Project ID: 31022

Establish a Water Cleanup Plan (temperature TMDL)
for the
East Fork of the Lewis Subbasin

Response to ISRP Questions

1. Provide a more detailed documentation of the problem.

Currently, four species of salmon use the lower East Fork Lewis River for spawning and rearing. Of these species, fall Chinook (*Oncorhynchus tshawytscha*), steelhead (*Oncorhynchus mykiss)* and chum salmon (*Oncorhynchus keta)* are listed by the National Marine Fisheries Service as threatened under the Endangered Species Act (ESA) with coho salmon (*Oncorhynchus kisutch)* a listing candidate (Federal Register, 1998;1999).

Stocks Present	Status	ESA Fed. List Col. R. ESU
Fall Chinook	----------	Threatened (3/99)[@]
Steelhead	Depressed*	Threatened (3/98)[#]
Coho	Depressed*	Candidate
Chum	----------	Threatened (3/99)[“]

* 1992 Washington State Salmon and Steelhead Stock Inventory. WDFW, 1993
(Depressed is a stock whose production is below expected levels based on available habitat and natural variation in survival rates, but above the level where permanent damage to the stock is likely.)
[@] Federal Register. March 24, 1999. Dept. of Commerce, NOAA 50 CFR Parts 223 & 224.
[#]Federal Register. March 25, 1999. Dept. of Commerce, NOAA. 50 CFR Part 223.
[“]Federal Register. March 19, 1998. Dept. of Commerce, NOAA. 47 CFR Part 73.

Spawning habitat occurs primarily in the lower 10 miles of the river including its major tributaries (NWPPC, 2001). Steelhead, however, are able to access the upper watershed to spawn, passing over several falls, when conditions are favorable.

Following their emergence, juveniles of several of these species reside within the East Fork Lewis system for up to several years prior to their migration to the Pacific Ocean. During this rearing period, environmental conditions such as cool water temperatures are critical to their survival.

Currently, Washington State's 303(d) list of water bodies not meeting water quality standards includes the lower East Fork Lewis River and two of its tributaries, McCormick Creek and Lockwood Creek, due to elevated water temperatures. Washington State's water temperature standard for Class A and AA designated waters is 18 degrees Celsius (^{o} C) and 16^{o} C, respectively. (The section of the East Fork Lewis from Moulton Falls, at RM 24.6, to its mouth is designated as Class A.)

Based on the limiting factors analysis conducted for East Fork Lewis, among the most significant factors limiting salmon production in the East Fork Lewis is elevated water temperatures (Wade, 2000). As it will be discussed below, summer water temperatures

have routinely been recorded in excess of 18° C**,** a temperature level that exceeds healthy rearing conditions for salmon.

References

Federal Register. March 24, 1999. Dept. of Commerce, NOAA 50 CFR Parts 223 & 224.
Federal Register. March 25, 1999. Dept. of Commerce, NOAA. 50 CFR Part 223.
Federal Register. March 19, 1998. Dept. of Commerce, NOAA. 47 CFR Part 73.

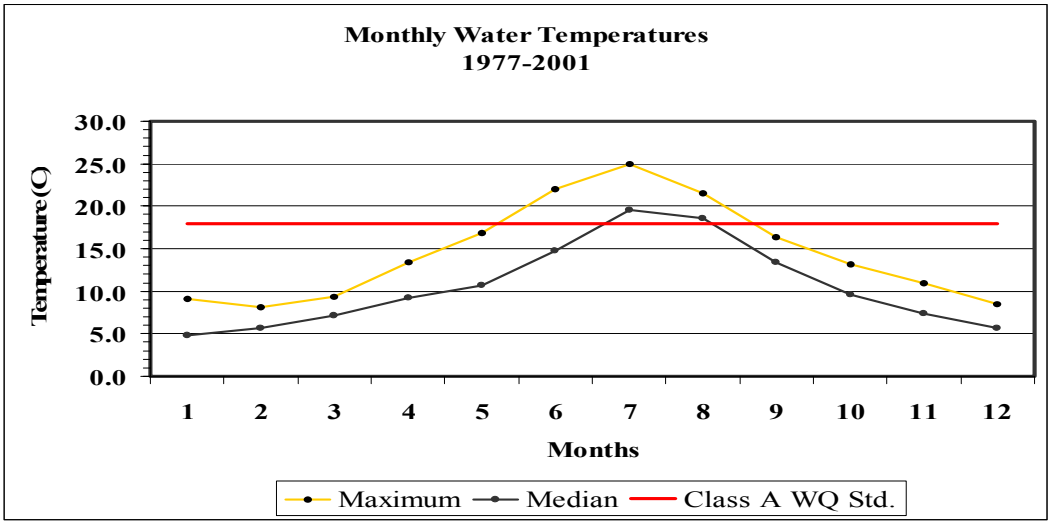
Northwest Power Planning Council (NWPPC). 2001. Draft – Lewis River Subbasin Summary.

Wade, Gary. Washington Conservation Commission. 2000. Habitat Limiting Factors, Water Resource Inventory Area 27, Kalama, North Fork Lewis River, and East Fork Lewis River.

Washington Department of Fish and Wildlife (WDFW) and Western Washington Treaty Indian Tribes. 1993. Washington State Salmon and Steelhead Stock Inventory.

2. What is known about thermal patterns in the East Fork and any evidence (data) they have that temperature is a major factor limiting salmonid production?

Water temperature measurements have been collected monthly by the Washington State Department of Ecology on the East Fork Lewis River (RM 10.3, near Dollar Corner) since 1977. These data, when examined collectively, display a chronic pattern of elevated water temperatures during the summer months. This is evident in the graph below of median and maximum monthly water temperatures. During the months of July and August, the median water temperatures were 19.5 and 18.6° C, respectively. This indicates that 50 percent of the time monthly water temperatures measurements have been taken, during July and August, covering a 24-year period (1977 to 2001), temperatures have exceeded the 18° C water quality standard. The maximum water temperatures recorded for June, July, and August (covering the same period) are 22.0, 25.0, and 21.5, respectively.



Continuous water temperature measurements (collected every 0.5 hours) were collected by the Washington State Department of Ecology during August 2001 at their routine monitoring station (RM 6.2). During August, maximum water temperatures exceeded the water quality standard 28 of the 31 days measured. Within that period, there were 8 continuous days (192 hours) where the water temperature remained above 18^{o} C, the water quality standard. Peak water temperatures during the period from August 6^{th} through the 13^{th} had a range between 23.2^{o} C, (August 6^{th}) and 25.1^{o} C, (August 13^{th}).

Washington State's water quality standard for temperature was established to provide protection to species that require cold water habitat for their survival, like salmon. Collectively, these data further validate the conclusion of the Habitat Limiting Factors analysis that among the most significant factors limiting salmon production in the East Fork Lewis is elevated water temperatures (Wade, 2000).

References

Wade, Gary. Washington Conservation Commission. 2000. Habitat Limiting Factors, Water Resource Inventory Area 27, Kalama, North Fork Lewis River, and East Fork Lewis River.

3. Provide more detail on the methodology.

Temperature is a major impairment of the waters of the East Fork Lewis River for ESA-listed salmonid use in summer (May to September). The Washington Department of Ecology (WDOE) is mandated to assess 303(d) listed waters and develop remedial measures under the Clean Water Act (CWA).

To meet this goal, this project plans to use Forward Looking Infra-Red technology (FLIR) to collect surface water temperature data remotely by helicopter for 70 miles of waterways in the East Fork Lewis subbasin. In addition, during the study period, which will overlap the FLIR flight, water temperature measurements will be collected *in-situ*. This information will then be incorporated into a river temperature model ($QUAL_2K$) and used to develop a Total Maximum Daily Load (TMDL) for temperature. Eventually, through the TMDL process, remedial measures to reduce elevated water temperatures will be implemented.

FLIR will give a broad spatial "snapshot"; submersible recorders will give ground-truth information and indicate where spatial variations are present; GIS will handle the spatial data; modeling will assimilate the data for predictive purposes; and the TMDL analyses by Washington Department of Ecology (WDOE), will satisfy the CWA mandate and offer solutions and an implementation plan.

Standard color aerial photos (taken simultaneously) will be used in conjunction with the FLIR imagery to identify habitat features as they relate to temperature conditions. Rather than just providing pictures and numerical temperatures, however, the proposal would go the next step and incorporate the FLIR data, the in-situ calibration temperatures, and additional temperature data, collected during the study period, into a model of water

temperatures along the length of the study reaches. The TMDL assessments will evolve into a local plan designed to implement BMPs to lower elevated water temperatures.

The water cleanup plan will be the basis for developing an effective subbasin plan for the East Fork Lewis River system. The sequence of project activities are listed below:

- Collect Forward Looking Infrared Radiometry (FLIR) multi-spectral imaging information of riparian vegetation, stream temperatures, and habitat over approximately 70 miles of the watershed. (FLIR products, which will include a digital video, enable the identification of heat sources and provide an assessment of thermal refugia and streamside conditions.)

- Validate the broad spatial scale FLIR data using in-stream water temperature data loggers and continuous flow gages operated by Ecology and others. From this data, accurate data profiles will be generated to understand water quality and aquatic habitat factors as they relate to temperature. The data will help to identify and model heat inputs and prescribe effective implementation plans to reduce water temperatures to healthy levels.

- Document and share stream temperatures and habitat conditions within the East Fork Lewis subbasin with federal, state, and tribal fish managers, for improved habitat assessments.

- Digitize data for streambank and riparian vegetation attributes for use in Arcview mapping software. Maps will show stakeholders the location and magnitude of temperature problems and associated land use activities throughout the East Fork Lewis system. This information, along with the digital video produced by FLIR, is a catalyst for establishing future local implementation plans and activities to correct water temperature exceedences. In addition, this information will be used to demonstrate to landowners, and resource agencies, of the importance of riparian restoration to achieve lower water temperatures.

- Analyze stream temperatures using predictive models to determine appropriate vegetative shade targets to achieve water quality standards. This task defines the total maximum allowable daily loads from various sources to reduce temperatures and meet anadromous fish needs. Technical analysis is essential to the credibility of designated shade targets to improve water temperatures.

- Formulate shade targets into load allocations. These load allocations represent the targets for developing a detailed implementation plan (DIP) with the involvement of landowners, local government, and other federal and state agencies. The detailed implementation plan will specify commitments to BMPs, time schedules, sources of funding, adaptive management, and effectiveness monitoring to achieve the targets in the plan. WDOE will facilitate this process with local entities, building and monitoring the implementation plan as a cost share to this project.

4. Why is FLIR needed rather than just using in-stream data loggers?

The overriding purpose of this project is to collect water temperature data for analysis that assists in the development of workable, and locally accepted, stream temperature best management practices for the East Fork Lewis River Basin. The role of cold-water habitats, groundwater influences, and temperature profiles across the entire watershed are best sampled with Forward Looking Infrared (FLIR) temperature analysis.

FLIR has been demonstrated as a reliable, cost-effective, and accessible technology for monitoring and evaluating stream temperatures from the scale of watersheds, to individual habitats. Traditional methods for monitoring stream temperatures have relied on in-stream temperature monitors to gather data. These monitors provide temporally continuous data, but provide little insight into the spatial variability of temperatures. Remote sensing, using FLIR, provides a method to map stream temperatures across entire stream networks at a point in time. FLIR technology has proven to be a highly portable and cost-effective method to collect very detailed data over large areas in very little time. The combination of temporally and spatially continuous data provides very powerful tools for understanding the dynamics of stream temperature hierarchically across multiple scales (pools → reaches → streams → watersheds).

Temperature problems within river system often extend for many miles and traverse multiple land uses. Identification of source (heating) areas, as well as areas that induce stream cooling, requires spatially continuous data. FLIR stream temperature analysis was developed in part for this purpose. To date, no other data collection platform can deliver spatial temperature data comparable to the resolution and feasibility offered by FLIR stream temperature analysis.

By mapping the extent of source (heating) and cool thermal refugia areas in the watershed, a baseline for long-term recovery tracking can be established. This proposed FLIR effort will provide the baseline measures for recovery tracking. In addition, the FLIR digital and Infra-red photos serve as an important tool, allowing landowners the ability to visualize the relationship between land use activities and water temperatures. This exchange provides a credible foundation, allowing responsible choices to be made to restore stream habitat.

5. When and how often will the FLIR flights be undertaken?

The FLIR flights in this proposal are projected to take place between July 30th and August 1, 2003. This is the period that past data indicate that the highest water temperatures will occur.

6. How many data loggers will be placed in the river and for how long?

Approximately 35 data loggers will be installed in the mainstem and tributaries. They will be placed in June, measuring water temperatures bi-hourly through October.

7. Provide more detail on the modeling component of the project.

Three specialized software tools will be used to analyze water temperature and riparian shade conditions in the East Fork Lewis River. They include: Ttools, HeatSource, and $Qual_2K$. The FLIR data, interpreted in a GIS format, will be central to this analysis.

Ttools

The Oregon Department of Environmental Quality's (ODEQ) Ttools extension for Arcview will be used to sample and process the GIS based water temperature data (an end product of the FLIR flight). This information will then serve to calibrate the ODEQ's HeatSource model and the $QUAL_2K$ model.

HeatSource

The HeatSource model (ODEQ, 2000) will be used to estimate effective shade along the mainstem and its major tributaries. Effective shade will be calculated at 50 to 100-meter intervals then averaged over 500 to 1000-meter intervals for input to the $QUAL_2K$ model.

$QUAL_2K$

FLIR temperature information will be integrated, with key habitat attributes, into the $QUAL_2K$ model. The model will be used to calculate the components of the heat budget and simulate water temperatures. $QUAL_2K$ simulates diurnal variations in stream temperature for a steady flow condition. It is applied by assuming that flow remains constant for a given condition, such as a 7-day or 1-day period, but key variables are allowed to vary with time over the course of a day. For temperature simulation, the solar radiation, air temperature, relative humidity, headwater temperature, and tributary water temperatures are specified or simulated as diurnally varying functions. $QUAL_2K$ uses the kinetic formulations for the components of the surface water heat budget. Diurnally varying water temperatures at 500 to 1000 meter intervals will be simulated using a finite difference numerical method. The water temperature model will be calibrated to in-stream data.

Previous use of this model by WDOE used the hottest 7-day period occurring during the study for additional calibration of the $QUAL_2K$ model with the coolest 7-day period used for verification to test the model calibration.

The calibrated $QUAL_2K$ model will then be used to determine the loading capacity for effective shade for streams in the East Fork Lewis River basin. Loading capacity will be determined based on the prediction of water temperatures under typical and extreme flow and climate conditions combined with a range of effective shade conditions.

8. What temperature model will be used?

Refer to question 7.

9. What are the inputs and outputs (of the models) and how do these relate to the data that will be collected?

The HeatSource and $Qual_2K$ models share common data input variables their output, however, differs. Common input includes: spatial information (i.e. latitude/longitude, aspect etc.), stream data (i.e. wetted width, flow volume and velocity etc.), buffer data (i.e. vegetative canopy density, shade angle etc.), and atmospheric data (i.e. air temperature, relative humidity wind speed etc.) Effective shade, or the portion of the solar load that is attenuated before reaching the stream surface, is the primary output of interest from the HeatSource model. Effective shade is then used as a surrogate input variable to the $Qual_2K$ model. The output of $Qual_2K$ is the predicted temperature of water. The FLIR data serves to calibrate the output of these models.

10. At what spatial scale will the model be applied?

Shade calculations will be determined every 50 to 100 meters and water temperatures predicted every 100-500 meters.

The typical scale of data sources include:

- River and tributary mapping will be determined at the 1:3,000 scale from 1-meter-resolution Digital Orthophoto Quads (DOQ).

- Riparian vegetation size and density mapping will be determined at the 1:15,840 scale and sampled along the stream at 100-meter intervals. At each stream transect location the vegetation grid will be sampled orthogonal to the stream at 10-meter intervals starting at the wetted edge and progressing to 300 feet from each side of the stream.

- Near-stream disturbance zone (NSDZ) width measurement will be determined at the 1:3000 scale.

- West, east, and south topographic shade angles calculations will be made from the 10-meter DEM grid using ODEQ's Ttools extension for Arcview.

- Stream elevation and gradient will be sampled from the 10-meter DEM grid with the Arcview Ttools extension. Gradient will be estimated from the topographic contours on the USGS 7.5-minute Quad maps.

- Aspect (stream flow direction in decimal degrees from north) will be calculated by the Ttools extension for Arcview.

11. What, specifically, will the model be used for?

Ultimately, the results of this work will be a tool which will assist in recovery planning to improve in-stream water temperatures through the development of a TMDL analysis. The salmonid species which are likely to benefit most from this work are those which rear year-round in the East Fork Lewis River and its tributaries and are, therefore, currently exposed to deleterious warm water temperatures during the summer period.

The end product of the modeling effort will be the determination of shade targets. The shade targets will then serve as the foundation for developing a detailed implementation plan with the involvement of landowners, local governments, and other federal and state agencies. The detailed implementation plan will specify commitments to BMPs, time schedules, sources of funding, adaptive management, and effectiveness monitoring to achieve the targets in the plan. WDOE will facilitate this process with local entities, building and monitoring the implementation plan, as a cost share to the project.

12. Discussion of the potential for improving water temperature within the East Fork also would be helpful.

There is clearly interest and cooperation from the local government entities and the U.S. Forest Service for improving water temperatures within the East Fork Lewis River (see answers to questions below). There is a real opportunity in the East Fork Lewis to implement the BMPs necessary to lower water temperatures during the critical summer months. The entities (Yakama Tribe; the Lower Columbia Fish Recovery Board; Clark County; Clark Public Utilities; Clark Conservation District; the Departments of Fish and Wildlife and Natural Resources) understand the TMDL process and are ready to accept the load allocations of the TMDL and to participate in developing a Detailed Implementation Plan (DIP). The DIP will organize the energies and resources of these key entities to produce real results. Further, approximately one year after the TMDL is approved by EPA, the DIP will specify commitments to BMPs, time schedules, sources of funding, adaptive management, and effectiveness monitoring to achieve the targets in the plan. WDOE will work with local entities, over time, to build and monitor the implementation plan as a cost share to this project.

In addition, there are local citizen groups, such as the Friends of East Fork, who will add to, and ensure, complete implementation.

13. Will it be practical to institute the needed land use and management changes?

Yes! There is an opportunity in this watershed to be capitalized upon. The FLIR flight will complement the development of a temperature TMDL technical report which will lead to a temperature TMDL for the East Fork Lewis River. Once the TMDL load allocations are in place, Clark County Public Works will, by provisions of their existing stormwater permit, start implementation of strategies to restore the stream. Under existing Growth Management Requirements, Clark County is revising its Critical Area Ordinances to develop buffer widths along streams that would allow for plantings to increase the shade on East Fork Lewis waters. The specific monitoring and modeling information inherent to the development of a TMDL will provide the factual basis for implementing those buffer widths. In addition, the Clark Conservation District is ready to assist with the development of farm plans for properties affected by the land use changes that will be required by the TMDL.

Other entities which have indicated a readiness to receive and act on a technical TMDL are the local planning groups for the East Fork Lewis watershed; the Yakama Tribe; the Lower Columbia Fish Recovery Board; Clark County; Clark Public Utilities; Clark Conservation District; the Departments of Fish and Wildlife and Natural Resources.

14. Is there a commitment from the USFS and private landowners to make the necessary changes?

The U.S. Forest Service (USFS) has signed a memorandum of agreement (MOA) with the Washington Department of Ecology (WDOE) that reaffirms its commitment to comply with the federal Clean Water Act and to work cooperatively with Ecology in establishing and implementing TMDLs. In addition to these two commitments, the MOA specifically requires the Forest Service to bring all of its roads up to state standards by 2015. Because the upper 30% of the East Fork Lewis watershed is in Forest Service ownership, we believe there is a very high likelihood they will cooperate in developing a TMDL to reduce water temperatures. The U.S. Forest Service's commitment to the combination of implementing the Northwest Forest Plan riparian buffers and the road improvements required in the MOA will help restore the original stream geometry and functioning riparian corridors, and will result in water temperature reductions.

The US Forest Service has already demonstrated its commitment to WDOE by cooperatively completing a TMDL and a Water Quality Restoration Plan in the Olympic National Forrest in June 2001. Currently, the USFS is in active negotiations with WDOE for technical assistance to develop temperature TMDLs in the Wenatchee and Colville National Forests over the next two years.

State and private forest landowners are covered by the restorative provisions of the Forest and Fish agreement. For the other landowners in the area, it is too early to provide a sense of their potential commitment. Local private land owners cannot commit until after the TMDL is under development and presentations are made to them explaining specific monitoring and modeling results and load allocations (targets). Such information needs to demonstrate their land's relationship to the overall temperature problem in the river. The FLIR digital and Infra-red photos are key to their visualizing direct land use relationships to water temperature and to establishing the land owners responsibilities and choices to restore the stream.