100*s / (\text{avg } [x_1 \text{ and } x_2])$, where s is the standard deviation.

Additional fecal coliform monitoring sites were chosen to isolate the pollution sources contributing to Tributary 1. Flow measurements are expected to enhance both temperature and fecal coliform modeling in the study area.

Table 3. South Prairie Creek Monitoring Sites

Station ID	Water Body	Location Description
SPCSR	South Prairie Creek	South Prairie Creek at Spiketon Rd, from Ryan Rd in Buckley
SPCWC	South Prairie Creek	South Prairie Creek at Wilkeson Creek confluence near train trestle; access through KC Crusaders Paintball
SPCSP	South Prairie Creek	South Prairie Creek at Rte 162, downstream of bridge near fire station
SPCOF	South Prairie Creek	South Prairie Creek downstream of South Prairie wastewater treatment plant outfall
SPCID	South Prairie Creek	South Prairie Creek at Inglin Dairy
SPCB4	South Prairie Creek	South Prairie Creek, Rte 162, fourth bridge north of Carbon River
SPCB2	South Prairie Creek	South Prairie Creek, Rte 162, second bridge north of Carbon River
SPCB1	South Prairie Creek	South Prairie Creek, Rte 162, first bridge north of Carbon River
SPCM	South Prairie Creek	South Prairie Creek at mouth, from South Prairie Creek Rd.
WCM	Wilkeson Creek	Wilkeson Creek, at mouth; access from KC Crusaders Paintball
SKTSR	Spiketon Creek	Spiketon Creek where it crosses Spiketon Road in Buckley
SKT165	Spiketon Creek	Spiketon Creek at Highway 165 culvert
SKTM	Spiketon Creek	Spiketon Creek, near mouth, from Lower Burnett Rd.
T1-US162	Unnamed tributary 1	Tributary 1 upstream of Hwy. 162 at upstream end of Foothills Trail culvert
T1-DS162	Unnamed tributary 1	Tributary 1, downstream of Hwy. 162 drainage ditch.
T1-ID	Unnamed tributary 1	Mouth of Tributary 1 at S. Prairie Cr. RM 4.2. Access from Inglin dairy
T2	Unnamed tributary 2	Tributary 2 measuring site is at Spring Site Road. The mouth of Tributary 2 is at RM 3.8 of S. Prairie Cr.
T3	Unnamed tributary 3	Tributary 3 measuring site is at the end of Spring Site Rd. The mouth of Tributary 3 is at RM 4.0 of S. Prairie Cr.
T4	Unnamed tributary 4	The measuring site is where Tributary 4 crosses Pioneer Way. The mouth of Trib. 4 is at RM 0.5 of Tributary 1.

Table 4. Monitoring Parameters by Site

Station ID	Fecal Coliform	Temperature	Discharge	Latitude	Longitude
SPCSR		X			
SPCWC		X			
SPCSP	X	X		47.13950	-122.09202
SPCOF	X		X	47.14257	-122.10437
SPCID	X		X	47.1345764	-122.1207762
SPCB4	X		*X*	47.1312334	-122.1269669
SPCB3					
SPCB2	X	X		47.1229961	-122.1336871
SPCB1	X				
SPCM	X	X	X		
WCM		X			
SKTSR	X	X		47.14934	-122.02615
SKT165	X	X		47.14124	-122.05255
SKTM	X			47.13898	-122.06362
T1-US162	X				
T1-DS162	X				
T1-ID	X		X	47.1355196	-122.1189819
T2	X			47.1230275	-122.1335829
T3	X				
T4	X				

Field Sampling Protocols and Analytical Procedures
Field sampling will follow published protocols:

Temperature

Stream temperature will be continuously monitored using Onset HOBO Water Temp Pro data loggers. Data will be collected in accordance with the TFW Method Manual for the Stream Temperature Survey (Schuett-Hames, et. al., 1999) and will be recovered from the data loggers approximately monthly.

Data loggers will be placed as indicated in Table 3, including companion loggers for air temperature at selected stream temperature sites.

Flow

Where appropriate, flow in South Prairie Creek and tributaries will be measured by the wading discharge method in accordance with TFW Method Manual for Wadeable Stream Discharge Measurement (Pleus, 1999). Price AA or Pygmy or Flow Probe flow meters will be used where appropriate. This method will not be appropriate for high flows in South Prairie Creek and may not be appropriate for the small flows in the tributaries.

If flows in the tributaries are too low for wading discharge measurements, then the Timed Filling Procedure will be used as outlined in Field Operations and Methods for Measuring the

Ecological Condition of Wadeable Streams (Lazorchak, et. al., 1998). If flows are too high for wading measurements then discharge measurements will not be made.

Fecal coliform

Fecal coliform samples will be collected monthly at sites identified in Table 3 using sterile sample containers supplied by a Department of Ecology approved laboratory in the area. Field sampling and measurement protocols will follow those described in the Field Sampling and Measurements Protocols for the Watershed Assessments Section (Watershed Assessments Section, 1993), except that samples will be stored at 4°C, and delivered to the lab for analysis within 6 hours of sampling. An extra set of sample containers will be available should any of the bottles be lost or contaminated.

Laboratory processes to quantify fecal coliform abundance will use the Membrane Filter method described in section 9222D, Standard Methods for the Examination of Water and Wastewater (Clesceri, L., et. al., 1989).

Table 5 presents summary information on field and laboratory measurements, target precision, reporting limits and methods.

Table 5: Summary Field and Laboratory Measurements

Parameter	Precision Target (Field Measurement)	Report-ing Limit (Lab)	Methods	Equip-ment	Sample size	Con-tainer	Preser-vation	Holding Time
Fecal coliforms	NA	1/100mL	MF 9222D[6]	Grab sample	250 ml	Sterile poly	4°C	24 hours
Temper-ature	±0.5 °C		Electronic data logger	HOBO Water Temp Pro stakes, nylon ties, laptop computer, hammer and stake-driving tool	-	-	-	-
Flow	±5% in SPC 10% in tributaries	-	Wading Discharge Measure-ment[7] or Timed Filling Method[8]	Current meters, wading rod, stop watch, digital flow calc, custom portable weir and measuring container.	-	-	-	-

Quality Control Procedures

Field variability will be addressed through close adherence to standard field procedures and sampling methods. A two part 12-month test program to reduce sampling procedure bias for fecal coliform will be conducted. First, for four sites on the mainstem of South Prairie Creek, three samples will be collected across the sampling section at 1/6, ½, and 5/6, of the horizontal distance to identify lateral variation and produce a weighted mean concentration. Second, for two small tributary sites, three samples will be collected at 5-minute intervals. At the end of the test program, the results will be evaluated for effectiveness in controlling sample bias.

[6] Clesceri, L., et. al., 1989

[7] Schuett-Hames, et. al., 1999

[8] Lazorchak, et. al., 1998

Total variation for field sampling and analytical variation will be assessed by collecting replicate samples in addition to lab duplicates and comparing to data quality objectives. Replicate samples and measurements will be taken at a rate of ten percent for fecal coliform samples and discharge measurements. Lab splits will be required as a check on lab procedures. Laboratory quality control procedures will be used to control analytical bias.

Microbiological samples will be analyzed by a Department of Ecology approved laboratory. The laboratory's data quality objectives and quality control procedures are documented in laboratory's user manual. Field sampling for fecal coliforms will follow quality control protocols described in WAS (1993).

Data logger variations will be checked using the calibrated field thermometer upon deployment and monthly data recovery. Field sampling and measurement procedures will follow quality control protocols described in the TFW Stream Temperature Survey protocols (Schuett-Hames, et al., 1999). The HOBO water temp pros will be pre- and post-calibrated in accordance with the TFW stream temperature survey protocols and manufacturers instructions to document instrument bias and performance at representative temperatures. An NIST certified reference thermometer will be used for calibration of the temperature recorders and for calibration of the field thermometer. Temperature recorders will be checked using the calibrated field thermometer upon deployment, retrieval, and at monthly field surveys.

Replicate field temperature readings will not be recorded, because previous Department of Ecology experience has demonstrated that the thermometers consistently show a high level of precision, rarely varying by more than 0.2˚C.[9]

Replicate wading discharge measurements will be made with alternate current meters at a ten percent rate. All wading discharge measurements will be made in accordance with the TFW Wadable Stream Discharge Measurement protocols (Pleus, 1999). The flow meters will undergo a spin test, cleaning and checking of parts after each field survey. For timed fill measurements, replicate samples will be collected at a rate of 30 percent.

Field replicate samples will be collected at one site per monthly survey for fecal coliform bacteria. The selected laboratory will follow standard quality control procedures.

Data Reduction Review and Reporting

Once data has been collected, data sheets will be reviewed for completeness before leaving the site. Samples will be examined to ensure each sample is correctly labeled. Standard laboratory procedures for analytical data reduction, review and reporting will be followed. The laboratory will send a hard copy of the data to the project manager. Lab and field data will be matched with sample times and locations, analyzed for questionable values and problems. Instantaneous loads will be computed and then entered into Microsoft Excel spreadsheets and the Department of Ecology's Environmental Information Management (EIM) database.

[9] Roberts, 2001

Temperature data will be stored in its raw form in Microsoft Excel spreadsheets. Once it has been reviewed for errors and data gaps, the daily minimum, maximum, and average temperatures will be computed and entered into the EIM database.
Discharge data will be stored in its raw form in Microsoft Excel spreadsheets. Once it has been reviewed for errors and data gaps, the information will be entered into the EIM database in accordance with Department of Ecology procedures
Semi-annual reports will be prepared after each six-month interval of sampling and measuring. Data results will be discussed and volunteer efforts will be evaluated including recruitment, training and performance. Corrective measures will be discussed and applied as needed.

References Cited

Barreca, Jeannette, and Roberts, Mindy. 2003. *South Prairie Creek Bacteria and Temperature Total Maximum Daily Load (Water Cleanup Plan) Submittal Report.* http://www.ecy.wa.gov/pubs/0310055.pdf

Clesceri, L., Greenberg, A., and Trussell, R., 1989, *Standard Methods for the Examination of Water and Wastewater,* 17th Edition p. 1-65.

Lazorchak, James M., Klemm, Donald J., and Peck, David V. 1998. *Field Operations and Methods for Measuring the Ecological Condition of Wadable Streams*, U. S. EPA, Environmental Monitoring and Assessment Program – Surface Waters, EPA/620/R-94/004F September.

Lund, Stephanie. December 1994. *South Prairie Creek Scoping Project.* Pacific Lutheran University and Pierce County Conservation District.

Mastin, M.C. 1998. *Flood Potential of South Prairie Creek, Pierce County, Washington.* Water-Resources Investigations Report 98-4009. Prepared in cooperation with Pierce County Department of Public Works, Tacoma, WA.

Pleus, Allen E., 1999. *TFW Monitoring Program Method Manual for the Wadable Stream Discharge Method*. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM-99-009. DNR #111. June.

Hubbard, E. F., Thibodeaux, K.G., and Duong, Mai N. 1999. Quality Assurance of U.S. Geological Survey Stream Current meters: *The Meter Exchange Program 1988-98.* U.S. Geological Survey, Open File Report 99-221

Roberts, Mindy. 2001. *South Prairie Creek Total Maximum Daily Load Phase II Evaluation, Quality Assurance Project Plan*, Washington State Department of Ecology Environmental Assessment Program, Olympia, WA 98504. Publication No. 01-03-064.

Schuett-Hames, Dave, Pleus, Allen E., Rashim. Ed, and Matthews, Jim. 1999. *TFW Monitoring Program Method Manual for the Stream Temperature Survey*. Prepared for the Washington State Dept. of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-005. DNR #107. June.

Schuett-Hames, Joanne. October 7, 1994. Watershed Briefing Paper. Water Quality Program, Department of Ecology, Olympia, Washington.

Watershed Assessments Section, 1993. *Field Sampling and Measurement Protocols for the Watershed Assessments Section.* Washington State Department of Ecology, Olympia, WA. Publication No. 93-e04.

Appendix D

South Prairie Creek TMDL Temperature Reduction Targets
(From Barreca and Roberts, 2005)

Station	Reach	Distance from upstream boundary to middle of stream reach (km)	Distance from mouth to middle of stream reach (km)	Reach-average effective shade for current conditions (%)	Reach-average solar radiation received at the water surface on August 1 with current vegetation (langley/day)	Reach-average effective shade with mature riparian vegetation (%)	Reach-average solar radiation received at the water surface on August 1 with mature riparian vegetation (langley/day)	Load allocation for effective shade assuming mature riparian vegetation (180 ft and 90% canopy density)
SPCSR	1	0.15	16.6	52%	316	71%	193	71%
	2	0.46	16.3	58%	279	72%	191	72%
	3	0.76	16.0	51%	318	74%	186	74%
	4	1.07	15.7	45%	353	72%	167	72%
	5	1.37	15.4	53%	304	77%	185	77%
	6	1.68	15.1	58%	274	76%	153	76%
	7	1.98	14.8	61%	260	77%	156	77%
	8	2.29	14.5	62%	248	78%	152	78%
	9	2.59	14.2	70%	202	78%	146	78%
	10	2.90	13.9	68%	211	73%	149	73%
	11	3.20	13.6	53%	310	75%	177	75%
	12	3.51	13.3	69%	203	77%	165	77%
SPCLB	13	3.81	13.0	77%	147	78%	147	78%
	14	4.12	12.7	78%	148	78%	148	78%
	15	4.42	12.4	78%	148	71%	148	78%
	16	4.73	12.0	63%	242	74%	193	74%
SKTM	17	5.03	11.7	46%	346	66%	167	66%
	18	5.34	11.4	33%	433	79%	223	79%
	19	5.64	11.1	79%	139	79%	139	79%
SPCW	20	5.95	10.8	79%	141	69%	141	79%
	21	6.25	10.5	69%	206	76%	220	76%
	22	6.56	10.2	69%	202	75%	156	75%
	23	6.86	9.9	70%	187	74%	161	74%
	24	7.17	9.6	62%	252	77%	174	77%
SPCSP	25	7.47	9.3	63%	244	78%	150	78%
	26	7.78	9.0	48%	336	76%	145	76%
	27	8.08	8.7	47%	349	78%	160	78%
	28	8.39	8.4	52%	313	78%	146	78%
SPCOF	29	8.69	8.1	52%	312	76%	147	76%
	30	9.00	7.8	58%	274	78%	155	78%
	31	9.30	7.5	44%	369	76%	149	76%
	32	9.61	7.2	48%	336	77%	154	77%
	33	9.91	6.9	58%	279	75%	154	75%
	34	10.22	6.6	55%	293	76%	162	76%
	35	10.52	6.3	48%	335	75%	158	75%
SPCB4	36	10.83	5.9	49%	334	71%	167	71%
	37	11.13	5.6	46%	354	76%	190	76%
	38	11.44	5.3	47%	345	72%	160	72%
	39	11.74	5.0	36%	413	72%	183	72%
	40	12.05	4.7	25%	485	72%	180	72%
	41	12.35	4.4	53%	307	75%	184	75%
SPCB2	42	12.66	4.1	37%	414	71%	162	71%
	43	12.96	3.8	49%	331	64%	189	64%
	44	13.27	3.5	48%	338	70%	237	70%
	45	13.57	3.2	49%	332	73%	196	73%
	46	13.88	2.9	42%	374	72%	178	72%
	47	14.18	2.6	56%	290	74%	184	74%
	48	14.49	2.3	47%	348	74%	170	74%
	49	14.79	2.0	58%	276	73%	169	73%
SPCB1	50	15.10	1.7	64%	232	70%	179	70%

Station	Reach	Distance from upstream boundary to middle of stream reach (km)	Distance from mouth to middle of stream reach (km)	Reach-average effective shade for current conditions (%)	Reach-average solar radiation received at the water surface on August 1 with current vegetation (langley/day)	Reach-average effective shade with mature riparian vegetation (%)	Reach-average solar radiation received at the water surface on August 1 with mature riparian vegetation (langley/day)	Load allocation for effective shade assuming mature riparian vegetation (180 ft and 90% canopy density)
	51	15.40	1.4	45%	355	64%	193	64%
	52	15.71	1.1	51%	324	67%	235	67%
	53	16.01	0.8	61%	256	72%	218	72%
SPCM	54	16.32	0.5	63%	239	73%	184	73%
	55	16.62	0.2	55%	293	73%	178	73%