Pend Oreille River Temperature Total Maximum Daily Load

Water Quality Improvement Report

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Cover photos:

Top:	Pend Oreille River approximately 1919 by Frank Palmer Studios, courtesy Spokane Public Library, Northwest Room
Bottom:	Pend Oreille River approximately 2007

Project Codes and 1996 303(d) Water Body ID Numbers

Data for this project are available at Ecology's Environmental Information Management (EIM) website at www.ecy.wa.gov/eim/index.htm. Search User Study ID, PPIC0006.

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Pend Oreille River Temperature Total Maximum Daily Load

Water Quality Improvement Report

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Executive Summary

Introduction

The Washington State Department of Ecology (Ecology) initiated this total maximum daily load (TMDL) analysis of water temperatures within the Pend Oreille River in response to observations of chronically elevated temperatures at levels exceeding the river's specific criteria. Elevated temperatures result in impacts to salmonid spawning, rearing, and migration, which is the designated use established for the river and protected by the water quality standards.

Section 303, part d of the federal Clean Water Act requires states to account for waters not meeting water quality criteria. The temperature excursions led to the inclusion of 17 locations of the Pend Oreille River within Washington State, and six tributary segments on Ecology's 303(d) list of impaired waters (Table ES-1). Once a water body is included on the 303(d) list, a TMDL study is required. This TMDL applies to the Pend Oreille River and its tributaries, aside from Calispell Creek, up to the Colville National Forest boundary, with the exception of East Branch LeClerc Creek. All private and state-owned lands within the East Branch LeClerc Creek watershed above the Colville National Forest Boundary are included in this TMDL because the creek received a shade allocation above the national forest boundary.

Table ES-1. Waters on the 2008 303(d) List addressed by this TMDL.

Water Body Name	Identification Number	Township	Range	Section
Pend Oreille River	8610	37N	43E	05
	8617	31N	46E	07
	11452	39N	43E	21
	42513	38N	43E	20
	42512	38N	43E	19
	42515	40N	43E	10
	43539	40N	43E	03
	48297	31N	46E	18
	48345	35N	44E	18
	48346*	35N	44E	20
	48347	33N	44E	07
	48348	33N	44E	19
	48349	32N	44E	16
	48350	32N	44E	27
	48351	32N	45E	29
	48352	32N	45E	35
	48386	36N	43E	04
Cedar (Ione) Creek	38212	38N	43E	31
East Branch LeClerc Creek	21710	35N	44E	17
	21711	36N	44E	33
Little Muddy Creek	21715	37N	43E	06
Lost Creek	21717	36N	43E	22
Smalle Creek	21837	33N	43E	27

* Ecology rolled listing 48925 into listing 48346 because they were duplicates.

What is a total maximum daily load (TMDL)?

The federal Clean Water Act (CWA) requires that a TMDL be developed for each of the water bodies on the 303(d) list. The TMDL study determines the extent of the water quality problem(s) and the underlying causes, and then specifies a limit on the amount of pollutants to improve water quality and return the surface water to criteria, achieving its beneficial uses. Then Ecology, with the assistance of local governments, agencies, and the community develops a plan that describes actions to control the pollution and a monitoring plan to assess the effectiveness of the water quality improvement activities. The water quality improvement report (WQIR) consists of the TMDL study and implementation strategy or plan.

Study area

The Pend Oreille River is part of the Pend Oreille/Clark Fork watershed, which drains parts of Montana, Idaho, and Washington as well as a portion of British Columbia, Canada before entering the Columbia River. The Kalispel Indian Tribe (Tribe) Reservation is located along a ten-mile stretch the Pend Oreille River in Washington. The bulk of the reservation is on the east side of the river north of Usk, but a small portion is located on west side of the river north of Cusick.

The focus of this study is the 72-mile section of the Pend Oreille River from its entrance into Washington, near the city of Newport, to its northern exit into British Columbia, Canada. The Pend Oreille River watershed in Washington State encompasses about 1,000 square miles and comprises water resource inventory area (WRIA) 62. For the analysis, the river was divided into 12 reaches.

Within the study area, river hydraulics are affected by three hydroelectric facilities including:

1) Albeni Falls Dam, located in Idaho upstream of the Washington-Idaho Stateline and operated by the U.S. Army Corps of Engineers (COE).
2) Box Canyon Dam, located near the town of Ione and owned by the Pend Oreille Public Utility District.
3) Boundary Dam, located 18 miles below Box Canyon Dam and operated by Seattle City Light.

Temperature criteria and its assessment

The Pend Oreille temperature criteria has two parts. Part 1 applies when temperatures are over 20^{o}C. If the natural condition temperatures exceed 20^{o}C, then the allowable increase is 0.3^{o}C. Part 2 of the criteria applies when temperatures are under 20^{o}C.

Both Washington State's and the Kalispel tribal water quality criteria reference both an existing and a natural temperature condition designed to protect salmonids. The natural condition is a river temperature regime present prior to hydroelectric management, point source discharge, and riparian vegetative alteration. Because of the current changes to the river as a consequence of the dams, the natural temperature condition is one that can only be estimated through the application of a water quality model. For this reason, this study used the CE-QUAL-W2 water quality model to describe both the existing and natural conditions for the Pend Oreille River. The model was used to examine, individually, the relative influence of riparian shade levels, point source discharges, and the hydroelectric facilities' operations on current river temperatures.

Overview of results

Results indicate that both the Pend Oreille Public Utility District's Box Canyon Dam and Seattle City Light's Boundary Dam increase the heat load to the Pend Oreille River to levels that result in the exceedance of the temperature criteria. Cumulatively, the effect of the hydroelectric facilities on Pend Oreille River water temperature is subtle: daily maximum temperatures in many reaches of the river are cooler than what is predicted to have occurred naturally and, where warming does occur (most prominently in the reaches directly upstream of the facilities) it tends to be low, about 1°C above what occurred naturally. There are several reasons for this:

Water source: Lake Pend Oreille provides the vast majority of flow through the study area, both historically and currently. At Newport, the most upstream reach in Washington and situated below Albeni Falls dam, river temperatures are cooler now than what is predicted to have occurred naturally. This is due to the dam maintaining the lake level in the mid and late summer higher than what it would have been under natural conditions. The higher lake level allows for deeper, cooler water from the lake to enter the Pend Oreille River. This cool water buffers sources of river warming from Newport to Blueslide so that river temperatures are cooler now than before the dams were built. Box Canyon and Boundary dams also depress the maximum temperatures observed in their associated tailrace reaches by withdrawing cooler subsurface water from their forebays and discharging it downstream after power generation.

Hydraulic changes: Because of the dams the river is now deeper and wider, with lower average velocities in comparison to what occurred naturally. These changes are most evident during the critical summer months when the warmest temperatures occur. This increased storage now buffers the river from large temperature fluctuations and is one of the reasons why cooler temperatures found at Newport (downstream of the Albeni Falls tailrace) can now be observed in temperature profiles 40 miles down-river at Blueslide. These hydraulic characteristics also buffer temperature changes associated with alterations in mainstem or tributary shading and the presence of NPDES discharges. In comparison, the Pend Oreille River's natural channel flow characteristics were narrower and shallower and subject to greater gains and losses in heat which, in turn, affected the range in temperature.

Temperature criteria exceedances

Despite the hydraulic changes and their overall effect on buffering temperature shifts, the temperature criteria for the Pend Oreille River was exceeded in particular reaches (Table ES-2). This occurred most prominently in the forebays of Box Canyon and Boundary dams, where Part 1 of the criteria, concerning maximum temperatures, was exceeded by an average (2004, 2005) of 0.94°C and 0.59°C, respectively.

For Part 2 of the criteria, Ecology analyzed temperatures under 20°C to 12°C. The 12°C lower limit was applied because bull trout use the river for migration in the early fall and are sensitive to temperatures above that level. (Pend Oreille River bull trout are listed for protection under the

Federal Endangered Species Act.) During the time-frame associated with these temperatures (September through October), the criteria was exceeded for all of the Boundary reaches. The level of exceedance increased longitudinally from 0.14°C at Metaline to 0.53°C at the Boundary tailrace (Table ES-2).

Allocations

State line: Ecology set an assumption to comply with 2004 existing temperatures at the Idaho-Washington Stateline. Setting this allocation protects the river from additional heating upstream and ensures viability of allocations downstream.

Hydroelectric facilities: When natural condition river temperatures are greater than 20°C (July and August), load allocations have been set equivalently at 0.12°C above the natural temperature condition for the Box Canyon and Boundary facilities due to the inter-relationship of the temperature impacts and the associated cumulative impacts in the watershed. The temperature reduction required to achieve the load allocations for Box Canyon and Boundary is 1.13°C and 0.76°C, respectively, based on 2004 results. These reductions apply during July and August in the forebays of the dams, which are the areas of maximum temperature impairment.

Table ES-2. Pend Oreille River reaches and their compliance with Parts 1 and 2 of the Washington State temperature Criteria.

Criteria	Reach	River Mile Segment	Criteria Met		Level of Criteria Exceedance (°C)*	
			2004	2005	2004	2005
Part 1– Washington State Pend Oreille River Temperature Criteria	Newport	88.0 - 84.4	Yes	Yes	==	==
	Dalkena	84.3 – 77.0	Yes	Yes	==	==
	Skookum	76.8 – 72.4	No	No	0.21°C	0.20°C
	Kalispel	72.3 – 63.7	Yes	Yes	==	==
	Middle	63.6 – 56.1	Yes	Yes	==	==
	Blueslide	56.0 – 47.7	Yes	Yes	==	==
	Tiger	47.6 – 36.4	No	No	0.44°C	0.51°C
	Box Canyon Forebay	36.2 – 34.6	No	No	0.95°C	0.93°C
	Metaline	34.4 – 27.1	No	No	0.58°C	0.17°C
	Slate	26.9 – 19.6	No	No	0.45°C	0.19°C
	Boundary Forebay	19.5 – 17.1	No	No	0.70°C	0.47°C
	Boundary Tailrace	16.8 – 16.2	No	No	0.53°C	0.27°C
Part 2– Washington State Pend Oreille River Temperature Criteria	Newport	88.0 - 84.4	Yes	Yes	==	==
	Dalkena	84.3 – 77.0	Yes	Yes	==	==
	Skookum	76.8 – 72.4	Yes	Yes	==	==
	Kalispel	72.3 – 63.7	Yes	Yes	==	==
	Middle	63.6 – 56.1	Yes	Yes	==	==
	Blueslide	56.0 – 47.7	Yes	Yes	==	==
	Tiger	47.6 – 36.4	Yes	Yes	==	==
	Box Canyon Forebay	36.2 – 34.6	Yes	Yes	==	==
	Metaline	34.4 – 27.1	No	No	0.14°C	==
	Slate	26.9 – 19.6	No	No	0.24°C	==
	Boundary Forebay	19.5 – 17.1	No	No	0.61°C	==
	Boundary Tailrace	16.8 – 16.2	No	No	0.53°C	==

* The level of exceedence listed, for each reach, indicates the temperature extension beyond the relevant criteria; 0.3°C for part 1 and the allowable temperature increase for part 2.

The allocations are set for the forebays of each facility as opposed to each reach, because the temperature impacts identified in all of the reaches can be associated with operations of the facilities. To achieve water quality standards in the forebays, Ecology anticipates that actions will need to be taken throughout the reservoirs and in the tributaries.

When river temperatures are under 20°C in late summer and early fall (September through October), the Pend Oreille River exceeded the temperature criteria for each of the Boundary reaches to varying levels. To achieve criteria during September and October, the level of temperature reduction required for the reaches are:

Metaline: 0.14°C Slate: 0.24°C Boundary forebay: 0.61°C Boundary tailrace: 0.53°C

Point source discharges: NPDES point source discharges were not found to cause any significant shift in river temperatures. In addition, during the summer critical period temperature data from the point sources show that temperature increases at their mixing zone boundary were below 0.3°C.

Tributary and mainstem shading: Temperatures will be reduced in Pend Oreille River tributaries and along the mainstem through the establishment of potential natural vegetation conditions. Providing optimal riparian shade conditions to reduce peak temperatures will further increase the extent of viable habitat augmenting the river's designated uses.

Reserve capacity: The remainder of the 0.3°C load capacity when natural temperatures are above 20°C is 0.06°C (0.24°C was split among the dams), which has been set aside as a reserve. Ecology established this reserve to account for future economic growth associated with the expansion of public and private enterprise. Any future NPDES discharges to the Pend Oreille River in Washington will be allocated a portion of this reserve capacity. No reserve capacity is allocated to nonpoint sources or to the dams.

Planning and implementation to achieve criteria

The Pend Oreille Public Utility District (PUD) and Seattle City Light own and operate Box Canyon Dam and Boundary Dam, respectively. As part of their Federal Energy Regulatory Commission (FERC) license, these utilities will complete actions in their 401 Water Quality Certifications to achieve the temperature criteria for the Pend Oreille River. Specifically, Seattle City Light and the Pend Oreille PUD will follow the dam compliance schedule outlined in the state water quality standards [WAC 173-201A-510(5)]. In addition, Pend Oreille River watershed residents and landowners are called upon to reduce water temperature by increasing the number of native trees and shrubs along the Pend Oreille River and its tributaries.

In addition, seven facilities have National Pollutant Discharge Elimination System permits to discharge to surface waters. However, only four facilities (the town of Ione, city of Newport, Ponderay Newsprint and the Pend Oreille Mine) discharge when the river temperatures exceed 20°C. All seven facilities will be required to monitor temperatures, and the four facilities will have temperature limits placed in their permits.

Since the Tribe is affected by this TMDL, Ecology will work with those listed previously as well as Pend Oreille County to ensure that the Tribe's temperature criteria are met for their waters.

Why this matters

Reducing Pend Oreille River temperatures is important to protect the native salmonids and migrating bull trout that use the river. Salmonids' ability to feed, grow, reproduce, resist disease, compete with other fish, and avoid predators is negatively affected if water temperatures are too warm1. Actions to reduce water temperatures are necessary to ensure survival of bull trout, a threatened fish under the Endangered Species Act.

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[1]EPA. 2001. Technical Synthesis: Scientific issues relating to temperature criteria for Salmon, Trout, and Char Native to the Pacific Northwest. U.S. Environmental Protection Agency. EPA 910-R-01-007

Acknowledgements

Karin Baldwin was responsible for project management and report writing.

Anthony Whiley, P.E. was responsible for the analysis and interpretation of the mainstem temperature model results in addition to report writing.

Paul Pickett, P.E. conducted the field data collection and analysis; ran initial model scenarios; and analyzed tributary and point source flow and temperatures.

The authors of this report thank the following people for their participation in the TMDL development process:

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- Diane Williams, Tri-State Water Quality Council
- Ruth Watkins
- Pend Oreille Watershed Advisory Group members
- Tetra Tech, Inc. staff from the Fairfax, VA office

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What is a Total Maximum Daily Load (TMDL)

Federal Clean Water Act requirements

The Clean Water Act (CWA) established a process to identify and clean up polluted waters. The CWA requires each state to have its own water quality standards designed to protect, restore, and preserve water quality. Water quality standards consist of: (1) designated uses for resource protection (for example cold water biota or drinking water supply), and (2) criteria, usually numeric criteria, to achieve those uses.

The water quality assessment and the 303(d) list

Every two years, states are required to prepare a list of water-bodies that do not meet water quality standards. This list is called the CWA 303(d) list. In Washington State, this list is part of the water quality assessment (WQA) process.

To develop the WQA, the Washington State Department of Ecology (Ecology) compiles its own water quality data along with data from local, state, and federal governments, tribes, industries, and citizen monitoring groups. All data in this WQA are reviewed to ensure that they were collected using appropriate scientific methods before they are used to develop the assessment. Depending on water quality conditions and stage of study process, water bodies are placed into the following categories:

Category 1 – Meets standards for parameter(s) for which it has been tested.

Category 2 – Waters of concern.

Category 3 – Waters with no data or insufficient data available.

Category 4 – Polluted waters that do not require a TMDL because:

- 4a – Have an approved TMDL being implemented.
- 4b – Have a pollution control program in place that should solve the problem.
- 4c – Are impaired by a non-pollutant such as low water flow, dams, culverts.

Category 5 – Polluted waters that require a TMDL – the 303(d) list.

The list of waters that do not meet standards [303(d) list] is the Category 5 part of the larger assessment. The CWA requires that a total maximum daily load (TMDL) be developed for each of the water bodies on the 303(d) list. A TMDL is numerical value representing the highest pollutant load a surface water body can receive and still meet water quality standards. Any amount of pollution over the TMDL level needs to be reduced or eliminated to achieve clean water.

Further information is available at Ecology's Water Quality Assessment web site.

TMDL process overview

Ecology uses the 303(d) list to prioritize and initiate TMDL studies across the state. The TMDL study identifies pollution problems in the watershed, and specifies how much pollution needs to be reduced or eliminated to achieve clean water. Ecology, with the assistance of local governments, tribes, agencies, and the community then develops a strategy to control and reduce pollution sources and a monitoring plan to assess the effectiveness of the water quality improvement activities. Together, the study and implementation strategy comprise the *water quality improvement report* (WQIR).

The U.S. Environmental Protection Agency (EPA) approves the TMDL study portion of the WQIR. Once Ecology receives the approval, a water quality implementation plan (WQIP) is completed within one year. The WQIP identifies specific tasks, responsible parties, and timelines for reducing or eliminating pollution sources and achieving clean water.

Who should participate in this TMDL?

The Pend Oreille Public Utility District (PUD) and Seattle City Light own and operate Box Canyon Dam and Boundary Dam, respectively. These utilities will work through their 401 Water Quality Certifications, a part of their Federal Energy Regulatory Commission (FERC) license, to achieve the temperature standard of the Pend Oreille River. Pend Oreille River watershed residents and landowners are called upon to reduce water temperature by increasing the number of native trees and shrubs along the Pend Oreille River and its tributaries, because everyone has the potential to affect water quality.

In addition, seven facilities have permits to discharge to the Pend Oreille River. However, only five facilities (the town of Ione, city of Newport, Ponderay Newsprint, Selkirk High School and the Pend Oreille Mine) discharge when the river temperatures exceed the state standard. All seven facilities will be required to monitor temperatures, and the five facilities will have temperature limits placed in their permits.

The Kalispel Tribe reservation is located along the Pend Oreille River, and they have water quality standards for tribal waters. Since the Tribe is affected by this TMDL, Ecology will work with those previously listed as well as Pend Oreille County to ensure that the Tribe's temperature standard is met for their waters.

Elements the Clean Water Act requires in a TMDL

Loading capacity, allocations, seasonal variation, margin of safety, and reserve capacity

A water body's *loading capacity* is the amount of a given pollutant that a water body can receive and still meet water quality standards. The loading capacity provides a reference for calculating the amount of pollution reduction needed to bring a water body into compliance with the standards.

The portion of the receiving water's loading capacity assigned to a particular source is a *wasteload* or *load* allocation. If the pollutant comes from a discrete (point) source subject to a National Pollutant Discharge Elimination System (NPDES) permit, such as a municipal or industrial facility's discharge pipe, that facility's share of the loading capacity is called a *wasteload allocation*. If the pollutant comes from diffuse (non-point) sources not subject to an NPDES permit, such as general urban, residential, or farm runoff, the cumulative share is called a *load allocation*. The dams addressed in this TMDL will receive load allocations.

The TMDL must also consider *seasonal variations*, and include a *margin of safety* that takes into account any lack of knowledge about the causes of the water quality problem or its loading capacity. A *reserve capacity* for future pollutant sources is sometimes included as well.

Therefore, a TMDL is the sum of the wasteload and load allocations, any margin of safety, and any reserve capacity. The TMDL must be equal to or less than the loading capacity.

Surrogate measures

To provide more meaningful and measurable pollutant loading targets, this TMDL also incorporates *surrogate measures* other than daily loads. EPA regulations [40 CFR 130.2(i)] allow other appropriate measures in a TMDL. See the Glossary section of this document for more information.

Surrogate measures for use in this TMDL are discussed below. The ultimate need for, and the selection of a surrogate measure for use in setting allocations depends on how well the proposed surrogate measure matches the selected implementation strategy.

Temperature is used as a surrogate measure, rather than heat load, to depict loading capacity for a couple reasons:

- The water quality criteria refer to a maximum daily temperature and also limit the temperature increase when natural condition temperatures are above 20^{o}C. So, determining compliance with water quality criteria is more straightforward using temperature.
- Since the criteria is based on a daily maximum temperature, the TMDL analysis used the modeled river segments with the highest temperature in the water column. Although the Pend Oreille River is not stratified, the subsurface portion of the river can be cooler than that closer to the water surface where the daily maximum temperatures are typically found. So, calculating the loading capacity using the highest maximum temperature and entire river volume would be an inaccurate representation of heat present in the river.

Potential natural vegetation or shade is a surrogate of heat flux. It is defined as the portion of potential solar shortwave radiation blocked by vegetation and topography before reaching the stream surface. Allocations for potential natural vegetation are established to address nonpoint sources of pollution in the watershed because it is a better measure of compliance than a heat load.

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Why Ecology Conducted a TMDL Study in this Watershed

Ecology conducted a TMDL study in this watershed because the Pend Oreille River had five segments on the 1998 303(d) list for temperature. These segments were placed on the 303(d) list because temperature data collected by Ecology in 1988 indicated that the 20°C criteria was exceeded four out of seven times between July and November. The Pend Oreille River appeared six times on the 2004 303(d) list for temperature. More recently, 17 river segments and 6 tributary segments were included on the 2008 303(d) list for temperature.

In the late 1990s, the Pend Oreille Public Utility District (PUD) was working towards relicensing Box Canyon Dam with the Federal Energy Regulatory Commission (FERC). During that process, the two water quality models used to examine water temperature impacts did not agree on the impact the dam operations had on the Pend Oreille River's temperature. Therefore, Ecology requested a TMDL be completed which, if necessary, would be used to amend the 401 Water Quality Certification issued to the PUD in 2003 as part of their FERC license. The timing of this TMDL also coincides with Seattle City Light's efforts to relicense Boundary Dam.

Ecology collected temperature and other environmental data for this TMDL in 2004 from the Idaho-Washington Stateline to Box Canyon Dam. The quality assurance project plan (Pickett, 2004) that guided the data collection is available at www.ecy.wa.gov/biblio/0403109.html. Seattle City Light contracted with Taylor Associates, Inc. to collect water quality data for their reservoir (Box Canyon Dam tailrace to the Canadian border) in 2004 through 2006 (Taylor Associates, Inc., 2007).

Impairments addressed by this TMDL

Table 1 lists the temperature impairments in the Pend Oreille River and its tributaries. With the exception of Calispell and Browns creeks, all waters on the 303(d) list for temperature in watershed resource inventory area (WRIA) 62 will be addressed by this TMDL. Calispell Creek is not addressed by this TMDL because the Kalispel Tribe worked with Tetra Tech to develop a temperature model specifically for Calispell Creek. Information from this modeling effort will be used to either develop a TMDL or perform actions to improve temperatures in the future. The Browns Creek listing is not addressed because it is located on the Colville National Forest and will be addressed by another effort.

Table 2 lists segments of the Pend Oreille River and its tributaries that are listed as waters of concern (Category 2) on Washington's 2008 Water Quality Assessment. If a water segment is listed as a Category 2, then there is some evidence of a water quality problem, but more data is needed. The water segments of concern listed in Table 2 are included because they fall within the TMDL project area and are likely to be improved as a result of implementation activities.

This TMDL applies to the Pend Oreille River and its tributaries (aside from Calispell Creek) up to the Colville National Forest boundary, except for East Branch LeClerc Creek. All private and state-owned lands within the East Branch LeClerc Creek watershed above the Colville National Forest boundary are included because the creek received an allocation above the national forest boundary.

There are other 303(d) listed segments in the watershed not addressed by this report:

- Chlorinated pesticides and PCBs in the Pend Oreille River and Bead Lake
- Low dissolved oxygen levels in numerous tributaries
- Elevated levels of fecal coliform bacteria in Skookum Creek
- Elevated pH levels in the Pend Oreille River and several of its tributaries

The primary focus of this study is on water temperature in the Pend Oreille River and its principal tributaries within Washington. Additional analyses may be conducted in the future to address these other parameters. However, Ecology encourages landowners, businesses and local governments to implement actions now to improve other water quality parameters as well.

Table 1. Pend Oreille River and tributary segments on the 2008 303(d) list addressed by this TMDL.

Water Body Name	Listing Identification	Township	Range	Section
Pend Oreille River	8610	37N	43E	05
	8617	31N	46E	07
	11452	39N	43E	21
	42513	38N	43E	20
	42512	38N	43E	19
	42515	40N	43E	10
	43539	40N	43E	03
	48297	31N	46E	18
	48345	35N	44E	18
	48346*	35N	44E	20
	48347	33N	44E	07
	48348	33N	44E	19
	48349	32N	44E	16
	48350	32N	44E	27
	48351	32N	45E	29
	48352	32N	45E	35
	48386	36N	43E	04
Cedar (Ione) Creek	38212	38N	43E	31
LeClerc Creek, E.B.	21710	35N	44E	17
	21711	36N	44E	33
Little Muddy Creek	21715	37N	43E	06
Lost Creek	21717	36N	43E	22
Smalle Creek	21837	33N	43E	27

* Ecology rolled listing 48925 into listing 48346 because they were duplicate listings.

Table 2. Pend Oreille River and tributary segments listed as Category 2 on the 2008 Water Quality Assessment.

Water Body Name	Listing Identification	Township	Range	Section
Pend Oreille River	8612	36N	43E	10
	8614	34N	43E	12
	8616	33N	44E	32
Cedar Creek	8594	38N	42E	36
LeClerc Creek, W.B.	21842	35N	44E	06
Smalle Creek, E.F.	38324	33N	43E	22

Water Quality Standards and Numeric Targets

Temperature

Temperature affects the physiology and behavior of fish and other aquatic life. It is among the most important environmental factors limiting the distribution and health of aquatic life and can be greatly influenced by human activities. Temperature levels fluctuate over the day and night in response to changes in meteorological conditions and river flows. (See Appendix B for an overview of stream heating processes.) The health of aquatic species is tied predominantly to the pattern of maximum temperatures and, for this reason, so is the temperature criteria.

Pend Oreille River and Tributary water temperature criteria

In Washington State the water quality standards are based on the protection of sensitive species and life-stage conditions [WAC 173-201A-200; 2006 edition]. In the Pend Oreille watershed, there are three different designated uses:

- Salmonid spawning, rearing and migration
- Char spawning and rearing
- Core summer salmonid habitat

The applicable designated use for the Pend Oreille River is salmonid spawning, rearing, and migration. The Washington State Attorney General's Office completed a legal interpretation of the temperature standard for the Pend Oreille River (Appendix F). The Pend Oreille River has special temperature criteria (WAC173-201A-602) which, in this report, will be referred to as Parts 1 and 2:

Part 1: Temperature shall not exceed a 1-day maximum (1-DMax) of 20°C due to human activities. When natural conditions exceed a 1-DMax of 20°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C;

Part 2: Nor shall such temperature increases, at any time, exceed $t = 34/(T + 9)$
where: *t = the allowable temperature increase; and*
T = the background temperature measured at a point unaffected by the discharges. The Pend Oreille River is affected by discharges from dams in both Washington and Idaho, so the modeled natural condition, which represents the unaffected river, is used to define T in this TMDL.

Several tributaries to the Pend Oreille River, or a portion of them, are designated as char [bull trout (*Salvelinus confluentus*)] spawning and rearing including:

- Calispell Creek upstream of Smalle Creek
- Cedar Creek from latitude 48.7500, longitude -117.4349 to the headwaters, including tributaries
- Indian Creek from the mouth to the headwaters
- East Branch LeClerc Creek, including tributaries
- West Branch LeClerc Creek, including tributaries
- Slate Creek from the mouth to headwaters (including tributaries)
- Sullivan Creek above the junction with Outlet Creek (including tributaries) to the headwaters
- Tacoma Creek including the South Fork and tributaries

According to WAC173-201A-201 (c), the numeric temperature standard for char spawning and rearing is:

> The highest 7-day average daily maximum temperature must not exceed 12°C (53.6°F) more than once every ten years on average.

Three tributaries designated as core summer salmonid habitat are:

- Cedar Creek from the mouth to latitude 48.7500, longitude -117.4349, including tributaries.
- LeClerc Creek from the mouth to the junction with West Branch LeClerc Creek, including tributaries.
- Mill Creek from the mouth to the headwaters, including tributaries.

The temperature criterion to protect salmonids in the tributaries [WAC173-201A-201 (c)] listed above is:

> The highest 7-day average daily maximum temperature must not exceed 16°C (60.8°F) more than once every ten years on average.

Washington State uses the various criteria described above to ensure that where a water body is naturally capable of providing full support for its designated aquatic life uses, that condition will be maintained. The standards recognize, however, that not all waters are naturally capable of staying below the fully protective temperature criteria. When a water body is naturally warmer than the above-described criteria, the state provides a small allowance for additional warming due to human activities. In this case, the combined effects of all human activities must not cause more than a 0.3°C (0.54°F) increase above the naturally-higher temperature condition. Whether or not the water body is naturally high in temperature is determined using a water quality model. The model approximates natural conditions, and is appropriate for assessing compliance with the temperature criteria.

Kalispel Tribal water quality standards

In addition to Washington State temperature criteria, the Kalispel Tribe also has criteria that apply to the Pend Oreille River for a section under its jurisdiction. The United States Environmental Protection Agency approved the Kalispel Tribe's water quality standards on June 24, 2004. The Kalispel's temperature criteria for the Pend Oreille River are designated to meet the use of adult salmonid migration and includes:

- The criteria for salmon migration are a 7-day average of the daily maximum (7-DADMax) of 18^{o}C.
- 1-day maximum (1-DMax) of 20.5^{o}C.

For all designated uses, if natural conditions are above criteria then human influences can raise water temperatures by no more than 0.3^{o}C.

British Columbia water quality guidelines

British Columbia established water quality guidelines for temperature based on the type of fish species present and their life stage. Neither Environment Canada nor the British Columbia Ministry of Environment have developed site-specific guidelines for the Pend Oreille River. So, the British Columbia province-wide ambient temperature guidelines apply (BCMWLAP, 2001). The applicable guideline for the Pend Oreille River is the mean weekly maximum temperature (MWMT) of $18^{o}C$, a maximum daily temperature of $19^{o}C$, an hourly rate of change not to exceed $1^{o}C$, and a maximum incubation temperature of $12^{o}C$ in the spring and the fall.

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Description of Study Area

Pend Oreille watershed

The Pend Oreille River is part of the Pend Oreille/Clark Fork watershed (Figure 1). The watershed drains parts of Montana, Idaho, and Washington as well as a portion of British Columbia, Canada before entering the Columbia River. The Clark Fork begins in the Rocky Mountains in western Montana, flows through northern Idaho and then empties into Lake Pend Oreille. The Pend Oreille River begins at the outlet of Lake Pend Oreille in northern Idaho and flows west across the Idaho Panhandle. It is the only outlet from Lake Pend Oreille, which is Idaho's largest and deepest natural lake (MDEQ et al., 2007). The river flows about 26 miles in Idaho before reaching Albeni Falls Dam, just east of the border between Idaho and Washington. The entire Pend Oreille/Clark Fork watershed upstream of the Washington-Idaho Stateline covers over 24,000 square miles.

Of the greater Pend Oreille River watershed, the study area covered by this TMDL is the river section (along with its tributary drainage) flowing through the state of Washington. The Pend Oreille River enters Washington near the city of Newport and flows north for about 72 miles before entering Canada (Figure 2). The river flows about fifteen more miles through British Columbia before entering the Columbia River two miles north of the international border.

The Pend Oreille River watershed in Washington State encompasses about 1,000 square miles and makes up water resource inventory area (WRIA) 62. The watershed is bounded by the Selkirk Mountains. Much of the sub-basin's land falls within the boundaries of the Kaniksu and Colville National Forests. The Salmo-Priest Wilderness area, a part of the Colville National Forest, is located in the far northeastern corner of the Pend Oreille Sub-basin in Washington. The watershed is geologically complex, with extensive meta-sedimentary rock formations rich in minerals and a surface formed by glacial scouring and deposition (Entrix, 2002).

Elevations range from 1,700 feet at Boundary Dam, to 2,150 feet at Newport, to over 7,300 feet at the mountain tops. Prior to hydroelectric power generation, the river flowed through a wide, level valley bottom from Newport north to about Jared, then cut through the mountains in a series of canyons and waterfalls (e.g. Box Canyon, Metaline Falls, and Z Canyon) with a few local alluvial terraces.

Many small tributaries enter the Pend Oreille River in Washington. The largest is Sullivan Creek, with a watershed area of 142 square miles. Other larger tributaries include Calispell, LeClerc, Lost, Skookum, Slate, and Tacoma creeks. Most of the flow in the Pend Oreille River enters from upstream in Idaho, while the tributaries in Washington contribute only a small fraction of the total flow. The seven-day average low flow with a ten year average recurrence (7Q10) for the Pend Oreille River below Box Canyon Dam is about 12,300 cubic feet per second (cfs), while the 7Q10 for Sullivan Creek is about 66 cfs, representing about 0.5 percent of the river flow.

Climate in the Pend Oreille River watershed is characterized by summer air temperatures at Newport averaging 63°F with an average daily maximum air temperature of 79°F and temperatures sometimes into the 90s °F. Annual precipitation in the watershed averages 26 inches in the valley and over 50 inches in the higher elevations. Only 11 to 18 percent of the annual precipitation falls during the summer (July-August).

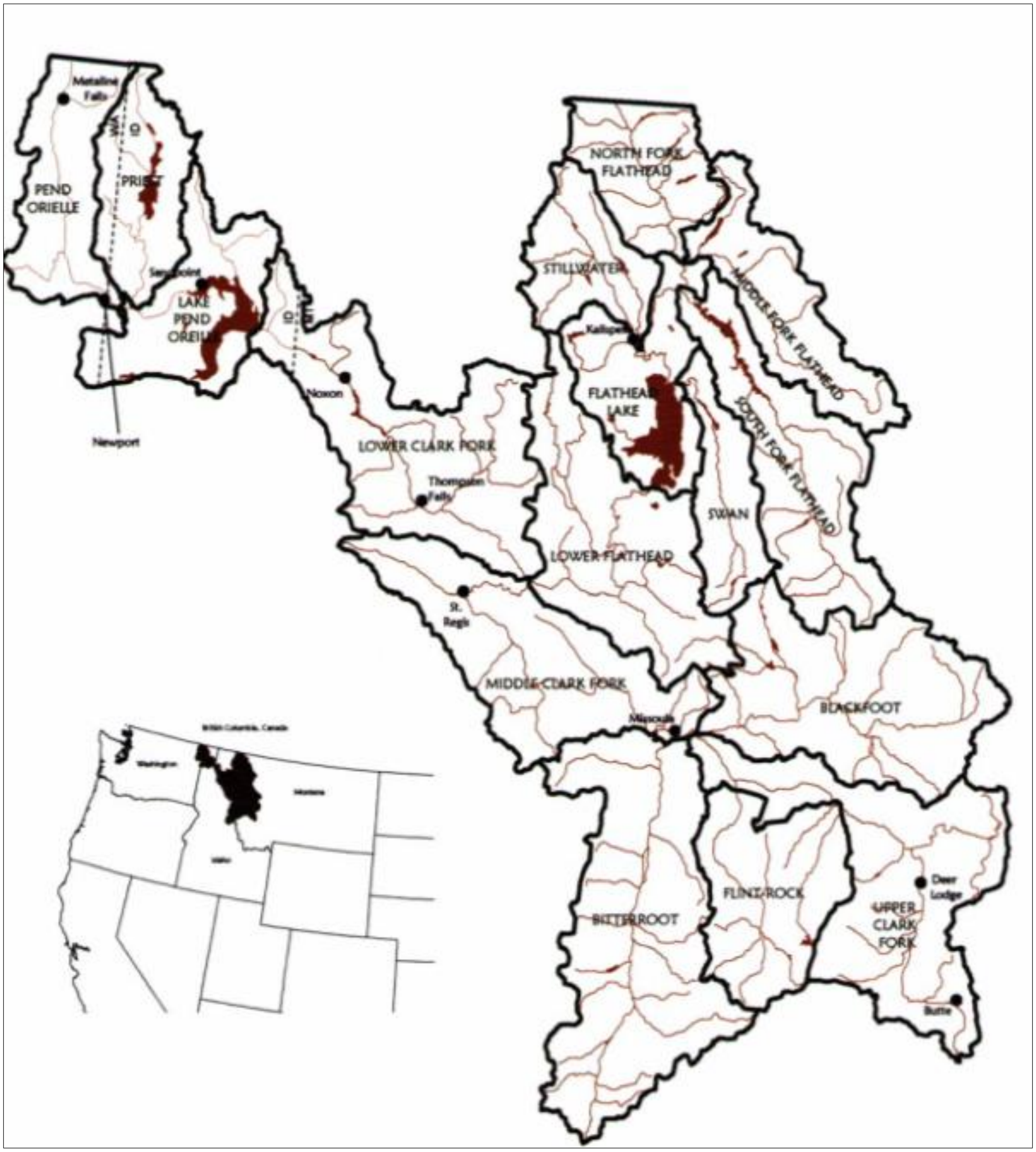

Figure 1. The greater Pend Oreille/Clark Fork watershed within the United States (Pickett, 2004). *The study area is comprised of the "Pend Oreille" sub-drainage, within Washington (upper left corner in figure).*

Downstream of Newport, the river passes through Kalispel tribal lands which occupy about 4,600 acres along the Pend Oreille River in Washington, with nearly 1,000 additional acres in trust. Tribal lands also encompass portions of Calispell and Cee Cee Ah Creeks. The Kalispel Indian Reservation lies primarily in the lowlands bordering the Pend Oreille River, with the bulk of the Reservation on the River's east side. Tribal lands on the river's west side include the confluence of Calispell Creek with the Pend Oreille River.

With a population of around 12,000, Pend Oreille County is Washington State's eighth smallest in population and seventh smallest in population density. The town of Newport has a population of 2,000 and about 1,000 people live in the towns of Cusick, Ione, Metaline, and Metaline Falls combined. The remaining 9,000 live in the county.

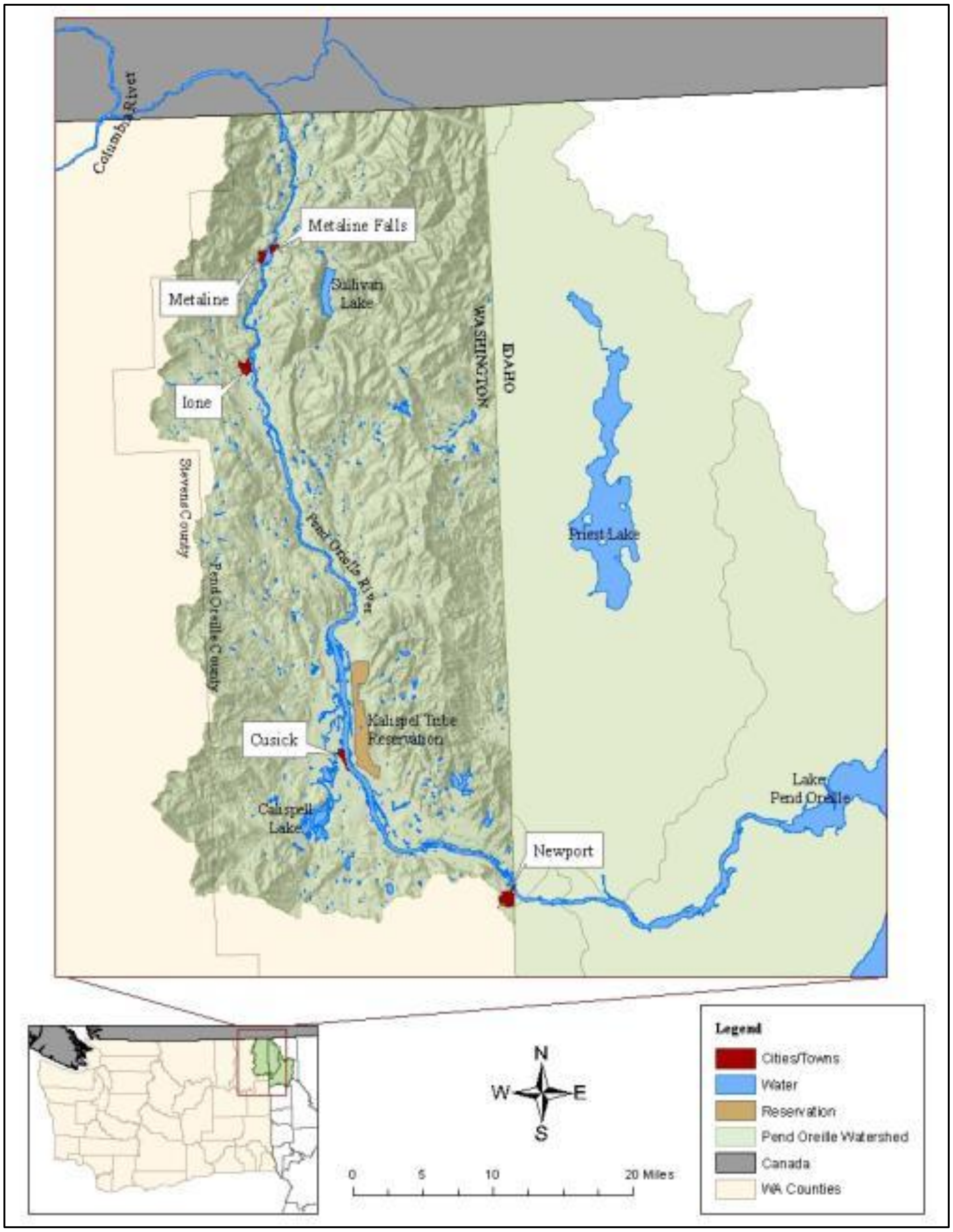

Figure 2. Pend Oreille River watershed in Washington.

Almost 60 percent of the county is a part of the national forest, whereas another five percent of the land is owned by the state, Kalispel Tribe, and local governments. Approximately 35 percent of the land is privately owned. Forest lands make up about 93 percent of land use, while agriculture and range lands make up roughly 6 percent, which is mostly concentrated in the river and tributary valleys.

There are five dams on the Pend Oreille River downstream of Lake Pend Oreille. Albeni Falls dam is located just upstream of the Washington-Idaho State line in Idaho. Albeni Falls Dam was built in 1952, about 26 miles downstream from where the river leaves Lake Pend Oreille. The water surface levels of Pend Oreille Lake and Pend Oreille River are controlled by the U.S. Army Corps of Engineers (COE) who operate Albeni Falls dam (Council, 2005). Two other dams, Box Canyon Dam and Boundary Dam, are located on the river in Washington. Box Canyon Dam, completed in 1956, is just downstream of Ione. Boundary Dam, built in 1967, is about one mile upstream from the Canadian border. Once in Canada, the river passes through two more dams: Seven Mile Dam built in 1979 eleven miles downstream from Boundary Dam; and Waneta Dam completed in 1954 near the mouth of the Pend Oreille River.

Box Canyon Dam is owned by the Pend Oreille Public Utility District. Box Canyon is a run-of-the-river dam with very little active storage capacity. The reservoir inundates areas along the banks and floodplain of the original river. At times, the head of the reservoir can extend to the foot of Albeni Falls Dam. Water levels at Cusick and Newport are used to manage the reservoir.

Boundary Dam is owned by Seattle City Light. Boundary Dam is operated for peak load-following and providing operating reserves. Water is typically released during the day and the reservoir refills at night. Currently, reservoir water levels fluctuate ten feet during the summer and 20 feet the remainder of the year. The head of the reservoir can extend to Box Canyon Dam during high water. The reservoir inundated the historic Z Canyon and Metaline Falls. Because of the canyons, the reservoir tends to be deep rather than broad.

Several of the tributaries (Trimble, Calispell, Cusick, Gardiner, and Middle creeks) were diked to prevent flooding from runoff events and from the impounded river. Pumps at Trimble and Calispell creeks are operated to control stream levels by moving water into the reservoir.

Timber and recreation are the primary economic activities in the watershed. Mining is also a significant activity, with several large zinc/lead mines located in the Metaline Falls area. Limestone was also historically mined for cement production at a plant in Metaline Falls, but the production plant was demolished in 1996 (although the silos are still in use). The Ponderay Newsprint Company also contributes to the local economy through the operation of a pulp mill near the town of Usk.

Local groups, such as the WRIA 62 Watershed Planning Unit and Tri-State Water Quality Council, invested significant levels of effort in examining water quality issues. The WRIA 62 Watershed Planning Unit (www.ecy.wa.gov/programs/eap/wrias/Planning/62.html) included water quality as a parameter in their Phase II Assessment (Entrix, 2002) and included recommendations addressing water quality issues in their adopted watershed plan (Golder Associates, Inc., 2005). The Pend Oreille Watershed Roundtable, an off-shoot of the planning unit, provides a forum where people can learn about water-related issues in WRIA 62. The Tri-State Water Quality Council (www.tristatecouncil.org/index.html) includes membership from Montana, Idaho, and Washington.

Their primary focus has been nutrient loading from the Clark Fork watershed to Lake Pend Oreille, as well as reducing or keeping nutrient concentrations low in the Clark Fork and Pend Oreille Rivers and Lake Pend Oreille. They also have an interest in water quality in general throughout the basin.

There are seven facilities with National Pollutant Discharge Elimination System (NPDES) permits in the watershed in Washington (Table 3). Three facilities, all located along the Box Canyon reservoir, discharge continuously. These facilities include the city of Newport's wastewater treatment plant (WWTP), the town of Ione WWTP, and the Ponderay Newsprint Company. Four facilities are located along the Boundary Reservoir. These include Selkirk High School, the town of Metaline WWTP, the town of Metaline Falls WWTP, and the Pend Oreille Mine (TeckCominco). Of these four, the Pend Oreille Mine is the only facility that discharges to the Pend Oreille River all year. The town of Metaline Falls WWTP discharges to Sullivan Creek from November through May and the Selkirk High School only discharges when school is in session (Sept.-June). Metaline discharges year round to a wetland not directly connected to the river.

Table 3. Point source discharges within the Pend Oreille Study area.

Facility	Discharges to:	NPDES Permit No.	Expiration Date	Maximum Monthly Discharge (mgd)*
City of Newport WWTP	Pend Oreille River	WA0022322	04/30/2013	0.500
Ponderay Newsprint Company	Pend Oreille River	WA0045268	05/13/2012	5.210
Town of Ione WWTP	Pend Oreille River	WA0045373	05/31/2013	0.215
Selkirk School District #70 (Selkirk High School)	Pend Oreille River	WA0044938	03/31/2007 *(in process of re-issuing)*	0.005
Town of Metaline WWTP	Wetland	WA0020699	6/30/2014	0.044
Town of Metaline Falls WWTP	Sullivan Creek	WA0021156	05/31/2015	0.390
Teck Cominco Pend Oreille Mine	Pend Oreille River	WA0001317	05/31/2009 *(under administrative extension)*	1.440

** mgd = million gallons per day*

Analysis framework

CE-QUAL-W2 temperature model

Both Washington State's and the Kalispel Tribe's temperature criteria refer to a natural condition. Natural conditions are those that occurred prior to altered levels of shade-producing vegetation along the mainstem and its tributaries, point source discharges, and the dams and their collective influence on river hydraulics. In order to the apply the specific criteria for the Pend Oreille River, in addition to understanding how these various changes have affected the natural temperature condition, a temperature model was required. Toward this end, the water quality model CE-QUAL-W2 was developed for two sections of the Pend Oreille River in Washington and are referred to in this TMDL as:

1. Box Canyon Model: applied from the Albeni Falls Dam to the Box Canyon Dam tailrace
2. Boundary Model: applied from the Box Canyon tailrace to the Boundary Dam tailrace

Portland State University developed the Box Canyon model for Ecology and Battelle-Pacific Northwest Division created the Boundary model for Seattle City Light.

Ecology used results from a CE-QUAL-W2 model of the Pend Oreille River in Idaho (Idaho model) to provide the upstream boundary conditions for the Box Canyon model. Portland State University also developed the Idaho model. For more information on the Idaho model, see http://www.deq.idaho.gov/about/regions/pend_oreille_river_tribs_wag/modeling_report_1007.pdf.

The CE-QUAL-W2 model is a two-dimensional, laterally averaged, hydrodynamic water quality model. Basic eutrophication processes are simulated, such as temperature-nutrient-algae-dissolved oxygen-organic matter and sediment relationships. However, for this TMDL only flow and temperature were simulated. Since the model assumes lateral homogeneity, it is typically suited for relatively long and narrow water bodies exhibiting longitudinal and vertical water quality gradients. The United States Army Corps of Engineers Waterways Experiment Station (WES) Environmental Laboratory developed the original model with recent enhancements by Portland State University.

While the CE-QUAL-W2 model was used to simulate the natural and existing temperature conditions in the mainstem Pend Oreille River, the existing temperature conditions for its tributaries were examined with the model rTemp. rTemp is a simple model that predicts a time-series of water temperatures in response to heat fluxes determined by meteorological data, groundwater inflow, and other forcing functions (see http://www.ecy.wa.gov/programs/eap/models.html). The shade produced by potential natural vegetation (PNV) was used to develop temperature time series for the natural scenario.

Temperature monitoring for model calibration

To develop the Box Canyon model, the Washington State Department of Ecology monitored water temperatures at numerous locations within the Pend Oreille River from the Idaho/Washington state line, extending to the Box Canyon Dam tailrace. Both continuous (time series) and vertical profile temperature measurements were collected. Continuous, or time series data, indicate temperatures over an extended period at one location and depth. Ecology collected continuous temperature data from 11 sites along the Pend Oreille River (Box Canyon Model) and 3 sites were sampled for Seattle City Light

(Boundary Model). The vertical profile data provided a snapshot of temperatures at one location but at many depths. Ecology measured temperatures at different depths at 15 locations and 6 locations were measured for Seattle City Light.

In addition, several tributaries discharging to the river within the study area were also monitored including Marshall Creek; Indian Creek; Calispel Creek; Tacoma Creek; Mill Creek; LeClerc Creek; Ruby Creek; and Sullivan Creek.

The methods used for the temperature surveys followed the study's quality assurance project plan (QAPP) (Pickett, 2004; http://www.ecy.wa.gov/pubs/0403109.pdf). Surveys of the river and selected tributaries were conducted on June 22-25, July 27-29, August 18-20, September 21-23, and October 19-20, 2004. Figure 3 shows the TMDL study area, including Pend Oreille River dams and Ecology's temperature monitoring locations. Figure 4 provides additional information about the monitoring locations in the Boundary Dam reservoir. Table C-1 in Appendix C lists the monitoring locations used in the study, with information about the dates surveyed and the location and fate of the thermistors deployed.

Refer to Appendix C for the results of Ecology's 2004 water quality monitoring study of the Pend Oreille River from the stateline to Sullivan Creek. Appendix C also provides an assessment of data quality, which was found to be adequate for the TMDL analysis. A review of historical data is available in the QAPP (Pickett, 2004; http://www.ecy.wa.gov/pubs/0403109.pdf). Appendix E provides web site links to the data summary report and model calibration report for the river from the Box Canyon tailrace to the Canadian border.

All natural condition temperatures were generated from the CE-QUAL-W2 model since temperature data does not exist from before the dams were completed. Therefore, all statements made about natural conditions in this TMDL refer to model-predicted temperatures that occurred before the dams were built.

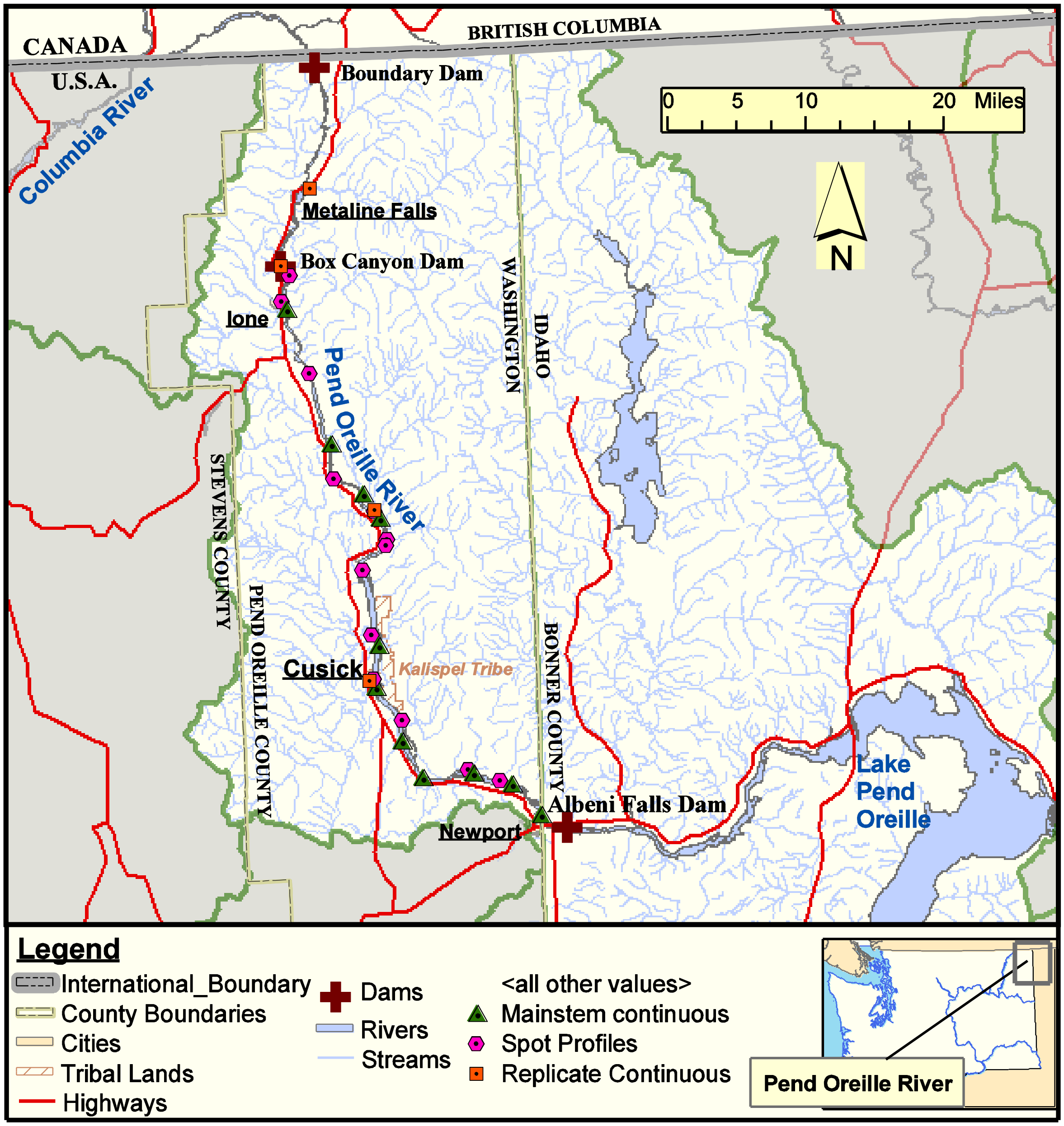

Figure 3. Water quality monitoring stations for the Pend Oreille River TMDL.

Figure 4. Temperature monitoring locations in the Boundary Dam portion of the Pend Oreille River (Breithaupt and Khangaonkar, 2007).

Model calibration

The Box Canyon model used during the dam's relicensing process was previously calibrated for 1997 and 1998. Portland State University revised and recalibrated this model to 2004 observed data. The average root mean square error (RMSE) for continuous temperature data for all three years was 0.41^{o}C. Ecology used results from a CE-QUAL-W2 model of the Pend Oreille River in Idaho (Idaho model) to provide the upstream boundary conditions for the Box Canyon model. Portland State University developed the Idaho model, which was also calibrated to 2004 and 2005 data. The Idaho model RMSE for continuous temperature data was 0.68^{o}C. For more information on the Idaho model see http://www.deq.idaho.gov/about/regions/pend_oreille_river_tribs_wag/pend_oreille_river_model_entire.pdf.

The Boundary model was calibrated to observed data for 2004 and 2005. The RMSE for temperature time series data was 0.41^{o}C. Battelle, consultant for Seattle City Light, developed the calibrated model in addition to analyzing a second scenario which examined the change in river temperatures, assuming the absence of the Boundary Dam facility. Ecology developed the additional TMDL scenarios (description follows).

Reports describing model development, calibration, and scenarios are available under the following titles at http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/technical.html:

Annear, R., C. Berger, and S. Wells (PSU). 2006b. Pend Oreille River, Box Canyon Model: Model Development and Calibration. Technical Report EWR-04-06, Department of Civil and Environmental Engineering, Portland State University, Portland, OR.

Annear, R., C. Berger, and S. Wells (PSU). 2007b.Pend Oreille River, Box Canyon Model: Model Scenario Simulations. Technical Report EWR-03-07. Department of Civil and Environmental Engineering, Portland State University, Portland, OR.

Breithaupt, S.A. and T. Khangaonkar. 2007. Temperature Modeling of the Pend Oreille River, **Boundary Hydroelectric Project: CE-QUAL-W2 Model Calibration Report. Prepared for Seattle City** Light by Battelle – Pacific Northwest Division, Richland Washington.

Analysis period and its characterization

The analysis period for this study extended from January 2004 to September 2005 and so included two summer critical periods (July-August) when the warmest water temperatures occur in the Pend Oreille River and one fall critical period (September-October 2004). The characterization of this study period, in relation to historic conditions, is evaluated in terms of discharge levels and air temperature. The discussion of air temperatures serves only as a surrogate indicator of the meteorological conditions important in the heating of water. However, discharge levels, and associated water depths in particular, have a significant effect on the level of water heating.

Discharge

June is when the greatest flows occur in the Pend Oreille River, with the 90th percentile levels approaching 100,000 cubic feet per second (cfs) (Figure 5). From their June peak, discharge levels typically decline rapidly; July is a transitional period between the mid-June flow peak and mid-August annual low. During 2004 and 2005, peak flows occurred from late-May through the middle of June. At the United State Geological Survey (USGS) station below Box Canyon, the daily average peak flow was 49,800 cfs in 2004 and 71,100 cfs in 2005. In the Boundary Dam reservoir, the peak hourly flow measured during the data collection period was 86,100 cfs on June 9, 2005 **(**Breithaupt and Khangaonkar 2007). The lowest flows in the Pend Oreille River in 2004 and 2005 occurred in the middle of August. A flow of 4,620 cfs was recorded at Newport in 2005.

As observed, flow levels were below average in 2004 for much of June and July, returning to normal levels by August. Overall, the daily average flows for June and July in 2004 were observed at the 13th and 29th percentiles, respectively, based on the 55-year record. Below average flows were also observed in June and July of 2005 at the 29th percentile of the flow record.

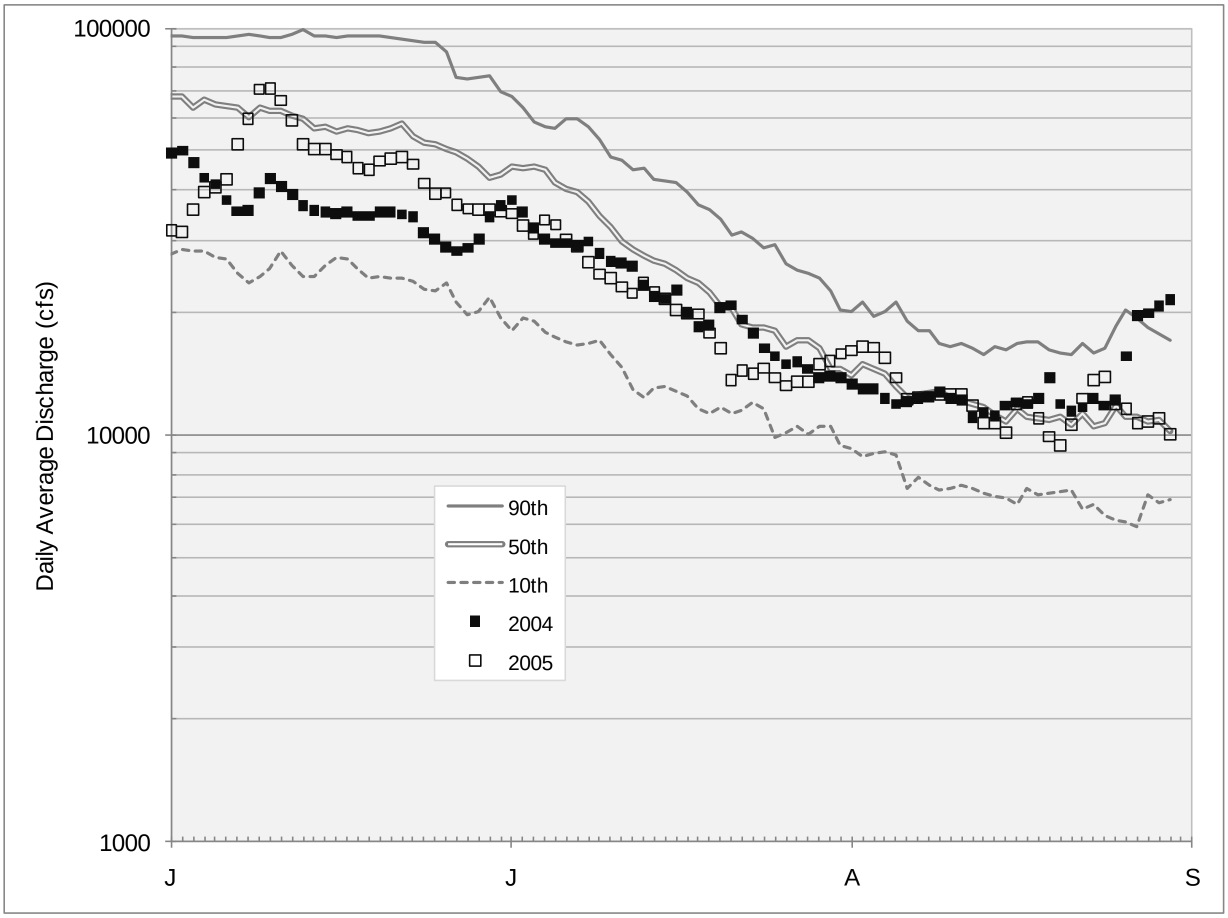

Figure 5. Study period daily average discharge levels in relation to 1953-2008 discharge percentiles. *USGS station 12396500, Pend Oreille River below Box Canyon near Ione, WA.*

Air temperature

In terms of air temperature, the critical period of 2004 tended to be warmer than that of 2005, with daily average temperatures exceeding the 1996-2009 period 90th percentile, 24 days or 26 percent of time (Figure 6). The air temperatures in 2004 were also characterized by wide variation. The median percentiles of daily average air temperatures above and below the median were represented by the 90th and 30th percentiles, respectively. In particular, a rapid and significant decline in the daily average air temperature occurred from an annual peak on August 2 at 26^{o}C to 13^{o}C over a four-day period.

In 2005, daily average air temperatures were cooler with less variation in comparison to 2004. The daily average air temperatures in 2005 exceeded the 1996-2008 90th percentile just 3 days or 3 percent of the period. Collectively, air temperatures observed above and below the 1996-2009 median were represented by the 70th and 30th percentiles respectively. This indicates a temperature variation centered around the longer term median as opposed to 2004, which had a higher representation of warmer temperatures.

As will be shown, the environmental conditions present in 2004 during the critical period lead to more elevated temperatures in comparison to 2005.

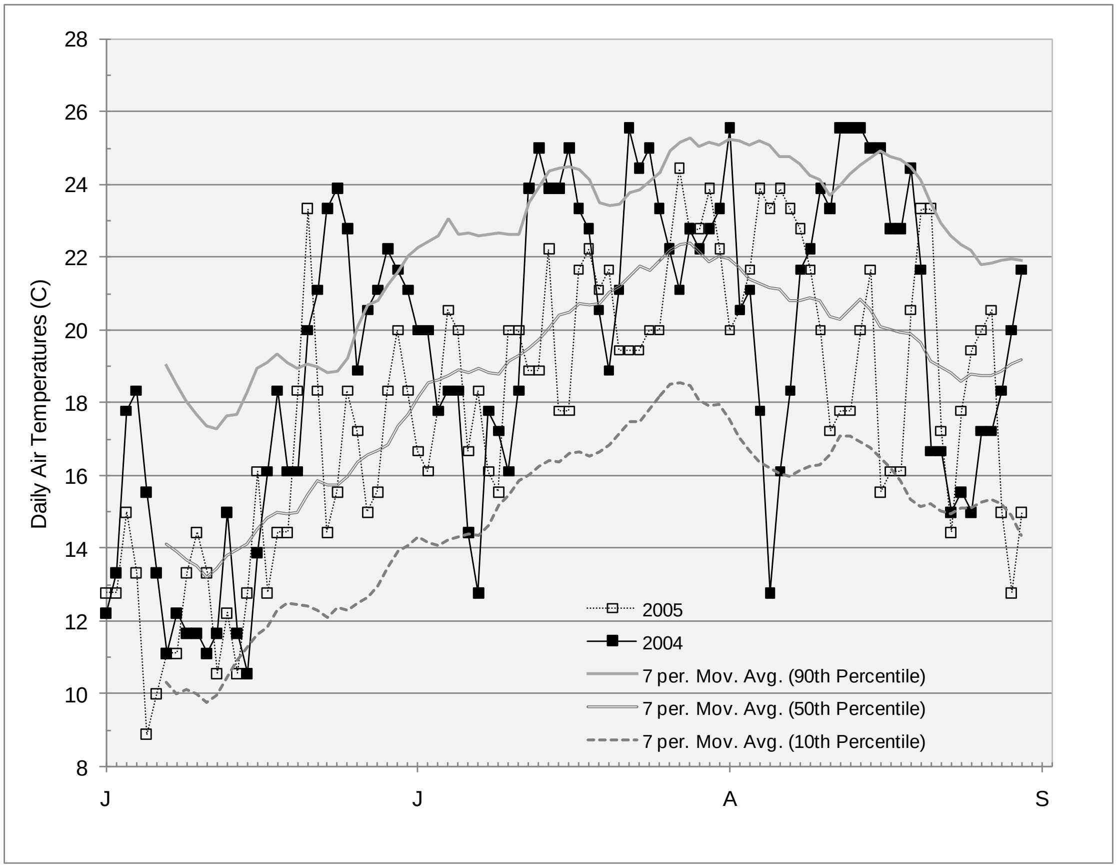

Figure 6. Daily average air temperatures observed at the Spokane National Weather Service station. *Temperatures observed during the critical period (June-August) 2004 and 2005, in relation to 1996-2009, 7-day moving average percentiles.*

Model temperature predictions

Both the Box Canyon and Boundary models generated predictions of water temperature through the analysis period (January 1, 2004 through Sept. 8, 2005) based on a 30-minute frequency. Within the Box Canyon model, data was generated at 336 locations, or segments, from the Idaho/Washington border to the Box Canyon facility. Given the distance of 53 miles, this relates to about 6 temperature predictions per mile or one every 880 feet. A similar segmentation scheme was also applied with the Boundary model. 107 segments were used over the 18-mile Boundary study area. The CE-QUAL-W2 model uses a laterally averaged (bank to bank) temperature prediction method while water column predictions are based on a 1-meter depth interval.

From this substantial base of data, the daily maximum temperature for each model segment was considered for further analysis. This data consideration follows from the temperature criterion that applies to the Pend Oreille River, which is based on daily maximum temperatures.

Modeling scenarios

Model runs were conducted to depict temperatures for the existing and natural temperature conditions. Within the study area, the existing temperature condition is primarily influenced by three hydroelectric facilities (Albeni Falls, Box Canyon, and Boundary), the level of shade-producing vegetation present along the principal tributaries and the mainstem, and point source discharges. The model run for the natural condition examined temperature variation without any hydroelectric facilities or point source discharges present and with riparian vegetative conditions at optimal or potential natural vegetative (PNV) growth conditions (Table 4).

Comparisons between the natural and existing modeling scenarios were used to examine compliance with the criteria. This included the comparison of Scenarios 1 and 8 (Table 4).

In addition to the natural and existing model conditions, several alternative scenarios were also run to examine the relative influence of factors having the potential to modify temperature under the existing condition. As previously mentioned, these include the influence of the hydroelectric facilities Albeni Falls, Box Canyon, and Boundary, point source discharges, and riparian shade conditions. Table 4 includes the scenario number, and its underlying model assumptions, and a short description of its purpose. The intent of these scenarios is to individually examine the relative effect each of these factors has on influencing the existing temperature structure.

Table 4. TMDL modeling scenarios examined and their assumptions.

Scenario Number & Description	Name	Upstream Condition	Downstream Condition	NPDES	Tributary Condition	Mainstem Shade
1 Existing Condition	Existing Condition	Albeni Falls / Box Canyon	Box Canyon / Boundary	NPDES	Existing	Existing
2 Influence of NPDES	NPDES	Albeni Falls / Box Canyon	Box Canyon / Boundary	w/o NPDES	Existing	Existing
2.5 Influence of Tributary Shade	Tributary PNV	Albeni Falls / Box Canyon	Box Canyon / Boundary	NPDES	PNV Temperatures	Existing
4 Influence of Box Canyon Influence of Boundary	w/o Box Canyon w/o Boundary	Albeni Falls Box Canyon	w/o Box Canyon w/o Boundary	NPDES	Existing	Existing
7 Influence of Mainstem Shade	Mainstem PNV	Albeni Falls / Box Canyon	Box Canyon / Boundary	NPDES	Existing	PNV Shade
8 Natural Condition	Natural Condition	w/o Albeni Falls w/o Box Canyon	w/o Box Canyon w/o Boundary	w/o NPDES	PNV Temperatures	PNV Shade

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TMDL Analysis

The special temperature condition for the Pend Oreille River is based on the potential change in the magnitude of existing temperatures compared to what occurred naturally. These potential temperature changes are addressed in two ways:

1) Temperature shall not exceed a 1-day maximum (1-DMax) of 20°C due to human activities. When natural conditions exceed a 1-DMax of 20°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C
2) nor shall such temperature increases, at any time, exceed t = 34/(T + 9)

    t = the allowable temperature increase
    T = the background temperature measured at a point unaffected by the discharges. The Pend Oreille River is affected by discharges from dams in both Washington and Idaho, so the modeled natural condition, which represents the unaffected river, is used to define T in this TMDL.

The criteria addresses potential temperature changes both within and outside of the period when temperatures are at their annual peak. This TMDL analysis addresses both parts of the special criteria. While the analysis methods used to examine both conditions have much in common, there are differences. For this reason, the methods to examine peak temperatures (when natural temperatures are greater than 20°C) will be discussed first, followed by methods to analyze temperatures below 20°C. Within this report, Part 1 and 2 of the special temperature criteria for the Pend Oreille River will be referred to as peak and off-peak periods, respectively.

While this TMDL is only for Washington State waters, an analysis of the Kalispel Tribe's temperature criteria is necessary to determine compliance at the reservation boundary. The Tribe's temperature criteria are also based on two parts, though both are directed at peak temperature conditions. Both Parts 1 and 2 of the temperature criteria are based on the comparison between natural and existing conditions, although differing temperature metrics and thresholds apply. The Tribe's criteria are:

1) Based on a 7-day average of the daily maximum temperatures, existing temperatures should remain at or below 18°C. When temperatures exceed 18°C naturally, then the existing condition cannot exceed the natural level by more than 0.3°C.
2) Based on a 1-day maximum, existing temperatures should remain at or below 20.5°C. When temperatures exceed 20.5°C naturally, then the existing condition cannot exceed the natural level by more than 0.3°C.

Similar to Washington State, the Kalispel tribal criteria sets the allowable temperature increase when natural conditions exceed the threshold, at 0.3°C. While focused on the peak temperature period, the Kalispel criteria, by applying a lower threshold condition (18°C) incorporates a more extended critical period. The analysis of Pend Oreille River temperature conditions, through application of the Kalispel criteria, will be presented in the peak temperature section.

Methods

Peak temperature analysis methods – Washington State criteria

A cumulative frequency distribution (CFD) was conducted on the daily maximum temperatures for each scenario by reach and year. In this method data are pooled, based on the temperature criteria conditions, river sections, time frames, and modeling scenarios. A cumulative frequency distribution was then preformed on each set of pooled data. The results of the cumulative frequency distribution were used to examine compliance with the Pend Oreille River temperature criteria and the effect that the various hydroelectric facilities and land use actions (riparian vegetative shade, point source discharge) have on the existing river temperature condition.

The use of a cumulative frequency type analysis approach was chosen to evaluate compliance with water quality standards in this TMDL for several reasons:

- The dams have altered the hydrologic characteristics of the river from the natural condition. Not only has the volume of water increased, but there is also a difference in flows. These differences between the natural and existing conditions makes direct time-based (i.e. day-to-day) temperature comparisons difficult. For example, Battelle's Pacific Northwest National Laboratory calculated that the time of travel through the Boundary Dam reservoir is about a half day under natural conditions, whereas with the dam in place the travel time is approximately two and a half (2.5) days (Breithaupt et al., 2008). In addition, Boundary Dam is operated in a peaking mode (high flows during the day and near-zero at night) and Box Canyon is a run-of-the-river operation. The cumulative frequency distribution minimizes these differences and so allows different hydrologic conditions to be compared.
- The effect of short-term events such as weather fronts are minimized; Breithaupt et al. (2008) also analyzed the temperature response in the Boundary reservoir and found that under natural conditions the response is less than one day, and under existing conditions (with the dam) the response is about four and a half (4.5) days.
- By using a cumulative frequency analysis it is possible to determine how often temperatures occur within a specific amount of time.

The cumulative frequency method took the following form:

Daily maximum temperatures

While Ecology considered all model temperature predictions within the entire water column, by segment, and throughout the study period, only the daily maximum temperatures, determined for each segment, were used for further analysis. Daily maximum temperatures were determined for each river segment for all modeling scenarios for both 2004 and 2005.

The use of daily maximum temperatures is consistent with the Pend Oreille River temperature criterion. Using other measurements, such as a volume or flow weighted temperature, would be inappropriate for the TMDL analysis because the temperature criterion is a threshold value that should not be applied as a water body average. In addition, averaging the entire column of the reservoir could not be reasonably compared to the natural condition of the shallower river. Using maximum daily temperatures allows for that comparison.

Grouped by reach

To provide greater refinement to the analysis, each model's segments were grouped longitudinally into distinct reaches (Figure 7). The division of the reaches was based on common river channel morphological conditions. For this reason, the length of the individual reaches varies. The 53-mile Box Canyon section of the Pend Oreille River was divided into 8 reaches, ranging in length from 8.6 miles for the Kalispel reach to 1.6 miles for the Box Canyon forebay reach (Table 5). Similarly, the Boundary model was divided into 4 reaches ranging in length from 7.3 miles for both the Metaline and Slate reaches to 0.6 miles for the Boundary tailrace. The output of daily maximum temperatures from both the Box Canyon and Boundary models, encompassing the entire data set, was grouped by reach for further analysis.

Data filtered

The majority of the scenarios considered for the Pend Oreille River depict water temperatures as either the current condition (Scenario 1.0) or a variation of the current condition, provided some selective modification to factors affecting the river's heating (Scenarios 2.0, 2.5, 4.0, and 7.0) (refer to Table 4). In comparison, Scenario 8.0 depicts the temperatures of a natural or pre-developed condition.

Given these differences, the analysis considers the existing condition scenarios and the natural condition scenario differently in how it examines compliance with the temperature criteria and modification to existing temperatures.

For each reach, by year (2004 and 2005), the daily maximum temperatures less than or equal to 20^{o}C were removed from the model output for Scenarios 1.0, 2.0, 2.5, 4.0, and 7.0. Daily maximum temperatures for Scenario 8, the natural condition remained complete. Following this data filtering, the existing condition datasets (Scenarios 1, 2, 2.5, 4, and 7) were used as a template to complete a one-to-one data match (sharing the same date and segment) with the complementary natural data sets. Therefore, these new natural scenario data sets became a reflection of each associated existing scenario's data set. The end result is that for each existing condition scenario, by reach and year, there is a corresponding natural condition dataset for when the existing condition scenario temperatures were above 20^{o}C.

Cumulative frequency distribution

A cumulative frequency distribution (CFD) of the daily maximum water temperatures was then determined for each existing scenario and its associated natural data set by reach and year. The cumulative frequency analysis of individual datasets considers temperature magnitude and its frequency of occurrence among the data to describe a distribution. Each dataset was evaluated separately. The distribution is described by percentiles with the 0th percentile, the minimum temperature within the dataset, and the 100th percentile, the maximum. The 50th percentile is the median; 50% of the temperatures reside above this level and 50% below. Percentiles were calculated from 0 to 100 in increments of 1.

Table 5. Pend Oreille River reaches and their model segment and river mile boundaries.

Reach Name	Upstream Boundary		Downstream Boundary		Total Segment Number	Total River Length (miles)
	Model Segment	River Mile	Model Segment	River Mile		
Newport	15	88.0	38	84.4	23	3.6
Dalkena	39	84.3	86	77.0	47	7.3
Skookum	87	76.8	115	72.4	28	4.4
Kalispel	116	72.3	171	63.7	55	8.6
Middle	172	63.6	220	56.1	48	7.5
Blueslide	221	56.0	274	47.7	53	8.3
Tiger	275	47.6	347	36.4	72	11.2
Box Canyon Forebay	348 / 350	36.2	358 / 360	34.6	10	1.6
Metaline	2	34.4	45	27.1	43	7.3
Slate	46 / 48	26.9	94 / 96	19.6	48	7.3
Boundary Forebay	95 / 99	19.5	110 / 116	17.1	16	2.4
Boundary Tailrace	113 / 117	16.8	116 / 120	16.2	3	0.6

Peak temperature analysis methods – Kalispel tribal criteria

In addition to the Washington State criteria, the Kalispel Tribe's criteria was also used to assess peak Pend Oreille River temperatures. This assessment took a similar form as used for Washington State temperature criteria. Fundamental to both analyses is the use of daily maximum temperatures generated by the CE-QUAL-W2 model. However, in the case of the Kalispel criteria, instead of grouping the segments (model temperature output) into discrete reaches, only Model segment 115 was evaluated in order to determine compliance with the Tribe's water quality criteria at their reservation boundary. Model segment 115 is located at approximately river mile 72 (most downstream end of the Skookum reach-based segments) and defines the upstream boundary where the Kalispel criterion applies. For comparative purposes, Ecology also evaluated model segment 172, situated at approximately river mile 64. This segment defines the lower river boundary where the Kalispel temperature criteria apply. These segments bracket the primary contiguous Kalispel tribal lands adjacent to the Pend Oreille River.

Daily maximum temperatures

The Kalispel temperature criteria are divided into two parts. Both evaluate peak temperature conditions and are based on daily maximum temperatures (refer to section on water quality criteria). However, they differ in how the daily maximum temperatures are considered. The first part of the criteria is based on the 7-day average of the daily maximum temperatures when natural conditions exceed 18^{o}C; the second part is based solely on daily maximum temperatures when natural conditions exceed 20.5^{o}C. For both parts, once the specific temperature threshold is met, the comparable existing temperature condition is not to exceed the natural temperature condition by more than 0.3^{o}C. Following from the criteria, only daily maximum temperatures were used for this assessment.

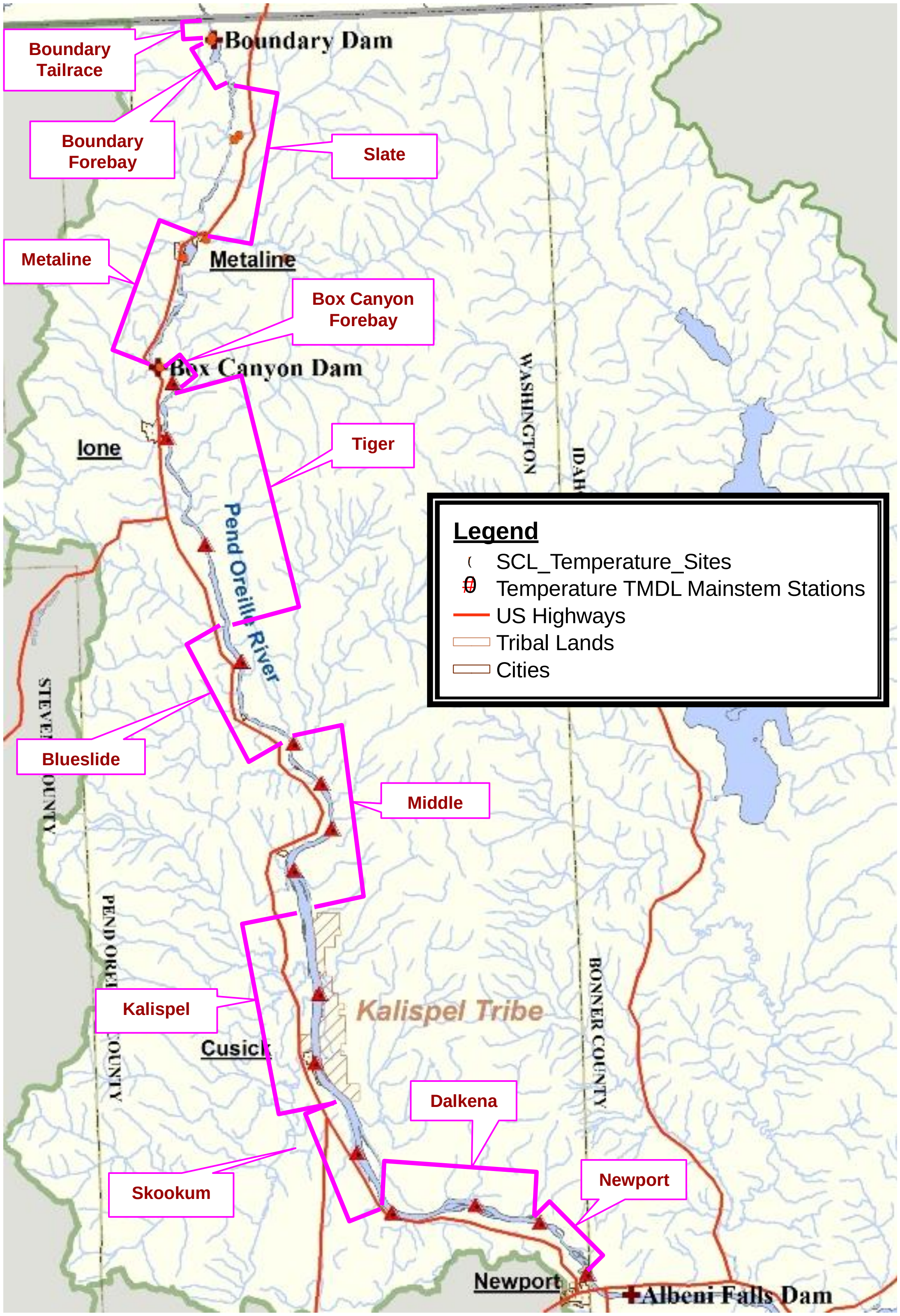


Figure 7. Pend Oreille River reaches and monitoring locations.

Data filtered

To assess temperatures in terms of Part 1 of the Kalispel criteria, seven-day averages of the daily maximum temperatures were determined for the existing and natural conditions observed in 2004. This was conducted for all study segments, though this analysis focused on segments 115 and 172. This statistic is generated based on the average of the daily maximum temperature observed on the day evaluated and the prior six. Consistent with the criteria, only existing condition averages greater than 18°C were further considered.

For the second part of the criteria the assessment was based on the daily maximum temperatures, though only existing condition temperatures greater than 20.5°C were considered.

From these selections, a one to one (1:1) match was determined between existing condition temperatures (to which the data selection was applied) and natural condition temperatures. If, for a particular day for segment 115, the existing condition seven-day average of the daily maximum was greater than 18°C then, for comparative purposes, the natural seven-day average of the daily maximum temperature was matched to it. This criteria-driven data matching process, using the existing data set as a template, was used to create an associated natural data set for both parts of the criteria. With the two conditions determined (existing and natural), a cumulative frequency distribution was then generated for each.

Cumulative frequency distribution

Based on these selections, a cumulative frequency distribution was generated for both the natural and existing conditions for both parts of the Kalispel temperature criteria, for segments 115 and 172. The cumulative frequency distribution was based on a percentile interval of 1 from the 0^{th} percentile to the 100^{th} percentile for each data set. Only temperature output for 2004 was used. The reason for this is that the output in 2005 ended early September, when daily maximum temperatures (and 7-day averages) remained above 18°C. To evaluate whether the criteria was exceeded, a temperature differential was determined by subtracting the existing from the natural condition percentiles. The criteria was considered exceeded if, for any percentile, the temperature differential was greater than 0.3°C when natural conditions exceeded 18°C (7-day average) or 20.5°C (daily maximum).

Off-peak temperature analysis methods – Washington State criteria

Similarities between the methods used to examine peak (T>20°C) and off-peak (T<=20°C) temperature conditions included:

- Use of daily maximum temperatures, by segment, for natural and existing conditions.
- Grouping of segments into the same river reaches for assessment.
- Application of a cumulative frequency distribution type of analysis.

Differences in the peak and off-peak analyses included using different criteria to establish the data sets and applying the equation [$t = 34/(T+9)$] to assess the allowable temperature increase.

Data filtered

From the existing daily maximum temperature output for 2004, only temperatures less than or equal to 20°C, but greater than 12°C, were considered for this part of the special condition. The upper bound of 20°C follows from Part 1 of the special condition. The lower limit of 12°C was chosen because it indicates a temperature condition identified as optimal for bull trout, the species most sensitive to increased heating within the Pend Oreille study area. The 2005 model run only extended to early-September when temperatures remained above 12°C. For this reason, only the 2004 data was used for this part of the criteria.

Similar methods were used to assess Part 2 of the criteria as Part 1 of the criteria. After the existing condition data set was filtered for daily maximum temperatures between 12°C and 20°C, the existing condition data set was used as a template to complete a one-to-one data match with the complementary natural data set. Therefore, the new natural scenario data set became a reflection of the existing condition data set, each sharing the same dates and segments for when the existing condition scenario temperatures were between 20°C and 12°C.

Cumulative frequency distribution

The period when river temperatures are greater than 20°C extends approximately from early-July to late-August each year. On either side of this peak period, temperatures are ascending in the spring or descending in the fall. So the criteria used to select for the off-peak temperatures creates two sets or blocks of temperature data: the spring and fall. The spring period was not analyzed because high river temperatures are not typically observed due to the river heating up more slowly now than it did before the dams were in place. The fall was identified as the critical period for application of Part 2 of the special criteria because the river cools at a slower rate and bull trout are known to migrate during this timeframe.

A cumulative frequency distribution (CFD) of the daily maximum water temperatures for September through October 2004 was then determined for the existing condition dataset and its associated natural dataset by reach. The cumulative frequency distribution was determined in one-percentile increments from 0 to 100.

Application of special condition formula

Part 2 of the special temperature criteria also uses the natural condition as a reference for comparison to the existing condition. However, instead of having a set allowable temperature increase (i.e. 0.3°C) it is determined through application of an equation [$t = 34/(T + 9)$]. The equation uses the natural temperature condition, as indicated by the variable T, as input leading to the determination of an allowable temperature increase, specified by t. In application, because the natural temperature condition varies, so does the allowable increase specified. (As stated earlier, T is defined as the background temperature measured at a point unaffected by the discharges. However, because the Pend Oreille River is affected by discharges from dams in both Washington and Idaho, Ecology used the modeled natural condition, which represents the unaffected river, to represent T in this TMDL.)

Comparisons – compliance and heating effects

The comparison of temperatures based on similar percentiles was completed for each modeling scenario and its associated natural condition by reach and year. To examine compliance with Part 1 of the Pend Oreille River temperature criteria, the analysis focused on the comparison between the natural and existing condition data sets (Scenarios 1 and 8 - refer to Table 4). It was assumed that, when the natural temperature percentiles exceeds 20°C, the difference between the existing and natural data sets, for each percentile, must remain at 0.3°C or less to achieve the temperature criteria. The determination of compliance with the second part of the temperature criteria applied similar analysis methods though the allowable increase was determined by the formula.

The next series of comparisons focused on scenarios that examined factors affecting the existing river's heating. Referring to Table 4, these include Scenarios 2.0, 2.5, 4.0, and 7.0. While the examination of compliance with the temperature criteria focused on the comparison of the existing and natural data sets, these scenarios are a reflection of how these various factors affect the existing temperature condition. Therefore, the ultimate reference for this effect is the existing temperature condition observed within the various reaches of the study area. For this reason, these scenarios were compared to the existing condition and the overall average difference, or temperature effect, through the full spectrum of temperatures above 20°C, was calculated by reach and year. This provided an assessment of the average temperature shift as a consequence of the action depicted by the scenario.

In summary, two general types of temperature comparisons were made as part of this analysis: compliance with criteria and modification to the existing temperature condition. These comparisons were determined based on both Washington State's and the Kalispel's temperature criteria.

Assessing compliance with criteria and temperature modification

Peak temperature criteria

The cumulative frequency distributions (CFD) derived for the existing condition (Scenario 1) and associated natural condition (Scenario 8) were compared to examine compliance with the Pend Oreille River temperature criteria. To determine compliance with criteria, the existing condition temperature CFD was subtracted from the associated natural condition temperature CFD, based on similar percentiles, to derive what is referred to as a temperature differential. The temperature differential presents the change in temperature from the existing condition in relation to the natural condition. This difference can indicate:

- No change (the existing and natural temperature conditions are equal).
- A decrease in temperature (natural condition is warmer and the difference is -). or
- An increase in temperature (the existing condition is greater and the difference is +).

Temperature differentials were completed for each of the 12 study reaches for 2004 and 2005. For every percentile, when the natural condition temperature (Tn) exceeds 20°C, then the associated existing condition temperature (Te) cannot exceed it by more than 0.3°C and remain within criteria.

In this analysis the nomenclature for describing these relationships, which will be presented later through a series of figures, includes:

Existing Condition (T_e) *= Scenario 1.0*
Natural Condition (T_n) *= Scenario 8.0*
Temperature Modification Scenarios (T_s) *= Scenarios 2.0, 2.5, 4.0, 7.0*

Therefore, the temperature differential, or the difference between the distribution of daily maximum temperatures for the existing (T_e) and natural (T_n) conditions, by percentile is:

$(T_e - T_n)$ *= Scenario 1-8*

Off-peak temperature criteria

Similar to Part 1 of the special condition analysis, a temperature differential was initially determined by subtracting the existing from the natural temperature for each common percentile. In terms of compliance, only positive increases in temperature were considered because they indicate that the existing condition is warmer than what occurred naturally. Whether that increase was of a magnitude that exceeds the criteria was determined by application of the special formula.

Temperature percentiles, generated from the natural condition cumulative frequency distribution, for each reach, were used as input to the variable T in the equation. The equation's solution then lead to the determination of the allowable temperature increase (t). An allowable increase was determined for each percentile of the natural condition for each reach. In terms of assessing compliance, positive temperature differentials, occurring at any percentile, were compared to the associated allowable temperature increase. If the temperature differential exceeded the allowable limit then the criteria was exceeded.

Modification to existing river temperatures

The potential effect on existing river temperatures associated with point source discharges, tributary and mainstem riparian vegetation conditions, and the hydroelectric facilities were also examined. These comparisons were used to assess the effect these various temperature modifiers have on the existing temperature condition. For this reason, the ultimate reference condition for these comparisons is the existing temperature condition. However, consistent with the prior analysis that examined criteria compliance, all of these heating effects scenarios were initially referenced to their respective natural datasets (T_s-T_n).

Applying this type of referencing provided information on whether the temperature criteria would be met provided changes in the heating pathways considered by the scenario. In addition, the potential shift in maximum temperatures above 20^{o}C was considered by comparing the compliance temperature reference (T_e-T_n) to each scenario reference (T_s-T_n). The shift was calculated based on the average overall difference between (T_e-T_n) and (T_s-T_n). The utility of this type of comparison is that it provides an assessment of the overall change in temperature as a consequence of the scenario in relation to the existing condition. These comparisons provide answers to questions such as: are daily maximum temperatures affected as a result of increased mainstem or tributary riparian shade and, if so, what is the magnitude of the temperature effect in comparison to the existing condition? Appendix D provides the complete graphical representation of the results of these analyses. The results for Scenario 4.0, the effect on the existing condition provided the absence of the Box Canyon and Boundary hydroelectric facilities, will be presented in the main text.

Tributary and mainstem shade

Shade estimates were determined for the Pend Oreille River and its principal tributaries based on a combination of remote sensing through the application of geographic information systems (GIS) analysis methods along with on the ground vegetative measurements. GIS analysis included the use of digital ortho-photos and the ArcView extension tTools. tTools was used to sample and process GIS data for input to the shade and temperature models.

Effective shade inputs to models require an estimate of stream-side vegetation growth characteristics, specifically height, canopy density, and width. These characteristics serve as important model input to estimate effective shade. Shade information was collected using a spherical densiometer, and also with a hemispherical lens and digital camera, which was used to take 360° pictures of the sky and shading vegetation at the center of the stream. The digital images were processed and analyzed using the Hemiview© software program.

Ecology stream temperature survey methods were followed for the collection of data during shade surveys (Pickett, 2006). The surveys were conducted in August 2006 at mainstem and tributary sites established by Ecology. The location of each site was established with Global Positioning System (GPS) equipment. At each tributary shade site, depending on stream access, hemispheric digital photos were taken mid-stream at several transects upstream of temperature monitoring stations. Spherical densitometer readings were taken at one or more sites on each tributary. At shade measurements sites, stream channel information was collected including: bank full width and depth, wetted width and depth, channel incision (stream depth profile), width of the near stream disturbance zone, and descriptions of tree heights and riparian vegetation composition.

Mainstem sites were selected from locations with significant stands of shade vegetation representative of reaches of river shoreline with similar soils, river valley topography, and solar aspect. At each mainstem site, spherical densiometer and hemispheric digital photos were taken and the site location and vegetation conditions documented.

From the GIS sampling, a shade calculator (available at: www.ecy.wa.gov/programs/eap/models.html) was used to estimate effective shade along the tributaries and mainstem. Effective shade was calculated at 250-meter intervals along the mainstem, at 50 to 100-meter intervals along the tributaries for about 1,000 meters above the temperature monitoring stations, and then averaged over the 1,000-meter intervals for input to the temperature model. The shade program was used to process tTools output data for model input data. The estimates of current shade served as direct input into the CE-QUAL-W2 model.

While the CE-QUAL-W2 model was used to simulate the natural and existing temperature conditions in the mainstem Pend Oreille River, the existing temperature conditions for its tributaries were examined with the model rTemp. The rTemp model predicts a time-series of water temperatures in response to heat fluxes determined by meteorological data, groundwater inflow, and other forcing functions (see http://www.ecy.wa.gov/programs/eap/models.html). The shade produced by potential natural vegetation (PNV) was used to develop a temperature time series for the natural scenario. The rTemp output based on existing and natural potential vegetation shade characteristics was used as input to the larger CE-QUAL-W2 model. Natural system-potential shade was estimated by using soils and forestry information. Changes in tributary channel morphology were estimated using statistical methods that compared disturbed and undisturbed watersheds.

Point source discharge temperature

Table 3 lists the seven facilities regulated with NPDES permits. Ecology obtained daily temperature data for Ponderay Newsprint and the Pend Oreille Mine or generated some daily temperatures from interpolations of the existing data. However, temperature data does not exist for Newport, Selkirk High School, and Metaline because their previous NPDES permits did not contain temperature monitoring requirements.

To obtain daily temperature data for the wastewater treatment plants, Ecology generated regression analyses. Before performing the analysis, Ecology took flow data from Newport and temperature data from Ione and Metaline Falls to obtain data for each wastewater treatment plant. Regression analyses were then performed for the treatment plants. After completion of the analysis, seasonal maximum flows and temperatures were then identified from the daily data. Temperatures generated represent temperatures at the end of pipe and not at the end of a mixing zone.

Graphical depiction of analysis

The results of these analyses are best examined graphically. For this reason, several examples are presented along with an explanation on their interpretation. Initially, as a reference, a time-series depicting the median of the daily maximum temperature conditions in 2004 for the Blueslide reach is presented (Figure 8). Though this figure provides a comparison of temperatures between the current and natural conditions, based on a common time frame, this was not the analysis approach applied in this TMDL. It is only used to illustrate some observations regarding temperature in the Pend Oreille River. As discussed earlier, due to differences in hydraulics as a result of the three hydroelectric facilities situated within the greater study area, the river is now deeper and has a slower average velocity in comparison to what occurred under the natural condition. This leads to complications in applying day-to-day type comparisons as a method of assessing temperature change. However, a time-series comparison provides information as to when various temperatures occur while also providing a means of assessing temperature patterns characteristic of both the existing and natural datasets, information that is not apparent in the results of a cumulative frequency distribution method.

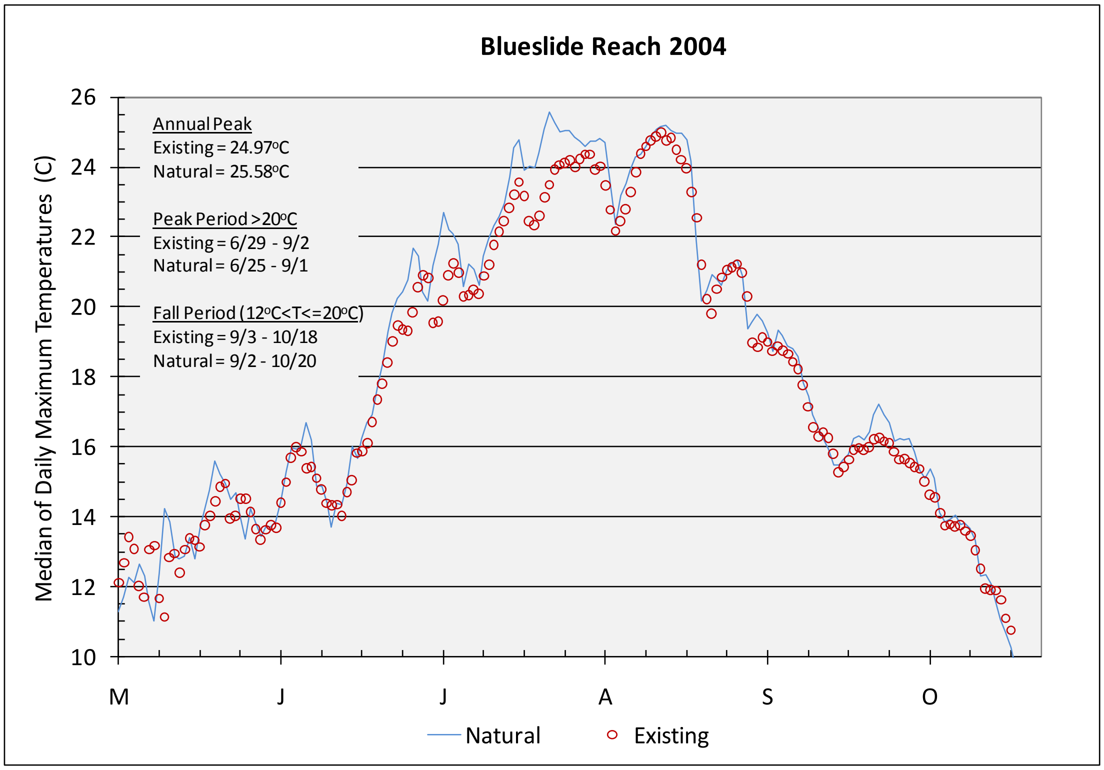


Figure 8. Modeled natural and existing median daily maximum temperatures for the Blueslide reach in 2004.

Referring to Figure 8:

- Existing maximum temperatures exceed 20°C in late-June and decline below 20°C in early-September, a similar time-frame to the natural condition. (This period is referred to as the critical period.)
- Though the river now has more volume (storage) during the critical period as a consequence of the hydroelectric facilities, that increase has only altered travel times through the study reaches on the order of days (as opposed to weeks) in comparison to those that occurred naturally. This results in the close coincidence in heating patterns between the existing and natural conditions.
- In comparison to the existing condition, the fluctuation in natural condition maximum temperatures is greater. Under natural conditions, river temperatures responded faster to changing meteorological conditions. Now, greater storage of water in the river channel has buffered the river from these types of temperature swings.
- The highest maximum temperatures for the natural condition are, in many cases, greater than those occurring under the existing condition. The reason for this also has to do with changed hydraulics. River depths during the critical period were shallower for the natural condition with less volume for a given solar short-wave radiation load. However, as shown below, for some of the study reaches, other factors are now more significant in determining peak temperatures.

Peak temperature condition

The previous figure presents only the median of the daily maximum temperatures for the Blueslide reach. The TMDL analysis; however, considered all of the daily maximums for all of the segments within each reach. In the case of Blueslide in 2004 this represented 3413 maximum temperatures within the 54 segments of the reach (maximum temperatures for the existing condition were above 20°C for 65 days within some segments of the reach). These data, for both the existing and natural conditions, were used to generate cumulative frequency distributions (CFD) for all twelve of the study reaches for both 2004 and 2005. Figure 9 (left) presents the cumulative frequency distribution of the daily maximum temperatures for the existing condition, depicted as circles, and its associated natural condition, depicted as a line for 2004.

The existing daily maximum temperatures range from a maximum (100th percentile) of 25.1°C to a minimum (0th percentile) approaching 20°C. In comparison, for the associated natural condition, daily maximum temperatures range from 25.8°C to 19.1°C. (As previously discussed, existing daily maximum temperatures greater than 20°C was an initial condition imposed on the model output. Therefore, in all of these graphics, minimum existing condition temperatures will approach, but remain above 20°C, whereas minimum natural condition temperatures may fall below 20°C.) The median, or 50th percentile, for the existing and natural conditions are 22.7°C and 23.8°C, respectively.

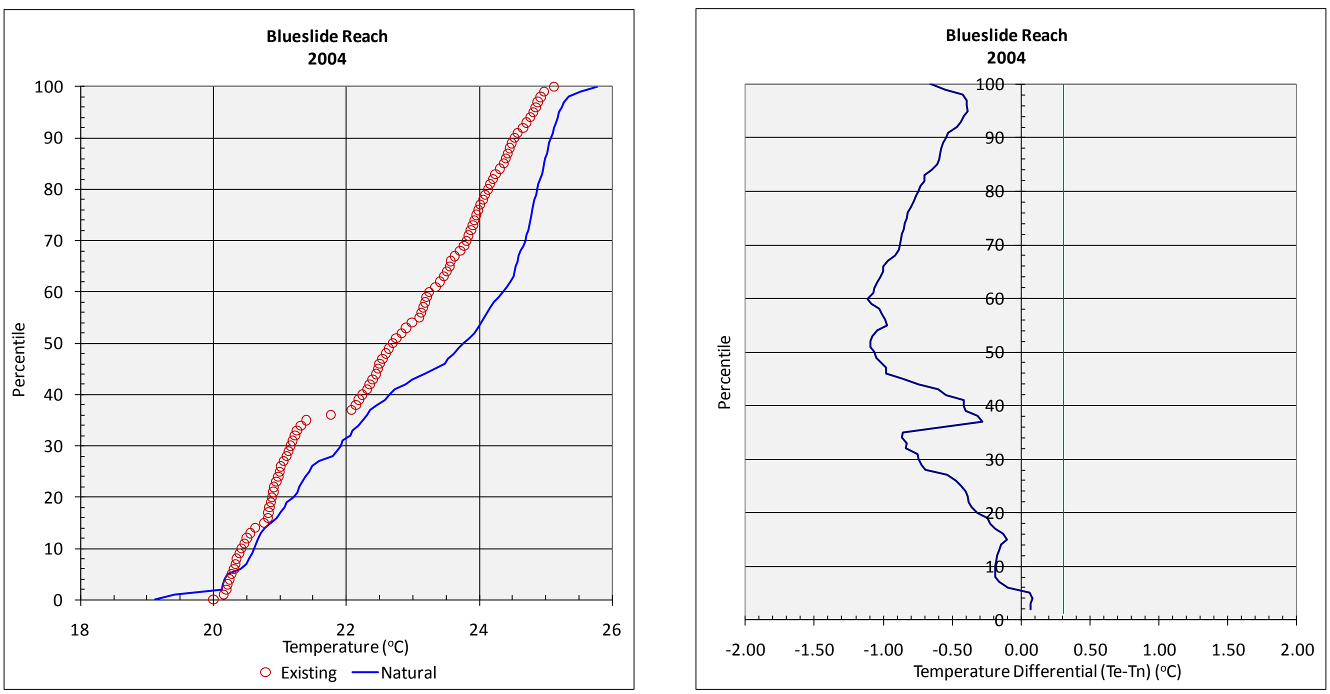


Figure 9. The cumulative frequency distribution of existing and natural daily maximum temperatures. *Distributions when existing daily maximum temperatures exceed 20°C (left). The temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 20°C (right).*

As observed, for the majority of the percentiles, daily maximum temperatures are greater for the natural condition in comparison to the existing condition. These temperature differences were also evident in the time series figure (Figure 8). Only at the lowest percentiles (those below the 5th percentile) are existing temperatures greater than comparable natural condition temperatures.

Figure 9 also presents (right) the difference between the existing and associated natural daily maximum temperatures. By percentile, the existing temperature was subtracted from the natural temperature. This is represented as Te-Tn and is referred to as the temperature differential.

The criteria is applied when daily maximum temperatures for the natural condition (Tn) exceed 20^{o}C. In the graph, the vertical line at Te-Tn equal to 0.3^{o}C, is the temperature criteria limit. If the existing condition temperatures are greater than those occurring naturally by more than 0.3^{o}C, for any percentile, then the criteria is exceeded. In 2004, for the Blueslide reach, the natural temperature condition is warmer than the existing condition resulting in a negative temperature differential. Therefore, the temperature criteria was not exceeded for Blueslide in 2004. A similar series of graphs are presented in the following section depicting temperature conditions in 2004. (The 2005 series are included in Appendix D.)

Off-peak temperature condition

The examination of potential temperature effects in the off-peak period takes a similar form as that undertaken to examine the peak period. Differences are in the analysis period and temperature conditions examined and in the way the allowable temperature increase is determined. From the cumulative frequency distribution, a temperature differential is calculated by taking the difference between the existing and natural percentiles. For the Blueslide reach in 2004, for the majority of the temperature spectrum examined, the natural condition is greater than the existing leading to a negative differential (Figure 10). As observed, on the right is the allowable temperature increase for the reach. Percentiles of the natural condition, representing the cumulative frequency distribution, serve as input to the equation used to determine the allowable limit. The limit ranges between approximately 1.6^{o}C, for the lowest percentiles (coldest temperatures) to approximately 1.2^{o}C (the highest temperatures). At the Blueslide reach in 2004, when temperatures ranged between 20^{o}C and 12^{o}C, the natural condition tended to be warmer than the existing condition leading to a negative temperature differential for all but the lowest percentiles (coldest temperatures). Where a positive temperature differential did occur it was well within the allowable limit. Therefore, there was no exceedance of criteria.

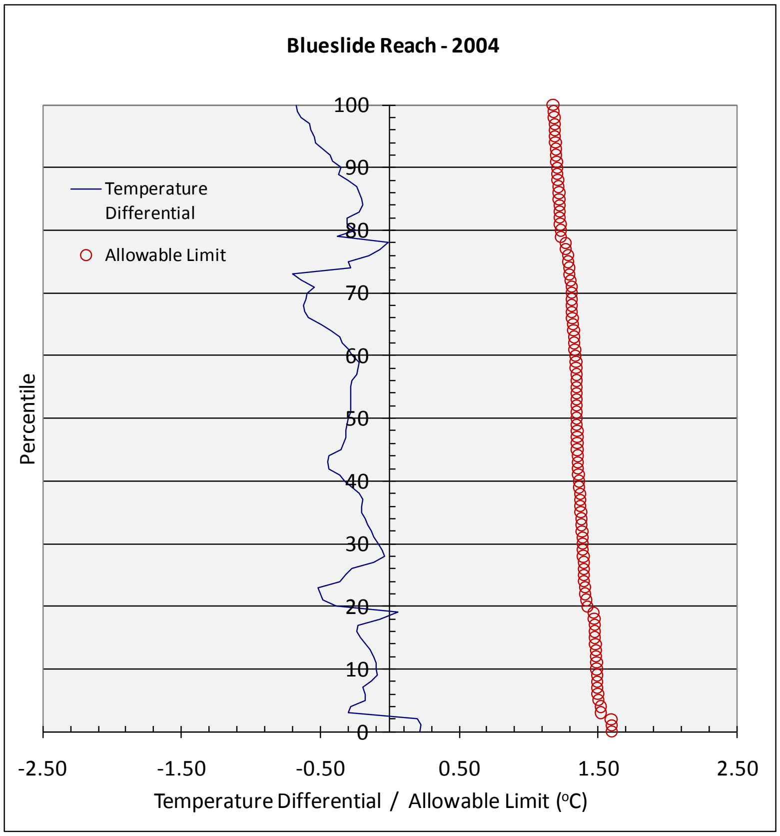


Figure 10. Temperature differential in relation to the allowable temperature limit for the Blueslide reach in 2004.

Existing temperature modification

The second component of the analysis examined the relative significance that several temperature modifiers have on affecting current maximum temperature conditions. The modifiers included: the hydroelectric facilities (Box Canyon and Boundary dams), riparian shade, and NPDES discharges.

Figure 11 below presents the temperature differential for the Blueslide reach (2004) for the existing (Te-Tn) and Scenario 4.0 (Box Canyon facility removed) (Ts-Tn) conditions. The scenario temperature differential is represented by the continuous line while the existing condition is represented by the circles. As observed, in terms of the Blueslide reach in 2004, maximum temperature conditions increased without the Box Canyon facility in place. The temperature differential depicted by Scenario 4.0 is oriented to the right (more positive) in relation to that of the existing temperature differential, indicating the increased heating. In the analysis, the overall average temperature shift was determined by scenario, reach and year for the full temperature spectrum (0^{th} to 100^{th} percentile). For this example, maximum temperatures increased by approximately 0.7°C in the Blueslide Reach as a consequence of the scenario in comparison to the existing condition; though temperatures remained overall lower in comparison to the natural condition.

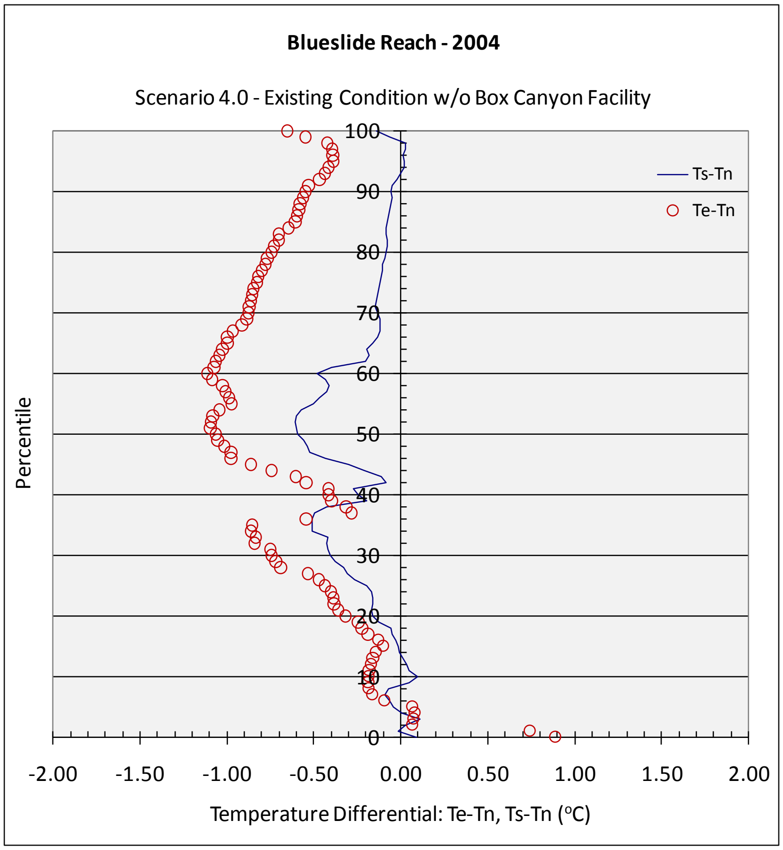


Figure 11. Temperature differentials of the existing condition and Scenario 4.0 for the Blueslide reach in 2004.

For simplicity, only the graphical results for 2004 that examine compliance with the temperature criteria and the influence of the hydroelectric facilities (Scenario 4.0) will be presented in the main body of this report though all of the figures depicting all scenarios and periods examined are included in Appendix D.

Results

Compliance with criteria

Peak temperature – Washington State criteria

Referring to Table 6 and the series of figures that follow, temperatures for the majority of the upper reaches of the study area, Newport to Blueslide, were within compliance with the Pend Oreille River's Part 1 special temperature criteria. That is, the maximum temperature differential between the existing and natural conditions remained less than or equal to 0.3°C. In fact, overall, maximum temperatures observed at the majority of the upper river reaches are cooler now than what occurred naturally. The exception is the Skookum Reach where a maximum differential of 0.51°C and 0.50°C was determined for 2004 and 2005, respectively (refer to Table 6 and Figure 13).

While the majority of the upper reaches remain within criteria, those from Tiger to the Boundary tailrace exceed criteria to varying degrees. The maximum temperature differential occurred in the forebay reaches of both Box Canyon and Boundary at 1.25°C and 1.00°C in 2004. A similar level of exceedance was observed in 2005 at 1.23°C and 0.77°C, respectively. Of the study reaches, Tiger and Box Canyon forebay display the most chronically elevated heating pattern (Figure 15). Throughout the range in temperatures observed for these reaches, the existing condition is warmer than what occurred naturally, a pattern not observed for the other reaches. This condition was most evident at the Box Canyon forebay (Figure 15). Similar patterns of heating were observed at each reach for 2004 and 2005.

Table 6. Pend Oreille River reach compliance with Part 1 of the criteria. *Highlighted reaches exceed criteria*.

Reach	Criteria Met		Maximum Temperature Differential [1] (Existing – Natural)		Average Temperature Differential[2]		Level of Criteria Exceedence [3]	
	2004	2005	2004	2005	2004	2005	2004	2005
Newport	Yes	Yes	==	==	-0.55°C	-0.55°C	==	==
Dalkena	Yes	Yes	==	==	-0.30°C	-0.23°C	==	==
Skookum	No	No	0.51°C	0.50°C	+0.03°C	+0.11°C	0.21 °C	0.20 °C
Kalispel	Yes	Yes	==	==	-0.38°C	-0.49°C	==	==
Middle	Yes	Yes	==	==	-0.64°C	-0.81°C	==	==
Blueslide	Yes	Yes	==	==	-0.59°C	-0.75°C	==	==
Tiger	No	No	0.74°C	0.81°C	+0.34°C	+0.39°C	0.44 °C	0.51 °C
Box Canyon Forebay	No	No	1.25°C	1.23°C	+0.78°C	+0.76°C	0.95 °C	0.93 °C
Metaline	No	No	0.88°C	0.47°C	-0.11°C	-0.07 °C	0.58 °C	0.17 °C
Slate	No	No	0.75°C	0.49°C	-0.13°C	-0.12 °C	0.45 °C	0.19 °C
Boundary Forebay	No	No	1.00°C	0.77°C	+0.18°C	+0.26 °C	0.70 °C	0.47 °C
Boundary Tailrace	No	No	0.83°C	0.57°C	-0.47°C	-0.50 °C	0.53 °C	0.27 °C

1. Criteria is exceeded if maximum temperature differential exceeds 0.3°C.
2. The average difference between the existing and natural temperature profiles through the full percentile range.
3. The level of exceedence listed for each reach is the maximum temperature differential minus the 0.3°C allowed by the criteria.

Heating patterns and temperature shifts

Also included in Table 6 (and Figures 12-17 below), are differences between the existing and natural cumulative frequency distributions, by reach, for the full range in temperatures observed when the existing temperatures are greater than 20^{o}C. The criterion is based on the maximum temperature difference for any given percentile. Therefore, this measure has no basis to the criteria but is included here to provide an indication of the overall magnitude of the shift in temperatures from the existing condition in reference to the natural condition. It supplements the criteria information by providing insight on overall temperature patterns within the study area.

With the exception of the Skookum reach, the Pend Oreille River, from Newport to Blueslide, is cooler now in relation to the natural condition by about 0.5^{o}C. This is particularly evident for the uppermost Newport Reach, situated just downriver from the Albeni Falls hydroelectric facility. The cooler maximum temperatures at Newport appear to be the result of Albeni Falls Dam maintaining the level of Lake Pend Oreille higher in the summer than it would have been under natural conditions. The higher lake level allows for deeper, cooler water from the lake to enter the Pend Oreille River. At Newport, the existing condition is now cooler by approximately 0.6^{o}C in comparison to the natural condition. Prior to completion of Albeni Falls Dam, the primary source of flow to the river was from the upper surface layer of Lake Pend Oreille. As with most lakes, during the critical summer period, the upper water column (epilimnion) has the greatest water temperatures due to high exposure to solar short-wave radiation. Albeni Falls Dam has now altered this pattern. Because cooler subsurface water from the lake continues to be the dominant source of flow to the river, with few significant tributaries through the study reaches, lower temperatures are evident through much of the upper 40 miles of the river. During the critical season, the passage of cooler water along with changed hydraulics (increased river volume) result in cooler maximum temperatures now in comparison to what occurred naturally. Once this cooler water is passed below Albeni Falls, the increased river volume due to the impoundments buffers the river from temperature variation. This is why even at Blueslide, approximately 40-miles below Newport, the overall existing condition remains cooler than the natural condition by about 0.7^{o}C.

While this effect likely provides some moderation to peak temperatures in the Tiger and Box Canyon forebay reaches, its effect is not the dominant one. For these reaches, it is the influence of the Box Canyon facility that is most important and is the primary reason why existing temperatures begin to exceed those that occurred naturally. The average velocity has been slowed sufficiently to lead to the increased heating. (The effect of the Box Canyon and Boundary facilities on daily maximum temperatures will be discussed in more detail when the modeling scenarios are presented.) For Tiger and Box Canyon Forebay reaches, the existing temperature condition exceeds the natural condition by 0.37^{o}C and 0.77^{o}C, respectively (average 2004/2005) (Table 6, Figure 15). The existing temperature profiles at both Tiger and Box Canyon forebay are consistently above the natural condition throughout the observed temperature range, indicative of chronic heating influences.

Similar to Albeni Falls, the Box Canyon facility withdraws water for power generation from a deeper and colder region of the water column in its forebay. Following power generation, this water is discharged downstream and its effect on peak river temperatures is particularly evident in the downstream Metaline and Slate reaches, though its effects are also apparent in the Boundary forebay reach.

As observed from Figures 15 and 16, when the temperature differential profiles between the Box Canyon forebay and Metaline reaches are compared, it is apparent that the majority of the temperature exceedence at the Box Canyon forebay is not observed at Metaline. Instead, the temperature differential profiles of both Metaline and Slate indicate that through much of the temperature spectrum, maximum temperatures are now cooler in comparison to the natural condition (Figure 16). Maximum temperatures are now warmer at the lower percentiles where the differences are large enough to exceed the criteria. This temperature pattern, set by the Box Canyon discharge, is carried through the 17-mile river section to Boundary Dam. Though providing a cooling effect, depressing the highest maximum temperatures in mid-summer, the withdrawal of deeper, cooler water maintains a base of warmer temperatures longer into the late summer when, under the natural condition (prior to hydroelectric power generation) temperatures decreased more rapidly.

Considering the whole temperature profile, both Metaline and Slate are now cooler than the natural condition by approximately 0.1^{o}C (Table 6). However, much of this cooling effect is lost by the Boundary forebay reach, with existing temperatures exceeding the natural temperature condition by an average of 0.22^{o}C. Boundary maintains the similar temperature profile characteristic of the Box Canyon discharge (as observed at the Metaline Reach), but that profile has been shifted to the right, reflecting an overall increase in heat related to the facility.

The cooler temperatures noted downstream of the Albeni Falls and Box Canyon facilities are also present at Boundary Dam. At the Boundary tailrace, overall temperatures are about 0.49^{o}C (average 2004 / 2005) cooler now in relation to the natural condition. The decrease in temperature, considering the full daily maximum temperature profile, is approximately 0.7^{o}C between the forebay and tailrace due to the withdrawal of deeper, cooler water. In addition, there is a possibility that a backwater effect created by Seven Mile Dam, located 11 miles downstream of Boundary Dam, may contribute to higher temperatures in the Boundary tailrace. The effects of Seven Mile Dam were not accounted for in the modeling.

To further illustrate these observations, the time-series of median daily maximum temperatures of the existing and natural conditions for the Box Canyon and Boundary forebay reaches in 2004 are presented (Figures 18 and 19). As observed, at the Box Canyon forebay, generally daily maximum temperatures, characterizing the existing condition (circles), reside above those characterizing the natural condition (line) throughout the period existing temperatures are above 20^{o}C. In comparison, at the Boundary forebay, up until approximately mid-August the existing maximum temperatures reside slightly below those characterizing the natural condition (Figure 19). By mid-August this pattern diverges, when the river naturally cooled at a faster rate than what presently occurs at Boundary, resulting in the temperature criteria exceedance observed.

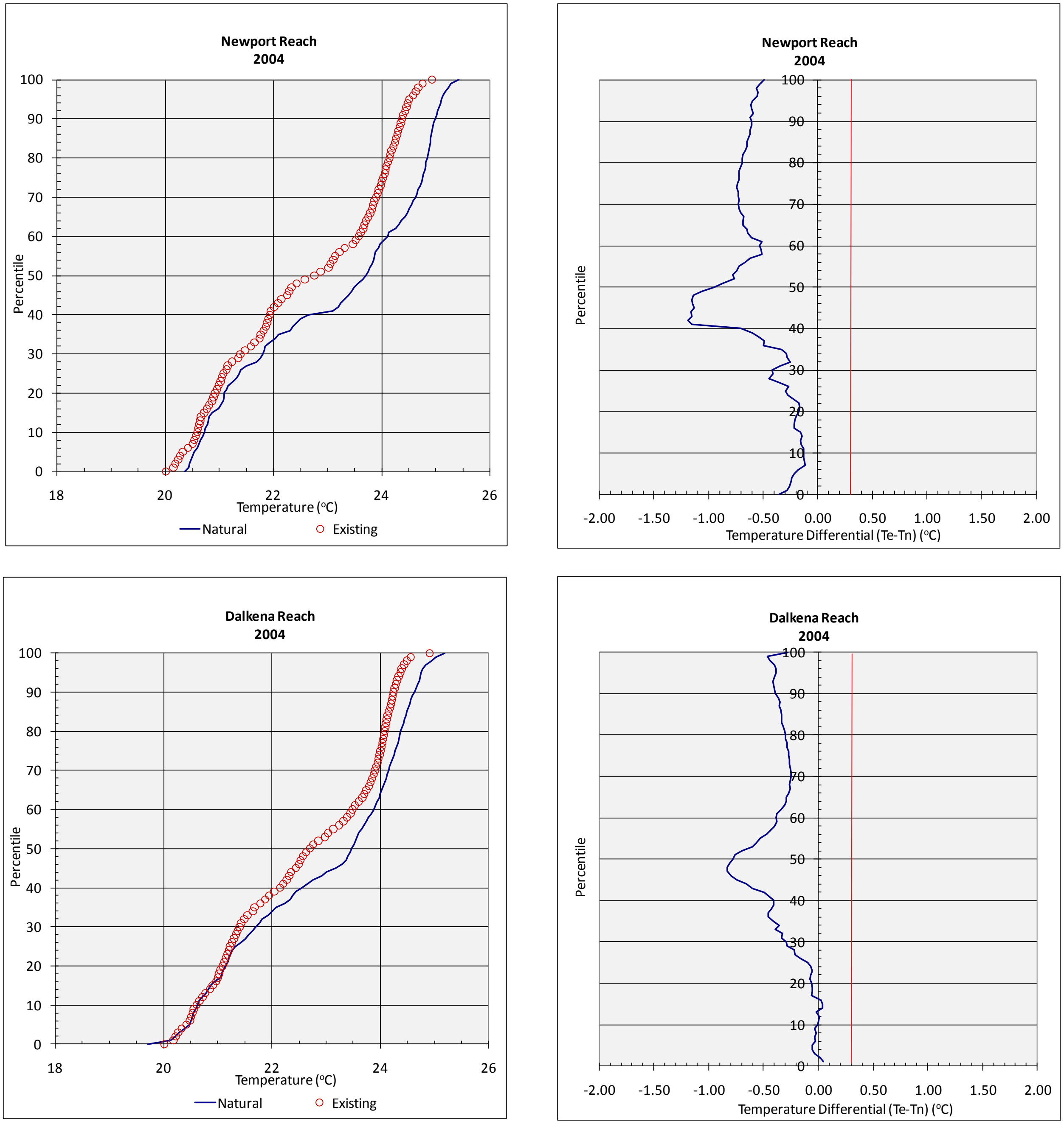


Figure 12. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Newport and Dalkena reaches, 2004.

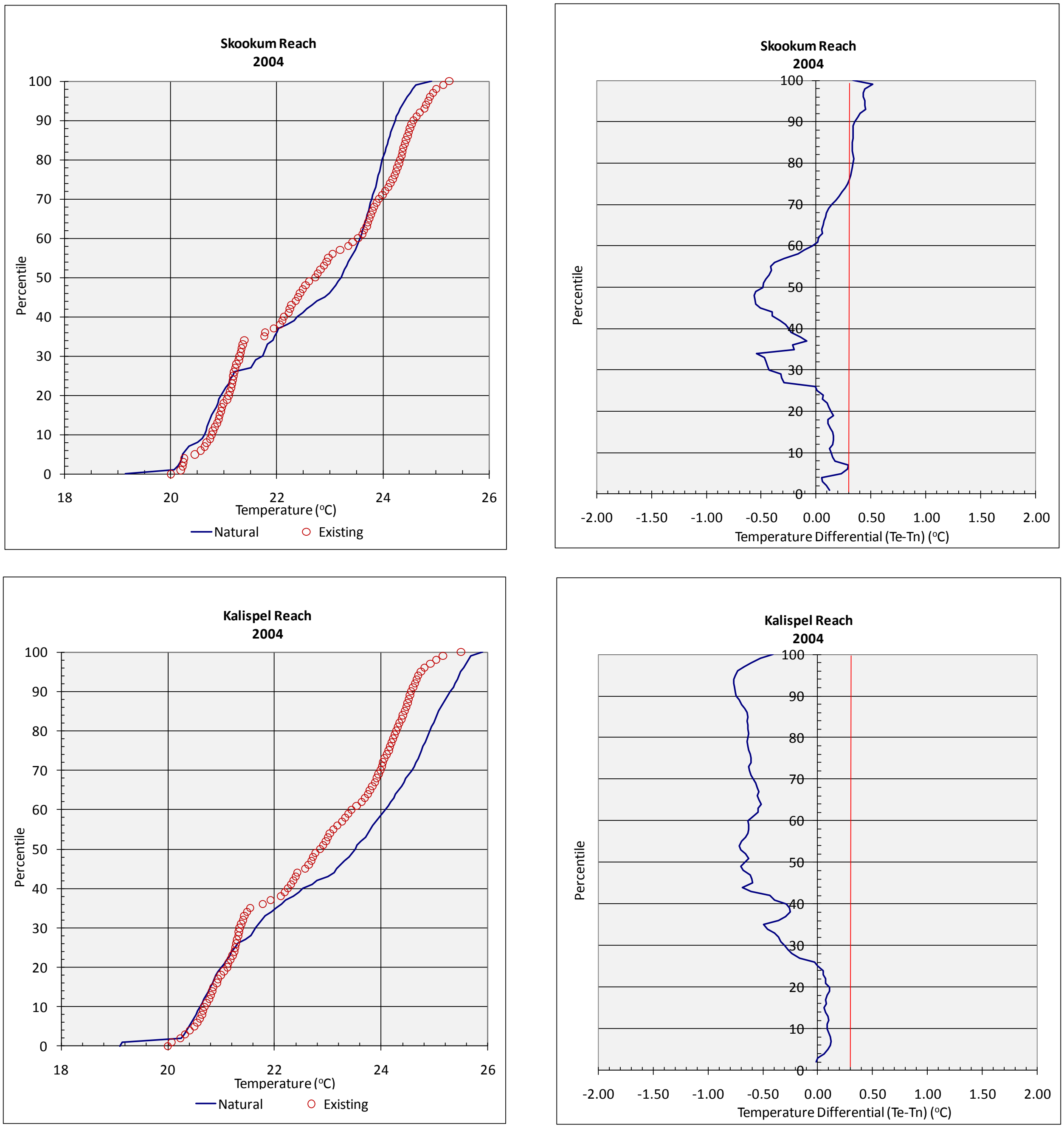


Figure 13. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Skookum and Kalispel reaches, 2004.

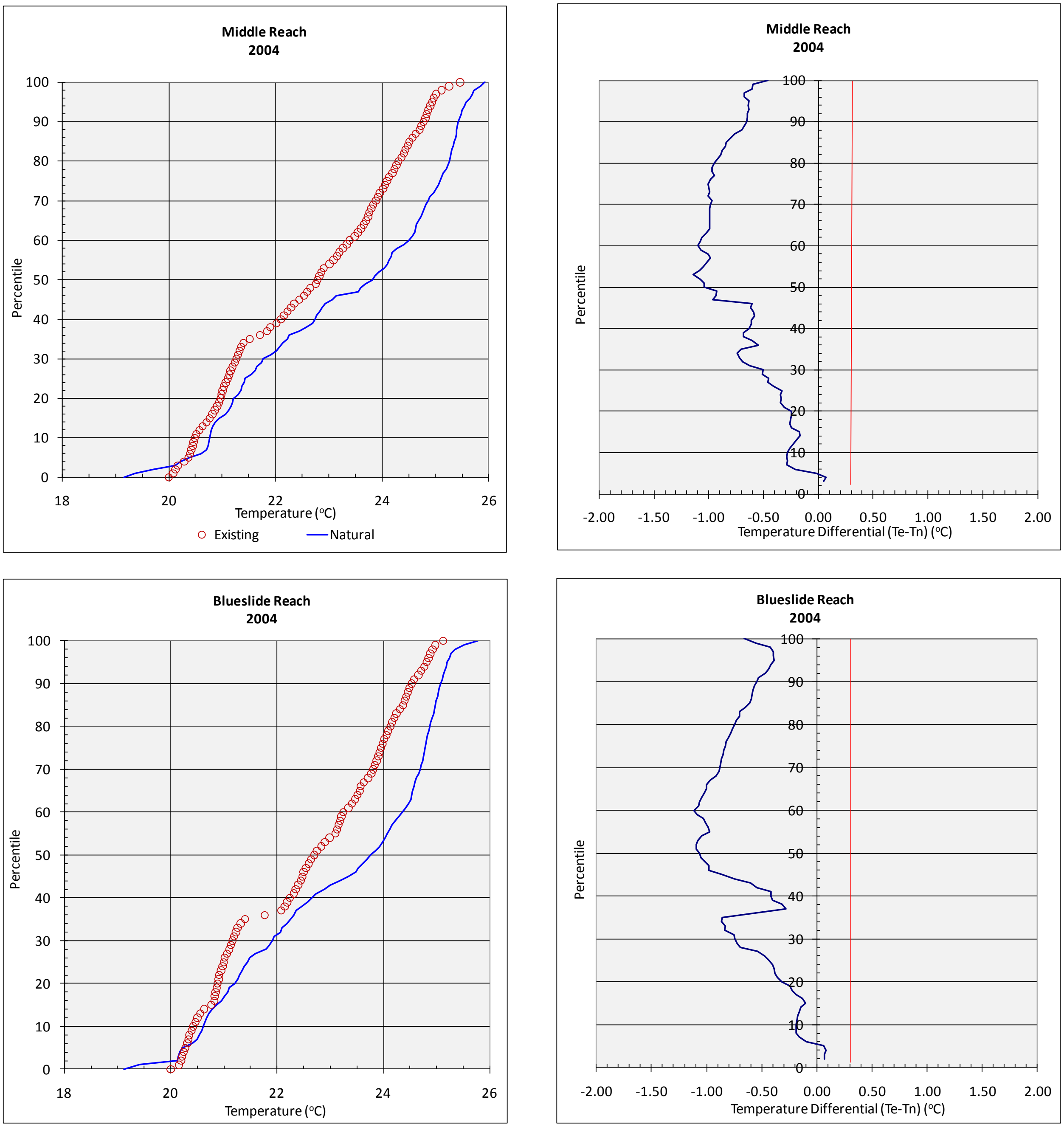


Figure 14. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Middle and Blueslide reaches, 2004.

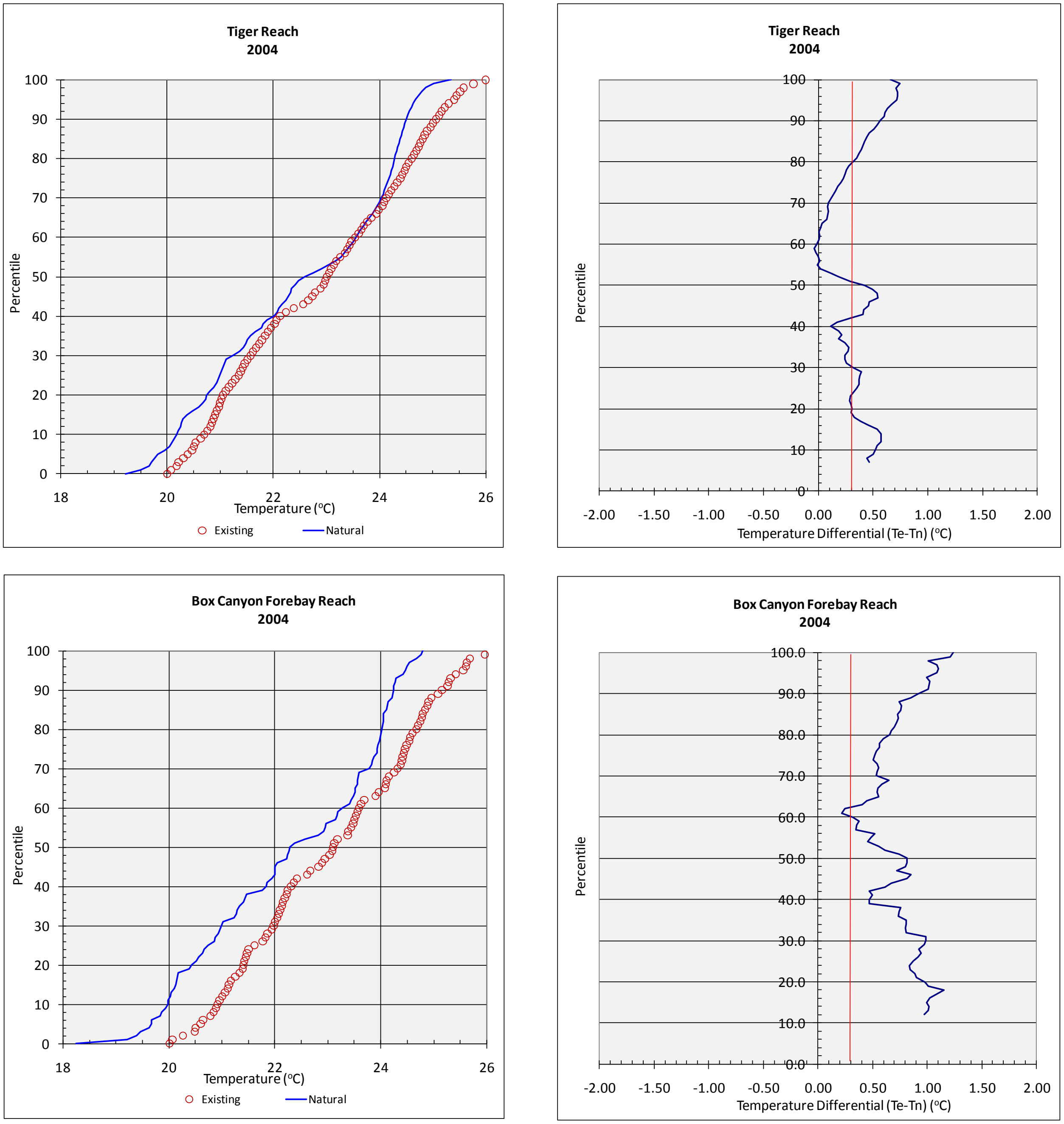


Figure 15. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Tiger and Box Canyon Forebay reaches, 2004.

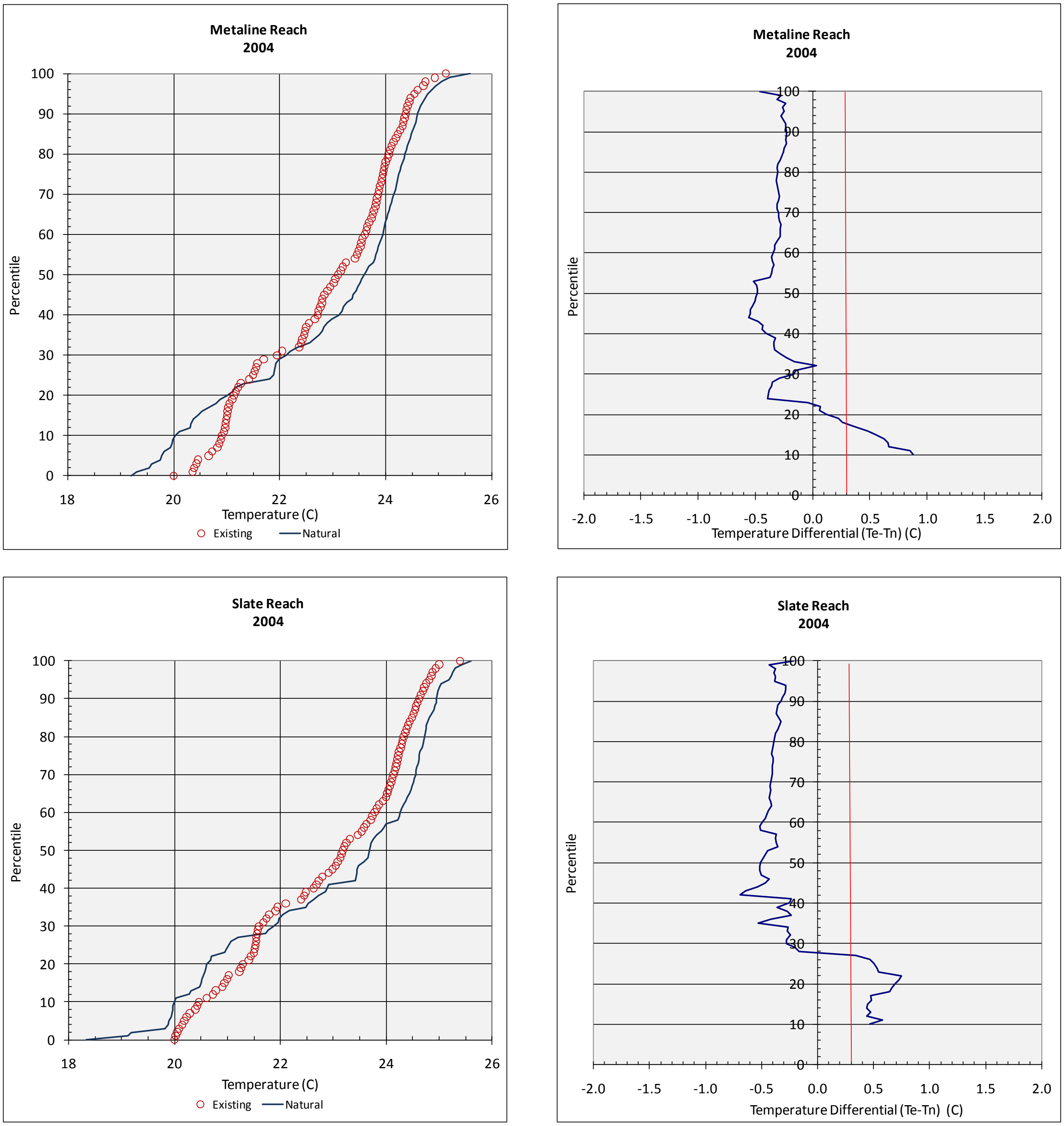


Figure 16. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Metaline and Slate reaches, 2004.

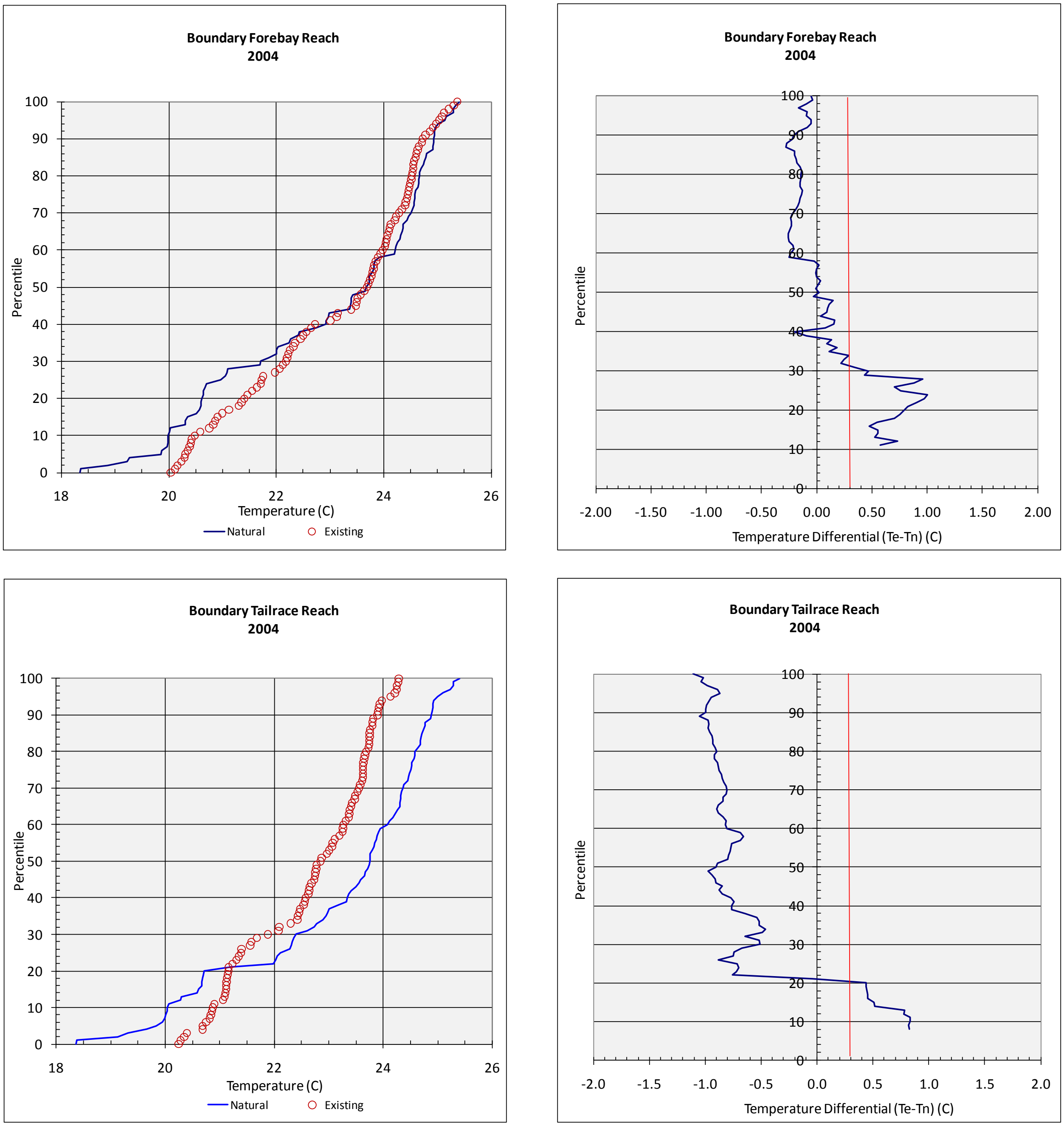


Figure 17. The cumulative frequency distribution of daily maximum temperatures and temperature differential for the Boundary Forebay and Tailrace reaches, 2004.

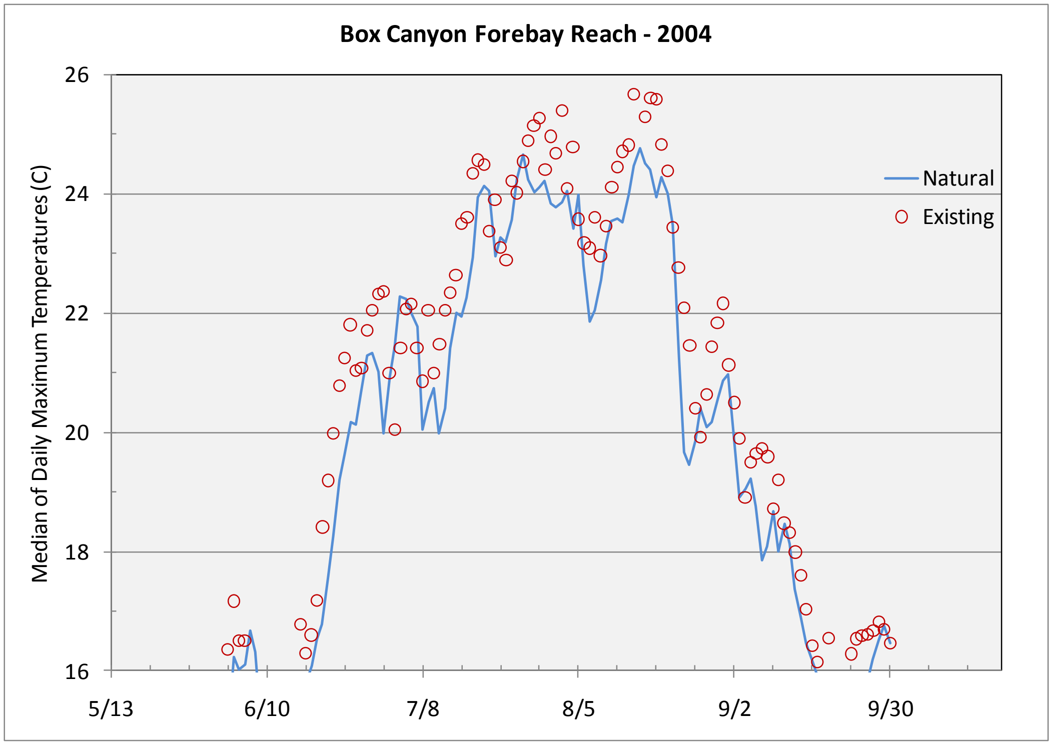


Figure 18. The median of the daily maximum temperatures for the natural and existing conditions for the Box Canyon Forebay reach in 2004.

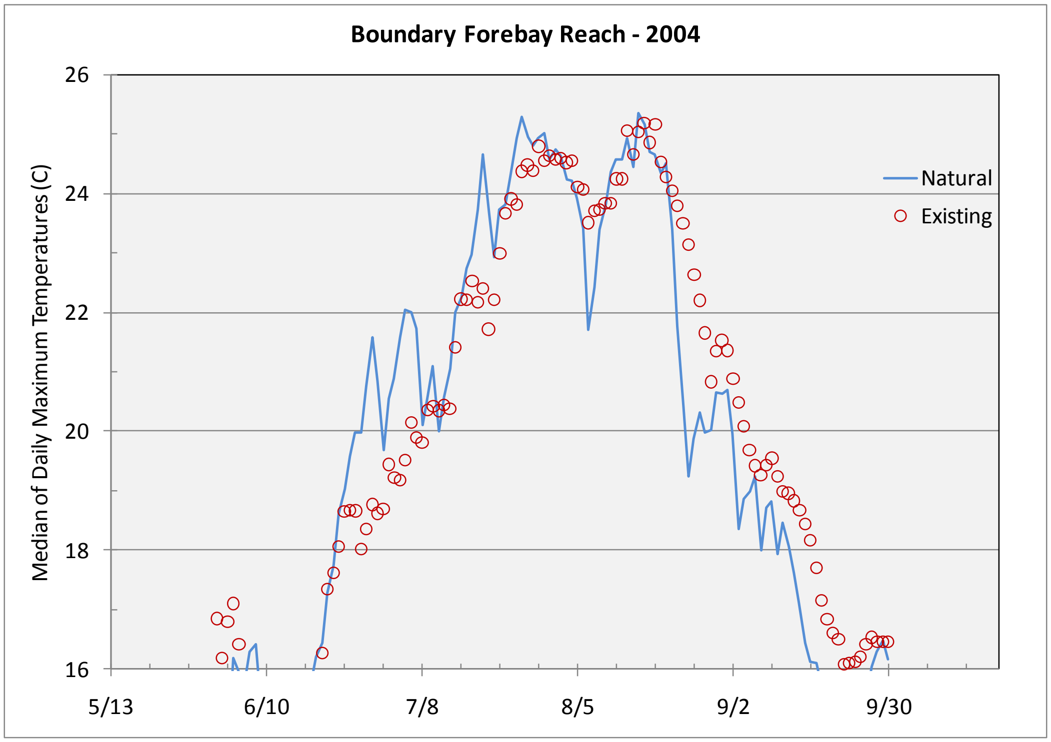


Figure 19. The median of the daily maximum temperatures for the natural and existing conditions for the Boundary Forebay reach in 2004.

Kalispel Tribal criteria

The Kalispel temperature criteria are based on an evaluation of daily maximum temperatures for two conditions:

- Based on a 7-day average of the daily maximum temperatures, when temperatures exceed 18^{o}C naturally then existing temperatures cannot exceed the natural temperature condition by more than 0.3^{o}C.
- Based on the 1-day maximum, when temperatures exceed 20.5^{o}C naturally then existing temperatures cannot exceed the natural temperature condition by more than 0.3^{o}C.

These criteria were evaluated at model segments 115 and 172, bracketing the upper and lower boundaries of Tribal lands adjacent to the Pend Oreille River, respectively. (As a reference, segment 115 is the most downstream segment of the Skookum reach while segment 172 is the most upstream segment in the Middle reach.)

Results indicate that peak temperatures observed at segment 115 (lower Skookum reach, river mile 72) exceeded both parts of the Kalispel tribal temperature criteria while at the lower tribal boundary (represented by segment 172, upper Middle reach), maximum water temperature conditions remained within the criteria threshold (Table 7 and Figures 20-23).

The plots of the cumulative frequency distribution of the 7-day average of the daily maximum temperatures for segments 115 and 172 are similar to those generated based on whole reach conditions corresponding to the Skookum and Middle reaches, respectively (refer to Washington State criteria, previous section). For this reason, these results are consistent with those found through application of Washington State criteria.

The first part of the Kalispel criteria is based on the 7-day average of the daily maximum temperatures. When natural conditions exceed 18^{o}C, existing temperatures conditions should remain at 0.3^{o}C or less. In 2004, at segment 115, the maximum temperature differential reached 0.40^{o}C, an exceedance level of 0.1^{o}C. However, for the majority of the temperature profile, the existing temperature condition is colder than what occurred naturally. When the full temperature profile is considered (the average temperature differential), the existing temperature is colder than the natural condition by 0.03^{o}C. At the lower tribal boundary (segment 172), the maximum temperature differential for the 7-day average was 0.14^{o}C, 0.16^{o}C below the criteria threshold. The findings for both of these reaches, based on the application of the 7-day average part of the Kalispel criteria, is consistent with that found through the application of the Washington State criteria. Temperatures observed in 2004 within the Skookum reach (which includes segment 115) exceed criteria, while those in the Middle reach (which includes segment 172) did not.

The second part of the Kalispel temperature criteria is based on the comparison of existing and natural condition daily maximum temperatures when natural conditions exceed 20.5^{o}C. The results of its application were similar to that found for Part 1 maximum temperatures observed in segment 115 exceed criteria, though by a slightly larger margin (0.3^{o}C as opposed to 0.1^{o}C), while temperature conditions in segment 172 remained within criteria. The bottom-line results are again consistent with those observed though application of the Washington state temperature criteria.

Table 7. Application of Parts 1 and 2 of the Kalispel temperature criteria. *Assessment of compliance and overall temperature deviation from the natural condition for segments 115 and 172.*

Reach/Location	7-Day Average of Daily Maximum			1-Day Maximum		
	Criteria Met	Max. Temp. Differential	Full Temperature Differential	Criteria Met	Max. Temp. Differential	Full Temperature Differential
Lower Skookum / (Seg. 115)	No	0.40°C	-0.03°C	No	0.60°C	0.06°C
Upper Middle / (Seg. 172)	Yes	0.14°C	-0.51°C	Yes	0.22°C	-0.50°C

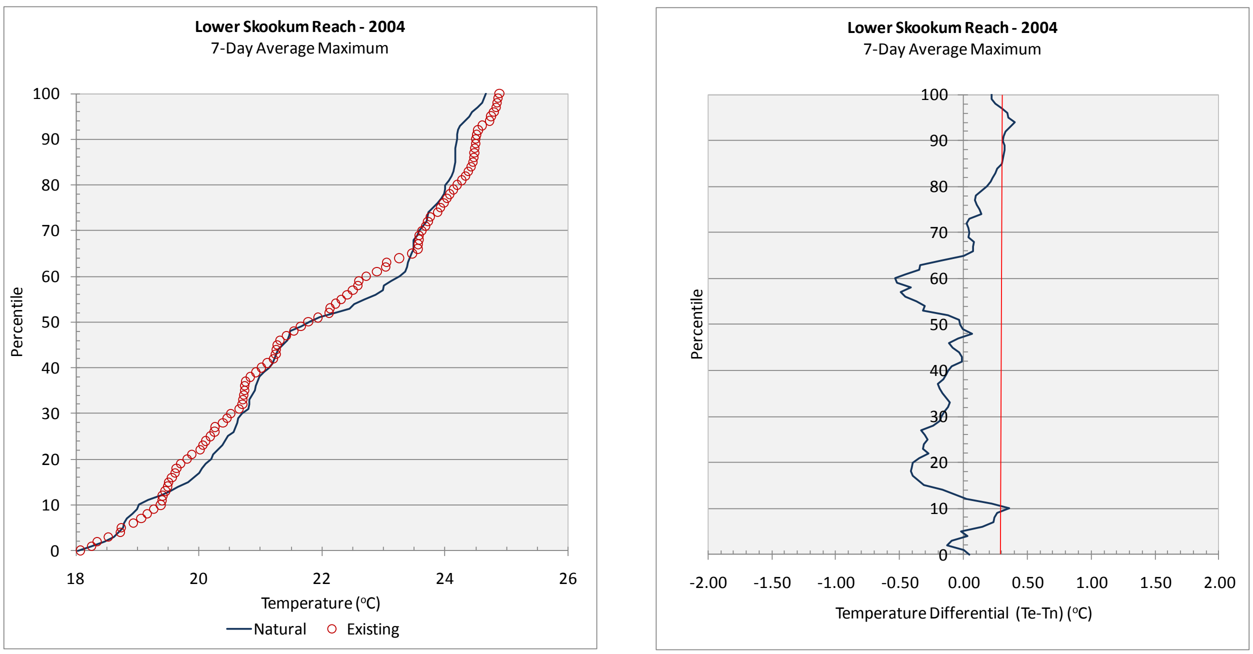
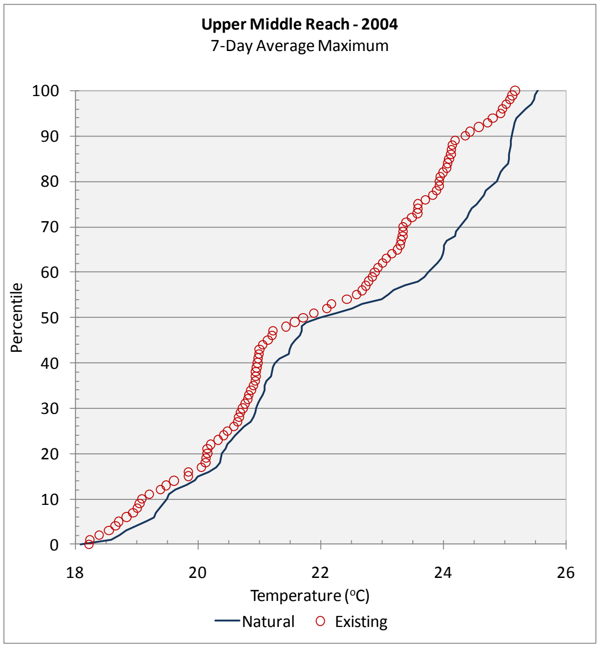


Figure 20. Segment 115 cumulative frequency distribution of the 7-day average of the daily maximum temperatures along with the associated temperature differential. *Analysis includes the natural and existing conditions observed at lower Skookum reach (segment 115) in 2004.*



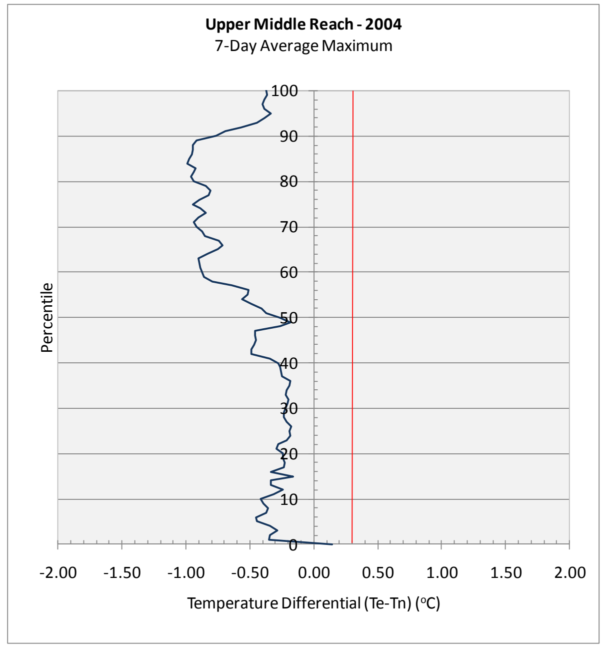
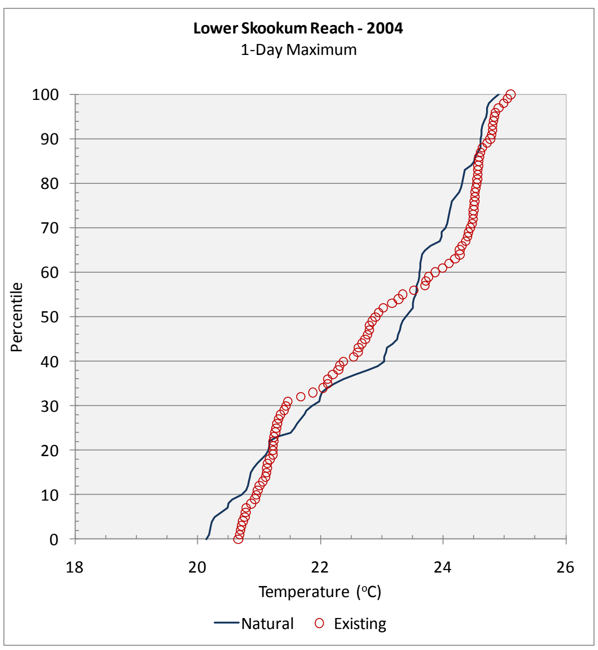


Figure 21. Segment 172 cumulative frequency distribution of the 7-day average of the daily maximum temperatures along with the associated temperature differential. *Analysis includes the natural and existing conditions observed at upper Middle reach (segment 172) in 2004.*



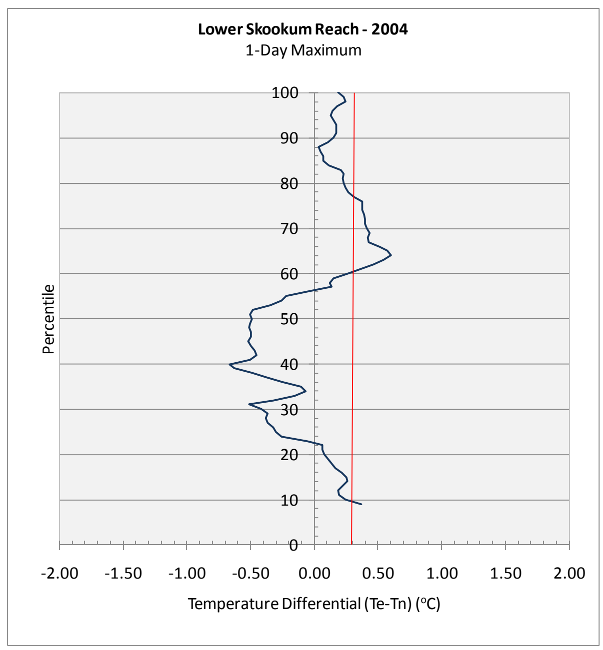
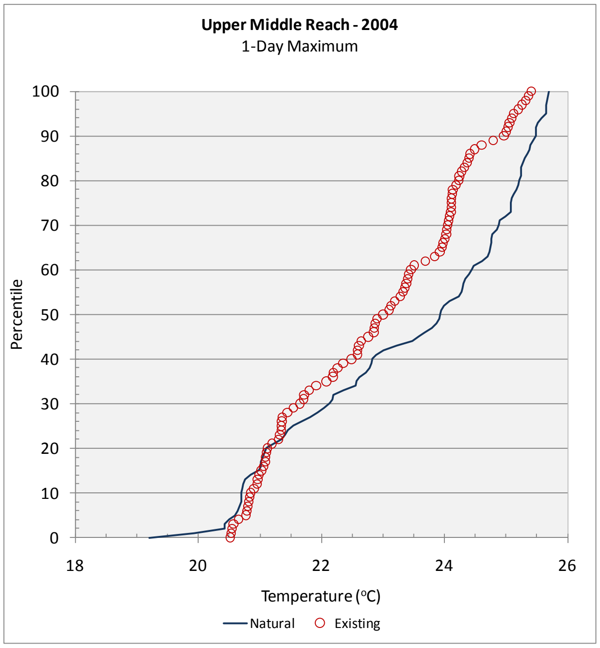


Figure 22. Segment 115 cumulative frequency distribution of daily maximum temperatures along with the associated temperature differential. *Analysis includes the natural and existing conditions observed at lower Skookum reach (segment 115) in 2004.*



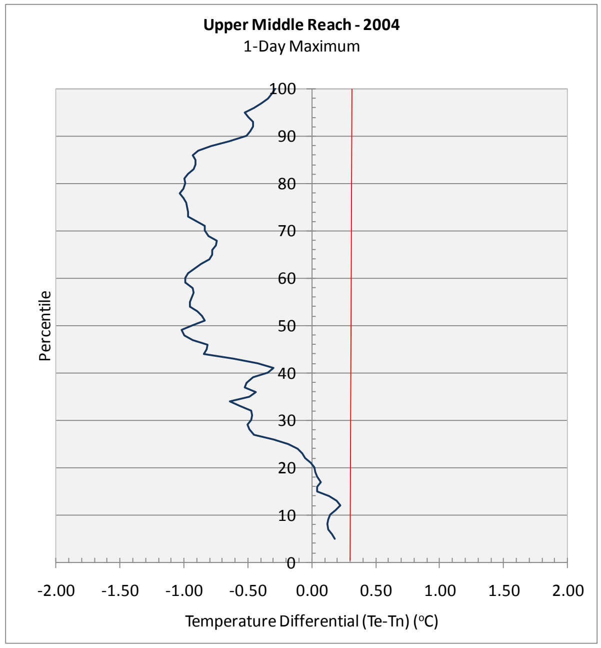


Figure 23. Segment 172 cumulative frequency distribution of daily maximum temperatures along with the associated temperature differential. *Analysis includes the natural and existing conditions observed at upper Middle reach (segment 172) in 2004.*

Off-peak temperatures – Washington State criteria

Part 2 of Washington's Pend Oreille River temperature criteria address potential heating occurring outside the peak temperature period. This analysis defined this period as when existing daily maximum temperatures were less than or equal to 20°C though greater than or equal to 12°C. The upper limit is defined by Part 1 of the criteria, while the lower limit of 12°C was set based on the migration and feeding habitat requirements of bull trout (*Salvelinus confluentus*); an Endangered Species Act threatened species found in the Pend Oreille River system.

Part 2 of the criteria stipulate that, at any time, temperature increases remain below a level specified by the equation t=34/(T+9). The variable t is the allowable increase while T is the natural temperature condition.

Based on this assessment, the upper reaches of the Pend Oreille River, from Newport to the Box Canyon forebay, had maximum temperature differentials within the allowable increase limits (Table 8, Figures 24-25). In contrast, all of the Boundary reaches from Metaline to the tailrace had temperature differentials extending beyond the allowable limit, therefore resulting in criteria exceedance (Figure 26). In some cases, for instance the Boundary forebay and tailrace reaches (Figure 26), the criteria was exceeded for a number of different percentiles, indicating that the exceedances occurred at varying times and temperature conditions. However, the level of exceedance of criteria presented in Table 8 is defined as the maximum difference between the temperature differential and the allowable limit. The level of exceedence increased longitudinally from 0.14°C at the Metaline reach to 0.61°C at the Boundary forebay. As observed, all Boundary reaches display a characteristic temperature differential pattern indicating dominant upstream influences.

Table 8. The Pend Oreille reaches, their maximum temperature differential, allowable limit and level of exceedance.

Reach	Criteria Met	Max. Temperature Differential (^oC)	Allowable Limit (^oC)	Level of Exceedance(^oC)
Newport	Yes	0.63^{o}C	1.64^{o}C	==
Dalkena	Yes	0.48^{o}C	1.21^{o}C	==
Skookum	Yes	0.63^{o}C	1.22^{o}C	==
Kalispel	Yes	0.48^{o}C	1.64^{o}C	==
Middle	Yes	0.23^{o}C	1.64^{o}C	==
Blueslide	Yes	0.22^{o}C	1.60^{o}C	==
Tiger	Yes	0.52^{o}C	1.29^{o}C	==
Box Canyon Forebay	Yes	0.83^{o}C	1.22^{o}C	==
Metaline	No	1.90^{o}C	1.76^{o}C	0.14^{o}C
Slate	No	2.01^{o}C	1.77^{o}C	0.24^{o}C
Boundary Forebay	No	1.94^{o}C	1.33^{o}C	0.61^{o}C
Boundary Tailrace	No	2.31^{o}C	1.78^{o}C	0.53^{o}C

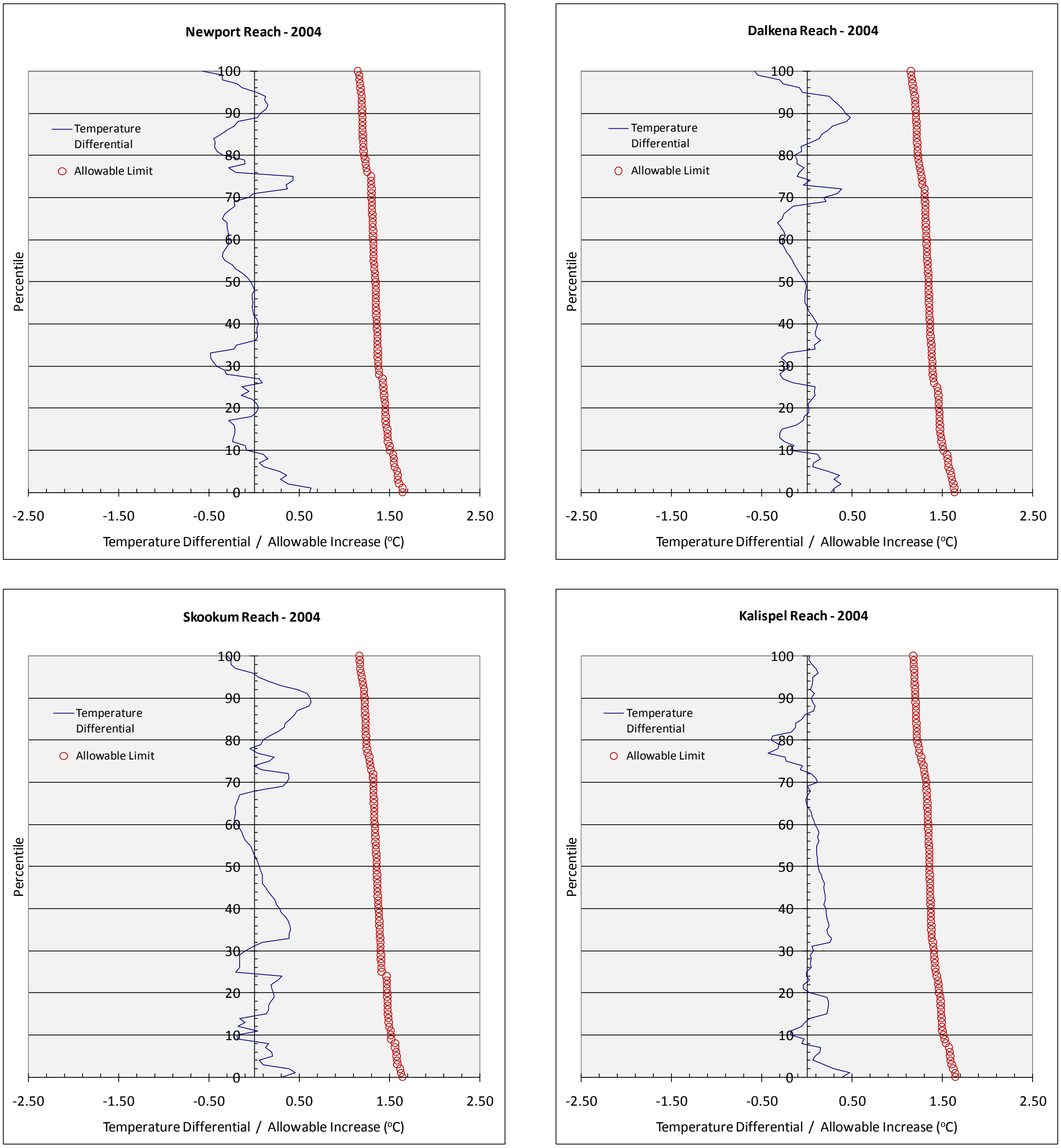


Figure 24. The temperature differential and allowable increase for the Newport, Dalkena, Skookum and Kalispel reaches in 2004.

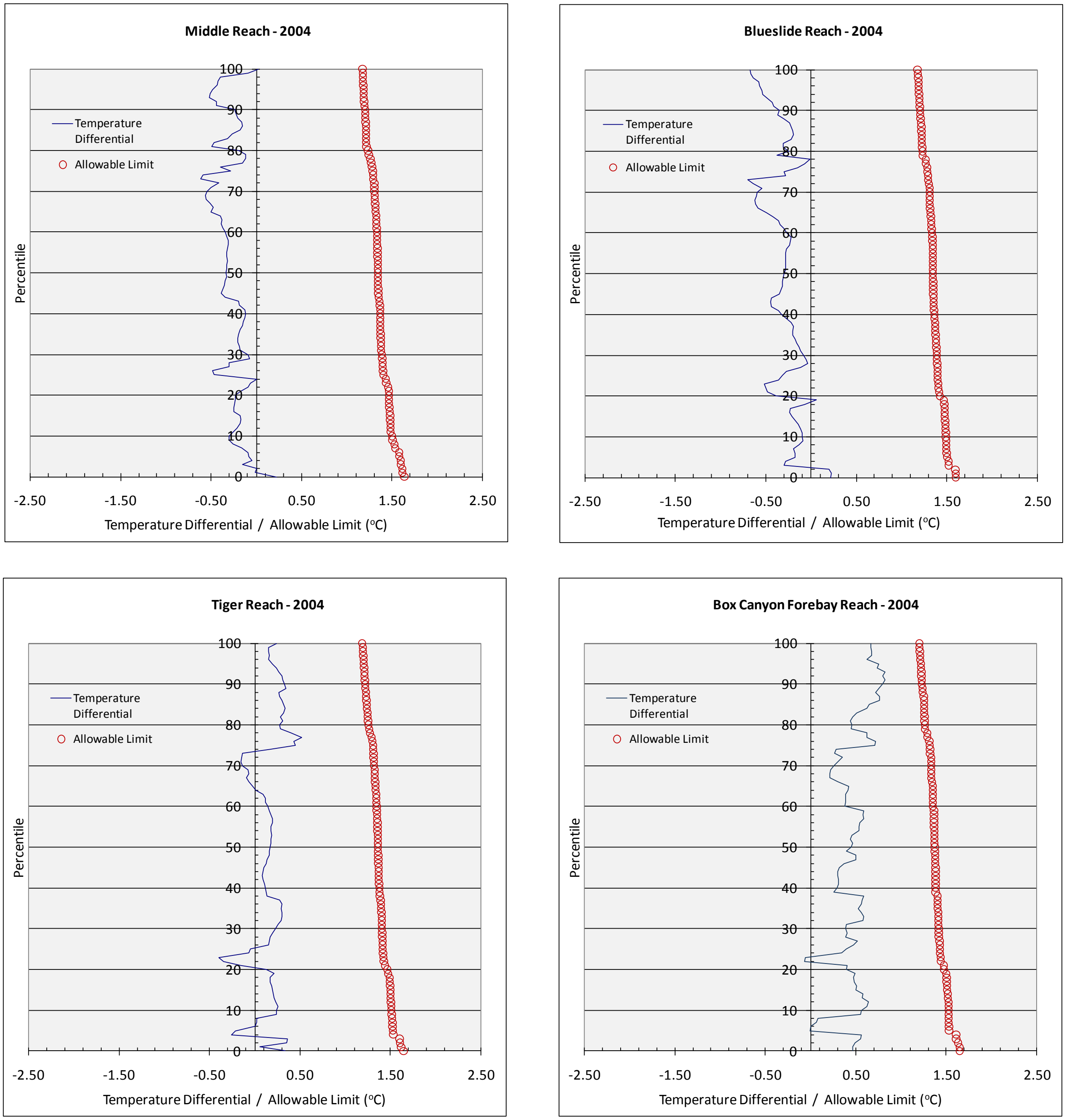


Figure 25. The temperature differential and allowable increase for the Middle, Blueslide, Tiger and Box Canyon reaches in 2004.

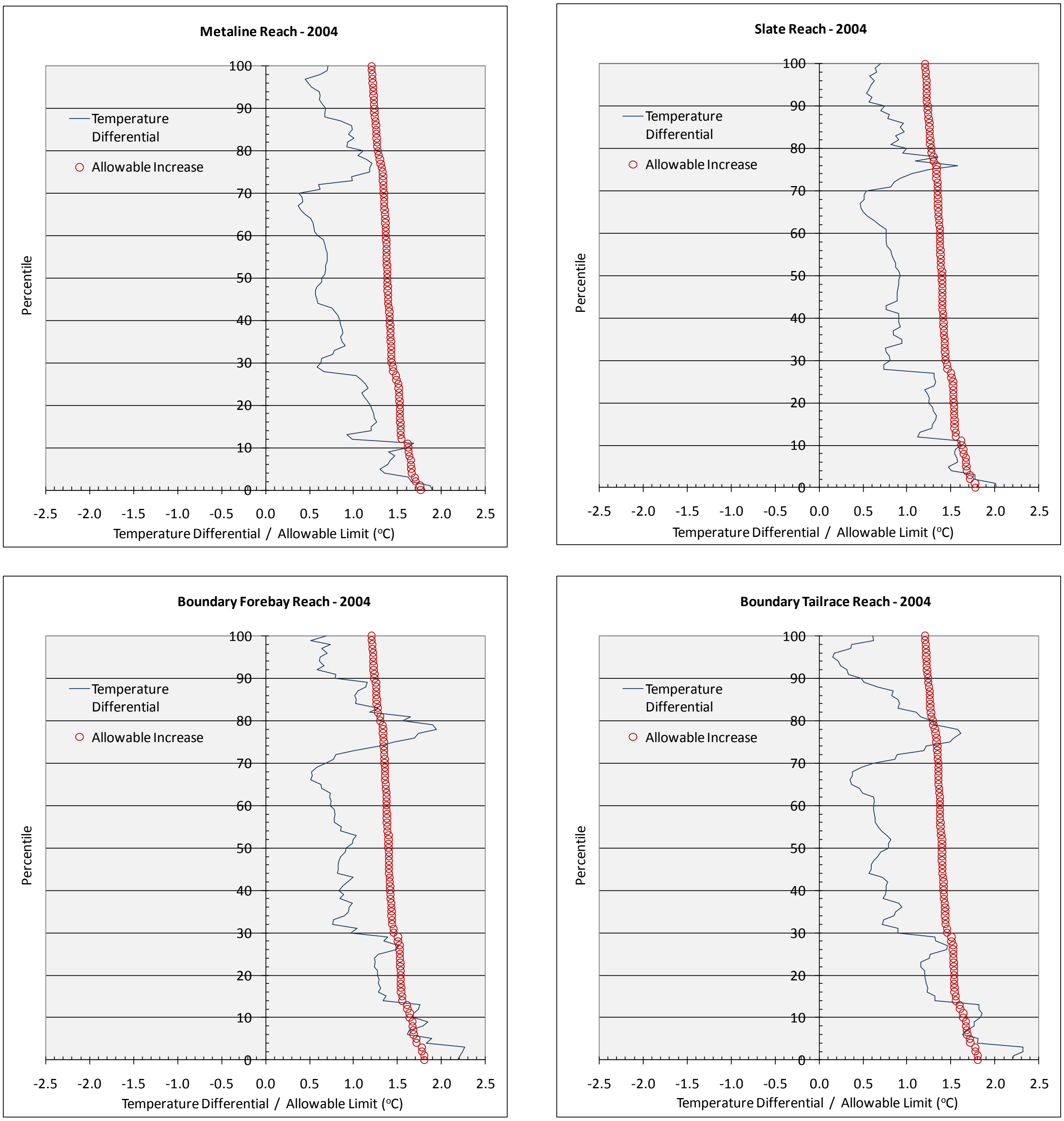


Figure 26. The temperature differential and allowable increase for the Metaline, Slate, Boundary Forebay and Tailrace reaches in 2004.

Influence of heat modifiers

Washington State criteria

In addition to the existing and natural model runs which were used to examine compliance with the temperature criteria, several scenarios were also completed to examine the influence of potential temperature moderating factors on the river's existing temperature condition. These factors included the influence of: NPDES discharges, tributary and mainstem shade, and the Box Canyon and Boundary hydroelectric facilities (Table 4). These factors were examined in isolation so that their individual influence on the existing temperature condition could be determined. The reference for these scenarios is the existing temperature condition in contrast to the examination of criteria compliance which used the natural temperature condition as the ultimate reference. However, consistent with the prior analysis method, both the existing and scenario datasets, by reach, are referenced to their associated natural datasets. From these datasets, cumulative frequency distributions of the maximum temperatures were determined and then temperature differentials generated. The existing condition temperature differential, for each reach and year, is the same as expressed in the prior section which addressed compliance with the criteria. The scenario temperature differential, derived in the same manner, is a reflection of any change from that condition.

The utility of this analysis is that it allows the examination of the relative magnitude each of these heat modifying factors has on influencing existing temperatures. The overall shift in temperature, as a consequence of these factors, will be examined as well as whether criteria are achieved for those reaches that currently exceed it.

Point source discharge (NPDES)

Scenario 2 is the examination of the effect of National Pollution Discharge Elimination System (NPDES) permitted discharges to existing maximum temperatures observed within the study area. Referring to Table 9, together these discharges had no definable influence on existing temperatures. It appears that NPDES inflow (and its associated temperature), within any of the reaches, is too low in comparison to the total river flow to have any measurable influence. In addition, during the summer critical period temperature data from the point sources show that temperature increases at their mixing zone boundary were below 0.3^{o}C, (Refer to Figures D-26 through D-31 in Appendix D.)

Riparian shade / natural potential vegetation

The cooling effect provided by maximum shade [natural potential vegetation (NPV)], either associated with tributary inflow or situated along the mainstem Pend Oreille River, was examined in Scenarios 2.5 and 7.0, respectively. In terms of Scenario 2.5, cooler tributary inflow provided no definable change to maximum temperatures observed in the upper reaches of the study area. From Newport to Skookum, for both 2004 and 2005, no shift in existing maximum temperatures was determined (Table 9). However, by Kalispel, overall maximum temperatures began to decline slightly. The average level of decline was 0.05^{o}C between Kalispel and the Box Canyon forebay, considering 2004 and 2005.

A similar pattern is present for the Boundary reaches. The assumption of colder tributary inflow provides no shift in maximum temperatures for the Metaline reach for either 2004 or 2005. However, from Slate through the Boundary forebay, maximum temperatures were found to decline, though by a relatively insignificant level. Maximum temperatures declined by an average of approximately 0.01°C in 2004 and 0.02°C in 2005.

Table 9. The average scenario temperature shift (oC), relative to the existing condition, [(Ts-Tn) - (Te-Tn)]. *Shift considers the full temperature profile, by scenario, for the Box Canyon and Boundary reaches (2004 and 2005).*

Reach		Average Temperature Change by Modeling Scenario*							
		No. 2.0 NPDES		No. 2.5 Tributary NPV		No. 7.0 Mainstem NPV		No. 4.0 Hydro-Facility	
		2004	2005	2004	2005	2004	2005	2004	2005
Box Canyon Reaches	Newport	0.00°C	-0.01°C	0.00°C	-0.01°C	-0.01°C	-0.02°C	-0.04°C	-0.06°C
	Dalkena	0.00°C	0.00°C	0.00°C	0.00°C	-0.01°C	-0.01°C	0.11°C	0.11°C
	Skookum	0.00°C	0.00°C	0.00°C	0.00°C	0.00°C	-0.01°C	-0.19°C	-0.22°C
	Kalispel	0.00°C	0.00°C	-0.03°C	-0.03°C	-0.01°C	-0.01°C	0.13°C	0.26°C
	Middle	0.00°C	0.00°C	-0.05°C	-0.08°C	-0.02°C	-0.02°C	0.44°C	0.70°C
	Blueslide	0.00°C	0.00°C	-0.05°C	-0.08°C	-0.03°C	-0.03°C	0.40°C	0.67°C
	Tiger	0.00°C	0.00°C	-0.05°C	-0.06°C	-0.04°C	-0.05°C	-0.52°C	-0.48°C
	Box Canyon Forebay	0.00°C	0.00°C	-0.04°C	-0.06°C	-0.04°C	-0.06°C	-0.99°C	-0.93°C
Boundary Reaches	Metaline	0.00°C	0.00°C	0.00°C	0.00°C	0.00°C	0.00°C	0.01°C	0.06°C
	Slate	0.00°C	0.00°C	-0.01°C	-0.01°C	-0.01°C	-0.01°C	0.01°C	0.17°C
	Boundary Forebay	0.00°C	0.00°C	-0.01°C	-0.02°C	-0.03°C	-0.04°C	-0.33°C	-0.29°C
	Boundary Tailrace	0.00°C	0.00°C	-0.01°C	-0.04°C	-0.01°C	-0.04°C	0.32°C	0.39°C

*

No. 2.0 = *existing model run with the elimination of NPDES permit discharges.*
No. 2.5 = *existing model run with tributary inflow temperatures reflective of natural potential vegetation conditions.*
No. 7.0 = *existing model run with mainstem shade at natural potential vegetation conditions.*
No. 4.0 = *existing model run with Albeni Falls present though with Box Canyon absent – for Box Canyon reaches.*
= *existing model run with Box Canyon present though with Boundary absent – for Boundary reaches.*

A negative entry indicates a reduction in river temperatures as a result of the scenario relative to the existing temperature structure.

Also, the effect of maximum shade along the mainstem (Scenario 7.0) was found to provide only minor reductions in peak river temperatures through both the Box Canyon and Boundary sections (Table 9). From Newport to Skookum the average level of decline was approximately 0.01 °C for 2004 and 2005. There is a slight, though steady, decline in maximum temperatures from Kalispel (0.01 ^{o}C) to Box Canyon forebay (0.05 ^{o}C). These reduction levels were consistent between 2004 and 2005.

A similar pattern is observed for the Boundary reaches: no shift in maximum temperatures for the upper Metaline reach, with an increasing, though relatively low level of decline from Slate (0.01 ^{o}C) to the Boundary forebay (0.04^{o}C). (Refer to Figures D-10 through D-15 and D-18 through D-23 in Appendix D.)

In evaluating the effect of increased shade levels, whether associated with tributary inflow or along the mainstem, similar to the NPDES discharges, scale is an important consideration. Regarding Scenario 2.5, within any of the reaches, the amount of tributary inflow is low in relation to the total river flow, decreasing the tributaries' influence on river temperatures. While considering Scenario 7.0, even with mainstem riparian vegetation growth at an optimal level, the river is too wide for shade to provide a significant cooling effect. In fact, the model results indicate that cooler tributary inflow provides a greater cooling effect on the river than that of the mainstem riparian vegetative growth even at NPV conditions. This is primarily the result of the substantial width of the river in relation to even the maximum expected height of riparian NPV, reducing the cooling effect of mainstem shade. In addition to the river's channel characteristics, its existing hydrology is also an important factor.

The vast majority of the Pend Oreille River's flow is introduced at its origin, the outflow from Lake Pend Oreille, with relatively minor tributary additions through the reaches. Regarding the study area, the temperature conditions of the river following the discharge from Albeni Falls first establishes a base temperature condition, and that condition is largely buffered from modification due to the river's now changed hydraulics: primarily associated with the greater channel storage (deeper water column) as a consequence of the Box Canyon and Boundary hydroelectric facilities. It is really only the hydroelectric facilities that overcome these temperature buffering characteristics to cause significant temperature shifts.

Hydroelectric facilities

More definable shifts in temperature were found based around the presence (or absence) of the hydroelectric facilities (Table 9, Figures 27-29). Scenario 4.0 examined the effect of maintaining the current structure: upstream dam in place with existing upstream flow and temperatures, though with the downstream dam absent. For the Box Canyon section of the study area, Scenario 4 examines the effect of the absence of the Box Canyon facility on existing river temperatures (reaches above Box Canyon), assuming that the Albeni Falls facility remained in place. The results of these analyses are present in Table 9 and in Figures 27-28 that follow this section.

The temperature structure at the Newport and Dalkena reaches remained similar between the existing and scenario conditions. This indicates that the Box Canyon facility has a low level of influence on maximum temperatures for these reaches. However, the Box Canyon facility appears to influence the highest maximum temperatures at the Skookum reach.

Referring to Figure 27, without Box Canyon in place, the upper maximum temperatures, those above the 60th percentile level, declined by approximately 0.4^{o}C. This is a temperature range where the criterion is exceeded at Skookum, and this reduction is large enough to result in Skookum achieving the temperature criteria. The Skookum reach appears transitional between the hydraulic effects of Box

Canyon and Albeni Falls. An aerial thermal infrared survey conducted in 2001 for the Kalispell Tribe indicated significant heating occurring within a major side channel complex located between river miles 73.5 and 76.5 (Watershed Sciences, 2001). (The Skookum reach is located between river miles 72.4 and 76.8.) Survey results indicate that water temperatures reached 30^{o}C within the side-channel. This side-channel is likely a historic meander channel of the river that has become inundated due to the backwater effect of Box Canyon dam. Within the side channel, the depth of flow is relatively shallow in comparison to the main channel, and has a low velocity. These characteristics result in the elevated observed temperatures. Without the dam in place, and the backwater effect removed, the level of flow through this side channel is substantially reduced and, in the process, the overall maximum temperatures through the segments comprising the Skookum reach are significantly reduced.

Skookum is the exception for the upper river reaches (Dalkena to Blueslide), because for much of the upper river maximum temperatures increase with the absence of Box Canyon from a 2004/2005 average of 0.11^{o}C at Dalkena to 0.5^{o}C by the Middle and Blueslide reaches. This temperature increase is due to shallower river depths as the backwater effect of Box Canyon is removed. The solar shortwave radiation load occurs within a decreased water depth resulting in the increased heating. The increase in heat is not significant enough to result in the exceedance of criteria.

However, by the Tiger reach this effect is offset by the larger influence of the Box Canyon facility. With its absence, maximum temperatures in the Tiger and Box Canyon Forebay reaches decline significantly by an average (2004 / 2005) of 0.50^{o}C and 0.96^{o}C, respectively throughout the range of maximum temperatures observed (20-26^{o}C) (Table 9 and Figure 28). These temperature decreases were large enough to result in achievement of the criteria for both reaches (Figure 28).

The primary shift in temperature related to the Box Canyon facility occurs most prominently in the upper percentiles of the maximum temperatures, not in the lower percentiles (Figures 27-28). This is most apparent from Newport to Kalispel though also present in the profiles determined for the Middle and Blueslide reaches. The similarity in the temperature structure for these lower percentile temperatures suggests that they are primarily determined by the temperature dynamics related to Albeni Falls discharge. This temperature signal is present, to varying degrees, in all of the temperature profiles of the Box Canyon reaches, where the lowest daily maximum percentiles remain above the natural condition despite the absence of the Box Canyon facility.

Regarding the Boundary reaches, both Metaline and Slate are not significantly affected by the absence of the Boundary facility. This indicates that the temperature through this approximately 15-mile stretch of river is primarily controlled by discharge from the Box Canyon facility. However, the daily maximum temperatures in the Boundary forebay reach are affected by the Boundary facility and, with its absence, maximum temperatures decline by about 0.3^{o}C (Table 9, Figure 29).

A temperature signal from Box Canyon is evident in the temperature profiles of the Boundary forebay. Lower magnitude daily maximum temperatures are maintained by the Box Canyon facility for a longer period in comparison to what occurred naturally. This results in the continued exceedance of the Pend Oreille River temperature criteria in the Boundary reaches despite the absence of the Boundary facility. (This was noted previously in the section of the report that examined off-peak temperatures.) As previously discussed, the Albeni Falls facility has a similar affect on the Box Canyon reaches, though of a lower magnitude. This effect of colder water withdrawal and downstream discharge occurring at each of the hydroelectric facilities is clearly displayed at the Boundary tailrace reach.

Without the Boundary facility, the scenario temperature profiles between the Boundary forebay and tailrace reaches are similar. However, their relation to the existing profile and, therefore, the presence of the Boundary facility, differ. In the Boundary forebay reach, the absence of the facility results in a decline in overall daily maximum temperatures by about 0.31^{o}C. This decline is balanced by an increase in temperature for the tailrace reach by an average of 0.36^{o}C. This difference occurs because with Boundary Dam in place, colder water is withdrawn and discharged to the tailrace, resulting in the colder maximum temperatures.

It is important to note that Scenario 4.0 always maintains an upstream hydroelectric facility in place; Albeni Falls for the Box Canyon reaches and Box Canyon for the Boundary reaches. Even with the absence of the downstream hydroelectric facility, the majority of the daily maximum temperatures remain below those that occurred naturally (Figures 27-29). The reason for this is the cooling effect of the discharge of colder subsurface water associated with each of the upstream hydroelectric facilities. Paradoxically, the upstream storage that results in cold water discharge, depressing the highest downstream maximum temperatures, also leads to increased heating at the lowest maximum temperatures. The reason for this is that the Pend Oreille River under the natural condition was shallower and therefore able to gain and lose heat at a greater rate in comparison to the existing condition with its increased volume and heat storage capacity. Heat is now gained and lost at a slower rate as a consequence of this storage. In late August, under the natural condition, the temperature of the river dropped at a faster rate than it does now, leading to a positive temperature differential (gain in heat in relation to the natural condition). This separation is present in the graphics and is characterized by the positive temperature differential present for the lowest maximum temperature percentiles. It is particularly prominent in the temperature differential profiles for the Boundary reaches.

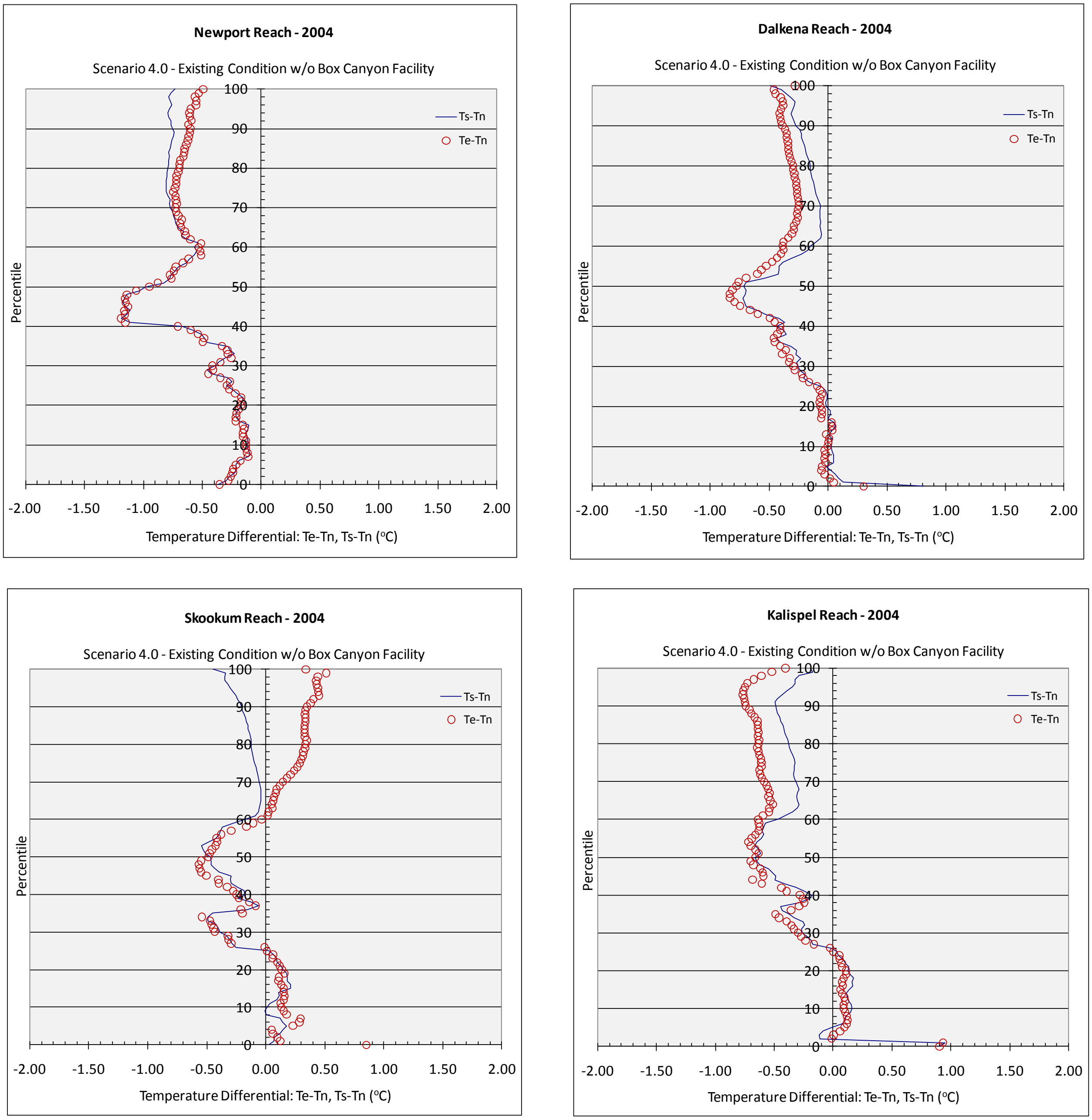


Figure 27. Existing and Scenario 4.0 temperature differential profiles for the Newport, Dalkena, Skookum, and Kalispel reaches, 2004. *The existing condition is represented by (Te-Tn) and alteration to that condition (Scenario 4.0) through removal of the Box Canyon facility (Ts-Tn).*

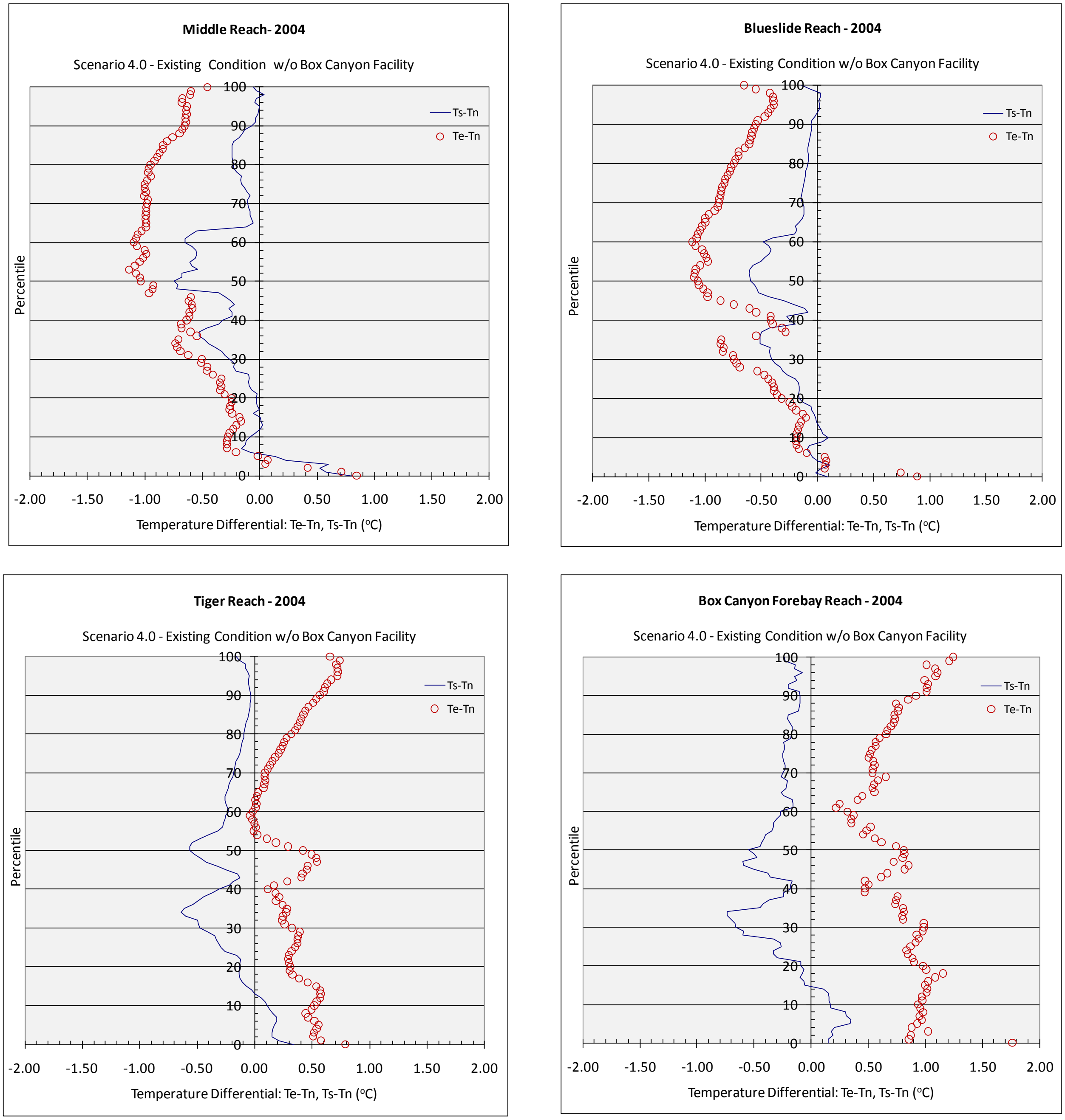


Figure 28. Existing and Scenario 4.0 temperature differential profiles for the Middle, Blueslide, Tiger and Box Canyon Forebay reaches, 2004. *The existing condition is represented by (Te-Tn) and alteration to that condition (Scenario 4.0) through removal of the Box Canyon facility (Ts-Tn).*

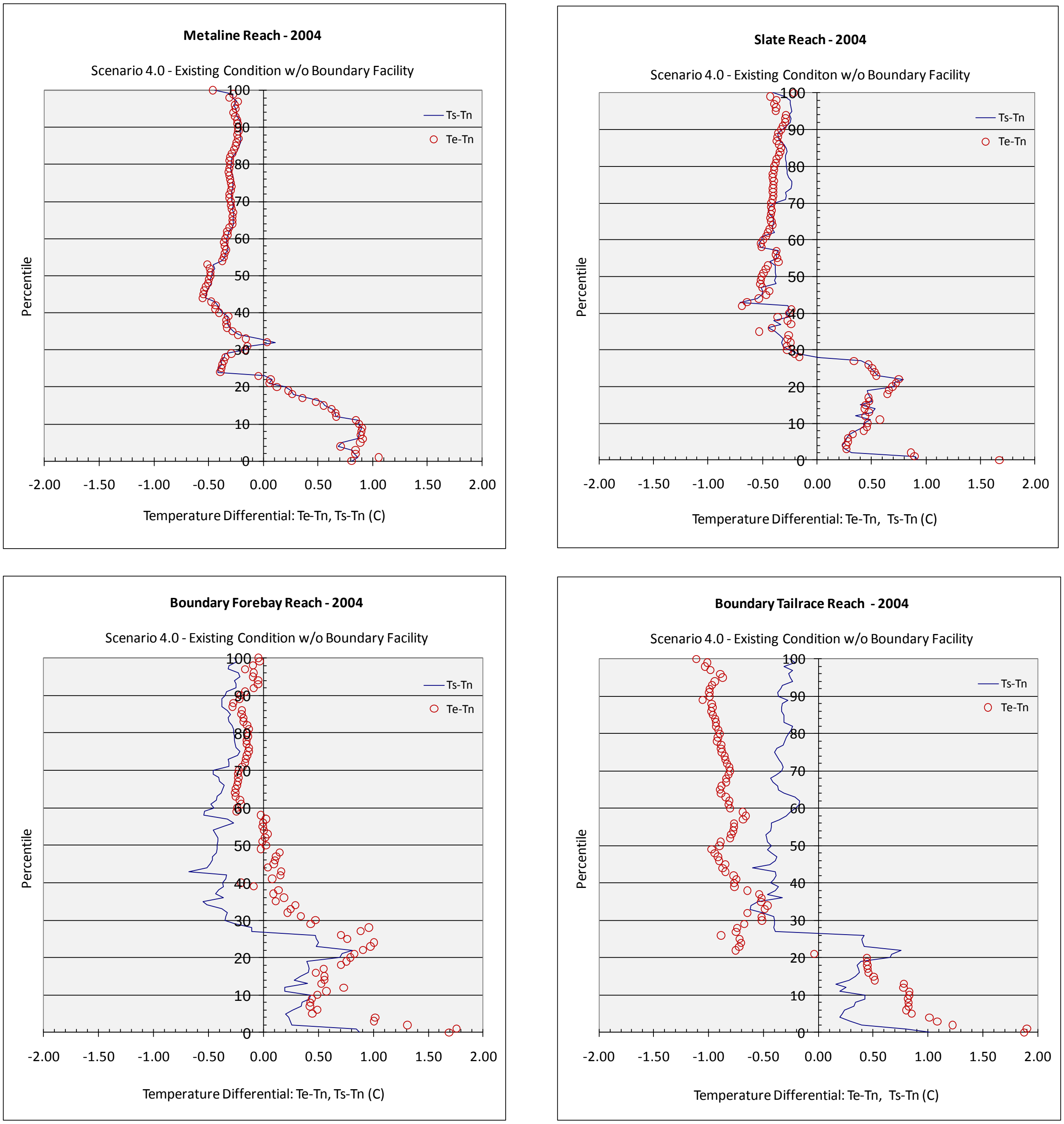


Figure 29. Existing and Scenario 4.0 temperature differential profiles for the Metaline, Slate, Boundary Forebay and Tailrace reaches, 2004. *The existing condition is represented by (Te-Tn) and alteration to that condition (Scenario 4.0) through removal of the Box Canyon facility (Ts-Tn).*

Kalispel criteria

Application of the Kalispel criteria to the various modeling scenarios produced similar results as determined by application of Washington State criteria (refer to previous discussion). The average shift in temperature resulting from the various modeling scenarios considered, in relation to the existing temperature condition, is included in Table 10. For reference, segment 115, situated at approximately river mile 72 (lower Skookum reach), defines the upper tribal boundary and segment 172, approximately river mile 64, defines the lower tribal boundary. Table 10 presents the average temperature shift based on the application of the Kalispel's 7-day average of the daily maximum as well as the 1-day maximum. As observed, the two types of criteria produced similar temperature shift levels.

Point source discharge (NPDES)

Scenario 2 is the examination of the effect of National Pollution Discharge Elimination System (NPDES) permitted discharges to existing maximum temperatures observed within the study area. Similar to what was determined through application of Washington's criteria, point source discharges have no definable influence on the existing temperature condition for either segment (refer to Table 10). As presented earlier, it is believed that the magnitude of point source discharge is too low in comparison to the total river flow to have any measurable influence.

Riparian shade / natural potential vegetation

Reductions in temperature provided by maximum shade [natural potential vegetation (NPV)], either associated with tributary inflow (Scenario 2.5) or situated along the mainstem Pend Oreille River (Scenario 7.0) provided only minimal reductions in maximum temperatures. For segment 115 the results of both Scenarios 2.5 and 7.0 resulted in a reduction of 0.01^{o}C for both criteria. The effect of Scenario 2.5 was greater for segment 172 with a reduction of 0.05^{o}C and 0.07^{o}C based on the 7-day average and 1-day maximum, respectively. There was no temperature shift provided by mainstem NPV for segment 172 based on either criteria.

Hydroelectric facilities

As observed previously, more definable shifts in temperature were found based around the presence (or absence) of hydroelectric facilities (Table 10, Figures 30-31 following). Scenario 4.0 examined the effect of maintaining the current structure: upstream dam in place with existing upstream flow and temperatures, though with the downstream dam absent. For the Box Canyon section of the study area, in which segments 115 and 172 are located, Scenario 4 examines the affect of the absence of the Box Canyon facility on existing river temperatures (reaches above Box Canyon), assuming that the Albeni Falls facility remained in place. The results of these analyses are present in Table 10 and in the following series of figures.

For segment 115, the absence of the Box Canyon facility results in an overall decrease in the existing temperature condition by 0.22^{o}C (7-day average) to 0.27^{o}C (1-day average). Previously, through application of Washington's temperature criteria, the reduction for the Skookum reach (segment 115 defines the lower segment of the Skookum reach) was an average of 0.21^{o}C (Table 9). As was determined previously, this temperature reduction is large enough to result in the achievement of the temperature criteria.

While the absence of the Box Canyon facility decreases maximum temperatures at segment 115, the result is an increase at segment 172. A similar level of temperature shift is observed through the application of either criteria at approximately +0.26^{o}C. This result is also consistent with that observed previously where, based on the application of Washington's criteria, an increase of +0.44^{o}C was found

(2004). This temperature increase is due to shallower river depths as the backwater effect of Box Canyon is removed. The solar shortwave radiation load occurs within a decreased water depth resulting in the increased heating. The increase in heat is not significant enough to result in an exceedance of criteria (Figures 30-31).

Table 10. Average temperature s**hift (oC), relative to the existing condition, by scenario, for segments 115 and 172, 2004.** *Shift [(T_s-T_n) - (T_e-T_n)] considers the full temperature profile.*

Reach	Criteria	Modeling Scenarios*			
		No. 2.0 NPDES	No. 2.5 Tributary NPV	No. 7.0 Mainstem NPV	No. 4.0 Hydro-Facility
Skookum / Segment 115	7-day Average	0.00	-0.01	-0.01	-0.22
Middle / Segment 172		0.01	-0.05	0.00	0.26
Skookum / Segment 115	1-day Maximum	0.00	-0.01	-0.01	-0.27
Middle / Segment 172		0.00	-0.07	0.00	0.27

*

No. 2.0 = existing model run with the elimination of NPDES permit discharges.
No. 2.5 = existing model run with tributary inflow temperatures reflective of natural potential vegetation conditions.
No. 7.0 = existing model run with mainstem shade at natural potential vegetation conditions.
No. 4.0 = existing model run with Albeni Falls present though with Box Canyon absent – for Box Canyon reaches.
= existing model run with Box Canyon present though with Boundary absent – for Boundary reaches.

A negative entry indicates a reduction in river temperatures as a result of the scenario relative to the existing temperature structure.

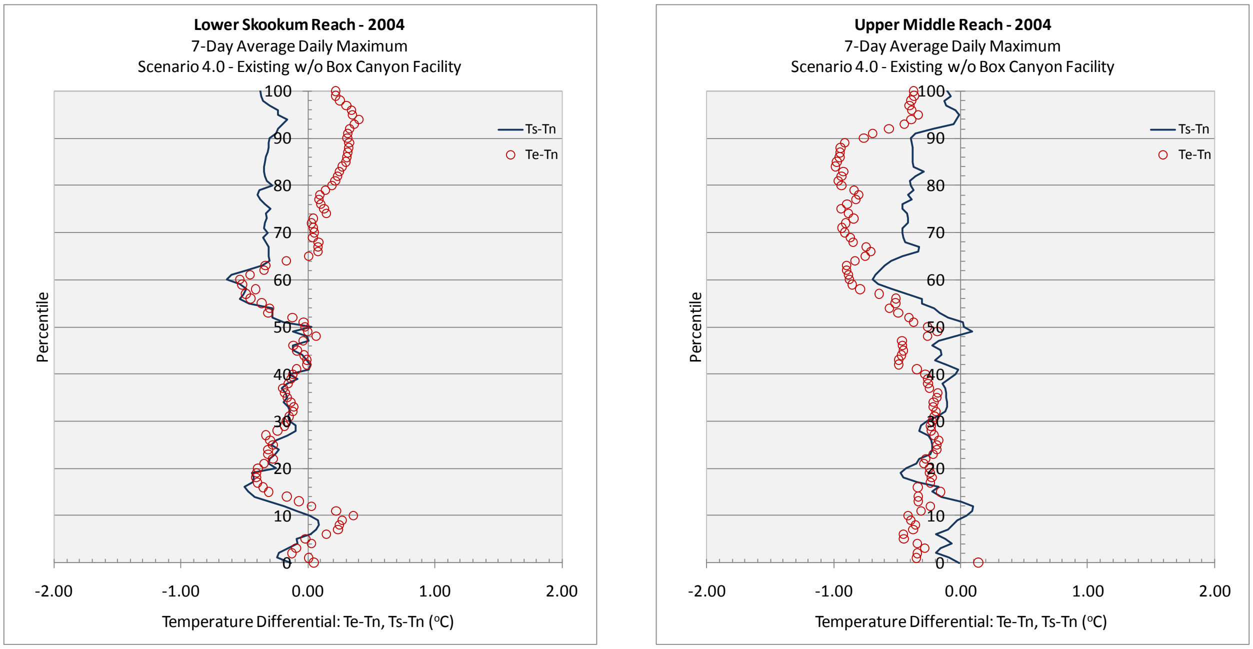


Figure 30. Comparison of the existing and Scenario 4.0 (Box Canyon removal) temperature conditions (2004) at segments 115 and 172 based on the 7-day average of the daily maximum temperatures.

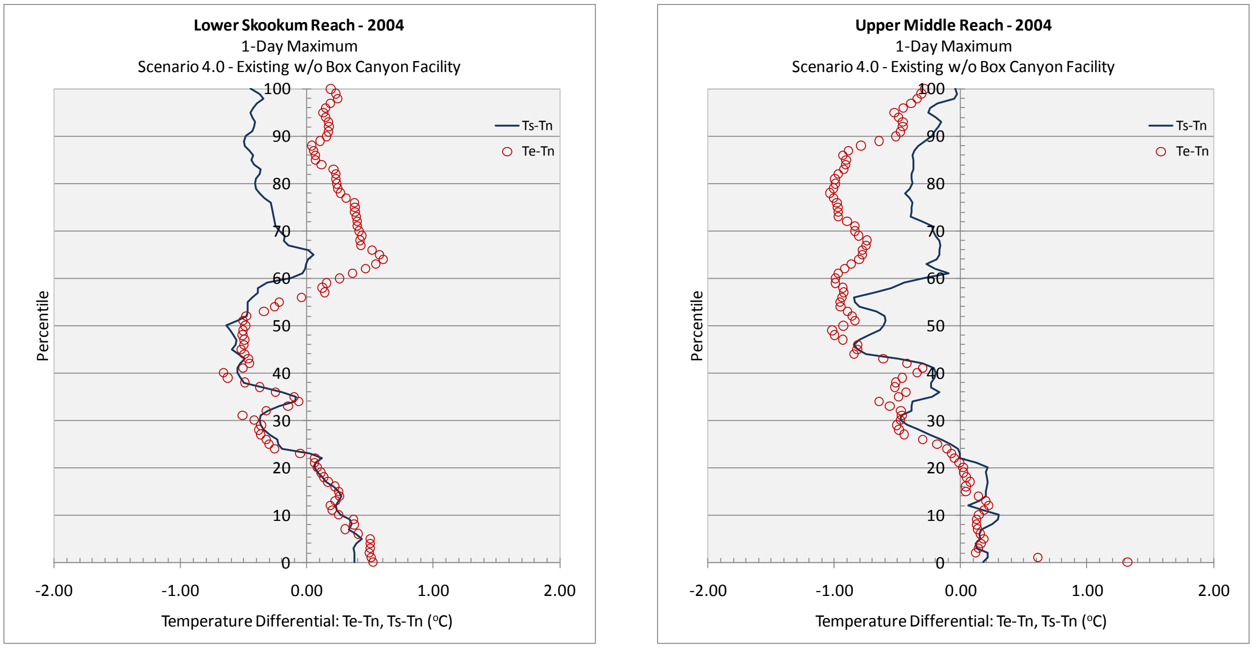


Figure 31. Comparison of the existing and Scenario 4.0 (Box Canyon removal) temperature conditions (2004) at segments 115 and 172 based on daily maximum temperatures.

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Loading Capacity

For water temperature, the loading capacity is the maximum amount of heat a water body can receive and still meet water quality standards. The loading capacity must ensure that standards are met regardless of seasonal variation and foreseeable increases in future loads. The loading capacity can be expressed as a heat load in kilocalories per day (kcal/day) through application of Equation 1.

Equation 1. The calculation of heat load in kilocalories (kcal) per day.

$$Heat\ Load\ \left(\frac{kcal}{day}\right) = T\ (°C) * Flow\ \left(\frac{m3}{s}\right) * \left(1000\frac{L}{m3}\right) * \left(\frac{Kcal}{L - °C}\right) * (86{,}400\ sec./day)$$

HL = Heat Load (kcal/d)
Q = Discharge (cubic meters per second)
T = Temperature (^{o}C)

** A kilocalorie (kcal) =energy needed to increase temperature of 1 kg (or 1 L) of water by 1^{o}C.*

In the case of the Pend Oreille River, this equation must be applied carefully, particularly when calculating and comparing heat loads representing the existing and natural conditions. This is because river hydraulics within the study area have been significantly altered as a result of the hydroelectric facilities. For this reason, the comparison between the natural and existing conditions based on their respective total discharges is not appropriate. Instead, comparisons should be made based on the flow within similar upper water column depths. Those depths, extending from the water surface, should be isothermal and not exceed a level beyond that found for the natural condition. Regardless, there are still complications to this approach in terms of fundamental differences in the heat budget characterizing each of these conditions.

Recognizing these differences, and to provide more meaningful and measurable pollutant loading targets, this TMDL applies *surrogate measures* other than applying daily heat loads. The United States Environmental Protection Agency (EPA) regulations allow other appropriate measures in a TMDL [40 CFR 130.2(i)]. The loading capacity for this TMDL follows from the water temperature criteria and analysis methods. Regarding maximum temperatures, the loading capacity is defined by a limit in the increase beyond the natural temperature condition (at any given percentile characterizing the natural condition) to a level equal to 0.3^{o}C. The natural condition is the same as that applied in this analysis for each reach in the Pend Oreille River using the 2004 condition as the reference. Therefore, the loading capacity for the Pend Oreille River is 0.3^{o}C based on a natural condition reference while considering cumulative temperature impacts. Following from the criteria, the summer critical period is defined (and when the loading capacity is applied) as timeframe when natural condition daily maximum temperatures exceeds 20^{o}C (generally July through August).

Similarly, for Part 2 of the criteria which addresses temperature increases outside the period when maximum temperatures occur, the loading capacity is defined by the maximum temperature increase allowed by the solution of $t = 34/(T + 9)$. This equation is also based on a natural temperature foundation defined by those occurring for the modeling year 2004. The critical period for Part 2 of the criteria (fall critical period) is when river temperatures are less than or equal to 20^{o}C, but greater than

12°C (generally September through October). The upper bound of 20°C follows from Part 1 of the special condition and the lower limit of 12°C is the temperature needed to protect bull trout in the river.

The loading capacity will defer to the Washington State criteria as opposed to designating entirely separate ones based on the Kalispel tribal criteria. This is because this TMDL only applies to Washington State waters. Moreover, the application of both Washington State and Kalispel tribal criteria to Pend Oreille River temperatures identified similar heating patterns in the coincidental reaches and segments examined.

Load and Wasteload Allocations

Table 11 provides a summary of the reaches exceeding temperature criteria. To meet water quality standards during the summer critical period, 0.3°C above natural condition temperatures must be divided among the various sources. During the fall critical period, a reduction in temperature is assigned for the reaches exceeding Part 2 of the criteria. Ecology expects the allocations will reduce river temperatures so that all reaches with exceedences in Table 11 will meet the standard.

Table 11. Pend Oreille River reaches examined and their compliance with Parts 1 and 2 of the Washington State temperature criteria.

Criteria	Reach	River Mile Segment	Criteria Met		Level of Criteria Exceedance (°C)*	
			2004	2005	2004	2005
Part 1– Washington State Pend Oreille River Temperature Criteria	Newport	88.0 - 84.4	Yes	Yes	==	==
	Dalkena	84.3 – 77.0	Yes	Yes	==	==
	Skookum	76.8 – 72.4	No	No	0.21°C	0.20°C
	Kalispel	72.3 – 63.7	Yes	Yes	==	==
	Middle	63.6 – 56.1	Yes	Yes	==	==
	Blueslide	56.0 – 47.7	Yes	Yes	==	==
	Tiger	47.6 – 36.4	No	No	0.44°C	0.51°C
	Box Canyon Forebay	36.2 – 34.6	No	No	0.95°C	0.93°C
	Metaline	34.4 – 27.1	No	No	0.58°C	0.17°C
	Slate	26.9 – 19.6	No	No	0.45°C	0.19°C
	Boundary Forebay	19.5 – 17.1	No	No	0.70°C	0.47°C
	Boundary Tailrace	16.8 – 16.2	No	No	0.53°C	0.27°C
Part 2– Washington State Pend Oreille River Temperature Criteria	Newport	88.0 - 84.4	Yes	Yes	==	==
	Dalkena	84.3 – 77.0	Yes	Yes	==	==
	Skookum	76.8 – 72.4	Yes	Yes	==	==
	Kalispel	72.3 – 63.7	Yes	Yes	==	==
	Middle	63.6 – 56.1	Yes	Yes	==	==
	Blueslide	56.0 – 47.7	Yes	Yes	==	==
	Tiger	47.6 – 36.4	Yes	Yes	==	==
	Box Canyon Forebay	36.2 – 34.6	Yes	Yes	==	==
	Metaline	34.4 – 27.1	No	No	0.14°C	==
	Slate	26.9 – 19.6	No	No	0.24°C	==
	Boundary Forebay	19.5 – 17.1	No	No	0.61°C	==
	Boundary Tailrace	16.8 – 16.2	No	No	0.53°C	==

* The level of exceedence listed, for each reach, indicates the temperature extension beyond the relevant criteria; 0.3°C for part 1 and the allowable temperature increase for part 2.

Idaho-Washington Stateline

Ecology developed an assumption for the summer critical period at the state line. The assumption is that existing river temperatures will continue to be cooler now than under natural conditions. Ecology assumes river temperatures entering Washington at the Idaho-Washington state line will be consistent with 2004 observed temperatures during low flow and warm weather conditions (Figure 32). The state line assumption provides a baseline for establishing allocations downstream. Therefore, Ecology is not assigning a portion of the 0.3°C allowance to the state line during the summer critical period. An assumption during the fall critical period is not required.

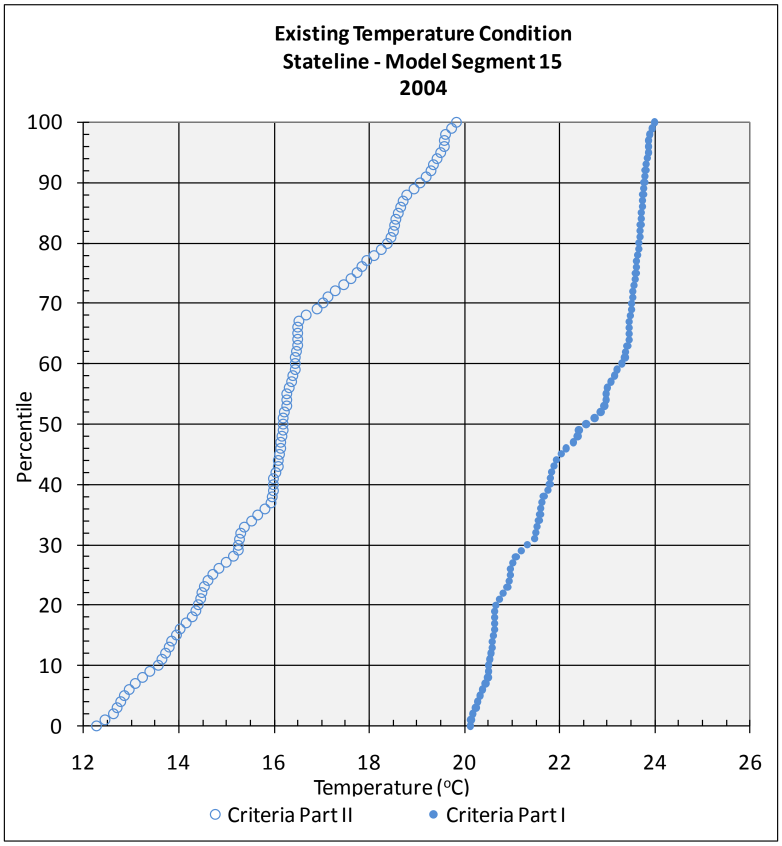

Figure 32. The cumulative frequency distribution of existing water temperatures observed at the stateline (model segment 15) in 2004. *Analysis based on the application of Parts 1 and 2 of the temperature criteria.*

Wasteload allocations

NPDES permitted facilities

Table 3 lists the seven facilities regulated by NPDES permits within the study area. As discussed previously, the Department of Ecology found that cumulatively these point sources have very little impact to the temperature of the Pend Oreille River. This is due to the fact that they have very small flow levels in comparison to those of the river. Of the seven facilities in Washington with NPDES permits, only four are receiving wasteload allocations during the summer critical period: the city of Newport, Ponderay Newsprint, the town of Ione, and the Pend Oreille Mine. The other three (the Selkirk School District and the towns Metaline and Metaline Falls) do not require wasteload allocations. The Selkirk School District is not in session during the summer critical period and only discharges to the river from September through June; the town of Metaline discharges to a wetland which is not directly connected to the river; and the town of Metaline Falls discharges to Sullivan Creek outside the critical period from November through May.

Because the four facilities receiving wasteload allocations have minimal impact to Pend Oreille River temperatures, no reductions are required and a portion of the 0.3°C is not being assigned. However, wasteload allocations are assigned to protect against future increases. Wasteload allocations for all four facilities are current operating conditions, which is characterized by heat loads and end-of-pipe temperatures listed in Table 12. Heat loads were calculated using Equation 2. An uncertainty factor of 1.1 was applied to the municipal permittees because of the uncertainty in the regressions used to calculate the wasteload allocations. The wasteload allocations apply throughout the summer critical period.

Table 12. Current operating conditions for the NPDES permittees.

Facility	Flow (m^3/s)	Temperature (°C)	Uncertainty Factor	Daily Wasteload allocation (10^6 kcal/day)	Critical Period	
					Summer	Fall
Newport wastewater treatment plant	0.022	22.9	1.1	47.6	x	
Ponderay Newsprint Company	0.228	32.2	1.0	635.0	x	
Ione wastewater treatment plant	0.009	22.9	1.1	20.5	x	
Pend Oreille Mine (Teck Cominco)	0.063	22.3	1.0	121.56	x	x
Selkirk High School	0.0002	19.0	1.1	0.40		x

Equation 2. Calculation of daily heat load for discharging NPDES sources in Washington.

$$\text{Heat Load}\ \frac{\text{kcal}}{\text{day}} = \text{Flow}\ \frac{\text{meter}^3}{\text{second}} \times \text{max seasonal temp} \times \text{uncertainty factor} \times \frac{1000\ \text{liters}}{\text{meter}^3} \times \frac{1\ \text{kcal}}{\text{liter}} \times \frac{86{,}400\ \text{seconds}}{\text{day}}$$

where: 1.1 is 110% of the seasonal maximum temperature to account for uncertainty in regressions for municipal permitees

As discussed earlier, the analysis of Part 2 of the criteria showed that the only reaches found to be impaired during the fall critical period (September through October) are Metaline, Slate, Boundary Forebay, and Boundary tailrace. Only the Metaline reach receives discharge from NPDES permitted facilities:

- Selkirk High School
- Pend Oreille Mine
- Metaline Falls (discharges to Sullivan Creek)

However, only the Pend Oreille Mine and Selkirk High School discharge during the September through October fall critical period. As stated above, Metaline Falls discharges November through May and does not require a wasteload allocation for the fall critical period. Due to the small volume of flow from these facilities relative to the flow in the Pend Oreille River and the dominant effect of stored heat in the reservoir, the wasteload allocation for the fall critical period (September through October) for the Pend Oreille Mine and Selkirk High School is current operating conditions (Table 12).

Storm water permits

Phase II storm water permits are not required for Pend Oreille County or cities and towns in the watershed. Therefore, wasteload allocations for Phase II storm water are not included in this TMDL for either Part 1 or Part 2 of the criteria. Similarly, wasteload allocations for construction and industrial stormwater are not specified. However, a portion of the reserve (see below) may be used for activities generating stormwater when temperatures are above 20°C.

Load allocations

Mainstem shading

The load allocation, or expectation for vegetative shading along the Pend Oreille River's riparian corridor, is that provided by natural potential vegetation. This load allocation applies all year long to comply with both parts of the temperature criteria. The required level of riparian vegetative growth will produce the shade needed to reduce temperatures near the shores and protect cool water refuge. The potential natural vegetation is characterized by the average increase needed in canopy cover and tree height for the right and left banks for each of the 12 river reaches (Table 13). Establishing allocations for each reach and shoreline ensures that activities to reduce water temperature will occur along both sides of the entire river and not just at the point of maximum impairment.

Analysis results indicate that shade produced from potential natural vegetation only slightly lowers the river's temperature. This result is not unexpected given the width of the Pend Oreille River. Even the shade provided by optimal vegetative growth is not enough to extend beyond its margins. The CE-QUAL-W2 model applied in this study averages temperatures across the width of the river. Therefore, temperature reductions along the shores from an increase in shade are unknown but are likely to occur.

Because the loading capacity is 0.3°C above natural conditions, and the allocation for mainstem shade is for potential natural vegetation (i.e. natural conditions), a portion of the 0.3°C load capacity is not assigned to mainstem shading.

The reason for mainstem shade allocations has to do with providing for a margin of safety to the overall load capacity, recognizing a certain level of analysis uncertainty. In addition, achievement of potential natural vegetation conditions in the riparian corridor will help to reduce temperatures in other ways. For example, riparian plants reduce the amount of sediment that enters the river. Sediment increases water temperature by absorbing heat from the sun as well as reducing the depth of the river. In addition, the shade from potential natural vegetation will help maintain cool water inputs into the river from tributaries and springs. These cool water inputs are important for bull trout and other fish species seeking refuge from high water temperatures. Also, increased mainstem shade levels provides for natural resource benefits.

Table 13. Increases required in canopy cover (%) and vegetation heights (feet) for Pend Oreille River reaches in Washington.

Pend Oreille River Reach	Potential Natural Vegetation Canopy Cover (%)		Average Needed Increase in Canopy Cover (%)		Potential Natural Vegetation Tree Height (feet)		Average Needed Increase in Tree Height (feet)		2008 303(d) List ID Numbers	2008 Cat 2 Listings
	West side (LB)[1]	East side (RB)[2]	West side (LB)[1]	East side (RB)[2]	West side (LB)[1]	East side (RB)[2]	West side (LB)[1]	East side (RB)[2]		
Newport	82.8	76.2	13.0	3.0	89.0	87.8	34.9	36.7	8617 48297 48352	---
Dalkena	80.6	78.8	6.2	4.0	88.7	88.1	36.1	56.3	48350 48351	---
Skookum	82.9	77.0	9.1	2.5	88.6	87.9	54.3	58.1	48349	---
Kalispel[3]	81.6	77.5	7.4	1.8	88.1	87.6	70.7	59.4	48347 48348	8616
Middle	84.8	81.8	12.1	6.2	89.3	88.3	45.5	52.5	48346*	8614
Blueslide	87.6	80.7	15.0	4.9	89.6	88.7	32.7	39.5	48345	---
Tiger	86.2	82.2	18.7	8.4	89.2	88.9	55.0	38.7	8610 48386	8612
Box Canyon Forebay	80.3	81.6	11.0	4.4	89.3	88.5	26.0	32.6	42513	---
Metaline	85.1	82.7	19.8	8.6	89.8	89.4	39.7	32.4	11452 42512	---
Slate	83.6	83.5	8.7	6.3	89.2	89.8	26.0	24.0	-	---
Boundary Forebay	81.4	84.0	10.6	8.4	89.2	89.5	32.3	21.9	42515	---
Boundary Tailrace	85.0	85.2	6.4	7.9	88.5	89.0	54.5	37.0	43539	---

[1] *LB = left bank looking downstream*
[2] *RB = right bank looking downstream*
[3] *Shared waters of Kalispel Tribe and State of Washington.*
* *Listing ID 48925 has been rolled into Listing ID 48346 because they were duplicate listings.*

Tributary shading

Tributary shade targets have also been determined for all identified major tributaries (except Calispell Creek): 18 tributaries to the Box Canyon reservoir and 4 tributaries to the Boundary reservoir. The targets are based on maximum shade or potential natural vegetation, which is necessary to meet the water quality standards for individual tributaries (Table 14). Tributaries in this TMDL have targets established to address current 303(d) listings and impairments. However, some tributaries have allocations already set under the EPA-approved Colville National Forest TMDL (http://www.ecy.wa.gov/pubs/0510047.pdf), but those allocations only apply within the national forest.

This TMDL is intended to address all 303(d) listed tributaries included in Table 1. Also included are several tributaries not currently included on Washington's 303(d) list though determined during this study to not meet temperature criteria. Load allocations were determined by setting shade levels equal to potential natural vegetation. The exception among the Pend Oreille River tributaries to receive a shade allocation is Calispell Creek because a separate modeling effort occurred on Calispell Creek.

Table 14. Shade allocations for impaired tributaries to the Pend Oreille River.

Water Body		Load Allocation (Potential Natural Vegetation) (%)	Increased Shade Required (%)	2008 303(d) List ID Numbers	2008 Cat 2 Listings (waters of concern)
Pend Oreille TMDL	Indian Creek	91	6	Impaired	---
	NF Skookum Creek	85	5	Impaired	---
	Cee Cee Ah Creek[1]	77	7	Impaired	---
	Mill Creek	88	3	Impaired	---
	LeClerc Creek	43	8	Impaired	---
	East Branch LeClerc Creek (lower)	91	56	21710	---
	East Branch LeClerc Creek (upper)	90	25	21711	---
	West Branch LeClerc Creek	82	27	---	21842
	Lost Creek	60	30	21717	---
	Little Muddy Creek	67	7	21715	---
	Cedar Creek	79	28	38212	8594
	Smalle Creek	82	15	21837	---
	Smalle Creek, E.F.	82	15	---	38324
Colville Forest TMDL*	Tacoma Creek	81	11	---	---
	Cusick Creek	82	29	---	---
	Ruby Creek	83	23	---	---
	SF Lost Creek	83	13	---	---
	Big Muddy Creek	82	7	---	---
	Sullivan Creek	64	39	---	---
	Slate Creek	78	0	---	---
	Lime Creek	97	9	---	---
	Flume Creek	85	0	---	---

[1]*Shared waters of Kalispel Tribe and state of Washington. All other tributaries are state only.*
** Established by the Colville National Forest TMDL, these allocations only apply in the national forest.*

Part 2 of the temperature criteria only applies to the Pend Oreille River so allocations under 20^{o}C are not required on the tributaries.

Hydroelectric facilities

Study results indicate that the operations of the Pend Oreille Public Utility District's Box Canyon Dam and Seattle City Light's Boundary Dam are associated with increased heat loads in the Pend Oreille River. In both cases the increase is significant enough to result in the exceedance of the Pend Oreille River temperature criteria. Among the 12 river reaches examined as part of this study, the forebays of both facilities had the greatest level of temperature exceedance. The highest maximum temperatures were observed at the Box Canyon forebay where temperatures were found to chronically exceed the criteria throughout the maximum range examined. In comparison, maximum temperatures observed at the Boundary forebay were less chronically elevated, though it appears that the facility is the beneficiary of proximity.

The discharge of cooler subsurface water from Box Canyon's forebay downstream (following power generation) results in reducing the highest range of maximum temperatures in the Boundary reaches. However, this same discharge dynamic from Box Canyon maintains warmer temperatures later into the summer when the river naturally cooled at a faster rate. For this reason, the Boundary reaches exceed the temperature criteria within the lower range in maximum temperatures, as opposed to Box Canyon which exceeds criteria through the full spectrum of maximum temperatures observed. Despite Box Canyon's significant influence on the heating dynamics observed in the Boundary reaches, the Boundary facility was also found to contribute to the heating within its forebay. So, the temperature impacts observed in the Boundary reaches are associated with the combined operations of the Box Canyon and Boundary facilities resulting in a complex relationship.

Given the interrelationship in the temperature impacts of Box Canyon and Boundary facilities and their associated cumulative impacts, the load allocations have been set equivalently for both at 0.12^{o}C above the natural temperature condition. This totals 0.24^{o}C of the 0.3^{o}C allowance, which is the greatest equitable temperature that leaves a sufficient temperature reserve for future economic growth in the watershed. Based on the forebays, the most impacted reaches within the study area, 2004 results indicate that the level of temperature reduction required to achieve this load allocation for Box Canyon and Boundary is 1.13^{o}C and 0.76^{o}C, respectively (Table 15).

The 1.13^{o}C temperature reduction target for the Box Canyon Dam forebay is derived by taking the 1.25^{o}C maximum temperature differential for the Box Canyon Forebay from Table 6 and subtracting 0.12^{o}C.

The 0.76^{o}C temperature reduction target for the Boundary Dam forebay is calculated by subtracting 0.12^{o}C for the PUD's allocation and 0.12$_{o}$C for SCL's allocation from the 1.00^{o}C maximum temperature differential for the Boundary Forebay in Table 6. [Boundary forebay maximum impairment (1.00^{o}C), minus the PUD's allocation that is passed downstream (0.12^{o}C), minus SCL's allocation (0.12^{o}C), equals the temperature reduction required in the Boundary forebay (0.76^{o}C).]

Study results indicate that the criteria exceedances observed in the Skookum and Tiger reaches are associated with the operation of the Box Canyon facility, so an allocation is not required for either reach. To achieve water quality standards in the forebays, Ecology anticipates measures, actions, and efforts will need to be taken or made throughout the reservoirs and in the tributaries. Table 11 along with the mainstem shade and tributary allocations can be used to guide where implementation activities should occur in the watershed. So, by taking actions to reduce temperatures along the entire river and in the tributaries, impairments in the forebays and upstream reaches will be addressed.

Part 2 of the temperature criteria for the Pend Oreille River was exceeded for each of the Boundary reaches at varying levels. While, in some cases, the criteria was exceeded at varying times and temperature conditions, the allocations specified and, therefore, the temperature reduction required, are based on the greatest observed excursion between the existing and natural temperature conditions and those determined based on an allowable temperature increase limit. To achieve the load allocation, the level of temperature reduction required for Metaline is a reduction of 0.14^{o}C, Slate (0.24^{o}C), Boundary forebay (0.61^{o}C), and for the tailrace (0.53^{o}C) (Table 15). The hydroelectric facilities are the biggest contributor of heat during the fall critical period, and equally share the temperature reductions needed to achieve the Part 2 allocations in each reach. Ecology believes that all activities completed to reduce water temperatures will cumulatively help achieve these temperature reductions.

Compliance at the Kalispel Tribe Reservation

To achieve compliance with the Kalispel Tribe's criteria, the one-day temperature maximum needs to be reduced by 0.27°C, and the seven-day average maximum temperature must be reduced by 0.22°C at segment 115 or river mile 72.4 (see Table 10). As stated above, these reductions are expected to occur through efforts to achieve the load allocation for the Box Canyon Dam forebay. However, Ecology will work to ensure that implementation activities occur within the Skookum reach so that the Tribe's criteria are met.

Reserve capacity for future growth

The load capacity reserve is 0.06°C. This reserve is what remains of the loading capacity after the 0.12°C allocations for each Box Canyon and Boundary dams is subtracted. Ecology established this reserve capacity to account for future growth of the towns or businesses within the study area. Any future NPDES discharges to the Pend Oreille River in Washington will be allocated a portion of this reserve capacity. No reserve capacity is allocated to nonpoint sources or to the dams.

Table 15. Hydroelectric facilities load allocations.

Reaches Requiring Temperature Reductions		Temperature Reduction Level Required to Achieve Criteria	
		Part 1 **Natural Condition + 0.12°C** **Summer Critical Period (July – August)**	**Part 2** **Fall Critical Period (September – October)**
Box Canyon	Box Canyon Forebay	1.13°C	=====
Boundary	Metaline	====	0.14°C
	Slate	====	0.24°C
	Forebay	0.76°C	0.61°C
	Tailrace	====	0.53°C

Seasonal Variation

Seasonal variation is accounted for in this TMDL through the use of daily maximum temperatures for 2004 and most of 2005. In addition, the assessment of the Pend Oreille River's special temperature criteria required that the analysis address seasonal variation. The criteria have two parts: one applying during the period that peak temperatures occur, and the other outside of this season peak.

Margin of Safety

This TMDL incorporates an implicit margin of safety through conservative model assumptions and standard interpretation. The two model years (2004 and 2005) were evaluated for flow and weather conditions and represent a hot weather/low flow year, and a median year. Compliance under the conditions represented by these two years will ensure compliance in other years of differing weather and hydrology. However, the 2004 data set was used to set allocations because the conditions in 2004 were more extreme than in 2005, resulting in more conservative load allocations. Further, compliance was evaluated for over 600 individual dates during those two years and for all segments in the model, with a detailed analysis to determine critical locations for compliance. This ensures that compliance with the TMDL allocations will ensure compliance in all locations. The resulting TMDL allocations are based on the maximum temperature in the water column, which ensures compliance at all locations in the water column.

Margin of safety for the tributaries is provided implicitly through collecting data during hot weather and low flow conditions, using a conservative analysis, and setting allocations equivalent to natural conditions. Ecology collected data under conditions equivalent to 7-day low flows during July and August with a recurrence interval of 10 years (7Q10). The improvement from a restored riparian area would also create a microclimate effect that reduces air temperatures near the stream and moderates daily stream temperature patterns as well as potentially shallower and narrower stream channels; however, Ecology did not include these factors into our analysis. Finally, Ecology set allocations for the tributaries equivalent to natural potential vegetation, which would produce the maximum shade that could exist on the tributaries. Together these conservative assumptions will protect tributary temperatures under reasonable worst-case conditions.

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Reasonable Assurance

When establishing a TMDL, reductions of a particular pollutant are allocated among the pollutant sources (both point and nonpoint sources) in the water body. For the Pend Oreille River temperature TMDL, both point and nonpoint sources exist. TMDLs (and related action plans) must show "reasonable assurance" that these sources will be reduced to their allocated amount. However in this TMDL, point sources were not given less stringent wasteload allocations based upon the assumption that nonpoint source reductions would occur. Rather, Ecology assigned allocations to the point sources for current operating conditions even though the analysis showed they did not contribute to heating the river.

Ecology believes the following activities already support this TMDL and will add to the assurance that water temperature in the Pend Oreille River will meet Washington State water quality standards. Education, outreach, technical and financial assistance, FERC license and permit administration, and enforcement will all be used to ensure that the goals of this water quality improvement report will be met. Ecology assumes that the activities described below and included in the FERC licenses for Boundary and Box Canyon dams will be continued and maintained.

The goal of the Pend Oreille River Temperature TMDL is for the waters of the basin to meet the state's water quality standards. There is considerable interest and local involvement toward identifying and resolving water quality problems in the Pend Oreille River. Numerous organizations and agencies are already engaged in stream restoration and source correction actions that will help resolve any temperature problem. The following activities will help provide reasonable assurance that the Pend Oreille River point and nonpoint source TMDL goals will be met by the dates identified in Table 16 under "What is the schedule for achieving water quality standards."

- Federal Energy Regulatory Commission (FERC) reissued the Pend Oreille Public Utility District's (PUD) license in July 2005 for a period of fifty years. The 401 water quality certification as part of that license states that "…the provisions of the TMDL implementation plans…shall supersede the conditions of this order." License conditions are mandatory and enforced by FERC. The license includes water quality, shoreline and erosion management plans. More information about the PUD's new FERC license for Box Canyon Dam and the management plans is available at: www.popud.com/license.htm.

- Seattle City Light is in the process of relicensing Boundary Dam. Seattle City Light worked with Ecology and other agencies on a comprehensive settlement agreement package which was sent to FERC. For more information about Seattle City Light's relicensing efforts see www.seattle.gov/light/News/Issues/BndryRelic/.

- Ecology writes the 401 water quality certification that is a component of FERC licenses. The 401 sets conditions that ensure water quality standards will be met. One condition within the 401 is that the dams can have up to a ten year compliance schedule [WAC 173-201A-510(5)]. The dam compliance schedule requirements and the adaptive management process included in the 401 certification provide reasonable assurance that water quality standards will be met.

- Kalispel Tribe's Natural Resources Department conducted a study on fish populations in the Box Canyon reach and habitat surveys on East Fork Smalle Creek. The Tribe has a history of completing or assisting with several riparian and wetland enhancement projects. In addition, the Tribe maintains an extensive water quality monitoring program in the Pend Oreille River and several tributaries. For more information about the Tribe's Natural Resources Department visit www.kalispeltribe.com/fisheries-and-water-resources-division/.

- The Pend Oreille Conservation District (POCD)* is providing technical and financial assistance for riparian buffers along the Pend Oreille River and its tributaries. Since the spring of 2007, POCD has assisted in several riparian restoration projects/buffers totaling approximately 12,000 plants, trees and shrubs on nearly twelve hundred feet of river bank at several different locations. Once established, these planting projects will aid in the decrease of non-point source pollution and provide habitat to both fish and wildlife. In addition to creating shade, these plantings will address temperature by reducing the amount of other pollutants entering the water, such as sediment. The conservation district offers educational opportunities on the importance of riparian buffers. Educational events include public meetings, workshops and three annual conservation-related events held for school-aged children within the county. Additional information about the conservation district can be found at www.pocd.org.

  **As of Jan. 1, 2011, the POCD office is closed due to funding shortages, but the Board of Supervisors is operating the District on a limited basis. The goal is to search for and obtain funding in order to re-staff the office.*

- The WRIA 62 planning unit* envisioned completing several implementation projects related to water quality, such as a riverbank stabilization demonstration site on the Pend Oreille River, bank stabilization workshops, milfoil eradication from Tiger Inlet, milfoil research and funding for a state-certified water quality lab in Selkirk High School, to name a few.

  **The Planning Unit completed their mandated tasks and is no longer a formal group. However, the Pend Oreille Watershed Roundtable is an offshoot of the Planning Unit and is interested in educating the public about water related issues.*

- Ecology typically includes wasteload allocations into NPDES permits when they are reissued. Reasonable assurance that the wasteload allocations will be achieved is provided by Ecology reissuing and enforcing the NPDES permits.

While Ecology is authorized under Chapter 90.48 RCW to impose strict requirements or issue enforcement actions to achieve compliance with Washington State water quality standards, it is the goal of all participants in the Pend Oreille River TMDL process to achieve clean water through voluntary control actions. Ecology will consider and issue notices of noncompliance in accordance with the Regulatory Reform Act in situations where the cause or contribution to the cause of noncompliance with load allocations can be established.

Implementation Strategy

Introduction

This implementation strategy describes what will be done to improve water quality. It explains the roles and authorities of cleanup partners (those organizations with jurisdiction, authority, or direct responsibility for cleanup), along with the programs or other means through which they will address these water quality issues.

The following pages include:

- Potential actions to improve water quality.
- Recommended monitoring activities to track progress toward meeting allocations.
- Potential funding sources to help implement the activities.
- Steps taken to involve and inform the public about the TMDL.

This implementation strategy was developed jointly through a collaborative process involving the Pend Oreille River watershed advisory group (WAG), landowners, land managers, and responsible resource agencies.

This implementation strategy provides a non-exclusive menu of options for organizations to consider for improving water quality. After the U.S. Environmental Protection Agency (EPA) approves this TMDL, interested and responsible parties will work together to develop a *water quality implementation plan* (WQIP). (The implementation plan is usually developed within one year after EPA approves the TMDL.) The WQIP will build upon this implementation strategy and will describe and prioritize specific actions organizations anticipate completing to help reduce the water temperature.

What needs to be done?

Since the TMDL assigned different allocations depending upon the heating source, each category requires a distinct set of implementation actions.

Point sources

A facility, such as a city wastewater treatment plant, or a manufacturing plant that discharges effluent through a pipe into surface water, is called a point source. Table 16 lists all the point sources in the Pend Oreille watershed. Point sources receive wasteload allocations in TMDLs.

The entities that discharge treated wastewater into the Pend Oreille River receive National Pollutant Discharge Elimination System (NPDES) permits, which are reissued every five years. The wasteload allocation for each entity will be inserted into their NPDES permit when they are reissued (the next permit cycle). The point sources are required to meet their wasteload allocations upon the finalization of their reissued permit. However, because the wasteload allocations are based on current operating conditions, the point sources are already in compliance.

As described earlier, the temperatures of the municipal wastewater treatment plants' effluent used in the analysis were calculated from regression analyses. To verify the calculated effluent temperatures, the wastewater treatment plants will collect temperature data for all days they discharge during the summer and fall critical periods for the duration of their current, or soon to be re-issued, NPDES permit. Ecology will evaluate the data. If the calculated temperatures and loads listed in Table 11 are not reflective of actual operating conditions, Table 11 will be updated with any necessary changes.

Table 16. NPDES permit holders in the watershed.

Point Source	Permit Number	Expiration Date
Ione*	WA0045373	05/31/2013
Metaline Falls	WA0021156	10/15/08 (in process of re-issuing)
Metaline	WA0020699	06/30/2014
Newport*	WA0022322	4/30/2013
Ponderay Newsprint Company*	WA0045268	5/13/12
Selkirk School District #70	WA0044938	3/31/07 (in process of re-issuing)
Teck Cominco (Pend Oreille Mine)*	WA0001317	5/31/09 (extended until TMDL approved)

* NPDES permit holders receiving wasteload allocations in this TMDL

Nonpoint sources

Nonpoint sources are dispersed throughout a watershed and enter surface water through several different pathways. Daily human activities can cause nonpoint pollution. Nonpoint sources receive load allocations in TMDLs. For this temperature TMDL, nonpoint sources include human activities that reduce vegetation along the river and its tributaries, which increase the amount of sunlight reaching the water surface. The dams are also included in this category. The following paragraphs discuss some actions the utilities and individuals may take to address the temperature impacts from nonpoint sources.

Box Canyon and Boundary dams

In this TMDL, Box Canyon and Boundary dams will receive a load allocation. The Pend Oreille Public Utility District (PUD) and Seattle City Light are not required to have an NPDES permit to operate their dams. Instead, Ecology, acting upon delegated authority under Section 401 of the federal Clean Water Act, writes the 401 certification for non-federal dams. Ecology's 401 certification is specific for each dam and becomes part of the federal Energy Regulatory Commission (FERC) license. Therefore, actions the Pend Oreille PUD and Seattle City Light will take to meet water quality standards for their dams will be a condition of their respective FERC licenses. Ecology requires non-federal dams to comply with the provisions of their 401 certification and oversees the utilities' progress. 401 certifications are subject to amendment or change if water quality standards or TMDLs are revised.

The Pend Oreille PUD received their 401 certification from Ecology in 2003 and a new FERC license for Box Canyon Dam in July 2005. A condition of the Pend Oreille PUD's 401 certification states that the provisions in the TMDL's WQIP will supersede the water temperature conditions in their 401 certification.

Seattle City Light is in the process of relicensing Boundary Dam (the license expires in 2011). Therefore, any provisions needed to comply with this TMDL will be incorporated into Seattle City Light's 401 water quality certification.

The approach the Pend Oreille PUD and Seattle City Light will use to meet the load allocations in this TMDL will be consistent with requirements found in the state water quality standards [Washington Administrative Code (WAC) 173-201A-510(5)], which assigns a ten-year compliance schedule to dams. This rule requires dam owners to develop a water quality attainment plan. The water quality attainment plan provides a detailed approach for achieving compliance and must contain five elements specific to temperature:

- A schedule to achieve compliance that does not exceed ten years.
- The identification of all reasonable and feasible improvements that could be used to meet standards, or if meeting the standards is not attainable, then achieve the highest attainable level of improvement.
- A description of the methods used to evaluate the reasonable and feasible improvements.
- A plan to conduct water quality monitoring after activities are implemented with appropriate adaptive management steps.
- The benchmarks and reporting requirements that will be used to track the progress of implementing the water quality attainment plan and meeting water quality standards.

When developing a water quality attainment plan, the Pend Oreille PUD and Seattle City Light will collaborate with the Kalispel Tribe (Tribe), Washington State Department of Fish and Wildlife, Ecology, and others. The water quality attainment plan must provide assurances that all applicable water quality standards and load allocations set in this TMDL will be met. In addition, the 401 certification also requires that there be reasonable assurance that the owner of the dam will meet water quality standards. Reasonable assurance that water quality criteria will be achieved is provided by the approach outlined in WAC 173-201A-510(5), because it includes implementing a compliance schedule and other 401 requirements, conducting effectiveness monitoring, and applying adaptive management when necessary.

To meet the allocations in the dam forebays, Ecology suggests implementing measures in all reaches or along the entire length of the reservoirs. Examples of measures that might be considered reasonable and achievable are tributary habitat enhancement and shoreline and tributary shading. Dam construction raised the surface elevation of the Pend Oreille River in some locations. This resulted in flooding portions of the mouths of certain tributaries to the river. Tributary mouths provide important habitat for fish and other aquatic life. These mouths are important areas to focus on when trying to improve the water quality of reservoirs. Other actions the dam owners may examine in the reasonable/feasible analysis may include engineering and operational modifications that could improve water quality.

After the Water Quality Attainment Plan is implemented, Ecology and the dam operator will decide what the next steps are (whether completed actions meet water quality standards; another compliance schedule is appropriate; or surface water quality standards should be changed). If after the Pend Oreille PUD or Seattle City Light complete all reasonable and feasible improvements under WAC 173-201A-510(5)(g), and their load allocation is still not met by the timeline set in this TMDL, then the dam owner would take the following steps to achieve compliance with the standards:

- Evaluate new reasonable and feasible technologies or other options.
- Develop a new compliance schedule to evaluate and incorporate any new technology.
- If no new reasonable and feasible technologies are identified, propose other alternatives as allowed by WAC173-201A-510.

Pend Oreille River and tributaries up to the Colville National Forest boundary

Increasing the amount of mature, natural riparian vegetation is the most important, easy, and effective tool to reduce temperatures of most streams. Mature riparian trees and shrubs are important because the shade they provide blocks the amount of sunlight that heats the water. Riparian buffers that contain a variety of native trees, shrubs, and grasses may help to decrease water temperature in other ways, such as:

- Reducing the amount of erosion from (or increasing stability of) stream banks. The roots of the riparian vegetation act as a web that holds the soil in place. So, the amount of suspended sediment that can contribute to heating the water is reduced.
- Helping runoff and rain water infiltrate into the ground, which helps cool streams when it re-enters as ground water. This increase in ground water is important to maintain stream flows into the summer months.
- Maintaining narrow and deep tributary channels so that there is a reduced amount of stream surface subjected to solar heating.
- Increasing channel roughness, which increases the diversity of habitat types in stream channels and helps to create cold water refuge.

Planting vegetation along streams is needed to create shade and reduce the impact direct sunlight has on increasing stream temperatures. So, landowners with property along the Pend Oreille River and tributaries need to establish or augment mature riparian vegetation. Although riparian shading will have a greater impact on tributary streams than on the Pend Oreille River due to its width, some cooling may be achieved along the stream banks. Cooling along the stream banks may help provide additional habitat for temperature-sensitive fish, such as bull trout. Where riparian trees and shrubs exist, it is important to protect them and the amount of shade they provide. For example, trees and shrubs providing shade to streams need to be avoided during timber harvest activities.

Forestry

Timber harvest in riparian corridors on private and state forestlands is regulated by the Washington State Department of Natural Resources (DNR). Applying these regulations is an important component of implementing the TMDL, because they protect the trees that provide existing shade. The next several paragraphs provide information about the state's forest practices regulations, how they will be relied upon to implement the TMDL on private and state forestlands, and the process that will be taken by Ecology if the regulations do not achieve compliance with the water temperature criteria.

The state's forest practices regulations will be relied upon to bring waters into compliance with the load allocations established in this TMDL on private and state forest lands. This strategy, referred to as the Clean Water Act Assurances, was established as a formal agreement to the 1999 Forests and Fish Report (www.dnr.wa.gov/Publications/fp_rules_forestsandfish.pdf).

The state's forest practices rules were developed with the expectation that the stream buffers and harvest management prescriptions were stringent enough to meet state water quality standards for temperature and turbidity, and provide protection equal to what would be required under a TMDL. As part of the 1999 agreement, new forest practices rules for forest roads were also established. These new road construction and maintenance standards are intended to provide better control of road-related sediments, provide better stream bank stability protection, and meet current best management practices.

To ensure the rules are as effective as assumed, a formal adaptive management program was established to assess and revise the forest practices rules, as needed. The agreement to rely on the forest practices rules in lieu of developing separate TMDL load allocations or implementation requirements for forestry is conditioned on maintaining an effective adaptive management program.

Consistent with the directives of the 1999 Forests and Fish agreement, Ecology conducted a formal ten-year review of the forest practices and adaptive management programs in 2009:

> www.ecy.wa.gov/programs/wq/nonpoint/ForestPractices/CWAassurances-FinalRevPaper071509-W97.pdf

Ecology noted numerous areas where improvements were needed, but also recognized the state's forest practices program provides a substantial framework for bringing the forest practices rules and activities into full compliance with the water quality standards. Therefore, Ecology decided to conditionally extend the CWA assurances with the intent to stimulate the needed improvements. Ecology, in consultation with key stakeholders, established specific milestones for program accomplishment and improvement. These milestones were designed to provide Ecology and the public with confidence that forest practices in the state will be conducted in a manner that does not cause or contribute to a violation of the state water quality standards.

SEPA/planning

Local governments should consider TMDLs during state Environmental Policy Act (SEPA) and other local land use planning reviews. If the land use action under review is known to potentially impact temperature as addressed by this TMDL, then the project may have a significant adverse environmental impact. SEPA lead agencies and reviewers are required to look at potentially significant environmental impacts and alternatives and to document that the necessary environmental analyses have been made. Land use planners and project managers should consider findings and actions in this TMDL to help prevent new land uses from violating water quality standards. Ecology recently published a focus sheet on how TMDLs play a role in SEPA impact analysis, threshold determinations, and mitigation (www.ecy.wa.gov/biblio/0806008.html). Additionally, the TMDL should be considered in the issuance of land use permits by local authorities.

Bull Trout

Bull trout were listed as a threatened species on November 1, 1999. The Pend Oreille River watershed is designated as a bull trout core area, which is a geographic area occupied by at least one population. Bull trout use waters in the Pend Oreille watershed core area for rearing, foraging, migrating, and as overwintering habitat (USFWS 2008).

The United States Fish and Wildlife Service (USFWS) wrote a Biological Opinion as part of the Endangered Species Act Consultation for the 2008 approval of Washington State's water quality standards. In Appendix B of the Biological Opinion, the USFWS states the bull trout recovery objectives for the Pend Oreille River watershed core area are to:

- Preserve current populations.
- Re-establish bull trout to areas historically inhabited.
- Sustain stable or increase numbers of bull trout.
- Re-establish and preserve habitat for all life stages.
- Protect genetic diversity and allow chances for genetic exchange through migration.

The USFWS suggests these objectives can be obtained by "improving connectivity, reducing the abundance of nonnative fishes, improving stream channel and riparian conditions, and operating dams to minimize negative effects" (USFWS 2008). Organizations working to improve water temperatures should also consider how their actions may improve habitat for bull trout.

Enforcement of the dam compliance schedules, forest practices regulations, etc. may be necessary to comply with the TMDL and the water quality standards. Entities with enforcement authority are responsible for following up on the schedule or permits and take any necessary enforcement actions. Permittees are responsible for meeting requirements in their permits. Those entities installing riparian restoration projects or best management practices (BMPs) are responsible for monitoring plant survival rates and maintenance of improvements, structures and fencing.

Who needs to participate?

Following is a list of several parties expected to play a role in implementing this TMDL. Some information included may change as personnel and available funding are better defined during the development of the WQIP. There are numerous opportunities for the listed entities to coordinate with each other to achieve the targets in this TMDL. Coordination among groups should help achieve temperature reductions more efficiently and effectively. Ecology will work with these groups to improve water quality in the basin. Ultimately, however, it is the on-the-ground land managers, landowners, and citizens who are responsible for implementation.

Bureau of Land Management: The Bureau of Land Management (BLM) manages several hundred acres of land on the west side of the Pend Oreille River north of Metaline Falls along the Boundary Dam reservoir. BLM manages the public lands for multiple uses to best meet the public's present and future needs. This means the agency considers the health, diversity, and productivity of the resource when making decisions.

The BLM is actively managing the public property in the Pend Oreille watershed for recreation, mining, and timber production. BLM maintains natural camping sites near Boundary Dam. Agency staff manage current mine claims, and are working to clean up old mining sites as funding and resources allow. The agency also collaborates with the Pend Oreille County Weed Board to control weeds on the property. To ensure the activities occurring on BLM-managed lands are not impacting water quality, staff conduct water monitoring above and below the property.

In the past, timber was harvested from the upland areas, but there have not been any timber harvest activities in recent years and none are planned. The Boundary Dam timber sale (which took place 20 years ago) harvested trees on benches above the river with little or no erosion and overland flow into the stream channel.

County and city governments: Local regulatory programs involving land-use planning and permitting are expected to protect riparian vegetation that shades the tributaries and shorelines of the Pend Oreille River. Shorelines of streams with mean annual flows greater than 20 cubic feet per second (cfs) are protected under the Shoreline Management Act. Larger rivers greater than 200 cfs east of the Cascade crest are defined as shorelines of statewide significance. Counties, as well as cities, develop and manage plans for streams protected by the Shoreline Management Act. In addition, land management practices next to streams may be limited by cities or counties if there are local critical areas ordinances. These ordinances are established by cities and counties and typically prescribe buffer widths for streams or wetlands. County and city governments are tasked with protecting these buffer requirements while permitting activities. City and county governments must periodically update their shoreline management plans and critical areas ordinances. Pend Oreille County is in the process of updating their shoreline regulations. More information about the shoreline update is available at http://pendoreilleco.org/county/shoreline_master_program_update.asp.

NPDES Permittees: Permittees are required to follow their permits including conducting monitoring and reporting results.

Idaho Department of Environmental Quality: The Idaho Department of Environmental Quality (IDEQ) is the designated lead management agency responsible for TMDL implementation. They will make efforts to address past, present, and future pollution problems in an attempt to link them to watershed characteristics and management practices designed to improve water quality and restore the beneficial uses of the water body. IDEQ will work to comply with Washington's temperature standard and the assumption at the state line.

Kalispel Tribe: As mentioned previously, the Tribe established water quality standards for their waters, which are administered by their water resources program within the Kalispel Natural Resource Department. The objective of the water resources program is to preserve, protect, and restore aquatic resources, where fitting, to meet the water quality needs of all current and future tribal water uses (KNRD 2010). To achieve this objective, the Tribe monitors water quality, educates the public, works on projects to improve water quality, and coordinates with other groups, organizations and agencies with a water quality role. For more information visit http://www.kalispeltribe.com/fisheries-and-water-resources-division.

Natural Resources Conservation Service (NRCS): The United States Department of Agriculture (USDA) NRCS offers technical and financial assistance to landowners for water quality-related projects through a variety of programs. One example is the Environmental Quality Improvement Program (EQIP). This program seeks the input of a local work group to help NRCS establish priority conservation practices eligible for funding. For more information on the funding available through NRCS and other USDA programs, please see the Funding section in this report.

*Pend Oreille Conservation District**: Conservation districts have authority under Chapter 89.08 of the Revised Code of Washington (RCW) to develop farm plans that protect water quality. Conservation districts also provide information, education, and technical assistance to residents on a voluntary basis. In 1988, Ecology signed a Memorandum of Agreement (MOA) with conservation districts. This MOA establishes a process for conservation districts to address and resolve agriculture-related water quality complaints received by Ecology.

The Pend Oreille Conservation District (POCD) offers a wide variety of educational workshops and events that increase knowledge and awareness of water quality and available financial assistance for the residents of Pend Oreille County. For example, POCD offers shoreline and bank stabilization workshops, which include a checklist for landowners and information on:

- Hydrology
- Soils and vegetation
- Potential effects of the reservoir on shoreline erosion
- Native vegetation to stabilize the shoreline

POCD also hosts an annual Water Festival where fifth-grade students in Pend Oreille County learn how to protect ground and surface water. The POCD also annually coordinates the Northeast Washington Regional Envirothon Competition where school-aged children monitor water quality and answer questions related to natural resources. Additional activities and events are developed as needs are identified.

**As of Jan. 1, 2011, the POCD office is closed due to funding shortages, but the Board of Supervisors is operating the District on a limited basis. The goal is to search for and obtain funding in order to re-staff the office.*

Pend Oreille Public Utility District (PUD): The Pend Oreille PUD is responsible for implementing provisions of their license for Box Canyon Dam that FERC issued in July 2005. In February 2003, Ecology issued a water quality certification which is included as part of the FERC license.

Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispel Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreille PUD to implement a Trout Habitat Restoration Program (THRP). The THRP calls for the restoration and maintenance of 164 miles of tributary habitat, of which 66 miles will occur in the first ten years, 66 in the second ten years, and 32 in the remaining five year period. The THRP will include a combination (some or all) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:

- Channel improvements (limited to geomorphologic improvements and barrier removal)
- Floodplain restoration
- Riparian corridor restoration
- Pend Oreille Temperature Water Quality Improvement Report Amendment
- Conservation easements and/or purchases

Similar to Seattle City Light's Water Quality Attainment Plan (see next bulleted item), Ecology will use current actions from Pend Oreille PUD settlement agreement as evidence demonstrating that the PUD is moving toward meeting applicable temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the ten-year compliance schedule.

The Pend Oreille PUD should keep the public; Kalispel Tribe; Idaho DEQ; Ecology; the Tri-State Water Quality Council; and the EPA informed of the status of the project. A copy of the license for Box Canyon Dam can be found on the PUD's website: www.popud.com/license.htm.

*Pend Oreille (WRIA 62) Watershed Planning Unit**: The watershed planning process offers a tool to allow local guidance in identifying, prioritizing, and developing solutions to water resource management issues.

The planning unit developed a detailed implementation plan which identifies obligations for organizations and timelines to complete them. However, agencies are only required to fulfill obligations if funding is available to do so. Types of obligations range from writing letters to the legislature, placing advertisements in the newspaper regarding watershed issues, educational events, research, bank stabilization projects, etc.

**The Planning Unit completed their mandated tasks and is no longer a formal group.*

Pend Oreille Watershed Roundtable: The Pend Oreille Watershed Roundtable is an offshoot of the WRIA 62 planning unit. The purpose of this group is to educate and exchange information about water-related issues in the watershed among agencies, organizations, and citizens. The newly formed group is slated to meet two to three times per year.

Seattle City Light: Seattle City Light is working on relicensing Boundary Dam. Studies conducted to identify and understand the environmental and other effects of the dam will help identify water quality conditions that may be incorporated into Ecology's 401 certification. Seattle City Light will be responsible for implementing requirements of its water quality attainment plan and provisions of its new FERC license.

Seattle City Light has a settlement agreement that was signed on March 23, 2010, by the Bureau of Indian Affairs; National Park Service; United States Fish and Wildlife Service; Untied States Department of Agriculture Forest Service; Washington Department of Fish and Wildlife; Washington Department of Ecology; Kalispel Tribe; Public Utility District No. 1 of Pend Oreille County; Washington; American Whitewater; Selkirk Conservation Alliance; and the Lands Council. Seattle City Light developed a temperature Water Quality Attainment Plan that Ecology approved. The plan will rely on all actions in the settlement agreement that may improve temperatures in the mainstem and tributaries. The first ten years of the 401 compliance schedule includes the following activities:

- Mill Pond Dam Removal and Stream Channel Restoration.
- Stream and Riparian Improvements in Sullivan Creek North Fork Sullivan Creek.
- Large woody debris placement and Road improvements in Sullivan Creek and selected tributaries upstream of the confluence with Outlet Creek.
- Habitat protection, riparian improvement, and stream channel enhancement in Sullivan Creek.
- Cold water release structure at Sullivan Dam.
- Mainstem large woody debris at tributary deltas; two at Sullivan, one at Sweet, Slate, and Linton Creeks.
- Mainstem erosion control measures and riparian plantings.

Monitoring will be required in the tributaries where improvements are expected and in the mainstem of the river.

Seattle City Light should keep the public; Kalispel Tribe; Ecology; the Tri-State Water Quality Council; and the EPA informed of the status of its progress in addressing specified water quality conditions. The format and venue for sharing information regarding compliance may be detailed in the water quality attainment plan. Information about Seattle City Light's relicensing efforts is available on the Web at: www.ci.seattle.wa.us/light/news/isssues/bndryRelic/br_document.asp.

United States Forest Service: The Forest Service is responsible for oversight of activities on National Forest System Lands. The Colville National Forest was required by the National Forest Management Act (NFMA) of 1976 to have a national forest land and resource management plan (Forest Plan). The plan established goals, objectives, standards, and guidelines that direct how national forest lands are managed. The goal of the Forest Plan is to "provide a management program reflective of a mixture of management activities that allow use and protection of the forest resources; fulfill legislative requirements; and address local, regional, and national issues and concerns" (CNF 1988).

Objectives of the Forest Plan as they relate to water quality are:

- Protect Washington State waters through the application and effectiveness monitoring of BMPs.
- Create and follow range allotment management plans, which protect water quality.
- Provide recreational opportunities and education while protecting water quality.
- Adhere to the Inland Native Fish Strategy (INFS) to prohibit water quality degradation because of management activities.
- Follow the approved Environmental Management System (EMS), which is a process to identify, evaluate, and manage environmental impacts.

The general approach the Colville National Forest will use to achieve water quality standards is:

- Conduct further monitoring to determine the location of the water quality impairments.
- Work with grazing permit holders to apply BMPs per allotment management plans.

- Carry out guidance for management and maintaining riparian vegetation.
- Supply managed recreation opportunities that protect riparian vegetation and water quality as directed in the Forest Plan.
- Provide educational material to visitors to increase awareness about water quality.

Washington State Dept. of Ecology (Ecology): Ecology has been delegated authority under the federal Clean Water Act by the U.S. Environmental Protection Agency (EPA) to:

- Establish water quality standards.
- Administer the NPDES wastewater-permitting program.
- Issue water quality certifications and monitor/evaluate implementation of conditions.
- Enforce water quality regulations under Chapter 90.48 RCW.

Ecology is responsible for issuing 401 water quality certifications to non-federal hydropower facilities. Ecology works with the applicant, fish and wildlife agencies, tribes, and others to ensure water quality standards are being met and that flow levels are adequate. The conditions set in a 401 water quality certification are adopted into the federal FERC license for the dam (Water Quality Program, 2008). Ecology issued a 401 certification to the Pend Oreille PUD in 2003 for Box Canyon Dam. Ecology will work with Seattle City Light to certify Boundary Dam before their current license expires in 2011.

Ecology staff provides a variety of other services related to this TMDL:

- Grant and loan money is distributed via a competitive process to local governments and non-profit organizations. Grants and loans from Ecology are used to plan and install best management practices (BMPs) and improve wastewater treatment facilities.
- Technical assistance visits to people interested in installing BMPs.
- Responding to complaints, conducting inspections, and issuing permits as part of the NPDES, State Waste Discharge and Stormwater permit regulations.
- Water monitoring to determine if water quality is improving.

Ecology is authorized under Chapter 90.48 RCW to initiate enforcement actions if voluntary compliance with state water quality standards is unsuccessful. However, it is the goal of all participants in the Pend Oreille River temperature TMDL process to achieve water quality standards through voluntary control actions.

Washington State Dept. of Natural Resources (DNR): DNR has primary administrative and enforcement responsibilities for the Forest Practices Act (Ch. 76.09 RCW), which includes implementation of the 1999 "Forests and Fish Report." The Forests and Fish Report (ESHB 2091) was adopted by the state legislature to protect salmon listed under the federal Endangered Species Act, other aquatic species, and clean water, while keeping the timber industry economically viable. The resulting rules address forest roads, unstable slopes, riparian shading, and effectiveness monitoring. This report can be found online at www.dnr.wa.gov/forestpractices/rules/forestsandfish.pdf.

Load allocations are included in this TMDL for non-federal forest lands in accordance with Section M-2 of the Forests and Fish Report. DNR is encouraged to condition forest practices to prohibit any further reduction of stream shade, and not waive or modify any shade requirements for timber harvesting activities on state and private lands.

WSU/Pend Oreille County Extension: WSU/Pend Oreille County Extension (Extension) is engaged in water quality education throughout the watershed. In 2001, the Extension and the Kalispel Tribe teamed up to create a quarterly newsletter titled "Diggings: Discovering a Sense of Place in Pend Oreille County." The newsletter, available at www.diggings.org, provides information on conservation, protecting water quality, fish and wildlife, plants, and the area's history. "Diggings" also announces workshops and events the public can attend, such as Family Stream Day or the Pend Oreille River Celebration. WSU/Pend Oreille County Extension also collaborated with the Pend Oreille River Tourism Alliance to establish a Pend Oreille Water Trail. These educational events present a great opportunity to share information about actions people can take to reduce water temperature.

What is the schedule for achieving water quality standards?

The goal of this TMDL is to meet water quality standards for temperatures in the Pend Oreille River and its tributaries. Timelines for meeting standards are specific to a particular source:

- NPDES permit holders are expected to meet their wasteload allocation upon approval of the TMDL by EPA, since the allocations are based on current operating conditions.
- Box Canyon Dam will have one year from the completion of the WQIP to finalize a water quality attainment plan, and have up to ten years from the approval of the WQIP to meet water quality standards. This timeframe is consistent with WAC 173-201A-510(5) compliance schedules for dams.
- Boundary Dam will have one year from the completion of the WQIP to finalize a water quality attainment plan and have up to ten years from the issuance of its FERC license (anticipated to be in 2011) to meet water quality standards. This is consistent with the 401 certification process and WAC 173-201A-510(5) compliance schedules for dams.
- Tributary and mainstem shade allocations are expected to be achieved in 50 years from the completion of the WQIP. Fifty years is allowed due to the amount of time needed for trees to mature and produce the required amount of shade. Final and interim timelines to achieve shade targets are believed to be adequate based upon research in the Oregon Cascades, which found that stream shading achieved fifty percent in five years (Andrus & Froehlich 1988). In addition, typical growth rates of riparian vegetation in eastern Washington forests range from seven to twenty-four inches per year (Kovalchik & Clausnitzer 2004). Ecology may need to alter this timeline if unforeseen natural disturbances, such as wildfire, occur in the watershed.

Interim targets or milestones are being established so that progress toward compliance with the temperature criteria can be evaluated. The interim and final targets are listed in Table 17.

Table 17. Interim and final targets after completion of the WQIP.

Target (years)	NPDES permit holders	Box Canyon Dam	Boundary Dam	Tributary shade	Mainstem Canopy Cover
1	meet permit conditions	water quality attainment plan submitted to Ecology	water quality attainment plan submitted to Ecology	n/a	n/a
5	n/a	0.5°C reduction	0.5°C reduction	n/a	n/a
10	n/a	natural conditions + 0.12 °C	natural conditions + 0.12 °C	10% increase	7% increase
20	n/a	n/a	n/a	15% increase	10% increase
30	n/a	n/a	n/a	25% increase	13% increase
40	n/a	n/a	n/a	40% increase	17% increase
50	n/a	n/a	n/a	potential natural vegetation (see Table 14)	potential natural vegetation (See Table 13)

Adaptive management

This implementation strategy identified interim targets for meeting the TMDL goals. Partners will work together to monitor progress toward these goals, evaluate successes, obstacles, and changing needs, and make adjustments to the cleanup plan as needed. It is ultimately the responsibility of Ecology to assure that cleanup is being actively pursued and water quality standards are achieved.

TMDL reductions for some sources should be achieved ten years after completion of the water quality implementation plan. The Pend Oreille PUD has up to ten years from the completion of the WQIP to meet water quality standards. Seattle City Light has up to ten years from the date their FERC license is reissued to meet water quality standards. For tributary and shoreline shading, TMDL targets should be achieved 50 years after the completion of the WQIP. If the TMDL targets are not met, but the water quality standards are, then this TMDL has been satisfied. Ecology, as resources allow, will evaluate the status of this TMDL every five to ten years.

Adaptive management is required when results from water quality monitoring show that load allocations and/or interim targets in this TMDL are not being met. An adaptive management strategy will also be used if the load allocations and/or targets are met, but the Pend Oreille River still does not meet temperature water quality standards. Effectiveness monitoring to support adaptive management will be conducted approximately five to ten years after the implementation plan is finalized.

If implementation activities are not producing expected or required results, Ecology may choose to conduct additional studies to identify the significant sources of heat input to the river system or to identify other ways to meet water quality standards. If the causes can be determined, implementation of additional BMPs, educational efforts, or a combination of these will likely be taken. However, if some unforeseen event affects the landscape, such as a wildfire, the timelines to meet the load allocations in this TMDL may need some modification.

Monitoring progress

Monitoring is a crucial component of any TMDL because the data provides information that management decisions are based upon. Monitoring is needed to track actions that organizations are taking to meet their allocations, measure improvements the actions are having on water quality, and identify whether targets and allocations in the TMDL are being met (TMDL effectiveness). Monitoring is a vital piece of the adaptive management approach because it provides feedback on the effectiveness of implementation actions and water quality improvements.

Several entities are committed to monitoring within the Pend Oreille/Clark Fork watershed. Following is a list of current monitoring efforts:

- The Pend Oreille County Public Utility District (PUD) monitors water quality on a monthly basis upstream and downstream of Box Canyon Dam by instantaneous grab samples (Entrix 2001). The objective is to document baseline water quality conditions immediately above and below Box Canyon Dam relative to its current operation. In addition, the PUD is striving to supplement existing baseline water quality data for the entire reservoir. Shore-based sampling occurs once a month.

- Monitoring and assessment programs are conducted by the Kalispel Tribe's water resources program for on-reservation waters (Wingert and Gross 2006). The Tribe also monitors waters off the reservation, including about two dozen tributaries along the Pend Oreille River in Washington. The Tribe contracts limnological studies of lakes in the lower Pend Oreille annually.

  The Kalispel Tribe's Natural Resources Department, Water Quality Program collects water quality data at 60 sites in the Pend Oreille subbasin. Two of these sites are on reservation waters. Each of these sites has continuous temperature monitoring and 15 of these sites have continuous flow monitoring. Nutrients are sampled monthly at two of the sites except during periods of high runoff when they are sampled every other week. Metals are sampled at one site on the same schedule as nutrients. A quality assurance project plan covering sampling activities is on file with the EPA.

- Ecology currently monitors two sites monthly on the Pend Oreille River: the bridge near Newport (station number 62A150) and the bridge near Metaline Falls (station number 62A090). Ecology analyzes the water for temperature; pH; conductivity; dissolved oxygen; total suspended solids; fecal coliform; turbidity, and nutrients. For additional information about these monitoring sites, please see www.ecy.wa.gov/apps/watersheds/riv/station.asp?sta=62A150.

- The Pend Oreille Conservation District (POCD) monitors surface waters on a project basis and as funding allows. POCD recently completed a water quality study of seven different streams in the watershed through a grant from Ecology. POCD monitored twelve different locations to identify the types and amounts of pollutants in streams originating on United States Forest Service (USFS) land. This information will be used to assist the USFS in managing the Colville National Forest and identify reaches of streams that are over state standards. Streams were monitored for conventional water quality parameters such as dissolved oxygen, temperature, and fecal coliform bacteria. POCD will pursue funding for further water quality studies based on the findings from this study or as needed.

- The Tri-State Water Quality Council monitors waters throughout the Pend Oreille/Clark Fork system. This group monitors primarily nutrients, nuisance algae, and metals and looks at trends in water quality throughout the entire basin.

Monitoring implementation actions

Tracking the actions that organizations are completing in order to improve water quality is a crucial component of the adaptive management process. If the targets are not being met, decision makers need to know what actions were completed so they can assess if their current plan is adequate or if different actions are needed.

The water quality implementation plan (WQIP) will provide information on the specific actions organizations will use to improve water quality. After the plan is completed, the Ecology TMDL Lead will organize annual meetings to review the work that was completed the previous year. The WQIP will include an appendix with tables where each organization's progress will be recorded.

Monitoring improvements in water quality from specific actions

The purpose of this monitoring is to discover if management activities and BMPs completed are positively improving water quality. Evaluating how well the activity works at improving water quality is important because it identifies the most effective and cost-efficient actions. In addition, information can be shared on what activity works in a particular situation and provides insight on which actions should be continued.

Organizations that complete the activities will be responsible for evaluating them. For example:

- Entities with enforcement authority are responsible for following up on any enforcement actions.
- Point source permittees are responsible for meeting the requirements of their permits.
- Those conducting restoration projects or installing best management practices (BMPs) are responsible for monitoring plant survival rates and maintenance of improvements, structures and fencing.

Monitoring water quality to determine TMDL effectiveness

TMDL effectiveness monitoring is performed to determine if the Pend Oreille River meets water quality standards or TMDL interim targets. Ecology is responsible for effectiveness monitoring and will initiate the monitoring in five to ten-year increments after the WQIP is finished, depending on the availability of resources.

The effectiveness of the TMDL will be assessed by monitoring the Pend Oreille River temperatures at sites identified in Table 18. However, due to safety concerns Ecology with work with Seattle City Light to confirm the location of the Boundary tailrace monitoring location.

Ecology will use data from the monitoring effort to update the existing model. Ecology will rerun the model to identify if the river is meeting the interim targets, allocations and/or the temperature criteria. The model will need to be rerun to determine compliance because natural conditions, which the allocations are based on, will vary year to year. If the Pend Oreille River does not meet the goals, then adaptive management actions will be adopted.

Table 18. Effectiveness monitoring locations.

Name	Reservoir - Reach	River Mile	Model Segment	
			Existing	Natural
Near Newport (Kelly Island)	Box Canyon – upstream reach	87.5	18	18
Near Dalkena	Box Canyon – upstream reach	77.7	81	81
Above Skookum Creek	Box Canyon – upstream reach	74.6	101	101
Near Cusick	Box Canyon – Kalispel reach	70.3	129	129
Above LeClerc Creek	Box Canyon – middle reach	56.7	216	216
Near Ione	Box Canyon – middle reach	38.4	334	334
Box Canyon Dam Forebay	Box Canyon – Box Canyon reach	34.8	357	359
Metaline Pool	Boundary	28.4	39	39
Slate Creek Pool	Boundary	22.5	79	79
Boundary Dam Forebay	Boundary	17.0	110	116
Boundary Dam Tailrace	Boundary	16.1	116	120

Monitoring will be needed periodically when water quality standards are achieved and the model re-run to verify that the Pend Oreille River remains in compliance.

A quality assurance project plan (QAPP) should be prepared for whatever monitoring is conducted. The QAPP should follow Ecology guidelines (Lombard and Kirchmer, 2004), paying particular attention to consistency in sampling and analytical methods.

Potential funding sources

A wide variety of potential funding sources exists for the water quality improvement projects in the Pend Oreille watershed. There is potential to collaborate with other agencies, organizations and planning processes to maximize available funding. Funding sources appropriate for some projects may not be suitable for others. Federal and state government programs administer public sources of funding. Private sources of funding normally come from private foundations. Foundations provide funding to nonprofit organizations with tax-exempt status.

The source of funding for best management practices (BMPs) can be dependent on the landowner. Projects on federal lands are typically funded through the agency that manages those lands. Projects conducted on private or state lands may be funded through a variety of funding mechanisms mentioned below.

Potential funding sources available through Ecology's water quality financial assistance program include:

- Centennial Clean Water Fund grants.
- Section 319 grants established under the federal Clean Water Act.
- State Revolving Fund (SRF) loans.
- Terry Husseman (Coastal Protection Funds).

Financial assistance for wastewater and stormwater projects in Washington State is available through the following organizations:

- Department of Community, Trade and Economic Development
- Public Works Board
- United States Department of Agriculture Rural Development
- Washington State Department of Health

These organizations provide funding for the Public Works Trust Fund, Community Development Block Grants, and Drinking Water State Revolving Fund. Ecology provides loans to cities for upgrades or improvements to their wastewater treatment plants and storm water projects. Ecology does give grants to communities for wastewater treatment plant upgrades when they can show an economic burden to rate payers.

The Pend Oreille Conservation District (CD) may also provide financial assistance to farmers and ranchers. The Conservation District can apply for Washington State Conservation Commission and Ecology grants to provide financial assistance to landowners. Implementing BMPs on private property usually requires that individual landowners contribute 25 percent of project costs; therefore, landowners are also using their own money to install BMPs.

The Natural Resources Conservation Service (NRCS) provides technical, educational, and financial assistance to eligible farmers and ranchers. The programs aid landowners in addressing natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. For more information about these programs, please visit NRCS' Web site at www.wa.nrcs.usda.gov/programs/index.html.

Pend Oreille PUD and Seattle City Light will be responsible for securing funding for carrying out provisions of their respective FERC licenses for Box Canyon and Boundary dams.

Summary of public involvement methods

TMDLs are successful only when the watershed landowners and other residents are involved. They are the closest to and most knowledgeable of the watershed resources. In the Pend Oreille watershed, local, state, federal and tribal agencies along with residents and non-governmental organizations are all working to improve water quality.

The Pend Oreille Watershed Advisory Group (WAG) is made up of citizens and agencies from Idaho and Washington. The WAG met to review and discuss this temperature TMDL on the following dates:

- October 20, 2005
- May 25, 2006
- October 26, 2006
- January 25, 2007
- March 20, 2007
- May 10, 2007
- June 25, 2007
- August 16, 2007
- September 28, 2007
- October 25, 20007
- Dec. 13, 2007
- February 25, 2008
- April 28, 2008
- May 12, 2008

The Tri-State Water Quality Council (Council) created meeting notes, which are all posted on the IDEQ's Web site at: www.deq.state.id.us/about/regions/pend_oreille_river_tribs_wag/index.cfm#wag. Documents, presentations, and upcoming meeting information are also posted on this Web site. The Council also sends TMDL-related announcements to an email distribution list made up of WAG members and interested parties.

Since the spring of 2008:

- Seven meetings and a few conference calls took place with the Kalispel Tribe, Idaho Department of Environmental Quality, and EPA.
- Two meetings occurred with Seattle City Light due to the connection between their efforts to relicense Boundary Dam and this TMDL.
- The Council forwarded approximately three emails to WAG members with updates on the TMDL's progress.
- Two meetings took place with the Pend Oreille Public Utility District and Seattle City Light in late summer 2010 to review and discuss the draft TMDL.

Ecology maintains a web site about the TMDL at www.ecy.wa.gov/programs/wq/tmdl/pend_oreille/index.html.

This TMDL went through a 60-day public comment period from October 1 until November 30, 2010. Ecology held a public meeting the evening of October 14, 2010 at the Pend Oreille Public Utility District office in Newport, Washington. Ecology sent a news release to area newspapers and advertised the comment period and public meeting in the following publications:

- Newport Miner
- Selkirk Sun

Responses to the comments are located in Appendix G.

Next steps

Once EPA approves the TMDL, Ecology must develop a water quality implementation plan (WQIP) within one year. The WQIP will guide TMDL implementation in Washington and will also include activities to improve total dissolved gas (TDG). (The Pend Oreille River TDG TMDL was approved in 2008.) Ecology will continue to work with Washington State stakeholders and the Pend Oreille Watershed Advisory Group to create the WQIP, who may refine and expand on information provided in this TMDL. The WQIP will include a(n):

- Table of who will do what, where and when.
- Strategy of how to measure effectiveness and progress.
- Approach to take if the plan does not work.
- List of potential funding sources.

Once this TMDL is in place, Ecology will strive to coordinate with other agencies and entities involved with implementation activities in the Pend Oreille River watershed.

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Appendix A:
Glossary, Acronyms, and Abbreviations

1-DMax or 1-day maximum temperature: The highest water temperature reached on any given day. This measure can be obtained using calibrated maximum and minimum thermometers or continuous monitoring probes having sampling intervals of 30 minutes or less.

7-DADMax or 7-day average of the daily maximum temperatures: The arithmetic average of seven consecutive measures of daily maximum temperatures. The 7-DADMax for any individual day is calculated by averaging that day's daily maximum temperature with the daily maximum temperatures of the three days prior and the three days after that date.

7Q2 flow: A typical low-flow condition. The 7Q2 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every other year on average. The 7Q2 flow is commonly used to represent the average low-flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q2 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

7Q10 flow: A critical low-flow condition. The 7Q10 is a statistical estimate of the lowest 7-day average flow that can be expected to occur once every 10 years on average. The 7Q10 flow is commonly used to represent the critical flow condition in a water body and is typically calculated from long-term flow data collected in each basin. For temperature TMDL work, the 7Q10 is usually calculated for the months of July and August as these typically represent the critical months for temperature in our state.

90th percentile: A statistical number obtained from a distribution of a data set, above which 10 percent of the data exists and below which 90 percent of the data exists.

303(d) list: Section 303(d) of the federal Clean Water Act requires Washington State periodically to prepare a list of all surface waters in the state for which beneficial uses of the water – such as for drinking, recreation, aquatic habitat, and industrial use – are impaired by pollutants. These are water quality-limited water bodies (ocean waters, estuaries, lakes, and streams) that fall short of state surface water quality standards, and are not expected to improve within the next two years.

Angular canopy density (ACD): The percentage of time that a given point on a stream will be shaded from direct beam solar radiation between 10 a.m. and 2 p.m. local solar time. For example, if a point on a stream is always shaded from 10 a.m. to 2 p.m. in August, then August ACD at that point is 100 percent. If that point is never shaded between 10 a.m. to 2 p.m., then ACD at that point is zero. Average ACD of a stream reach is estimated by sampling it over the width and length of the reach. Typical values of the ACD for old-growth stands in western Oregon have been reported to range from 80 to 90 percent.

Bank-full stage: Formally defined as the stream level that "corresponds to the discharge at which channel maintenance is most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels" (Dunne and Leopold, 1978).

Best management practices (BMPs): Physical, structural, or operational practices that, when used singularly or in combination, prevent or reduce pollutant discharges.

Char: Char (genus *Salvelinus*) are distinguished from trout and salmon by the absence of teeth in the roof of the mouth, presence of light colored spots on a dark background, absence of spots on the dorsal fin, small scales, and differences in the structure of their skeleton. (Trout and salmon have dark spots on a lighter background.)

Chronic critical effluent concentration: The maximum concentration of effluent during critical conditions at the boundary of the mixing zone assigned in accordance with WAC 173-201A-100. The boundary may be based on distance or a percentage of flow. Where no mixing zone is allowed, the chronic critical effluent concentration shall be 100 percent effluent.

Clean Water Act: A federal act passed in 1972 that contains provisions to restore and maintain the quality of the nation's waters. Section 303(d) of the Clean Water Act establishes the TMDL program.

Critical condition: When the physical, chemical, and biological characteristics of the receiving water environment interact with the effluent to produce the greatest potential adverse impact on aquatic biota and existing or designated water uses. For steady-state discharges to riverine systems, the critical condition may be assumed to be equal to the 7Q10 (see definition) flow event unless determined otherwise by the department.

Designated uses: Those uses specified in Chapter 173-201A WAC (Water Quality Standards for Surface Waters of the State of Washington) for each water body or segment, regardless of whether or not the uses are currently attained.

Diel: Of, or pertaining to, a 24-hour period.

Dilution factor: The relative proportion of effluent to stream (receiving water) flows occurring at the edge of a mixing zone during critical discharge conditions as authorized in accordance with the state's mixing zone regulations at WAC 173-201A-100. http://apps.leg.wa.gov/WAC/default.aspx?cite=173-201A-020

Diurnal: Of, or pertaining to, a day or each day; daily. (1) Occurring during the daytime only, as different from nocturnal or crepuscular, or (2) Daily; related to actions which are completed in the course of a calendar day, and which typically recur every calendar day (for example, diurnal temperature rises during the day and falls during the night.)

Effective shade: The fraction of incoming solar shortwave radiation that is blocked from reaching the surface of a stream or other defined area.

Existing uses: Those uses actually attained in fresh and marine waters on or after November 28, 1975, whether or not they are designated uses. Introduced species that are not native to Washington, and put-and-take fisheries comprised of non-self-replicating introduced native species, do not need to receive full support as an existing use.

Hyporheic: The area under and along the river channel where surface water and ground water meet.

Load allocation: The portion of a receiving water's loading capacity attributed to one or more of its existing or future sources of nonpoint pollution or to natural background sources.

Loading capacity: The greatest amount of a substance that a water body can receive and still meet water quality standards.

Margin of safety: Required component of TMDLs that accounts for uncertainty about the relationship between pollutant loads and quality of the receiving water body.

Municipal separate storm sewer systems (MS4): A conveyance or system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, manmade channels, or storm drains): (1) owned or operated by a state, city, town, borough, county, parish, district, association, or other public body having jurisdiction over disposal of wastes, stormwater, or other wastes and (2) designed or used for collecting or conveying stormwater; (3) which is not a combined sewer; and (4) which is not part of a publicly owned treatment works (POTW) as defined in the Code of Federal Regulations at 40 CFR 122.2.

National Pollutant Discharge Elimination System (NPDES): National program for issuing and revising permits, as well as imposing and enforcing pretreatment requirements, under the Clean Water Act. The NPDES permit program regulates discharges from wastewater treatment plants, large factories, and other facilities that use, process, and discharge water back into lakes, streams, rivers, bays, and oceans.

Near-stream disturbance zone (NSDZ): The active channel area without riparian vegetation that includes features such as gravel bars.

Nonpoint source: Pollution that enters any waters of the state from any dispersed land-based or water-based activities, including but not limited to, atmospheric deposition; surface water runoff from agricultural lands; urban areas; or forest lands; subsurface or underground sources; or discharges from boats or marine vessels not otherwise regulated under the National Pollutant Discharge Elimination System Program. Generally, any unconfined and diffuse source of contamination. Legally, any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act.

Phase I stormwater permit: The first phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to medium and large municipal separate storm sewer systems (MS4s) and construction sites of five or more acres.

Phase II stormwater permit: The second phase of stormwater regulation required under the federal Clean Water Act. The permit is issued to smaller municipal separate storm sewer systems (MS4s) and construction sites over one acre.

Point source: Sources of pollution that discharge at a specific location from pipes, outfalls, and conveyance channels to a surface water. Examples of point source discharges include municipal wastewater treatment plants, municipal stormwater systems, industrial waste treatment facilities, and construction sites that clear more than five acres of land.

Pollution: Such contamination, or other alteration of the physical, chemical, or biological properties, of any waters of the state. This includes change in temperature, taste, color, turbidity, or odor of the waters. It also includes discharge of any liquid, gaseous, solid, radioactive, or other substance into any waters of the state. This definition assumes that these changes will, or are likely to, create a nuisance or render such waters harmful, detrimental, or injurious to (1) public health, safety, or welfare, or (2) domestic, commercial, industrial, agricultural, recreational, or other legitimate beneficial uses, or (3) livestock, wild animals, birds, fish, or other aquatic life.

Riparian: Relating to the banks along a natural course of water.

Salmonid: Any fish that belong to the family *Salmonidae*. Basically, any species of salmon, trout, or char. www.fws.gov/le/ImpExp/FactSheetSalmonids.htm

Stormwater: The portion of precipitation that does not naturally percolate into the ground or evaporate but instead runs off roads, pavement, and roofs during rainfall or snow melt. Stormwater can also come from hard or saturated grass surfaces such as lawns, pastures, playfields, and from gravel roads and parking lots.

Surface waters of the state: Lakes, rivers, ponds, streams, inland waters, salt waters, wetlands and all other surface waters and watercourses within the jurisdiction of Washington State.

Surrogate measures: To provide more meaningful and measurable pollutant loading targets, EPA regulations [40 CFR 130.2(i)] allow other appropriate measures, or surrogate measures in a TMDL. The Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program (EPA, 1998) includes the following guidance on the use of surrogate measures for TMDL development:

> *When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional "pollutant," the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not.*

System potential: The design condition used for TMDL analysis.

System potential channel morphology: The more stable configuration that would occur with less human disturbance.

S**ystem potential mature riparian vegetation:** Vegetation that can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.

System potential riparian microclimate: The best estimate of air temperature reductions that are expected under mature riparian vegetation. System potential riparian microclimate can also include expected changes to wind speed and relative humidity.

System potential temperature: An approximation of the temperatures that would occur under natural conditions. System potential is our best understanding of natural conditions that can be supported by available analytical methods. The simulation of the system potential condition uses best estimates of *mature riparian vegetation, system potential channel morphology, and system potential riparian microclimate* that would occur absent any human alteration.

Total maximum daily load (TMDL): A distribution of a substance in a water body designed to protect it from exceeding water quality standards. A TMDL is equal to the sum of all of the following: (1) individual wasteload allocations for point sources, (2) the load allocations for nonpoint sources, (3) the contribution of natural sources, and (4) a margin of safety to allow for uncertainty in the wasteload determination. A reserve for future growth is also generally provided.

Wasteload allocation: The portion of a receiving water's loading capacity allocated to existing or future point sources of pollution. Wasteload allocations constitute one type of water quality-based effluent limitation.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Acronyms and Abbreviations

Following are acronyms and abbreviations used frequently in this report.

BMPs	Best management practices
cfs	Cubic feet per second
Ecology	Washington State Department of Ecology
EPA	U.S. Environmental Protection Agency
GIS	Geographic Information System software
NAF	New Approximation Flow
NPDES	National Pollution Discharge Elimination System
NSDZ	Near-stream disturbance zones
RM	River mile
TIR	Thermal infrared radiation
TMDL	Total Maximum Daily Load (water cleanup plan)
USFS	United States Forest Service
USGS	United States Geological Survey
WDFW	Washington Department of Fish and Wildlife
WRIA	Water Resources Inventory Area
WWTP	Wastewater treatment plant

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Appendix B:
Temperature - Overview of Stream Heating Processes

The temperature of a stream reflects the amount of heat energy in the water. Changes in water temperature within a particular segment of a stream are induced by the balance of the heat exchange between the water and the surrounding environment during transport through the segment. If there is more heat energy entering the water in a stream segment than there is leaving, the temperature will increase. If there is less heat energy entering the water in a stream segment than there is leaving, then the temperature will decrease. The general relationships between stream parameters, thermodynamic processes (heat and mass transfer), and stream temperature change is outlined in Figure B-1.

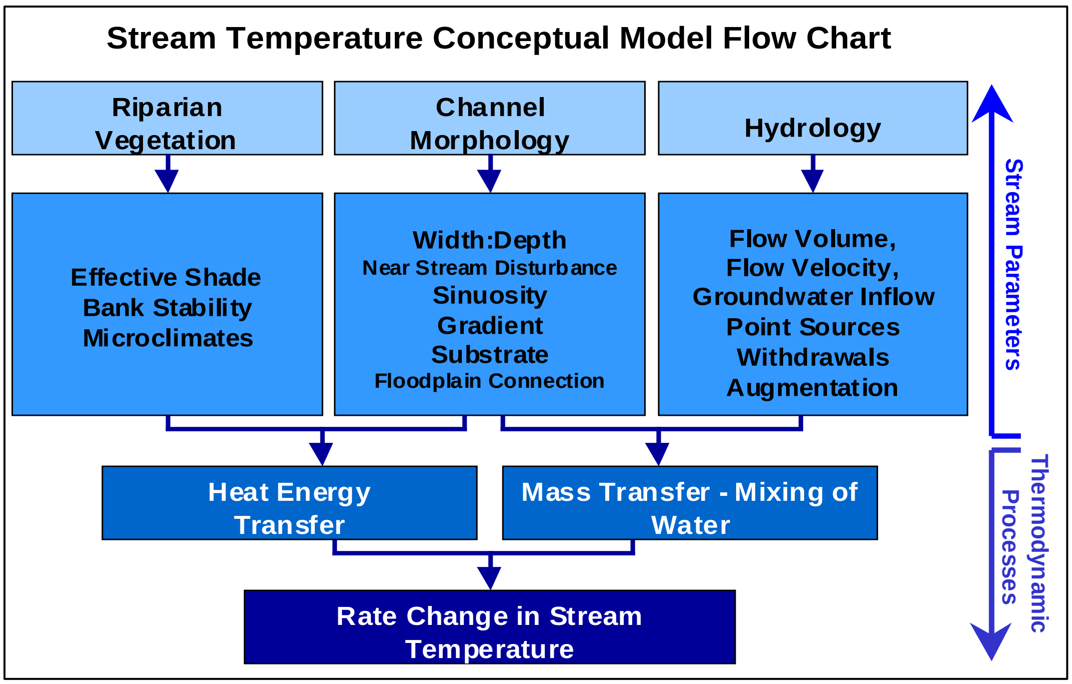

Figure B-1. Conceptual model of factors that affect stream temperature.

Adams and Sullivan (1989) reported that the following environmental variables were the most important drivers of water temperature in forested streams:

- **Stream depth.** Stream depth affects both the magnitude of the stream temperature fluctuations and the response time of the stream to changes in environmental conditions.
- **Air temperature.** Daily average stream temperatures and daily average air temperatures are both highly influenced by incoming solar radiation (Johnson, 2004). When the sun is not shining, the water temperature in a volume of water tends toward the dew-point temperature (Edinger et al., 1974).

- **Solar radiation and riparian vegetation.** The daily maximum temperatures in a stream are strongly influenced by removal of riparian vegetation because of diurnal patterns of solar heat flux. Daily average temperatures are less affected by removal of riparian vegetation.
- **Groundwater.** Inflows of groundwater can have an important cooling effect on stream temperature. This effect will depend on the rate of groundwater inflow relative to the flow in the stream as well as the difference in temperatures between the groundwater and the stream.

Heat budgets and temperature prediction

Heat exchange processes occur between the water body and the surrounding environment; these processes control stream temperature. Edinger et al., (1974) and Chapra (1997) provide thorough descriptions of the physical processes involved. Figure B-2 shows the major heat energy processes or fluxes across the water surface or streambed.

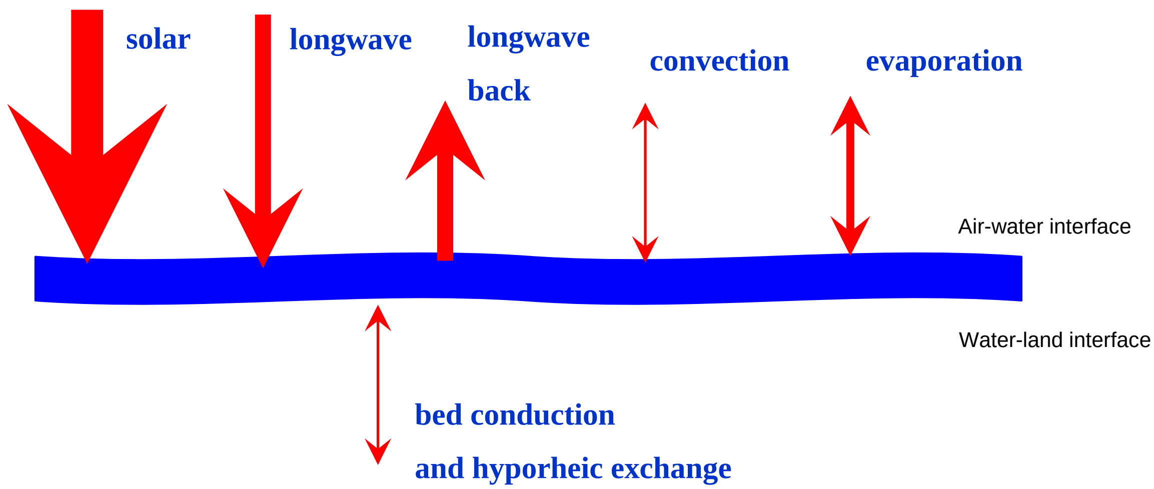

Figure B-2. Surface heat exchange processes that affect water temperature *(net heat flux = solar + longwave atmosphere + longwave back + convection + evaporation + bed). Heat flux between the water and streambed occurs through conduction and hyporheic exchange.*

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

- **Shortwave solar radiation**: Shortwave solar radiation is the radiant energy that passes directly from the sun to the earth. The shortwave radiation entering a stream will be the difference between the energy that comes directly from the sun and that reflected by the water. Shortwave solar radiation is contained in a wavelength range from 0.14 μm and about 4 μm.

  Example: At Washington State University's (WSU) Tree - Forest Research and Extension Center (TFREC) station in Wenatchee, the daily average global shortwave solar radiation for August 2002 was 259 W/m2. At the University of Washington Atmospheric Sciences building roof in Seattle, the daily average global shortwave solar radiation for July-August 2001 was 240 W/m2 (NOAA, 2003).

The peak values during daylight hours are typically about three times higher than the daily average. Shortwave solar radiation constitutes the major thermal input to an un-shaded body of water during the day when the sky is clear. Solar exposure was identified as the most influential factor in stream heating processes (Sinokrot and Stefan, 1993; Johnson and Jones; 2000).

- **Long-wave atmospheric radiation.** Long-wave radiation from the atmosphere ranges in wavelength from about 4 μm to 120 μm. Longwave atmospheric radiation depends primarily on air temperature and humidity and increases as both of those increase. It constitutes the major thermal input to a body of water at night and on warm cloudy days. The daily average heat flux from long-wave atmospheric radiation typically ranges from about 300 to 450 W/m^2 at mid-latitudes (Edinger et al., 1974). *Example: NOAA's Integrated Surface Irradiance Study (ISIS) station in Seattle measures long-wave radiation.*
- **Long-wave back radiation from the water to the atmosphere.** Water sends heat energy back to the atmosphere in the form of long-wave radiation in the wavelength range from about 4 μm to 120 μm. Back radiation accounts for a major portion of the heat loss from a body of water. Back radiation increases as water temperature increases. The daily average heat flux out of the water from long-wave back radiation typically ranges from about 300 to 500 W/m^2 (Edinger et al., 1974).

The remaining heat exchange processes generally have less magnitude and are as follows:

- **Evaporation flux at the air-water interface** is influenced mostly by the wind speed and the vapor pressure gradient between the water surface and the air. When the air is saturated, the evaporation stops. When the gradient is negative (vapor pressure at the water surface is less than the vapor pressure of the air), condensation, the reversal of evaporation takes place. This term then becomes a gain component in the heat balance.
- **Convection flux at the air-water interface** is driven by the temperature difference between water and air, and by the wind speed. Heat is transferred in the direction of decreasing temperature.
- **Streambed conduction flux and hyporheic** component of the heat budget represents the heat exchange through conduction between the bed and the water body and the influence of hyporheic exchange. The magnitude of bed conduction is driven by the size and conductance properties of the substrate. The heat transfer through conduction is more pronounced when thermal differences between the substrate and water column are higher. This usually affects the temperature diel profile, rather than affecting the magnitude of the maximum daily water temperature.

  Hyporheic exchange recently received increased attention as a possible important mechanism for stream cooling (Johnson and Jones, 2000, Poole and Berman, 2000, Johnson, 2004). The hyporheic zone is defined as the region located beneath the channel characterized by complex hydrodynamic processes that combine stream water and groundwater. The resulting fluxes can have significant implications for stream temperature at different spatial and temporal scales.

Heat exchange between the stream and the streambed has an important influence on water temperature. The temperature of the streambed is typically warmer than the overlying water at night and cooler than the water during the daylight hours (Figure B-2). Heat is typically transferred from the water into the streambed during the day, then back into the stream during the night (Adams and Sullivan, 1989). This has the effect of dampening the diurnal range of stream temperature variations without affecting the daily average stream temperature.

The bulk temperature of a vertically mixed volume of water in a stream segment under natural conditions tends to increase or decrease with time during the day, according to whether the net heat flux is positive or negative. When the sun is not shining, the water temperature tends toward the dew-point temperature (Edinger et al., 1974; Brady et al., 1969). The equilibrium temperature of a natural body of water is defined as the temperature at which the water is in equilibrium with its surrounding environment and the net rate of surface heat exchange would be zero (Edinger et al., 1968; Edinger et al., 1974).

The dominant contribution to the seasonal variations in the equilibrium temperature of water is from seasonal variations in the dew-point temperature (Edinger et al., 1974). The main source of hourly fluctuations in water temperature during the day is solar radiation. Solar radiation generally reaches a maximum during the day when the sun is highest in the sky, unless cloud cover or shade from vegetation interferes.

The complete heat budget for a stream also accounts for the mass transfer processes, which depend on the amount of flow and the temperature of water flowing into and out of a particular volume of water in a segment of a stream. Mass transfer processes in open channel systems can occur through advection, dispersion, and mixing with tributaries and groundwater inflows and outflows. Mass transfer relates to transport of flow volume downstream, instream mixing, and the introduction or removal of water from a stream. For instance, flow from a tributary will cause a temperature change if the temperature is different from the receiving water.

Thermal role of Riparian Vegetation

The role of riparian vegetation in maintaining a healthy stream condition and water quality is well documented and accepted in the scientific literature. Summer stream temperature increases due to the removal of riparian vegetation is well documented (e.g., Holtby, 1988; Lynch et al., 1984; Rishel et al., 1982; Patrick, 1980; Swift and Messer, 1971; Brown et al., 1971; and Levno and Rothacher, 1967). These studies generally support the findings of Brown and Krygier (1970) that loss of riparian vegetation results in larger daily temperature variations and elevated monthly and annual temperatures. Adams and Sullivan (1989) also concluded that daily maximum temperatures are strongly influenced by the removal of riparian vegetation because of the effect of diurnal fluctuations in solar heat flux.

Summaries of the scientific literature on the thermal role of riparian vegetation in forested and agricultural areas are provided by Belt et al., 1992; Beschta et al., 1987; Bolton and Monahan, 2001; Castelle and Johnson, 2000; CH2M Hill, 2000; GEI, 2002; Ice, 2001; and Wenger, 1999. All of these summaries recognize that the scientific literature indicates that riparian vegetation plays an important role in controlling stream temperature. Important benefits that riparian vegetation has on the stream temperature include:

- Near-stream vegetation height, width, and density combine to produce shadows that can reduce solar heat flux to the surface of the water.
- Riparian vegetation creates a thermal microclimate that generally maintains cooler air temperatures, higher relative humidity, lower wind speeds, and cooler ground temperatures along stream corridors.
- Stream-bank stability is largely a function of near-stream vegetation. Specifically, channel morphology is often highly influenced by land-cover type and condition by affecting flood plain and in-stream roughness, and contributing coarse woody debris as well as influencing sedimentation, stream substrate compositions, and stream-bank stability.

The warming of water temperatures as a stream flows downstream is a natural process. However, the rates of heating can be dramatically reduced when high levels of shade exist and heat flux from solar radiation is minimized. Riparian vegetation restoration was identified as one of the most important management steps that may improve stream temperatures (Johnson and Jones, 2000). The overriding justification for increases in shade from riparian vegetation is to minimize the contribution of solar heat flux in stream heating. There is a natural maximum level of shade that a given stream is capable of attaining, and the importance of shade decreases as the width of a stream increases.

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

Effective shade

Shade is an important parameter that controls the stream heating derived from solar radiation. Solar radiation has the potential to be one of the largest heat-transfer mechanisms in a stream system. Human activities can degrade near-stream vegetation and/or channel morphology (widening), and in turn, decrease shade. Reductions in stream surface shade have the potential to cause significant increases in heat delivery to a stream system. Stream shade is an important factor in describing the heat budget for the present analysis. Stream shade may be measured or calculated using a variety of methods (Chen, 1996; Chen et al., 1998; Ice, 2001; OWEB, 1999; Teti, 2001; Teti and Pike, 2005).

Shade is the amount of solar energy that is obscured or reflected by vegetation or topography above a stream. Effective shade is defined as the fraction or percentage of the total possible solar radiation heat energy that is prevented from reaching the surface of the water:

$$\text{effective shade} = (J_1 - J_2)/J_1$$

where J_1 is the potential solar heat flux above the influence of riparian vegetation and topography, and J_2 is the solar heat flux at the stream surface.

Canopy cover is the percent of sky covered by vegetation and topography at a given point. Shade is influenced by cover but changes throughout each day, as the position of sun changes spatially and temporally with respect to the canopy cover.

In the Northern Hemisphere, the earth tilts on its axis toward the sun during summer months, allowing longer day length and higher solar altitude, both of which are functions of solar declination (i.e., a measure of the earth's tilt toward the sun) (Figure B-3). Geographic position (i.e., latitude and longitude) fixes the stream to a position on the globe, while aspect provides the stream/riparian orientation (direction of stream flow). Near-stream vegetation height, width, and density describe the physical barriers between the stream and sun that can attenuate and scatter incoming solar radiation (i.e., produce shade) (Table B-1). The solar position has a vertical component (solar altitude) and a horizontal component (solar azimuth) that are both functions of time/date (solar declination) and the earth's rotation.

While the interaction of these shade variables may seem complex, the mathematics that describes them is relatively straightforward geometry. Using solar tables or mathematical simulations, the potential daily solar load can be quantified. The shade from riparian vegetation can be measured with a variety of methods, including hemispherical photography and solar pathfinder. (Ice, 2001; OWEB, 1999; Boyd, 1996; Teti, 2001; Teti and Pike, 2005):

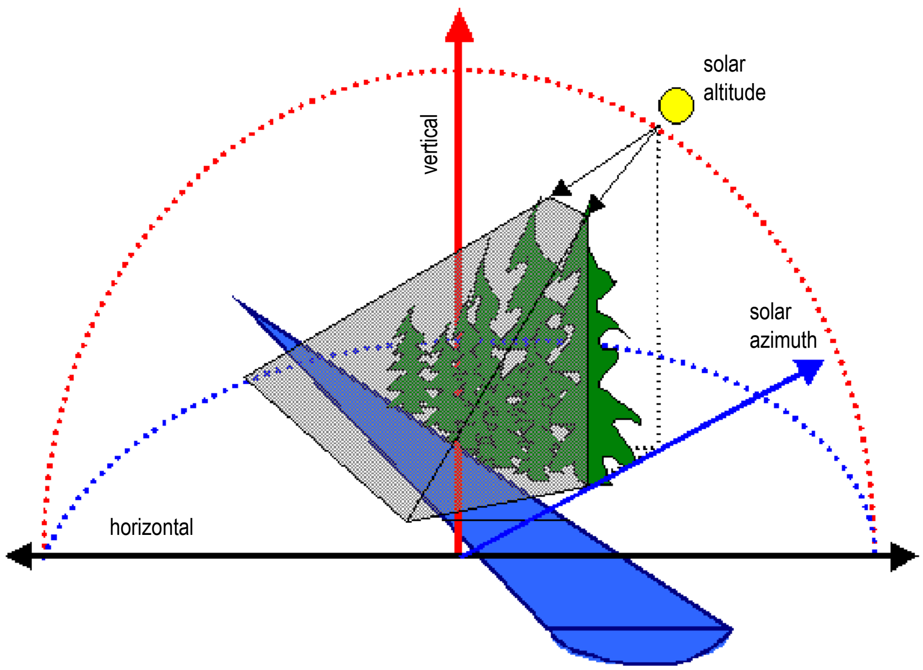

Figure B-3. Parameters that affect shade and geometric relationships.
Solar altitude is a measure of the vertical angle of the sun's position relative to the horizon. Solar azimuth is a measure of the horizontal angle of the sun's position relative to north. (Boyd and Kasper, 2003.)

Computer programs for the mathematical simulation of shade may also be used to estimate shade from measurements or estimates of the key parameters listed in Table B-1 (Ecology 2003a; Chen, 1996; Chen et al., 1998; Boyd, 1996; Boyd and Park, 1998).

Table B-1. Factors that influence stream shade *(italics indicate influenced by human activities).*

Description	Parameter
Season/time	Date/time
Stream characteristics	Aspect, *channel width*
Geographic position	Latitude, longitude
Vegetative characteristics	*Riparian vegetation height, width, and density*
Solar position	Solar altitude, solar azimuth

Riparian buffers and effective shade

Trees in riparian areas provide shade to streams and minimize undesirable water temperature changes (Brazier and Brown, 1973; Steinblums et al., 1984; Teti, 2003). The shading effectiveness of riparian vegetation is correlated to riparian area width (Figure B-4).

The shade, as represented by angular canopy density (ACD) for a given riparian buffer width, varies over space and time. This is because of differences among site potential vegetation, forest development stages (e.g., height and density), and stream width. For example, a 50-foot-wide riparian area with fully developed trees could provide from 45 to 72% of the potential shade in the two studies shown in Figure B-4.

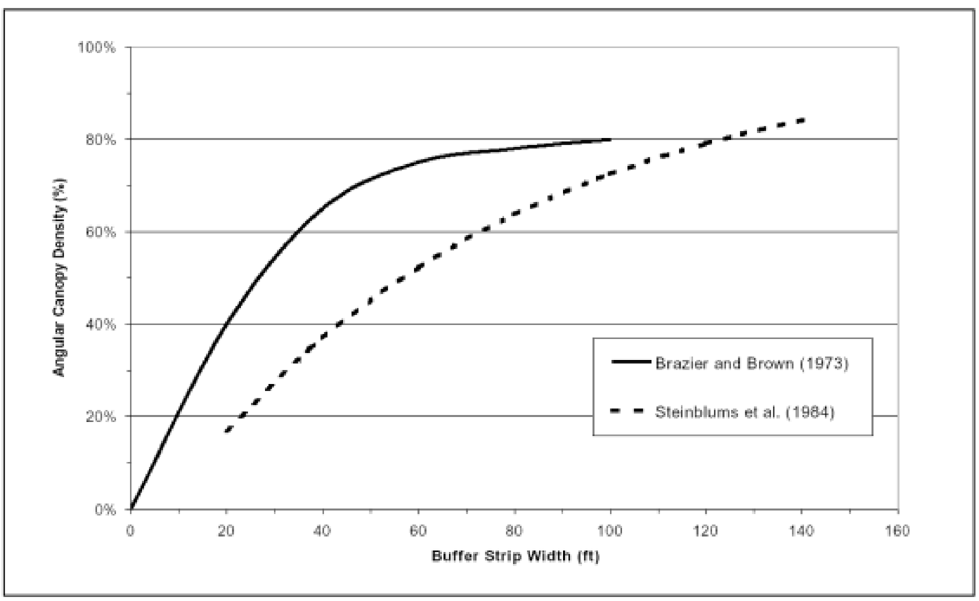

Figure B-4. Relationship between angular canopy density (ACD) and riparian buffer width *for small streams in old-growth riparian stands (after Beschta et al., 1987 and CH2M Hill, 2000).*

The Brazier and Brown (1973) shade data show a stronger relationship between ACD and buffer strip width than the Steinblums et al., (1984) data. The r^2 correlation for ACD and buffer width was 0.87 and 0.61 in Brazier and Brown (1973) and Steinblums et al., (1984), respectively. This difference supports the use of the Brazier and Brown curve as a base for measuring shade effectiveness under various riparian buffer proposals. These results reflect the natural variation among old growth sites studied, and show a possible range of potential shade.

Several studies of stream shading report that most of the potential shade comes from the riparian area within about 75 feet (23 meters) of the channel (CH2M Hill, 2000; Castelle and Johnson, 2000):

- Beschta et al., (1987) report that a 98-foot-wide (30-m) buffer provides the same level of shading as that of an old-growth stand.
- Brazier and Brown (1973) found that a 79-foot (24-m) buffer would provide maximum shade to streams.
- Steinblums et al., (1984) concluded that a 56-foot (17-m) buffer provides 90% of the maximum ACD.
- Corbett and Lynch (1985) concluded that a 39-foot (12-m) buffer should adequately protect small streams from large temperature changes following logging.
- Broderson (1973) reported that a 49-foot-wide (15-m) buffer provides 85% of the maximum shade for small streams.
- Lynch et al., (1984) found that a 98-foot-wide (30-m) buffer maintains water temperatures within 2°F (1°C) of their former average temperature in small streams (channel width less than 3 m).

GEI (2002) reviewed the scientific literature related to the effectiveness of buffers for shade protection in agricultural areas in Washington. They concluded that buffer widths of 10 meters (33 feet) provide nearly 80% of the maximum potential shade in agricultural areas. Wenger (1999) concluded that a minimum continuous buffer width of 10-30 m should be preserved or restored along each side of all streams on a municipal or county-wide scale to provide stream temperature control and maintain aquatic habitat. GEI (2002) considered the recommendations of Wenger (1999) to be relevant for agricultural areas in Washington.

Steinblums et al., (1984) concluded that shade could be delivered to forest streams from beyond 75 feet (22 m) and potentially out to 140 feet (43 m). In some site-specific cases, forest practices between 75 and 140 feet from the channel have the potential to reduce shade delivery by up to 25% of maximum. However, any reduction in shade beyond 75 feet would probably be relatively low on the horizon. Therefore, the impact on stream heating would be relatively low because the potential solar radiation decreases significantly as solar elevation decreases.

Microclimate - surrounding thermal environment

A secondary consequence of near-stream vegetation is its effect on the riparian microclimate. Riparian corridors often produce a microclimate that surrounds the stream where cooler air temperatures, higher relative humidity, and lower wind speeds are characteristic. Riparian microclimates tend to moderate daily air temperatures. Relative humidity increases result from the evapotranspiration that is occurring by riparian plant communities. Wind speed is reduced by the physical blockage produced by riparian vegetation.

Riparian buffers commonly occur on both sides of the stream, compounding the edge influence on the microclimate. Brosofske et al., (1997) reported that a buffer width of at least 150 feet (45 m) on each side of the stream was required to maintain a natural riparian microclimate environment in small forest streams (channel width less than 4 m) in the foothills of the western slope of the Cascade Mountains in western Washington with predominantly Douglas-fir and western hemlock.

Bartholow (2000) provided a thorough summary of literature of documented changes to the environment of streams and watersheds associated with extensive forest clearing. Changes summarized by Bartholow (2000) are representative of hot summer days and indicate the mean daily effect unless otherwise indicated:

- **Air temperature.** Edgerton and McConnell (1976) showed that removing all or a portion of the tree canopy resulted in cooler terrestrial air temperatures at night and warmer temperatures during the day, enough to influence thermal cover sought by elk (*Cervus canadensis*) on their eastern Oregon summer range. Increases in maximum air temperature varied from 5 to 7°C for the hottest days (estimate). However, the mean daily air temperature did not appear to have changed substantially since the maximum temperatures were offset by almost equal changes to the minima.

  Similar temperatures have been commonly reported (Childs and Flint, 1987; Fowler et al., 1987), even with extensive clearcuts (Holtby, 1988). In an evaluation of buffer strip width, Brosofske et al., (1997) found that air temperatures immediately adjacent to the ground increased 4.5°C during the day and about 0.5°C at night (estimate). Fowler and Anderson (1987) measured a 0.9°C air temperature increase in clearcut areas, but temperatures were also 3°C higher in the adjacent forest. Chen et al., (1993) found similar (2.1°C) increases.

  All measurements reported here were made over land instead of water, but in aggregate support about a 2°C increase in ambient mean daily air temperature resulting from extensive clearcutting.

- **Relative humidity.** Brosofske et al., (1997) examined changes in relative humidity within 17 to 72 m buffer strips. The focus of their study was to document changes along the gradient from forested to clearcut areas, so they did not explicitly report pre- to post-harvest changes at the stream. However, there appeared to be a reduction in relative humidity at the stream of 7% during the day and 6% at night (estimate). Relative humidity at stream sites increased exponentially with buffer width. Similarly, a study by Chen et al., (1993) showed a decrease of about 11% in mean daily relative humidity on clear days at the edges of clearcuts.

- **Wind speed**. Brosofske et al., (1997) reported almost no change in wind speed at stream locations within buffer strips adjacent to clearcuts. Speeds quickly approached upland conditions toward the edges of the buffers, with an indication that wind actually increased substantially at distances of about 15 meters from the edge of the strip, and then declined farther upslope to pre-harvest conditions. Chen et al., (1993) documented increases in both peak and steady winds in clearcut areas; increments ranged from 0.7 to 1.2 m/s (estimated).

Thermal role of channel morphology

Changes in channel morphology (widening) impact stream temperatures. As a stream widens, the surface area exposed to heat flux increases, resulting in increased energy exchange between a stream and its environment (Chapra, 1997). Further, wide channels are likely to have decreased levels of shade due to the increased distance created between vegetation and the wetted channel and the decreased fraction of the stream width that could potentially be covered by shadows from riparian vegetation. Conversely, narrow channels are more likely to experience higher levels of shade.

Channel widening is often related to degraded riparian conditions that allow increased streambank erosion and sedimentation of the streambed. Both erosion and sedimentation correlate strongly with riparian vegetation type and condition (Rosgen 1996). Channel morphology is not solely dependent on riparian conditions. Sedimentation can deposit material in the channel, fill pools, and aggrade the streambed, reducing channel depth and increasing channel width. Channel straightening can increase flow velocities and lead to deeply incised streambanks and washout of gravel and cobble substrate.

Channel modification usually occurs during high-flow events. Land uses that affect the magnitude and timing of high-flow events may negatively impact channel width and depth. Riparian vegetation conditions will affect the resilience of the streambanks/flood plain during periods of sediment introduction and high flow. Disturbance processes may have differing results depending on the ability of riparian vegetation to shape and protect channels. Channel morphology is related to riparian vegetation composition and condition by:

- **Building streambanks**. Riparian vegetation traps suspended sediments, encouraging deposition of sediment in the flood plain (instead of the streambed) and reducing incoming sources of sediment.
- **Maintaining stable streambanks**. High rooting strength and high streambank and flood plain roughness prevents streambank erosion.
- **Reducing flow velocity** (erosive kinetic energy). Riparian vegetation supplies large woody debris to the active channel, increases the pool-to-riffle ratio, and adds channel complexity that reduces shear stress exposure to streambank soil particles.

Global climate change

Changes in climate are expected to affect both water quantity and quality in the Pacific Northwest (Casola et al., 2005). Summer stream flows depend on the snowpack stored during the wet season. Studies of the region’s hydrology indicate a declining tendency in snow water storage coupled with earlier spring snowmelt and earlier peak spring stream flows (Hamlet et al., 2005). Factors affecting these changes include climate influences at both annual and decadal scales, and air temperature increases. Increases in air temperatures result in more precipitation falling as rain rather than snow and earlier melting of the winter snowpack.

Ten climate change models were used to predict the average rate of climatic warming in the Pacific Northwest (Mote et al., 2005). The average warming rate is expected to be in the range of 0.1-0.6°C (0.2-1.0°F) per decade, with a best estimate of 0.3°C (0.5°F) (Mote et al., 2005). Eight of the ten models predicted proportionately higher summer temperatures, with three indicating summer temperature increases at least two times higher than winter increases. Summer stream flows are also predicted to decrease as a consequence of global climate change (Hamlet and Lettenmaier, 1999).

The expected changes coming to our region's climate highlight the importance of protecting and restoring the mechanisms that help keep stream temperatures cool. Stream temperature improvements obtained by growing mature riparian vegetation corridors along stream banks, reducing channel widths, and enhancing summer base flows may all help offset the changes expected from global climate change – keeping conditions from getting worse. It will take considerable time, however, to reverse those human actions that contribute to excess stream warming. The sooner such restoration actions begin and the more complete they are, the more effective we will be in offsetting some of the detrimental effects on our stream resources.

These efforts may not cause streams to meet the numeric temperature criteria everywhere or in all years. However, they will maximize the extent and frequency of healthy temperature conditions, creating long-term and crucial benefits for fish and other aquatic species. As global climate change progresses, the thermal regime of the stream itself will change due to reduced summer stream flows and increased air temperatures.

The state is writing this TMDL to meet Washington State's water quality standards based on current and historic patterns of climate. Changes in stream temperature associated with global climate change may require further modifications to the human-source allocations at some time in the future. However, the best way to preserve our aquatic resources and to minimize future disturbance to human industry would be to begin now to protect as much of the thermal health of our streams as possible.

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Appendix C:
Temperature Monitoring Results Pend Oreille River: Newport to Sullivan Creek June – October 2004

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Abstract

Temperature was monitored in the Pend Oreille River with data logging thermistors, thermometer, and a profiling multiparameter instrument from June through October 2004 at several locations in the mainstem river and selected tributaries. The collected data will support the development of the total maximum daily load of temperature in the Pend Oreille River. Data show temperature changes over time at these sites and allow comparisons to data collected by other organizations.

Introduction

The Pend Oreille River is part of the Pend Oreille/Clark Fork watershed, which drains the Rocky Mountains in Western Montana and Northern Idaho. The Clark Fork empties into Lake Pend Oreille, and the Pend Oreille River begins at the outlet of the lake. The river enters Washington near the city of Newport and flows northward towards the international border with Canada (Figure C-1). Downstream of Newport, the river passes through the reservation of the Kalispel Tribe of Indians. A short reach of the river flows through Canada to its confluence with the Columbia River just upstream of the international border.

The Washington State Department of Ecology (Ecology), Idaho Department of Environmental Quality (IDEQ), the Kalispel Tribe of Indians (Tribe), and the U.S. Environmental Protection Agency (EPA) are jointly determining the total maximum daily load (TMDL) of temperature in the mainstem Pend Oreille River from its outlet at Lake Pend Oreille to the Canadian border. Ecology has listed the Pend Oreille River as impaired for temperature on its 1996 and 1998 303(d) water quality assessment lists, and has proposed Category 5 listings ("polluted waters that require a TMDL") for the Pend Oreille River on its 2002/2004 303(d) list. The Pend Oreille River is listed for temperature on the state of Idaho's 1998 303(d) list of impaired waters, and IDEQ has recently received funding to begin a study of temperature in this reach.

Recently Ecology, IDEQ, the Kalispel Tribe, and EPA concurred with a plan to the joint issuance of this TMDL (EPA, 2005). Under this agreement, Ecology is the lead for TMDL development in waters of Washington and the Kalispel Reservation, while Idaho is the lead for its waters. Ecology and Idaho will issue the TMDL for their waters and submit the TMDL to EPA for approval, and EPA will issue the TMDL for waters of Washington State outside the Kalispel Indian Reservation.

The Washington State Water Quality Standards, set forth in Chapter 173-201A of the Washington Administrative Code, include designated beneficial uses, waterbody classifications, and numeric and narrative water quality criteria for surface waters of the state. A revised version of the standards was adopted in 2003 and is currently awaiting approval by U.S. EPA. For temperature, the 1997 standards still apply under a TMDL.

Under the old standards (1997 version), the Pend Oreille River is classified as "Class A" waters, and a special condition is defined for temperature:

Pend Oreille River from Canadian border (river mile 16.0) to Idaho border (river mile 87.7). Special condition - temperature shall not exceed 20.0°C due to human activities. When natural conditions exceed 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9).

Under the new standards, the mainstem Pend Oreille River is protected for "non-core salmon and trout." The new standards contain a special condition for temperature:

Temperature shall not exceed a 1-day maximum (1-DMax) of 20.0^{o}C due to human activities. When natural conditions exceed a 1-DMax of 20.0^{o}C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3^{o}C; nor shall such temperature increases, at any time, exceed t=34/(T+9). ("T" represents the background temperature as measured at a point, or points, unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge.)

The temperature special condition for the Pend Oreille River are identical in both versions of the standards.

The Kalispel Tribe has adopted water quality standards, which U.S. EPA approved on June 24, 2004. The Pend Oreille River is designated to meet the use of adult salmonid migration. The criteria for salmon migration are a seven day average of daily maximum temperatures (7-DADMax) of 18^{o}C and 1-DMax of 20.5^{o}C. For all designated uses, if natural conditions are above criteria then human influences can raise water temperatures by no more than 0.3^{o}C.

Washington is required under federal case law to meet the Kalispel tribal standards. This TMDL is being developed jointly with EPA and the Kalispel Tribe, and the TMDL analysis will address the most stringent provisions of either standard.

Ecology developed a quality assurance project plan (QAPP) for temperature TMDL technical development in the waters of Washington and the Kalispel Tribe (Ecology, 2004a). The QAPP provides a detailed description of the TMDL, including historical and on-going monitoring studies and programs. Ecology conducted monitoring in 2004 to meet the QAPP objectives, which included:

- Developing a data set for enhancement of the temperature model for the Box Canyon Reservoir;
- Collecting data for comparison to monitoring by the Army Corps of Engineers, Pend Oreille Public Utility District, the city of Seattle, the Kalispel Tribe, the U.S. Forest Service, and the Pend Oreille Conservation District.
- Evaluting temperatures in potential biologically important areas.

The methods and results of Ecology's monitoring are described below.

Methods

The methods used for the temperature surveys followed the quality assurance project plan (Ecology, 2004a), with the changes and exceptions noted below. Figure C-1 shows the TMDL study area, including Pend Oreille River dams and Ecology's temperature monitoring locations for this study. Table C-1 lists the monitoring locations used in the study, with information about the dates surveyed and the location and fate of thermistors.

Surveys were conducted on June 22-25, July 27-29, August 18-20, September 21-23, and October 19-20, 2004. Daily average river flows prior to, during, and following the surveys are shown in Figure C-2 for the U.S. Geological Survey (USGS) Box Canyon gage. Surveys captured conditions beginning with the declining leg of the early summer hydrograph, two surveys during mid-summer low flow, and two surveys during higher fall flows. Flows in the summer of 2004 were very low, with minimum flows below the 7Q10 low flow of 12,300 cubic feet per second (cfs).

The TidbiT® thermistors in general performed well. All were calibrated consistent with the protocols described in the QAPP before being deployed. Seven were deployed near the bottom of the river on a cable attached to a buoy and pier block. Five buoy deployments were removed from the river and the thermistors lost (except for one that was returned after the season).

Six thermistors were installed inside ten-foot long PVC casings attached to wooden pilings. Piling deployments performed very well. The PVC casings were lowered in July (because of falling water levels), resulting in a few that were just under water in the fall, but still accessible. Of all thermistors recovered, one month of data from one thermistor was not recovered for unknown reasons.

Thermistors at two tributary sites and two mainstem sites (Box Canyon Dam and Newport – Kelly Island) were attached to cables from the bank, and one tributary thermistor was attached directly to a post in the stream:

- The Kelly Island cable site was used with permission of Pend Oreille Public Utility District who had installed the cables for total dissolved gas monitoring.
- At Box Canyon Dam the thermistor was attached to a cable on the draft tube deck between two powerhouses, one turbine down from the Seattle City Light deployment. This site had problems with the cable winding up and the meter coming out of the water. During a later survey this problem was fixed by attaching a large fishing weight.
- The Sullivan Creek site was located in swift water adjacent to the Seattle City Light monitoring location under the highway bridge at the USGS flow gage.
- The Calispel Creek site was just upstream of the pump site in a bed of weeds. Pumps run intermittently at this site, resulting is stagnant conditions between pump cycles and rapid drawdown and currents while pumping occurred.
- At LeClerc Creek the meter was attached to a steel post that held a stream gage.

During the June survey, a thermistor on a cable was used for temperature profiles. For the rest of the surveys a Hydrolab® multiparameter meter was used for profile measurements. Meters performed well, except for some occasional problems with the dissolved oxygen circulator. A number of depth-profiles were collected at the TidbiT® sites, midchannel near the TidbiT® sites, and at the mouths of selected creeks. No flow measurements were taken during surveys.

Data quality procedures from the QAPP were followed as described, except that the final thermistor check after monitoring was conducted in May 2005. For the pre- and post-monitoring checks, the TidbiT® thermistors were soaked in two water baths, one bath around 16 degC and another near 0 degC, measuring temperatures every one minute. The thermistor data were compared to a NIST certified thermometer and the average difference of ten measurements was calculated. Thermistors passed the accuracy check if the average difference was within the thermistors' specified accuracy range.

. Data quality procedures for the Hydrolab® meters as described in Ecology (2004b) were followed.

Results

Data quality

The analyses of monitoring data quality are shown in Tables C-2 through C-4. The root mean square error (RMSE) of measurements that meet measurement Quality Objectives are shown in bold, while RMSEs that exceed the MQOs are shaded.

Table C-2 shows the results of paired measurements between a TidbiT® and a profile thermistor reading. Although the pooled results from all sites was slightly above the MQOs (“All pairs”), all mainstem monitoring sites and the Sullivan Creek site met the MQO of 0.2 ^{o}C, indicating a well-mixed river with a slow temporal response. The Sullivan Creek site also met the MQO. The Calispel and LeClerc Creek sites were outside the MQO, probably as a result a more dynamic temperature regime and more spatial variability (especially at Calispel Creek) which made the monitoring of identical conditions difficult. Tributary site monitoring data is usable, but higher variability will be taken into account. Tributary sites will be used for paired data comparisons with other monitoring data at those locations when such data become available.

Table C-3 shows the comparison of profile averages from near the Tidbit® thermistor and midchannel. Overall, both profiles varied by less than 0.2 ^{o}C, indicating again that the river is well-mixed. A difference slightly above 0.2 ^{o}C was observed at the site near Cusick, suggesting that data from that site might vary slightly from midchannel conditions.

Table C-4 presents the calibration check results (both pre- and post-survey) for the Hydrolab® meter. Temperature and pH showed consistently acceptable results. Conductivity and DO showed some slight deviation from the calibration standards. Conductivity readings appear to be accurate at ±5% of the readings. DO readings in August and September fall well within the MQO of ±5% saturation or ±0.5 mg/L, while readings in July and October may be less accurate but appear to still fall within a range of ±10% saturation or ±1.0 mg/L.

The results of the post-monitoring thermistor accuracy check show that all TidbiT® thermistors except one met the MQO of ±0.2 ^{o}C. The average differences between the reference thermometer and thermistor #598748, used at Box Canyon Dam, were -0.237 ^{o}C for the ice bath and -0.288 ^{o}C for the warm bath (the thermistor was consistently reading low). The pre-season accuracy check for this thermistor was good with the results of 0.09 ^{o}C for the ice bath and -0.132 ^{o}C for the warm bath, so the thermistor was meeting the MQO at the beginning of the study. Also, the field check during the final survey was only 0.01 ^{o}C different, and the post-monitoring check was close to the MQO and was measured months after the survey. Therefore, the data from this thermistor appears acceptable for use, but should be used with caution with the post-monitoring measured differences taken into account.

Field Data

Figures C-3 through C-17 show the results of the TidbiT® monitoring. These figures also show the seven-day average of the daily maximum and minimum reading, and the spot field measurements from the profiles. Overall, the time series show similar patterns over the season, which likely reflect meteorological and flow conditions. Mainstem sites are very similar, while tributaries show greater variability and characteristics unique to each site. Calispel Creek had the warmest temperatures, peaking near 26 ^{o}C, while LeClerc Creek was the coolest, with temperatures rarely exceeding 16 ^{o}C. Peak temperatures occurred in the second half of August, followed by an overall cooling trend as the season progressed.

Data gaps reflect the date of installation (July for some sites), lost equipment, or missing data:

- The August data for the mainstem site near Cusick (Figure C-8) was not recorded for reasons unknown.
- Data during June at Lost Creek (Figure C-14) showed indications that the meter was removed from the river for several weeks and then replaced. These data were deleted.
- Data at Box Canyon (Figure C-16) indicated that tailrace water elevations dropped during the night, so that the meter was exposed to cool night temperatures and then was back in the water during the day. Data were screened and blocks of data reflecting air temperatures were deleted. Therefore, some of the data reflect daily maximums but not minimums.

Figure C-18 shows the trend in maximum temperatures from upstream to downstream. For each site, the warmest observed daily maximum is shown, along with the date it occurred. Maximum temperatures were all above 23 ^{o}C, and above 24 ^{o}C downstream of Dalkena. The highest temperature measured in the mainstem was 25.0 ^{o}C above Skookum Creek on August 18. The highest seven-day average of daily maximum temperatures was measured near Ione at 24.7 ^{o}C.

Depth-profile data are reported in Table C-5 and shown in Figures C-19 through C-22. As described above, profiles showed the river to be consistently well-mixed. Only isolated dissolved oxygen readings fell below the water quality criterion of 8 mg/L, and the only readings significantly below 8 mg/L were in off-channel areas near the mouths of Calispel and Tahoma Creeks. All pH readings were above 7.0, and all pH readings from the mainstem were above 8.0 (readings between 7 and 8 were found at the creek mouths). Readings above the water quality criterion of 8.5 were widespread in the mainstem, especially in August. The Pend Oreille River is listed on Ecology's 303(d) list for pH, and past studies have attributed high pH to productivity from the river's milfoil beds (Golder Associates, 2004). Conductivity readings were between 130 and 150 uS/cm in the mainstem, while a few readings below 100 were found at the creek mouths.

Conclusions and Recommendations

Continuous temperature data were successfully collected from eleven mainstem Pend Oreille River sites and three tributary sites. Data are of good quality, although higher variability was indicated for certain data at certain times that must be taken into account. Monitoring results met the project objective of characterizing temperatures for model development.

Project logistics went well except for buoy deployments – five out of seven deployments were removed and one appeared to be removed and put back. Future projects should avoid this method, and should focus on piling and cable deployments. Cable deployments that hang loose in a high energy environment need adequate weight attached to avoid self-winding.

Temperatures were consistent with previous studies, with maximum temperatures that exceeded 24 ^oC over much of the river in late August. Temperatures exceeded the numeric water quality criterion of 20 ^oC in the mainstem during most of July and August. High pH levels in excess of the water quality criterion of 8.5 were also observed, mostly during the August survey.

The Pend Oreille River is consistently well mixed. Small areas of unmixed waters were found in the vicinity of creek mouths. Conditions are similar throughout the mainstem sites, although some variations in temperature can be observed from upstream to downstream. Tributaries showed greater variability in temperature both at each site and between sites.

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Tables

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Table C-1. Description of Ecology's monitoring sites.

EIM[1] ID	RM[2]	Location[3]	Start Date	End Date	Thermistor No.	Thermistor Depth	Comments
1010	87.5	POR near Newport (Kelly Island)	27-Jun-04	20-Oct-04	598735	near bottom	
1020	84.5	POR above Marshall Creek	24-Jun-04	20-Oct-04	728520	near bottom	
1030		POR at Marshall Creek mouth	20-Aug-04	20-Aug-04	-		
1040	81.6	POR above Indian Island	24-Jun-04	23-Sep-04	728518	near bottom	tidbit and buoy removed and later returned
1050		POR at Indian Creek mouth	20-Aug-04	20-Aug-04	-		
1060	77.7	POR near Dalkena	24-Jun-04	20-Oct-04	728524	3m	
1070	74.7	POR above Skookum Creek	24-Jun-04	20-Oct-04	728530	3m	
1080	70.3	POR near Cusick	23-Jun-04	19-Oct-04	728531	3m	August data lost
2080		Calispel Creek above pumps	28-Jul-04	19-Oct-04	598747	bottom	
1090		POR at Calispell Creek mouth	19-Aug-04	19-Aug-04	-		
1110	67.2	POR above Tacoma Creek	24-Jun-04	19-Aug-04	728523 598754	near bottom	lost tidbit and buoy
1120		POR at Tacoma Creek mouth	19-Aug-04	19-Aug-04	-		
1125		POR near River Bend	24-Jun-04	22-Sep-04	466857	near bottom	lost tidbit and buoy
1130		POR above Mill Creek	24-Jun-04	22-Sep-04	728533	near bottom	lost tidbit and buoy
1135		POR at Mill Creek mouth	22-Jun-04	18-Aug-04	-		
1140	56.8	POR above LeClerc Creek	22-Jun-04	19-Oct-04	728541	3m	
1150		POR at LeClerc Creek mouth	18-Aug-04	18-Aug-04	-		
2140		LeClerc Creek near stream gage	29-Jul-04	19-Oct-04	598744	bottom	
1160	54.3	POR above Blueslide	24-Jun-04	19-Oct-04	728522	3m	
1170		POR at Ruby Creek Mouth	18-Aug-04	18-Aug-04	-		
1180	49.5	POR above Lost Creek	24-Jun-04	19-Oct-04	728540	near bottom	
1185		POR near Tiger	25-Jun-04	22-Sep-04	466860	near bottom	lost tidbit and buoy
1190	38.3	POR near Ione	25-Jun-04	19-Oct-04	598738	3m	
1220	34.4	POR at Box Canyon Dam – tailrace	29-Jul-04	19-Oct-04	598748	variable	
2220		Sullivan Creek- near USGS gage	29-Jul-04	19-Oct-04	560547	bottom	

[1] Environmental Information Management system (Department of Ecology environmental database)
[2] River mile
[3] POR = Pend Oreille River

Table C-2. Data quality assessment of temperature measurements: Paired comparison of thermistor and spot profile data points.

			Temperature (deg C)				
Location	Date	Time	Spot Reading	Thermistor	Resid[1]	Avg Resid[1]	RMSE[2]
Pend Oreille River (POR)	27-Jul-04	14:50	22.53	22.54	-0.01		
above Newport -	20-Aug-04	9:20	23.37	23.38	-0.01		
Kelly Island/Stateline	23-Sep-04	9:52	15.71	15.76	-0.05		
	20-Oct-04	9:40	12.79	12.80	-0.01	**-0.02**	**0.03**
POR above Marshall Creek	27-Jul-04	15:50	22.91	22.94	-0.03		
	20-Aug-04	10:15	23.12	23.28	-0.16		
	23-Sep-04	10:30	15.73	15.94	-0.21		
	20-Oct-04	10:35	12.79	12.97	-0.18	**-0.15**	**0.16**
POR above Indian Island	27-Jul-04	17:45	23.11	23.2	-0.09	**-0.09**	**0.09**
POR near Dalkena	27-Jul-04	16:45	22.84	23.02	-0.18		
	20-Aug-04	11:15	23.21	23.36	-0.15		
	23-Sep-04	12:30	15.80	15.85	-0.05		
	20-Oct-04	11:20	12.81	12.87	-0.06	**-0.11**	**0.12**
POR above Skookum Creek	28-Jul-04	10:30	22.46	22.62	0.01		
	19-Aug-04	9:03	22.84	22.96	-0.12		
	21-Sep-04	17:20	16.05	16.27	-0.22		
	20-Oct-04	11:41	12.76	12.97	-0.21	**-0.14**	**0.16**
POR near Cusick	7/28/2004	11:30	22.59	22.69	-0.10		
	8/19/2004	10:51	23.01	23.19	-0.18		
	9/21/2004	16:40	16.01	16.06	-0.05		
	10/19/2004	17:08	13.11	13.24	-0.13	**-0.12**	**0.12**
Calispel Creek above pumps	7/28/2004	14:30	23.7	23.4	0.30		
	9/22/2004	8:50	12.1	12.77	-0.67		
	10/19/2004	16:18	10.8	9.5	1.30	0.31	0.86
POR above Tacoma Creek	28-Jul-04	12:35	22.96	23.11	-0.15		
	19-Aug-04	10:05	23.16	23.28	-0.12		
	21-Sep-04	15:55	15.95	15.97	-0.02	**-0.10**	**0.11**
POR above LeClerc Creek	28-Jul-04	16:55	23.25	23.30	-0.05		
	18-Aug-04	11:15	23.65	23.82	-0.17		
	22-Sep-04	11:05	15.53	15.63	-0.10		
	19-Oct-04	15:00	12.81	12.99	-0.18	**-0.13**	**0.14**
LeClerc Creek	29-Jul-04	14:55	15.5	15.99	-0.49		
near stream gage	22-Sep-04	17:49	9.8	9.93	-0.13		
	19-Oct-04	8:45	7.4	7.16	0.24	**-0.13**	0.32
POR above Blueslide	28-Jul-04	17:32	23.24	23.38	-0.14		
	18-Aug-04	12:15	23.71	23.89	-0.18		
	22-Sep-04	11:30	15.46	15.56	-0.10		
	19-Oct-04	14:15	12.80	12.89	-0.09	**-0.13**	**0.13**
POR above Lost Creek	28-Jul-04	18:20	23.27	23.47	-0.20		
	18-Aug-04	13:45	23.90	23.98	-0.08		
	22-Sep-04	12:15	15.60	15.83	-0.23		
	19-Oct-04	13:25	12.80	13.03	-0.23	**-0.18**	**0.20**
POR near Ione	29-Jul-04	18:20	23.12	23.21	-0.09		
	18-Aug-04	17:20	23.97	24.07	-0.10		
	22-Sep-04	14:30	15.57	15.70	-0.13		
	19-Oct-04	11:30	13.03	13.19	-0.16	**-0.12**	**0.12**
POR at Box Canyon Dam – tailrace	19-Oct-04	10:05	13.05	13.04	0.01	**0.01**	**0.01**
Sullivan Creek -	22-Sep-04	16:47	11.6	11.69	-0.09		
near USGS gage	19-Oct-04	10:35	11.9	12.00	-0.10	**-0.09**	**0.10**
[1] Avg Resid = Average residual					All pairs:	**-0.09**	0.26
[2] RMSE = Root mean square error					Mainstem sites only:		**0.13**

Table C-3. Data quality assessment of temperature measurements: Paired comparison of spot profile average values at thermistor and midchannel.

			Temperature (deg C)			
Location[1]	Date	Time	@thermistor	Midchannel	Resid[2]	RMSE[3]
POR above Marshall Creek	20-Aug-04	10:25	23.12	23.16	**-0.04**	**0.04**
POR near Dalkena	20-Aug-04	11:41	23.26	23.25	**0.01**	**0.01**
POR above Skookum Creek	19-Aug-04	9:35	22.83	23.02	**-0.19**	**0.19**
POR near Cusick	19-Aug-04	11:13	23.02	23.25	-0.23	0.23
POR above Tacoma Creek	19-Aug-04	10:10	23.17	23.20	**-0.03**	**0.03**
POR above LeClerc Creek	18-Aug-04	11:25	23.61	23.68	**-0.07**	**0.07**
POR above Blueslide	24-Jun-04	16:10	18.10	18.2	**-0.10**	**0.10**
	18-Aug-04	12:40	23.73	23.75	**-0.02**	**0.02**
POR above Lost Creek	18-Aug-04	14:00	23.92	23.98	**-0.06**	**0.06**
				All pairs:	**-0.08**	**0.11**
[1] POR = Pend Oreille River; [2] Resid = Residual; [3] RMSE = Root mean square error						

Table C-4. Data quality assessment of field monitoring: Multi-parameter meter calibration checks.

Laboratory Calibration Check - tap water						
				Difference		
Date	Parameter	Meter	Liquid thermometer	Meter-thermometer	Target[1]	Comment
8/17/2004	Temperature	23.87	24.0	**0.1**	0.2	
9/21/2004		22.87	23.0	**0.1**	0.2	
10/18/2004		21.60	21.7	**0.1**	0.2	
10/21/2004		14.94	14.9	**0.0**	0.2	
Laboratory Calibration Check – standards						
				Difference		
Date	Parameter	Meter	Standard	Meter-Std	Target[1]	Comment
8/17/2004	Specific	103.7	103.4	**0.3**	5	Recalibrated after check
9/21/2004	Conductance	102.3	103.4	**1.1**	5	
10/18/2004		108.9	103.4	5.5	5	Recalibrated after check
10/21/2004		103.1	103.3	**0.2**	5	
8/17/2004	Dissolved	92.9%	100.0%	7.1%	5%	Recalibrated after check
9/21/2004	Oxygen	101.0%	100.0%	**1.0%**	5%	
10/18/2004	Percent	99.9%	100.0%	**0.1%**	5%	
10/21/2004	Saturation	108.7%	100.0%	8.7%	5%	
8/17/2004	pH	6.97	7.01	**0.04**	0.5	Recalibrated after check
8/17/2004		9.87	10.04	**0.17**	0.5	Recalibrated after check
9/21/2004	pH	7.02	7.01	**0.01**	0.5	
9/21/2004		10.05	10.04	**0.01**	0.5	
10/18/2004	pH	6.98	7.02	**0.04**	0.5	
10/18/2004		9.98	10.05	**0.07**	0.5	
10/21/2004	pH	7.01	7.00	**0.01**	0.5	
10/21/2004		10.01	10.03	**0.02**	0.5	
[1] Measurement Quality Objectives from Ecology (2004a)						

Table C-5. Results of Ecology's depth-profile measurements.

Site	Site ID	Date	Time	Depth (m)	Temp. (deg C)	DO (mg/L)	DO %Sat	pH (s.u.)	SP. Cond. (uS/cm)	Comments
POR near Newport (Kelly Island)	1010	27-Jul-04	14:50	0.1	22.55	8.82	101.4	8.42	143.3	
				1.0	22.55					
				2.0	22.55					
				3.0	22.55					
				4.0	22.54					
				5.0	22.55					
				6.0	22.53					
POR near Newport (Kelly Island)	1010	20-Aug-04	9:20	0.1	23.30	8.37	105.2	8.55	157.3	
				1.0	23.32	8.29	104.2	8.55	156.7	
				2.0	23.33	8.40	105.6	8.53	157.3	
				3.0	23.33	8.36	105.1	8.53	156.7	
				4.0	23.32	8.27	104.0	8.52	157.1	
				5.0	23.33	8.30	104.3	8.51	156.9	
				6.1	23.33	8.24	103.7	8.50	156.8	
				7.0	23.34	8.27	104.0	8.50	157.2	
				8.0	23.33	8.28	104.1	8.50	157.0	
				9.0	23.34	8.31	104.5	8.48	157.3	
				9.6	23.37	8.27	104.0	8.49	157.0	
POR near Newport (Kelly Island)	1010	23-Sep-04	9:52	0.1	15.70	9.12	98.4	8.34	156.1	
				1.0	15.70	8.95	96.6	8.31	157.0	
				2.0	15.70	8.95	96.6	8.30	156.8	
				3.0	15.71	8.88	95.8	8.31	156.7	
				4.0	15.71	8.87	95.6	8.30	156.8	
				5.0	15.70	8.88	95.7	8.29	156.7	
				6.1	15.70	8.88	95.8	8.29	156.7	
				7.1	15.70	8.91	96.2	8.29	156.6	
				8.0	15.71	8.88	95.8	8.29	156.4	
POR near Newport (Kelly Island)	1010	20-Oct-04	9:25	0.1	12.79	9.36	94.7	8.23	145.0	
				1.0	12.79	9.27	93.9	8.21	144.5	
				2.0	12.79	9.29	94.1	8.21	144.6	
				3.0	12.79	9.17	92.8	8.21	144.2	
				4.0	12.80	9.18	93.0	8.21	144.7	
				5.0	12.79	9.19	93.0	8.20	144.7	
				6.0	12.79	9.18	92.5	8.20	144.4	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Marshall Creek	1020	24-Jun-04	13:40	0.1	17.6					
				1.0	17.6					
				2.0	17.6					
				3.0	17.6					
				4.0	17.6					
				5.0	17.6					
POR above Marshall Creek	1020	27-Jul-04	15:50	0.1	22.94					
				1.0	22.92					
				2.0	22.91					
				3.0	22.91					
				3.5	22.91	9.28	107.3	8.53	143.4	
POR above Marshall Creek	1020	20-Aug-04	10:15	0.1	23.12	8.36	104.7	8.46	158.4	
				1.0	23.12	8.29	103.8	8.45	158.4	
				2.0	23.11	8.17	102.3	8.44	158.3	
				3.0	23.11	8.12	101.7	8.45	158.6	
				4.0	23.12	8.15	102.1	8.44	157.9	
				5.0	23.12	8.10	101.4	8.44	158.3	
POR above Marshall Creek	1020	20-Aug-04	10:25	0.1	23.18	8.16	102.3	8.48	158.2	midchannel
				1.0	23.16	8.11	101.7	8.47	158.3	
				2.0	23.16	8.10	101.6	8.47	158.1	
				3.0	23.15	8.12	101.8	8.47	158.1	
				4.0	23.16	8.11	101.7	8.46	158.1	
POR above Marshall Creek	1020	23-Sep-04	10:50	0.1	15.73	9.12	98.4	8.33	155.9	midchannel
				1.0	15.74	9.04	98.2	8.33	156.1	
				2.0	15.73	9.06	97.9	8.31	156.2	
				3.0	15.73	9.00	97.2	8.32	156.2	
				4.0	15.73	9.03	97.5	8.31	156.3	
				4.4	15.73	8.91	96.2	8.32	156.1	
POR above Marshall Creek	1020	20-Oct-04	10:35	0.1	12.78	9.41	95.3	8.19	147.1	midchannel
				1.1	12.79	9.29	94.0	8.18	147.0	
				2.1	12.79	9.26	93.7	8.18	147.0	
				3.1	12.79	9.17	92.8	8.17	146.5	
				4.0	12.79	9.23	93.4	8.24	147.0	

Definitions of abbreviations: POR = Pend Oreille River; m = meters; Temp = temperature; deg C = degree Centigrade; DO = dissolved oxygen; mg/L = milligrams per liter; %sat = percent of saturation; s.u. = standard units; SPCond = specific conductance

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR at Marshall Creek mouth	1030	20-Aug-04	12:33	0.1	16.48	9.34	103.2	8.31	138.6	
POR at Marshall Creek mouth	1030	20-Aug-04	12:33	0.2	13.55	10.12	104.0	8.17	131.5	
POR above Indian Island	1040	24-Jun-04	12:40	0.1	17.5					
				0.5	17.4					
				1.0	17.4					
				1.5	17.4					
				2.0	17.4					
				2.5	17.4					
				3.0	17.4					
				3.5	17.4					
POR above Indian Island	1040	27-Jul-04	17:45	0.1	23.11					
				1.0	23.11					
				2.0	23.11					
				3.0	23.11					
				4.0	23.11					
				4.4	23.11	9.24	107.4	8.54	143.4	
POR above Indian Island	1040	20-Aug-04	10:52	0.1	23.14	8.75	109.6	8.50	158.5	
				1.0	23.13	8.42	105.4	8.50	157.5	
				2.0	23.13	8.36	104.7	8.49	158.9	
				3.0	23.12	8.28	103.7	8.49	158.7	
				4.0	23.13	8.25	103.3	8.49	158.0	
				4.8	23.12	8.30	103.9	8.54	158.6	
POR above Indian Island	1040	23-Sep-04	11:30	0.1	15.79	9.12	98.6	8.34	155.7	
				1.1	15.78	9.06	97.9	8.33	155.7	
				2.0	15.77	9.02	97.5	8.33	155.7	
				3.0	15.78	9.06	97.9	8.32	155.3	
				4.0	15.77	9.03	97.5	8.31	155.4	
				4.8	15.77	8.89	96.1	8.32	155.8	
POR at Indian Creek mouth	1050	20-Aug-04	12:00	0.1	15.52	10.71	114.8	8.18	128.3	
				0.4	13.77	10.14	104.9	7.72	96.6	
POR near Indian Island		27-Jul-04	18:03	0.1		10.37	121.1	8.79	141.3	in milfoil bed

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR near Dalkena	1060	24-Jun-04	11:40	0.1	17.2					
				1.0	17.2					
				2.0	17.2					
				3.0	17.1					
				4.0	17.1					
				5.0	17.1					
				6.0	17.1					
				7.0	17.1					
				8.0	17.2					
				9.0	17.2					
POR near Dalkena	1060	27-Jul-04	16:45	0.1	22.88					
				1.0	22.87					
				2.0	22.84					
				3.0	22.84					
				4.0	22.84					
				5.0	22.83					
				5.5	22.84	9.08		8.51	143.6	
POR near Dalkena	1060	20-Aug-04	11:15	0.1	23.44	8.33	105.0	8.52	157.9	
				1.0	23.24	8.14	102.2	8.50	157.9	
				2.1	23.24	8.15	102.3	8.49	158.0	
				3.0	23.21	8.12	101.9	8.49	157.7	
				4.0	23.21	8.13	102.0	8.49	158.0	
				5.0	23.22	8.11	101.8	8.49	158.5	
				5.8	23.23	8.11	101.8	8.48	157.7	
POR near Dalkena	1060	20-Aug-04	11:41	0.1	23.42	8.05	101.3	8.48	158.6	midchannel
				1.0	23.30	7.99	100.4	8.48	158.2	midchannel
				2.0	23.25	8.07	101.3	8.48	158.7	midchannel
				3.0	23.21	8.06	100.6	8.47	158.1	midchannel
				4.0	23.20	7.98	100.1	8.47	158.2	midchannel
				4.9	23.20	8.02	100.6	8.47	158.4	midchannel
				6.0	23.20	8.00	100.4	8.48	158.5	midchannel

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR near Dalkena	1060	23-Sep-04	12:30	0.2	15.81	8.90	96.2	8.30	155.8	
				1.1	15.81	8.95	96.8	8.29	155.9	
				2.0	15.80	8.90	96.2	8.30	155.7	
				3.0	15.80	8.86	95.8	8.29	156.1	
				4.0	15.80	8.85	95.6	8.28	156.1	
				5.0	15.80	8.86	95.8	8.28	156.1	
				6.0	15.80	8.87	95.5	8.27	155.7	
				7.0	15.80	8.81	95.3	8.28	155.8	
POR near Dalkena	1060	20-Oct-04	11:20	0.1	12.79	9.20	93.2	8.16	147.0	
				1.0	12.81	9.22	93.3	8.15	148.3	
				2.1	12.81	9.25	93.6	8.13	146.0	
				3.1	12.81	9.15	93.6	8.12	146.6	
				4.1	12.81	9.17	92.9	8.12	145.1	
				5.0	12.81	9.14	92.6	8.12	145.7	
				6.0	12.81	9.12	92.3	8.13	146.0	
POR above Skookum Creek	1070	24-Jun-04	11:00	0.1	17.7					
				1.0	17.6					
				2.0	17.5					
				3.0	17.6					
				4.0	17.5					
				5.0	17.5					
				6.0	17.5					
				7.0	17.5					
				8.0	17.5					
				9.0	17.5					
POR above Skookum Creek	1070	28-Jul-04	10:30	0.1	23.01					
				1.0	22.81					
				2.0	22.54					
				3.0	22.46					
				3.5	22.41	8.92	102.2	8.61	141.3	

Table C-5 continued: results of profile measurements.

Site	Site ID	Date	Time	Depth (m)	Temp (deg C)	DO (mg/L)	DO %Sat	pH (s.u.)	SPCond (uS/cm)	Comments
POR above Skookum Creek	1070	19-Aug-04	9:03	0.1	22.81			8.42	155.5	
				1.1	22.84			8.42	156.0	
				2.0	22.83	7.56	94.2	8.41	155.9	
				3.0	22.84			8.39	155.6	
				4.0	22.84			8.41	155.6	
				4.3	22.84			8.40	155.5	
POR above Skookum Creek	1070	19-Aug-04	9:35	0.1	23.02			8.53	157.0	midchannel
				1.1	23.03			8.53	157.3	
				2.1	23.02	8.14	101.8	8.49	156.6	
				3.0	23.02			8.51	156.5	
				4.0	23.03			8.50	156.9	
POR above Skookum Creek	1070	21-Sep-04	17:20	0.1	16.06	10.56	114.8	8.67	151.5	
				1.1	16.03	10.21	110.9	8.65	151.8	
				2.1	16.05	10.30	112.0	8.66	152.0	
				3.0	16.05	10.05	109.2	8.64	152.0	
				4.0	16.04	10.10	109.8	8.63	152.0	
				4.8	16.04	10.03	109.0	8.63	152.2	
POR above Skookum Creek	1070	20-Oct-04	11:41	0.1	12.79	9.55	96.7	8.27	145.7	
				1.1	12.79	9.46	95.7	8.27	145.8	
				2.1	12.76	9.43	95.4	8.24	145.7	
				3.0	12.76	9.45	95.6	8.22	145.9	
				4.0	12.76	9.35	94.6	8.23	145.0	
POR near Cusick	1080	23-Jun-04	13:30	0.1	17.7					
				1.0	18.0					
				2.0	17.9					
				3.0	17.6					
				4.0	17.5					
				5.0	17.5					
				6.0	17.5					
				7.0	17.6					
				8.0	17.7					
				9.0	17.5					
				10.0	17.5					

Table C-5 continued: results of profile measurements.

Site	Site ID	Date	Time	Depth (m)	Temp (deg C)	DO (mg/L)	DO %Sat	pH (s.u.)	SPCond (uS/cm)	Comments
POR near Cusick	1080	28-Jul-04	11:30	0.1	22.76					
				1.0	22.74					
				2.0	22.67					
				3.0	22.59					
				4.0	22.58					
				4.4	22.58	8.88	102.3	8.57	143.0	
POR near Cusick	1080	19-Aug-04	10:51	0.1	23.10	8.15	102.1	8.50	156.7	
				1.1	23.02	8.03	100.3	8.47	155.9	
				2.1	23.01	7.90	99.2	8.47	155.9	
				3.0	23.01	7.93	99.1	8.46	156.5	
				3.9	22.99	7.89	98.6	8.46	156.3	
				4.4	23.00	7.89	98.3	8.44	156.7	
POR near Cusick	1080	19-Aug-04	11:13	0.1	23.28	8.46	106.3	8.57	157.4	midchannel
				1.1	23.25	8.54	107.2	8.56	157.6	
				2.0	23.25	8.73	109.6	8.56	157.2	
				3.0	23.25	8.65	108.5	8.55	156.9	
				4.0	23.24	8.74	109.7	8.54	157.9	
				5.0	23.25	8.82	110.0	8.54	158.0	
				6.0	23.25	8.28	103.9	8.53	158.3	
POR near Cusick	1080	21-Sep-04	16:40	0.1	16.01	9.76	106.0	8.50	151.6	
				1.1	16.01	9.55	103.7	8.49	151.8	
				2.1	16.01	9.55	103.7	8.48	152.0	
				3.1	16.01	9.41	102.1	8.48	152.2	
				4.1	16.01	9.45	102.6	8.48	152.2	
				5.0	16.01	9.42	102.3	8.47	152.0	
				5.7	16.01	9.41	102.2	8.47	152.3	
POR near Cusick	1080	19-Oct-04	17:08	0.1	13.10	9.82	100.1	8.35	144.0	
				1.0	13.11	9.71	99.0	8.35	144.3	
				2.1	13.11	9.65	98.4	8.35	144.4	
				3.0	13.11	9.64	98.3	8.34	144.5	
				4.0	13.12	9.54	97.3	8.34	144.3	
				5.0	13.12	9.57	97.6	8.33	144.3	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR at Calispell Creek mouth	1090	19-Aug-04	11:30	0.1	24.41	6.56	84.2	7.24	76.6	outside levy
				1.0	23.56	6.39	80.6	7.15	74.9	
				2.1	23.28	6.22	78.2	7.10	75.1	
				2.6	23.18	5.96	74.7	7.07	74.8	
Calispel Creek above pumps	2080	28-Jul-04	14:30	0.1	23.70					
Calispel Creek above pumps	2080	22-Sep-04	8:50	0.1	12.10					
Calispel Creek above pumps	2080	19-Oct-04	16:18	0.1	10.80					
POR above Tacoma Creek	1110	24-Jun-04	20:45	0.1	17.7					
				1.0	17.7					
				2.0	17.7					
				3.0	17.7					
				4.0	17.7					
				5.0	17.7					
				6.0	17.7					
				7.1	17.7					
POR above Tacoma Creek	1110	28-Jul-04	12:35	0.1	23.02					
				1.0	22.98					
				2.0	22.97					
				3.0	22.97					
				4.0	22.96					
				4.5	22.96	9.14	105.5	8.56	143.4	
POR above Tacoma Creek	1110	19-Aug-04	10:05	0.1	23.18	8.45	106.2	8.57	156.3	
				1.1	23.17	8.59	107.6	8.54	156.5	
				2.0	23.17	8.58	107.6	8.54	157.5	
				3.0	23.16	8.47	106.1	8.53	156.9	
				4.0	23.16	8.48	106.4	8.52	157.5	
				4.9	23.16	8.38	105.0	8.54	156.9	
POR above Tacoma Creek	1110	19-Aug-04	10:10	0.1	23.21	8.66	108.7	8.56	157.8	midchannel
				1.1	23.20	8.54	107.2	8.55	157.6	
				2.1	23.20	8.47	106.7	8.55	157.2	
				3.0	23.20	8.45	105.7	8.54	157.2	
				4.0	23.19	8.42	105.6	8.54	157.3	
				5.0	23.19	8.41	105.5	8.53	157.6	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Tacoma Creek	1110	21-Sep-04	15:55	0.1	15.94	9.26	100.5	8.36	152.6	
				1.0	15.96	9.15	99.5	8.36	153.0	
				2.0	15.95	9.17	99.5	8.33	152.8	
				3.0	15.95	9.15	99.3	8.32	153.0	
				4.3	15.95	9.06	98.2	8.32	152.8	
				5.4	15.95	9.05	98.4	8.32	153.1	
POR above Tacoma Creek	1110	19-Oct-04	17:52	0.1	13.10	9.54	97.4	8.25	144.9	buoy and tidbit lost
				1.0	13.10	9.43	96.4	8.24	144.9	
				2.0	13.10	9.37	95.5	8.23	144.9	
				3.1	13.10	9.42	96.0	8.23	145.0	
				4.0	13.10	9.35	95.4	8.23	145.0	
POR at Tacoma Creek mouth	1120	19-Aug-04	10:30	0.1	22.15	8.77	108.0	8.17	50.0	
				1.0	21.93	8.50	104.1	7.97	50.1	
				2.0	21.66	6.33	77.1	7.11	54.0	
				2.4	21.18	4.57	55.1	6.85	62.7	
POR near River Bend	1125	24-Jun-04	18:33	0.1	18.2					buoy and tidbit lost
				1.0	18.2					
				2.0	18.2					
				3.0	18.2					
				4.0	18.2					
				5.0	18.2					
				6.0	18.2					
				7.0	18.2					
				8.0	18.2					
POR near River Bend	1125	18-Aug-04	10:16	0.1	23.63	8.64	109.4	8.62	154.8	
				1.1	23.61	8.69	109.7	8.61	154.9	
				2.0	23.59	8.74	110.4	8.61	154.4	
				3.0	23.59	8.74	110.4	8.60	155.0	
				4.0	23.58	8.74	110.4	8.59	155.1	
				5.0	23.58	8.70	109.9	8.59	155.1	
				6.0	23.58	8.68	109.9	8.59	155.1	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR near River Bend	1125	22-Sep-04	10:15	0.1	15.71	9.57	102.9	8.49	154.1	buoy and tidbit lost
				1.1	15.64	9.50	102.4	8.45	154.2	
				2.1	15.65	9.50	102.3	8.45	154.6	
				3.1	15.64	9.40	101.2	8.45	153.8	
				4.0	15.62	9.38	101.0	8.43	154.2	
				5.0	15.63	9.32	100.4	8.44	153.8	
				6.0	15.62	9.34	100.6	8.42	154.2	
POR above Mill Creek	1130	22-Jun-04	15:00	1.0	17.50					
				2.0	17.50					
				3.0	17.50					
				4.0	17.40					
				5.0	17.40					
				6.0	17.40					
				7.0	17.30					
				8.0	17.30					
				9.0	17.30					
POR above Mill Creek	1130	22-Jun-04	15:25	1.0	17.40					midchannel
				2.0	17.30					
				3.0	17.40					
				4.0	17.30					
				5.0	17.30					
				6.0	17.20					
				7.0	17.20					
				8.0	17.20					
				9.0	17.20					
				10.0	17.20					

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Mill Creek	1130	24-Jun-04	18:04	1.0	18.2					
				2.0	18.2					
				3.0	18.2					
				4.0	18.2					
				5.0	18.2					
				6.0	18.2					
				7.0	18.2					
				8.0	18.2					
				9.0	18.2					
POR above Mill Creek	1130	18-Aug-04	10:40	0.1	23.67	8.65	109.4	8.60	155.1	buoy and tidbit lost
				1.0	23.66	8.72	110.2	8.60	154.8	
				2.0	23.64	8.76	110.5	8.58	155.2	
				3.0	23.64	8.82	111.6	8.58	155.7	
				4.0	23.64	8.88	112.4	8.59	155.4	
				5.0	23.64	8.95	113.4	8.57	155.2	
				6.0	23.64	8.96	113.3	8.57	155.2	
				6.9	23.64	8.59	108.8	8.56	155.3	
POR above Mill Creek	1130	22-Sep-04	10:40	0.1	15.62	9.36	100.8	8.38	154.3	
				1.1	15.62	9.26	99.7	8.37	154.2	
				2.1	15.62	9.20	99.1	8.37	154.1	
				3.1	15.62	9.23	99.4	8.36	154.3	
				4.1	15.61	9.22	99.3	8.35	154.1	
				5.0	15.61	9.14	98.4	8.36	154.6	
				6.0	15.61	9.09	97.9	8.35	154.2	
				7.0	15.61	9.13	98.3	8.35	154.2	
				8.0	15.61	9.21	99.2	8.34	154.5	
				8.6	15.61	9.32	100.3	8.37	154.3	
POR at Mill Creek mouth	1135	22-Jun-04	16:00	4.5	13.5					
POR at Mill Creek mouth	1135	18-Aug-04	10:55	0.1	23.14	8.70	109.0	8.57	151.5	
				0.2	17.60	8.90	101.0	8.12	93.20	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above LeClerc Creek	1140	22-Jun-04	16:05	1.0	17.4					
				2.0	17.5					
				3.0	17.4					
				4.0	17.4					
				5.0	17.4					
				6.0	17.4					
				7.0	17.5					
				8.0	17.5					
				9.0	17.5					
				10.0	17.5					
POR above LeClerc Creek	1140	28-Jul-04	16:55	0.1	23.96					
				1.0	23.30					
				2.0	23.27					
				3.0	23.25					
				4.0	23.20					
				4.5	23.00	8.60	99.0	8.48	142.7	
POR above LeClerc Creek	1140	18-Aug-04	11:15	0.1	23.63	9.04	114.4	8.61	156.8	
				1.0	23.65	8.84	111.8	8.60	157.1	
				2.0	23.65	8.78	111.1	8.59	156.9	
				3.0	23.65	8.73	110.4	8.59	157.2	
				4.0	23.65	8.70	110.1	8.58	157.1	
				5.0	23.45	8.52	107.2	8.55	156.7	
POR above LeClerc Creek	1140	18-Aug-04	11:25	0.1	23.68	8.78	111.2	8.62	157.4	midchannel
				1.0	23.68	8.75	110.7	8.62	157.0	
				2.0	23.68	8.76	110.8	8.62	157.2	
				3.0	23.68	8.75	110.8	8.62	157.2	
				4.0	23.68	8.77	111.0	8.61	157.2	
				5.0	23.67	8.73	110.4	8.61	157.4	
				6.0	23.67	8.72	110.4	8.60	157.5	
				6.9	23.68	8.75	110.7	8.60	157.3	
				7.6	23.67	8.84	111.8	8.64	157.1	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above LeClerc Creek	1140	22-Sep-04	11:05	0.1	15.51	9.41	101.1	8.39	153.4	
				1.1	15.53	9.29	99.8	8.39	153.2	
				2.1	15.52	9.17	98.6	8.38	153.3	
				3.1	15.53	9.15	98.3	8.38	153.0	
				4.1	15.54	9.11	98.0	8.37	153.8	
				5.0	15.54	9.11	98.0	8.37	153.2	
				5.3	15.55	8.83	95.0	8.30	154.2	
POR above LeClerc Creek	1140	19-Oct-04	15:00	0.1	12.81	9.52	96.4	8.20	144.5	
				1.0	12.82	9.37	94.9	8.20	144.6	
				2.1	12.81	9.32	94.4	8.19	144.7	
				3.0	12.81	9.32	94.4	8.19	144.6	
				4.0	12.81	9.29	94.1	8.18	144.3	
				5.0	12.80	9.28	93.9	8.19	144.6	
				6.0	12.81	9.29	94.0	8.18	144.8	
POR at LeClerc Creek mouth	1150	18-Aug-04	11:38	0.1	16.54	10.22	110.6	8.28	159.6	
				0.3	16.60	8.61	94.9	8.33	158.6	
LeClerc Creek near stream gage	2140	29-Jul-04	14:55	0.1	15.5					
LeClerc Creek near stream gage	2140	22-Sep-04	17:49	0.1	9.8					
LeClerc Creek near stream gage	2140	19-Oct-04	8:45	0.1	7.4					
POR above Blueslide	1160	24-Jun-04	16:00	0.1	18.2					midchannel
				1.0	18.2					
				2.0	18.1					
				3.0	18.1					
				4.0	18.1					
				5.0	18.1					
				6.0	18.1					

Table C-5 continued: results of profile measurements.

				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Blueslide	1160	24-Jun-04	16:10	0.1	18.2					
				1.0	18.2					
				2.0	18.2					
				3.0	18.2					
				4.0	18.2					
				5.0	18.2					
				6.0	18.2					
				7.0	18.2					
				8.0	18.2					
				9.0	18.2					
POR above Blueslide	1160	28-Jul-04	17:32	0.1	23.47					
				0.1	23.38					
				1.0	23.37					
				2.0	23.27					
				3.0	23.24					
				4.0	23.23					
				5.0	23.24					
				6.0	23.23					
				7.0	23.23	9.50	105.9	8.64	142.4	
POR above Blueslide	1160	18-Aug-04	12:15	0.1	23.76	9.05	114.8	8.63	156.1	
				1.0	23.76	8.94	113.1	8.62	156.5	
				2.0	23.77	8.83	111.9	8.62	156.3	
				3.0	23.71	8.80	111.5	8.61	156.7	
				4.0	23.72	8.73	110.5	8.62	156.6	
				5.0	23.70	8.73	110.6	8.61	156.6	
				6.0	23.70	8.72	110.3	8.61	156.7	
				7.0	23.70	8.74	110.6	8.61	156.8	
				7.4	23.70	8.72	110.4	8.61	156.6	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Blueslide	1160	18-Aug-04	12:40	0.1	23.81	8.61	109.2	8.62	156.5	midchannel
				1.0	23.82	8.68	109.9	8.61	156.3	
				2.0	23.75	8.65	109.6	8.61	156.3	
				3.0	23.73	8.64	109.4	8.61	156.5	
				4.0	23.73	8.68	109.9	8.60	156.6	
				4.9	23.72	8.61	109.4	8.59	156.4	
				5.9	23.72	8.67	109.8	8.59	156.3	
				7.0	23.71	8.66	109.7	8.58	156.6	
				8.0	23.72	8.67	109.9	8.58	156.2	
POR above Blueslide	1160	22-Sep-04	11:45	0.1	15.39	9.28	99.5	8.39	153.0	
				1.1	15.46	9.23	98.9	8.38	153.0	
				2.1	15.46	9.21	98.9	8.37	153.2	
				3.0	15.46	9.17	98.5	8.37	152.8	
				4.0	15.47	9.20	98.7	8.37	153.0	
				5.0	15.47	9.15	98.2	8.36	153.0	
				6.0	15.47	9.17	98.4	8.36	152.8	
				7.0	15.47	9.15	98.3	8.35	152.9	
				7.7	15.47	9.17	98.4	8.35	153.0	
POR above Blueslide	1160	19-Oct-04	14:15	0.1	12.79	9.44	96.0	8.21	144.1	
				1.0	12.80	9.32	94.4	8.22	144.4	
				1.9	12.80	9.39	95.1	8.21	144.4	
				3.0	12.80	9.32	94.4	8.21	144.4	
				4.0	12.80	9.33	94.5	8.21	144.4	
				5.0	12.79	9.41	95.3	8.22	143.9	
				6.0	12.79	9.34	94.6	8.22	144.9	
				7.0	12.79	9.37	94.8	8.22	144.1	
POR at Ruby Creek Mouth	1170	18-Aug-04	12:59	0.1	22.30	8.49	106.0	8.61	124.4	
				0.9	18.51	9.13	104.5	8.27	110.6	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Lost Creek	1180	22-Jun-04	17:00	0.1	17.4					midchannel
				1.0	17.3					
				2.0	17.3					
				3.0	17.3					
				4.0	17.2					
				5.0	17.2					
				6.0	17.2					
				7.0	17.2					
				8.0	17.2					
				9.0	17.2					
POR above Lost Creek	1180	22-Jun-04	17:30	0.1	17.3					right bank
				1.0	17.3					
				2.0	17.3					
				3.0	17.3					
				4.0	17.3					
				5.0	17.3					
				6.0	17.3					
				7.0	17.3					
				8.0	17.3					
				9.0	17.2					
POR above Lost Creek	1180	24-Jun-04	17:12	1.0	18.1					
				2.0	18.1					
				3.0	18.1					
				4.0	18.1					
				5.0	18.1					
				6.0	18.1					
				7.0	18.1					
				8.0	18.1					

Table C-5 continued: results of profile measurements.

				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Lost Creek	1180	28-Jul-04	18:20	0.1	23.49					
				1.0	23.35					
				2.0	23.33					
				3.0	23.27					
				4.0	23.27					
				5.0	23.28					
				6.0	23.27					
				7.0	23.27					
				7.3	23.27	9.00	104.6	8.40	142.6	
POR above Lost Creek	1180	18-Aug-04	13:45	0.1	23.95	8.51	109.0	8.61	155.5	circulator problem
				1.0	23.93	8.47	107.7	8.61	155.7	
				2.0	23.91	8.24	104.8	8.61	156.0	
				3.0	23.93	8.05	102.4	8.60	156.1	
				4.0	23.90	8.31	105.6	8.60	156.2	
				5.0	23.91	8.06	102.2	8.60	156.0	
				6.0	23.90	8.57	108.8	8.57	155.6	
POR above Lost Creek	1180	18-Aug-04	14:00	0.1	24.10	8.59	109.4	8.60	150.9	midchannel
				1.0	23.97	8.26	105.6	8.61	156.7	
				2.0	24.00	8.24	104.4	8.61	156.6	
				3.0	23.98	8.23	105.2	8.61	156.4	
				4.0	23.98	8.19	104.1	8.61	156.4	
				5.0	23.98	8.16	104.8	8.61	156.4	
				6.0	23.98	8.22	105.1	8.61	156.2	
				7.0	23.93	8.27	105.1	8.60	156.3	
				7.7	23.94	8.40	106.9	8.62	156.7	
POR above Lost Creek	1180	22-Sep-04	12:15	0.1	15.61	9.39	101.1	8.34	152.9	
				1.1	15.60	9.34	100.5	8.35	153.2	
				2.1	15.60	9.36	100.7	8.36	152.9	
				3.1	15.60	9.29	100.0	8.37	152.8	
				4.1	15.60	9.24	99.5	8.37	152.9	
				5.0	15.60	9.25	99.3	8.36	152.9	
				6.1	15.60	9.13	98.3	8.37	152.9	
				7.0	15.60	9.16	98.6	8.36	152.8	
				8.0	15.60	9.19	99.0	8.36	153.0	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR above Lost Creek	1180	19-Oct-04	13:25	0.1	12.80	9.64	97.6	8.18	143.9	
				1.0	12.80	9.51	96.2	8.20	144.0	
				2.0	12.80	9.50	96.2	8.20	144.1	
				3.0	12.80	9.43	95.5	8.19	144.5	
				4.0	12.80	9.44	95.6	8.18	144.1	
				5.0	12.80	9.40	95.2	8.18	144.0	
				6.0	12.80	9.38	95.0	8.17	144.1	
				7.1	12.80	9.37	95.0	8.18	144.2	
POR near Tiger	1185	25-Jun-04	10:22	0.1	18.2					alternate location
				1.0	18.2					
				2.0	18.2					
				3.0	18.2					
				4.0	18.2					
				5.0	18.2					
				6.0	18.2					
				7.0	18.2					
				8.0	18.2					
POR near Tiger	1185	25-Jun-04	10:35	0.1	18.2					
				1.0	18.3					
				2.0	18.2					
				3.0	18.2					
				4.0	18.2					
				5.0	18.2					
				6.0	18.2					
				7.0	18.2					
				8.0	18.2					
				9.0	18.2					

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR near Tiger	1185	22-Sep-04	15:10	0.1	15.65	9.62	103.6	8.41	151.9	buoy and tidbit lost
				1.1	15.66	9.52	102.6	8.40	152.4	
				2.1	15.66	9.49	102.5	8.40	152.8	
				3.0	15.66	9.48	102.2	8.41	152.3	
				4.0	15.66	9.45	101.8	8.40	152.3	
				5.0	15.66	9.40	101.3	8.40	152.1	
				6.0	15.66	9.40	101.3	8.39	151.7	
				7.0	15.66	9.39	101.2	8.40	152.0	
				8.0	15.66	9.38	101.2	8.38	152.1	
				9.0	15.65	9.38	101.1	8.38	152.0	
POR near Ione	1190	25-Jun-04	11:25	0.1	18.3					
				1.0	18.2					
				2.0	18.2					
				3.0	18.2					
				4.0	18.2					
				5.0	18.2					
				6.0	18.2					
				7.0	18.2					
				8.0	18.2					
				9.0	18.2					
POR near Ione	1190	29-Jul-04	11:20	0.1	23.34					
				1.0	23.29					
				2.0	23.21					
				3.0	23.12					
				4.0	23.09					
				5.0	23.08					
				6.0	23.06					
				7.0	23.07					
				8.0	23.06					
				9.0	23.05					
				10.0	23.05					
				11.0	23.05					
				12.0	23.05					
				12.2	23.05	8.46	97.5	8.56	143.3	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR near Ione	1190	18-Aug-04	17:20	0.1	24.04	8.45	107.6	8.61	155.0	circulator problem
				1.1	23.98	8.31	105.7	8.59	155.2	
				2.0	24.00	8.40	106.9	8.58	155.2	
				3.0	23.97	8.28	105.7	8.58	155.6	
				4.0	23.96	8.07	102.7	8.56	155.6	
				5.0	23.96	8.13	103.6	8.57	154.9	
				6.0	23.95	8.09	103.6	8.55	155.1	
				7.0	23.95	8.10	103.1	8.54	155.6	
				8.0	23.94	8.09	103.0	8.54	155.0	
				9.0	23.93	8.00	102.4	8.54	155.6	
				10.0	23.93	8.01	101.7	8.53	156.0	
				11.0	23.93	8.14	103.7	8.55	155.7	
				12.0	23.93	8.18	103.3	8.53	155.8	
				12.5	23.93			8.52	156.2	
POR near Ione	1190	22-Sep-04	14:30	0.1	15.57	9.64	103.7	8.46	149.5	
				1.0	15.57	9.56	102.9	8.43	149.9	
				2.1	15.58	9.48	102.0	8.42	149.9	
				3.0	15.57	9.47	101.9	8.43	150.3	
				4.0	15.57	9.42	101.3	8.42	150.0	
				5.0	15.56	9.42	101.3	8.41	150.0	
				6.0	15.56	9.42	101.3	8.41	150.2	
				7.0	15.56	9.44	101.5	8.40	150.0	
				8.0	15.56	9.37	100.7	8.39	150.0	
				9.0	15.55	9.40	100.8	8.39	149.9	
				10.0	15.55	9.35	100.6	8.38	150.3	
				11.0	15.55	9.35	100.6	8.38	150.0	
				12.0	15.55	9.33	100.3	8.38	150.3	
				12.7	15.54	9.33	100.3	8.38	150.4	

Table C-5 continued: results of profile measurements.										
				Depth	Temp	DO	DO	pH	SPCond	
Site	Site ID	Date	Time	(m)	(deg C)	(mg/L)	%Sat	(s.u.)	(uS/cm)	Comments
POR near Ione	1190	19-Oct-04	11:30	0.1	13.06	9.30	94.6	8.11	143.4	
				1.0	13.05	9.17	93.4	8.10	143.4	
				2.0	13.02	9.09	92.5	8.11	143.4	
				3.1	13.03	9.17	93.3	8.09	143.3	
				4.1	13.03	9.17	93.3	8.08	143.4	
				5.1	13.02	9.14	93.0	8.09	143.4	
				6.1	13.04	9.06	92.2	8.08	143.3	
				7.0	13.03	9.13	92.9	8.08	143.6	
				8.0	13.02	9.12	92.8	8.08	143.6	
				9.0	13.02	9.07	92.3	8.07	143.3	
POR at Box Canyon Dam - tailrace	1220	19-Oct-04	10:05	0.1	13.05	9.07	92.4	8.11	143.3	circulator problem
				2.0	13.05	8.95	91.1	8.08	143.5	(0.1 - 2.0 m)
				4.1	13.05	9.01	91.9	8.09	143.2	
				6.1	13.05	9.01	91.7	8.06	143.8	
Sullivan Creek- near USGS gage	2220	22-Sep-04	16:47	0.1	11.6					
Sullivan Creek- near USGS gage	2220	19-Oct-04	10:35	0.1	11.9					

Figures

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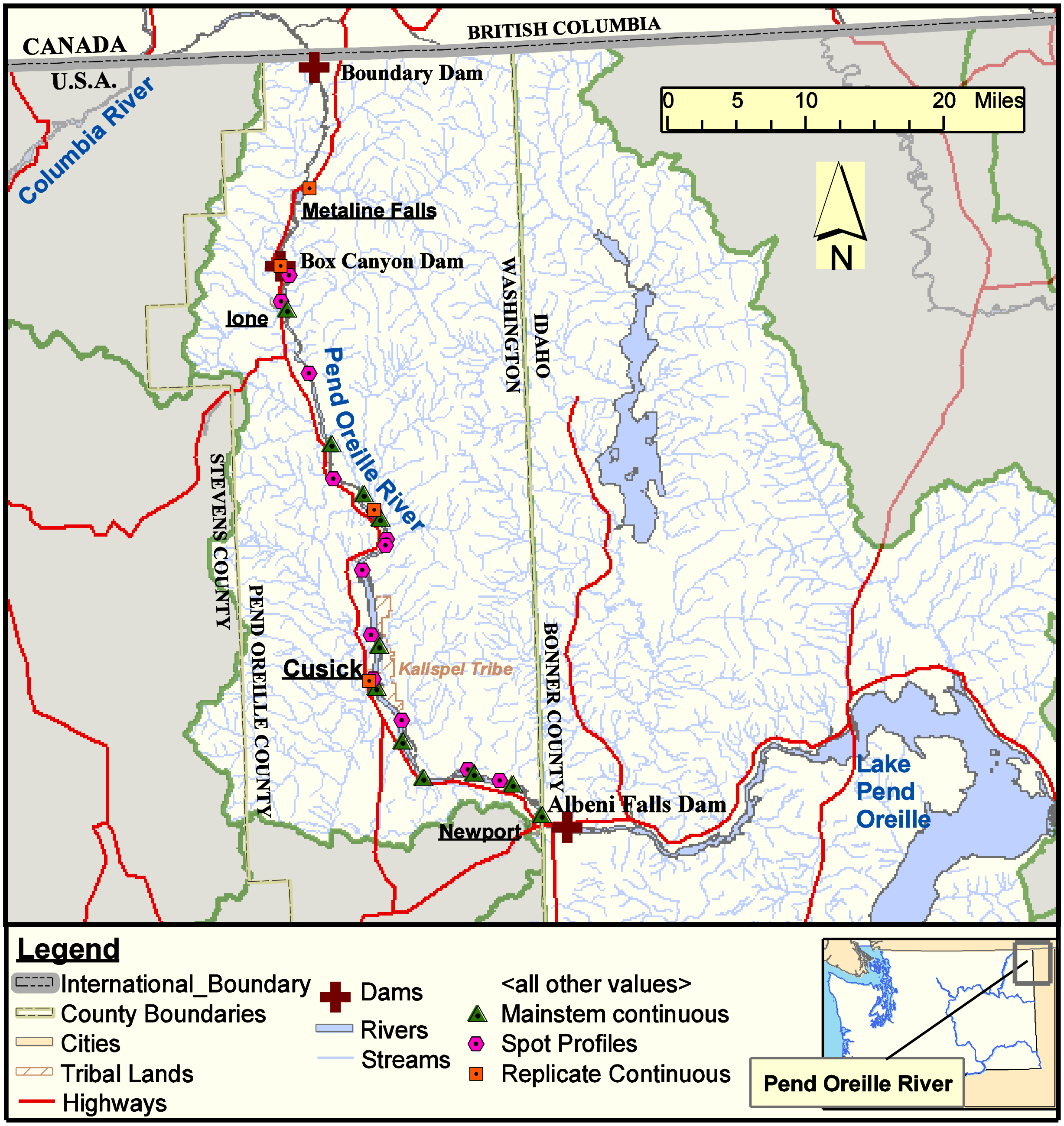


Figure C-1. Pend Oreille River temperature TMDL study area (Washington) as well as upstream (Idaho) and downstream (British Columbia) neighboring areas.

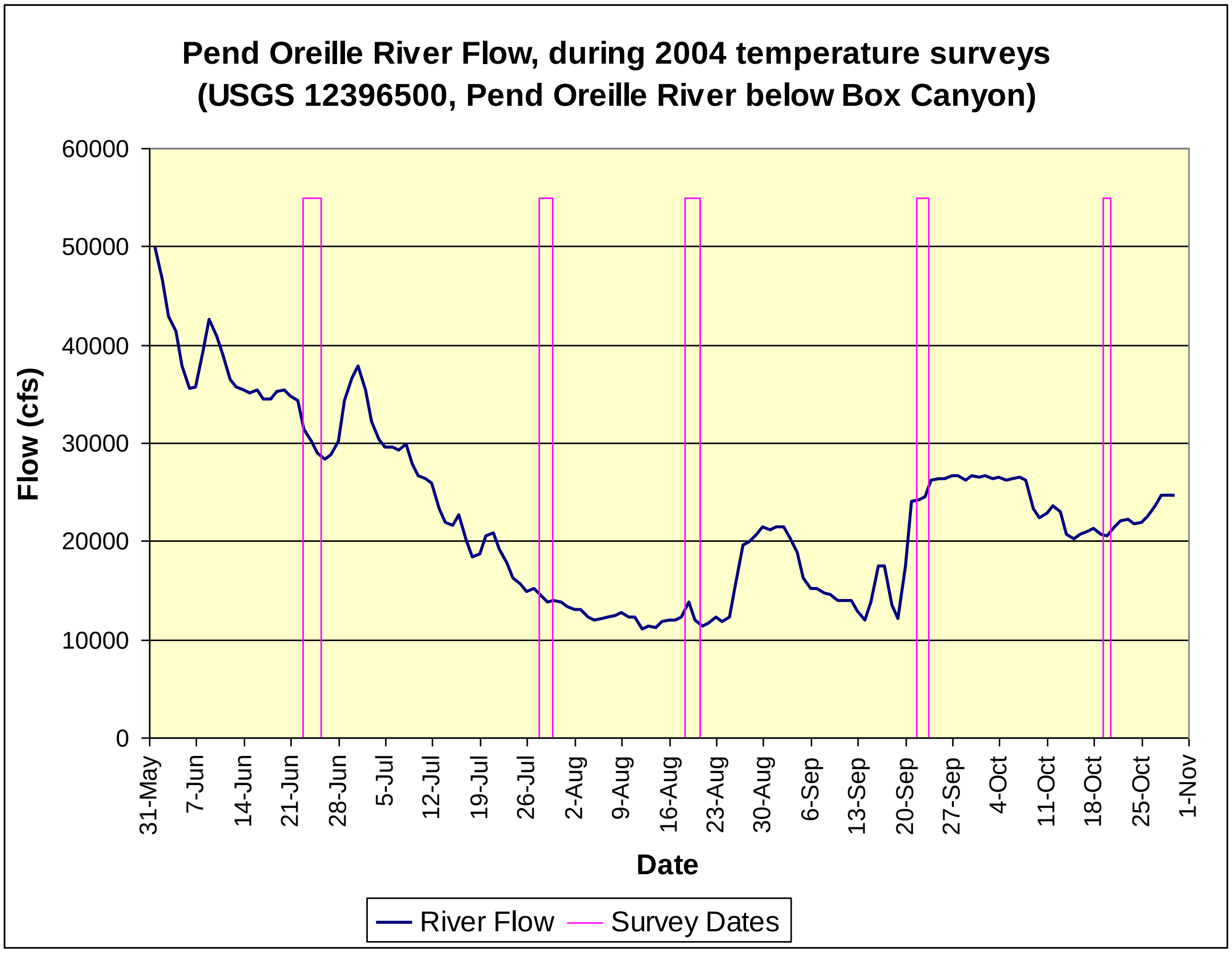


Figure C-2. Pend Oreille River flows during the monitoring period.

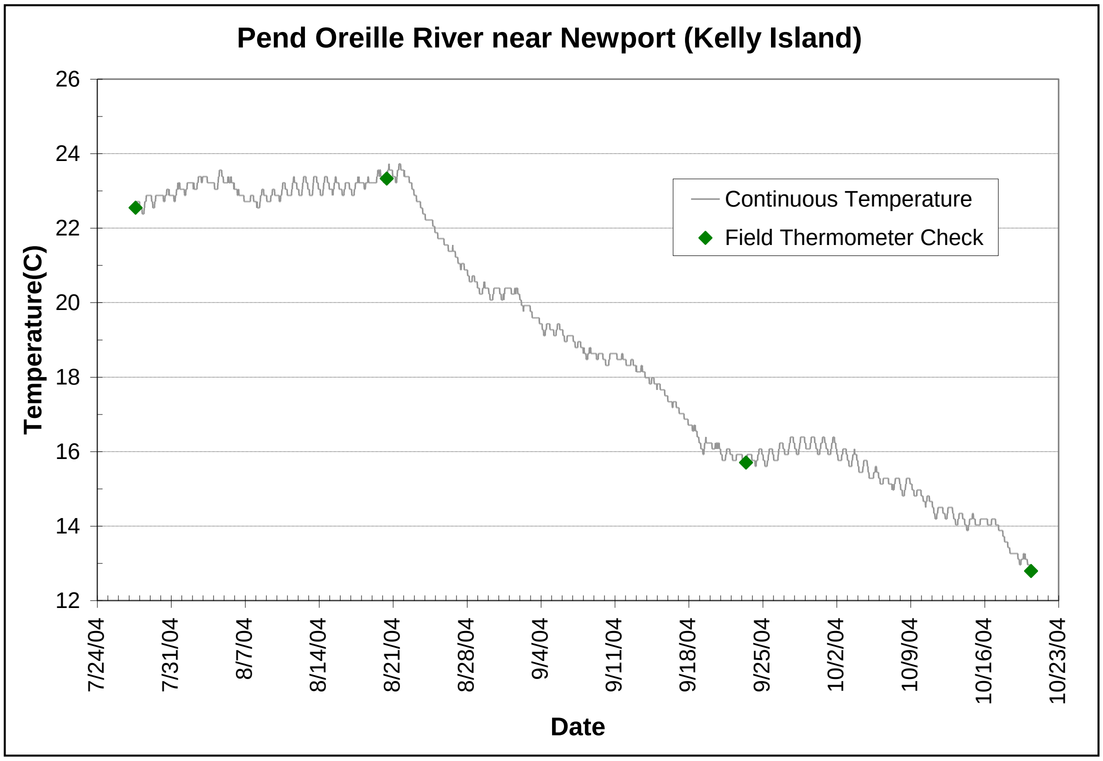


Figure C-3. Temperature measurements: Pend Oreille River near Newport (Kelly Island).

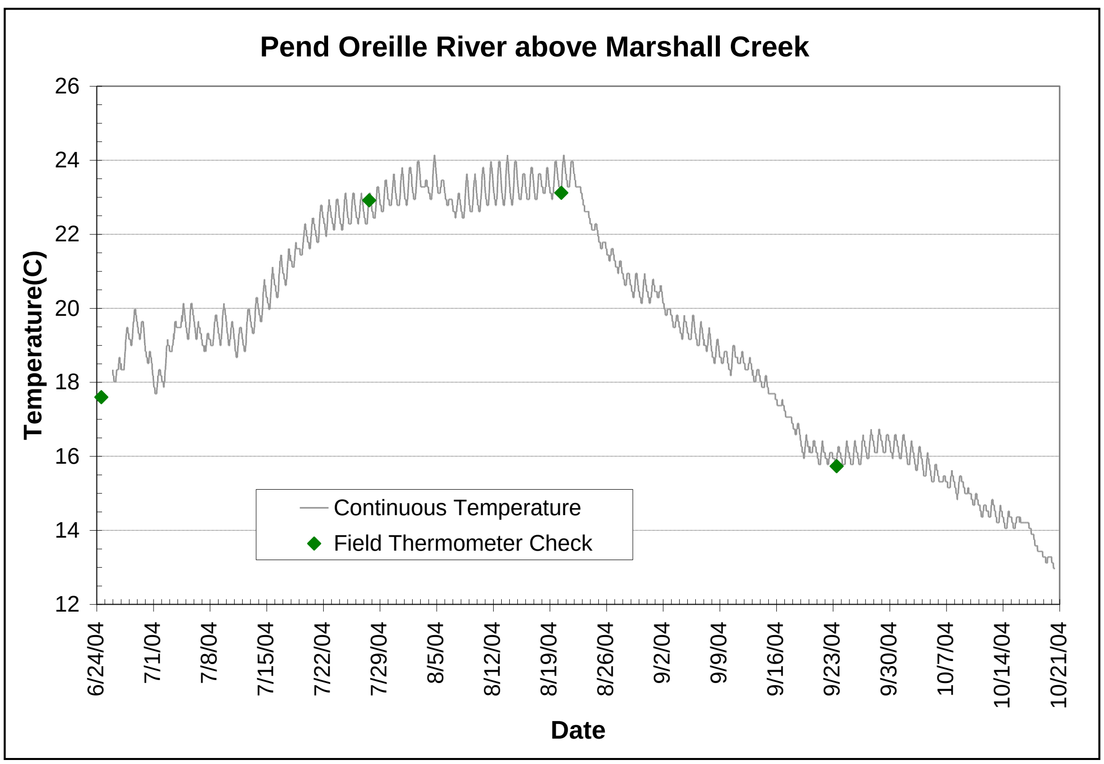


Figure C-4. Temperature measurements: Pend Oreille River above Marshall Creek.

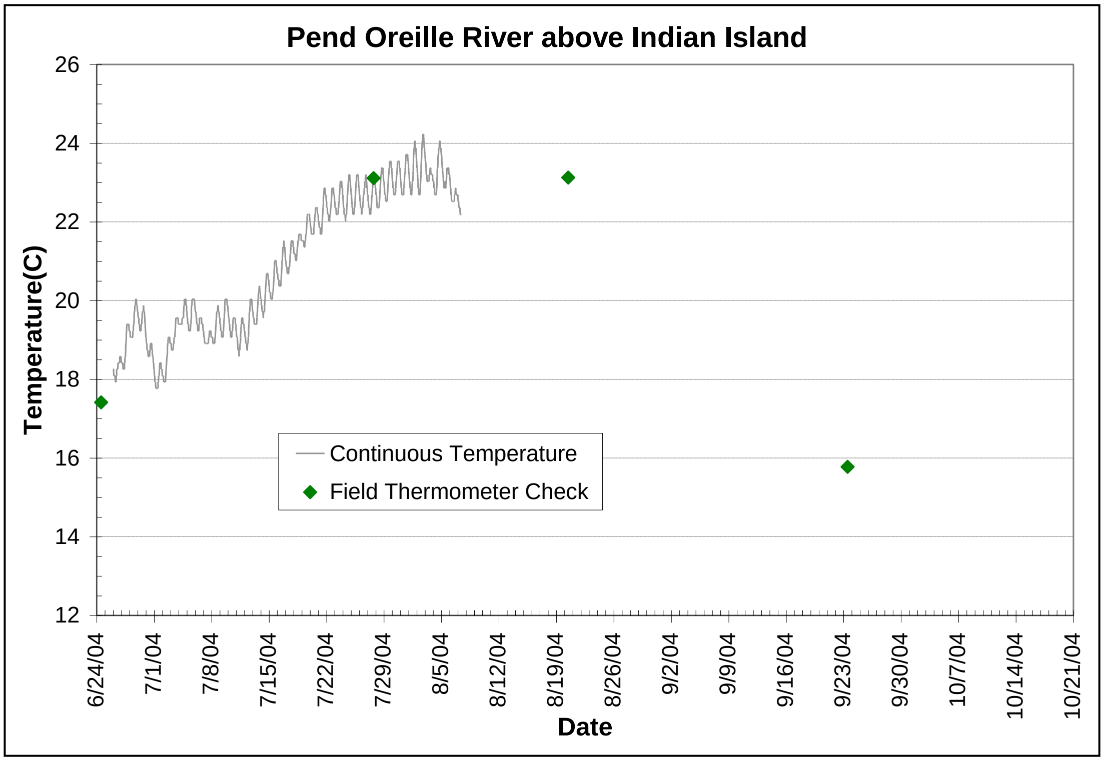


Figure C-5. Temperature Measurements: Pend Oreille River above Indian Island.

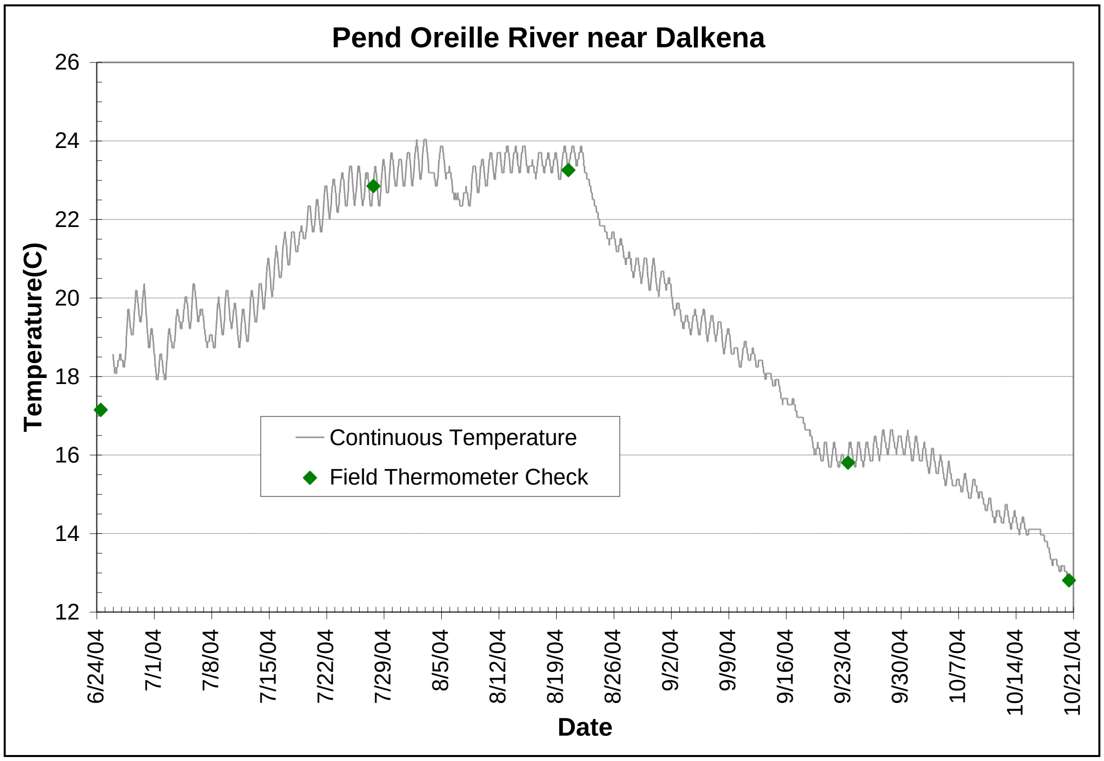


Figure C-6. Temperature Measurements: Pend Oreille River near Dalkena.

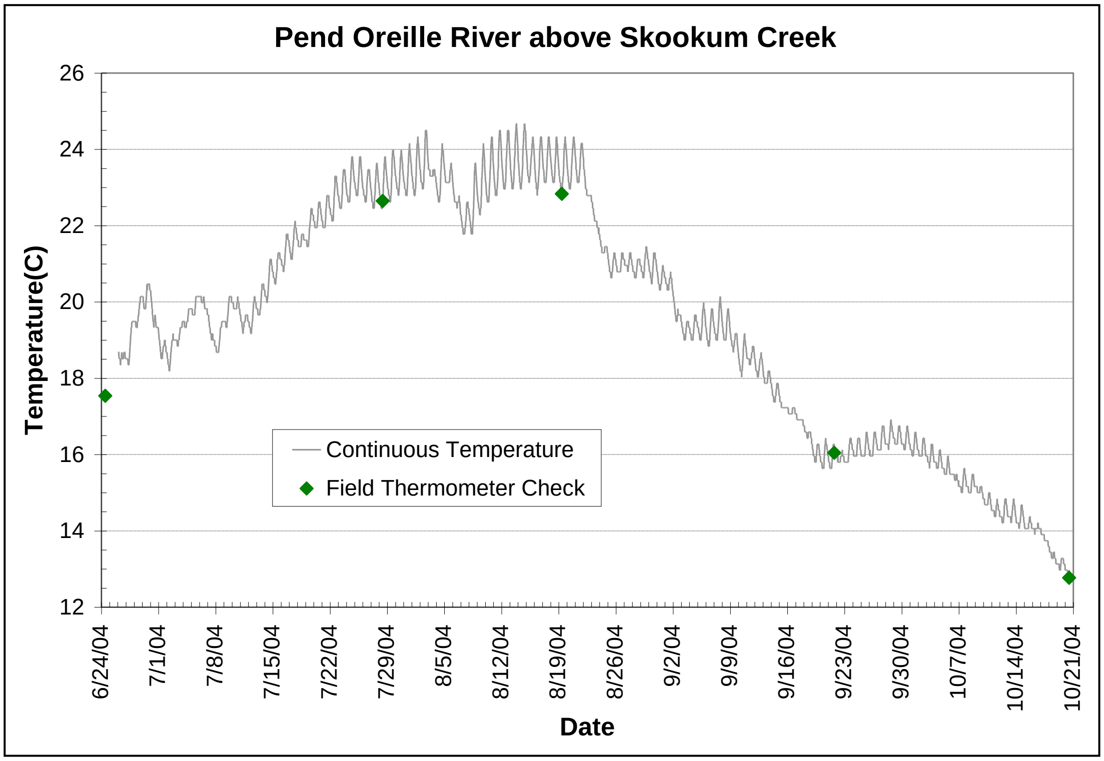


Figure C-7. Temperature Measurements: Pend Oreille River above Skookum Creek.

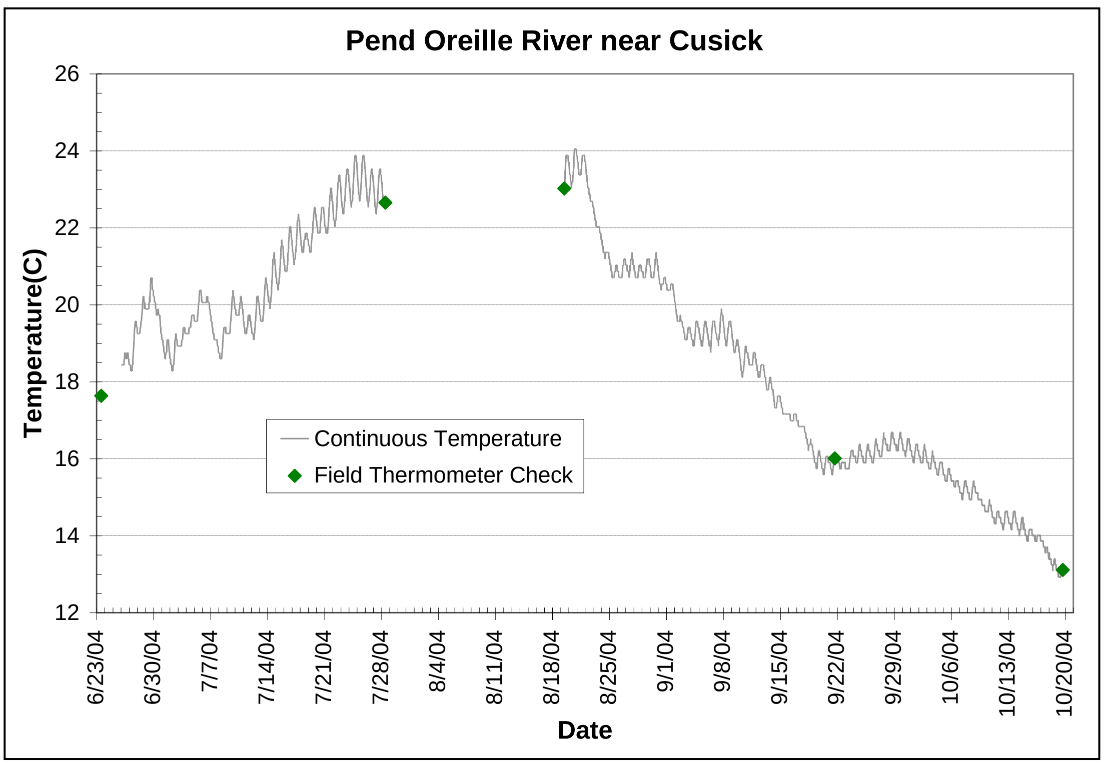


Figure C-8. Temperature Measurements: Pend Oreille River near Cusick.

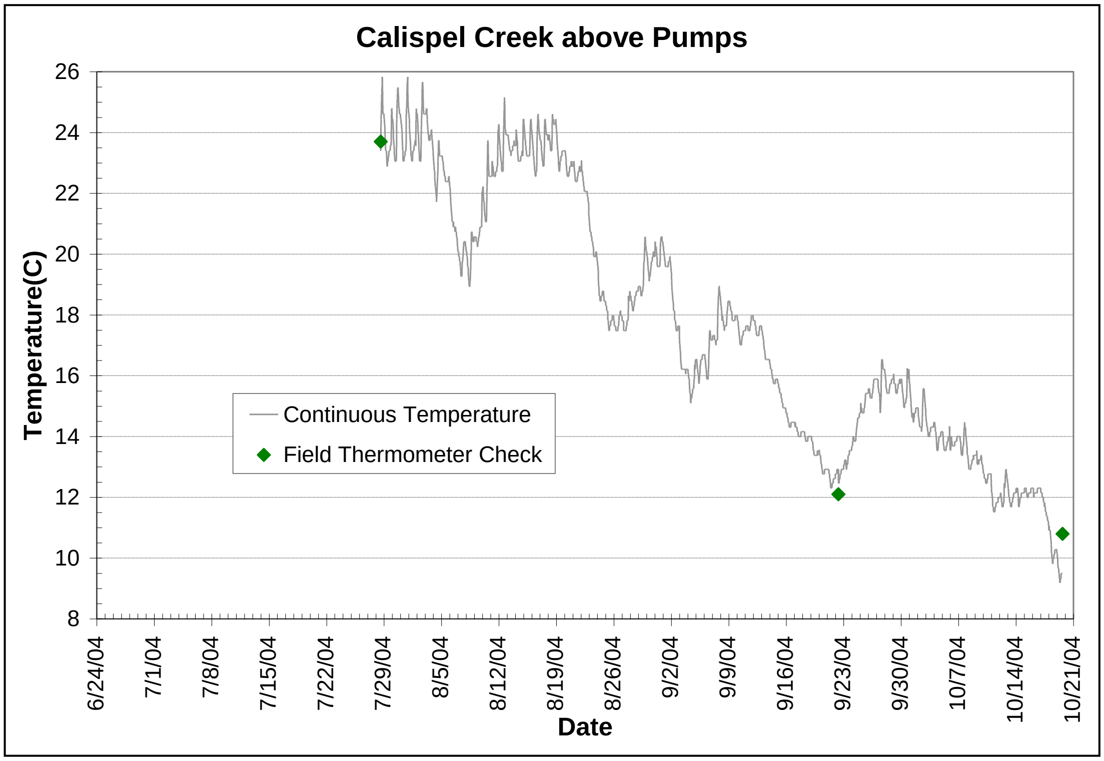


Figure C-9. Temperature Measurements: Calispel Creek above pumps.

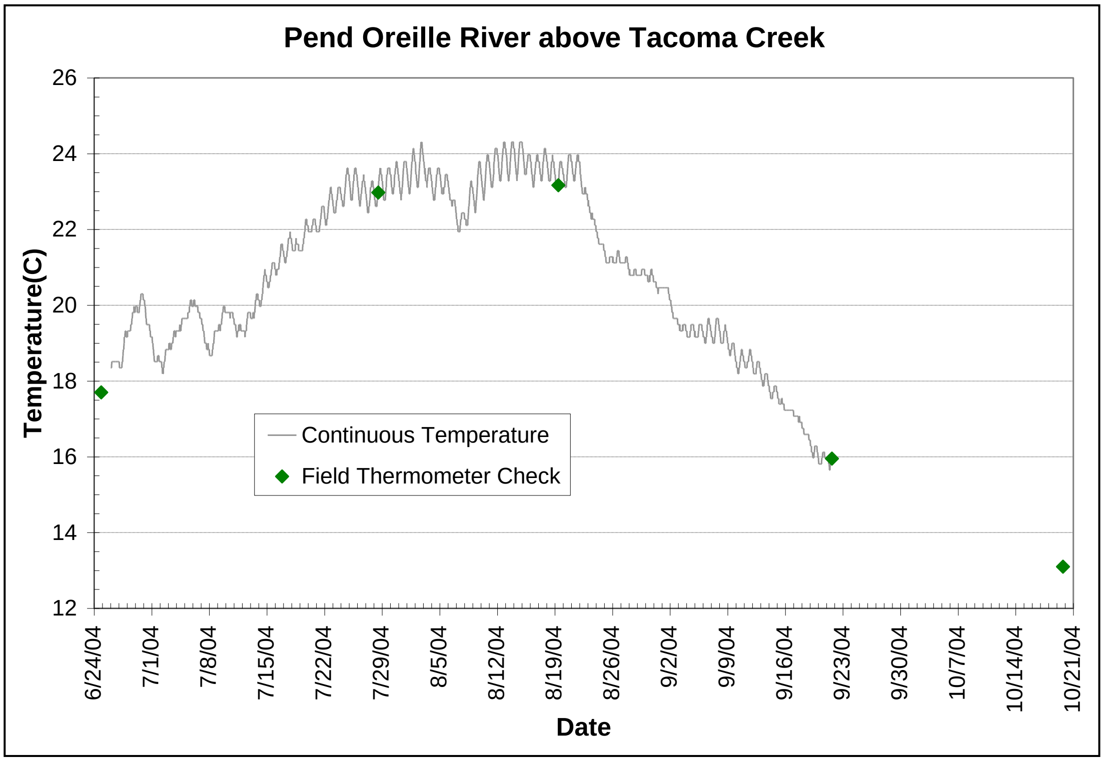


Figure C-10. Temperature Measurements: Pend Oreille River above Tacoma Creek.

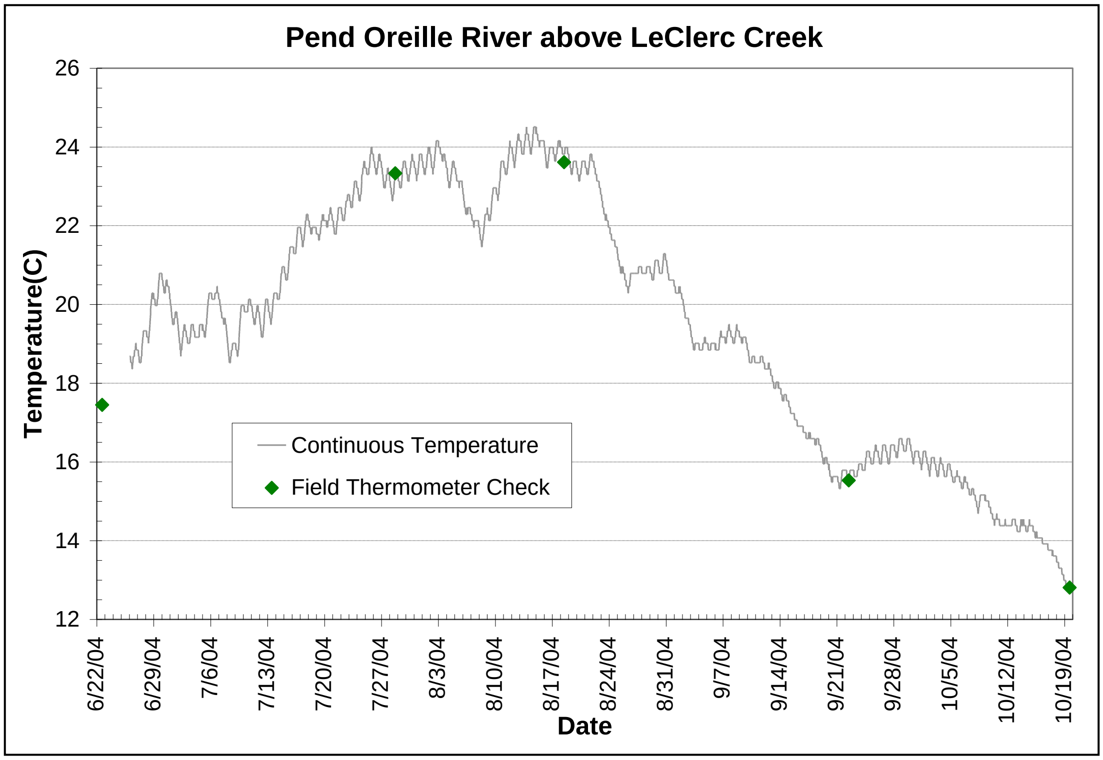


Figure C-11. Temperature Measurements: Pend Oreille River above LeClerc Creek.

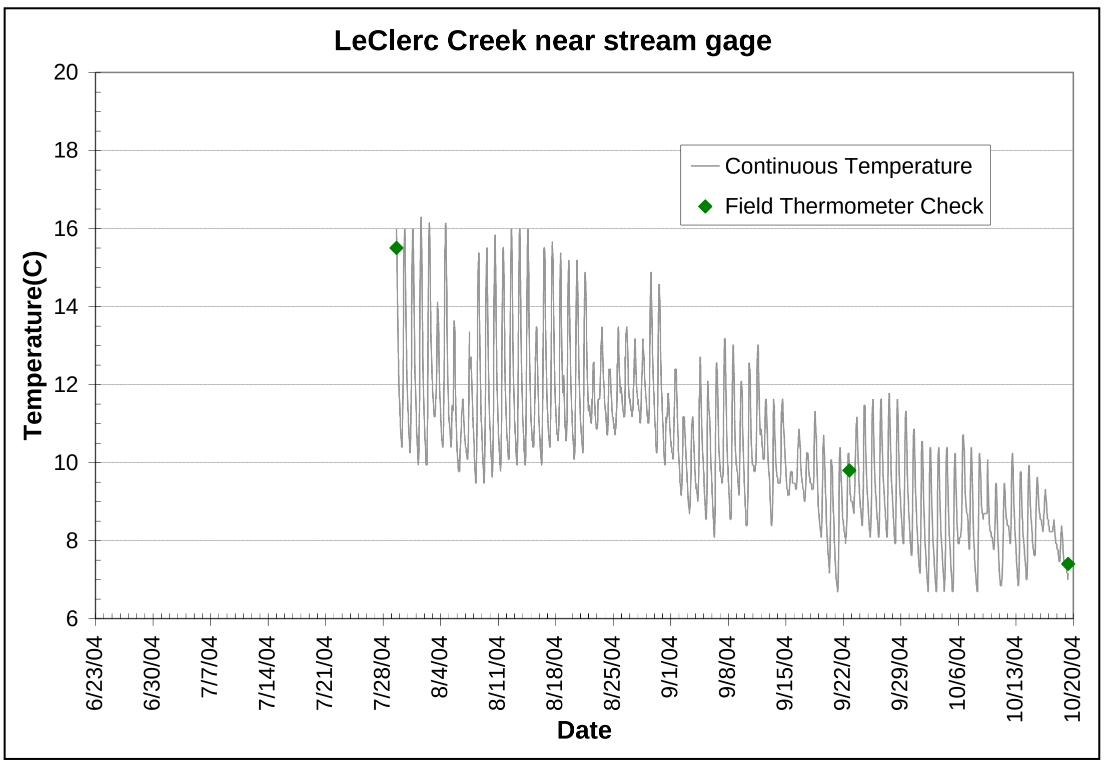


Figure C-12. Temperature Measurements: LeClerc Creek near stream gage.

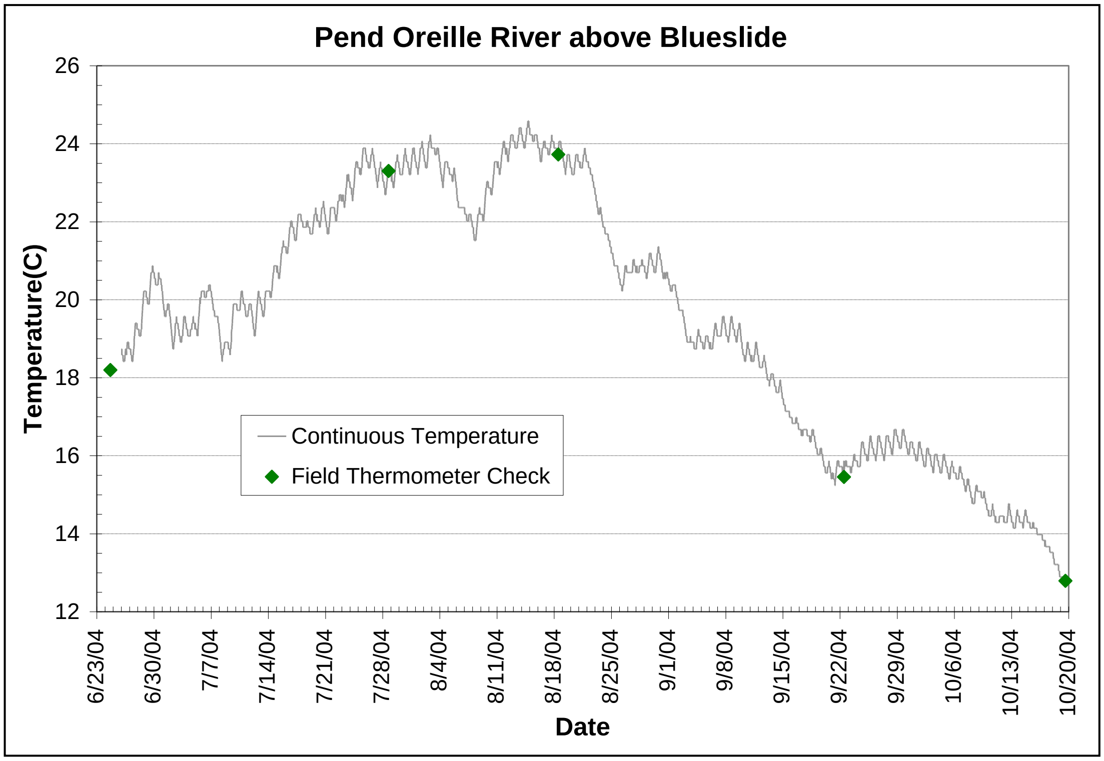


Figure C-13. Temperature Measurements: Pend Oreille River above Blueslide.

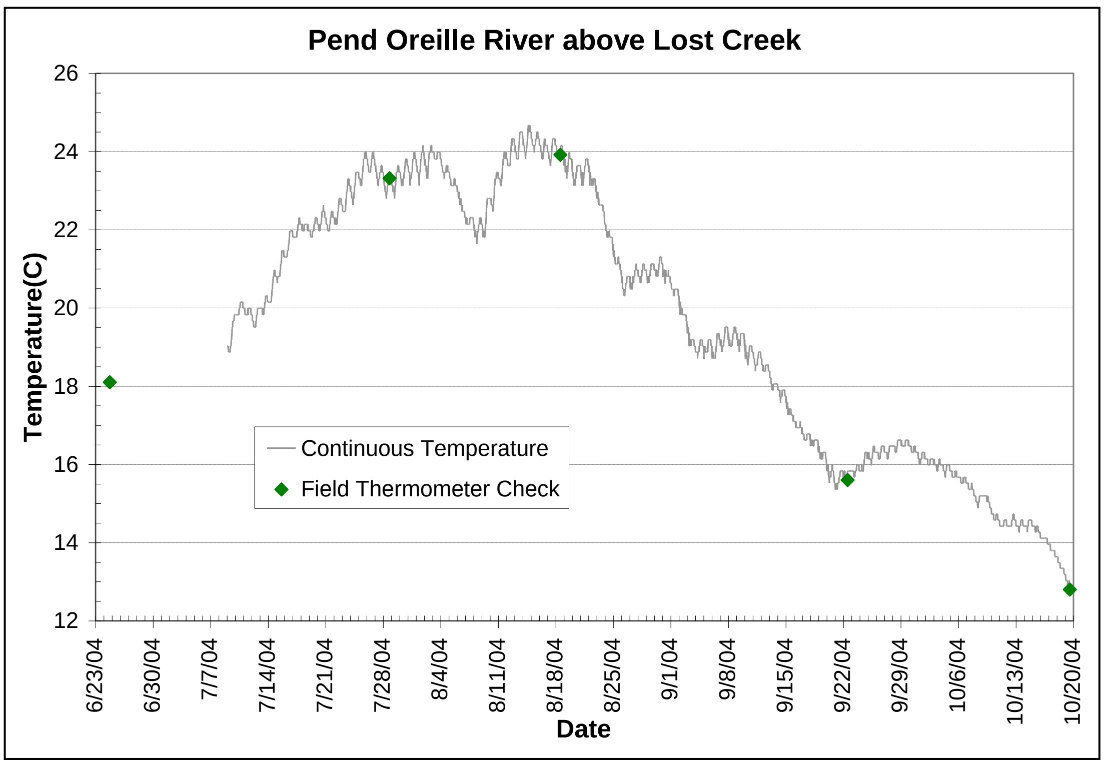


Figure C-14. Temperature Measurements: Pend Oreille River above Lost Creek.

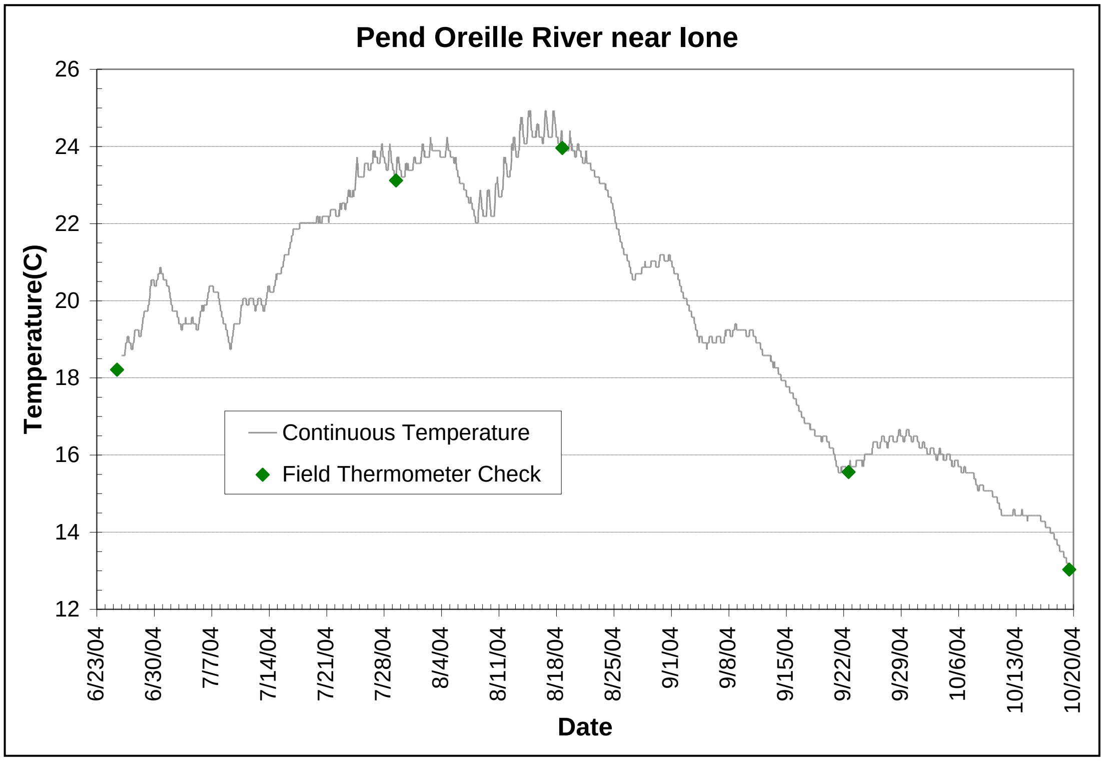


Figure C-15. Temperature Measurements: Pend Oreille River near Ione.

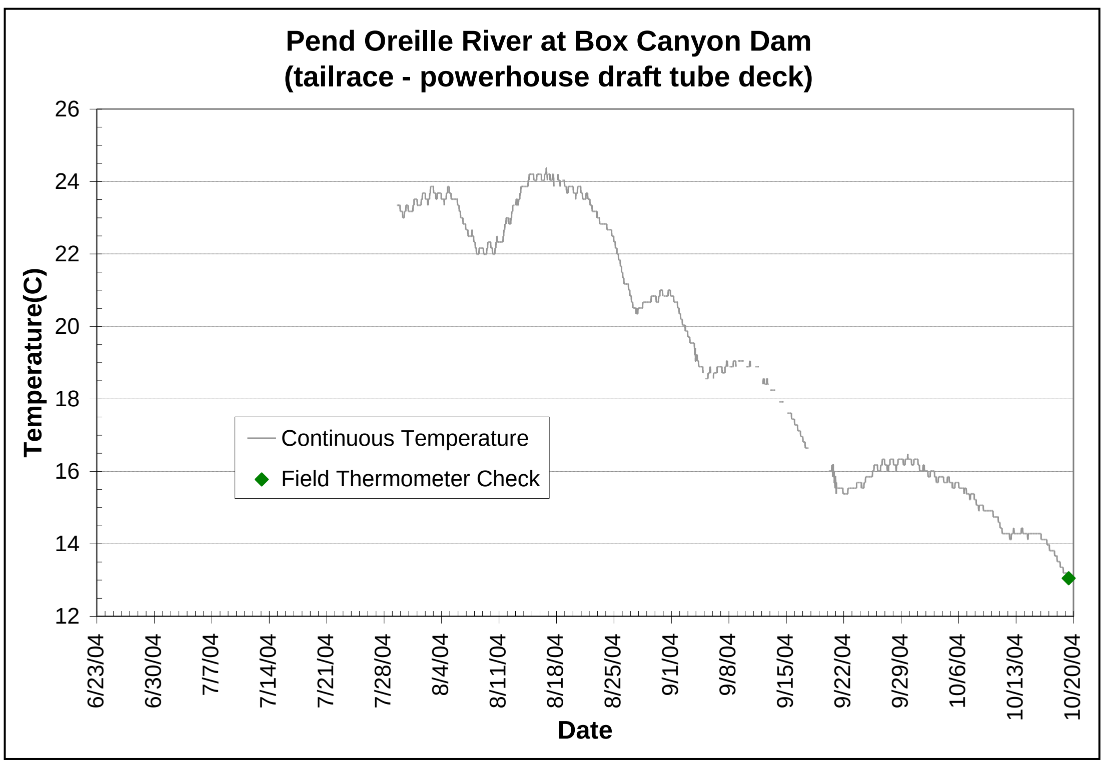


Figure C-16. Temperature Measurements: Pend Oreille River at Box Canyon Dam tailrace.

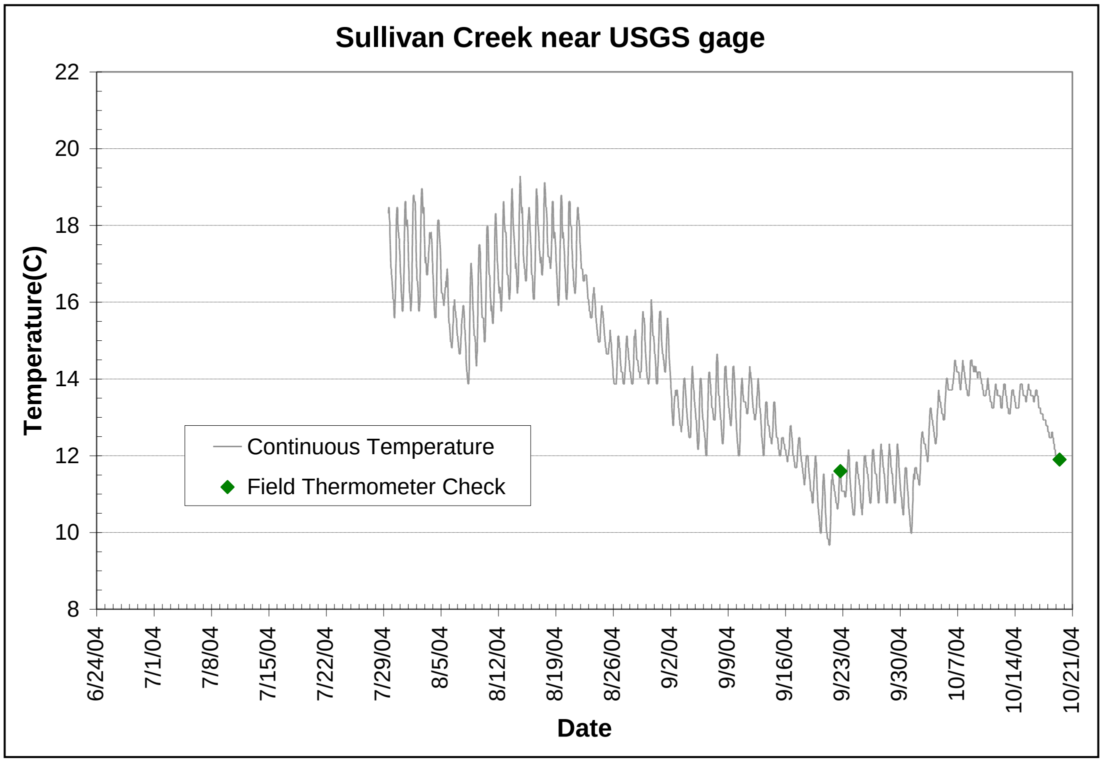
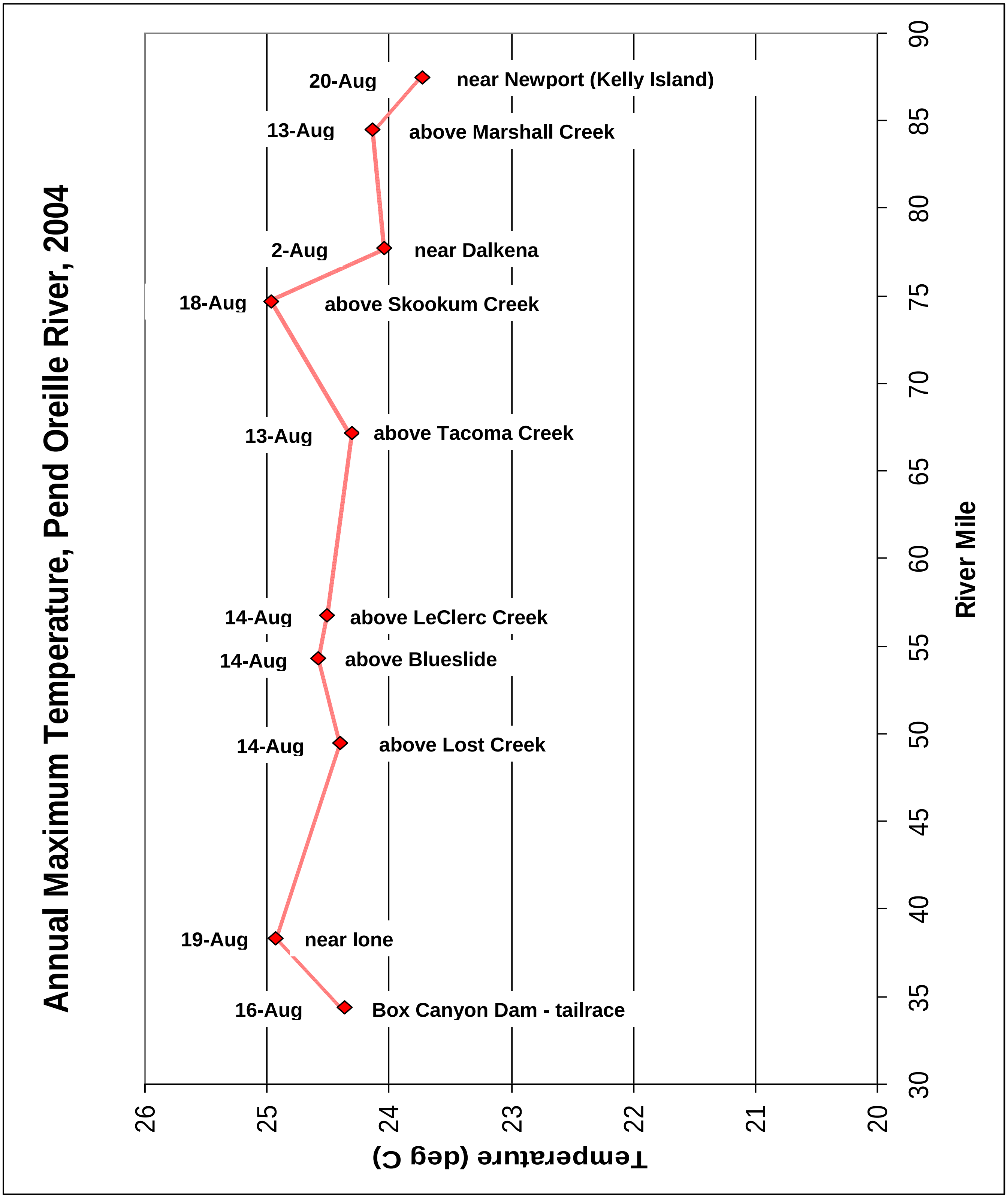


Figure C-17. Temperature Measurements: Sullivan Creek near USGS gage.



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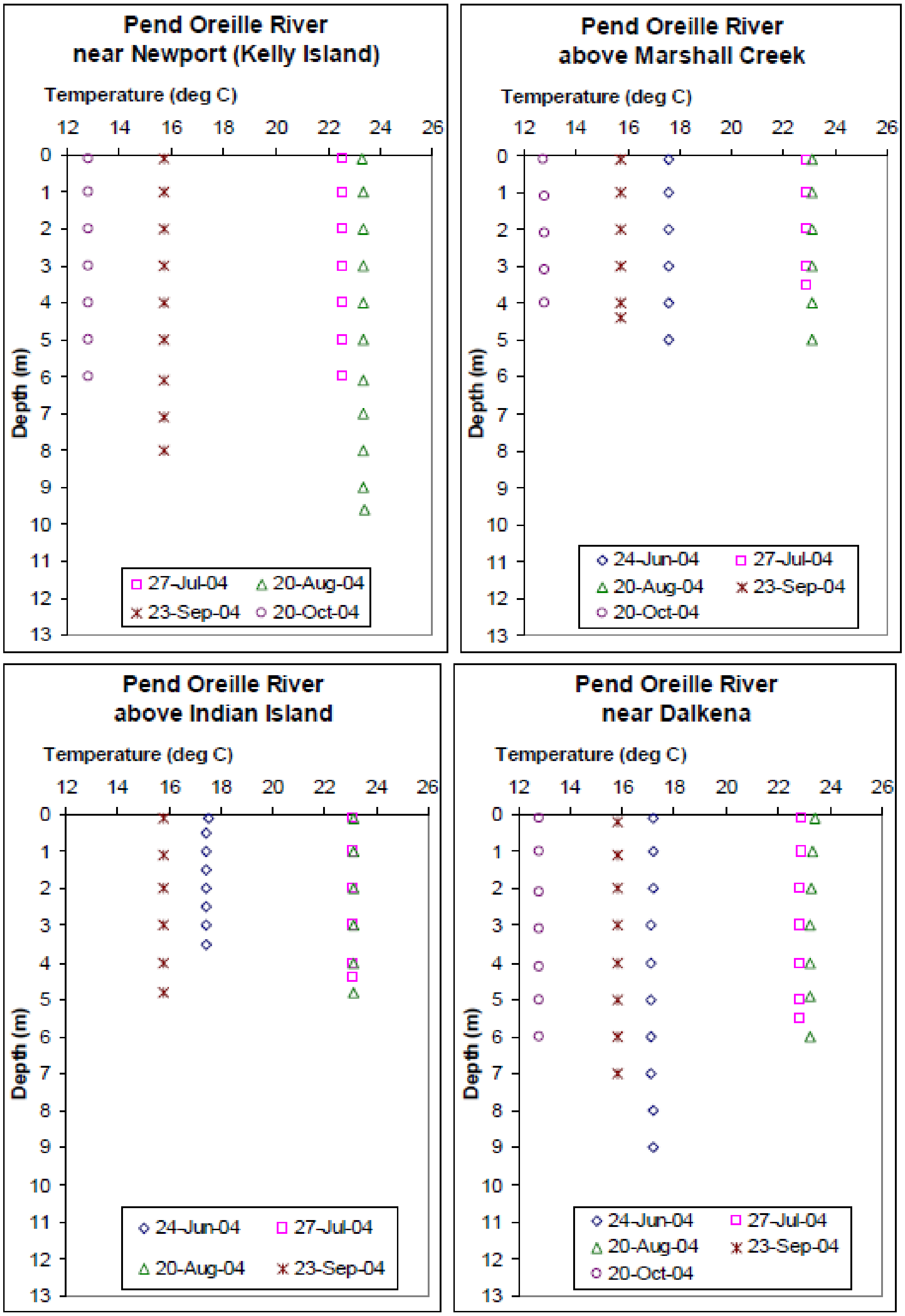

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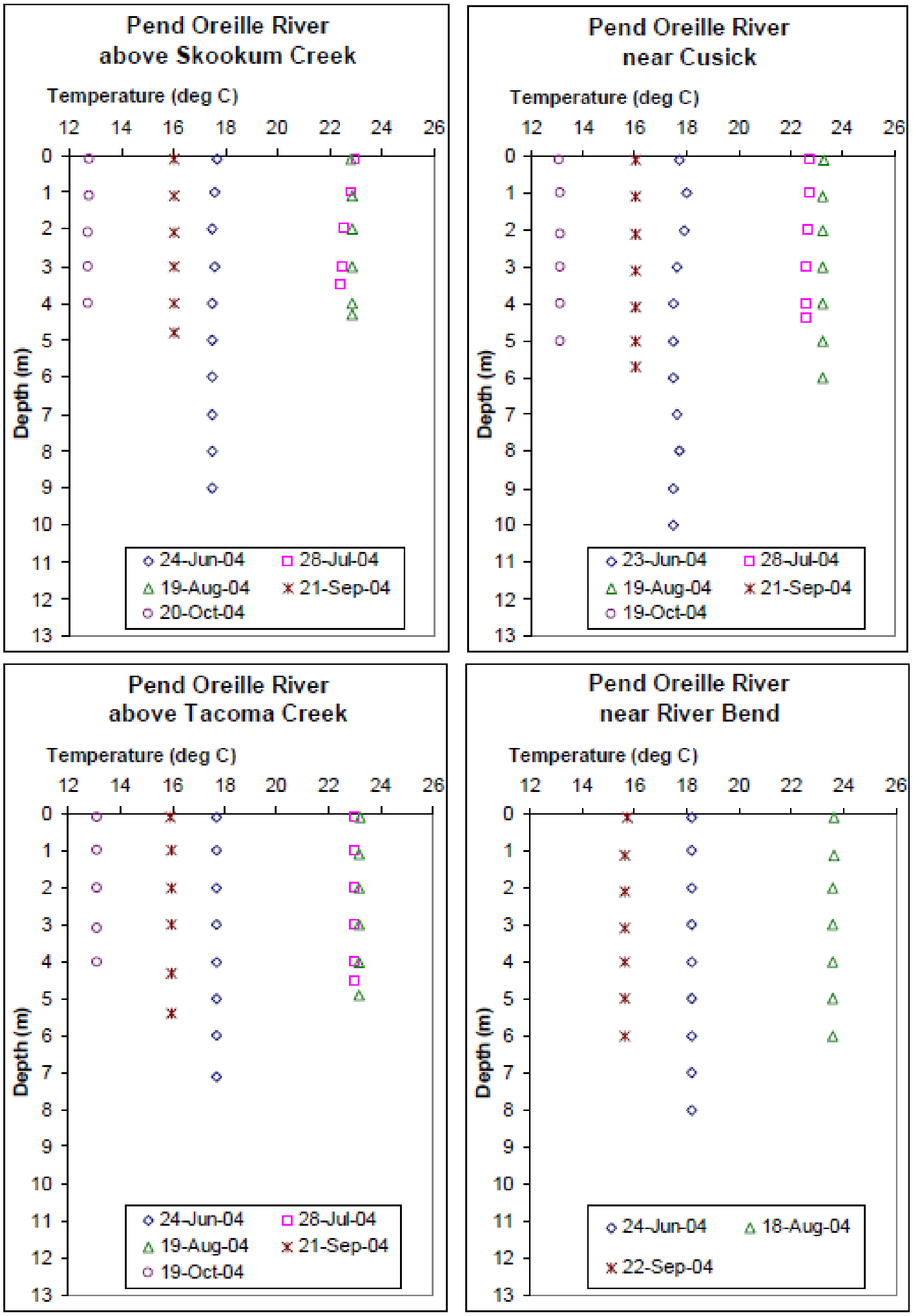

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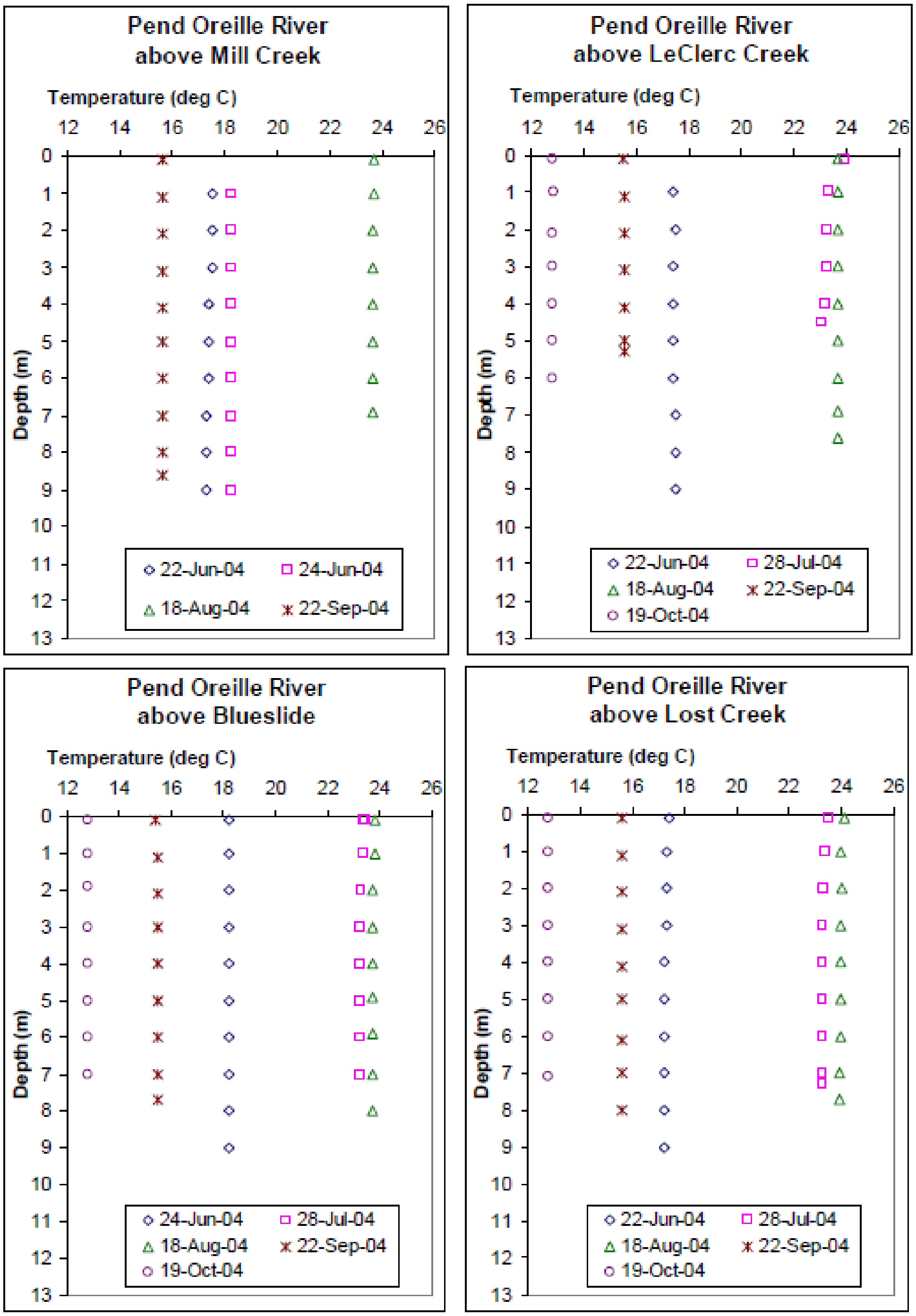

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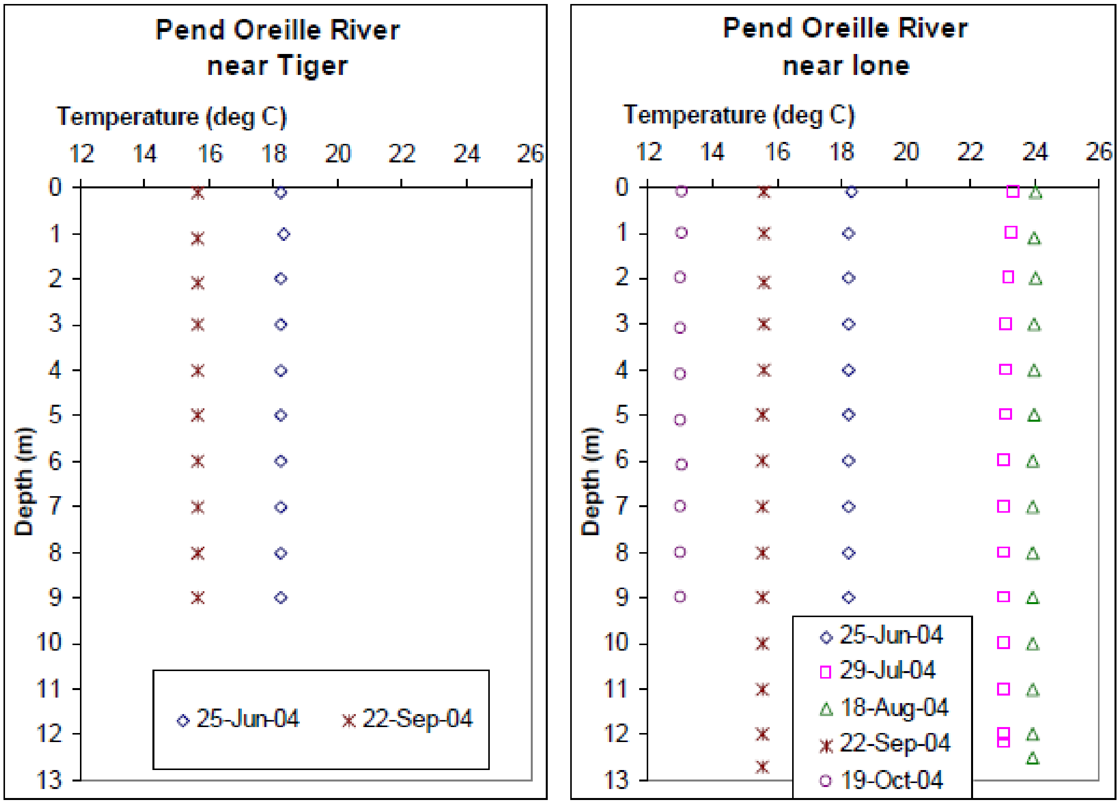

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Determination of Compliance with Washington State Criteria

Box Canyon and Boundary Reaches

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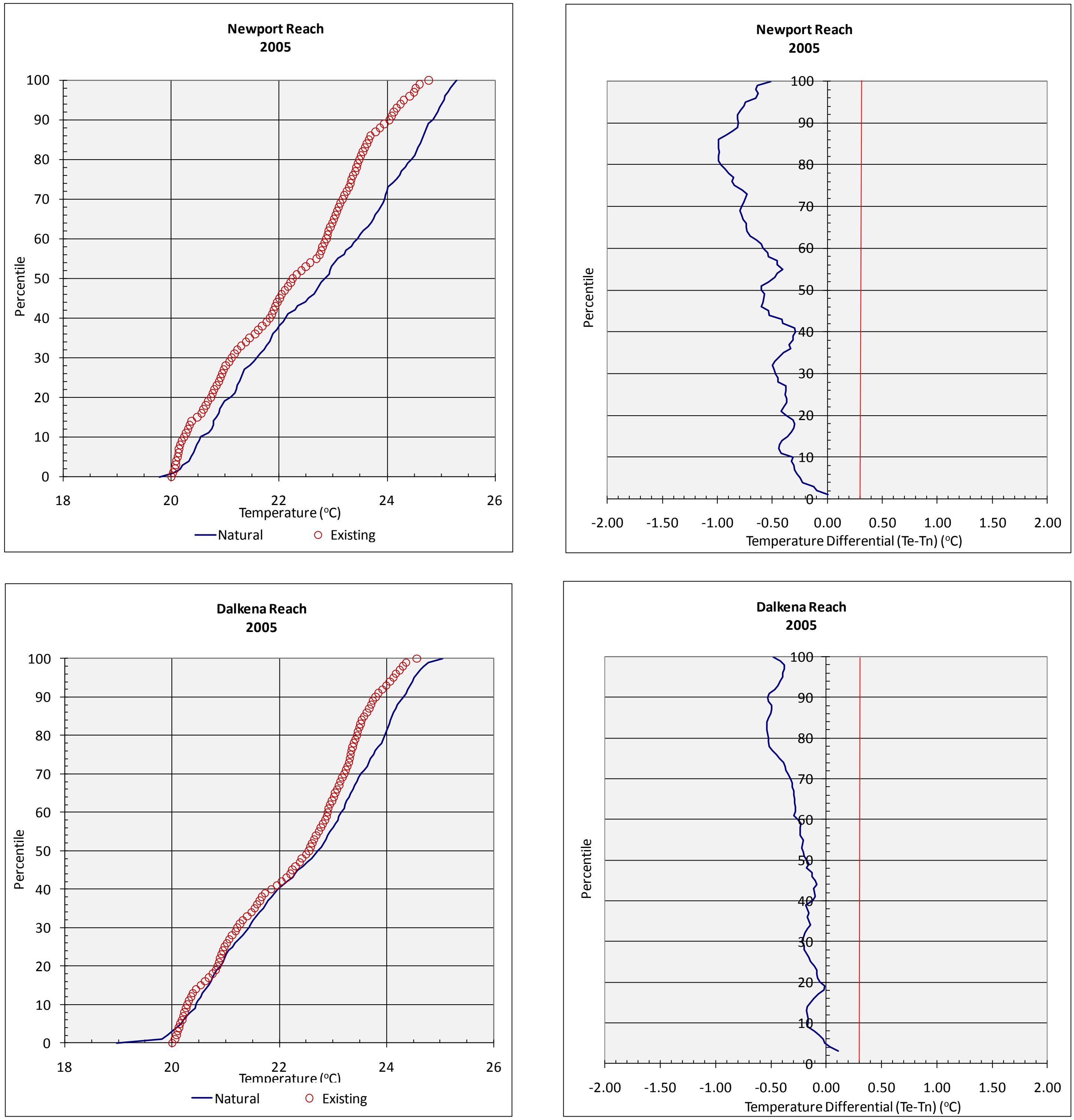

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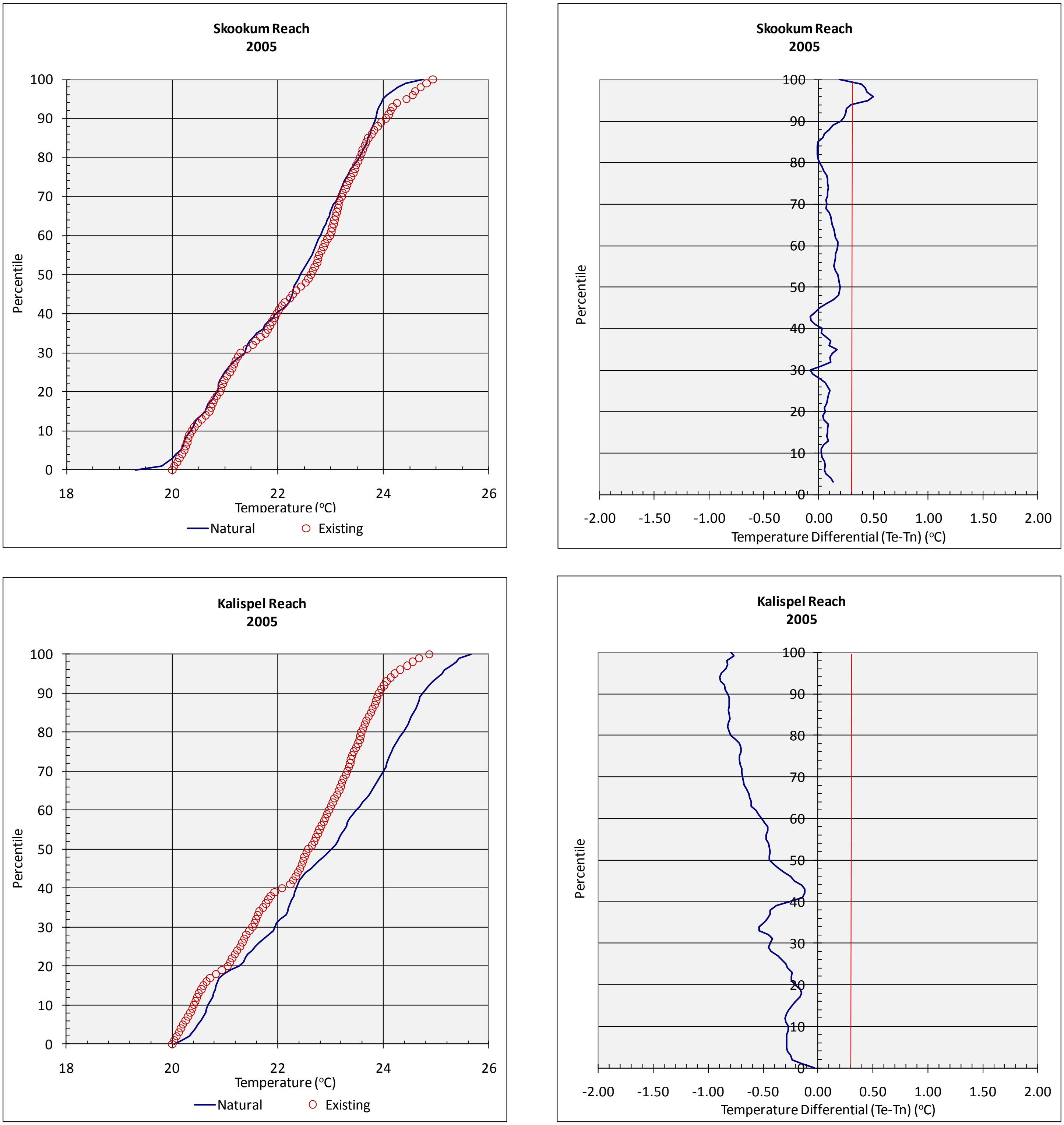

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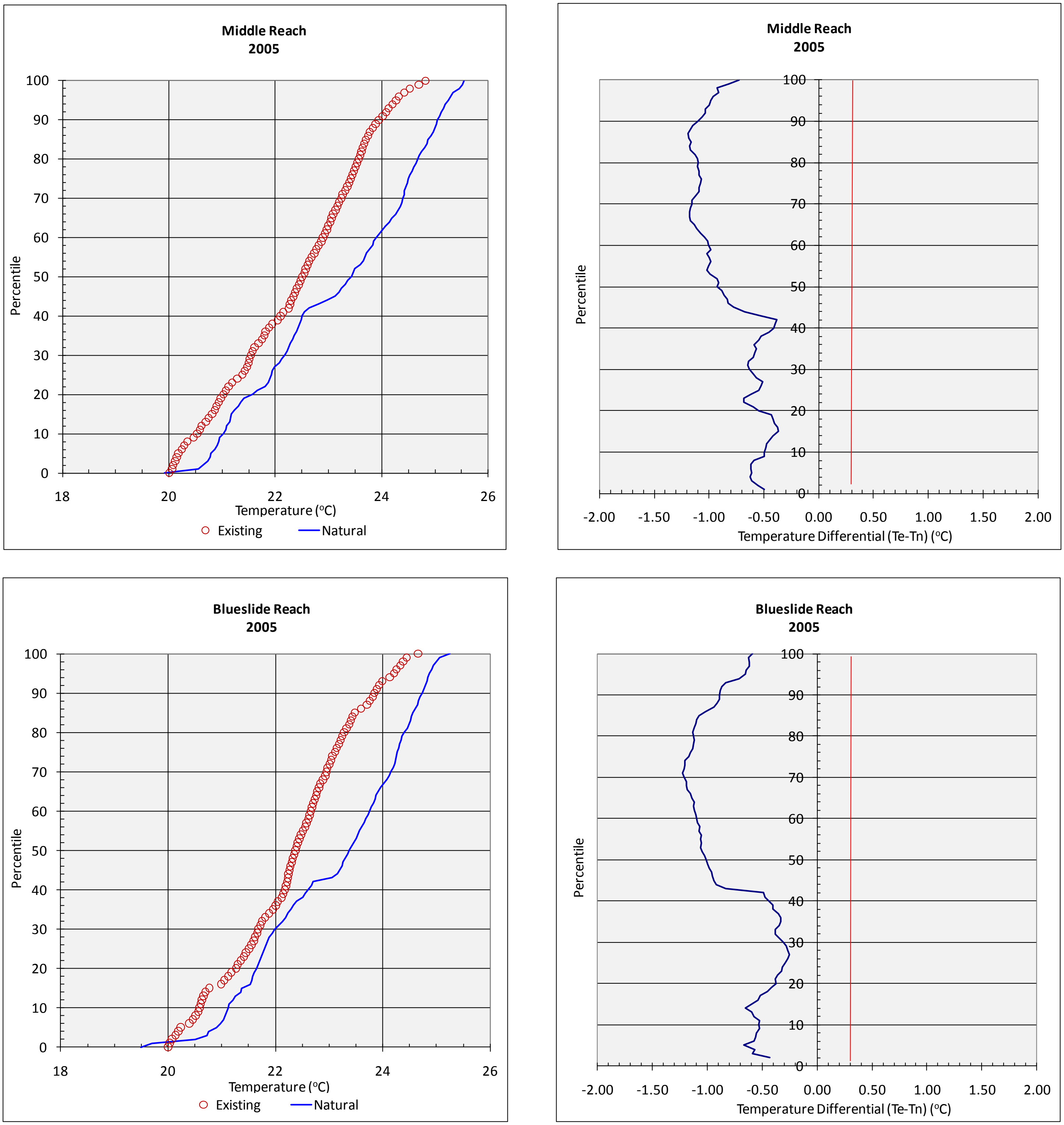

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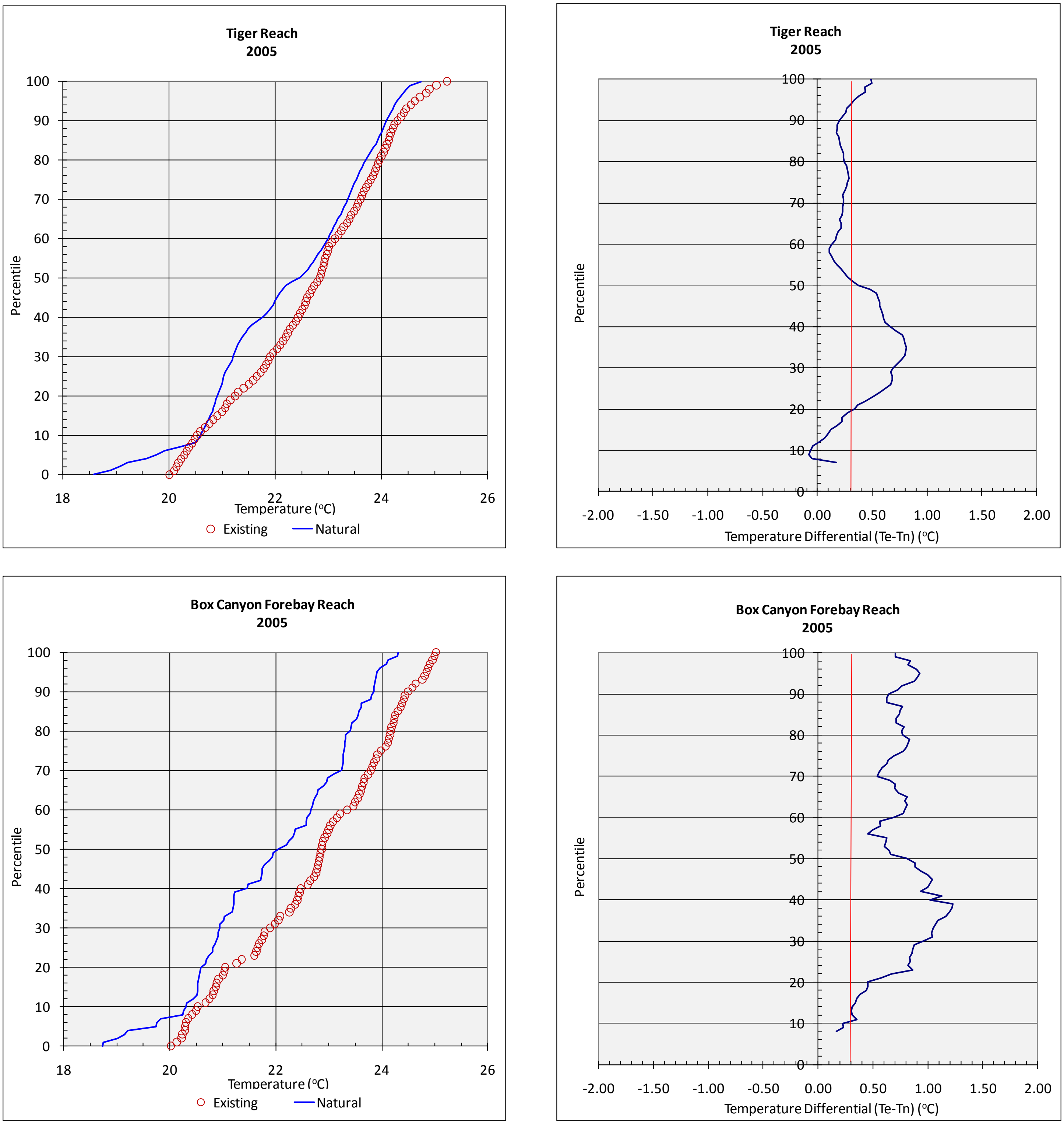

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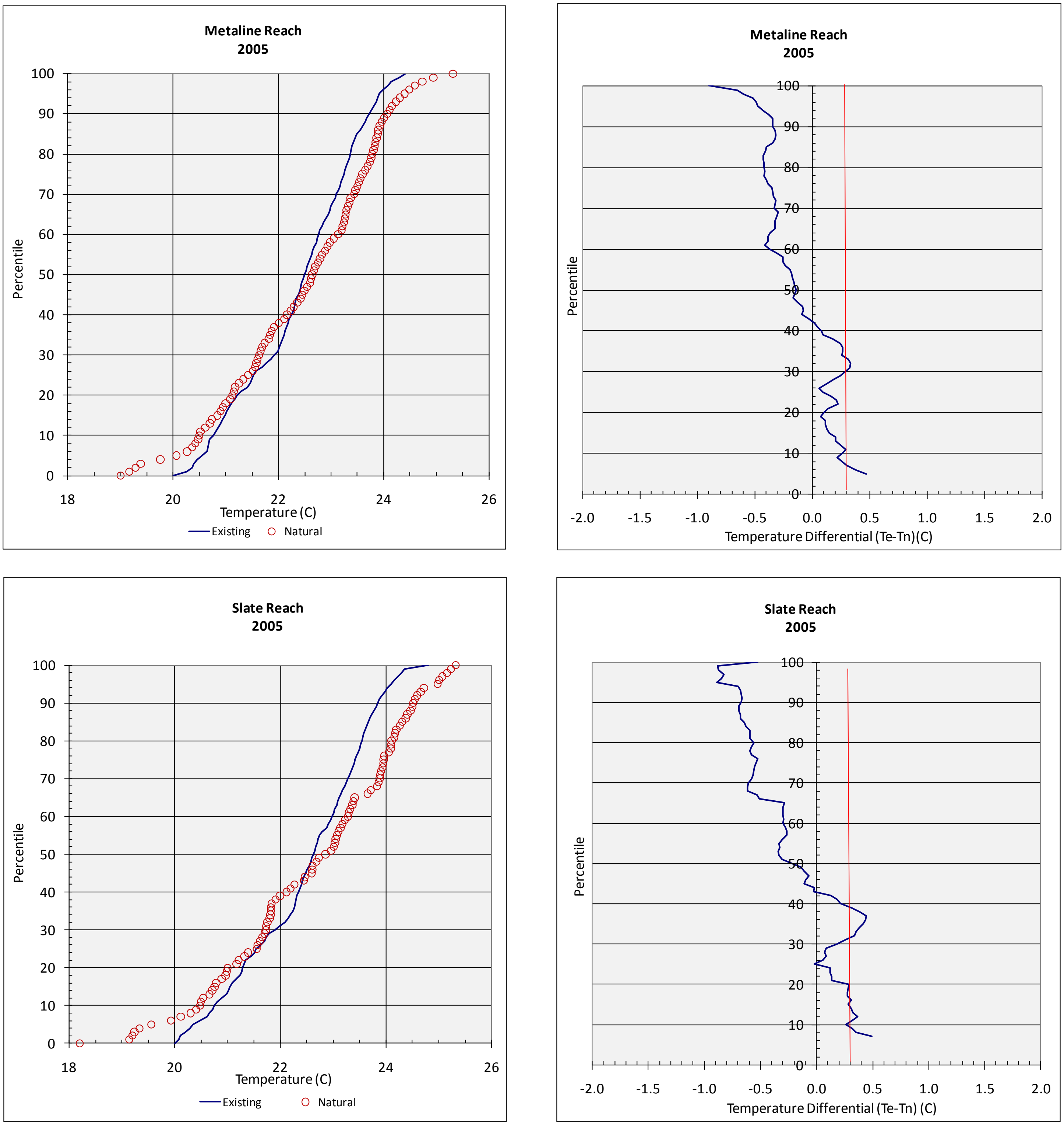

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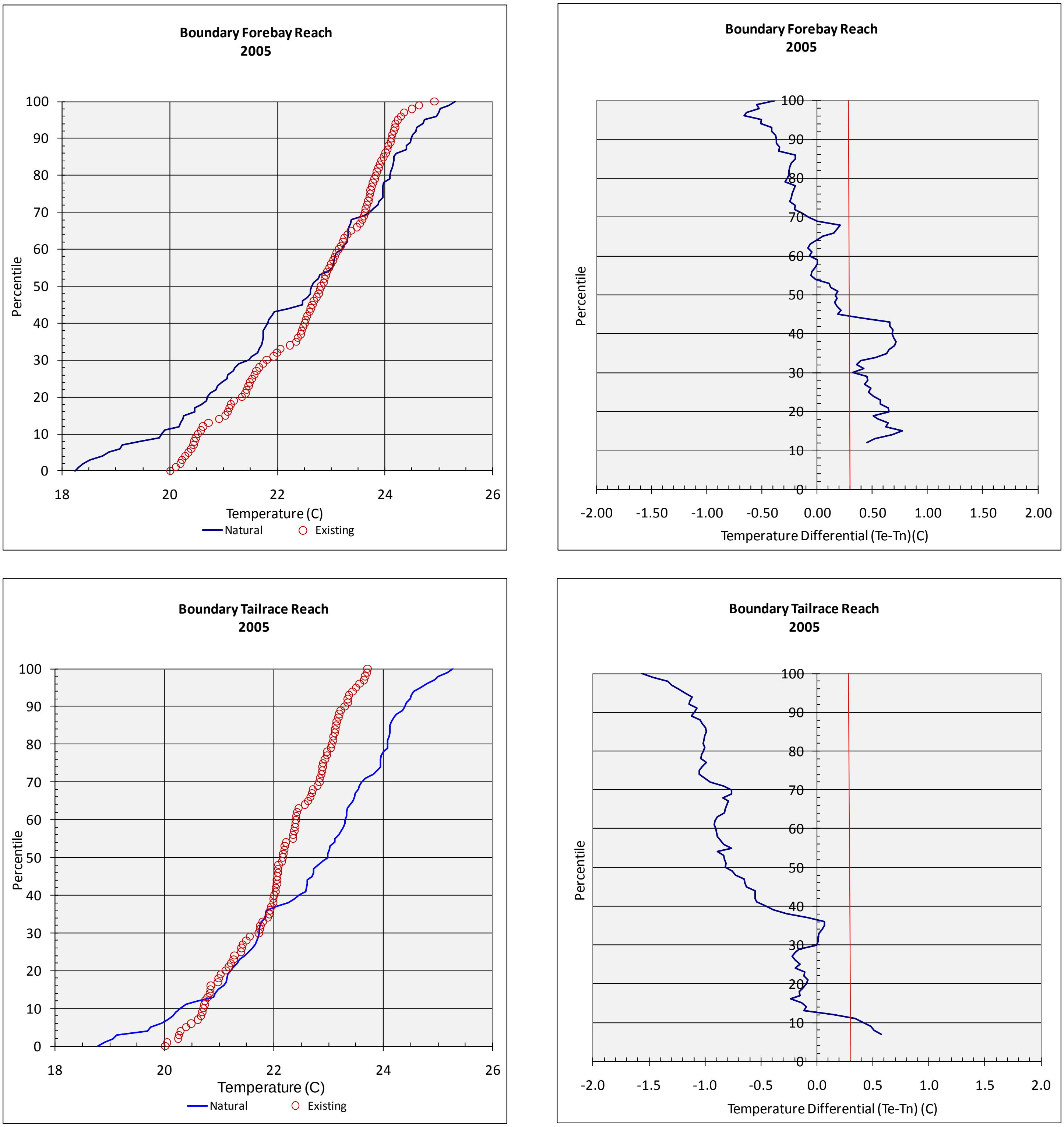

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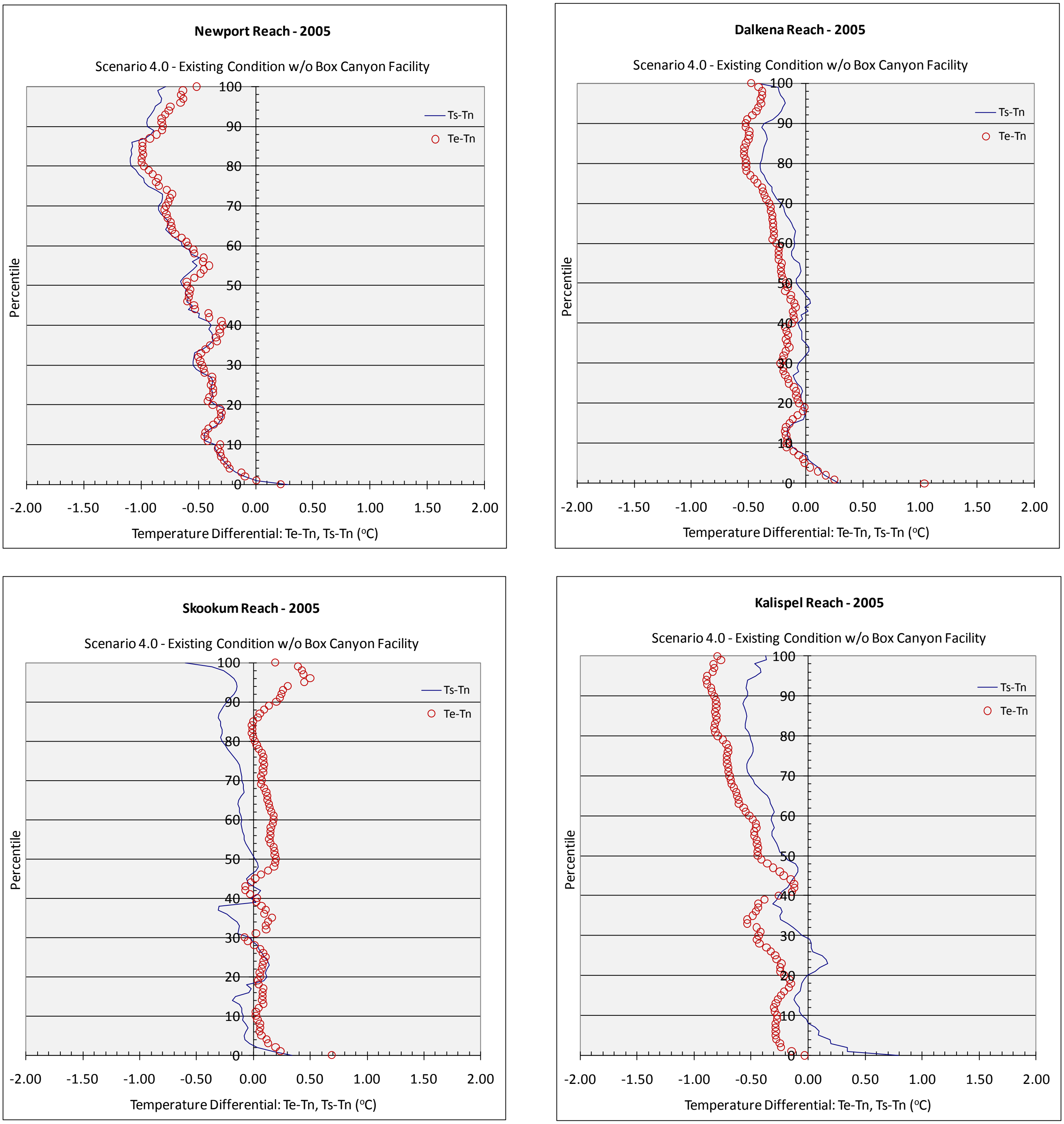

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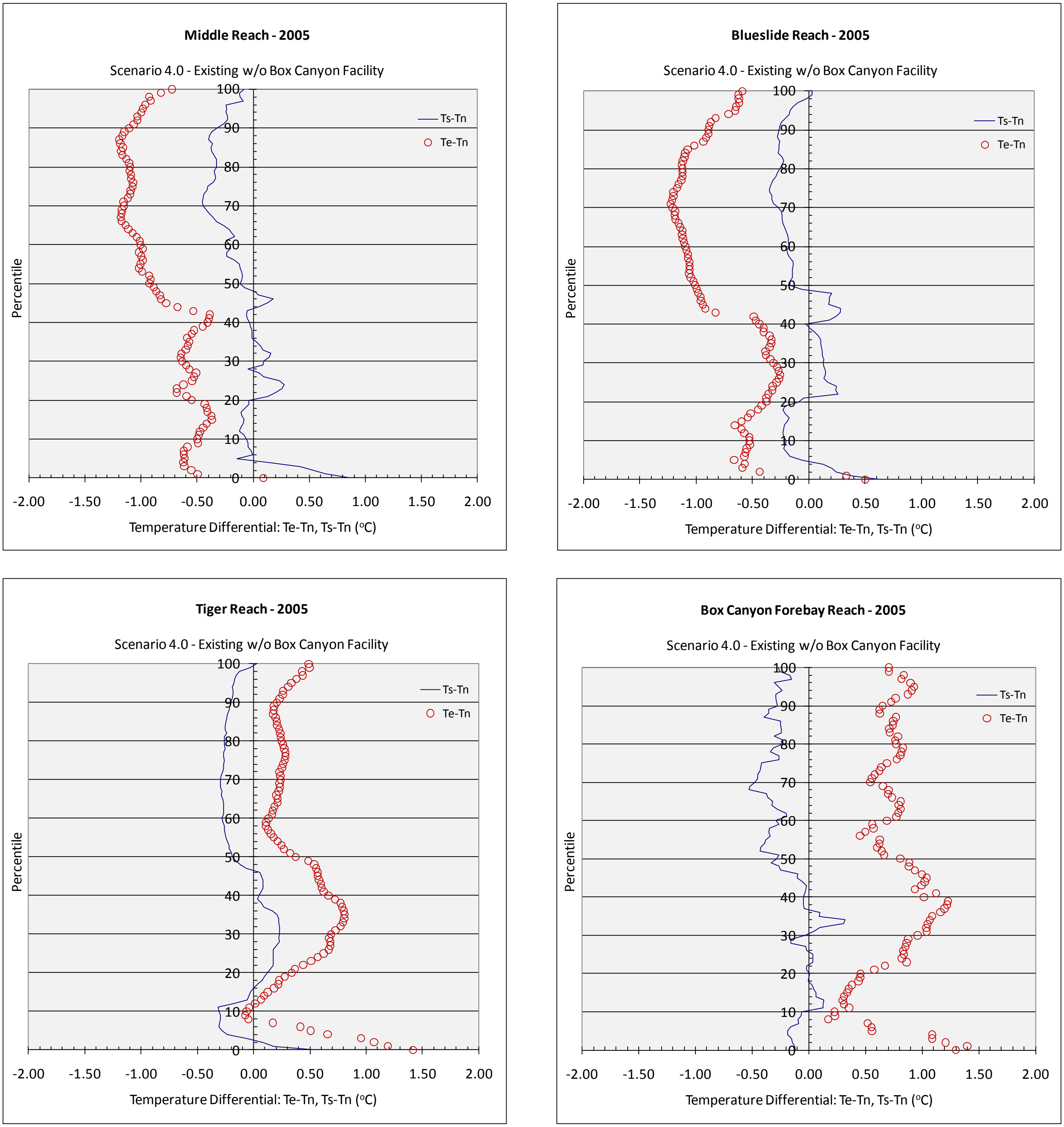

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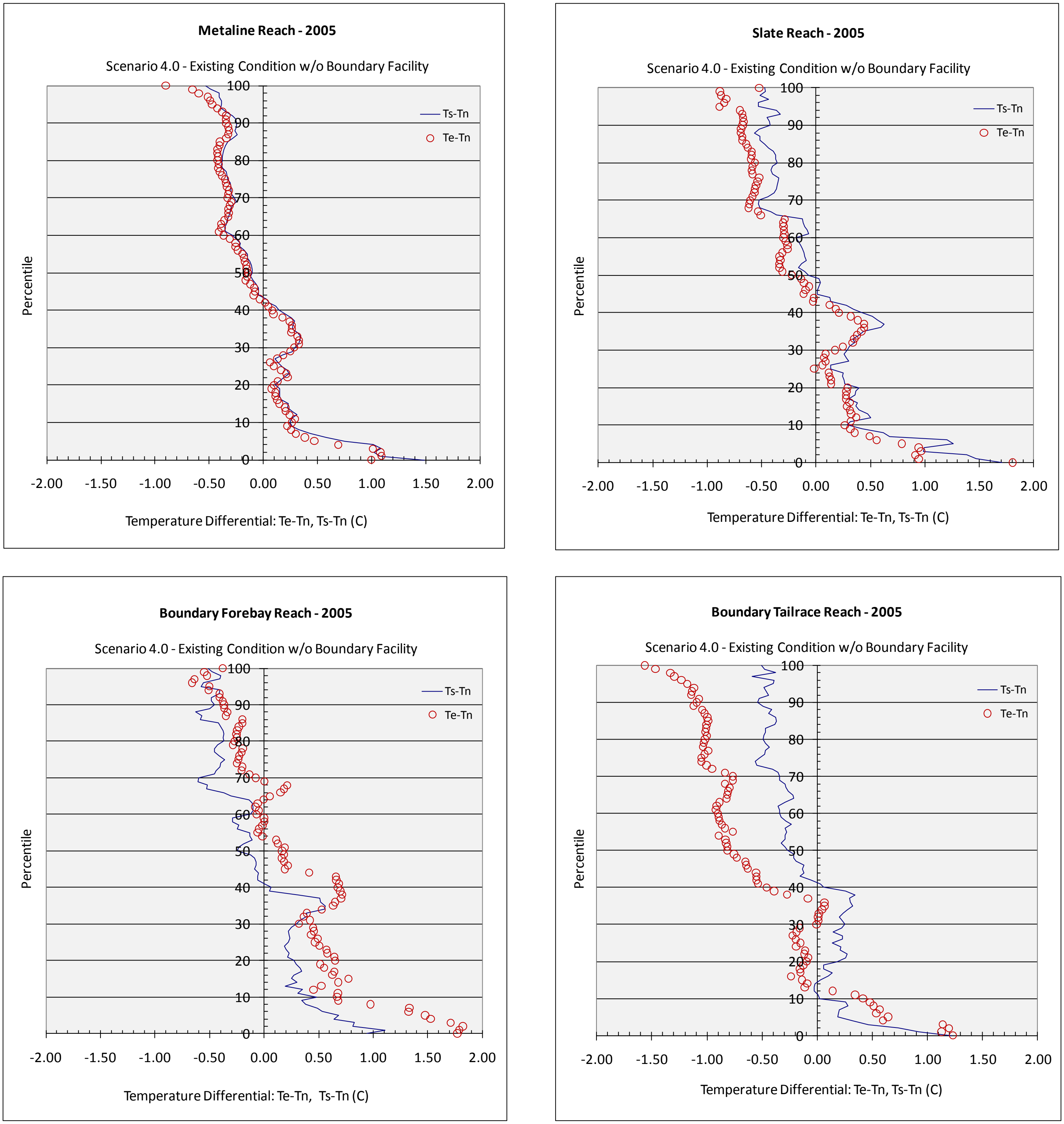

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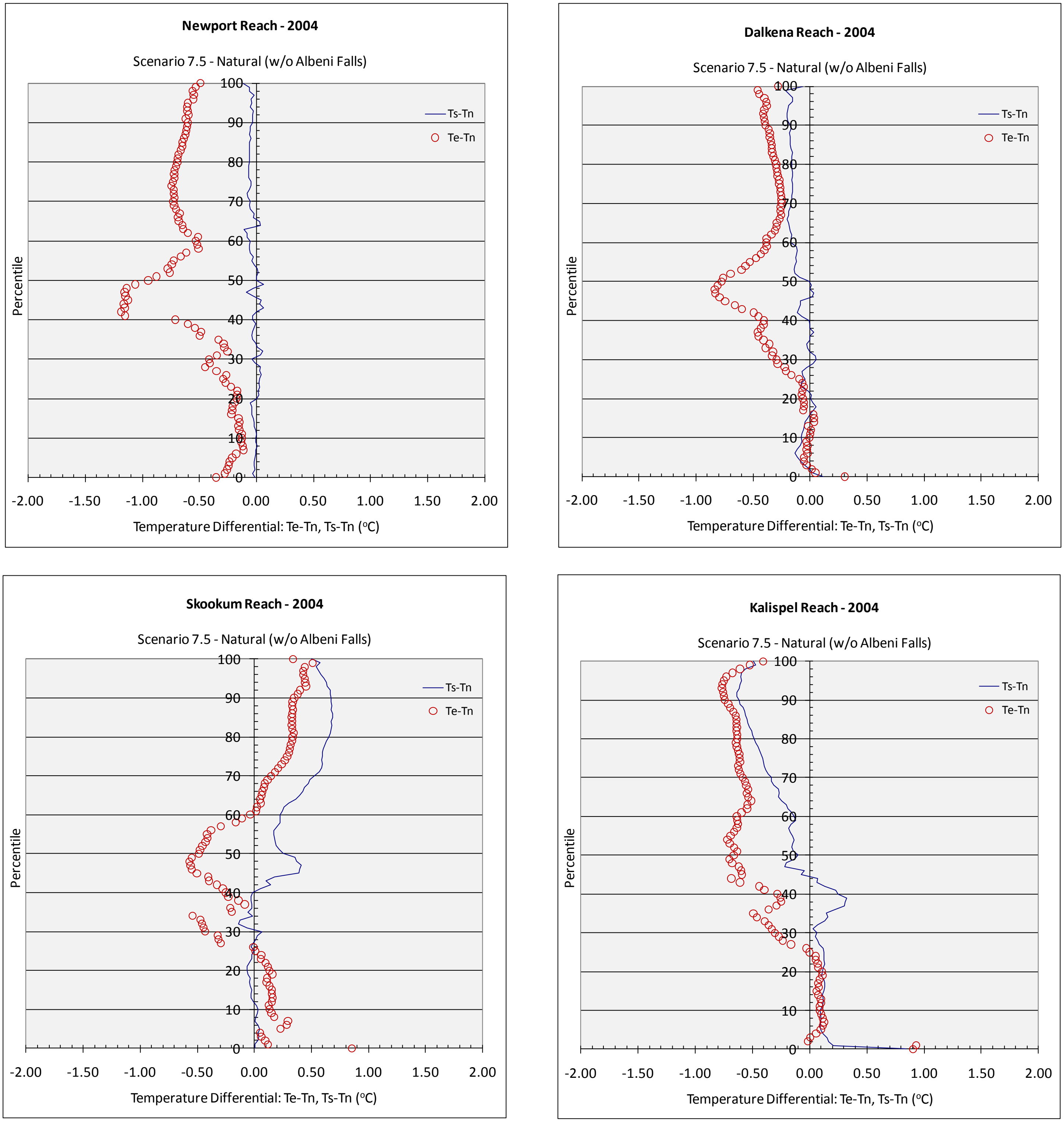

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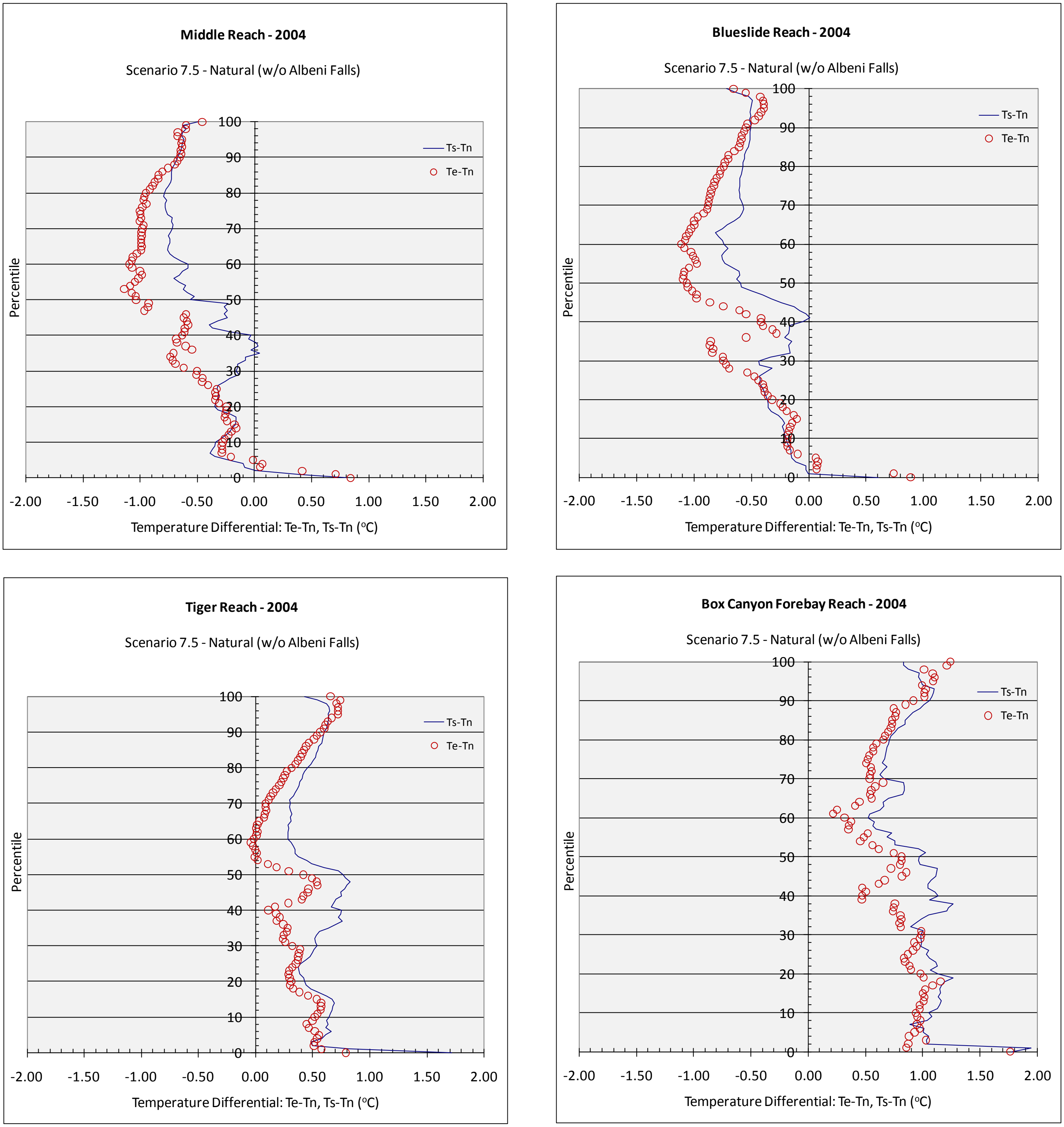

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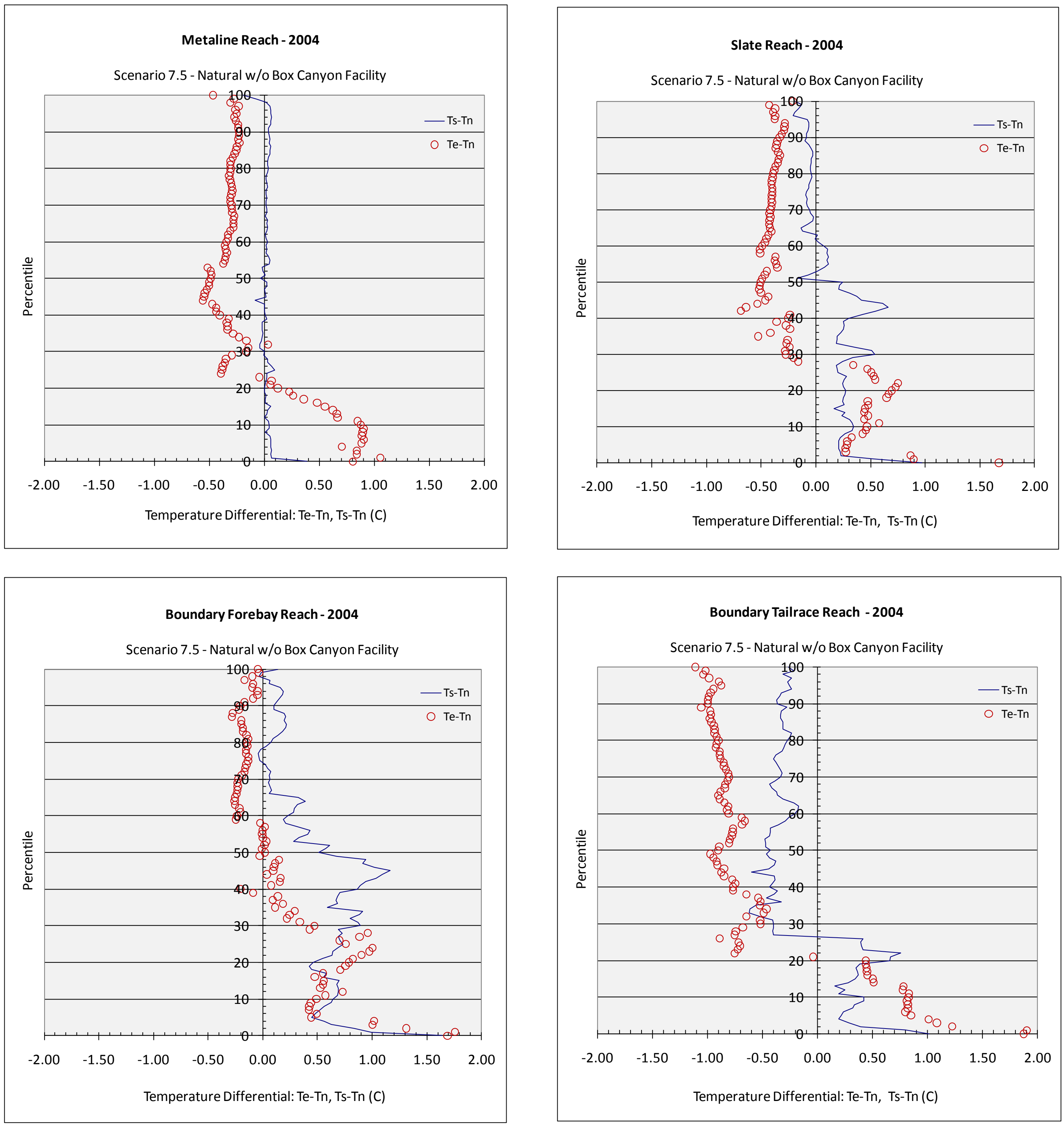

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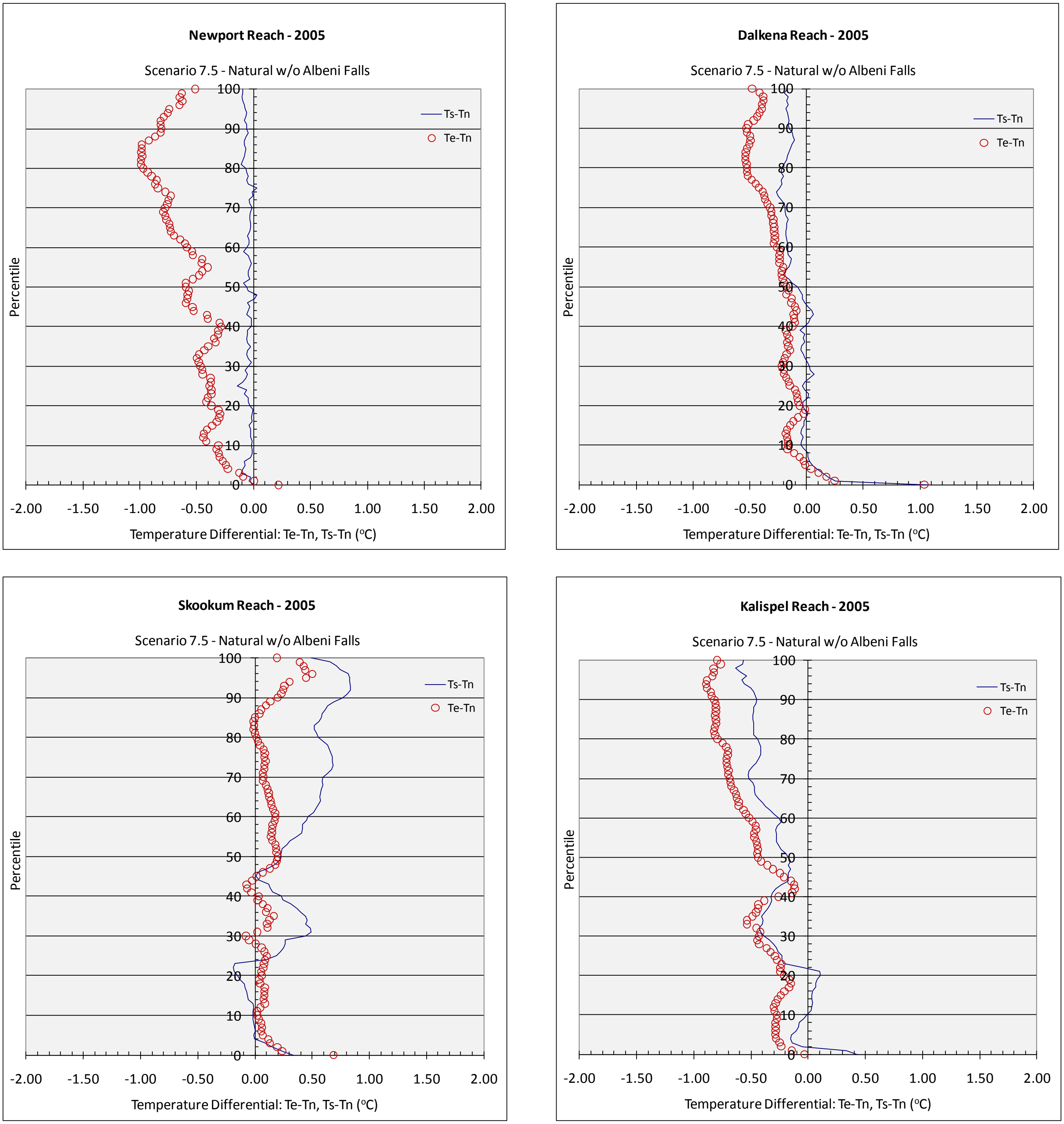

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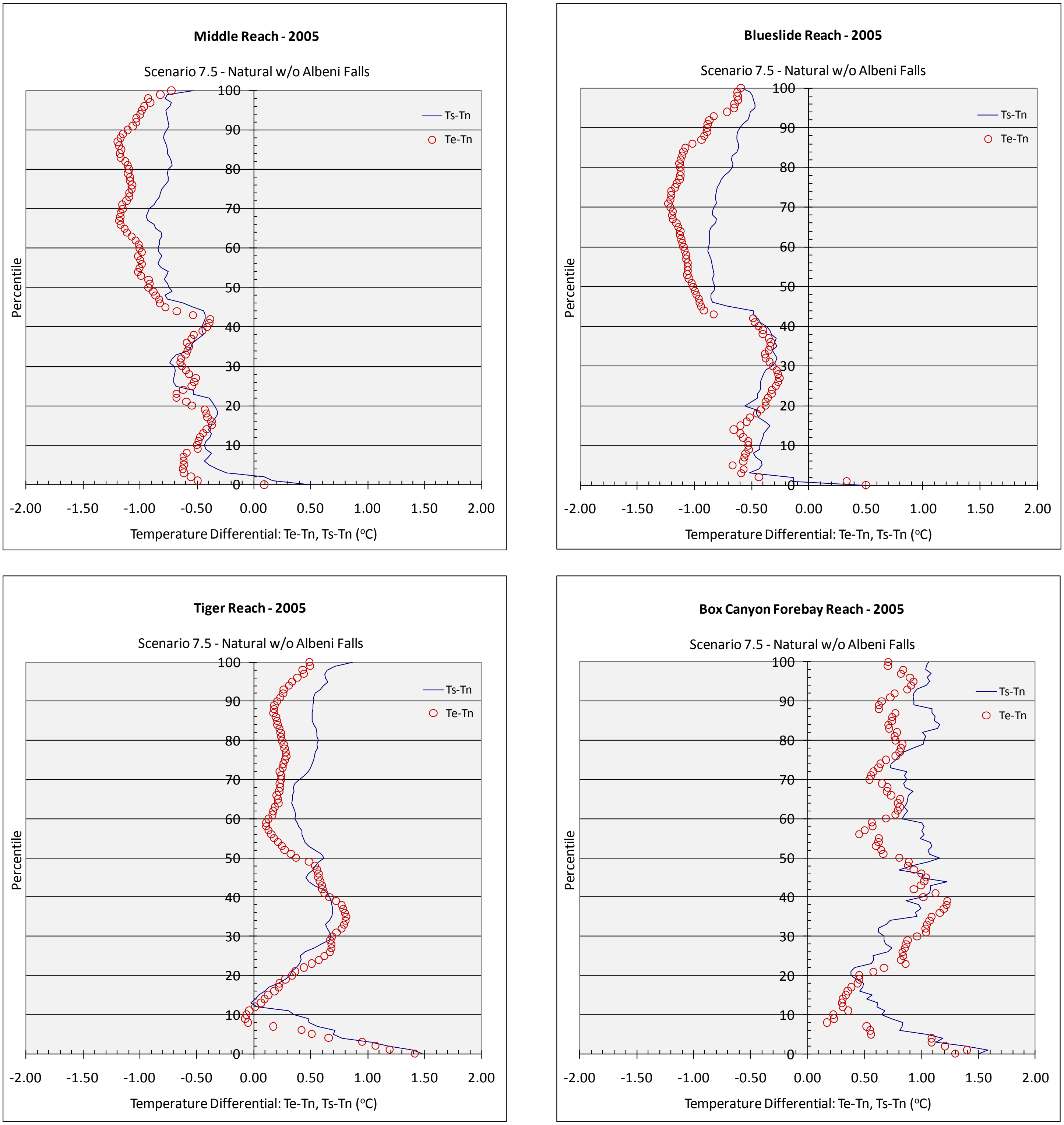

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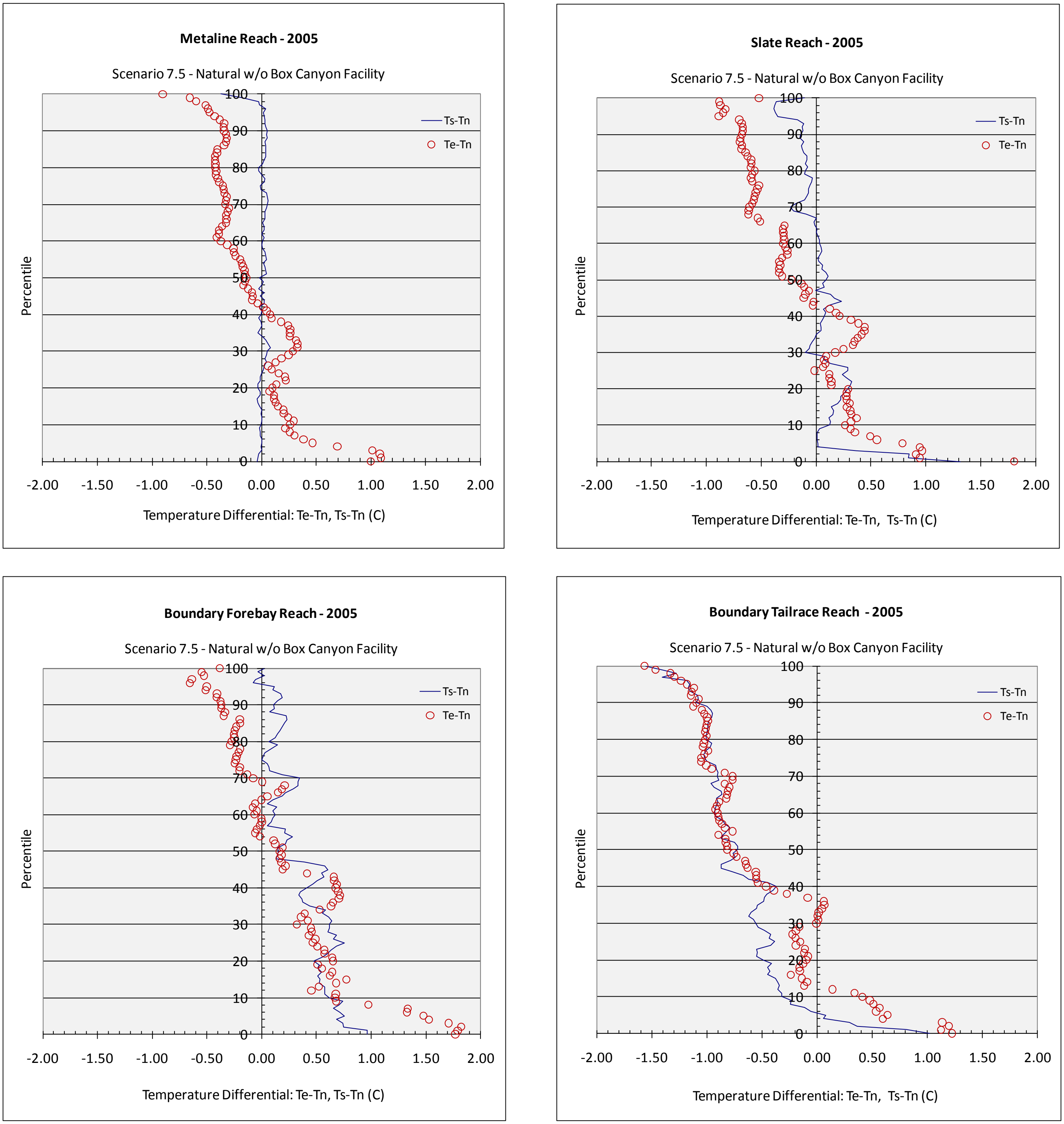

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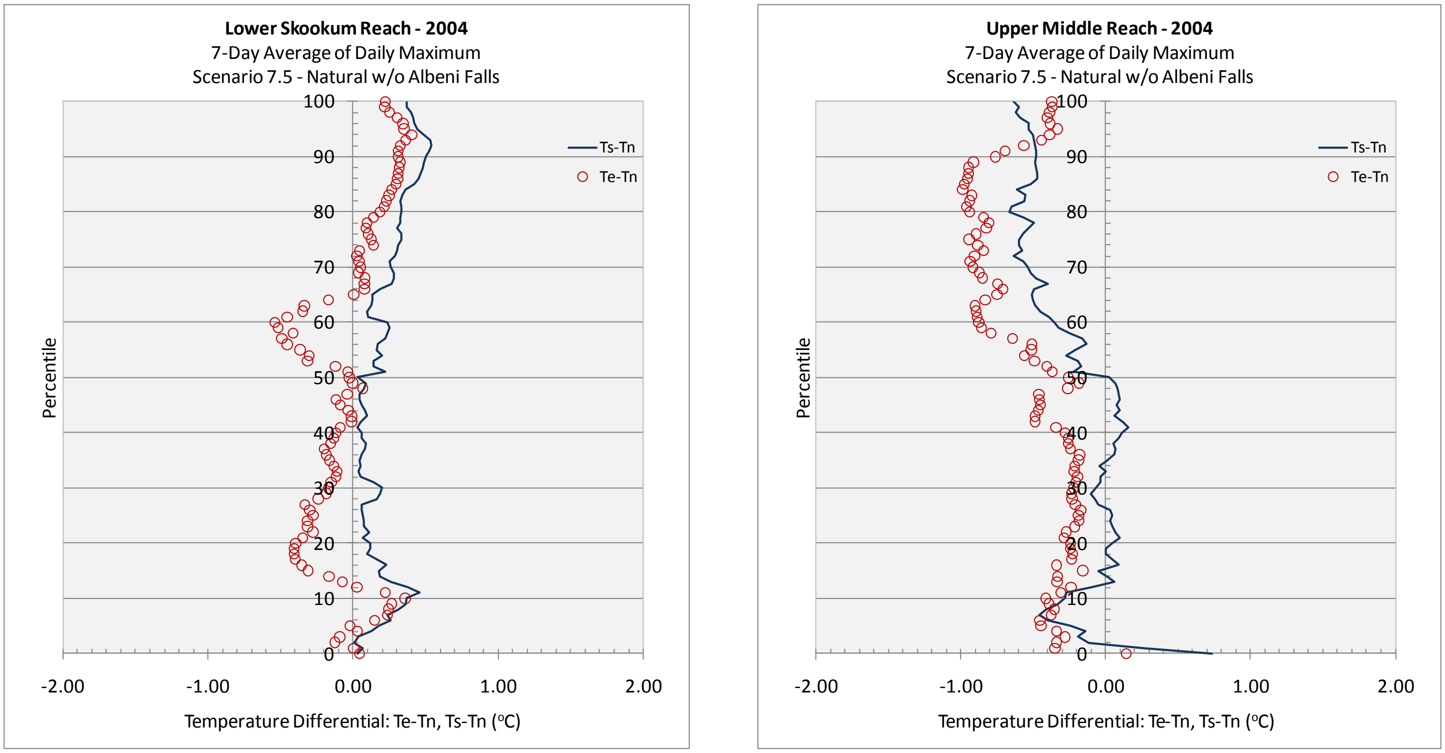

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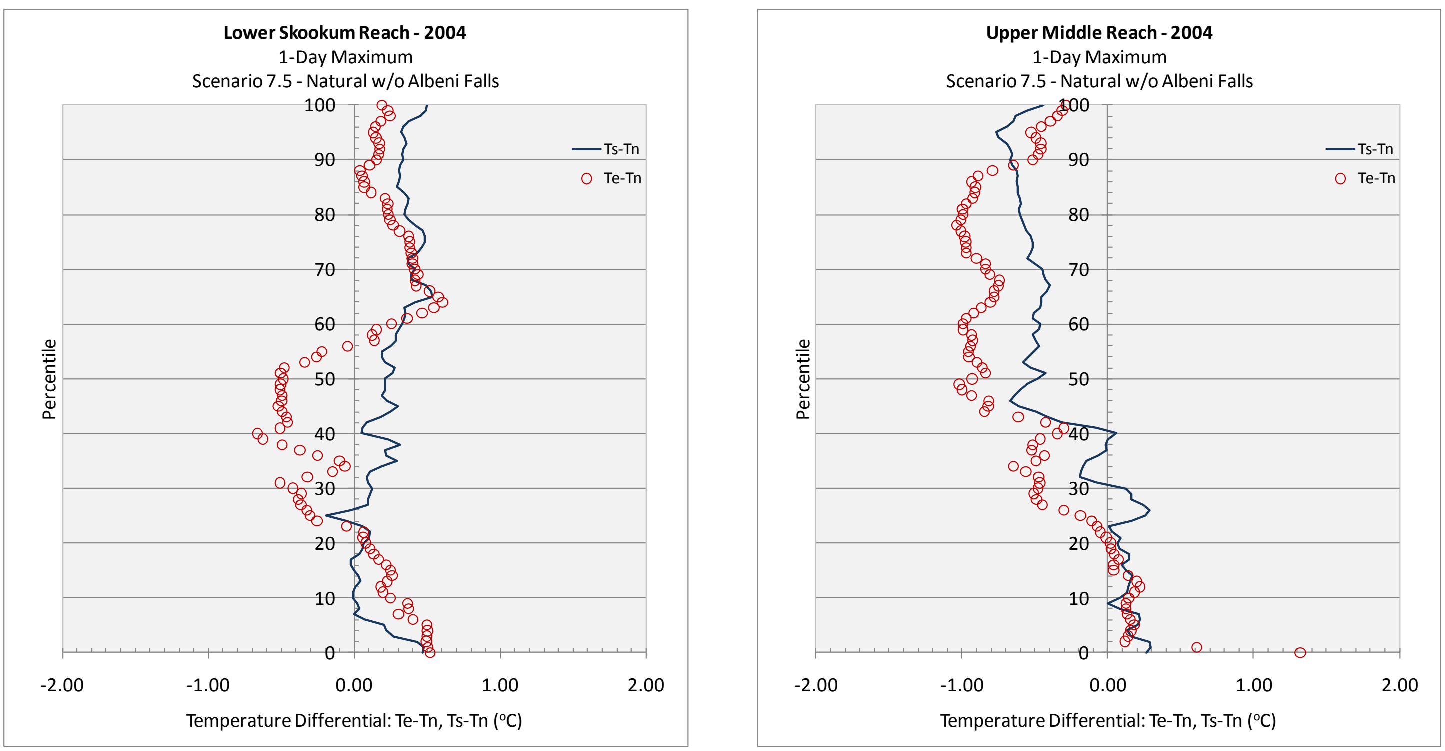

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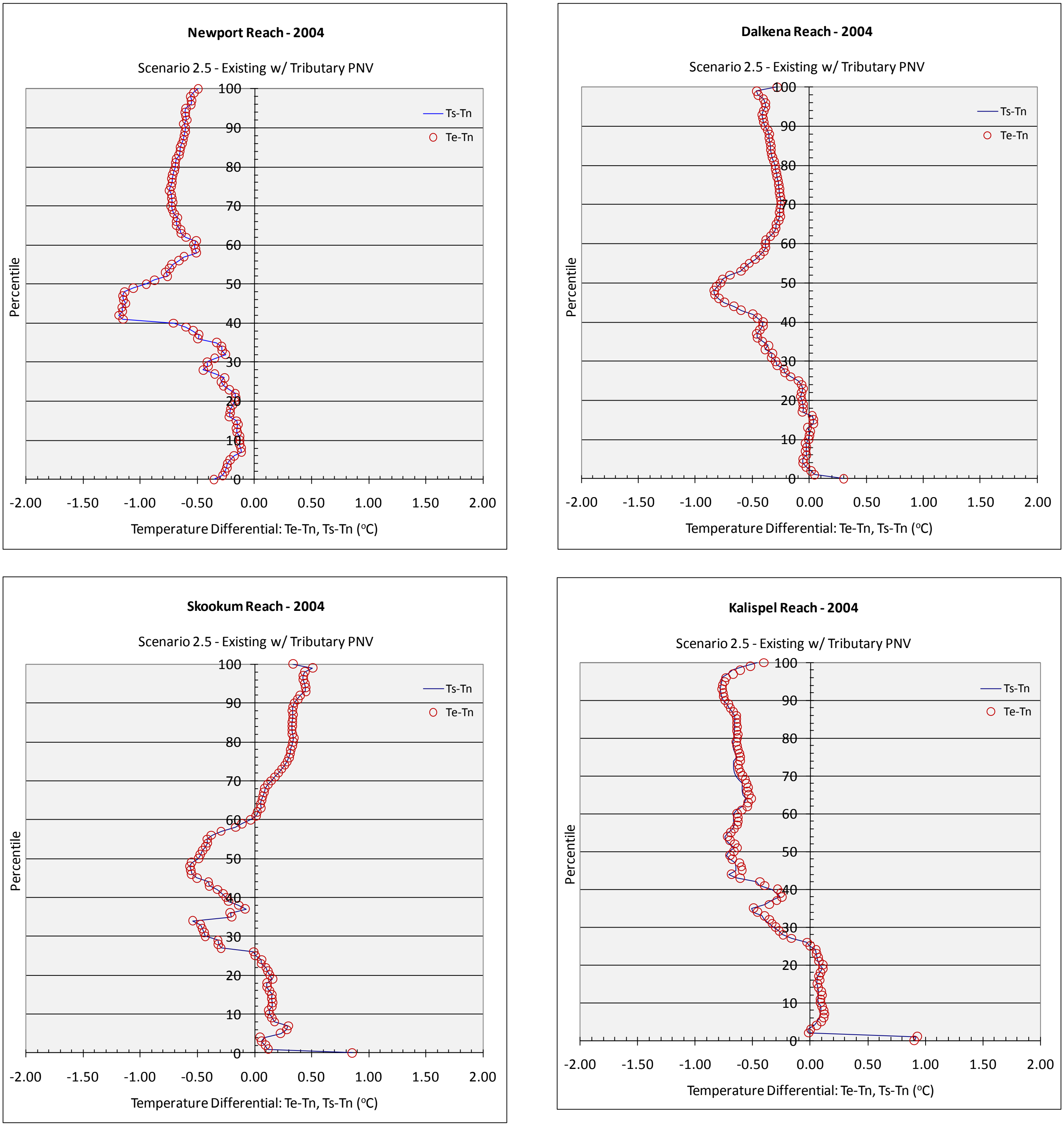

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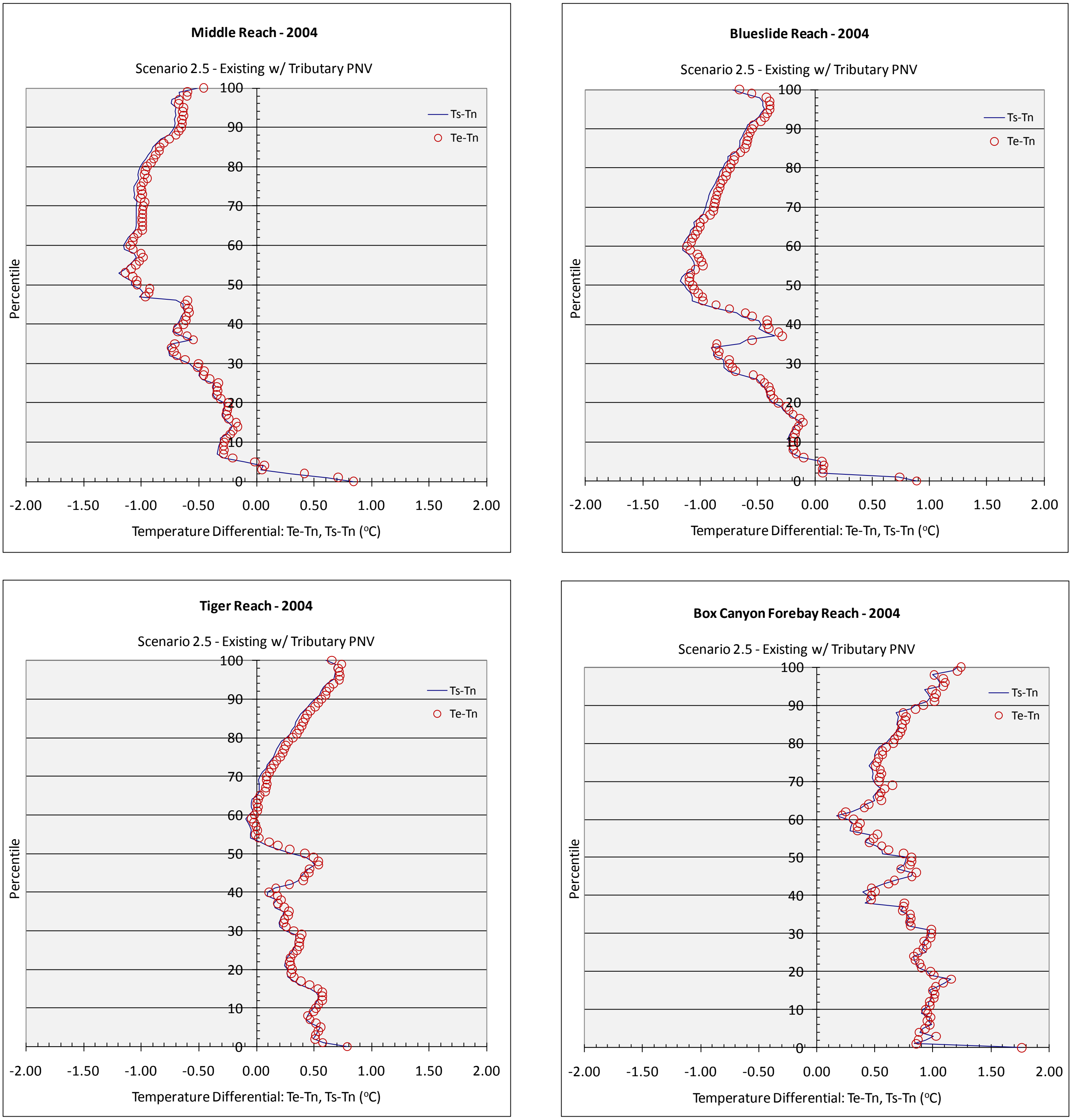

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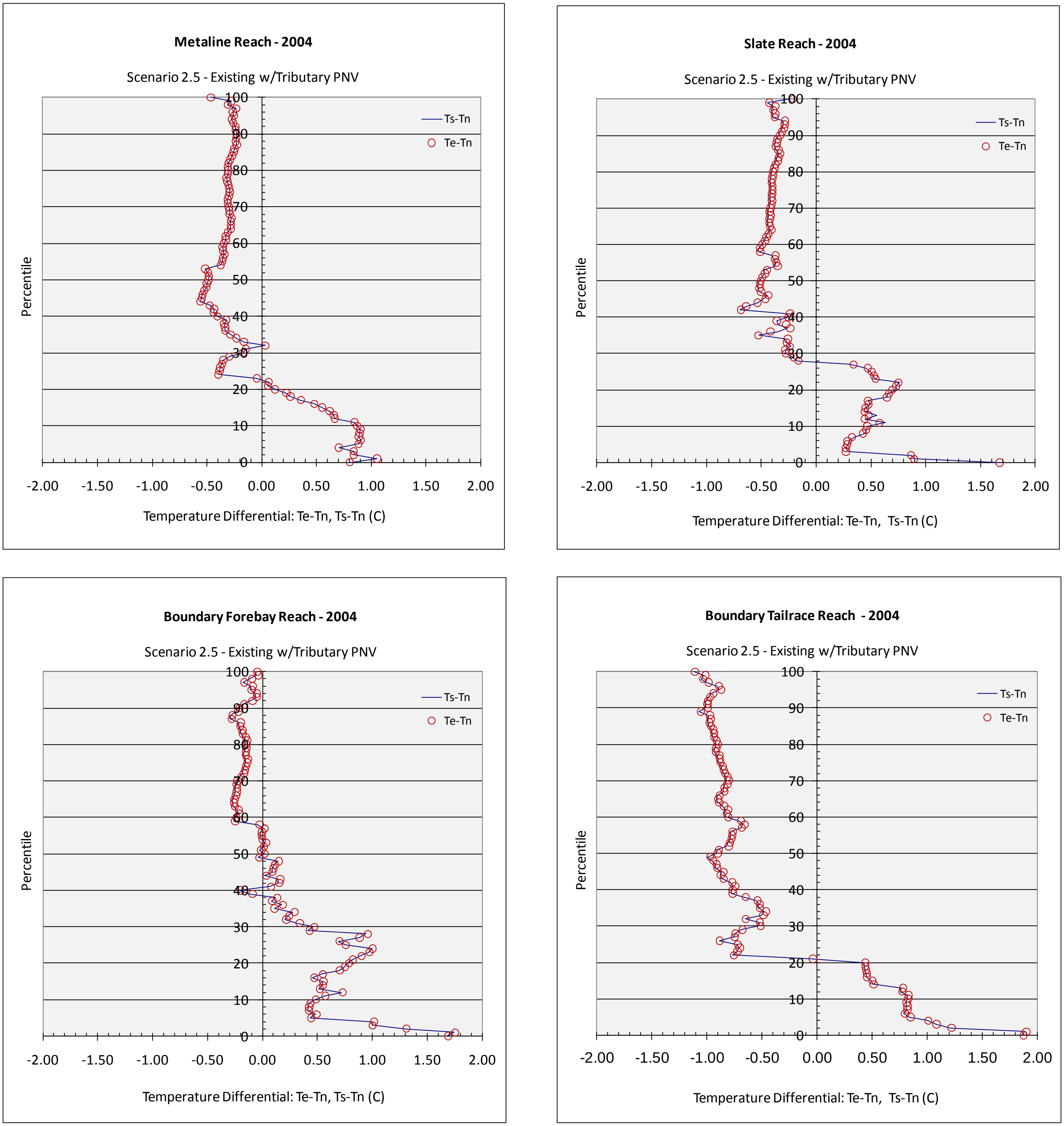

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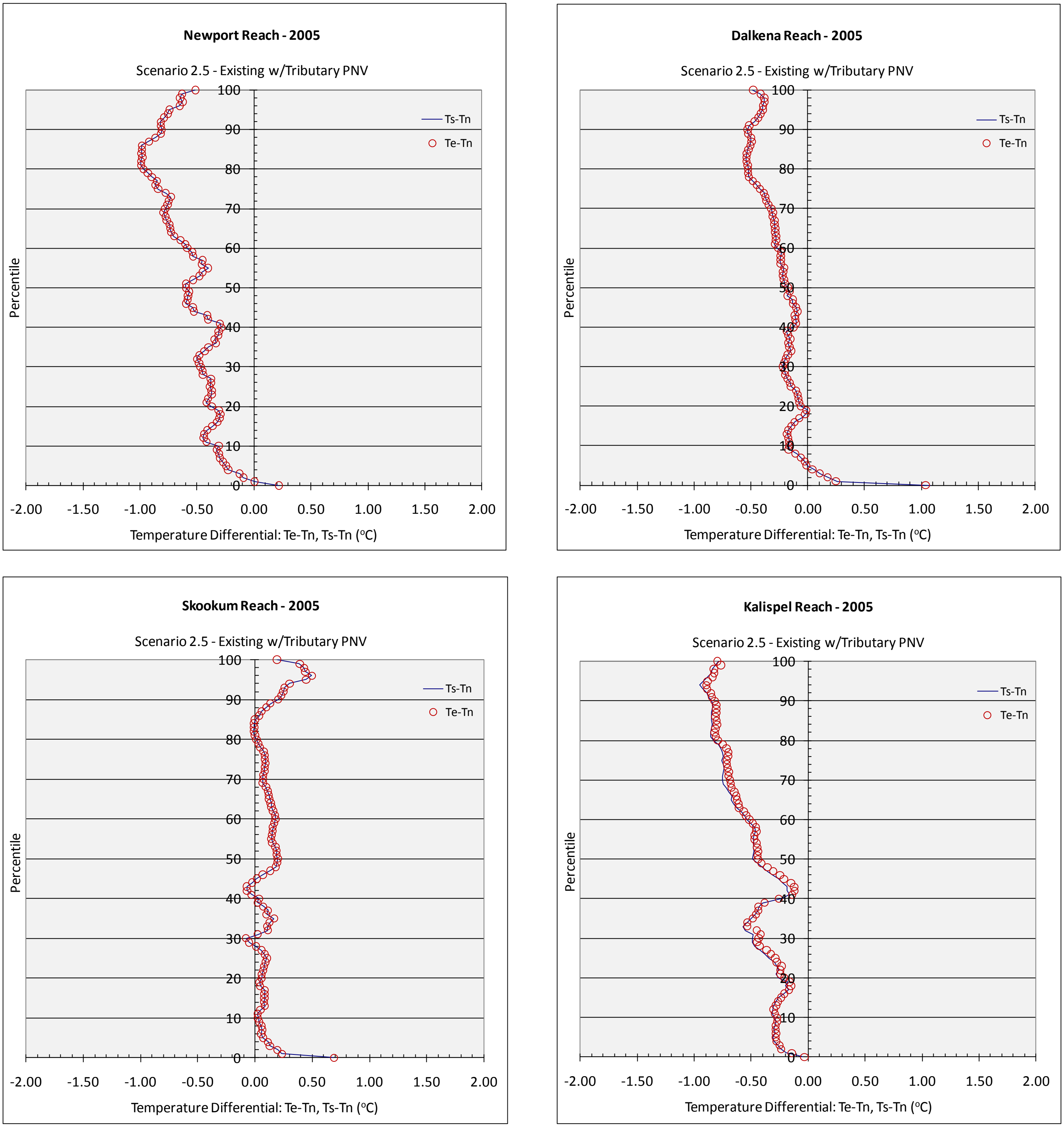

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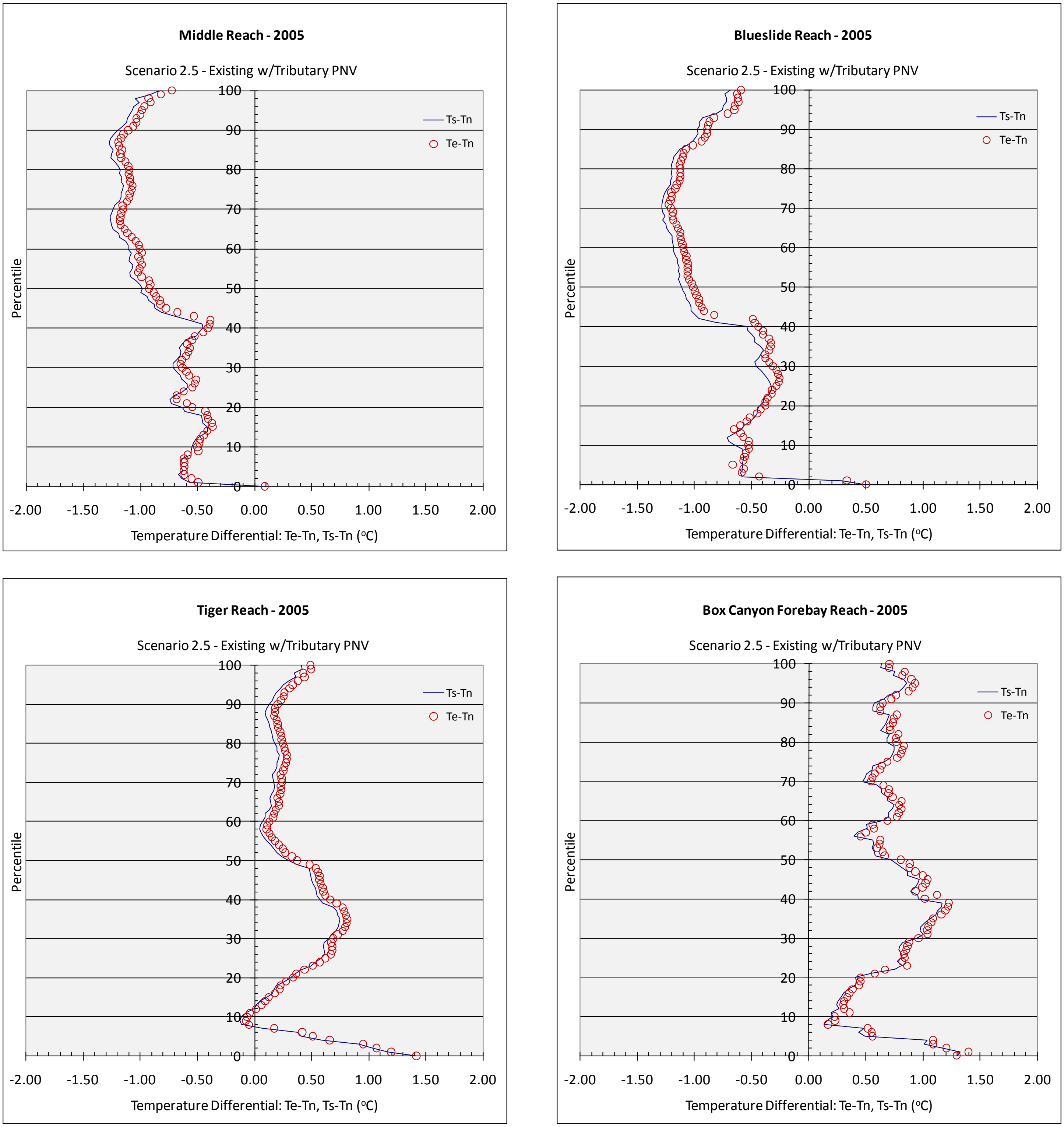

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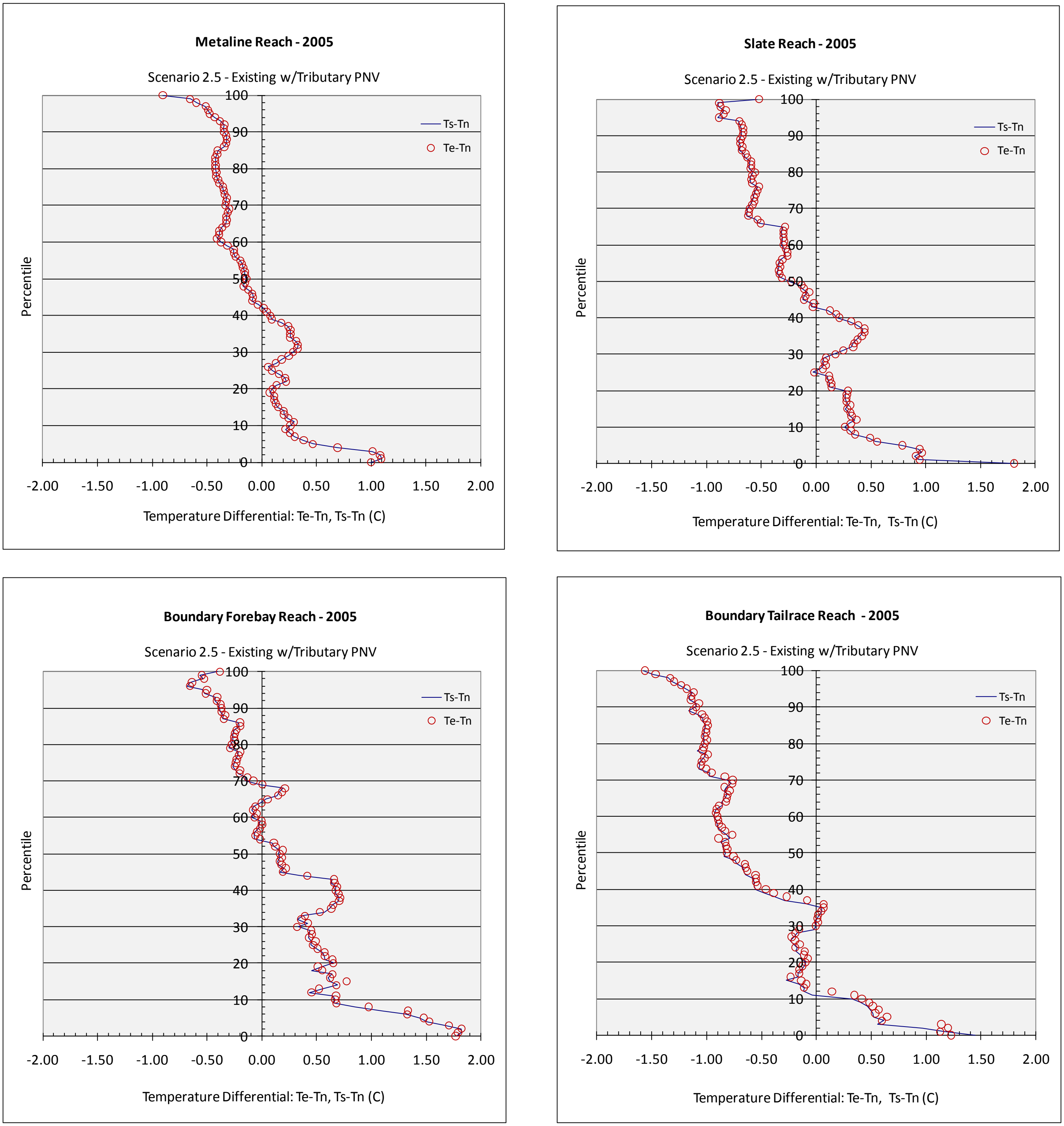

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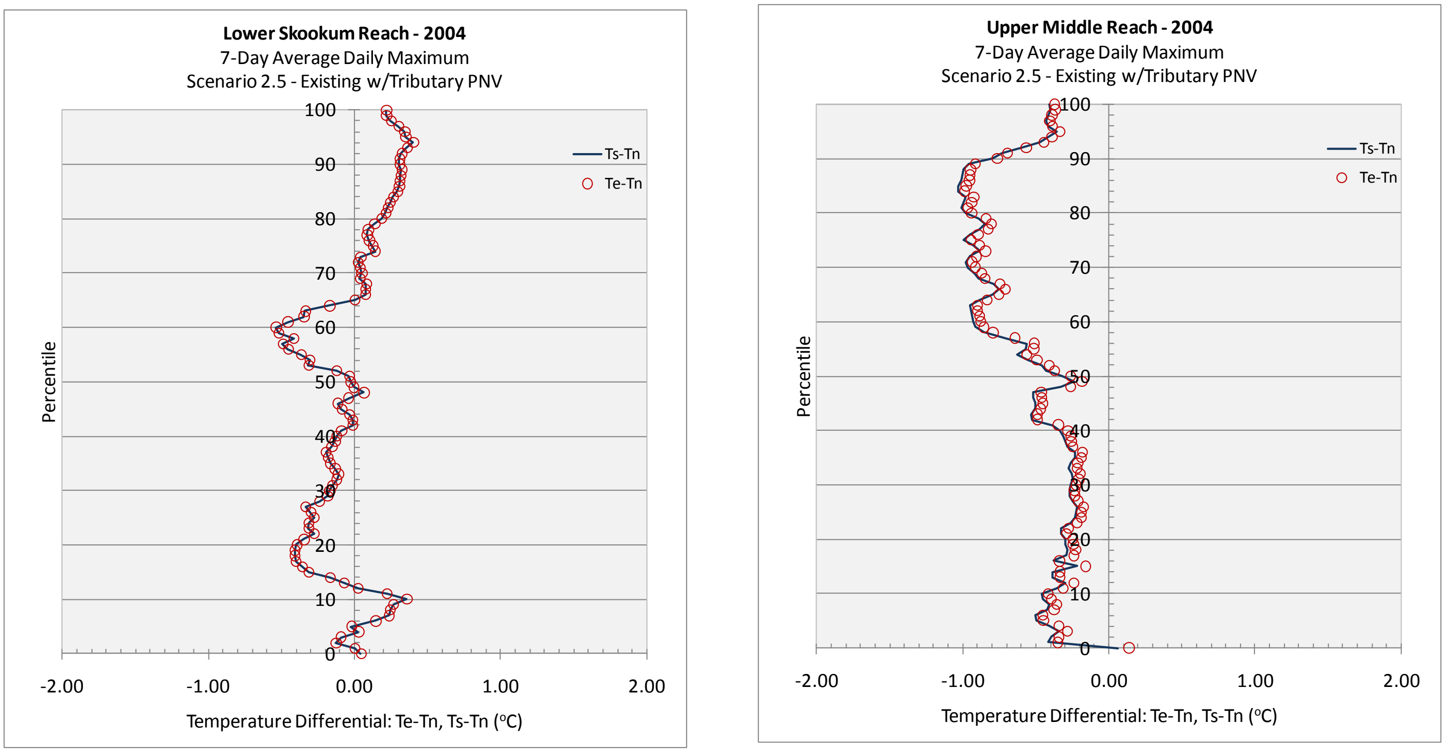

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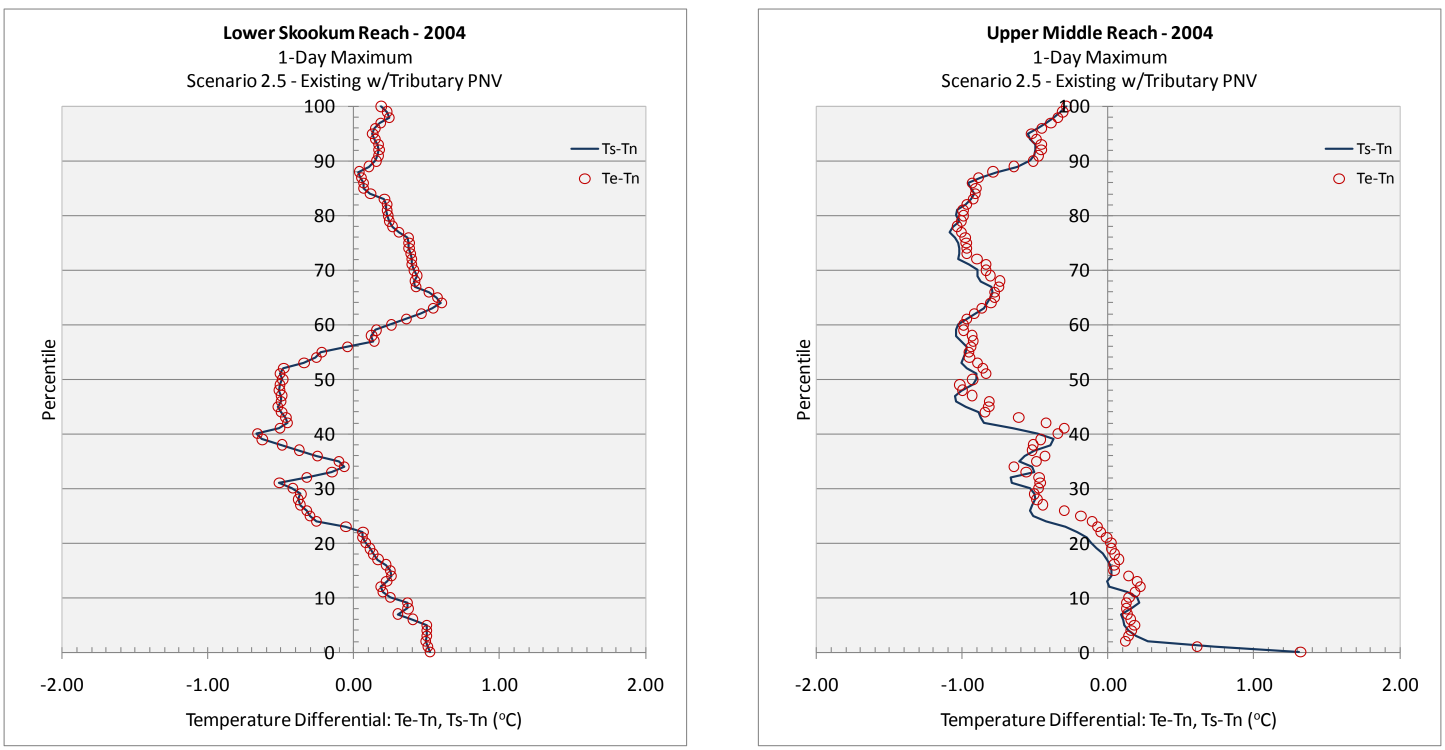

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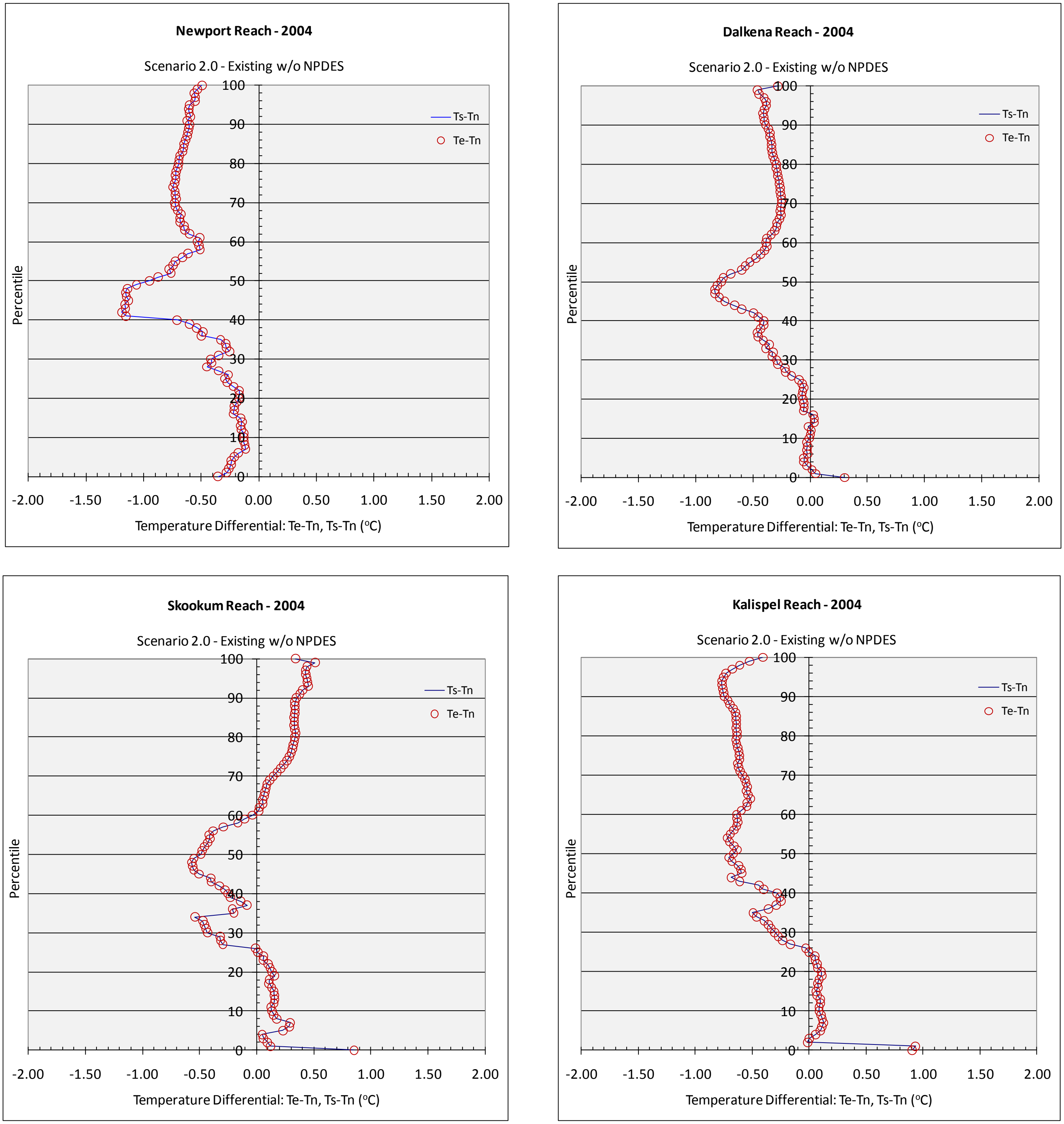

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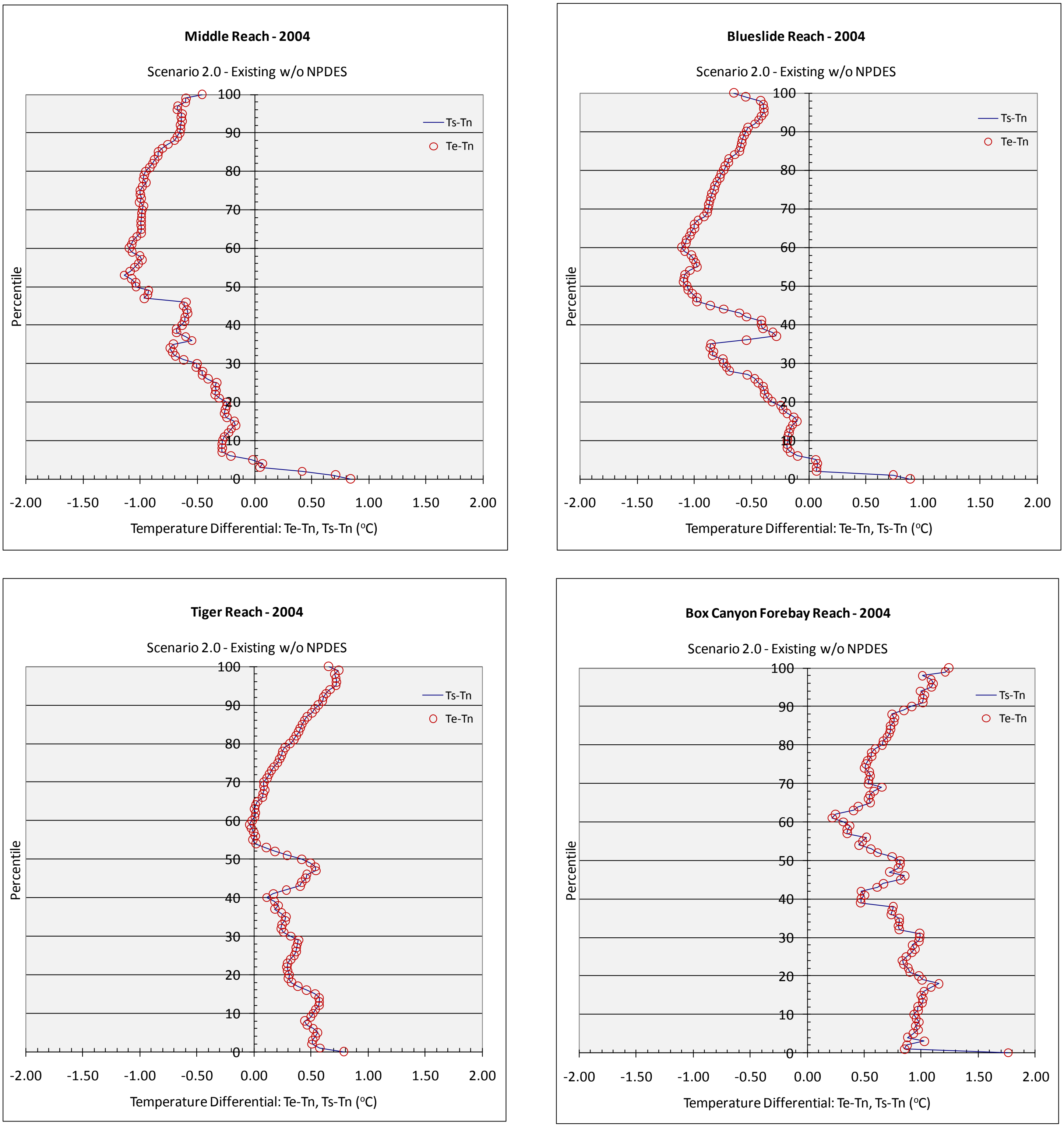

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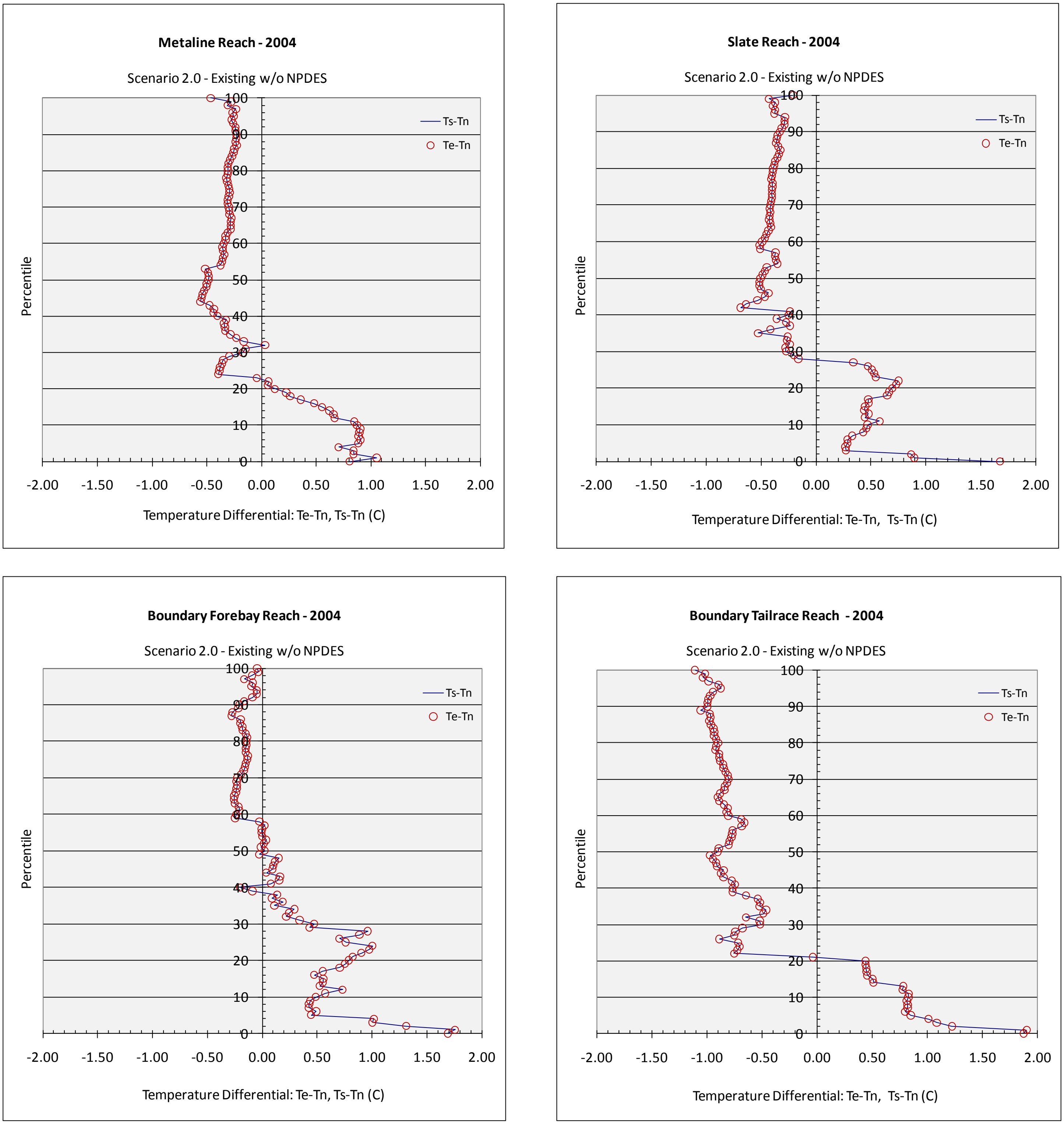

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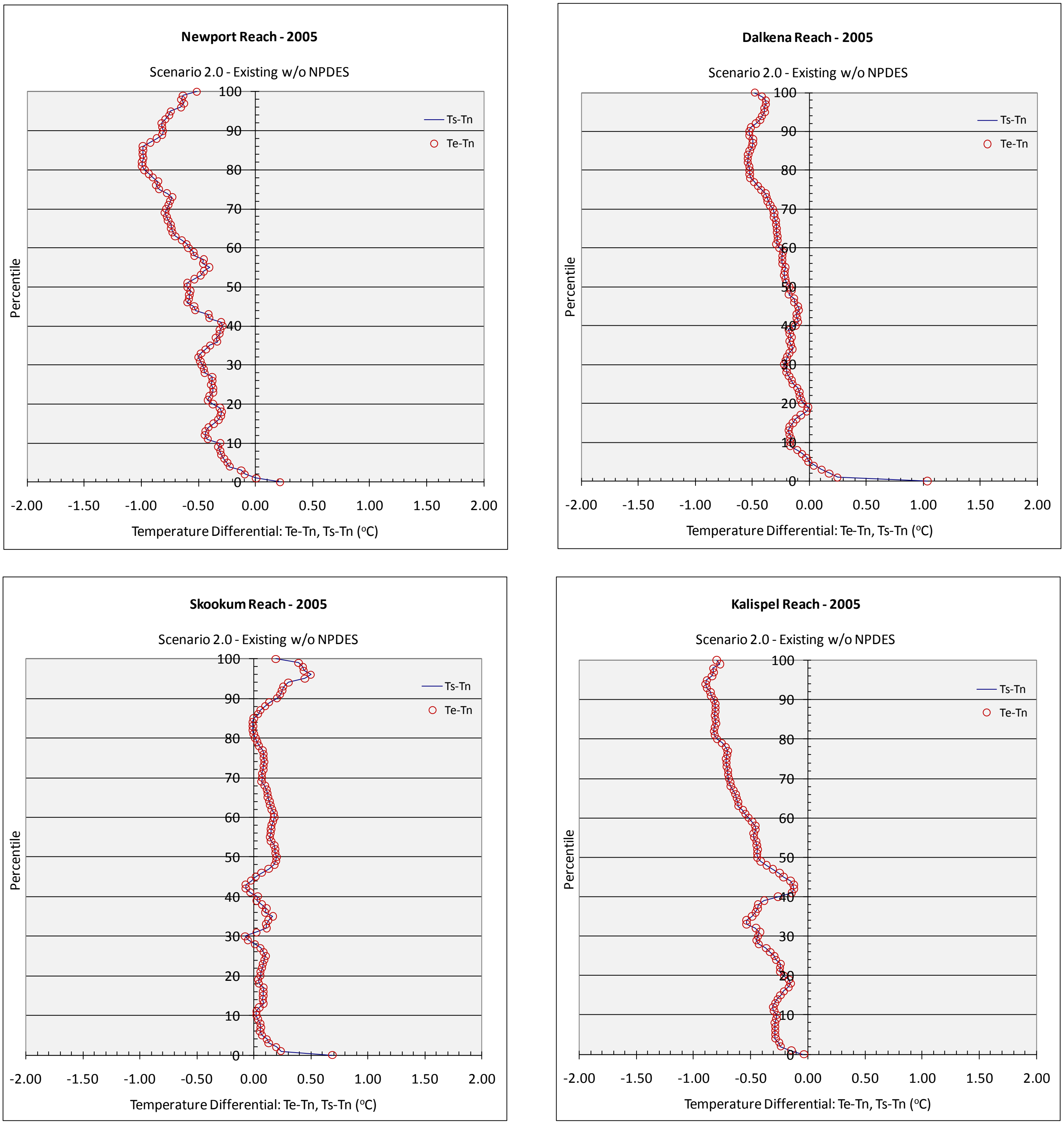

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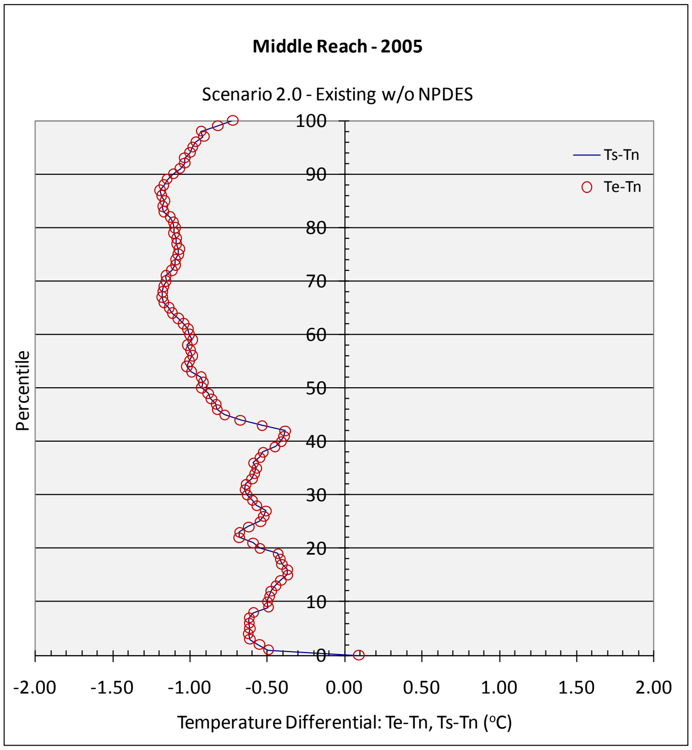

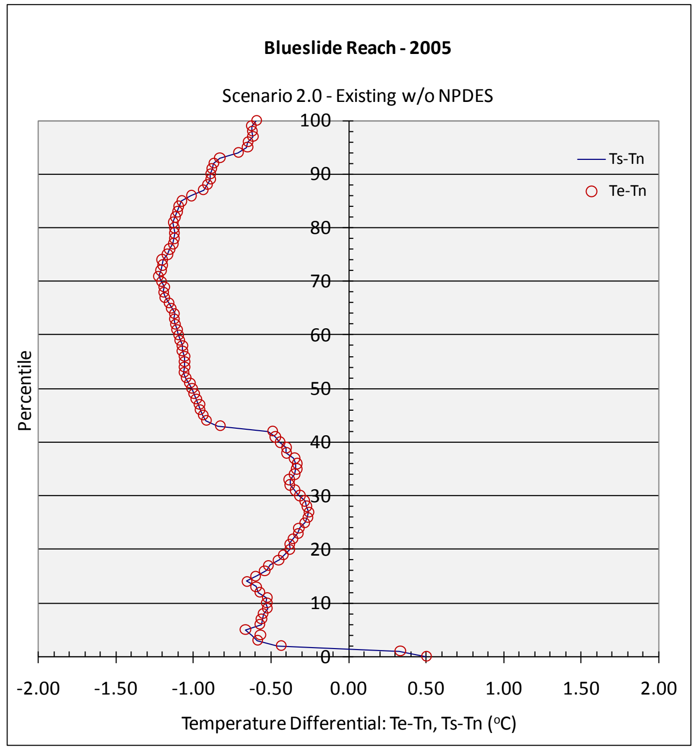

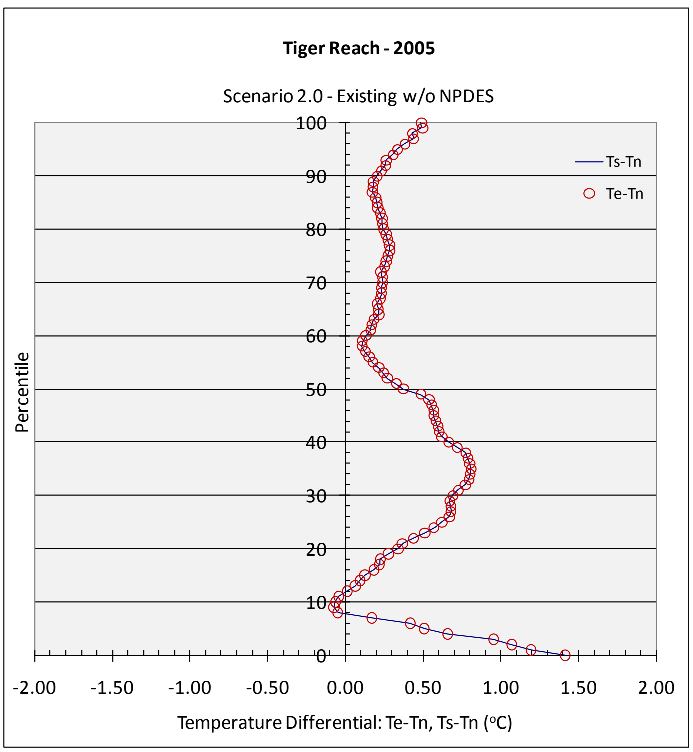

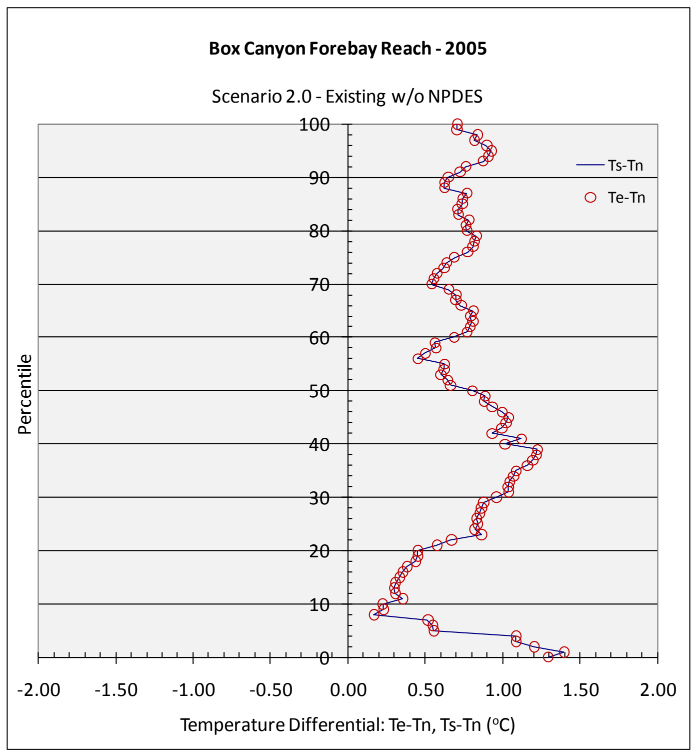

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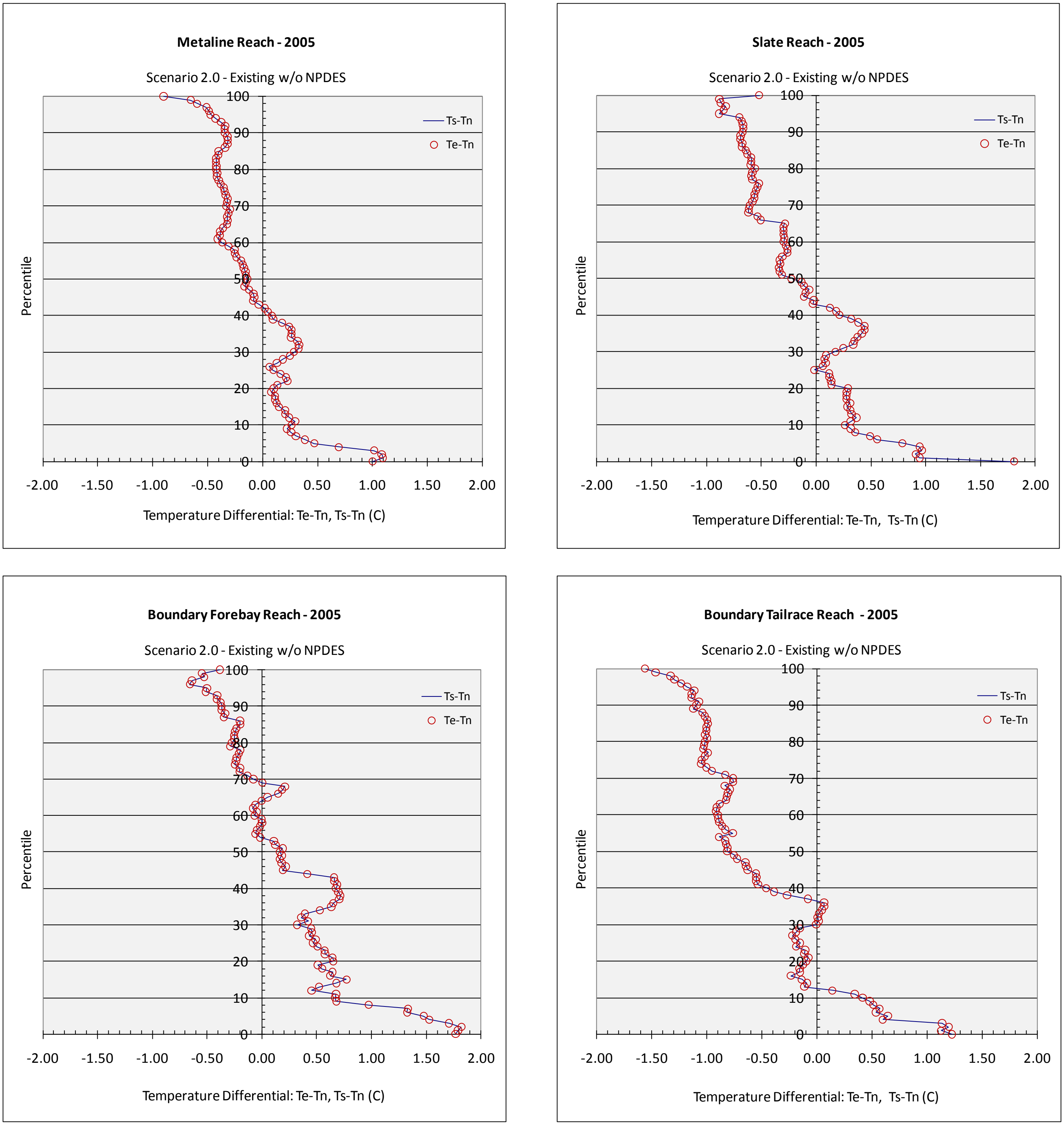

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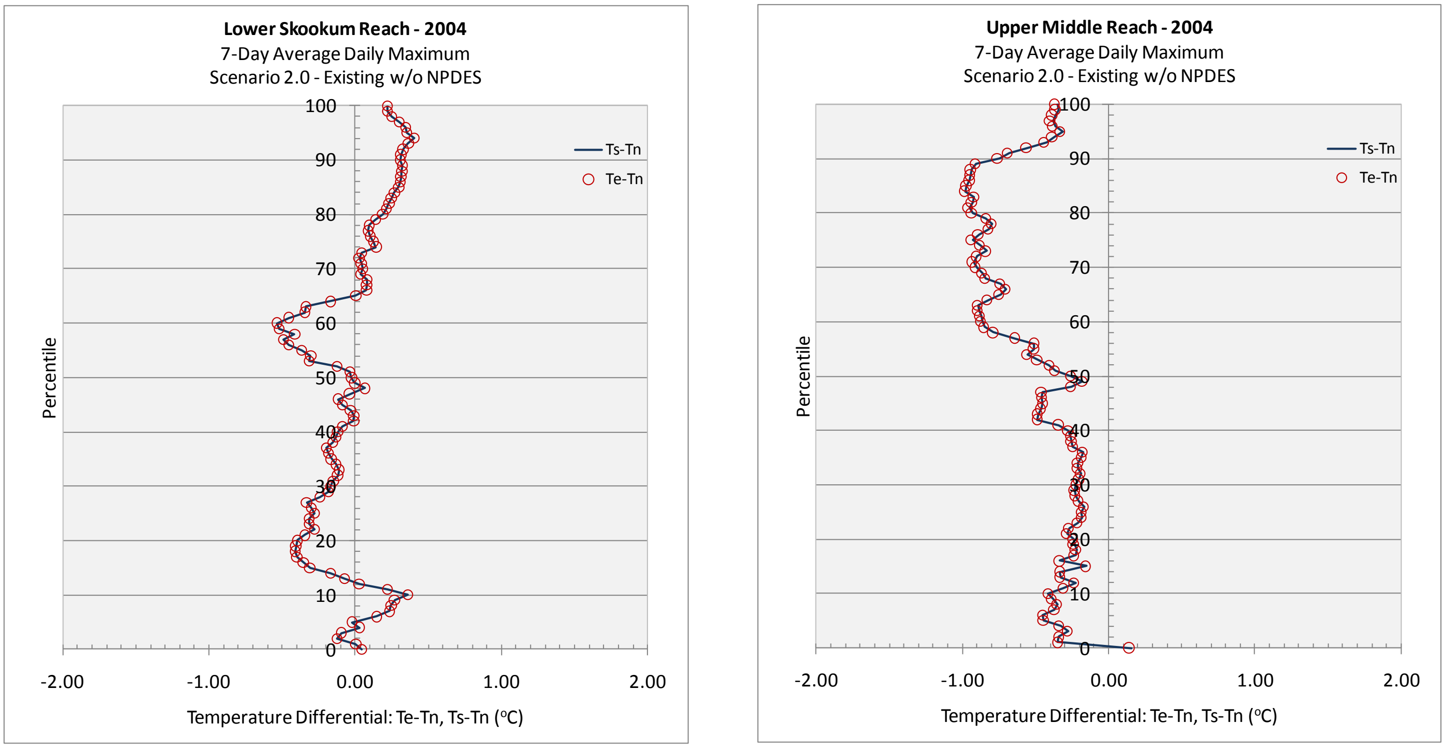

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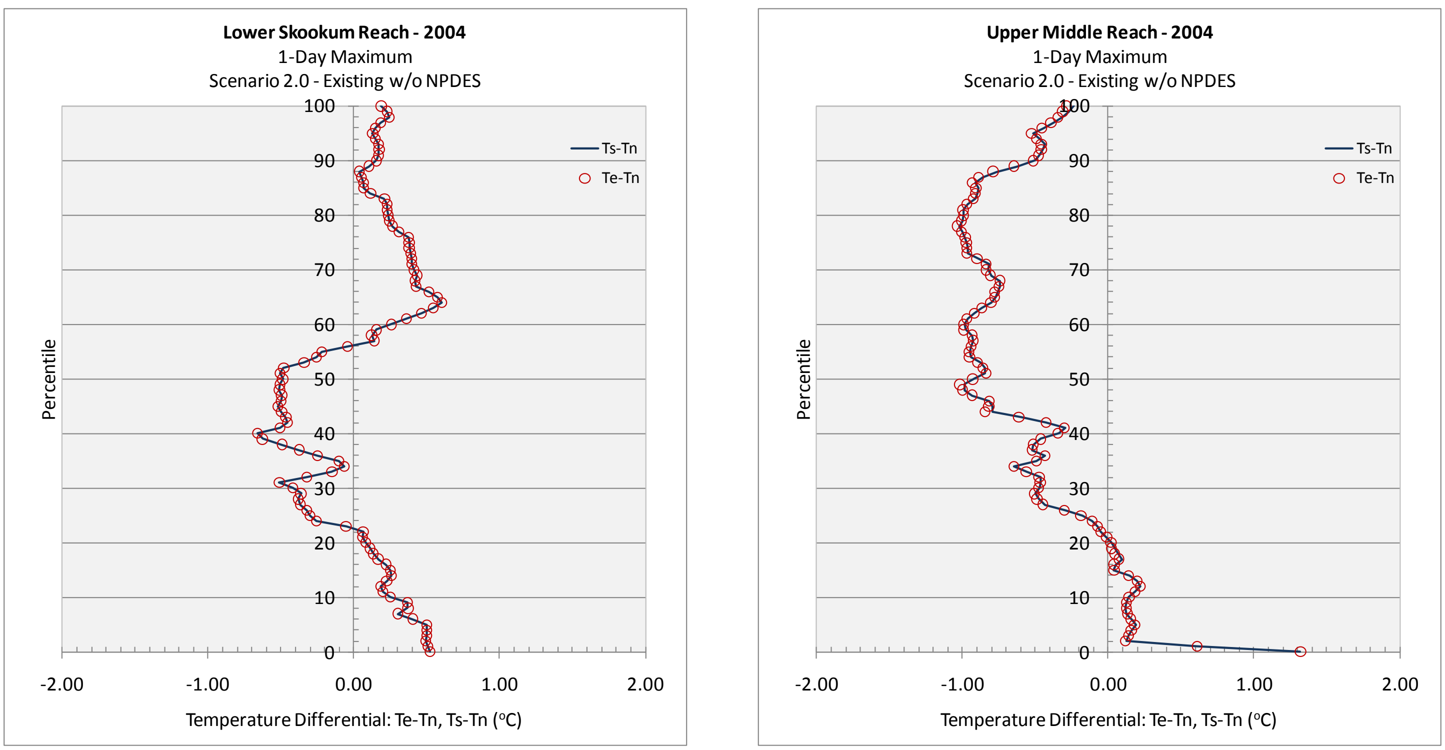

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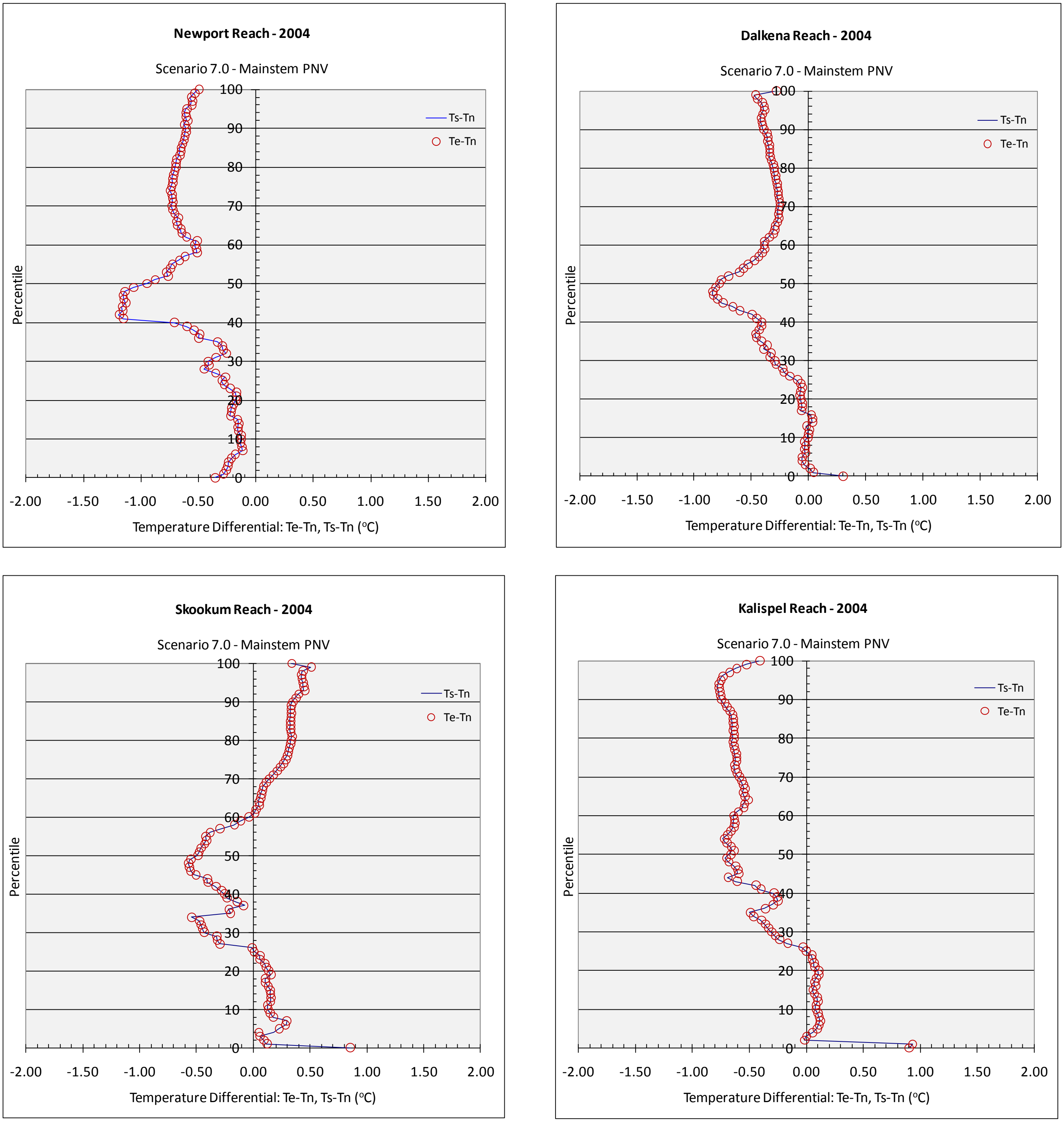

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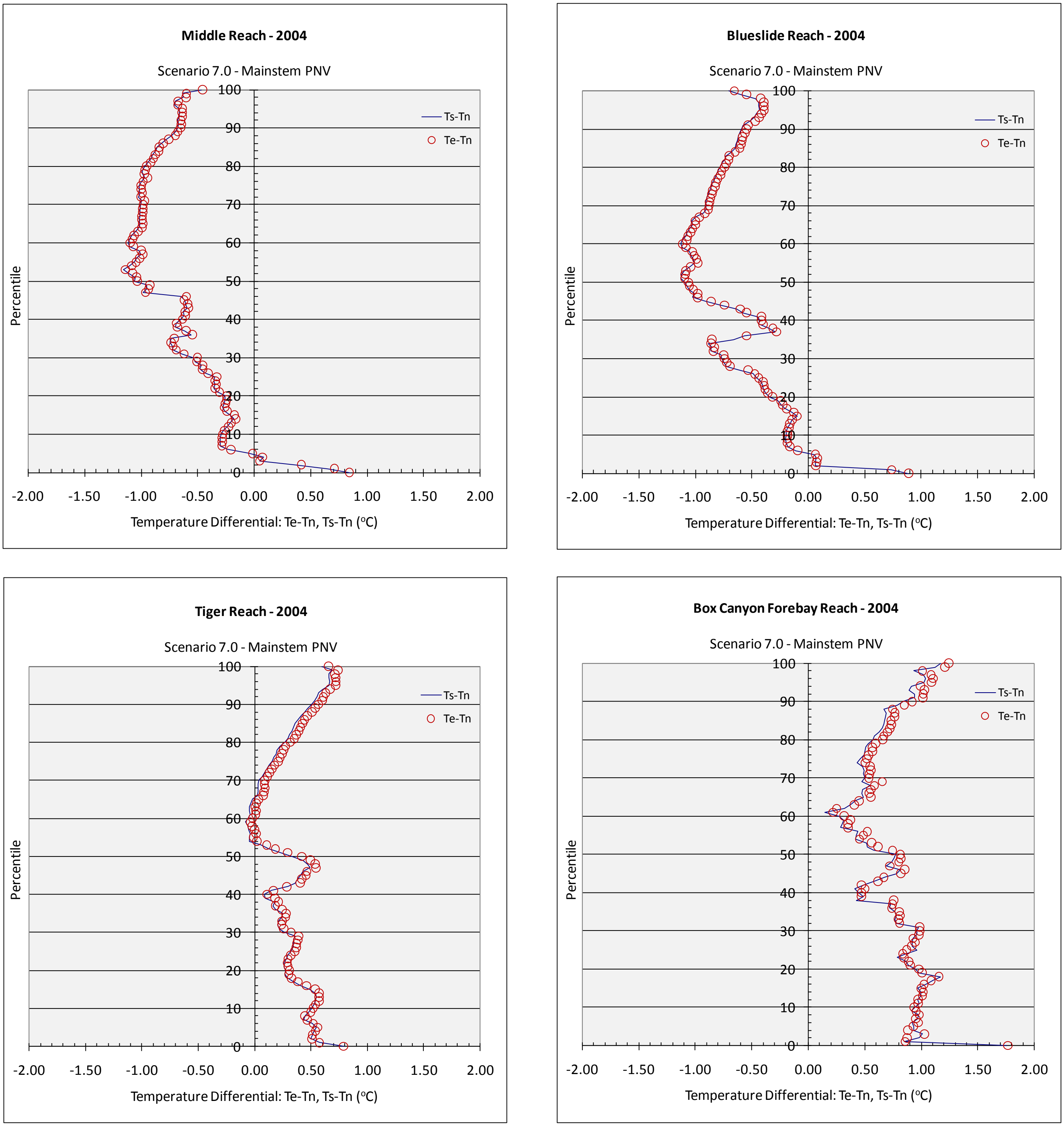

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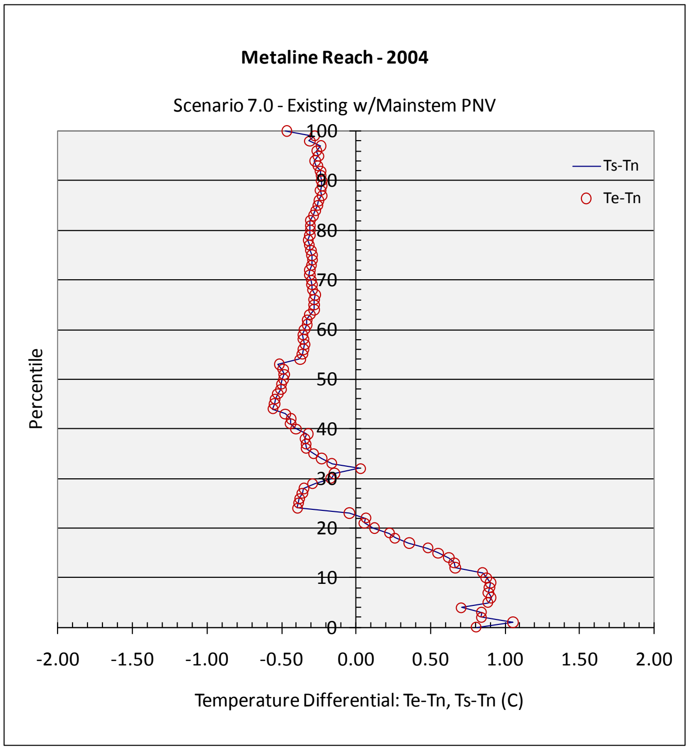

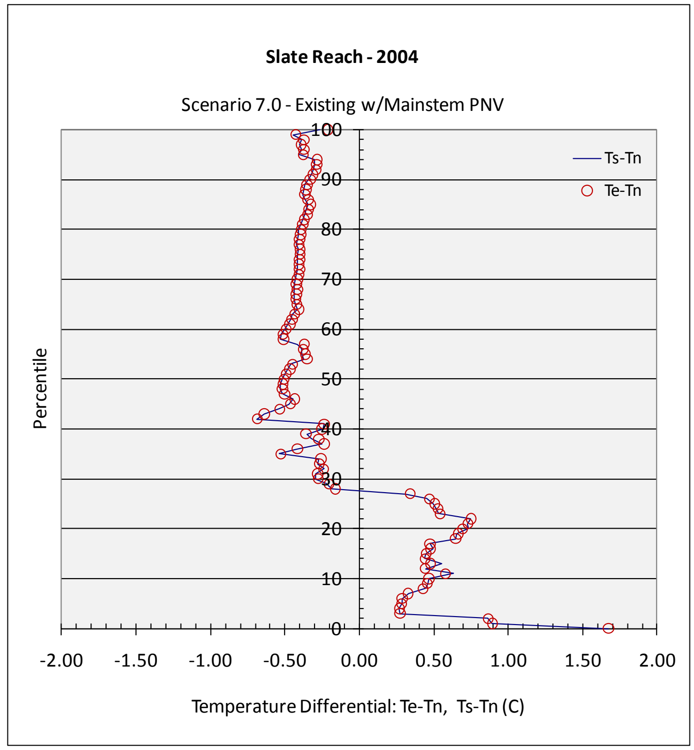

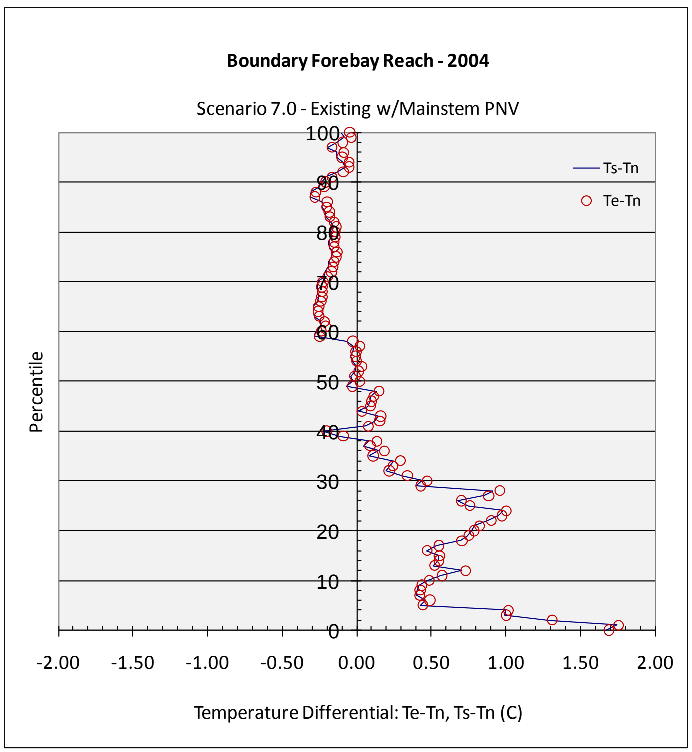

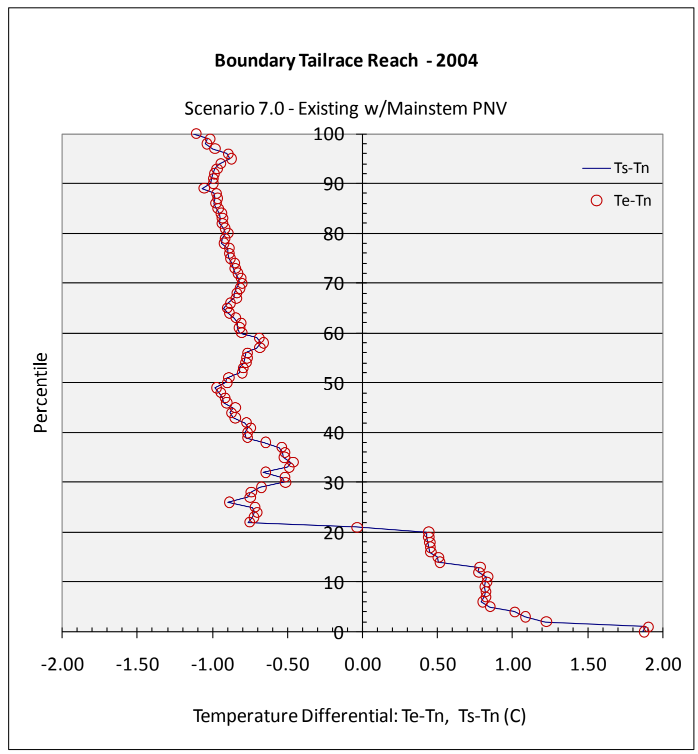

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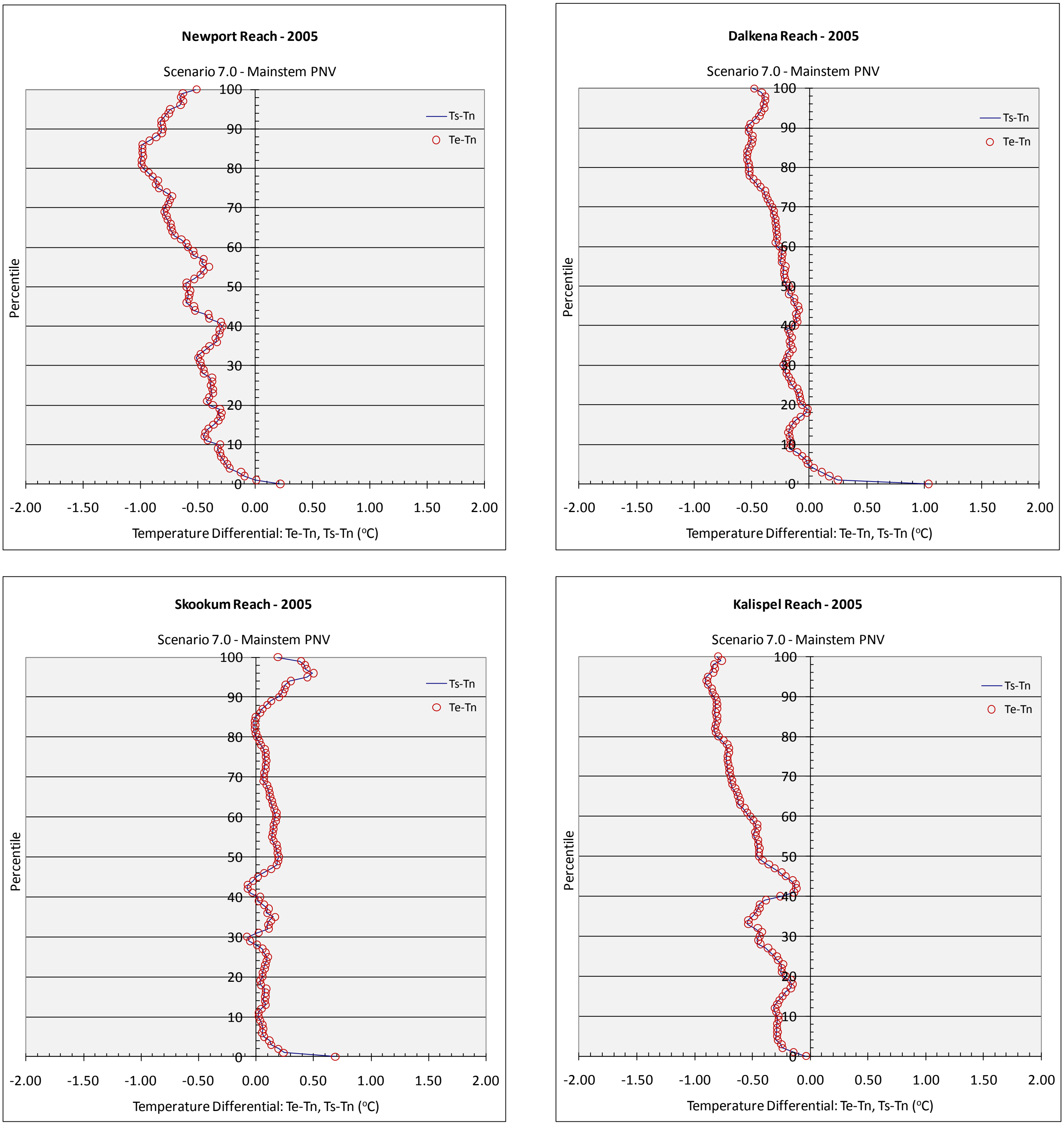

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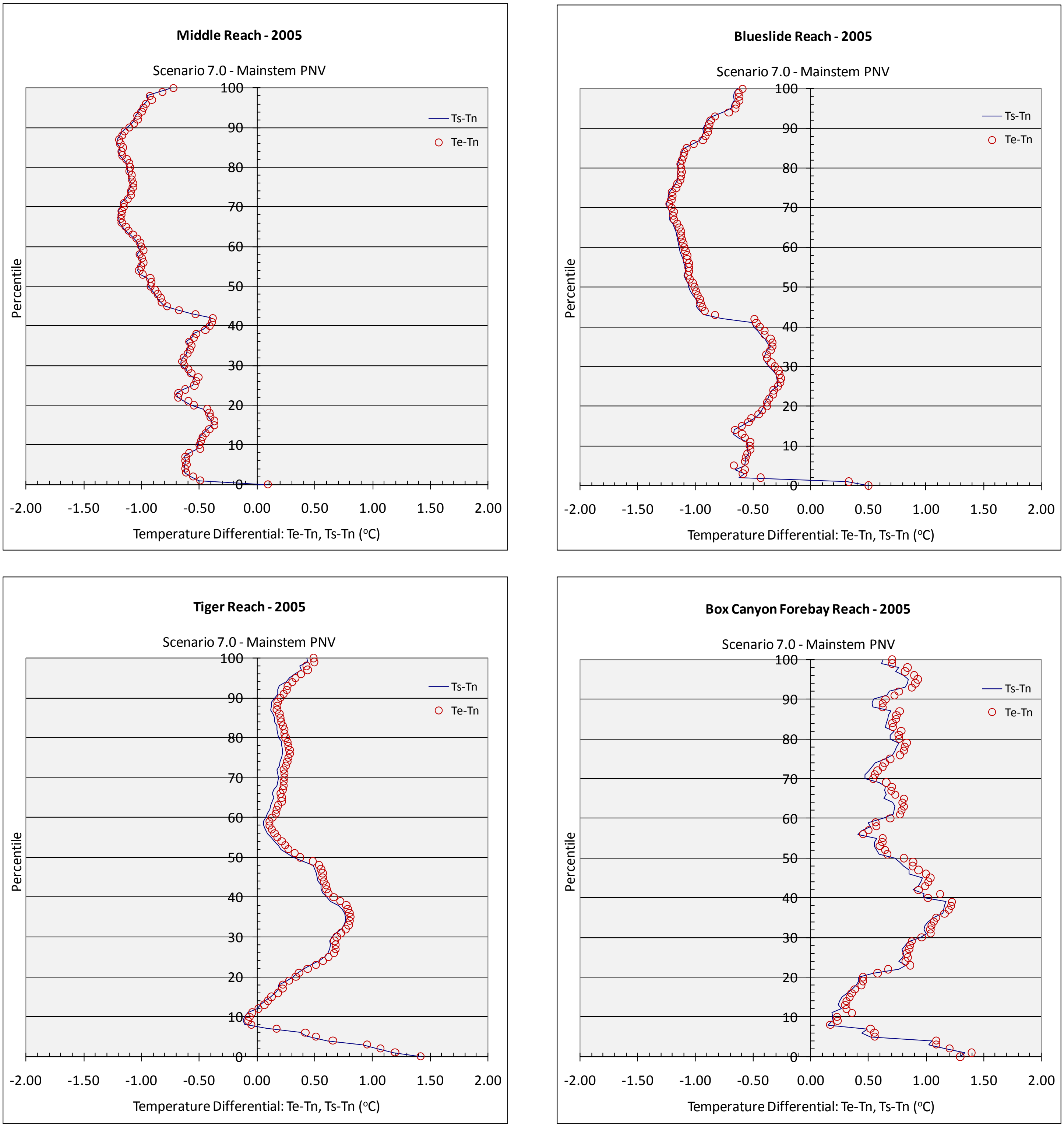

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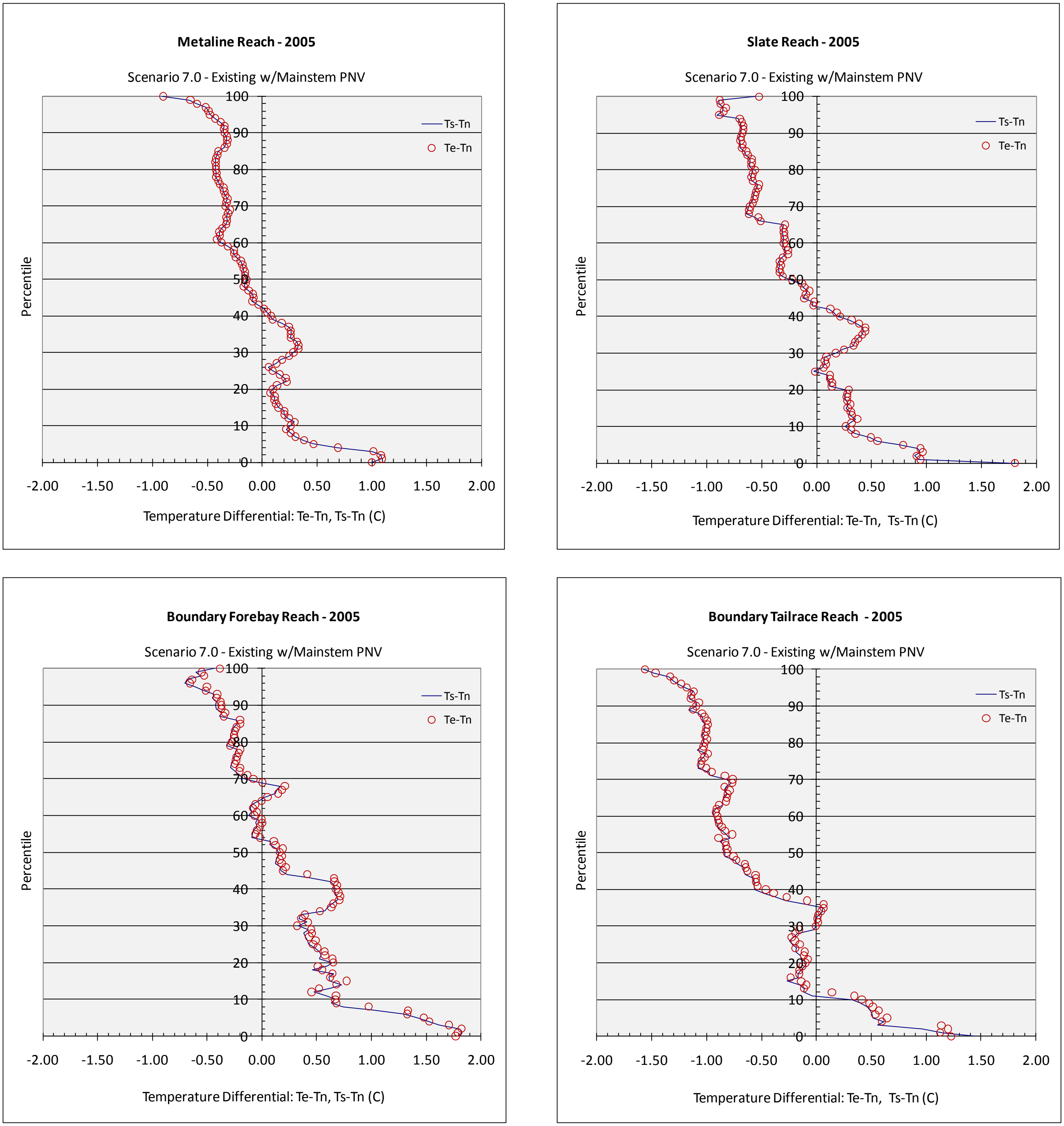

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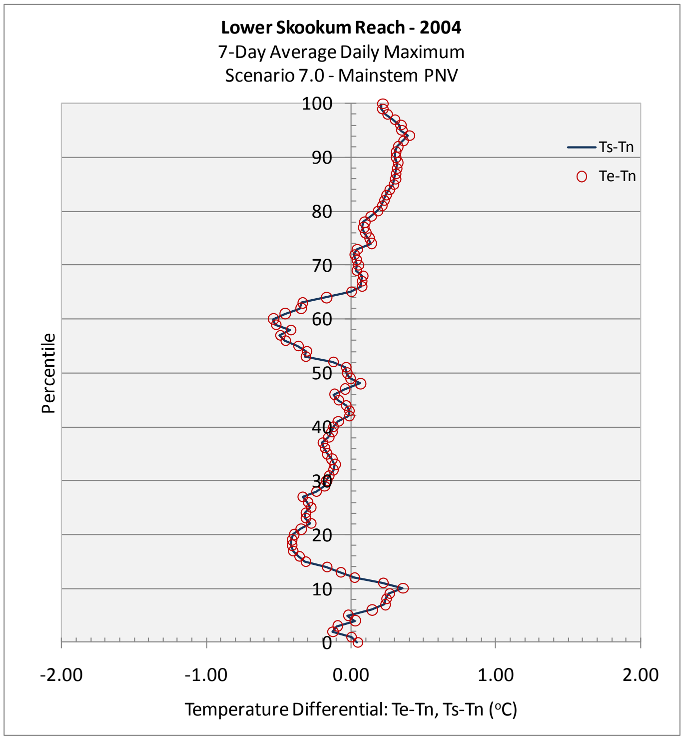


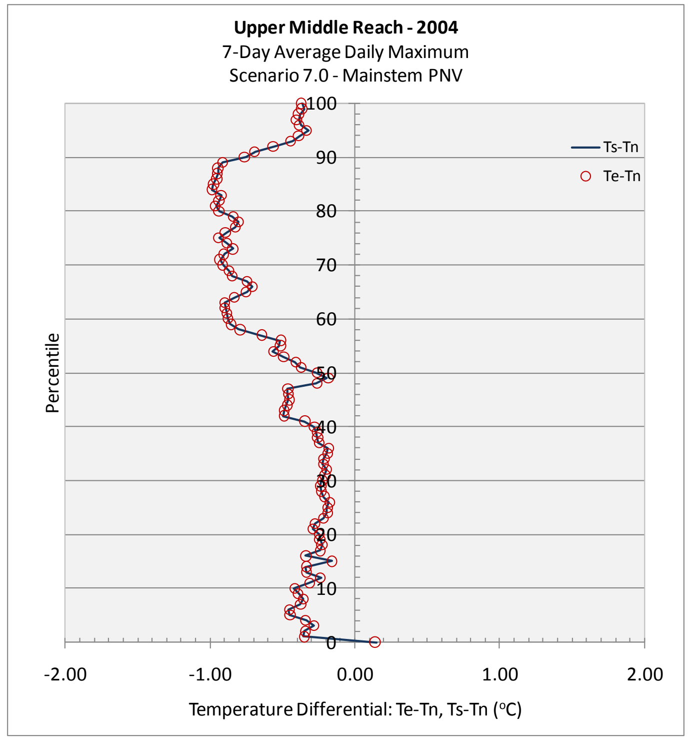
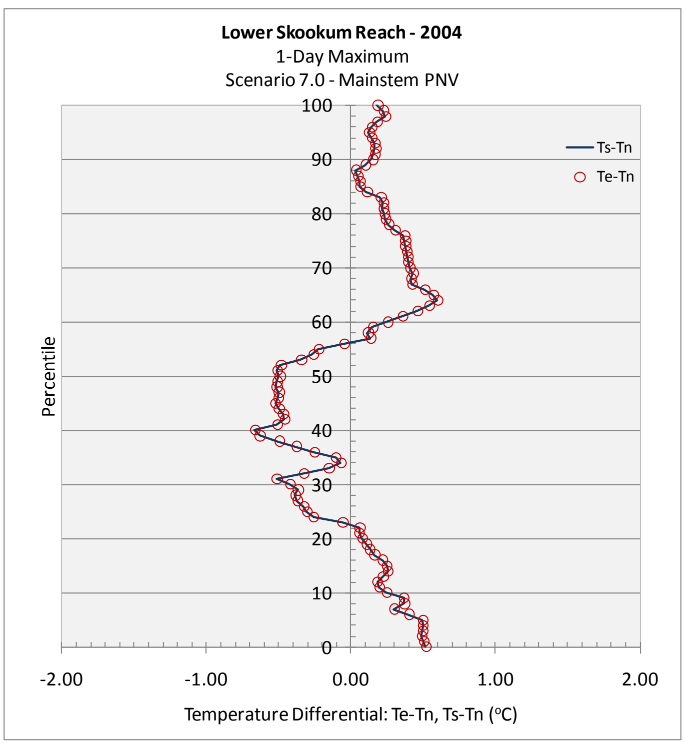


Figure D-40. Based on the 7-day average of the daily maximum temperatures, the comparison of existing (Te-Tn) and Scenario 7.0 (Ts-Tn) temperature profiles for the lower Skookum (segment 115) and upper Middle (segment 172) reaches, 2004.



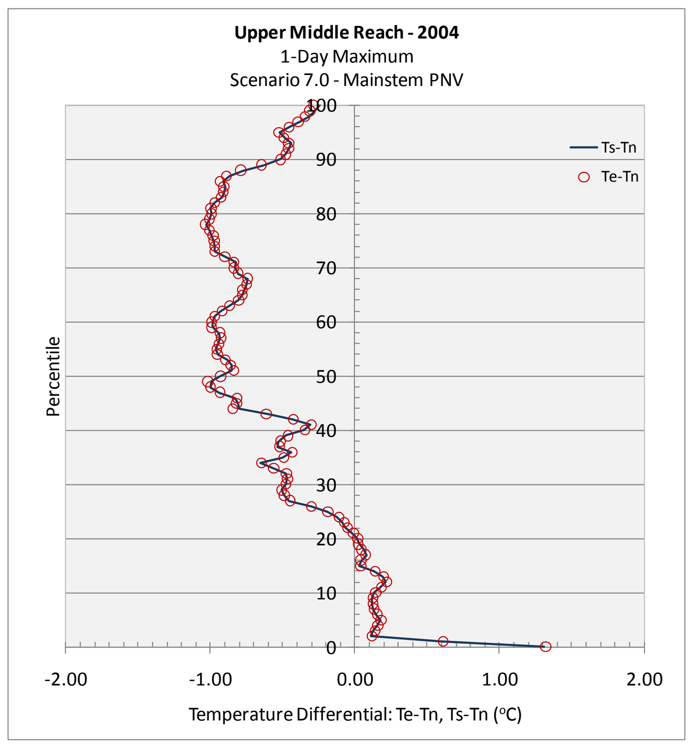


Figure D-41. Based on 1-day maximum temperatures, the comparison of existing (Te-Tn) and Scenario 7.0 (Ts-Tn) temperature profiles for the lower Skookum (segment 115) and upper Middle (segment 172) reaches, 2004

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Appendix E:
Temperature Monitoring and Modeling of the Pend Oreille River, Boundary Hydroelectric Project

Boundary Dam Hydroelectric Project
Water Quality Data Summary Report 2004-2006
Pend Oreille River – Boundary Reach

Taylor Associates, Inc.

May 2007

Prepared for
Seattle City Light

Web site link:
http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/Taylor2004-2006WQMonitoRptFinal0518071.pdf

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Temperature Modeling of the Pend Oreille River, Boundary Hydroelectric Project
CE-QUAL-W2 Model Calibration Report

Stephan A. Breithaupt
Tarang Khangaonkar

September 2007

Prepared for
Seattle City Light

Battelle – Pacific Northwest Division
Richland, Washington 99352

Website link:
http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/SCL-BoundaryRes-CalibRptFINALSept07.pdf

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Appendix F:
Attorney General Standards Memo

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Rob McKenna
ATTORNEY GENERAL OF WASHINGTON
Ecology Division
PO Box 40117 • Olympia, WA 98504-0117 • (360) 586-6770

MEMORANDUM

DATE: December 28, 2009

TO: Susan Braley, Unit Supervisor
Watershed Management Section

FROM: Ron Lavigne, Senior Counsel
Ecology Division

SUBJECT: **Pend Oreille Temp**

You previously requested a legal opinion regarding the use of the incremental warming provisions for temperature in Washington's water quality standards during development of a TMDL and specifically for the Pend Oreille TMDL. I responded to your previous request in a memorandum dated August 14, 2009. I understand that my August 14th memorandum has been interpreted by some as a legal opinion from me that the Pend Oreille River is not water quality impaired if the River is below 20° C even if temperature increases in the River exceed the temperature increases allowed by the equation in WAC 173-201A-602, fn.1, WRIA 62 (t=34/(T + 9)). My August 14th memorandum was not as clear as it should have been on this point, and this memorandum is intended to clarify and replace the August 14th memorandum.

Washington's water quality standards establish numeric temperature criteria that are not to be exceeded. WAC 172-201A-200(1)(c), Table 200(1)(c). The standards include a specific "shall not exceed" temperature criteria of 20°C for the Pend Oreille River. WAC 173-201A-602, fn. 1 for WRIA 62. Both the general temperature criteria and the Pend Oreille specific temperature criteria include provisions that limit the incremental warming of waterbodies from human actions. Since your question involves a temperature TMDL for the Pend Oreille River, I will focus on the Pend Oreille specific temperature criteria.

As discussed above, footnote 1 for WRIA 62 in Table 602 establishes a 1 day maximum temperature criteria of 20°C for the Pend Oreille River. The footnote also provides: "When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9)." The Pend Oreille River language in table 602 indicates that water quality can be impaired in two different ways. First, the River may exceed the 20° C 1 day maximum temperature criteria. If natural conditions exceed 20° C, Ecology cannot allow any temperature increase that raises the temperature in the River by more than 0.3°C. Second, the River is also water quality impaired if the River is below 20° C but temperature increases in the River at any time exceed t=34/(T + 9).

The water quality standards define "T" as "the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge." WAC 173-201A-200(1)(c)(ii)(A). This definition appears in the general temperature criteria rather than the Pend Oreille specific criteria. However, it is the only definition of "T" in the water quality standards and may therefore be applicable to both the general and Pend Oreille specific criteria. Since you are developing a TMDL that evaluates the impact of several point and nonpoint "discharges" the most logical point to evaluate "T" is at a point unaffected by the discharges within the scope of the TMDL (i.e. the most upstream discharge).

The language in Table 602, WRIA 62, footnote 1, prohibits temperature increases in the receiving water: "When natural conditions exceed a 1-DMax of 20.0°C, no temperature increase will be allowed which will raise the *receiving water* temperature by greater than 0.3°C; nor shall such temperature increases, at any time, exceed t=34/(T+9)." (Emphasis added). Consequently, "t" is the amount the temperature of the receiving water may be raised. In the context of a TMDL, the equation, t=34/(T+9), appears to apply to "temperature increases" from all sources being evaluated, rather than the temperature increase from a particular discharge. Consequently, "t" represents the cumulative allowable temperature increase in the Pend Oreille River from all point and nonpoint sources subject to the TMDL.

The WLAs and LAs Ecology establishes for the Pend Oreille River TMDL must be consistent with the restrictions in footnote 1 of Table 602. If natural conditions exceed 20°C Ecology must develop LAs and WLAs that insure the cumulative temperature increase does not raise the temperature in the River by more than 0.3°C. When the temperature of the River is below 20° C, the LAs and WLAs must also insure that cumulative temperature increases will not raise the temperature in the River by more than t=34/(T+9).

I hope this information is helpful. Please don't hesitate to call if you would like to discuss further.

RLL:ndj
cc:

LAVIGNE\TMDLS\PENDOREILLETEMPMEMO.DOC

Appendix G:
Response to Public Comments

Ecology received ten comment letters during the public comment period held from October 1 until November 30, 2010:

- Ponderay Newsprint Company
- Idaho Department of Environmental Quality
- Pend Oreille County Public Utility District
- US Environmental Protection Agency
- Colville National Forest
- City of Sandpoint
- Seattle City Light
- Pend Oreille Clean Water Alliance
- Kalispel Tribe
- US Army Corps of Engineers, Seattle District

In order for the public to review the responses more easily, Ecology grouped the comments into 11 categories, listed on the next page. Entire comment letters are available to review on Ecology's Pend Oreille TMDL web site: http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/index.html.

Contents

Water Quality Standards

1. Page 25, Temperature criteria bullet 2: A reference is made to the equation t=34/ (T+9) on page 7 and the definition of capital "T" in this relationship as the natural temperature condition. This interpretation contradicts the definition given in Appendix F were "T" is defined as the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge (a similar definition of "T" as representing the background temperature is also given in 2006 WAC 173-201A-200-1-c-ii-A as well as in previous versions of the Water Quality Standards). From this definition of "T" as background temperature or ambient water temperature in the vicinity of the discharge, it seems clear that is criterion should not be interpreted as an allowable change from 'natural water temperatures' and is application to thermal point sources to the river.

   Response: *You are correct that the memo from the Attorney General's Office in Appendix F defines "T" as the background temperature measured at a point unaffected by the discharge. The memo goes on further to state "Since you are developing a TMDL that evaluates the impact of several point and nonpoint "discharges" the most logical point to evaluate "T" is at a point unaffected by the discharges within the scope of the TMDL (i.e. the most upstream discharge)." In applying "T" to this TMDL, Ecology determined that because the Pend Oreille River is affected by discharges from dams in Washington and Idaho, the most appropriate representation of the unaffected river was to use the modeled natural condition data set. Using the modeled natural condition to define "T" also adds a margin of safety to the TMDL. We added language to clarify the definition of "T" at pages 7, 25, and 31 so that the reader understands how "T" was determined.*

2. The Special Temperature Condition for the Pend Oreille River likely does not adequately protect critical habitat for bull trout migration when the river is less than 20°C and greater than 10°C because it allows 1 to1.8°C increases from human causes above natural conditions for the entire river. The timing of the large allowable increase is during the late-summer critical period when bull trout would normally try to reenter the river for feeding and migration.

   Response: *The objective of TMDLs is to improve water quality so that the stream, river or lake will meet existing, EPA-approved water quality standards. The current designated use for the Pend Oreille River is salmonid spawning, rearing, and migration. A revision to the water quality standard rule (WAC 173-201A) would be needed to designate the Pend Oreille River for bull trout migration.*

   Ecology initiated a Triennial Review of the state water quality standards in November 2010. The Triennial Review process is required by federal law and provides a forum to discuss changes to or issues with the water quality standards and their implementation. The Kalispel Tribe formally commented as part of this review process on December 17, 2010, and we note that this is the appropriate forum to seek designated use changes affecting the Pend Oreille

River. For more information about the water quality standard Triennial Review process visit: http://www.ecy.wa.gov/programs/wq/swqs/triennial_review.html.

3. In the cover letter to the 2008 BiOp for EPA's approval of Washington's Water Quality Standards, USFWS stated the following:

   "*Based on the information provided in the BE, meetings, and written and verbal correspondence since the project started, the FWS has determined that approval and implementation of the 2006 Washington WQS will have adverse effects to bull trout and designated habitat for the bull trout in areas and/or situations where the standards do not provide adequate protection for essential habitat elements or the life history stage(s) that occur or may be present in the reach*".

   The USFWS appeared to have resolved a portion of the above issue with the Conservation Recommendation in the associated BiOp as follows:

   "*The WDOE did not revise the special temperature criteria for several rivers in eastern Washington, resulting in water bodies that were designated as "salmon spawning, rearing, and migration use" or "salmon rearing and migration" under the proposed action retaining temperature standards that are well above 17.5 °C. Based on the letter from WDOE to the EPA (dated January 28, 2008), the State has agreed to address the special temperature provisions in the TMDL process. The FWS recommends that, if model calculations indicate that the temperature criteria exceed the natural conditions, the standards be revised to ensure that aquatic life uses are protected.*"

   The Tribe's concern on this issue was clearly conveyed by Kalispel representatives to Ecology in meetings and written comments. Apparently those concerns have received little consideration. If temporal aspects for scenario comparison are not retained in analysis and implementation of the special temperature condition, then a new more protective criterion protecting thermal regime for bull trout restoration must be developed to replace the special condition in the Pend Oreille River per the USFWS/Ecology agreement.

   Response: *Ecology's letter of January 28, 2008 indicated that the state will use the TMDL process to model the natural thermal condition of the rivers with special temperature provisions. The intent of Ecology's letter was to ensure that if the TMDL found that the natural condition of the river was cooler than the special condition criteria, then the cooler natural condition would become the effective criteria target for the TMDL, and all point and non-point source allocations would be based on attaining these criteria. In fact, the TMDL for the Pend Oreille River found that the natural condition temperatures are warmer than the 20^{o}C special condition temperature criteria, and therefore based the WLA and LAs on this finding.*

4. Because there are errors and inconsistencies in the stream names and designated uses, all tributaries to the Pend Oreille River need to have reconfirmation of the appropriate use-based criteria for each stream and have the subsequent target shade requirements revised to meet

the designated Char use-based criteria. The criteria and revised tributary TMDL must be applied to the entire stream.

Response: *We are not aware of any errors and inconsistencies in the Pend Oreille watershed that would have negatively impacted the development of the Pend Oreille River temperature TMDL. Ecology is in the process of revising the water quality standards rule to fix minor typographical errors. For more information on the rule making visit* *http://www.ecy.wa.gov/programs/wq/swqs/RuleRev2011.html. See also Colville National Forest TMDL question # 3.*

5. The water quality standards (WQS) for the Pend Oreille River, as well as other surface waters in the State of Washington, are being reviewed by the Department of Ecology. The triennial review by Ecology will not be completed until 2011. Is it logical to complete a TMDL regulation for the Pend Oreille River before the results of the triennial review of the WQS for the Pend Oreille River has been completed?

   Response: *Ecology's long-standing policy with implementing water quality programs, such as TMDLs and NPDES permitting, is to not delay activities because a future rule-making may change criteria or standards affecting that activity. Putting activities on hold for this reason would needlessly delay pollution control required by federal law to bring a river, stream, or lake into compliance with water quality standards. Ecology describes how TMDL work will be considered when a rule-making is about to go into effect. For an example of how Ecology manages TMDLs in light of rule changes, see page 4 of the Implementation Plan developed for the 2006 water quality standards approval:* *http://www.ecy.wa.gov/pubs/0610072.pdf.*

   We also note that the Triennial Review process provides a forum to discuss changes to or issues with the water quality standards and their implementation. Ecology initiated a review process of the state water quality standards in November 2010. The Triennial Review is not a rule-making process, but may lead to developing guidance or future revisions to the standards. For more information about the water quality standard review process visit: *http://www.ecy.wa.gov/programs/wq/swqs/triennial_review.html.*

6. Statements made in the temperature TMDL report regarding the Pend Oreille River are misleading, if not erroneous. On page 7 of the draft report, statement is made that the Pend Oreille River has a special temperature criteria. This is based upon the table at WAC 173-201A-602. What the report does not state is that the designated use of the Pend Oreille River for aquatic life is "Spawning/Rearing." The Pend Oreille River is not designated for char spawning and rearing. As shown in table 600 in WAC 173-201A-600, Spawning/Rearing has a key identifying characteristic with trout spawning and emergence that only occurs outside of the summer season (September 16 -June 14). No reference is made to this characteristic. As noted in the report, the temperature increases (if real) of 0.3° C occur during the months of July and August, not during the key characteristic period of September 16 -June 14.

   Response: *You are correct that the Pend Oreille River is not designated for char spawning and rearing. The TMDL evaluated compliance with the temperature standard consistent* *with the Attorney General Office memo in Appendix F. This memo states that the TMDL must apply load allocations and wasteload allocations when the Pend Oreille River is below 20°C to ensure that the temperature in the river is not raised more than that allowed by $t = 34/(T+9)$. Therefore, the criteria that results from this equation applies year round for the Pend Oreille River. Ecology established a fall critical period until river temperatures cooled to 12°C to provide additional protection for potential bull trout migration. At 12°C all aquatic species in the river would assumed to be protected.*

7. Application of the "Part 2" formula: SCL respectfully disagrees with Ecology's application of the "Part 2" formula in the TMDL context. Rather, SCL agrees with the Attorney General's initial interpretation of the water quality standards (August 14,2009 memorandum from Ron Lavigne to Susan Braley re "Pend Oreille Temp"). Specifically, the only relevant criteria for assessing impairment / attainment in the TMDL context is 20.0°C or, if natural condition is above 20.0°C, natural condition + 0.3 degrees. The "Part 2" formula is only applicable in the NPDES permitting context, where a point source discharge can be compared to observed background conditions in real time. The formula is not applicable in the TMDL context where existing 'conditions are compared to modeled natural conditions.

   In addition to the Attorney General's August 2009 memorandum, this interpretation is supported by closely comparing the Pend Oreille River's special temperature criteria to the general water quality criteria that it replaces. Specifically, the off-peak formula in the Pend Oreille criteria directly correlates with the general criteria provisions at WAC 173-201A-200(c)(ii); those provisions contain a very similarly phrased formula that applies exclusively to "Incremental temperature increases resulting from individual point source activities." The general criteria provision goes on to define the method for measuring compliance with the formula, indicating that it is a real time measurement relative to background, not a modeling comparison between existing and theoretical natural conditions (the temperature increase is "...as measured at the edge of a mixing zone boundary (where T = the background temperature as measured at a point or points unaffected by the discharge and representative of the highest ambient water temperature in the vicinity of the discharge)). Accordingly, the Part 2 formula is not applicable in the TMDL context and all sections of the TMDL related to the formula should be removed from the final document

   Response: Ecology sought legal counsel for interpreting this part of the special condition in Table 602 for the Pend Oreille River so that the resulting TMDL would be legally defensible. Please see Appendix F, which provides the Attorney General memo that we followed. The memo from the Attorney General's Office in Appendix F defines "T" as the background temperature measured at a point unaffected by the discharge. The memo goes on further to state "Since you are developing a TMDL that evaluates the impact of several point and nonpoint 'discharges' the most logical point to evaluate 'T' is at a point unaffected by the discharges within the scope of the TMDL (i.e. the most upstream discharge)." In applying "T" to this TMDL, Ecology determined that because the Pend Oreille River is affected by discharges from dams in Washington and Idaho, the most appropriate representation of the unaffected river was to use the modeled natural condition data set. Using the modeled natural condition to define "T" also adds a margin of safety to the TMDL.

Modeling

1. Page 16, CE-QUAL-W2 temperature model: Need to explain the Idaho section of the model. The output of the Idaho CE-QUAL-W2 model is the input to the Box Canyon model and thus is a very important boundary condition.

   Response: *The Idaho model was discussed briefly on page 19 in the TMDL under Model Calibration. Ecology added information about the Idaho model on page 16 and 19 of the TMDL.*

2. Page 19, Model Calibration, First Paragraph: Was the updated version of the Idaho model used for boundary conditions or did Ecology use the original 2006/2007 PSU version of the Idaho model for the boundary conditions? The Seattle District recommends that the updated version of the Idaho CE-QUAL-W2 model for the existing and natural conditions should be used to represent boundary conditions for the Box Canyon Model.

   Response: *Ecology used Portland State University's 2006/2007 model for the Pend Oreille River in Idaho for the upstream boundary condition. Ecology did not use the U.S. Army Corps (Corps) model for this portion of the river because peer-reviewed results were not available at the time we performed the TMDL analysis. Ecology was made aware that draft results of the model were available in Sept. 2009, but the USGS peer review and report was not available until June 2010. Ecology did not receive copies of the peer review or model report. The PSU model continues to provide reasonable temperature predictions.*

3. There should be a discussion of the uncertainty in model estimates and prediction error relative to decisions regarding compliance using a 0.3 C delta temperature threshold.

   Response: *A discussion of model accuracy is included on page 19 of the TMDL. The results indicate that the models were well-calibrated and the quality of the model results are acceptable for use in the TMDL. Since the water quality criterion is expressed as an allowable increase above the natural condition, the model is a necessary tool for estimating pollution levels that will achieve water quality standards. Ecology believes the model is adequate to establish allocations, and while we recognize the uncertainty in model predictions, we also believe the modeling results provide the best available information for developing the TMDL.*

   The prediction error of the model is important to evaluate and minimize to the extent feasible, but it is not directly relevant to the use of the model to evaluate the 0.3^{o}C temperature threshold. This is because the 0.3^{o}C effect is evaluated using the difference between two nearly identical model simulations, isolating the effect of a subset of model inputs (e.g., river geometry changes due to dams) on temperature. The error in that estimate is not the same as the difference between measured and simulated temperatures for the model as a whole.

In addition, uncertainty in a TMDL is accounted for in the margin of safety as specified in the Clean Water Act. The Clean Water Act mandates that a TMDL err on the side of protecting the water quality standards through the margin of safety.

4. Pg xi, paragraph 2, Overview of Results: Where are these predicted natural water temperatures from the models used in this document? It would be helpful if there was a reference to how the model justifies these predicted water temperatures.

   Response*: The TMDL analysis compared modeled existing temperatures to modeled natural condition temperatures, which is described in the TMDL Analysis section of the report. To estimate natural conditions with the CE-QUAL-W2 model, categories of human impacts were identified that were most likely to have altered temperature regimes and then removed from the model. Natural conditions for these impacts were determined as follows:*

   - *Upstream boundary conditions were based on the results from the natural conditions modeling scenario for the next upstream model. For example, the natural condition output from the Idaho model was used as boundary conditions for the Box Canyon model.*
   - *Tributary temperatures were modeled with rTemp using Potential Natural Vegetation.*
   - *Point source discharges were removed.*
   - *Mainstem riparian shade was set to Potential Natural Vegetation.*
   - *Downstream impoundments (i.e. the dams) were removed.*

   Separate modeling scenarios were developed for each of these impacts set to natural levels, and then a "natural conditions" scenario was developed with all impacts set to natural levels.

   Due to the complexity of the changes and a lack of information regarding pre-development conditions, some other human-related changes were not evaluated under the natural condition scenario. For example, changes in mainstem channel geometry or changes in climate were not analyzed. Also, the natural hydrologic and geomorphologic conditions of the tributaries were not estimated.

5. Page 98: Sentence: "The model will need to be rerun to determine compliance because natural conditions, which the allocations are based on…" What are the parameters the model uses to determine the natural condition of the river?

   Response: *See response to question 4 in this section.*

6. Page 19, Model Calibration: The important calibration estimate would be for the period when there is the most potential for critical conditions affecting the most sensitive species. The model calibration should focus on late summer conditions and be most accurate when excess heat load contributes to potential thermal barriers which limit use of the river that is normally available to bull trout, given seasonal and diurnal cooling. Calibrating the model for the entire season and not the most critical condition does not assure that the modeling method contributes to a margin of safety.

Response: *The reason why the model is calibrated to provide the best fit between predicted and measured temperatures for the entire study period, and not just a particular time segment, is because the Pend Oreille River temperature criteria applies throughout the year. For this reason, model calibration must reflect this perspective. Also, any seasonal uncertainty in model calibration is minimized by the process of comparing the difference of two model scenarios.*

7. How is uncertainty in the model predictions considered in the analysis and subsequently in determination of impairment for the Box Canyon Project? The draft TMDL (p. 19) states that the model calibration uncertainty (RMSE) was 0.41 0c. The determination of impairment is based upon the difference between predicted existing temperatures and predicted natural condition temperatures, in which case, statistically the errors in each of these two quantities should be added in quadrature, resulting in an overall error of 0.58°C. There is no discussion of modeling error, what it implies, or how it was considered in the TMDL. At the very least, charts and graphs should include appropriate error bars, and the text should include an explanation of how model uncertainty is considered. We request that a paragraph be added to discuss the implications of the error in the model, especially since the overall error (0.58°C) is very close to the value of the exceedance for the Box Canyon Reservoir.

   Response: *See response to question 3 in this section. Model error can be positive or negative, so using the example provided, the error would be +/- .4°C. Therefore, in subtracting one model scenario for another, it's most likely that the error is less than .4°C (assuming bias in both results subtract from each other). There is still a small possibility that the error could equal the "added in quadrature" value cited. However, that error is equally likely to under-predict the true level of impairment (i.e. show less impairment than actually exists) as to over-predict an impairment (show more impairment than actually exists). To address this, TMDLs require a margin of safety (MOS) to ensure we do not under-predict the impairment. If impairment possibly is overpredicted, then that can be included as part of the MOS for protecting the water quality standards.*

TMDL Analysis

1. The Seattle District agrees with the use of the cumulative frequency method to assess temperature differences between model scenarios. This methodology is beneficial for summarizing the thermal response of two river systems with small differences in travel time and provides a more meaningful statistical summary of water temperatures.

   Response: *Comment noted.*

2. Page 26, Daily maximum temperatures, First Paragraph: Please state the method used to determine the daily maximum temperature. Did Ecology use the maximum temperature in any single cell in a reach, the maximum surface cell temperature or the maximum volume weighted temperature?

   Response: *The model used by the TMDL averages temperature within each cell. One cell extends from stream bank to stream bank, downstream for about one hundred meters (or one segment), and one meter deep. So, each one-hundred meter long river segment has many 1 meter deep cells stacked on top of each other equal to the depth of the river. The river segments were then grouped into reaches (see Table 5 in the TMDL).*

   Ecology determined which cell had the highest, or maximum temperature, within each segment for every day during the summer and fall critical periods. So, for each day, every reach contains the same number of maximum temperatures as there are segments. Ecology did not use a volume or flow-weighted average temperature.

3. Page 42, Heating patterns and temperature shifts, General: The explanation of thermal patterns needs to consider the use of a grid cell based definition for daily maximum temperature where the reach specific maximum temperature will be based on the simulation of surface heating over a calendar day.

   Response: *The maximum temperatures used in the TMDL analysis considered all segments, for each day of the analysis period, for all the scenarios modeled.*

4. The emphasis on instantaneous surface temperatures to define daily maximum temperature in this investigation maybe mischaracterizing the prominent thermal patterns in the Pend Oreille River.

   Response: *The standard for the Pend Oreille River is a daily maximum, so the TMDL analysis focused on daily maximum temperatures. Since the river is well-mixed, warmest temperatures typically occur within the top one meter, but not always. Conducting the TMDL analysis using one-meter-deep cells at the surface is consistent with Ecology's general approach to developing TMDLs. Because modeling for TMDLs must consider critical conditions, assumptions made for modeling are not necessarily the same as those used for monitoring.*

5. The Draft TMDL masks water quality criteria (WQ) violations by erroneously assuming that the thermal load from Idaho is equivalent to natural conditions. As explained in the attached November 26th Keta Waters Report, median river temperatures downstream of the Albeni Falls Project are often higher than natural in the late summer. For instance, from August 22 – 30, 2004, the difference between natural and impounded daily median temperatures was up to 2.3°C warmer with an average of 0.9°C warmer. A similar trend continues for much of September 2004. Comparison of maximum temperatures also shows that they are often higher than natural conditions in late summer (Keta Waters, 2010(b)). By characterizing these late-summer increases in temperature as natural conditions, the Draft TMDL allows additional degradation of the resource.

   Response: *The TMDL does not assume the thermal load from Idaho is equivalent to natural conditions. Our analysis shows existing temperatures flowing across the Idaho-Washington state line are cooler now than they were before Albeni Falls Dam was constructed. Therefore, the Pend Oreille River at the state line meets the temperature water quality standard, and the goal of the TMDL is to maintain that compliance into the future.*

   The Nov. 26th Keta Waters Report appears to have analyzed the difference between the U.S. Army Corps of Engineers (Corps) model and the Portland State University (PSU) model for the Pend Oreille River in Idaho. The report states the Corps' model shows an average difference of 0.9°C and a maximum difference of 2.3°C between natural and existing conditions. The report fails to state where the maximum temperature difference occurred; was it in the Albeni Falls Dam forebay or at another location? The report also did not mention the PSU model's average and maximum difference between existing conditions and natural conditions. However, the report did show there is only a 0.19°C difference between the Corps and PSU models for average natural condition temperatures.

   Ecology used the PSU model to establish background conditions for the Box Canyon model. We did not use the Corps model because it was not available at the time we conducted our analysis. Ecology's analysis showed that the river complies with the temperature standard at the state line.

6. The Draft TMDL's use of Cumulative Frequency Analysis methodology further obscures water quality violations. The use of Cumulative Frequency Analysis (CFA) methodology has led to erroneous and misleading statements in the Draft TMDL and improper load allocations, now called target temperatures. CFA may be appropriate where observation of occurrences is independent of all others during the period in question and where the timing of occurrences is irrelevant when being used for comparison between sample sets. These assumptions are not appropriate when comparing a thermal regime with river modeling for changes in water temperatures which are temporally and spatially dependent and biologically important to migrating species.

   The Kalispel Tribe has consistently objected to the misuse of the CFA methodology, particularly as applied during the late summer when thermal barriers will likely delay the migration patterns of threatened bull trout.

Response: *TMDL development using water quality models requires decisions on how to process and interpret the output from the model. These decisions center on the issue of how to aggregate (combine) data over time and space. Data aggregation decisions are made on a case-by-case basis in TMDLs based on a variety of factors, including the pollutant of concern, language of applicable water quality criterion, type of water body, model output complexity, and margin of safety concerns.*

Ecology believes the modeling analysis done for the Pend Oreille TMDL is scientifically defensible and we do not agree with the assertion that the cumulative frequency distribution method hides late summer thermal impacts. In addition, EPA has approved the use of the cumulative frequency analysis in TMDLs for other impounded systems, such as the Willamette River temperature TMDL.

The cumulative frequency analysis approach was chosen to address the changed hydraulic condition of the Pend Oreille River now, with hydroelectric facilities in place, in relation to a natural condition or a hydraulic condition present prior to the hydroelectric facilities. Within the study area, the Pend Oreille River is affected by three hydroelectric facilities: Albeni Falls in Idaho, the Box Canyon and Boundary dams in Washington. Cumulatively, these facilities have altered the natural flow conditions by storing more water and, therefore, creating a greater channel volume (greater water width and depth,) which in turn has reduced the overall velocity or rate that water flows through the study area. Prior to hydroelectric power generation, particularly during the warmest summer months, when the greater water temperatures occur, the river flow was shallower and narrower. These hydraulic differences between the pre- and post-hydroelectric conditions affect the rate of travel (for more on hydraulic lag, see response to question 7 in this section).

The temperature criteria that applies to the Pend Oreille River is based on the comparison of the current temperature condition to the natural temperature condition. Given the hydraulic differences between the current and natural flow conditions, a direct time-based comparison, such as a day-to-day comparison of temperatures, was not deemed appropriate. This is because applying a time-based comparison at common locations results in comparing waters that have been exposed to different heating patterns. For this reason, Ecology chose the cumulative frequency approach for this analysis.

The cumulative frequency-type analysis also allows the effect of short-term events, such as weather fronts, to be minimized. Breithaupt et al. (2008) analyzed the temperature response in the Boundary reservoir and found that under natural conditions the response is less than one day, and under existing conditions (with the dam) the response is about four and a half (4.5) days. Also, by using a cumulative frequency analysis it is possible to determine how often temperatures occur within a specific amount of time.

One of the initial methods used to evaluate the Pend Oreille River temperature data was an examination of longitudinal patterns in heating and cooling. This was conducted for both the natural and existing datasets for the study area. Given the substantial volume of the river abrupt temperature discontinuities are few, occurring primarily upstream and downstream of the hydroelectric facilities. This diagnostic process is important in that it identifies any *unusual changes in temperature occurring within the study area. If an abrupt temperature change had been a reality for a particular model segment, then the size of the analysis reach would have been adjusted accordingly. For instance, in the TMDL assessment the dam forebay reaches were shorter (contained a smaller number of model segments for evaluation) than upstream reaches, because longer reaches would have included additional cooler temperatures and masked impairment.*

The TMDL's cumulative frequency distribution method examined temperature differences between the natural and existing conditions during defined periods based on the applicable State criteria, for instance, the period of the year when maximum temperatures exceed 20^{o}C. Ecology identified all the days when existing temperatures exceeded 20^{o}C for all of the modeling segments. Once that was completed, then a one-to-one match with the natural condition dataset was conducted to determine what the natural temperatures were on the days that the existing temperatures exceeded 20^{o}C. So through this process there is a day-to-day match. However, instead of analyzing the day-to-day differences, Ecology used a cumulative frequency distribution of each data set (natural and existing) for specific reaches (grouped model segments) and compared the temperatures percentile by percentile. The comparison entailed subtracting the existing temperatures from natural temperatures for each percentile. If the difference exceeded 0.3^{o}C, when natural temperatures were greater than 20^{o}C, then a violation of the temperature criteria was identified. (A similar method, though applying to a different critical period, was also applied for when maximum temperatures were less than 20^{o}C.)

In summary, Ecology believes the cumulative frequency method focuses the TMDL on persistent warming patterns related to the impoundments and not time lag effects.

7. The Draft TMDL purportedly uses CFA to correct for a small potential hydraulic lag (max 2-4 days), which hydropower project owners contend must be accounted for when evaluating temperature impacts on rivers. To evaluate the legitimacy of the claim that hydraulic lag justifies using CFA, the Kalispel Tribe asked Keta Waters to conduct a comparative analysis of CFA method for the Box Canyon reservoir using direct daily comparisons from Ecology's natural and existing model scenarios. That analysis shows that there is no hydraulic lag contributing to arbitrary WQ violations (Keta Waters, 2010(b)).

   Response: *Although general patterns in travel time changes (average velocity) between the natural and existing condition scenarios can be observed by comparing daily temperature (for instance, comparing the timing of seasonal temperature peaks at a particular river location), the results are approximate. The CE-QUAL W2 model, in addition to predicting temperature, also provides information on flow characteristics, including velocity. The results indicate that the change in travel times between the current and natural conditions, depending on the location and flow condition, can vary on the order of hours to days.*

   Battelle's Pacific Northwest National Laboratory calculated that the time of travel through the Boundary Dam reservoir is about a half day under natural conditions, whereas with the dam in place the travel time is approximately two and a half (2.5) days (Breithaupt et al., 2008). In addition, Boundary Dam is operated in a peaking mode (discharging high flows *during the day and near-zero at night), and Box Canyon is a run-of-the-river operation. The cumulative frequency distribution minimizes these differences and allows different hydrologic conditions to be compared.*

These travel time differences are why a direct time comparison of temperatures between the natural and existing conditions is not an appropriate method for this TMDL. Ignoring these travel time differences results in comparing the temperature conditions of waters that are subjected to different heating influences. In addition, because the criteria are based on the comparison of daily maximum temperatures, even travel time differences on the order of hours can be important.

8. Keta Waters' analysis also illustrates that CFA masks many WQ violations and reduces the apparent magnitude of river warming and detected violations throughout the Box Canyon Reservoir, including violations in Kalispel Tribal waters. These underestimations of magnitude and occurrences in WQ violations have resulted in a target temperature reduction in the TMDL that is 42% less stringent than what the actual target should be at the Box Canyon Forebay. And again, this underprotective reduction target does not account for Albeni Falls Dam impacts discussed previously.

   The scientific defensibility of Ecology's CFA methodology is also undercut by a simulation performed by Keta Waters in which a hypothetical discharge into an otherwise completely natural river resulted in a one-degree increase above natural conditions in the Skookum Reach on each day between August 1 and September 5, 2004. This one-degree theoretical increase, by definition in the state's special temperature criteria for the Pend Oreille River, must result in a WQ violation well above the 0.3°C allowable increase on 100 percent of the 35 days when the river was naturally over 20°C, and two more violations when the river was less than 20°C. However, when this theoretical data is inputted into the CFA methodology set forth in the TMDL, the output would indicate that the test-case pollution would only cause a one percent chance of a temperature violation and that the "full temperature profile differential" is equal to 0.022°C (Keta Waters, 2010 (b)). It is therefore clear that the CFA method is unacceptable when defining thermal pollution reduction targets in a TMDL designed to provide resource recovery needs for threatened migratory fish.

   Response: *It is important when discussing the identification and frequency of violations that the analysis approach used to derive them is acknowledged. As discussed in responses to questions 6 and 7 in this section, the method of comparing natural and existing temperatures, at a set location on the river, using the same time-frame (i.e. day-to-day), is not an appropriate approach due to differences in travel time, which in turn affect heating influences. Nevertheless, the cumulative frequency analysis approach applied in the TMDL analysis and the day-to-day comparison approach both identified the exceedance of temperature criteria at the Box Canyon forebay location as well as the upstream boundary of the Kalispel Tribe Reservation. So, it is not correct to suggest that the cumulative frequency method "masks" criteria exceedances.*

   Ecology disagrees that the cumulative frequency distribution method applied in the TMDL fails on scientific grounds. The methods used by Keta Water's to critique the cumulative *frequency approach were confusing and highly biased. The analysis methods outlined in an August 10, 2010 memo from Keta Waters to Ken Merrill of the Kalispel Tribe indicated that a synthetic series of existing temperature conditions were developed by adding 1^{o}C to the natural temperatures for model segment 115 after August 1, 2004 (page 7). On the following page, the memo indicates that the natural temperatures at segment 115 are the same as the existing temperatures prior to August 1, 2004 and are 1^{o}C cooler beginning August 1st.*

Despite this confusion, it is believed that the analysis took the form of setting the natural and existing daily maximum temperatures at equivalent levels by location (segment) and date for the Skookum reach. (The Skookum reach is comprised of 29 segments.) Then the natural condition temperatures at segment 115 were decreased by 1^{o}C following (or on) August 1st. This decrease in temperature was used to indicate a situation of criteria exceedance. Once these data changes were made, a similar analysis method as used in the TMDL was applied with the finding that in only one instance was the temperature criteria exceeded.

These methods used to critique the cumulative frequency distribution method were biased. For instance, 98% of 1784 daily maximum temperatures represented by the natural data set for the Skookum Reach were assumed to be equal to the existing dataset. Assuming that the distributions are equivalent for 98% of the data undermines the intent of the cumulative frequency distribution method, which is based on examining distribution differences. In addition, the assumption that the natural and existing temperature conditions are the same by date and location has no factual basis to the temperature conditions observed in the Pend Oreille River. Despite these selective data alterations, a criteria exceedance was still determined which indicates the underlying strength of the cumulative frequency method applied in this TMDL analysis, rather than exposing a weakness.

9. By using a data analysis method that ignores temporal impacts and compares occurrences of a given temperature regardless of timing in natural and impounded scenarios, the Draft TMDL introduces a misleading bias into the analysis that systematically ignores ecological impacts caused by changes in timing of cooling and potential negative impacts on migratory fish populations. Ignoring the temporal changes in thermal impacts is as misleading as it would be to compare temperatures regardless of where they occurred spatially in the river.

   Response: *Regarding the reason why the cumulative frequency distribution method was used to evaluate water temperatures in the Pend Oreille River, please refer to the response to questions 6 through 8 in this section.*

   Ecology disagrees that the CFA method ignores changes in water temperatures that are temporally and spatially dependent and biologically important to migrating species, particularly bull trout. A specific time frame of concern is late summer, when thermal barriers will likely delay the migration patterns of threatened bull trout.

   Regarding temporal aggregation, bull trout migrate in late summer and fall, and the TMDL recognizes changes in timing by establishing a summer and fall critical period, which were analyzed separately. The summer critical period is during July and August, while the fall critical period is September through October. These critical periods align with the *temperature standard for the Pend Oreille River, and the temperature standard protects designated uses of the river.*

Regarding spatial aggregation, the vertical variation is entirely captured (no aggregation) and the horizontal segmentation is a reasonable balance between the goal of maintaining simplicity in the TMDL allocations and the need to account for variation in river characteristics.

The allocations will also work in concert to address ecological impacts. For example, increases in canopy cover and tree height were determined for riparian vegetation on both sides of the Pend Oreille River. These allocations for additional mainstem shade were predicted to only slightly decrease overall river temperatures, but they were also established to protect cold water inputs into the river, lower temperatures near the shoreline, and provide fish habitat, thereby providing a migration corridor for bull trout. Combining the allocations for mainstem shade, tributary shade, NPDES permittees, and the dam forebays is projected to improve habitat requirements for bull trout migration.

10. Using an analysis method that hides these late summer thermal impacts caused by river impoundments is inconsistent with the goals of protecting critical habitat for threatened species under ESA and protecting designated beneficial uses under the CWA.

    Response: *See responses to questions 6 through 9 in this section.*

11. Page xi, third paragraph: A flawed analytical analysis ignoring temporal aspect and the heat load present in the river is the only thing that allows such a misleading statement saying the river is cooler. A direct daily analysis does not allow the same conclusion.

    Response: *See responses to questions 6 through 8 in this section.*

12. Page xi, fourth paragraph: The temperature criteria exceedances are significantly underestimated and violations are missed completely due to use of CFA method. Averaging of CFA derived underestimations of violations of a daily maximum metric is inappropriate and misleading.

    Response: *See responses to questions 6 through 8 in this section. Ecology calculated the full temperature profile differential using an average for informational purposes only. To set the TMDL allocations, Ecology used the maximum temperature difference between the natural and existing condition.*

13. Page xii, Table ES 2: The determination of compliance with WQ criteria is biased by inappropriate CFA methodology that misses and underestimates violations between scenarios, including violations at, and above, the boundaries with tribal waters.

    Response: *See responses to questions 6 through 8 in this section.*

14. Page 26-40, Methods: The CFA method creates a bias in the data analysis which results in allowances for excess degradation of resources that do not support designated beneficial uses, including those in Kalispel tribal waters. The direct daily comparison method of analysis in the Pend Oreille does not create arbitrary conclusions about criteria violations because a worst-case hydraulic lag time is around 4 days at Boundary Dam.

    Response: *See responses to questions 6 through 9 in this section.*

15. Page 41-69, Results: The CFA method has created an inaccurate representation of the human-caused thermal impacts by eliminating the important temporal factor. The analyses of existing violations and pollution effects are very much underestimated due to introduction of method bias which masks degradation caused by impoundments and prevents full opportunity for recovery of the resources.

    Response: *See responses to questions 6 through 9 in this section.*

16. Page 73, Table 11 - The values and conclusions presented are not accurate due to bias in CFA methodology, as described in previous comments.

    Response: *See responses to questions 6 through 8 in this section.*

17. There is no valid evaluation showing that the 2004/05 years were critical conditions for assessing the thermal regime, especially since the lowest flows of the study period, which occurred in September 2005, were not assessed.

    Response: *Refer to the "Analysis Period and its Characterization" section in the TMDL (pages 20-21) for a discussion of the flow and air temperature conditions characterizing the summer months of 2004 and 2005. (The annual peak water temperatures for the Pend Oreille River occur from mid-July to mid-August.) In summary, flow levels during the summer of 2004 were below average, with the daily average flows for June and July at the* 13^{th} *and* 29^{th} *percentiles based on the 55-year record. Flow levels for the same period in 2005 were observed at the* 29^{th} *percentile.*

    Air temperatures were warmer during the summer months in 2004 in comparison to 2005 with daily average temperatures exceeding the 90^{th} *percentile, based on observations from the 1996-2009 period, 24 days or 26 percent of the time. In comparison, the summer of 2005 was cooler, with only 3 days (3% of the days) exceeding the* 90^{th} *percentile based on the same record. Both the lower flow conditions and warm air temperatures (a surrogate for solar shortwave radiation levels) combined led to more elevated water temperatures in 2004 in comparison to 2005, and is the reason the TMDL allocations are based on 2004 conditions.*

18. Ecology's continued insistence on using a CFA method that masks the full temperature impacts and seasonal criteria violations further eviscerates any marginal protection offered to bull trout by the special temperature condition. This is especially important now since requirements for hydropower mitigation to restore the protective thermal regime for bull trout will rely on the accurate evaluation of temperature impacts in the TMDL.

    Response: *See responses to questions 6 through 9 in this section. Hydropower operators are required to complete all reasonable and feasible actions to meet the temperature criteria. Ecology does not consider these actions to be mitigation.*

19. Page 80, Margin of Safety: The use of CFA methodology, ignoring the heat coming from Idaho, and not accounting for point source contributions, does not provide an accurate initial assessment of existing impacts or provide for any margin of safety.

    Response: *Ecology disagrees with this assessment of the TMDL analysis. See responses to the questions 6 through 8 in this section, as well as response to question 9 under the Allocations section of this Response to Comments.*

    A margin of safety for the cumulative frequency distribution was provided by analyzing:

    - *The two critical periods separately.*
    - *Only those temperatures that exceeded the 20^{o}C criteria within each critical period.*
    - *River reaches independent of each other. The average reach size is 5.8 miles.*

    These factors result in a margin of safety because a specific and narrow dataset was analyzed with the cumulative frequency distribution, rather than including cooler temperatures that would have skewed the results toward compliance. In addition, as described on page 81 of the TMDL, Ecology provided a margin of safety by analyzing a hot weather/low flow year (2004), using conservative model assumptions and water quality standards interpretation, and establishing conservative allocations (potential natural vegetation, current operating conditions, etc.).

20. The report mis-characterizes the non-compliance: When the report is read in full detail, it is clear that the temperature non-compliance in the Box Canyon Reservoir occurs only from the period early-July through late-August (page 31, third paragraph). It only occurs in 17 miles of the 55 mile reservoir (the Skookum, Tiger and Box Forebay Reaches). It is also clear that not every day in this two month period experiences a noncompliance event, that non-compliance may be only for a few hours in duration on some days, and that the non-compliance is only at the surface of the river and does not extend down through the water column. We acknowledge that a non-compliance situation does occur at some times in some places. However, the report is very unclear about the extent of the non-compliance events, and, in fact, in places leads the reader to conclude that the non-compliance lasts all year (see Table 6 on p. 41 and Table 11 on p. 73 as examples). In reports by the press and on the radio after the draft TMDL was released, it was implied that non-compliance was year round by reporting the results shown in Tables 6 and 11, making the temperature exceedances seem much more serious and long lasting than they actually are. Table 6 and 11 say that non-

compliance is for the years 2004 and 2005. We request that these tables be altered or that an explanation be added under each table that says:

> *"Temperature non-compliance in the Box Canyon Reservoir indicated above has been determined to occur by use of a computer-based model, and occurs only from the period early-July through late-August. Non-compliance only occurs in* 17 *miles of the 55-mile reservoir (the Skookum, Tiger and Box Forebay Reaches). Not every day in this two-month period experiences a non-compliance event. Non-compliance may be only for a few hours in duration on some days, and non-compliance is only at the surface of the river and does not extend all the way down through the water column to the river bottom."*

Response: *The application of the temperature criteria is based on maximum temperatures, regardless of how long and where in the water column they occur. That is not to say this is not important information, particularly in properly interpreting the temperature data; it is just ancillary to the determination of whether a violation of the criteria occurs or not. The cumulative frequency distribution, which stakeholders asked Ecology to use, does not indicate the number of days when the criteria were exceeded. Ecology made statements throughout the TMDL describing the temperature violations and where they occur in the river. Ecology does not intend for our analysis to be completely described by one table in the TMD L; therefore, conclusions about the temperature violations should not be based upon two tables in the report. Ecology will be mindful in future press releases to clarify the extent of the temperature problem.*

21. Additionally, the District annual temperature monitoring at depth between Kelly Island in Newport and the Box Canyon Dam forebay shows minimum warming.

Response: *The definition of significant warming, in terms of the TMDL, is that the current daily maximum temperature condition in relation to what occurred naturally, when temperatures are greater than 20^{o}C, are not to exceed 0.3^{o}C. This is a relatively low threshold of temperature change. In addition, the application of the Pend Oreille River criteria is based on daily maximum temperatures. While the river is well mixed there is still some differentiation in the magnitude of daily maximum temperatures through the water column principally during the period when the greatest temperatures occur, mid-July to mid-August. This temperature differentiation is most noticeable in the forebay reaches. At these times and settings, greater daily maximum water temperatures occur within the upper water column as opposed to temperatures observed at the river bottom.*

Ecology is unaware of what is meant by "at depth," and in addition, sampling at a particular depth may not detect the maximum temperature in the water column. Also, the CE-QUAL-W2 model averages temperatures from across the river, one meter deep and for approximately 100 meters downstream. So, site-specific measurements would be expected to vary slightly.

22. The data report in Appendix C, on page C-135, third paragraph, says that the temperature monitoring measured profiles near shore and mid-channel, and that these measured temperatures were all very similar, "indicating again that the river is well-mixed." Yet the measured water temperatures downstream from Box Canyon Dam are clearly lower than those measured upstream. This indicates that there is a strong variation in temperature with depth just upstream of Box Canyon Dam, and this invalidates the "well-mixed" conclusion. This conclusion is borne out by the work done on model development and calibration by Portland State University in 2006, which indicates temperature stratification near-surface in the Box Canyon Reach in late July (refer to their Figures 122-125, and Figures 129-131). This discrepancy has to be addressed in the final report.

    Response: *The relatively small differences between surface and bottom daily maximum temperatures, tending to be less than 1^{o}C, may be the reason why the indicated study made the assessment that river temperatures through the water column were similar. Not even where the water column temperature variation is the greatest, in the forebay reaches, could the level of this variation be characterized as stratified.*

23. As otherwise discussed in these comments, some of the conclusions and results reported in the draft Temperature TMDL Report defy logic. At page 41 of the draft report, the statement is made that there is a "chronically elevated heating pattern" in the Tiger and Box Canyon Forebay reaches. However, there is no logical explanation for such conclusion. As noted in all of the other reaches, the maximum temperatures with the existing conditions are lower than those determined for the natural conditions. The river in the vicinity of Tiger and Box Canyon Forebay is significantly deeper with the existing conditions than the river would be under natural conditions. There is no logical reason to conclude that the maximum temperature would be greater with the existing condition than with the natural condition. Such conclusions are suspect and should be reviewed.

    Response: *Ecology is using a peer-reviewed model to provide the estimates for the TMDL, and we disagree that the results are suspect. The highest daily maximum temperatures of the year across the study area occur in the forebay reach of Box Canyon dam. The dam has altered the hydraulic characteristics of the river, leading to the increased heating. While this effect is most noticeable in the forebay reach, the upstream Tiger reach is also affected. With the dam's effect on river hydraulics removed (scenario 4), the heating patterns for Tiger and the Box Canyon forebay reaches conform to those of the upper reaches. Based on the TMDL's 2004 modeled temperatures analysis, applying to the period when daily maximum temperatures exceed 20^{o}C, the dam's removal resulted in an estimated decline in average daily maximum temperatures of 0.99^{o}C for the forebay reach and 0.52^{o}C for the Tiger reach. A similar magnitude in the decline in daily maximum temperatures was determined for 2005.*

24. Pages 41-43 and 54: In the discussion of results, the TMDL should acknowledge the potential upstream impacts of Seven Mile Dam. The Results sections for peak and off-peak temperatures (pp. 41-43 and 54, respectively) do not acknowledge the potential effects of Seven Mile Dam reservoir operations on the existing condition. As noted in SCL's September 26,2007 comment letter on the August 2007 Draft TMDL, these operations were not fully modeled in the tailrace reach. While specific exceedance levels in the tailrace may be moot due to the TMDL's application of load allocations to the forebays, SCL requests that the TMDL acknowledge the potential effect on the tailrace reach. SCL recommends that the following new sentence be added to both the peak and off-peak results sections:

> *"Seven Mile Dam creates a backwater effect that may contribute to thermal load at the Boundary tailrace but that has not been accounted for in the modeling."*

Response: *Ecology agrees with this statement for Part 1 of the criteria and included language in the TMDL on page 43. However, the analysis for Part 2 of the criteria indicates that because the reservoirs cool more slowly than under natural conditions, the reservoirs actually act as a source of warmer water to the tailraces in the fall. Therefore, during the fall critical period, the Boundary Forebay is more likely to contribute to temperature exceedences in the tailrace than Seven Mile Dam.*

Volume / Flow Weighted Average

1. The Seattle District Corps of Engineers recommends using daily maximum volume weighted temperatures at a model segment or reach for compliance determinations. Volume weighted temperatures represent the entire water column of the river and are more representative of the water quality in the river and of the dominant aquatic habitat compared to surface cells or single cells.

   Response: *TMDL development using water quality models requires decisions on how to process and interpret the output from the model. These decisions center on the issue of how to aggregate (combine) data over time and space. Data aggregation decisions are made on a case-by-case basis in TMDLs based on a variety of factors, including the pollutant of concern; language of applicable water quality criterion; type of water body; model output complexity; and margin of safety concerns.*

   Earlier in this document, Ecology responds to concerns about the CFA method used for aggregating information over time. This comment regards aggregation over space. Ecology decided not to aggregate the temperature in the vertical dimension. Alternatives such as volume-averaging and flow-averaging would have reduced the resolution of the TMDL in identifying vertical variations in temperature from the surface to the bottom of the water column.

   Washington's temperature standard for the Pend Oreille River is a one-day maximum temperature, rather than a daily average, requiring the TMDL analysis to use a maximum temperature. The temperature criterion is a threshold value that should not be applied as a waterbody average. Therefore, applying a volume-weighted average in the TMDL would be inappropriate.

   Conducting the TMDL analysis using one-meter-deep cells at the surface is consistent with Ecology's general approach to developing TMDLs. Because modeling for TMDLs must consider critical conditions, assumptions made for modeling are not necessarily the same as those used for monitoring. The water quality standards refer to dominant aquatic habitat for guidance on where to take temperature measurements and not how to determine compliance with the standard. For water quality monitoring, Ecology's Standard Operating Procedure for Manually Obtaining Surface Water Samples refers to the surface as the top fifteen centimeters or six inches. The top meter or three feet is not considered the surface.

   Ecology does not agree that the volume-weighted average would provide a more accurate and reliable representation of aquatic habitat. Moreover, the TMDL must include a margin of safety, and the approach taken provides a safety factor.

2. Use of volume weighted daily maximum temperatures would provide a more accurate and reliable representation of the dominant aquatic habitat compared to surface cells. The interpretation of multi-dimensional modeling results in determining compliance with water

quality standards are much more reliable when integrated over larger regions (many cells versus single cell) and time periods (daily average versus daily maximum). The volume of surface cells in CE-QUAL-W2 simulations of impounded and unimpounded river conditions can be significantly different contributing to thermal differences that may be numerically and not physically based.

Response: *See response to question 1 in this section. TMDLs determine compliance with water quality standards, which is a one-day maximum for the Pend Oreille River. The modeling is intended to determine natural and existing conditions for comparison purposes. For this TMDL, the natural condition of the un-impounded river cannot be reasonable compared to the hydrology of a reservoir. Averaging the entire column of the reservoir could not be reasonably compared to the natural condition of a shallower river. Using the upper layer of the water column allows for that comparison.*

Ecology believes the modeling and analysis for the TMDL is representative of the thermal impairments in the Pend Oreille River. The model used by the TMDL calculates average temperature within each cell that extends from stream bank to stream bank, downstream for about a hundred meters, and one meter deep. If the river is indeed well-mixed, then using the temperature at the top meter should not be that different from an average temperature from the water column, thereby not overestimating the amount of heating taking place. Using a vertical average or volume-weighted temperature may obscure the impacts of warmer surface waters. Washington's water quality standards discourage this approach.

3. Why were only maximum temperatures for each model segment (p. 26) considered in the analysis? Basing analyses on only maximum temperatures within each modeled segment effectively restricts the analysis to only the top 1-m of water in the reservoir. This approach does not accurately represent the heat load imparted to the water in the reservoir. A more realistic approach would be to average the temperatures throughout the water column, either a simple arithmetic average of the vertical temperature distribution or a weighted average based on the flow through each cell at each vertical location in the water column. If WDOE will not agree to this change in the analysis, we request that the report include a discussion of why averaging throughout the water column was not used and why this is the preferred analytic method.

   Response: *See response to questions 1 and 2 in this section. Ecology included a statement on page 26 of the TMDL explaining why a volume or flow-weighted average temperature is inappropriate to use in the analysis.*

4. There are inconsistent statements made in the draft temperature TMDL report for the Pend Oreille River. On page 3 of the draft report, it is noted that the subsurface portion of the Pend Oreille River can be cooler than that closer to the water surface where the daily maximum temperatures are typically found. This is essentially an admission that using daily maximum temperatures is inappropriate for the Pend Oreille River. Yet, on page 26 of the draft temperature TMDL report, the statement is made that "only the daily maximum temperatures... were used for further analysis." The draft report goes on to state, on p. 26, that "the sole use of daily maximum temperatures is consistent with the Pend Oreille River

temperature criterion specifically applicable to this TMDL study." Using daily maximum temperatures that occur at the surface does not represent the differences between existing conditions and the natural conditions where the water would be shallow without the Box Canyon Dam. Without Box Canyon Dam, the majority of locations would exhibit higher water temperatures -nearly all of the graphs comparing natural conditions with existing conditions illustrate the benefits of Box Canyon Dam for water temperature in the Pend Oreille River.

Response: *Ecology is unsure how the statements cited are inconsistent. See response to questions 1, 2, and 3 in this section.*

5. Use of maximum temperatures in the water column is not appropriate or representative of conditions in the river. As SCL and Ecology have discussed on numerous occasions, SCL believes that, for the Pend Oreille River TMDL, flow-weighted daily maximum temperature is the most appropriate metric for assessing compliance with water quality standards because it is most representative of conditions in the river. Rather than reargue the issue, SCL incorporates herein by reference its earlier comments on this issue as provided in our letters to Ecology and other addressees dated April 15, 2008, September 26, 2007 and May 24, 2007. In addition, the results of SCL's analysis using flow-weighted temperatures and indicating no exceedances of water quality standards in the Boundary forebay and no contribution of the Boundary project to exceedances, are contained in the technical memorandum regarding "Temperature Modeling and Alternative Operations Analyses for Boundary Hydroelectric Project -CWA 401 Certification Support," dated August 19, 2009 and in Exhibit E to the SCL's September 2009 License Application to the Federal Energy Regulatory Commission for the 'Boundary Project. SCL has previously provided both the Memorandum and Exhibit E to Ecology, and incorporates them herein by reference.

Response: *Comment noted. See responses to questions 1 through 3 in this section.*

Subsurface Withdrawal of Colder Water

1. Page xi, Overview of results, Second Paragraph: Albeni Falls forebay does not stratify and subsurface withdrawal is not the source of colder water. The cooling effect in Pend Oreille River temperatures is due to Albeni Falls maintaining a higher Lake Pend Oreille elevation during the summer which allows for the exchange of deeper cooler waters from Lake Pend Oreille into the Pend Oreille River for Existing Conditions. For Natural Conditions the lake elevation was lower and a sill at the outlet of the lake prevented the exchange of cooler deep water from the lake to the river resulting in warmer surface waters entering the Pend Oreille River under natural conditions.

   Response: *Ecology agrees that the river does not stratify. Thank you for the clarification on Pend Oreille Lake levels. We clarified that the dam allows cold water exchange on page xi and 42 of the TMDL.*

2. Page 78, Hydroelectric facilities, Second Paragraph: Are there field/model/calibration data that corroborate that the forebay of Box Canyon stratifies and has cooler subsurface water? Based on Box Canyon Model (PSU 2007) and Washington Ecology field data (Ecology 2004), the forebay at Box Canyon does not stratify and there is no source of deeper cooler water being withdrawn for power generation.

   Response: *The Pend Oreille River does not stratify, but there is a slight temperature difference from the top to the bottom of the water column in some reaches of the river, as shown by the temperature profile data in Appendix C of the TMDL. The TMDL identified that the temperature criteria is exceeded by less than 1^{o}C. So, when the dams withdraw water from deeper in the water column, the water is slightly cooler and does make a difference in downstream temperatures.*

3. Page 42, Heating patterns and temperature shifts, Fourth Paragraph: States *Similar to Albeni Falls, the Box Canyon facility withdraws water for power generation from a deeper and colder region of the water column in its forebay*. Disagree with statement. Albeni Falls forebay does not stratify with deeper cooler water being drawn for power generation. Also, based on Box Canyon Model (PSU 2007) and Washington Ecology field data (Ecology 2004), the forebay at Box Canyon does not stratify and there is no source of deeper cooler water being withdrawn for power generation.

   Response: *See response to questions 1 and 2 in this section*

4. Pg xi, paragraph 2, Overview of Results: Existing data collected during relicensing process for both Box Canyon and Boundary hydroelectric projects indicate that the reservoirs do not stratify except immediately upriver of each dam where the stratification is not significant. There is no data that we are aware of that indicates that the river cools down from Newport to Blueslide. A reference to the data that supports the above statement would be appropriate.

Response: *See response to question 2 in this section. The river does not cool between Newport and Blueslide, but the TMDL modeling indicates that with the exception of the Skookum reach, existing temperatures are cooler now than they were under natural conditions. The river is cooler now because slightly colder-than-natural water from Lake Pend Oreille buffers heat sources in this stretch of river, which is the intent of the statement in question. Ecology clarified the statement in the TMDL.*

5. Pg 42, paragraph 2, Heating Patterns and Temperature Shifts: There does not appear to be historic water temperature data for the portion of the Pend Oreille River between Albeni Falls Dam and Lake Pend Oreille for the above comments that the existing situation with the dam provides cooler water than without the dam. If so, this should be referenced.

   Response: *The CE-QUAL-W2 model generated temperature estimates for natural or pre-dam conditions upstream of Albeni Falls Dam. Ecology clarified the source of cooler water below Albeni Falls Dam in the TMDL.*

6. Based upon modeling data presented in the Idaho Pend Oreille River Model Scenario Simulations Technical Report, the high water temperatures coming out of Lake Pend Oreille are almost identical to water temperatures in the forebay of Albeni Falls Dam. The summer water temperatures, during the period of concern, range from about 22 to 25 Degrees C. with very little stratification. It is difficult to consider these cooler water temperatures passing below Albeni Falls.

   Response: *See response to questions 1 and 2 in this section.*

7. Pg 42, paragraph 4, Heating Patterns and Temperature Shifts: Previous information from the Application for New License: – Box Canyon Hydroelectric Project FERC No. 2042 indicates that "Data for maximum water temperatures and seasonal temperature regimes in the BCR are well documented in other reports (Pelletier and Coots 1990; Coots and Willms 1991; Skillingstad et al 1993; EPA 1993 miscellaneous District records). All studies showed the river to be homothermous throughout with no vertical or horizontal stratification." The discrepancy concerning stratification of the reservoir, between this draft TMDL and these documents, is confusing and should be addressed.

   Response: *The TMDL states that the Pend Oreille River is generally well-mixed and does not stratify. See response to question 2 in this section.*

8. Page xi, first paragraph: This statement using the word "subtle" and cooler is misleading. Reaches are not cooler than natural in late summer. The stored heat and reduced cooling present in the river causes much higher temperatures both on the average and maximum temperature in late summer which is evident when using appropriate analysis and accounting for upstream heat sources.

   Response: *TMDL analysis results show that depending upon the location in the river, natural conditions can be warmer than existing conditions, and existing conditions can be warmer than natural conditions. Figures 18 and 19 illustrate the relationship between the* *natural and existing temperatures from June through September in the forebay areas of Box Canyon and Boundary dams. See also responses to questions 6 through 8 in the TMDL Analysis section of this Response to Comments.*

9. Page xi, second paragraph: The river is not cooler for an extended period in late summer below Albeni Falls which is evident in an analysis that preserves temporal aspects of the thermal regime.

   Response: *Ecology's analysis shows that around 20^{o}C, existing temperatures are warmer than what is predicted to have naturally occurred, but the temperatures are within the temperature increase allowed by the standards. See responses to questions 6 through 8 in the TMDL Analysis section of this Response to Comments for a discussion on why Ecology used a cumulative frequency distribution analysis rather than a daily comparison of existing and natural conditions. Nevertheless, in a June 16, 2009 report from Keta Waters to the Kalispel Tribe, the river was reported to exceed the Washington State temperature standard only three (3) times at the state line in 2004 using a daily comparison of natural and existing temperatures. The average temperature exceedence recorded was 0.26^{o}C above the allowable 0.3^{o}C increase.*

10. How do you reconcile the result that implies that the highest temperatures in the Box Canyon forebay reach are on the order of 1°C higher than the highest temperatures in the Metaline reach immediately downstream? (compare Figures 15 and 16, pages 47 and 48, respectively). Where did the heat go? The apparent result is merely a remnant of the fact that only surface temperatures are considered in the analysis, and that temperatures at the surface in the Metaline reach result from mixing of the water after passing through Box Canyon Dam. There is no "cooling effect" due to Box Canyon dam, i.e., there is no negative heat load or loss of BTUs. Such illustrations in the TMDL resulting from consideration of only maximum temperatures can be misleading to the reader.

    Response: *As discussed previously, the criteria are based on daily maximum water temperatures that, during the summer period, occur in the upper water column. This is where the greatest daily maximum water temperatures are observed in the Box Canyon forebay reach. From the forebay, river water is withdrawn for power generation at a depth residing below where the daily maximum temperatures occur at the river surface. This flow is then discharged downstream, providing this cooling effect.*

11. Page xi. The paragraph describing the water source states:

    > *"At Newport, the most upstream reach in Washington and situated below Albeni Falls dam, river temperatures are cooler now than what is predicted to have occurred naturally. This is due to withdrawal of colder subsurface water within Albeni Falls forebay which is discharged downstream following power generation."*

    The statement is correct in that the temperature is cooler than the natural condition, but the explanation is incorrect. Albeni Falls dam is placed far down the outlet stream from Lake Pend Oreille. Unlike Box Canyon and Boundary dams, the Albeni Falls dam did not create the lake. Being far down the outlet stream, the water passing through the dam is not selectively drawn from colder subsurface water within the forebay. All the water moving down the outlet stream passes through the dam. The cooling effect comes from the fact that the dam maintains the level of the lake at a higher level than the natural level that occurred in the late summer when flows are reduced. Because the lake is at a higher level the surface waters of the lake drawn into the outlet stream include waters from 11 feet more of the water column of the lake than in the natural late summer condition. The dam has no ability to selectively draw cooler waters from behind it to discharge. PNC suggests the following change:

> *"At Newport, the most upstream reach in Washington and situated below Albeni Falls dam, river temperatures are cooler now than what is predicted to have occurred naturally. This is due to the dam maintaining the lake level in the mid and late summer higher than what the natural level would have been at times of low stream flow, such that the surface water drawn to the outlet of the lake comes from a greater depth range than under the natural condition." ~~withdrawal of colder subsurface water within Albeni Falls forebay which is discharged downstream following power generation~~."*

Response: *Thank you for the clarification. Ecology edited the TMDL as suggested.*

Skookum Heating

1. Page xii, Table ES-2: Why does the model show the Pend Oreille River to be in compliance upstream and downstream of the Skookum reach, but not in the Skookum reach? Please explain how this reach could be out of compliance when reaches upstream and downstream are in compliance.

   Response: *Page 61 and 62 of the TMDL explain that the heating in the Skookum reach is due to a submerged side channel, the Skookum Slough. The slough is an extensive backwater side channel occurring between river miles 74 and 76. A forward-looking infrared (FLIR) survey of the Pend Oreille River, conducted on August 16, 2001 by Watershed Science, LLC determined the temperature of the side channel at 27.3°C, about 3.4°C greater than the main river channel. In the TMDL analysis, one of the temperature modeling scenarios undertaken was one in which downstream hydroelectric facilities were removed in order to examine their effect on the existing temperature condition (scenario 4.0). The results of that scenario for the Box Canyon reaches were that with the removal of the Box Canyon facility and the dam's backwater effect removed, this side channel no longer functioned as a source or location for water heating. The reaches upstream and downstream of Skookum do not have any submerged side channels so they are cooler.*

2. Pg 41, Table 6: How can two reaches upstream and three reaches downstream be in compliance but the Skookum Reach be out of compliance. Could this be due to model uncertainty, error or calibration issues in the Skookum reach or possibly due to using surface cells?

   Response: *See response to question 1 in this section.*

3. Page 44, Figures 12, 13 and 14: An explanation of the change in the natural river temperatures seen over the Skookum Reach is needed. The existing river modeled temperatures are similar from Newport Reach through Kalispel Reach. However, the natural river modeled temperatures change which results in the Skookum Reach being out of compliance. The natural river temperatures are similar at Newport, Dalkena, and Kalispel Reaches but substantially cooler at Skookum Reach. Why does the natural river cool down through the Skookum Reach and then warm up through the Kalispel reach? Because the 4 mile long Skookum Reach represents the only location in the 40 miles between the Newport Reach and Tiger Reach where the temperature criteria is not met, a thorough analysis of the possible source(s) of non compliance is needed.

   Response: *See response to question 1 in this section.*

4. Page 62, Hydroelectric facilities, Third Paragraph: The explanation of backwater effect and side channel impacts on water temperatures in the Skookum Reach does not seem plausible for a laterally averaged 2-D model such as CE-QUAL-W2. Recommend WDOE more fully

analyze and explain the physical source for the odd occurrence of cooler/warmer waters in the Skookum Reach.

Response: *The Quality Assurance Project Plan (QAPP) includes a review of a TIR survey conducted by Watershed Science, LLC (http://www.ecy.wa.gov/pubs/0403109.pdf). The following statement from the TIR review supports the language in the TMDL*

> *"The side-channel complex on the right bank of the Pend Oreille between river miles 74.5-76 is a big heat sink. The side channel complex is near the Skookum Community Center* (see *Figure A-3). In big rivers, side-channels could help provide refugia for* fish *migrating along the river corridor but most side channels in the Pend Oreille show extremely warm temperatures in the TIR images."*

The Skookum reach begins at river mile 76.8 and ends at river mile 72.4, so the slough encompasses at least one and a half miles of the four mile reach. This is a large enough distance to increase maximum temperatures by 0.21^{o}C (the temperature above criteria) throughout the reach.

5. What is causing the modeled increased temperatures in the Skookum and Tiger reaches in the existing condition compared to natural conditions in the Box Canyon modeling scenario? Table 6 (p. 41), and Figures 13 and 15 (pp. 45 and 47, respectively) indicate existing temperatures can be increased by as much as 0.5°C and 0.8°C at the Skookum and Tiger reaches, respectively. These do not appear to be merely progressive temperature increases as one moves downstream, but are marked jumps in temperature compared to those reaches upstream or downstream. Examination of the model input parameters could lend insight as to the cause of these increases, which may in turn lead to suggestions for mitigation of these increases. However, we are concerned that part or all of these temperature jumps could be due to an artifact of the modeling, possibly due to specific placement locations of temperature monitoring sensors in these locations. We note that both the Tiger and Skookum reaches have a large slough associated with them that could skew temperature measurements depending on where the temperature sensors were placed. These jumps should be discussed and analyzed in the report body to provide a valid explanation of these predictions.

   Response: *See responses to 1 and 4 in this section. Ecology did review the model for errors. Model reports for the river (PSU 2006, PSU 2007, Breithaupt & Khangaonkar, 2007) discuss model development and calibration. The placement of temperature probes should not greatly influence the model output because the model averages the temperature across the river for approximately 100 meters downstream and one meter deep.*

6. For example, on page 42, third paragraph, the report states that by the time you reach Tiger and Box Forebay reaches, "the average velocity has been slowed sufficiently to lead to the increased heating." We request that the velocity analysis WDOE did to support this statement be added here in the report. What is the average velocity during the non-compliance time period today and pre-project? How did you conclude that the difference in velocity was "slowed sufficiently" to cause the heating? Doesn't the river slow more and more as you get closer to the dam? Therefore, you would expect the temperatures to increase slowly, in each

reach, as you move downstream. But this is not what the model predicts. Why did temperatures increase in the Skookum Reach and then apparently cool off in the next three reaches downstream? This is inconsistent with the "slowed sufficiently" concept. These modeling inconsistencies have to be addressed in the report.

Response: *As mentioned in the report, it is believed that the increased warming determined for the Skookum Reach is due to the inundation of an extensive backwater side channel occurring between river miles 74 and 76. A forward-looking infrared (FLIR) survey of the Pend Oreille River conducted on August 16, 2001 by Watershed Science, LLC determined the temperature of the side channel at 27.3^{o}C, about 3.4^{o}C greater than the main river channel. In the TMDL analysis, one of the temperature-modeling scenarios undertaken was one in which downstream hydroelectric facilities were removed in order to examine their effect on the existing temperature condition (scenario 4.0). The results of that scenario for the Box Canyon reaches were that with the removal of the Box Canyon facility, and the dam's backwater effect removed, this side channel no longer functioned as a source or location for water heating.*

7. Skookum Reach appears to be anomalous. In many different places throughout the TMDL report the Skookum Reach appears anomalous. Somehow in the modeling it is presented as having a very substantial heat increase in a short distance compared to the upstream Dalkena Reach, and then loses that substantial increase by the time it reaches the next downstream Kalispel Reach. The upstream and downstream reaches both show that the existing conditions are cooler than the natural, yet in Skookum Reach it shows that the natural conditions are cooler than the existing. PNC believes that this oddity does not make sense. An explanation for how this could be true would help. If it results from some error either in programming or in data, then the problem should be corrected and new figures and tables prepared. If no explanation is possible, then there should be an admission that it doesn't make sense, that Skookum Reach probably really does meet the temperature criteria, and that the glitch does not seem to affect the rest of the downstream presentations.

   Response: *See responses to questions 1 and 4 through 6 in this section.*

Kalispel Tribal Waters

1. Page 28, Peak temperature analysis methods-Kalispel tribal criteria, First Paragraph: Why was a different methodology of summarizing the cumulative frequency of water temperatures used for the Kalispel Tribe river reach? Why not use the entire Kalispel Reach, which encompasses all tribal lands, instead of a single upstream segment of the Skookum Reach and a single downstream segment of the Middle Reach?

   Response: *A different methodology for determining compliance in the Kalispel river reach was required because the Kalispel Tribe's water quality criteria are different than Washington State's. Because different temperature criteria apply to the reach, Ecology had to analyze the river differently. Ecology is required to meet the Tribe's criteria at the reservation boundary, which is why we only analyzed the segments bordering the Reservation. The TMDL does not apply to Kalispel Tribal waters, which is why we did not evaluate the entire river reach.*

2. Page 30, Data filtered, First Paragraph: Why use only data from segments 115 and 172 for the cumulative frequency analysis? Segments 115 and 172 bookend the Kalispel Reach, so why not use the Kalispel Reach instead of changing the methodology. The reason for the change in methodology needs to be explained in the document.

   Response: *See response to question 1 in this section. Ecology clarified the reason for the different methodology on page 28 in the TMDL.*

3. Page 51, Kalispel tribal criteria: Explain the large difference in the natural river temperature between segment 115 and 172. The existing river shows little change in temperature between segments 115 and 172 while the natural river warms up between segments 115 and 172.

   Response: *Because the natural and existing modeling scenarios represent hydraulic conditions prior to and following hydroelectric power generation on the Pend Oreille River, water temperature response to meteorological factors will reflect those changes. For instance, now with the hydroelectric facilities in place, during the mid-July to mid-August period, when the warmest water temperatures occur, the river is deeper due to greater storage. As a consequence, river water temperatures now are buffered from large temperature changes in response to changing meteorological conditions, particularly in comparison to those representing the natural condition. The natural condition water depths during the critical period were shallower and, therefore, both gained and lost heat at a faster rate, being more sensitive to changing meteorological conditions.*

4. The Draft TMDL does not explicitly state how Ecology's proposed load capacity, WLAs, and LAs will meet Kalispel water quality standards at the jurisdictional boundary.

   Response: *The purpose of the implementation strategy in the TMDL is to give a general overview of the types of activities that will be performed to meet water quality standards. Specific actions to achieve compliance with Tribal criteria will be included in the implementation plan. After EPA approves the TMDL, Ecology will work with the Tribe and other stakeholders to identify specific actions that explain who will do what activities, where in the watershed, and when.*

5. The Draft TMDL must ensure that target temperatures for the jurisdictional boundary are based on Kalispel water quality criteria and paired analysis rather than state criteria and CFA methodology. Any NPDES permits issued under the auspices of the TMDL must be developed in accordance with such target temperatures. At a minimum, the permits should prevent the degradation from getting worse by each discharger and require periodic engineering evaluations looking for opportunities to reduce heat loads.

   Response: *Ecology used the cumulative frequency distribution analysis at the Kalispel Tribe Reservation boundary so that the results are consistent along the entire river by applying the same analysis methodology to all the various temperature criteria for the river. Ecology's rationale for using the cumulative frequency distribution analysis, instead of the day-to-day analysis, is discussed in the TMDL Analysis section of this Response to Comments. See also response to question 13 in the General section of this Response to Comments.*

6. Kalispel analyses show that there are violations of Kalispel water quality standards at and just upstream of tribal waters in both 2004 and 2005. Ecology's current CFA analysis results in erroneous conclusions about compliance with both tribal and state temperature criteria.

   Response: *Ecology's analysis found that the Kalispel Tribe's criteria were exceeded at the upstream reservation boundary, but there are slight differences (0.24^{o}C) with Keta Waters' analysis in the maximum temperature impairment. Table 3 of the Aug. 10, 2010 memo from Keta Waters to the Kalispel Tribe indicates that there were 22 days that water temperatures did not meet criteria at the upstream Reservation boundary. The average violation was 0.26^{o}C and the maximum temperature was 0.54^{o}C above the allowable temperature increase. However, Keta Waters based their analysis on volume-weighted average temperatures, and it is unclear which Kalispel Tribal criterion produced the violations in the table (daily max of 20.5^{o}C, or 7-day average daily maximum of 18^{o}C).*

   Ecology did not use volume-weighted averages for several reasons discussed in the Volume / Flow Weighted Average section of this Response to Comments. In addition, Ecology found there is about 0.2^{o}C difference in the maximum impairment, depending upon which Kalispel Tribal criterion was used (see Table 7 in the TMDL). See also response to questions 6 through 8 in the TMDL Analysis section of this Response to Comments.

7. Instead of addressing noncompliance with tribal water quality standards, the Draft TMDL asserts:

   The loading capacity will defer to the Washington State criteria as opposed to designating entirely separate ones based on the Kalispel tribal criteria. This is because this TMDL only applies to Washington State waters. Moreover, the application of both Washington State and Kalispel tribal criteria to Pend Oreille River temperatures identified similar heating patterns in the coincidental reaches and segments examined.

   This explanation is inadequate for two reasons. First, the fact that the TMDL only applies to state waters does not relieve the State of its obligation to ensure that Kalispel water quality standards are met at the jurisdictional boundary. Second, the Tribe objects to the assertion that compliance with its water quality standards can be derived from the CFA methodology set forth in the Draft TMDL. To avoid authorizing violations of Kalispel WQ standards, the Draft TMDL must ensure that target temperatures for the jurisdictional boundary are based on Kalispel water quality criteria and paired analysis rather than state criteria and CFA methodology.

   Response: *See response to question 5 in this section.*

8. Page 72, second paragraph: The TMDL must explicitly state how Ecology's proposed load capacity, WLAs, and LAs will meet Kalispel water quality standards at the jurisdictional boundary. Kalispel analyses show that there were violations of Kalispel water quality standards at and just upstream of tribal waters in both 2004 and 2005. Ecology's current CFA analysis results in erroneous conclusions about compliance with both tribal and state temperature criteria.

   Response: *See responses to questions 4 and 6 in this section.*

9. The current statement in the draft TMDL below is not adequate.

   "*The loading capacity will defer to the Washington State criteria as opposed to designating entirely separate ones based on the Kalispel tribal criteria. This is because this TMDL only applies to Washington State waters. Moreover, the application of both Washington State and Kalispel tribal criteria to Pend Oreille River temperatures identified similar heating patterns in the coincidental reaches and segments examined*."

   This TMDL may only apply to Washington State waters but where those waters meet the Kalispel waters they must meet the Kalispel Tribe's standards. Thus the TMDL must demonstrate that the Tribe's standards will be met at the boundary.

   Response: *See response to questions 4 through 6 in this section.*

10. Page xiii, seventh paragraph & Page 2, paragraph 5: Ecology is obligated to do more than just work with point sources to implement provisions of a TMDL and other CWA requirements to meet the Kalispel criteria at the boundary with state waters. This needs be an explicit statement accurately based on legal requirements of the CWA for protecting boundary waters.

    Response: *This statement is in the executive summary for the TMDL. Information in the executive summary is not intended to be detailed and specific. Additional information about expected actions is included in the main body of the document. See also response to question 4 in this section.*

Allocations

1. Page 71, Equation 1: The use of a grid cell based definition for daily maximum temperatures is not consistent with the loading formulation presented in Equation 1. The application of a volume weighted daily maximum temperature is consistent with this equation and would also more appropriately reflect the dominant aquatic habitat in the Pend Oreille River.

   Response: *As stated on page 3 and 71 of the TMDL, Ecology recognizes that determining heat load based on maximum temperature and the entire river volume would overestimate the amount of heat in the river. For this reason, Ecology is using temperature in degrees C to measure compliance with the TMDL. However, the equation must be placed in the TMDL to satisfy EPA requirements.*

   The water quality standards refer to dominant aquatic habitat for guidance on where to take temperature measurements and not how to determine compliance with the standard. Therefore, dominant aquatic habitat is not a consideration in the TMDL.

2. Pg xiii, paragraph 3, Allocations - Tributary and mainstem shading: It is unclear the above conditions are expected to occur in tributaries to the Pend Oreille River under the current state forest practices rule which allows the removal of all riparian vegetation along intermittent streams and up to 30% of the riparian vegetation along non-fish bearing perennial streams.

   Response: *The state forest practices rule will be used to implement the TMDL consistent with the language on pages 88 and 89 of the TMDL. See also responses to questions 7 and 8 in the General section of this Response to Comments.*

3. Page 73: Table 11 … Part 2, last 4 rows do not meet criteria in 2005, but no level of exceedance values in 2005??

   Response: *Ecology could not calculate the level of exceedence for Part 2 of the criteria in 2005 because the model could only predict temperatures until Sept. 9, 2005. The reason the model could not be run past this date is that the upstream boundary conditions from the river in Idaho were not available.*

4. Page 77: Table 13 provides needed increases in height and % canopy cover, however there is no relative value to compare against. Is there a specific cover or height for all reaches or does each reach have its own value?

   Response: *Yes, each reach and side of the Pend Oreille River has its own value. We have added more information to the table to help clarify the targets.*

5. Page 96: 1) Standards are to be met in ten years. If shade is a component, then there are 50 years. This appears to be a discrepancy.

   Response: *The TMDL specifies different timelines to meet the allocations, depending upon the temperature source. Page 95 and 96 of the TMDL say that the Pend Oreille PUD and Seattle City Light have up to ten years to meet standards. These timelines are developed in the 401 Certification through compliance schedules in a Water Quality Attainment Plan as described by rule [WAC 173-201A-510(5)] and therefore must be followed. A similar rule does not exist for tributary and mainstem shade, which is why the TMDL allows up to 50 years to meet the allocations. Ecology set this timeline because many years are needed for trees to grow to the required height and canopy cover. The 50-year timeline is consistent with other temperature TMDLs with shade allocations.*

6. When setting pollution Load Allocations (LAs) and Waste Load Allocations (WLAs), the Draft TMDL must account for the cumulative impacts of all sources of upstream heating, particularly where the timing of such impacts is critical to bull trout migration.

   Response: *The TMDL evaluated all sources of heating: upstream sources in Idaho, mainstem shade, tributary shade, point sources, and dams. Ecology established load and wasteload allocations consistent with our analysis. See also the TMDL Analysis section of this Response to Comments.*

7. There is much confusion in the document about the use of the allocations, then inferring temperature reductions, but with no river flow, temporal, or atmospheric conditions associated with declaration of the values. Load allocations need to be determined for all seasons using the correct measure of thermal impact that doesn't bias the conclusion and then allowable pollutant loadings under TMDL design conditions must be clearly expressed. There are violations of both parts of the existing special criteria in most reaches of the river, including those at, and upstream of, Kalispel waters, when evaluated with the direct daily comparisons.

   Response: *Ecology's use of temperature rather than loads to set the allocations is consistent with other temperature TMDLs involving reservoirs (Willamette Basin, Snake River – Hells Canyon, and the draft Columbia/Snake Rivers developed by EPA). Temperatures are typically used for TMDLs involving dams because loads (the allowable heat multiplied by flow) over-estimate the amount of heat in the river. This is especially true in the Pend Oreille River TMDL because of the maximum temperature standard. Expressing the allocation as a load would be equivalent to the maximum temperature being present throughout the entire water column. In reality, maximum temperatures are typically, but not always, found near the top of the water column. See also pages 3 and 71 of the TMDL.*

   The TMDL established a summer and fall critical period, each two months long, which are based on the water quality standard for the Pend Oreille River. Air temperatures and river flows indicate that 2004 was a hot, low-flow year so it meets the TMDL critical condition requirement. See also the TMDL Analysis section of this Response to Comments. Ecology reviewed the document to identify and fix any confusing statements.

8. TMDLs for Pend Oreille tributaries must include all streams and use the correct Char-based temperature criteria, where appropriate, and apply criteria to the entire tributary length. All tributaries to the Pend Oreille River used as part of the LAs for the mainstem Pend Oreille draft TMDL must have complete and valid TMDLs. The TMDLs need to establish appropriate target shade requirements based on the correct use-based criteria for each tributary regardless of land ownership.

   Response: *With the exception of Calispell Creek, all Pend Oreille River tributaries that are listed as impaired are included in the Pend Oreille River temperature TMDL. As explained on page 5 of the TMDL, Calispell Creek was not included in the TMDL because a separate model was developed for the creek that could be used for developing a TMDL in the future or be used to direct implementation activities.*

   Ecology applied the correct criteria to the tributaries and page 34 of the TMDL describes how Ecology performed the shade analysis. The Colville National Forest temperature TMDL applies within the Colville National Forest. See also responses to questions 2 and 5 under the Colville National Forest TMDL section of this Response to Comments.

9. Page xiii, second paragraph - The permitted point source loads need to be subtracted from the total load capacity and tracked as measurable sources of thermal pollution to the river. If small sources of theoretical shade are being tracked and accounted for, so should all wastewater discharges of heat.

   Response: *The TMDL analysis showed that the treatment plants do not have an effect on river temperatures, and therefore do not use a portion of the load capacity. Table 9 on page 60 of the TMDL shows that in 2004 the point sources had a 0.00^{o}C effect on temperatures, whereas tributary and mainstem shade had an effect between 0.01 and 0.05^{o}C. In addition, during the summer critical season (low river flows and temperatures exceeding 20°C), temperature data from each point source showed that temperature increases at their mixing zone boundary were below 0.3°C. However, it is important to note that like shading, point sources received an allocation that Ecology will track and enforce in their permits. Ecology edited the language on page xiii to better reflect this information.*

10. There is no evidence, or plan, that suggests that LAs given to dams can be met. The existing heat load from point sources needs to be fixed at existing levels and not allowed to increase for possible expanded future flows. There is no room for growth, as the reserved capacity for permitted point sources' thermal loads indicates, unless it can be demonstrated that there is some sort of a plan and reasonable assurance the dams will be able to meet the correct LAs using the direct daily analysis.

    Response: *The implementation strategy in this TMDL is a general overview of what will be done to reduce temperatures and is not intended to provide information about specific actions each organization will take. Specific actions are included in the implementation plan such as who will do what, by when and where. Ecology will develop the implementation plan with help from the stakeholders once EPA approves the TMDL.*

Reasonable Assurance is required when a wasteload allocation is set at a lower limit due to assumptions that capacity will be available by reducing nonpoint sources. EPA Region 10 TMDL Review Guidelines (Jan. 2002) state that "…where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur, reasonable assurance that the nonpoint source reductions will happen must be explained." In the Pend Oreille temperature TMDL, the point sources did not have an impact on the river's temperature, yet they received a wasteload allocation for their current temperatures. So, the wasteload allocations are set at a level protective of water quality and are not dependent on nonpoint source load reductions. In the TMDL, Ecology also set aside a portion (0.06^{o}C) of the 0.3^{o}C human use allowance above natural conditions for future growth. For these reasons, Ecology believes there is a reserve capacity for future growth.

EPA's Region 10 TMDL Review Guidelines (Jan. 2002) also state that "Such reasonable assurances…may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs." Therefore, FERC licenses and Ecology's 401 Water Quality Certifications (401) qualify as components of Reasonable Assurance. The 401 provides a regulatory avenue for Ecology to ensure that actions taken to reduce temperatures are completed.

11. There needs to be a clear basis documented for how each tributary LA was derived from shade potential and how that LA and required shade potential achieves the char-based water quality criteria within each stream. These new LAs and target shade potentials need to be compared to those adopted under the Colville TMDL and explain why changes were, or were not made to each.

    Response: *Page 34 of the TMDL describes how Ecology performed the shade analysis. Not all tributaries in the TMDL have char spawning and rearing as a designated use. In fact, the char spawning and rearing designation does not apply to the entire length of most tributaries. For a list of the tributaries and tributary segments designated as char spawning and rearing, see page 7 of the TMDL. In the Pend Oreille River temperature TMDL, the load allocations set for the tributaries in Table 14 (page 78) are equivalent to natural potential vegetation or the trees that can grow and reproduce on a site given soil, elevation and weather conditions. Ecology clarified this information in the TMDL.*

    The Pend Oreille River temperature TMDL applies to the tributaries listed in Table 14 from the Colville National Forest boundary to the confluence of the Pend Oreille River, with the exception of the East Branch of LeClerc Creek. (The East Branch LeClerc Creek received a load allocation on state or private land within the Colville National Forest Boundary.) Table 14 included a list of Pend Oreille River tributaries and their allocations set by the Colville National Forest TMDL. To minimize confusion Ecology edited the table. See also the response to question 8 in this section and the Colville National Forest section of this Response to Comments.

12. Page xiii, fourth paragraph: There is no room in the total load capacity for reserved capacity assigned to future pollution growth since there is no reasonable assurance or any plan that the LAs given to the dams can ever be met.

    Response: *See response to question 10 in this section.*

13. Page xiii, fifth paragraph: "Reasonable assurances" does not just mean that there is another potential regulatory process. There needs to be a plan that has a reasonable potential to lower pollution and achieve the allowable thermal load capacity when it is implemented. The FERC action plan refers to a process, but no remedy is even remotely identified to meet the LAs for dams. Therefore, the other allocations, reserve capacity, and margin of safety are all arbitrary values.

    Response: *See response to question 10 in this section.*

14. Page 3, Surrogate Measures Section: The thermal loading in allocations was originally proposed in the first draft TMDL and a similar approach in this draft needs to be retained. Elimination of allocation loads does not provide more meaningful or measurable pollutant loading targets. While the heat load allocation derived at the TMDL design conditions can be converted to a potential temperature compliance value under a certain flow condition, it does not mean the expression of allowable loading should be eliminated from the TMDL. Currently there is a mix of temperature targets being called loads, and temperature reduction values being called allocations, with no explanation of why the thermal loading approach used in the previous draft TMDL needed to be abandoned and no explanation of why this was done without any discussion with the MOA participants.

    Response: *See response to question 7 in this section. After stakeholders reviewed the Aug. 2007 draft of the TMDL, stakeholders and MOA participants discussed and proposed to use temperature for the allocations while referencing a loading equation. In December 6, 2007, EPA sent an email to the MOA participants stating this approach is acceptable.*

15. Page 71, "*surrogate measures"*: The complete abandonment of quantifying heat load and instead using just temperature for allocations is neither justified nor appropriate. The report is confusing about load capacity, allocations using temperature reductions, temperature targets, and how, when, and under what kind of river conditions they would apply and how reductions might be quantified by source.

    Response: *See response to question 7 in this section.*

16. Page 74-75, NPDES permitted waste load allocations: Ignoring permitted heat contributions and not reducing the hydropower LAs is inappropriate as is giving allowances for expansion of heat discharges in a fictitious reserved capacity.

    Response: *Ecology fails to understand how the sources were "ignored" or "not reduced" when we assigned them allocations. The wasteload allocation for the point sources is* *current operating conditions. Each dam has an allocation of 0.12°C above natural conditions. See also responses to questions 9 and 10 in this section.*

17. Page 78-79, Hydroelectric Facilities load allocations: Allocation of 0.24°C allowable increase to Washington dams is inappropriate since there are upstream heat sources and wastewater sources contributing to warming above natural conditions and the CFA methodology has systematically underestimated the actual thermal impairment present under existing conditions in Kalispel waters and at Box Canyon dam.

    Response: *See response to question 16 in this section, as well as responses to questions 6 through 8 in the TMDL Analysis section of this Response to Comments.*

18. Page 79, Reserved Capacity: There is no plan that suggests how the dams will meet the already inflated allocations. Therefore fabricating reserved capacity to allow wastewater dischargers to increase thermal pollution is not warranted.

    Response: *See response to question 10 in this section.*

19. The Part 1 load allocation to the Boundary facility should acknowledge the cumulative effect of Box Canyon in the Boundary forebay reach. Assuming that the load allocation of 0.12°C to each hydropower facility is reasonable, SCL has concerns about the TMDL's application of the allocation at the Boundary forebay. Specifically, SCL is concerned that the allocation as calculated ignores the effect of Box Canyon on temperature conditions in the Boundary reaches that the report elsewhere acknowledges.[1] This issue becomes relevant in the TMDL's establishment of the temperature reductions necessary to meet the load allocation. Whereas the TMDL currently indicates that O.88°C of temperature reduction is required at the Boundary forebay to meet the allocation (i.e., to achieve temperatures of Natural + O.12°C), SCL believes that the reduction required should be O.76°C (i.e., to achieve temperatures of Natural + O.24°C, which would be the cumulative allowance at this location, calculated as the sum of the 0.12°C allowance to Box Canyon carried downstream and added to SCL's 0.12°C allowance). This issue appears at p. xii, p.79, and in Tables 15 and 17 (p. 80 and 95, respectively) of the TMDL.

    The text of the TMDL at pages xii and p. 79 should be revised to state that a reduction of O.76°C is needed at the Boundary forebay to achieve standards. The same change should be made to Table 15. Table 17 should be revised to indicate that the final target for the Boundary forebay is Natural condition + 0.24·C.

[1] *See* p. 62 "A temperature signal from Box Canyon is evident in the temperature profiles of the Boundary forebay. Lower magnitude daily maximum temperatures are maintained by the Box Canyon facility for a longer period in comparison to what occurred naturally. This results in the continued exceedance of the Pend Oreille River temperature criteria in the Boundary reaches despite the absence of the Boundary facility." *See also* p. 79 "So, the temperature impacts observed in the Boundary reaches are associated with the combined operations of the Box Canyon and Boundary facilities resulting in a complex relationship."

Response: *Ecology did not make the suggested changes. This summer critical period allocation is based on the amount of heating in the forebay of Boundary Dam. Any effect from Box Canyon Dam during the summer dissipates by the Slate river reach, upstream of the Boundary forebay, which is why the allocation cannot be additive. The maximum temperature difference during the summer in the forebay between the natural and existing conditions is 1.0^{o}C (see Table 6 on page 41 of the TMDL). Since Boundary Dam was allocated 0.12^{o}C above natural conditions, this is equal to a 0.88^{o}C temperature reduction. Page 79 of the TMDL explains another way to calculate the required temperature reduction.*

20. Assuming that the Part 2 criteria apply (see SCL General Comments), the TMDL's discussion of the Part 2 load allocation should be more clear that the allocation is set for each reach (not source), and that all parties' actions will cumulatively help achieve temperature reductions. The required reductions for Boundary reaches are a result of actions throughout the river, and the Part 2 reductions in the Boundary reaches are expected to be fulfilled by the cumulative benefit of actions taken by all parties. The following new sentence should be added to page 79, at the end of the last paragraph in the section "Hydroelectric facilities:"

    "The temperature reductions needed to achieve the Part 2 load allocations in each reach would be shared between the two hydropower facilities based on responsibility."

    Response: *Ecology added additional language on page 79 to clarify the Part 2 allocations.*

21. Page 75. PNC agrees with the modeling showing that the NPDES permitted point sources (including PNC) have "no definable influence on existing temperatures." Setting a limit based on the present effluent temperature limit and maximum flow makes sense. The method for translating such information to a kilocalories per day limit appears reasonable. PNC notes that the flow used for PNC was 0.228 *m3/sec* (or 5.20 mgd) and asks the basis for using 5.20 mgd. PNC's current permit does not have a flow limit, and the fact sheet for PNC's current permit shows a maximum flow of 5.7 mgd between January 2003 and July 2006. (Fact Sheet, table 1 pg 5.) PNC requests that the kilocalories per day limit be recalculated based on the present effluent temperature limit of 90°F and a flow of 5.7 mgd.

    Response: *Ecology reviewed Ponderay Newsprint's discharge monitoring report (DMR) data during the summer critical period and found that the maximum discharge during this time (July 2004) was 5.20 million gallons per day (mgd). We used this maximum flow to calculate the allocation. The maximum flow of 5.7 mgd referred to in the Fact Sheet for the NPDES permit occurred in May 2005, outside the summer and fall critical period. In response to your comment, we reviewed the DMR data from 2003 through November 2010. The data shows flows during the summer critical period have decreased since 2004. Therefore, we will continue to use 5.2 mgd to calculate Ponderay Newsprint's allocation.*

State Line Allocation

1. Page 73, Load and Wasteload Allocations, Idaho-Washington Stateline: Please explain how the temperature allocation for water temperatures at the Idaho-Washington state line based on observed conditions in 2004 will be applied. There will be years where water temperatures will be much warmer than presented in Figure 32 at the Idaho-Washington state line. We recommend dropping the reference to a specific year and referencing the maintenance of existing water temperature conditions in the Pend Oreille River at the state line.

   Response: *2004 is representative of critical conditions, which means that Ecology modeled the river under high temperatures and low flow conditions. This is done so that the TMDL allocations will likely be met during more extreme weather conditions. Daily average flows in June and July were at the 13th and 29th percentiles, respectively. Air temperatures in 2004 were very warm and exceeded the 90th percentile. (See pages 20-21 of the TMDL.) Therefore, if the weather is warm and flows are low, the results should not be that different from the TMDL.*

   To clarify the intent of applying the TMDL at the state line, Ecology edited the language in this section of the TMDL. Ecology replaced the term "allocation" with "assumption." The stateline assumption will be evaluated along with the allocations. Ecology will continue to collect monitoring data at Newport while agencies and organizations work to implement the TMDL. After several best management practices (BMPs) and other implementation measures have been applied and as resources allow, Ecology will use the monitoring data to update and rerun the model to determine compliance.

2. It appears that Idaho communities may have been given no opportunity for growth. This appears to be the result of the requirement that the summer/fall critical periods temperature at the Idaho/Washington border be maintained and Washington communities being given waste load allocations. I question whether the State of Washington can regulate permitted point sources in the State of Idaho.

   Response: *Ecology edited the language in the TMDL to clarify the intent of applying the TMDL at the state line. Ecology replaced the term "allocation" with "assumption." Ecology is not regulating point sources in Idaho by making an assumption about water temperature at the state line. Ecology had to make a baseline temperature assumption at the state line in order to establish allocations in Washington. The Idaho Department of Environmental Quality (IDEQ) is responsible for determining how sources in Idaho meet Idaho's water quality standards and with Washington's standards when the water crosses the state line. Because the state line assumption is based on a high temperature, low-flow year (see response to question 1 in this section), Ecology anticipates that IDEQ will not need to take further action.*

3. It seems disingenuous to allocate all the benefit from Albeni Falls Dam to the downstream users to "ensure viability of load and wasteload allocation established for downstream locations". The allocation at the state line should be the heat at natural conditions plus a portion of the load capacity allowance for existing use and growth. It is difficult to imagine but should the dam ever be removed, the TMDL would force Idaho users to cool 100% of the river even if no discharge was received upstream of the state line mostly for the benefit of downstream dischargers. Additionally, there may be some natural phenomenon that causes the water temperature at the state line to increase which Idaho dischargers have no control over yet would be responsible for mitigating. Idaho cannot be liable to mitigate a natural phenomenon.

   Response: *Loading capacity in the Pend Oreille temperature TMDL is the amount of heat the river can have in it and still meet state water quality standards. The TMDL acknowledges that at the state line, river temperatures meet standards because they are cooler than what occurred naturally. Therefore, establishing a loading capacity at the state line is not necessary. The goal of the TMDL is to maintain compliance with the temperature standard into the future, which is why Ecology assigned the assumption.*

   If something should happen to Albeni Falls Dam, Ecology would need to reassess the river because Albeni Falls Dam controls the river flows in Washington. See response to question 2 in this section.

4. Anti-degradation policies come into play during the permitting process where socio-economic factors can also be considered. Limiting the heat at the state line to 2004 values in a TMDL would prevent the consideration of socio-economic factors.

   Response: *Ecology's goal at the state line is to maintain temperatures that meet Washington's standard, which is also the goal of the anti-degradation policy. The intent of the language in the draft TMDL was to highlight this joint goal. To clarify the intent, Ecology edited the TMDL's language about the state line.*

   The purpose of setting a temperature value at the state line in the TMDL is to provide a baseline of what is coming from Idaho, from which to develop allocations in the TMDL for Washington sources. Anti-degradation policies (when the waters are cooler than the standard) would only come into play during the permitting process if a new or expanded discharge were to cause a measurable change in water quality. In the case of Washington dischargers, the measurable change would be defined as causing a greater than 0.3 C degree increase in temperature. The current point source discharge to the part of the river that is cooler than the temperature standard on the Washington side (City of Newport) is an existing discharger, and does not cause greater than a 0.3 C degree increase to the river. Therefore, the Tier II anti-degradation requirements to consider socio-economic factors would not apply. For Idaho dischargers that propose to cause a measureable change to temperature on the Idaho side, EPA would determine whether anti-degradation Tier II requirements would be imposed.

5. A TMDL should establish the loading capacity of a water body. No effort was made to estimate the loading capacity at the state line.

   Response: *See response to question 3 in this section. Establishing a loading capacity at the state line is not something that Ecology can do because it has no jurisdiction in Idaho.*

6. It is our understanding that the Idaho dischargers do not influence the temperatures measured in the Pend Oreille River (from the CE-QUAL modeling), as mentioned in the report. It would be nice if the report expanded on this topic to state that heat limits on the Idaho dischargers are not required to meet Washington water quality goals and beneficial uses.

   Response: *The suggested statement is beyond Ecology's jurisdiction. The Idaho Department of Environmental Quality (IDEQ) is responsible to determine what actions, if any, are needed to comply with Idaho's water quality standards and with Washington's standards when the water crosses the state line. See also response to question 2 in this section.*

7. Accounting for upstream thermal impacts from Idaho is similar to the approach addressing cumulative impacts of pollutant sources flowing into Washington from Idaho in the Spokane River Dissolved Oxygen TMDL (USEPA, 2008). Therefore, the Draft should be revised to fully consider the impacts of the Albeni Falls Project, including the Project's late-summer contribution to downstream WQ violations.

   Response: *Ecology analyzed the entire length of the Pend Oreille River in Washington from July through October. The analysis showed that the river met standards at the state line during this time frame.*

8. Page xii, first paragraph - Setting the allocation for the Stateline at 2004 conditions is inappropriate since excess heat flowing downstream in late summer is contributing further degradation downstream. The additional heat is contributing to temperature violations in WA and Kalispel waters detrimental to recovery of native trout populations.

   Response: *Ecology disagrees with this comment. The TMDL analysis indicated that the water flowing from Idaho is cooler now than historically, and this effect is detected for several miles downstream. See also the TMDL Analysis section of this Response to Comments.*

9. Page 73, Idaho-Washington Stateline - The Pend Oreille River water entering Washington is not cooler in late summer and only the use of CFA methodology makes it appear to be cooler. An allocation for "maintenance of existing condition temperatures observed in 2004" does not account for significantly warmer average river temperatures contributing to downstream violations during critical conditions in late summer.

   Response: *The TMDL analysis showed that downstream temperature violations are not the result of water temperatures from Idaho. The state line assumption protects the cooler water at that location. See the TMDL Analysis section of this Response to Comments.*

10. The draft TMDL provides a load allocation to the State of Idaho. Washington, however, has no authority to provide allocations to sources in Idaho. Please remove the reference to an allocation to sources in Idaho.

    Response: *The TMDL assumes that water coming from Idaho will be in compliance with Washington's water quality standards. This does not establish allocations to sources in Idaho. See also the response to question 2 in this section.*

11. The load allocation at the Idaho-Washington border as described on page 73 of the Draft Pend Oreille Temperature Water Quality Improvement Report is for the maintenance of existing condition temperatures as observed in 2004. Idaho cannot be accountable for climatic or other nonhuman-induced conditions that could increase water temperatures within the Pend Oreille River above temperatures Observed in 2004. Such conditions are beyond the control of sources in Idaho.

    Response: *2004 is representative of critical conditions, which means that Ecology modeled the river under high temperatures and low flow conditions. This is done so that the TMDL allocations will likely be met during more extreme weather conditions. Daily average flows in June and July were at the 13^{th} and 29^{th} percentiles, respectively. Air temperatures in 2004 were very warm and exceeded the 90^{th} percentile. (See pages 20-21 of the TMDL.) Therefore, if the weather is warm and flows are low, the results should not be that different from the TMDL, especially since the difference between natural and existing conditions is generally less than $1.0^{o}C$.*

12. Additionally, Idaho CE-QUAL-W2 modeling results evaluating the effect of NPDES-permitted facilities on temperatures in the Pend Oreille River are consistent with those reported on pages 59 and 67 of the Draft Pend Oreille Temperature Water Quality Improvement Report. Both results indicate that NPDES-permitted discharges have no measurable influence on existing maximum temperatures observed in the Pend Oreille River. As such, temperature limits on Idaho discharges are not required in order to meet Washington WQS. The TMDL should reflect this fact.

    Response: *The TMDL does not put temperature limits on Idaho dischargers. See response to question 2 and 6 in this section.*

Colville National Forest TMDL

1. This document covers the Pend Oreille River and tributaries up to the Colville National Forest boundary. Are the portions of these tributaries on private and state lands within the Colville National Forest boundary covered in the TMDL for the Colville National Forest, this document or another document?

   Response: *The privately or state-owned portions of the tributaries within the Colville National Forest boundary are not covered by either TMDL, with the exception of the East Branch of LeClerc Creek. The reason for this is that in the Pend Oreille TMDL, East Branch LeClerc Creek received a shade allocation for private land above the national forest boundary. Ecology clarified the TMDL on page 5 to reflect this distinction.*

2. The previously adopted Colville Forest temperature TMDL, Detailed Implementation Plan, and Colville National Forest Plans, were all drafted without using the appropriate Char use-based criteria of 12°C in the Pend Oreille watershed.

   Response: *The Colville National Forest TMDL used the 1997 temperature water quality standard because EPA disapproved the 2003 state-adopted temperature criteria. Federal actions, such as TMDLs, must use EPA-approved water quality standards. Ecology was required to use the 1997 temperature standard because it had EPA approval. The EPA did not approve the temperature criteria until February 2008, well after all the Colville National Forest TMDL documents were completed.*

   Not all watershed streams are designated as char spawning and rearing by the state water quality standards and therefore required to meet 12°C. For a list of tributaries listed as char spawning and rearing see the bottom of page 7 of the TMDL.

3. Because there are errors and inconsistencies in the stream names and designated uses, all tributaries to the Pend Oreille River need to have reconfirmation of the appropriate use-based criteria for each stream and have the subsequent target shade requirements revised to meet the designated Char use-based criteria. The criteria and revised tributary TMDL must be applied to the entire stream.

   Response: *The Colville National Forest calls for an average shade level of 80 percent. The Pend Oreille TMDL calls for shade from natural potential vegetation on the tributaries, which on average is roughly 80 percent (determined from Table 14 in the TMDL). Effectiveness monitoring of the Colville National Forest TMDL will provide information on whether the amount of shade is increasing (i.e. there is progress toward meeting the shade targets), and how well the shade is working to meet the temperature criteria. If data show the shade requirements will not meet the appropriate criteria for the stream (12°C or 16°C) and additional shade is possible, Ecology may amend the TMDL. See also question 4 in the Water Quality Standards section of this Response to Comments.*

4. Page xiii, third paragraph: Any existing TMDLs and associated allocations with safety margins for the Pend Oreille tributaries without Char-based criteria need to be voided immediately and redeveloped for the entire length of each stream following appropriate administrative procedures for establishing a TMDL.

   Response: *See response to question 3 in this section.*

5. There appear to conflicting conclusions for the impact of shading effects in tributaries, the amount of shade potential which will be needed, and which TMDL for temperature will regulate shade requirements in tributaries.

   Response: *The Colville National Forest temperature TMDL applies to tributaries within the Colville National Forest. The Pend Oreille River temperature TMDL applies to the tributaries listed in Table 14 in the TMDL from the Colville National Forest boundary to the confluence of the Pend Oreille River, with the exception of East Branch LeClerc Creek (see response to question 1 in this section).*

   Ecology is unaware of the conflicting conclusions referenced. However, because there are three different temperature criteria that apply in the tributaries to the Pend Oreille River, one can be easily confused. Beginning in the headwaters, which is in the Colville National Forest, tributaries with bull trout, or segments of them, have a 12^{o}C temperature criteria. Tributaries not designated as bull trout within the National Forest boundary have a 16^{o}C temperature criteria. Once the tributaries flow downstream of the National Forest boundary, the temperature criteria is 17.5^{o}C unless the water quality standards designates a tributary as char spawning and rearing, in which case the 12^{o}C criterion applies.

   The amount of required shade varies depending on the criteria and upon the tributary's location within the watershed. Table 14 lists the amount of shade needed for each tributary to meet the temperature criteria. Table 14 also includes a list of Pend Oreille River tributaries and their allocations set by the Colville National Forest TMDL. To minimize confusion, Ecology edited the table. For tributaries not within the Colville National Forest, the amount of shade referenced in Table 14 of the TMDL is equivalent to potential natural vegetation, or the amount and kind of trees and shrubs that will grow and reproduce on the site.

6. Apparently, the Colville Forest TMDL for temperature was submitted and approved by EPA in 2005 without using the appropriate char use-based temperature criteria for Pend Oreille tributaries (12°C), even though they were promulgated by the State in 2003. The Colville Forest TMDL used 16°C to develop shade targets to delist these tributaries. The TMDL was then used to develop a detailed implementation plan in 2005 and the USFS Colville Forest plans in 2006; those plans helped exclude listing of critical char habitat on federal land. Because the Colville Forest TMDL used the wrong temperature criteria for Pend Oreille tributaries with Char-based uses, the streams need to be placed back on the 303(d) list and TMDLs redeveloped for the entire length of each stream following appropriate administrative procedures for establishing TMDLs.

Response: *The Colville National Forest did not use the wrong temperature criteria. See response to questions 2, 3, and 5 in this section.*

7. The required levels and shade potential in current LAs are inconsistent with, and apparently in some cases less stringent than, the levels and shade potential needed to meet char used-based criteria; those used in the Colville Forest TMDL are no longer valid. There is neither justification for the shade targets identified for tributaries nor any citation to a technical report which documents adequate analyses for establishing multiple temperature TMDLs in bull trout habitat, including all the required components of an approvable TMDL including margin of safety and public participation.

   Response: *See response to questions 2, 3 and 5 in this section. Page 34 of the Pend Oreille temperature TMDL describes how Ecology performed the shade analysis. Ecology added information in the TMDL about the margin of safety for the tributary TMDLs on page 81, and information about public participation can be found on pages 100 and 101 of the TMDL.*

8. Because the Colville Temperature TMDL used out-dated temperature criteria, a concise statement needs to be made that explains both the validity of the Colville Temperature TMDL for most Pend Oreille tributaries and how each of the shade potential for each tributary was derived for the new proposed Pend Oreille TMDLs.

   Response: *See response to questions 2, 3, and 5 through 7 in this section.*

9. Page 77, Tributary Shading: Reference to an invalid Colville National Forest TMDL that did not use Char-based criteria to develop allocations is inappropriate. All char streams delisted using the adoption of Colville Forest TMDL must be relisted on the 303(d) list. All tributaries designated as Char waters need to be reassessed for their entire length with appropriate revised shade requirements to meet the 12°C criteria, including an evaluation of the margin of safety, with public review.

   Response: *See response to questions 2, 3, and 5 through 7 in this section, as well as response to question 11 under the Allocations section of this Response to Comments.*

General

1. From my understanding of the water quality modeling that Army Corps of Engineers and the State of Idaho have accomplished, temperatures now are lower than under pre-dam natural conditions. For this reason, why even develop a temperature TMDL?

   Response: *The Pend Oreille River in Washington is listed as impaired on Washington States' Water Quality Assessment. Water bodies listed as impaired need to have TMDLs or another similar plan developed to address the water quality impairment and remove the water body from the impaired waters list. A TMDL was also needed because Ecology's modeling has shown that in some reaches of the Pend Oreille River, existing temperatures are warmer than they were naturally.*

2. Wherever the term "natural conditions' is used in regard to water temperature, this should be qualified to instruct the reader that these are actually "modeled natural conditions" in lieu of actual pre-dam and pre-land management water temperature data.

   Response: *We made a clarifying statement on page 17 in the TMDL.*

3. Pg xi, paragraph 1, Overview of Results & Pg 41, paragraph 1, Results**,** Compliance with criteria, Peak temperature: We are not aware of any substantive and continuous water temperature data in the Pend Oreille River in Washington prior to the implementation of the Albeni Falls and Box Canyon dams. It would be appropriate if there was a reference to or presentation of this data to justify the above statement. As well, the phrases "occurred naturally" and "under natural conditions" are used throughout the draft and should be changed to "modeled natural condition" or "predicted to have occurred naturally" since a natural, pre-Albeni Falls and Box Canyon dams data set does not actually exist.

   Response: *We made a clarifying statement in the TMDL.*

4. Page 16: Discussion on assumptions relative to natural temperature conditions is missing.

   Response: *See response to questions 4 under Modeling.*

5. Page 27: Typo (Scenario 8.0 depicts the temperatures of a natural <u>or</u> pre-developed condition)

   Response: *We fixed the error.*

6. Page 76: Degree symbols??

   Because the loading capacity is 0.3<u>o</u>C above natural conditions, and the allocation for mainstem shade is for potential natural vegetation (i.e. natural conditions), a portion of the 0.3<u>o</u>C load capacity is not assigned to mainstem shading.

Response: *We fixed the error.*

7. It is obvious from the above statements that the WDOE considers effective shading to be key in meeting state water quality standards for temperature on tributaries to the Pend Oreille River. In the Colville National Forest TMDL report excerpt above, WDOE states that "an effective shade level of 80 percent is needed to maintain maximum water temperatures at or below 16°C". Yet the Forest and Fish Rules allow the harvest of up to 30% of riparian vegetation along non-fish bearing, perennial streams and complete removal of the riparian vegetation along intermittent streams.

   Response: *It is true that the state's forest practice regulations do not require leaving vegetated buffers along seasonal, non-fish bearing streams. For perennial non-fish waters, the regulations establish a 50-foot riparian buffer, measured horizontally from the bank full edge on each side of the stream. Trees can be cut from this zone as long as basal area requirements are met. Whether the rules allow removal of 30% of the trees or not depends on the type of harvest and on site-specific conditions. [See WAC 222-30-022 (2)(b).]*

8. Taken as a whole, the requirements for hydroelectric project licensees and the Colville National Forest, to address compliance with state water standards, appear to be more stringent than those listed for private timberland owners under the Forest and Fish Rules. This apparent uneven application of WDOE's authority to enforce the Clean Water Act needs to be addressed in this TMDL. Specific changes to Forest and Fish Rules will need to be made if effectiveness monitoring indicates that their application is causing an adverse effect to state water quality standards. This needs to be part of this draft TMDL language in order to be consistent with what is required of other entities and agencies.

   Response: *The implementation plan for the Colville National Forest TMDL (October 2006) requires the Colville National Forest (CNF) to follow Forest Service guidance for riparian areas as described in the Inland Native Fish Strategy (INFISH). INFISH standards specify larger riparian buffers than the state's forest practice regulations (WAC 222). The TMDL was written to be consistent with the Forest Service's internal standards and guidelines and was agreed to by the CNF. The Memorandum of Agreement (November 2000) between Region 6 of the Forest Service and Ecology only requires that activities on National Forests meet or exceed the water quality protections in the state forest practice rules.*

   The stream-side buffers and other requirements in the state forest practices regulations were developed with the expectation that they would be protective enough to meet the state's temperature standards. To check this, a formal adaptive management process was set up to assess and revise the rules, as needed. Ecology is actively involved in this adaptive management process along with the other cooperators in the Forest and Fish program. (See pages 88-89 of the TMDL). The adaptive management group is currently conducting a number of ongoing studies designed to evaluate the riparian rules.

9. Page 93: 1) Should the plan revision be mentioned? 2) Sentence: "Create and follow range allotment management plans …" [add: which protect water quality.]

   Response: *1) Forest Service staff provided the information about the Colville National Forest as it appears on page 93. Ecology is unaware of the progress in revising the Forest Plan for the Colville National Forest. According to the web site for the revision, the Forest Service has been preparing a new draft since 2009. 2) We added the suggested statement.*

10. Page 95: Table 17, year 50: What is the percent increase that accomplishes PNV?

    Response: *The percent increase in shade needed to meet potential natural vegetation varies depending upon the tributary or mainstem reach. The increase in shade required to meet potential natural vegetation is found in Tables 13 and 14 of the TMDL. We have clarified Table 17.*

11. Page 96: 2) PUD does shore based monitoring once a month…Is this for temperature or other water quality measures?

    Response: *According to Mark Cauchy, Director of Regulatory and Environmental Affairs for the Pend Oreille PUD, the PUD monitors temperature and other parameters at Kelly Island, the Usk bridge, and Box Canyon Dam. The PUD also monitors erosion at 42 locations along the Pend Oreille River shoreline.*

12. Page xiii, sixth paragraph: Wastewater point source permits must address impacts to temperature within both parts of the temperature criteria, not just when it exceeds 20°C. There should be a permit condition that fixes thermal loads at current conditions and requires point sources to periodically look for ways to reduce their thermal load over time.

    Response: *During the summer critical season (low river flows and temperatures exceeding 20°C), each discharger's temperature increase at their mixing zone boundary falls below 0.3°C. Lower receiving water temperatures generally occur at high river flows with corresponding larger dilution factors. The point sources do not have a reasonable potential to exceed less restrictive incremental temperatures increases given by the equation t=34(T+9), where "T" represents the background temperature as measured at a point or points unaffected by the discharge. These incremental increases range from 1.1°C at a background temperature of 20°C, and 1.8°C at a background temperature of 10°C.*

    The TMDL does fix thermal loads at current conditions. Please refer to the discussion on pages 74 through 75 of the TMDL. Modeling done as part of this TMDL showed that the NPDES point source dischargers did not cause significant shifts in river temperatures. Nonetheless, Ecology will encourage dischargers to look for opportunities to reduce effluent temperatures, in addition to requiring the dischargers to meet the WLAs in this TMDL.

13. The Draft TMDL must ensure that target temperatures for the jurisdictional boundary are based on Kalispel water quality criteria and paired analysis rather than state criteria and CFA methodology. Any NPDES permits issued under the auspices of the TMDL must be

developed in accordance with such target temperatures. At a minimum, the permits should prevent the degradation from getting worse by each discharger and require periodic engineering evaluations looking for opportunities to reduce heat loads.

Response: *The NPDES permits must contain effluent limits for temperature consistent with the WLAs contained in the TMDL. Ecology set these WLAs to prevent further degradation of receiving water temperatures from the point source dischargers. Modeling done as part of this TMDL showed that the NPDES point source dischargers did not cause significant shifts in river temperatures. Nonetheless, Ecology will encourage dischargers to look for opportunities to reduce effluent temperatures, in addition to requiring the dischargers to meet the WLAs in this TMDL. Also see response to question 5 in the Kalispel Tribal Waters section.*

14. Page xv, contributions - Please list Kalispel Tribe representatives as participants in the TMDL process rather than contributors to this document.

    Response: *We made the requested change.*

15. Page 81, Reasonable Assurances - There is no substantive plan provided on how the TMDL will be met. Providing reasonable assurances means that there should be a general idea of how the TMDL will be met and how implementation is assured to achieve compliance with WQ standards. Currently there is only a reference to a process with no foreseeable solution for the dams to achieve the required thermal impact reductions that are needed to meet the total thermal load capacity of the river, let alone provide capacity for wastewater discharge expansion and provide a margin of safety. Referring to a FERC process, with a continuous deferral of achieving the temperature criteria built into the state's WQ standards, is not adequate for restoring native trout back to the river and Kalispel people.

    Response: *Reasonable Assurance is required when a wasteload allocation is set at a lower limit due to assumptions that capacity will be available by reducing nonpoint sources. EPA Region 10 TMDL Review Guidelines (Jan. 2002) state that "…where a point source is given a less stringent wasteload allocation based on an assumption that nonpoint source load reductions will occur, reasonable assurance that the nonpoint source reductions will happen must be explained." In the Pend Oreille temperature TMDL, the point sources did not have an impact on the river's temperature, yet they received a wasteload allocation for their current temperatures. So, the wasteload allocations are set at a level protective of water quality and are not dependent on nonpoint source load reductions.*

    EPA's guidance further states that "Such reasonable assurances…may be non-regulatory, regulatory, or incentive-based, consistent with applicable laws and programs." FERC licenses and Ecology's 401 Water Quality Certifications (401) qualify as components of Reasonable Assurance. The 401 provides a regulatory avenue for Ecology to ensure that actions taken to reduce temperatures are completed.

After EPA approval of the TMDL, Ecology will develop an implementation plan in cooperation with the stakeholders. The implementation plan will answer who will do what, when, and where to reduce river temperatures and meet the TMDL allocations.

16. Pages 85-88, Implementation Strategy - As previously discussed, the implementation strategy needs to have at least some plan for restoring water quality so that it is more supportive of native trout recovery. A strategy that defers to a FERC process without having any plan for preventing violations of the temperature criteria in Kalispel waters, or throughout the rest of the river, is not acceptable. The State's 401 certification of the FERC licenses postponed the temperature issue to the TMDL process. Now the TMDL proposes to postpone development of solutions to restore water quality back to the FERC process, which is then allowed multiple cycles of 10 year compliance schedules in the State's WQ standards. The State needs to require more substantive potential solutions and include what the US Army Corp of Engineer will do to help correct temperature issues as part of an approvable TMDL.

    Response: *The implementation strategy in the draft TMDL is a general overview of what will be done to reduce temperatures and is not intended to provide information about specific actions each organization will take. Specific actions will be included in the implementation plan, such as who will do what, by when, and where. Ecology will develop the implementation plan with help from the stakeholders once EPA approves the TMDL.*

    Because the dam operated by the U.S. Army Corps of Engineers is in Idaho, they are outside Ecology's jurisdiction and will not be included in the implementation plan unless they voluntarily participate.

17. P. 21, Figure 5: There is a discrepancy between the legend and the line in the graph for 50^{th} percentile flow.

    Response: *Ecology fixed the discrepancy.*

18. P. 36, Figure 8: It would be helpful to have more explanation of the values in this figure. Do they represent modeled data points or actual data collected in the field?

    Response: *The data represented in the graph are from model output, which will be indicated in the TMDL.*

19. P. 61, Hydroelectric Facilities, paragraph 1, sentence 3: The word "affect" should be changed to "effect".

    Response: *We fixed the error.*

20. P. 81 Margin of Safety: A margin of safety is described for the Pend Oreille River TMDLs but not for the tributary TMDLs. These TMDLs margin of safety should also be described here.

    Response: *Ecology inserted language describing the margin of safety for the tributaries.*

21. On November 17,2010, Governor Gregoire issued an Executive Order suspending non-critical rule development and adoption. By Executive Order 10-06, the Governor of the State of Washington did "order and direct: (1) the suspension of non-critical rule development and adoption from the date of this Executive Order through December 31, 2011." The District suggests, and requests, that Ecology suspend the development and adoption of the TMDL rule for the Pend Oreille River at least through December 31, 2011. By suspending the development and adoption, Ecology will provide sufficient time for the District to obtain further data and information regarding the temperature models used by Ecology in its proposed TMDL rule.

    Response: *TMDLs are not rules. TMDLs are plans required when bodies of water do not meet state water quality standards. The water quality standards are the rule; TMDLs are a tool required by the federal Clean Water Act to make sure rivers, streams and lakes meet the standards. Ecology is proceeding with submitting the TMDL to EPA for approval.*

22. What can be done to facilitate private landowner cooperation in efforts to improve shade conditions, particularly small recreational property owners along the reservoir? The TMDL suggests increased shade along the main stem reservoir as a strategy to reduce water temperatures, and actually goes so far as to establish load allocations on main stem shade (Table 13, p. 77). However, much of the reservoir shoreline is under private ownership, and many property owners have purposely removed vegetation from reservoir shorelines in order to improve their view of the river. What would be the motivation for these landowners to agree to replanting of shoreline trees on their property, and what can be expected of the Pend Oreille PUD to effect such shade improvements on private property?

    Response: *Ecology is willing to partner with local agencies and groups to help educate private landowners in the watershed about the TMDL's shade requirement. Ecology is also able to provide technical assistance to landowners, and financial assistance to local governments to plant native trees and shrubs or help stabilize the river bank.*

    Pend Oreille County is in the midst of a comprehensive update to their Shoreline Master Program (SMP). Under the Shoreline Management Act (WAC 173-26), the county must develop shoreline goals, policies, and use regulations that when implemented will achieve no net loss of ecological functions. As a result, Pend Oreille County will have much more stringent requirements when it comes to shoreline vegetation management. While the updated SMP is not retroactive and cannot force landowners to replace vegetation that was legally removed, it will provide a strong incentive to maintain native riparian vegetation within shoreline jurisdiction into the future.

23. To what extent can the PUD expect to rely upon expected improvements to shade conditions in the reservoir and/or in tributaries due to its activities related to conditions of its license (e.g., Trout Habitat Improvement Project)? (Refer to Table 14, p. 78.)

    Response: *The PUD's 401 Water Quality Certification states that "Where they are more protective, the provisions of the TMDL implementation plans…shall* supersede the *conditions" of the 401. So, the actions in the implementation plan that will be developed* *after EPA approves the TMDL will be used to reduce temperatures in the river. Because the scope of the temperature problem in the Pend Oreille River was not known at the time the PUD's other license conditions were developed, the PUD will need to consider and complete additional actions to comply with the TMDL. A water quality attainment plan [WAC 173-201S-510(5)] will be developed from the actions in the implementation plan and be amended into the PUD's 401 Certification.*

24. To what extent can the Pend Oreille PUD expect to rely on the investment in the cold water release pipe at Sullivan Dam as partial mitigation for temperature issues above Box Canyon Dam? The cold water release pipe in Sullivan Lake will result in favorable temperature impacts downstream of Box Canyon Dam. How will this mitigation be factored in when considering efforts made by Pend Oreille PUD toward TMDL allocations above Box Canyon Dam?

    Response: *The cold water pipe planned for Sullivan Dam will not help satisfy TMDL requirements upstream of Box Canyon Dam because the cold water would be discharged downstream of Box Canyon Dam. Any cold water from the pipe will not contribute cool water to the reservoir created by Box Canyon Dam. However, if cold water from Sullivan Lake helps achieve the load allocations downstream of Sullivan Creek during the September through October fall critical period, Ecology would acknowledge the PUD's effort to comply with the TMDL.*

25. Page xii and xiii: In the Executive Summary, the characterization of temperature conditions in the river implies that the maximum criteria exceedances occur throughout the entire critical periods, over-stating the typical temperature variances between natural and existing condition, even though the criteria are frequently met during the critical periods where the TMDL applies:
    Part 1. At page xxii, the TMDL states that "These reductions apply during July and August in the forebays of the dams, which are the areas of maximum temperature impairment." The statement above should be rephrased as follows:

    > *"While the River often meets the criteria in July and August, these reductions are based on the maximum temperature impairment during the entire July - August period, that is, they are what is needed to meet standards on the worst case day in July and August. The reductions apply in the forebays of the dams, which are the areas of maximum temperature impairment,".*

    Part 2. At page xiii, the TMDL states that "To achieve criteria during September and October, the level of temperature reduction required for the reaches are ..." Assuming that the Part 2 criteria apply (see SCL General Comments), SCL recommends that the following statement be added after the list of temperature reductions for the four Boundary reaches:

    > *"While the River often meets the criteria in September and October, these reductions are based on the maximum temperature impairment in each reach during the entire September -October period) that is, they are what is needed to meet standards on the worst case day in September and October."*

Response: *Ecology believes the suggested language minimizes the level of impairment found and will not change the language. Figures 18 and 19 in the TMDL show that the forebays are frequently warmer than natural conditions during the summer and fall critical periods. In addition, more river reaches require temperature reductions than the dams' forebays (see Table 11 on page 73 in the TMDL). Ecology applied the load allocations to the forebays because they had the highest temperatures and they occurred throughout more temperature percentiles than other river reaches. However, actions will be needed throughout the length of both reservoirs to reduce temperatures in all reaches exceeding standards.*

26. Page 32: A reference to natural and existing temperatures appears to be reversed. In the subsection titled "Peak temperature criteria", the sentence "To determine compliance with criteria, the existing condition temperature CFD was subtracted from the associated natural condition temperature CFD, based on similar percentiles, to derive what is referred to as a temperature differential." Based on the methodology presented in the remainder of this section, SCL believes that the sentence should read,

> *"To determine compliance with criteria, the natural condition temperature CFD was subtracted from the associated existing condition temperature CFD, based on similar percentiles, to derive what is referred to as a temperature differential."*

Response: *The text in the TMDL correctly states the method, because the temperature criterion requires that the temperature be within 0.3°C of the natural condition.*

27. Page 43, paragraph 3, last sentence: To more accurately represent Boundary dam operating conditions, SCL recommends' deleting the word "selective" from the following sentence.:

> *"The decrease in temperature, considering the full daily maximum temperature profile, is approximately 0.70"C between the forebay and tailrace due to the selective withdrawal of deeper, cooler water."*

Response: *Ecology made the suggested change.*

28. Page 73, Table 11: There is a typo at the asterisk on Table 11. The note should read identically to the asterisk note on Table ES-2 (p.xii), i.e., " ...O.3°C for part 1 and the allowable temperature increase for part 2".

Response: *Ecology fixed the error.*

29. Page 80, title of Table 15: SCL recommends that the title be revised to read *"Temperature load allocations,"* because there are both facility and reach specific allocations in the table. "Hydroelectric facilities load allocations," should be revised to more accurately reflect the contents of the table.

Response: *The allocations were assigned by source. The four Boundary reaches received allocations in Table 13 (page 77 of the TMDL) for canopy cover and tree height. Therefore,* *the reach-specific allocations in Table 15 do apply to both hydroelectric facilities, which Ecology clarified in the TMDL.*

30. Page 96: SCL recommends that the description of the timeline for SCL's actions be revised for consistency as follows: "Boundary dam will ~~receive one year from completion of the WQIP to finalize a water quality attainment plan and~~ have up to ten years from the issuance of its FERC license to meet water quality standards."

    Response: *Ecology accepted SCL's temperature attainment plan (TAP) as a draft for purposes of the 401 application (Offer of settlement and joint explanatory statement in support of settlement agreements and in support of motion to consolidate, March 2010). Therefore, SCL has up to 1 year to finalize the TAP.*

31. Page 98, Table 18: SCL recommends adding a footnote to the Boundary Dam Tailrace row in Table 18 (p.98) to state, "SCL will work with Ecology during the development of the QAPP to confirm the specific location of the tailrace monitoring station." This is due to safety concerns at the tailrace monitoring station location and recognizing that the location may need to be adjusted.

    Response: *Ecology added the suggested statement in the text on page 98 in the TMDL.*

References for the Response to Comments

Annear, R., C. Berger, and S. Wells (PSU). 2006. Pend Oreille River, Box Canyon Model: Model Development and Calibration. Technical Report EWR-04-06, Department of Civil and Environmental Engineering, Portland State University, Portland, OR.

Annear, R., C. Berger, and S. Wells (PSU). 2007. Pend Oreille River, Box Canyon Model: Model Scenario Simulations. Technical Report EWR-03-07. Department of Civil and Environmental Engineering, Portland State University, Portland, OR.

Breithaupt, S.A. and T. Khangaonkar. 2007. Temperature Modeling of the Pend Oreille River, Boundary Hydroelectric Project CE-QUAL-W2 Model Calibration Report. Prepared for Seattle City Light. Battelle – Pacific Northwest Division. Richland, WA. PNWD-3835.

Breithaupt, S., T. Khangaonkar and T. Kim. 2008. Temperature Modeling Analyses for Boundary Hydroelectric Project – CWA 401 Certification Support. 12/4/2008 Memo to Christine Pratt, Seattle City Light. Project No. 57415. 42 pages.

Environmental Protection Agency Region 10 (EPA). 2002. Region 10 TMDL Review Guidelines. http://yosemite.epa.gov/R10/water.nsf/ac5dc0447a281f4e882569ed0073521f/85a5f7e5c7384848882569a60062f446/$FILE/tmdl_cklst%202002.pdf

Keta Waters. Review of temperature modeling, Pend Oreille River. June 16, 2009 memo to Ken Merrill, Water Resources Manager, Kalispel Tribe Natural Resources Department. [*Appendix B to Keta Waters August 10, 2010 memo to Ken Merrill, Kalispel Tribe Natural Resources Department. Available as an attachment to the Kalispel Tribe's comments on the draft Pend Oreille Temperature TMDL: http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/Kalispelcomments.pdf*]

Keta Waters. Approaches for comparing predicted temperatures for the Pend Oreille River under existing and natural conditions. August 10, 2010 memo to Ken Merrill, Water Resources Manager, Kalispel Tribe Natural Resources Department. [*Attachment to Kalispel Tribe's comments on the draft Pend Oreille Temperature TMDL: http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/Kalispelcomments.pdf*]

Keta Waters. Review of temperature modeling, Pend Oreille River, Albeni Falls Model. November 26, 2010 memo to Ken Merrill, Water Resources Manager, Kalispel Tribe Natural Resources Department. [*Attachment to Kalispel Tribe's comments on the draft Pend Oreille Temperature TMDL: http://www.ecy.wa.gov/programs/wq/tmdl/pendoreille/Kalispelcomments.pdf*]

Mark Cauchy, e-mail message to author, January 7, 2011.

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Appendix H:
Changes to TMDL following dispute resolution

On April 6, 2011, the Washington State Department of Ecology (Ecology) sent the Pend Oreille River temperature Total Maximum Daily Load (TMDL) to the Environmental Protection Agency (EPA) for approval. During EPA's review and prior to its final approval, affected parties Seattle City Light (SCL) and the Pend Oreille Public Utility District No. 1 (PUD) initiated Ecology's dispute resolution process. The dispute resolution process is a mechanism by which a local entity or citizen can request reconsideration of final TMDLs developed by Ecology, and/or bring a dispute of a procedural step in the TMDL development process. Among the outcomes of the dispute resolution process Ted Sturdevant, the Director of Ecology, decided to amend the TMDL with the following minor changes (see full director's letter in this appendix):

- The TMDL needs to clarify that the compliance path for the PUD is the compliance schedule outlined in the Water Quality Standards [WAC 173-201A-510(5)]. This is the same path as that used for all dams going through Federal Energy Regulatory Commission re-licensing.
- The temperature reduction target in the Boundary Dam forebay needs to reflect the temperature signal from the PUD's Box Canyon Dam. The required temperature reduction in the Boundary forebay should be 0.76^oC, not the 0.88^oC listed in the TMDL. However, SCL's allocation remains unchanged at natural conditions + 0.12^oC. The distinction is that the PUD's efforts to implement the TMDL will result in reduced temperatures flowing into Boundary Dam's forebay. Therefore, the cumulative temperature reduction from both the PUD and SCL is a temperature reduction of 0.76^oC in the Boundary Dam forebay.

To fulfill these required changes, Ecology developed an errata sheet (attached in this appendix) describing the specific sections and language changes to the TMDL. On September 14, 2011, Ecology requested comments on the errata from affected parties to the TMDL due by September 30, 2011. Three sets of comments (attached in this appendix) were received. Only comments that pertained to the errata sheet changes were considered for possible addition to the errata.

Additional technical analysis by Ecology following the dispute resolution process is also provided in this appendix.

Errata

Pend Oreille River Temperature Total Maximum Daily Load: Water Quality Improvement Report

October 2011
Publication No. 10-10-065

On April 6, 2011, the Washington State Department of Ecology sent the Pend Oreille River temperature Total Maximum Daily Load (TMDL) to the Environmental Protection Agency (EPA) for approval. During EPA's review and prior to its final approval, affected parties Seattle City Light (SCL) and the Pend Oreille Public Utility District No. 1 (PUD) initiated Ecology's dispute resolution process. The dispute resolution process is a mechanism by which a local entity or citizen can request reconsideration of final TMDLs developed by Ecology, and/or bring a dispute of a procedural step in the TMDL development process. Among the outcomes of the dispute resolution process Ted Sturdevant, the Director of Ecology, decided to amend the TMDL with the following minor changes:

- The TMDL needs to clarify that the compliance path for the Pend Oreille Public Utility District (PUD) is the compliance schedule outlined in the Water Quality Standards [WAC 173-201A-510(5)]. This is the same path as that used for all dams going through Federal Energy Regulatory Commission (FERC) re-licensing.

- The temperature reduction target in the Boundary Dam forebay needs to reflect the temperature signal from the PUD's Box Canyon Dam. The required temperature reduction in the Boundary forebay should be 0.76^oC, not the 0.88^oC listed in the TMDL. However, SCL's allocation remains unchanged at natural conditions + 0.12^oC. The distinction is that the PUD's efforts to implement the TMDL will result in reduced temperatures flowing into Boundary Dam's forebay. Therefore, the cumulative temperature reduction from both the PUD and SCL is a temperature reduction of 0.76^oC in the Boundary Dam forebay.

Ecology intends to make these and possibly other minor changes (noted in underlined and strike-out text) in the following locations in the online version of the TMDL (Ecology publication number 10-10-065) following review and comment by affected parties:

- Page xii, **Allocations**:

  Hydroelectric facilities: When natural condition river temperatures are greater than 20^oC (July and August), load allocations have been set equivalently at 0.12^oC above the natural temperature condition for the Box Canyon and Boundary facilities due to the inter-relationship of the temperature impacts and the associated cumulative impacts in the watershed. The temperature reduction required to achieve the load allocations for Box Canyon and Boundary is 1.13^oC and $\underline{0.76^oC}$, respectively, based on 2004 results. These reductions apply during July and August in the forebays of the dams, which are the areas of maximum temperature impairment.

- Page xiii, **Planning and implementation to achieve criteria**, first paragraph:

  The Pend Oreille Public Utility District (PUD) and Seattle City Light (SCL) own and operate Box Canyon Dam and Boundary Dam, respectively. As part of their Federal Energy Regulatory Commission (FERC) license, these utilities will complete actions in their 401 Water Quality Certifications to achieve the temperature criteria for the Pend Oreille River. <u>Specifically, Seattle City Light and the Pend Oreille PUD will follow the dam compliance schedule outlined in the state water quality standards [WAC 173-201A-510(5)]</u>. In addition, Pend Oreille River watershed residents and landowners are called upon to reduce water temperature by increasing the number of native trees and shrubs along the Pend Oreille River and its tributaries.

- Page 79, second paragraph is modified with the following:

  Given the interrelationship in the temperature impacts of Box Canyon and Boundary facilities and their associated cumulative impacts, the load allocations have been set equivalently for both at 0.12°C above the natural temperature condition. This totals 0.24°C of the 0.3°C allowance, which is the greatest equitable temperature that leaves a sufficient temperature reserve for future economic growth in the watershed. Based on the forebays, the most impacted reaches within the study area, 2004 results indicate that the level of temperature reduction required to achieve this load allocation for Box Canyon and Boundary is 1.13°C and <u>0.76°C</u>, respectively (Table 15). {<u>*paragraph break*</u>}

  ~~These temperatures are~~ <u>The 1.13°C temperature reduction target for the Box Canyon Dam forebay is</u> derived by taking the <u>1.25°C maximum temperature differential for the Box Canyon Forebay from Table 6 and subtracting 0.12°C.</u> ~~level of exceedence for the forebay found in Table 11 and adding 0.18°C. [Because in Table 11, the exceedence is the temperature above 0.3°C. However, the allocation is for 0.12°C above natural conditions, so the level of exceedence must be increased by the difference between 0.12°C and 0.3°C (0.3 - 0.12 = 0.18).]~~

  <u>The 0.76°C temperature reduction target for the Boundary Dam forebay is calculated by subtracting 0.12°C for the PUD's allocation and 0.12°C for SCL's allocation from the 1.00°C maximum temperature differential for the Boundary Forebay in Table 6. [Boundary forebay maximum impairment (1.00°C), minus the PUD's allocation that is passed downstream (0.12°C), minus SCL's allocation (0.12°C), equals the temperature reduction required in the Boundary forebay (0.76°C).]</u>

Page 80, Table 15. Hydroelectric facilities load allocations.

Reaches Requiring Temperature Reductions		Temperature Reduction Level Required to Achieve Criteria: Part 1 Natural Condition + 0.12°C Summer Critical Period (July – August)	Temperature Reduction Level Required to Achieve Criteria: Part 2 Fall Critical Period (September – October)
Box Canyon	Box Canyon Forebay	1.13°C	=====
Boundary	Metaline	====	0.14°C
	Slate	====	0.24°C
	Forebay	0.76°C	0.61°C
	Tailrace	====	0.53°C

- Pages 86-88, Nonpoint sources, **Box Canyon and Boundary dams**:
  - Page 86, second paragraph

    The Pend Oreille PUD received their 401 certification from Ecology in 2003, and a new FERC license for Box Canyon Dam in July 2005. **A condition of the Pend Oreille PUD's 401 certification states that the provisions in the TMDL's WQIP will supersede the water temperature conditions in their 401 certification.*** Seattle City Light is in the process of relicensing Boundary Dam (the license expires in 2011).

    **Bold text was originally struck in September 2011 errata and added back in response to comments.*

  - Page 87, second paragraph

    The approach the Pend Oreille PUD and Seattle City Light will use to meet the load allocations in this TMDL will be consistent with requirements found in the state water quality standards [Washington Administrative Code (WAC) 173-201A-510(5)], which assigns a ten-year compliance schedule to dams. This rule requires dam owners to develop a Water Quality Attainment Plan. The water quality attainment plan provides a detailed approach for achieving compliance and must contain five elements specific to temperature:

    - A schedule to achieve compliance that does not exceed ten years.
    - The identification of all reasonable and feasible improvements that could be used to meet standards, or if meeting the standards is not attainable, then achieve the highest attainable level of improvement.

- A description of the methods used to evaluate the reasonable and feasible improvements.

- A plan to conduct water quality monitoring after activities are implemented with appropriate adaptive management steps.

- The benchmarks and reporting requirements that will be used to track the progress of implementing the water quality attainment plan and meeting water quality standards.

  - Page 87, fifth paragraph

    After the Water Quality Attainment Plan is implemented, Ecology and the dam operator will decide what the next steps are (whether completed actions meet water quality standards; another compliance schedule is appropriate; or surface water quality standards should be changed). **If after the Pend Oreille PUD or Seattle City Light complete all reasonable and feasible improvements under WAC 173-201A-510(5)(g), and their load allocation is still not met by the timeline set in this TMDL, then the dam owner would take the following steps to achieve compliance with the standards:**

    - **Evaluate new reasonable and feasible technologies or other options.**

    - **Develop a new compliance schedule to evaluate and incorporate any new technology.**

    - **If no new reasonable and feasible technologies are identified, propose other alternatives as allowed by WAC173-201A-510.***

    **Bold text was originally struck in September 2011 errata and added back in response to comments.*

- Page 92, paragraph four, *Pend Oreille Public Utility District (PUD)*:

  Pend Oreille Public Utility District (PUD): The Pend Oreille PUD is responsible for implementing provisions of their license for Box Canyon Dam that FERC issued in July 2005. In February 2003, Ecology issued a water quality certification which is included as part of the FERC license.

  Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispel Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreille PUD to implement a Trout Habitat Restoration Program (THRP). The THRP calls for the restoration and maintenance of 164 miles of tributary habitat, of which 66 miles will occur in the first ten years, 66 in the second ten years, and 32 in the remaining five year period. The THRP will include a combination (some or all) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:

- Channel improvements (limited to geomorphologic improvements and barrier removal)
- Floodplain restoration
- Riparian corridor restoration
- Conservation easements and/or purchases

Similar to Seattle City Light's Water Quality Attainment Plan (see next bulleted item),, Ecology will use current actions from Pend Oreille PUD settlement agreement as evidence demonstrating that the PUD is moving toward meeting applicable temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the ten-year compliance schedule.

The Pend Oreille PUD should keep the public; Kalispel Tribe; Idaho DEQ; Ecology; the Tri-State Water Quality Council; and the EPA informed of the status of the project. A copy of the license for Box Canyon Dam can be found on the PUD's website: www.popud.com/license.htm

- Page 93, second paragraph, *Seattle City Light*:

  Seattle City Light: Seattle City Light is working on relicensing Boundary Dam. Studies conducted to identify and understand the environmental and other effects of the dam will help identify water quality conditions that may be incorporated into Ecology's 401 certification. Seattle City Light will be responsible for implementing requirements of its water quality attainment plan and provisions of its new FERC license.

  Seattle City Light has a settlement agreement that was signed on March 23, 2010, by the Bureau of Indian Affairs; National Park Service; United States Fish and Wildlife Service; Untied States Department of Agriculture Forest Service; Washington Department of Fish and Wildlife; Washington Department of Ecology; Kalispel Tribe; Public Utility District No. 1 of Pend Oreille County; Washington; American Whitewater; Selkirk Conservation Alliance; and the Lands Council. Seattle City Light developed a temperature Water Quality Attainment Plan that Ecology approved. The plan will rely on all actions in the settlement agreement that may improve temperatures in the mainstem and tributaries. The first ten years of the 401 compliance schedule includes the following activities:

  - Mill Pond Dam Removal and Stream Channel Restoration.
  - Stream and Riparian Improvements in Sullivan Creek North Fork Sullivan Creek.
  - Large woody debris placement and Road improvements in Sullivan Creek and selected tributaries upstream of the confluence with Outlet Creek.
  - Habitat protection, riparian improvement, and stream channel enhancement in Sullivan Creek.
  - Cold water release structure at Sullivan Dam.
  - Mainstem large woody debris at tributary deltas; two at Sullivan, one at Sweet, Slate, and Linton Creeks.
  - Mainstem erosion control measures and riparian plantings.

Monitoring will be required in the tributaries where improvements are expected and in the mainstem of the river.

Seattle City Light should keep the public; Kalispel Tribe; Ecology; the Tri-State Water Quality Council; and the EPA informed of the status of its progress in addressing specified water quality conditions. The format and venue for sharing information regarding compliance may be detailed in the water quality attainment plan. Information about Seattle City Light's relicensing efforts is available on the Web at: www.ci.seattle.wa.us/light/news/isssues/bndryRelic/br_document.as

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DEPARTMENT OF ECOLOGY
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711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

August 26, 2011

(See Distribution List)

RE: Pend Oreille Temperature TMDL Dispute

Dear Mr. Cauchy, Mr. Geddes, Ms. Greene and Mr. Merrill:

Thank you for the thought and time you put into your written submittals and verbal testimony regarding the Pend Oreille Temperature Total Maximum Daily Load (TMDL). The issues raised emphasize the complexity of developing a TMDL and the coming challenges of implementing one. The Dispute Resolution Panel carefully considered the issues and forwarded its recommendations to me. This letter constitutes my decision, as required by the Washington State Department of Ecology's (Ecology) TMDL Dispute Resolution Policy.

The TMDL will be resubmitted to the Environmental Protection Agency (EPA) with the following changes:

1. The TMDL will clarify that the compliance path for the Pend Oreille Public Utilities District (PUD) will be the compliance path that we have outlined in our Water Quality Standards and is the same compliance path that we have used with all dams that are going through Federal Energy Resource Commission (FERC) re-licensing.

2. The temperature target reduction value for the Boundary Forebay reach will be 0.76°C as recommended by the Dispute Panel (Panel). However, the wasteload allocation values for each dam will remain unchanged at 0.12°C.

Enclosed is a list of each of the claims and the related decisions that I have made. In three instances, the Panel recommended that Ecology staff perform additional analyses, which I considered in making my decisions.

Sincerely,

Ted Sturdevant by Polly Zehm

Ted Sturdevant
Director

Enclosure

Distribution List:
Mark Cauchy, Director, Regulatory and Environmental Affairs - Pend Oreille PUD No. 1
Bob Geddes, General Manager - Pend Oreille PUD No. 1
Barbara Greene, Boundary Licensing Project Manager - Seattle City Light
Ken Merrill, Water Resources Manager - Kalispel Tribe of Indians

cc: Jerry Boyd, Attorney - Pend Oreille PUD No. 1
Joan Marchioro, Attorney - Attorney General's Office
David Moore, WQ TMDL/Watershed Unit Supervisor - Ecology
Helen Rueda, TMDL Project Manager - U.S. Environmental Protection Agency
Kari Vander Stoep, Attorney - Seattle City Light
Matt Wells, Attorney - Seattle City Light
Laura White, Legal Secretary - Seattle City Light

Dispute claims:

Dispute Claim SCL-1: Maximum surface temperatures are not representative and should not be used to assess compliance.

Decision-Do not change Total Maximum Daily Load (TMDL). *Designated aquatic uses apply to the entire river and at all depths. With the exception of a water quality offset (or possibly mixing zones provided in permits), there is no exemption in the Surface Water Quality Standards to allow a violation of numeric criteria in portions of a waterbody simply because standards are met in other parts of the waterbody. All areas of the waterbody must meet the numeric criteria. Furthermore, the upper portion of the water column is critical habitat for many organisms due to a higher productivity occurring in the euphotic zone which encourages phytoplankton growth, and therefore provides food for the fish and other aquatic organisms being protected by the water quality standards. Fish and other aquatic organisms use this important habitat so it is important that the upper portions of the water column also meet water quality standards.*

Also, the water quality standards require that when there is an exceedance of the temperature criteria, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3C. This provision of the Water Quality Standards applies when natural temperatures exceed the numeric criteria, as is the case with the Pend Oreille River.

Dispute Claim SCL-2: The second part of the temperature criteria does not apply to the TMDL. The second part is correlated to a formula that applies to incremental temperature increases resulting from individual point source activities.

Decision-Do not change TMDL. *We disagree with this claim. Our Attorney General's December 28, 2009, legal opinion regarding the use of the incremental warming provisions for temperature in Washington's water quality standards during development of a TMDL clearly sets forth Ecology's position on this issue.*

Dispute Claim SCL-3: Load Allocation to the Boundary [Dam] facility should acknowledge the cumulative effect of Box Canyon [Dam] in the Boundary forebay reach.

Decision-Do not change TMDL. *The temperature reduction target listed for Part 1 of the criteria for the Boundary Dam forebay in Table 15 on Page 80 of the report will be changed from 0.88°C to 0.76 C. This will require a TMDL amendment.*

Dispute Claim PUD -1: Maximum surface temperatures are not representative of conditions in the river and should not be used to assess compliance.

Decision-Do not change TMDL. *Department of Ecology's (Ecology) Water Quality staff reviewed the model and met with Environmental Assessment Program staff that were responsible for the modeling. Summer-period water column temperatures measured late-July and mid-August (2004) indicate distinct differences in comparison to those predicted by the TMDL model (refer to figure below). Measured* *water column temperatures observed during monitoring events indicate only slight temperature variation whereas the model output displayed a consistent pattern of increased heating with decreasing depth (comparisons retained same location and times). This surface "flare" pattern was most pronounced for depths less than approximately 4-meters. Though segment 334 is displayed in the figure, this pattern was common among the 14 monitoring locations examined within the section of the river between the Washington/Idaho state-line and the Box Canyon facility. Ecology agrees that this relationship could be a concern because the TMDL analysis used daily maximum temperatures which occur within the very upper portion of the water column. In addition, the model-predicted temperatures were consistently greater than those observed during monitoring at the majority of the monitored locations again with the greatest differences occurring at shallower depths suggesting model bias.*

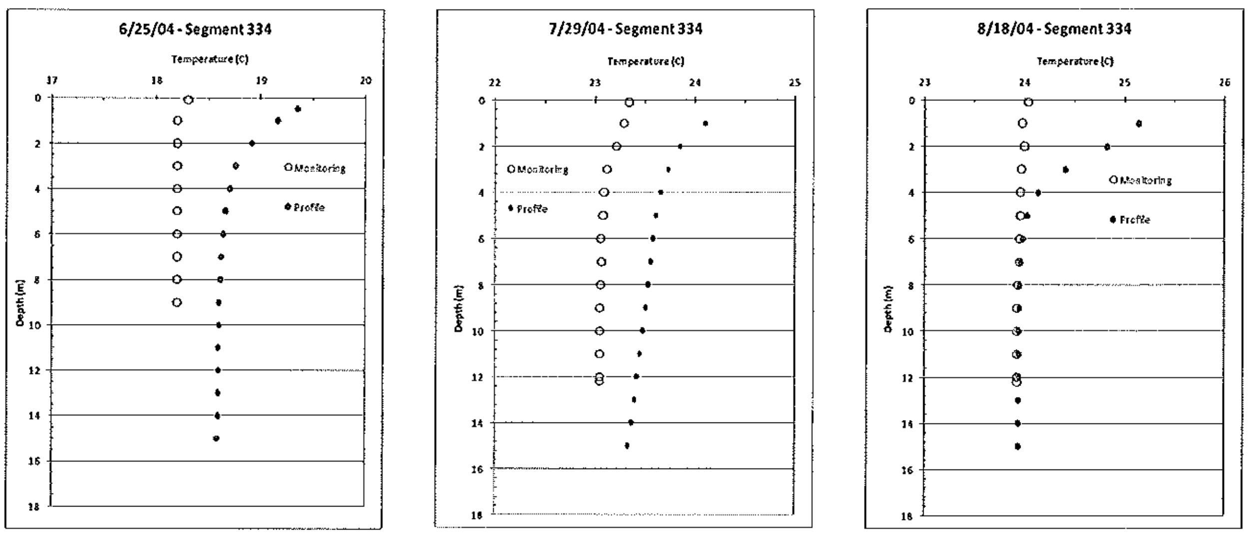

Figure. Relationship between measured (monitoring) and model-predicted (profile) temperatures for model segment 334 (river mile 38).

However, in examining differences between monitoring and modeled temperatures it is important to note that the monitoring events are only a "snapshot" of temperature variation. For instance, among the monitoring events undertaken only two occurred when water temperatures were above 20°C (defining the critical period) and did not coincide with times when the daily maximum temperature occurred. A more comprehensive perspective of the relationship between the model and measured temperatures was determined for segment 334 (river mile 38 within the Tiger reach) at 3-meters depth by comparing the daily maximum temperatures based on TidBit data logger measurements and model output (refer to figure below). As observed, there is a relatively close relationship between the measured (TidBit) and model. The mean error for the data depicted is -.01°C indicating insignificant bias with the root mean squared error of 0.64°C, indicating a good fit between the measured and predicted temperatures. Overall, these numbers are indicative of a well calibrated model. Similar numbers were found at the other monitoring locations. (TidBits were set at 7 locations within the Box Canyon section of the river.)

Importantly, there is not the systematic model bias present suggested by the comparison of "snapshot" measured and modeled vertical temperature profiles. In fact, referring to the figure below, for segment 334 on July 29, the model-predicted temperatures are slightly higher than measured by the TidBit while on August 18 they're close in magnitude, similar to the relationship presented in the figure above. This indicates the importance of taking a longer-term perspective when making these types of comparisons to account for overall variability. The TMDL was not based on one day rather it considered when temperatures were above 20°C a situation which, in 2004, occurred over an approximately 60-day period (below figure).

While the examination of temperatures at 3-meters indicates the model provides a reasonably good fit between measured and predicted temperatures what about for shallower depths? Unfortunately, there were no TidBit data-loggers set for depths shallower than 3-meters in reaches the TMDL found to be the most impacted by the Box Canyon facility (Tiger and Forebay). So there is no means to confirm the increased heating the model predicts for shallower depths.

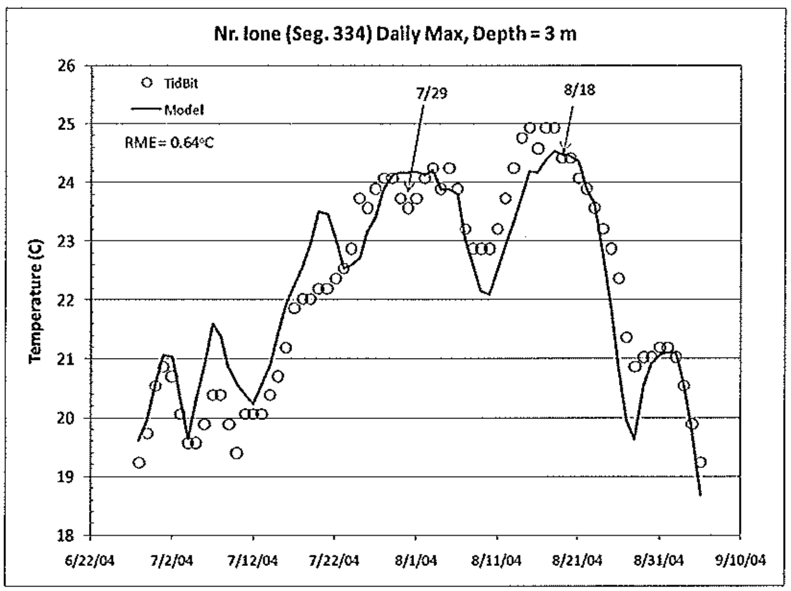

Figure. Relationship between measured (TidBit) and model-predicted daily maximum temperatures for segment 334 (Tiger reach, river mile 38.3).

A temperature impairment is still found for the Box Canyon forebay reach when the daily maximum temperatures at 3-meters are used, as opposed to the water column daily maximum (TMDL approach), though predictably the level of impairment is considerably lower (refer to figure below).

Summary:

- *The temperature model applied in the Pend Oreille River TMDL, based on a longer-term relationship between predicted and measured daily maximum temperatures (seven locations) within the Box Canyon affected section of the river, appears well calibrated.*

- *For the majority of the monitoring locations, this assessment of calibration occurs at a depth of 3-meters. This depth is approximately the inflection point that model-predicted temperatures were found to increase at a higher rate for shallower depths in comparison to those measured during routine water column monitoring.*
- *Temperature data-loggers were not set for depths shallower than 3-meters in the sections of the river found to be most affected by the Box Canyon facility (Box Canyon forebay and Tiger reaches). For this reason, there is no means to either directly confirm or deny that the model found to be well calibrated at 3-meters is also well-calibrated for shallower depths. Violations of the criteria exist 3 meters below and the model is valid for the purpose of moving forward with the TMDL. However further sampling and analysis will be helpful as part of the 10 year evaluation.*

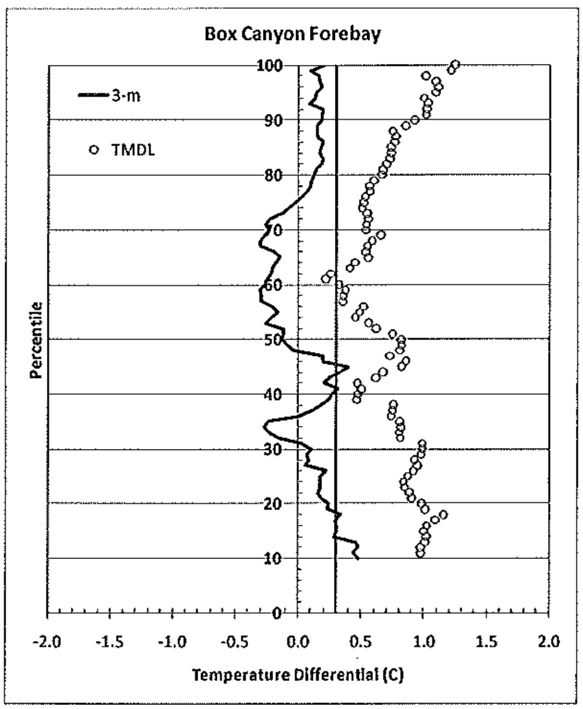

Figure. Temperature differentials based on the TMDL in comparison to daily maximum temperatures at 3-meters. (Differentials greater than 0.3°C (vertical red line) indicate a temperature impairment.)

Dispute Claim PUD -2 & Dispute Claim PUD-3: Ecology has no clear plan for judging success of future implementation measures employed toward meeting water temperature allocations. The TMDL establishes temperature goals that are unachievable by any reasonable means.

Decision: *We disagree with this claim, but will revise the TMDL to clearly articulate the following compliance pathway.*

In 2003 Ecology developed a regulatory pathway to issue Clean Water Act Section 401 certifications for existing dams. At that time we recognized that it would be a challenge to show that existing dams were not having an impact on water quality. We developed rule language that would have dam operators develop a Water Quality Attainment Plan to identify actions they can implement to address pollution. The Water Quality Attainment Plan will include monitoring after activities are implemented and adaptive management steps. The dams are given a 10 year compliance schedule and after the Water Quality Attainment Plan has been implemented Ecology and the dam operator will decide what the next steps are (completed actions meet water quality standards, another compliance schedule is appropriate, or surface water quality standards should be changed.

In this TMDL there are two dam operators and we are on the following paths to bring them into compliance with the dam compliance language in the Water Quality Standards:

Seattle City Light- Boundary Dam: *Seattle City Light has a settlement agreement that was signed on March 23, 2010, by Bureau of Indian Affairs, National Park Service, United States Fish and Wildlife Service, Untied States Department of Agriculture Forest Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, Kalispel Tribe, Public Utility District No. 1 of Pend Oreille County, Washington, American Whitewater, Selkirk Conservation Alliance, and the Lands Council. Seattle City Light has just recently (within the last 2 months) developed a Temperature Water Quality Attainment Plan that Ecology has approved. We have worked extensively with them and the plan will rely on all actions in the settlement agreement that may improve temperatures in the mainstem and tributaries. These will be the actions for the first 10 years of the 401 compliance schedule and include the following activities:*

- *Mill Pond Dam Removal and Stream Channel Restoration*
- *Stream and Riparian Improvements in Sullivan Creek North Fork Sullivan Creek*
- *Large Woody Debris placement and Road improvements in Sullivan Creek and Selected tributaries upstream of the confluence with Outlet Creek*
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- *Mainstem Large Woody Debris at tributary deltas; two at Sullivan, one at Sweet, Slate, and Linton Creeks*
- *Mainstem erosion control measures and riparian plantings*

Monitoring will be required in the tributaries where we expect to see improvements and we will also include monitoring stations in the mainstem of the river. This additional monitoring component is required by the Dam Compliance Provision in the Water Quality Standards WAC 173-201A-510(5).

Pend Oreille PUD Box Canyon Dam

Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispel Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreille PUD to implement a Trout Habitat Restoration Program (THRP). The THRP calls for the restoration and maintenance of 164 miles of tributary habitat of which 66 miles will occur in the first 10 years, 66 in the second 10 years and 32 in the remaining 5 year period. THRP will include a combination *(some or all) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:*

- *Channel improvements (limited to geomorphologic improvements and barrier removal)*
- *Floodplain restoration*
- *Riparian corridor restoration*
- *Conservation easements and/or purchases*

Similar to Seattle City Light's Water Quality Attainment Plan, we will use current actions from Pend Oreille PUD settlement agreement as evidence demonstrating that the PUD is moving toward meeting applicable temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the 10 year compliance schedule.

Dispute Claim PUD - 4: The TMDL does not take into account normal water temperatures, flows, seasonal variation, and existing sources of heat required by 33 U.S.C. 1313(d)(1)(D).

Decision: *We disagree with this claim. The TMDL, as written, takes into account normal water temperatures, flows, seasonal variation, and existing sources of heat. The use of the dynamic model to simulate multiple years (and seasons) using existing river flows and other environmental conditions exceeds the technical expectations or requirements for conducting a temperature TMDL study and assessment of the Pend Oreille River system. The use of the cumulative frequency distribution to assess changes in maximum temperatures within a reach between scenarios is technically appropriate, because using other methods would not account for spatial and temporal differences that are expected when comparing two different hydraulic systems (i.e., existing vs. natural).*

<u>Distribution List:</u>

Mark Cauchy, Director, Regulatory and Environmental Affairs - Pend Oreille PUD No. 1
Bob Geddes, General Manager - Pend Oreille PUD No. 1
Barbara Greene; Boundary Licensing Project Manager - Seattle City Light
Ken Merrill, Water Resources Manager- Kalispel Tribe of Indians

cc: Jerry Boyd, Attorney- Pend Oreille PUD No. 1
Joan Marchioro, Attorney - Attorney General's Office
David Moore, WQ TMDL/Watershed Unit Supervisor- Ecology
Helen Rueda, TMDL Project Manager- U.S. Environmental Protection Agency
Kari Vander Stoep, Attorney - Seattle City Light
Matt Wells, Attorney- Seattle City Light
Laura White, Legal Secretary - Seattle City Light

Dispute claims:

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Decision-Do not change Total Maximum Daily Load {TMDL}. Designated aquatic uses apply to the entire river and at all depths. With the exception of a water quality offset {or possibly mixing zones provided in permits), there is no exemption in the Surface Water Quality Standards to allow a violation of numeric criteria in portions of a waterbody simply because standards are met in other parts of the waterbody. All areas of the waterbody must meet the numeric criteria. Furthermore, the upper portion of the water column is critical habitat for many organisms due to a higher productivity occurring in the euphotic zone which encourages phytoplankton growth, and therefore provides food for the fish and other aquatic organisms being protected by the water quality standards. Fish and other aquatic organisms use this important habitat so it is important that the upper portions of the water column also meet water quality standards.

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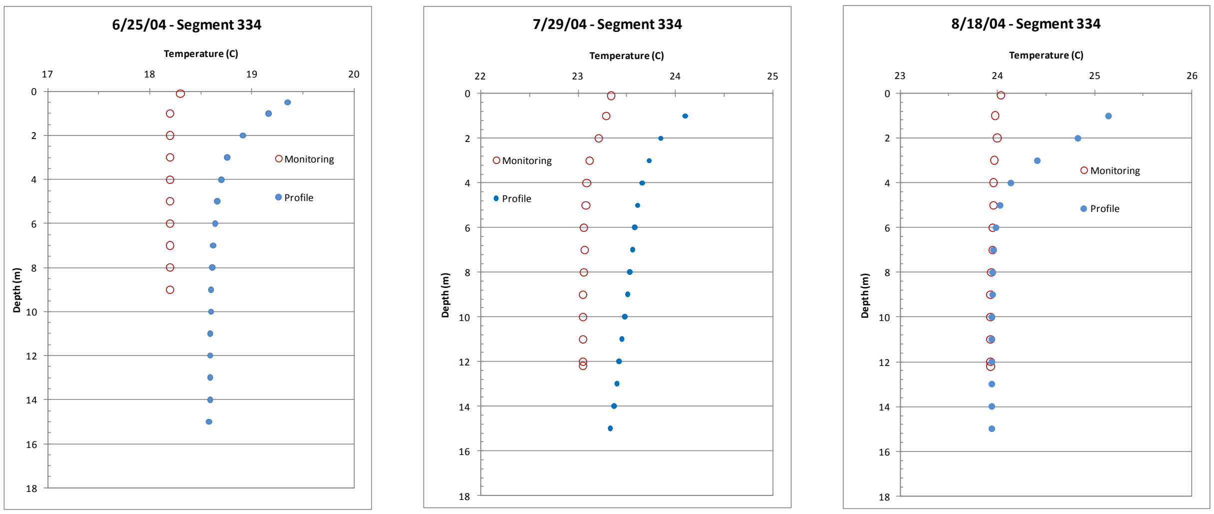

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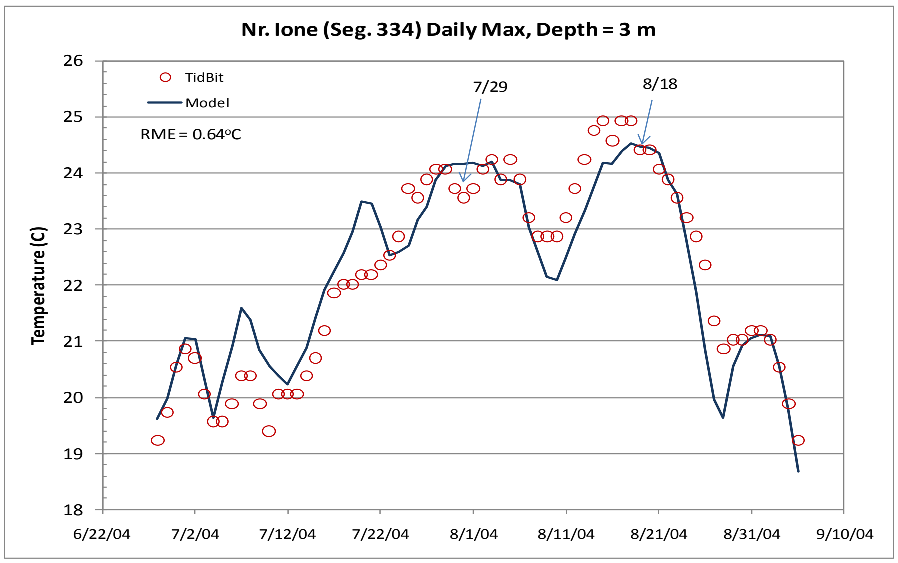

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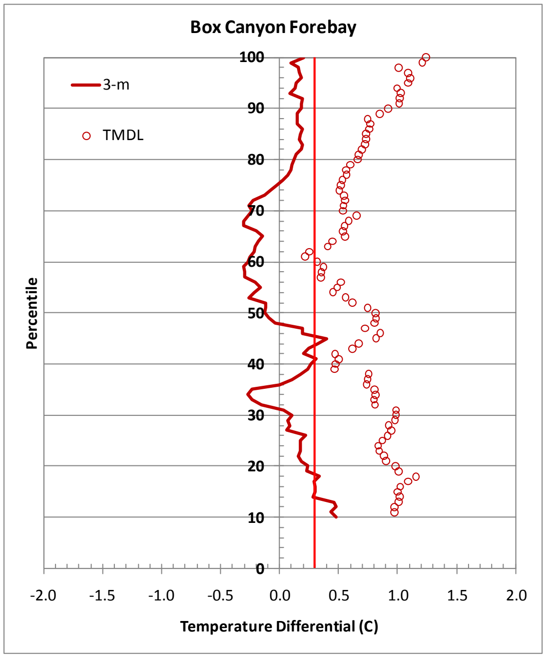

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Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispef Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreil/e PUD to implement a Trout Habitat Restoration Program (THRP}. The THRP calfs for the restoration and maintenance of 164 miles of tributary habitat of which 66 miles will occur in the first 10 years, 66 in the second 10 years and 32 in the remaining 5 year period. THRP will include a combination *(some or al1) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:*

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- *Floodplain restoration*
- *Riparian corridor restoration*
- *Conservation easements and/or purchases*

Similar to Seattle City Light's Water Quality Attainment Plan we will use current actions from Pend Oreille PUD settlement agreement as evidence demonstrating that the PUD is moving toward meeting applicable temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the 10 year compliance schedule.

Dispute Claim **PUD-** 4: The TMDL does not take into account normal water temperatures,flows, seasonal variation,and existing sources of heat required by 33 U.S.C.1313(d}(1)(D).

Decision: *We disagree with this claim. The TMDL, as written, takes into account normal water temperatures, flows, seasonal variation, and existing sources of heat. The use of the dynamic model to simulate multiple years (and seasons) using existing river flows and other environmental conditions exceeds the technical expectations or requirements for conducting a temperature TMDL study and assessment of the Pend Oreille River system. The use of the cumulative frequency distribution to assess changes in maximum temperatures within a reach between scenarios is technically appropriate, because using other methods would not account for spatial and temporal differences that are expected when comparing two different hydraulic systems (i.e., existing vs. natural).*

August 15, 2011

TO: Pend Oreille TMDL Dispute Panel

FROM: Melissa Gildersleeve, Manager
Watershed Management Section

RE: Additional work related to the panel recommendations

Below are our responses to the additional items that the Director wanted prior to making his final recommendation. Please let me know if I missed a key component that you thought needed additional attention. If this addresses the further analysis you wanted, then please let us know and we will forward this information to the Director so he can make a final decision. We have a meeting scheduled with him on August 17 and would like to get this additional information to him on August 15.

1. **The Panel recommends that Ecology develop a more detailed response that addresses the application and interpretation of the criteria to the Pend Oreille River, and that links the assumptions made in interpreting the water quality model results to the protection of beneficial uses.**

   Designated aquatic uses apply to the entire river and at all depths. With the exception of a water quality offset (or possibly mixing zones provided in permits), there is no exemption in the Surface Water Quality Standards to allow a violation of numeric criteria in portions of a water body simply because standards are met in other parts of the water body. All areas of the water body must meet the numeric criteria. Furthermore, the upper portion of the water column is critical habitat for many organisms due to a higher productivity occurring in the euphotic zone, which encourages phytoplankton growth, and therefore provides food for the fish being protected by the water quality standards. Fish cannot avoid this area since they must spend time there to eat, so it is important that waters at the surface meet water quality standards.

   In addition, the criteria say that when there is an exceedance, no temperature increase will be allowed which will raise the receiving water temperature by greater than 0.3C. This is the antidegredation provision of the Water Quality Standards (WQS).

Relation to recent TDG discussion

A similar argument that surface water habitat can be ignored has been made for exceeding TDG numeric criteria. It has been argued that if fish can move lower in the water column (below compensation depth) to avoid the effects of gas, Ecology can determine that designated uses are met. This argument is faulty because the ability for a set of organisms to avoid a pollutant is not a basis for allowing violations. Again, the upper portion of the water column is important habitat and cannot be ignored when applying numeric criteria.

Spatial and temporal averaging – the issue of the weighted volume method

A note on averaging of monitoring data to determine compliance with standards: The water quality standards contain specific instructions on averaging data spatially and temporally for determining compliance with standards. Bacteria and temperature are two examples where Ecology describes where it is appropriate to average values. In other words, the standards do not allow for spatial averaging of temperature. This is the basis for arguing against the volume-flow weighted approach that Seattle City Light (SCL) did in its Pend Oreille River (POR) temperature analysis. The volume-flow weighted approach uses spatial averaging to mask areas where the water is not meeting criteria. SCL has stated that if you average temperature in the water column then there is no violation of the temperature criteria. The point here is that the standards do not allow a spatial averaging for temperature in a river. If the WQS allowed this, it would state such.

2. **The Panel recommends that Ecology provide a summary that defines compliance expectations and measures of success including how to collect the temperature data needed to show compliance, especially in the mainstem.**

   In 2003, Ecology developed a regulatory pathway to issue 401 certifications for existing dams. At that time, we recognized that it would be a challenge to show that existing dams were not having an impact on water quality. We developed rule language that would have dam operators develop a water quality attainment plan to identify actions they will implement that will address pollution, monitoring after activities are implemented and adaptive management steps. The dams are given a ten-year compliance schedule. After the water quality attainment plan has been implemented, Ecology and dam operator will decide what the next steps are (completed actions meet water quality standards, or another compliance schedule, or change surface water quality standards).

In this TMDL, there are two dam operators. We are on the following paths to get them in compliance with the dam compliance language in the Water Quality Standards:

Seattle City and Light - Boundary dam: Seattle City and Light has a settlement agreement that was signed on March 23, 2010, by Bureau of Indian Affairs, National Park Service, United States Fish and Wildlife Service, Untied States Department of Agriculture Forest Service, Washington Department of Fish and Wildlife, Washington Department of Ecology, Kalispell Tribe, Public Utility District No. 1 of Pend Oreille County, Washington, American Whitewater, Selkirk Conservation Alliance, and the Lands Council. Seattle City and Light has just recently (within the last two weeks) developed a temperature water quality attainment plan that Ecology has approved. We have worked extensively with them and the plan will rely on all actions in the settlement agreement that have any connection to temperature issues in the mainstem and tributaries. In addition to those actions, we will require temperature monitoring on the mainstems. These will be the actions for the first ten years of the 401 compliance schedule and include the following activities:

- Mill Pond Dam Removal and Stream Channel Restoration.
- Stream and Riparian Improvements in Sullivan Creek North Fork Sullivan Creek.
- Large Woody Debris placement and Road improvements in Sullivan Creek and selected tributaries upstream of the confluence with Outlet Creek.
- Habitat protection, riparian improvement, and stream channel enhancement in Sullivan Creek.
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- Mainstem Large Woody Debris at tributary deltas; two at Sullivan, one at Sweet, Slate, and Linton Creeks.
- Mainstem erosion control measures and riparian plantings.

Monitoring will be required in the tributaries where we expect to see improvements and we will also include monitoring stations in the mainstem of the river.

Pend Oreille PUD and Box Canyon Dam

Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispell Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreille PUD to implement a Trout Habitat Restoration Program (THRP). The THRP calls for the restoration and maintenance of 164 miles of tributary habitat of which 66 miles will occur in the first 10 years, 66 in the second 10 years and 32 in the remaining 5 year period. THRP will include a combination (some or all) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:

- Channel improvements (limited to geomorphologic improvements and barrier removal)
- Floodplain restoration
- Riparian corridor restoration
- Conservation easements and/or purchases

Similar to the Seattle City and Light Attainment Plan, we will use Current Actions from Pend Oreille PUD settlement agreement to show the PUD is moving toward meeting Temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the ten-year compliance schedule.

Next Steps for working with Pend Oreille PUD following TMDL Approval

- Table 17 of the POR TMDL report lists interim and final targets for the TMDL with a timeline that begins with the development of the Water Quality TMDL Implementation Plan. A key piece of that implementation plan will be the development of the temperature water quality attainment plan. The attainment plan is already done for Boundary dam and work on the attainment plan for Box Canyon should begin following approval of the TMDL and not wait until a water quality improvement plan (WQIP) is finished.
- Our thoughts were that as Seattle City Light (SCL) had used habitat restoration components from their fish management plans contained in their settlement agreement to create a temperature attainment plan, Pend Oreille PUD would do the same.
- The only additional information or requirement Ecology will need is temperature monitoring to 1) meet the requirements of the temperature attainment plan and 2) show progress towards water quality standards. They may already be doing some of this monitoring. All of this information will need to be packaged into a temperature attainment plan to meet the requirements of WAC 173-201A-510(5).
- We expect to require monitoring in the tributaries where we expect to see improvements and will also include a monitoring station in the mainstem of the river.

3. The Panel noted that there could be differences in the scenario models versus the calibration models that could be causing the slight temperature increases in the surface layers of the model in some segments/reaches. Ecology and the PUD should review the modeling files to make sure they are correct.

Ecology Water Quality staff reviewed the model and met with EAP staff that were responsible for the modeling. Summer-period water column temperatures measured late-July and mid-August (2004) indicate distinct differences in comparison to those predicted by the TMDL model (refer to figure below). Measured water column temperatures observed during monitoring events indicate only slight temperature variation; whereas, the model output displayed a consistent pattern of increased heating with decreasing depth (comparisons retained same location and times). This surface "flare" pattern was most pronounced for depths less than approximately 4-meters. Though segment 334 is displayed in the figure, this pattern was common among the 14 monitoring locations examined within the section of the river between the Washington/Idaho state-line and the Box Canyon facility. This relationship could be a concern because the TMDL analysis used daily maximum temperatures that occur within the very upper portion of the water column. In addition, the model-predicted temperatures were consistently greater than those observed during monitoring at the majority of the monitored locations - again with the greatest differences occurring at shallower depths suggesting model bias.

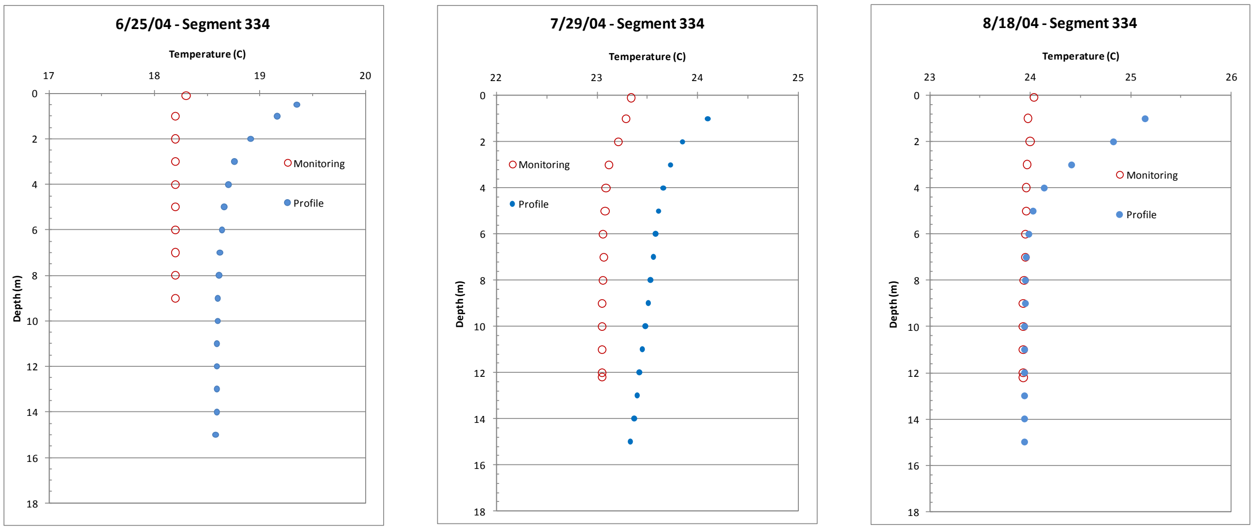

Figure. Relationship between measured (monitoring) and model-predicted (profile) temperatures for model segment 334 (river mile 38).

In examining differences between monitoring and modeled temperatures, it is important to note that the monitoring events are only a "snapshot" of temperature variation. For instance, among the monitoring events undertaken, only two occurred when water temperatures were above 20^{o}C (defining the critical period) and did not coincide with times when the daily maximum temperature occurred. A more comprehensive perspective of the relationship between the model and measured temperatures was determined for segment 334 (river mile 38 within the Tiger reach) at 3-meters depth by comparing the daily maximum temperatures based on TidBit data logger measurements and model output (refer to figure below). As observed, there is a relatively close relationship between the measured (TidBit) and model. The mean error for the data depicted is -.01^{o}C indicating insignificant bias with the root mean squared error of 0.64^{o}C, indicating a good fit between the measured and predicted temperatures. Overall, these numbers are indicative of a well calibrated model. Similar numbers were found at the other monitoring locations. (TidBits were set at seven locations within the Box Canyon section of the river.)

Importantly, there is not the systematic model bias present suggested by the comparison of "snapshot" measured and modeled vertical temperature profiles. In fact, referring to the figure below, for segment 334 on July 29, the model-predicted temperatures are slightly higher than measured by the TidBit; while on August 18 they are close in magnitude, similar to the relationship presented in the figure above. This indicates the importance of taking a longer-term perspective when making these types of comparisons to account for overall variability. The TMDL was not based on one day; rather it considered when temperatures were above 20^{o}C - a situation, which, in 2004, occurred over an approximately 60-day period (below figure).

While the examination of temperatures at 3-meters indicates the model provides a reasonably good fit between measured and predicted temperatures, what about for shallower depths? Unfortunately, there were no TidBit data-loggers set for depths shallower than 3-meters in reaches the TMDL found to be the most impacted by the Box Canyon facility (Tiger and Forebay). Therefore, there is no means to confirm the increased heating the model predicts for shallower depths.

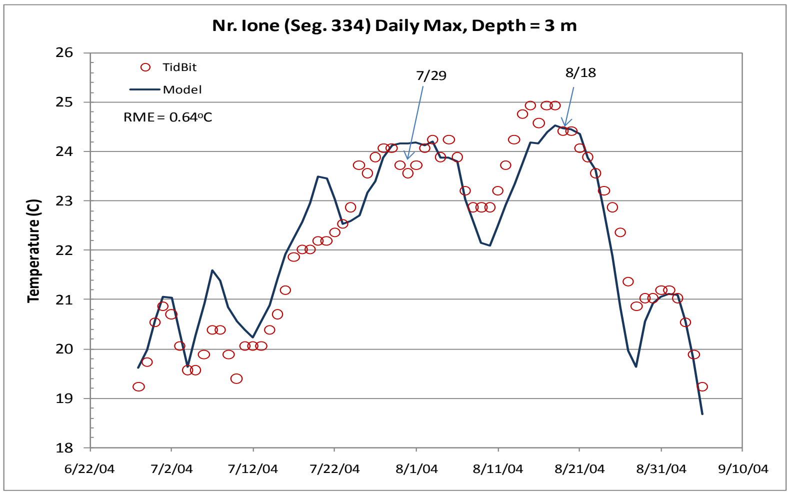

Figure. Relationship between measured (TidBit) and model-predicted daily maximum temperatures for segment 334 (Tiger reach, river mile 38.3).

A temperature impairment is still found for the Box Canyon forebay reach when the daily maximum temperatures at 3-meters are used, as opposed to the water column daily maximum (TMDL approach), though predictably the level of impairment is considerably lower (refer to figure below).

Bottom-line:

- The temperature model applied in the Pend Oreille River TMDL, based on a longer-term relationship between predicted and measured daily maximum temperatures (seven locations) within the Box Canyon affected section of the river, appears well calibrated.
- For the majority of the monitoring locations, this assessment of calibration occurs at a depth of 3-meters. This depth is approximately the inflection point that model-predicted temperatures were found to increase at a higher rate for shallower depths in comparison to those measured during routine water column monitoring.
- Temperature data-loggers were not set for depths shallower than 3-meters in the sections of the river found to be most affected by the Box Canyon facility (Box Canyon forebay and Tiger reaches). For this reason, there is no means to either directly confirm or deny that the model found to be well calibrated at 3-meters is also well-calibrated for shallower depths.

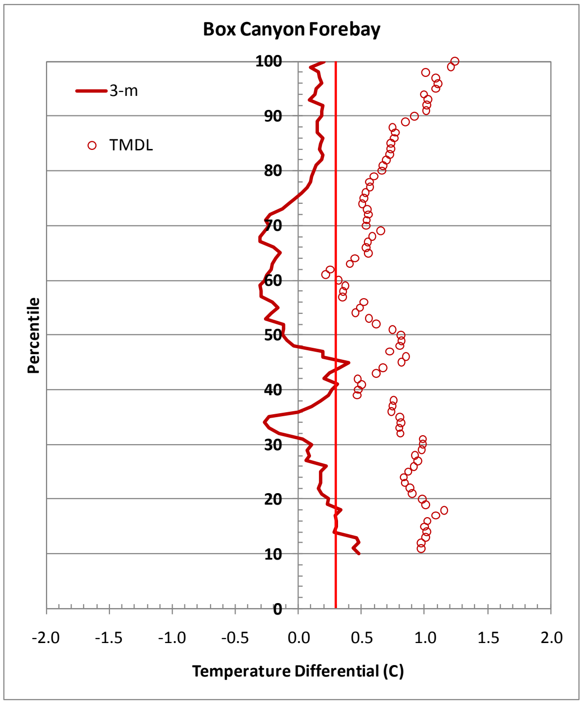

Figure. Temperature differentials based on the TMDL in comparison to daily maximum temperatures at 3-meters. (Differentials greater than 0.3°C (vertical red line) indicate a temperature impairment.)

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September 30,2011

David Moore
Washington State Department of Ecology
Water Quality Program- Eastern Regional Office
4601 North Monroe Street
Spokane, WA 99205-1295

RE: Kalispel Tribe Comments on the Revised Pend Oreille River Temperature TMDL

Dear Mr. Moore:

The Kalispel Tribe offers the following comments on the revisions to the Pend Oreille River Temperature TMDL resulting from the Department of Ecology's dispute resolution process.

1. Incorporating substantive revisions into the TMDL by way of an "Errata" is misleading; the TMDL should be republished and resubmitted to EPA.

Amending the TMDL through an errata sheet is not appropriate when some of the changes are substantive, such as those listed below, rather than minor corrections.

Revision 1: *"A condition of the Pend Oreille PUD's 401 certification states that the provisions in the TMDL's WQIP will supersede the water temperature conditions in their 401 certification."* (Errata at 3)

Concern 1: Because 401 certification at Box Canyon Dam preceded this TMDL, there was a possibility that the certification conditions would not be as protective of water quality as the provisions in the TMDL's implementation plan. Section II.B.l of the State's amended Box Canyon 401 certification addressed this risk by stating that TMDL implementation requirements would supersede the 401 certification conditions if they were more protective. The deleted provision above carried forward this requirement into the TMDL. Deleting it from the TMDL indicates that Ecology does not intend to incorporate more protective terms from the dam compliance schedule or any other TMDL implementation provision into Box Canyon's 401 cet1ification conditions. Such action would be impermissible under the terms of the original TMDL (as well as Box Canyon's 401 certification order) and is therefore a substantive amendment. The deleted language should be retained, or the TMDL should be revised to clearly explain what TMDL implementation conditions will supersede Box Canyon 401 certification conditions.

Revision 2: *"A plan to conduct water quality monitoring after activities are implemented with appropriate adaptive management steps."* (Errata at 3)

Concern 2: The quoted sentence is listed on page 87, paragraph 2 of the TMDL as one offi.ve temperature-specific elements of a water quality attainment plan required by WAC l73-201A-510(5). This provision of the WAC does not require that water quality monitoring be postponed until the completion of implementation actions. Water quality monitoring should be continuous from the TMDL's inception to accurately track the individual and cumulative effects of implementation activities. The underlined language should be stricken from the TMDL.

Revision 3: Inserted language on page 92, paragraph four of the TMDL indicating that Ecology will not require the PUD to take any temperature mitigation actions beyond those the PUD has already agreed to take in order to settle challenges to renewal of its FERC license. (Errata at 4).

Concern 3: The Trout Habitat Restoration Plan (THRP) required by Article 406 of the PUD's FERC license pre-dates the TMDL. As such, it does not account for the new temperature reduction target at Box Canyon set forth in the TMDL. It is therefore unreasonable for Ecology to expect that compliance with the THRP will result in the new temperature reduction required by the TMDL. Additional mitigation is necessary to obtain the temperature reduction target at the Box Canyon forebay.

Revision 4: Inserted language on page 93, second paragraph of the TMDL indicating that Ecology will not require Seattle City Light (SCL) to take any temperature mitigation actions beyond those SCL has already agreed to in order to settle challenges to renewal of its FERC license. (Errata at 5)

Concern 4: Same as concern 3. The mitigation actions in SCL's settlement agreement do not account for the additional temperature reduction required by the TMDL. Additional actions are needed to obtain the TMDL's temperature reduction target at the Boundary forebay.

2. There is no discernable nexus between the revised TMDL's temperature reduction targets and implementation actions.

The revised TMDL provides absolutely no technical analysis demonstrating that the implementation actions identified for Box Canyon and Boundary dams will result in the temperature reductions required by the TMDL. As explained above in concerns 3 and 4, the actions required by the PUD and SCL settlement agreements pre-date the TMDL and thus do not account for the new temperature reduction targets set by Ecology. Ecology is in effect giving the PUD and SCL a free pass to do nothing to address their incremental increase in temperature-reduction responsibility until they are finished performing mitigation that was not designed to address the increased reduction burden in the first place. This free pass undercuts the very purpose of the TMDL, which is to ensure that water quality standards are met by addressing the underlying causes of continued temperature violations. *See* TMDL Executive Summary at x.

EPA guidance states that implementation plans "should include measures to restore and protect the unique aspects of the natural condition," including "the spatial extent of cold water refugia. . ., the diurnal temperature variation, seasonal temperature variation, and shifts in the annual temperature pattern." *EPA Region 10 Guidance for Pacific Northwest State and Tribal Temperature Water Quality Standards* at 38 (EPA 2003). A conceptual plan should be included in the TMDL to explain how the selected implementation actions are going to restore these aspects of the natural condition within a 10-year compliance schedule. This plan should at least consider the possibility of operational adjustments.

3. The revised TMDL will not ensure compliance with Kalispel water quality standards because the cumulative frequency method of analyzing data obscures the thermal impact coming from Idaho and does not accurately account for the frequency or magnitude of temperature violations occurring within Kalispel waters.

The revised TMDL will not ensure compliance with Kalispel temperature standards because it does not accurately characterize the cumulative impacts from all sources contributing to Pend Oreille River warming. This noncompliance is a direct result of Ecology's sudden and arbitrary decision to abandon its 2007 draft TMDL, which evaluated temperature impacts through daily comparisons of natural and existing temperatures, in favor of a new TMDL utilizing the cumulative frequency method (CFM) of analyzing data. The Tribe opposed Ecology's decision to use CFM from the outset and has repeatedly voiced the following concerns:

a) There is no rational basis for using CFM to assess thermal impacts in the Pend Oreille River system.
b) CFM's failure to account for the timing of thermal impacts masks the heat load coming from Idaho, which enables the erroneous and misleading conclusions that existing river temperatures are equal to natural conditions at the Stateline, and additional heat can be added to the system without further contributing to downstream temperature violations.
c) CFM distorts the magnitude and frequency of temperature violations in Kalispel waters.

A recent technical review of the TMDL completed by the Kalispel Tribe reconfirms the validity of these concerns. See Attached June 10, 2011 Keta Waters Memorandum (KWM). Pertinent conclusions from this analysis include:

a) The TMDL sets forth two reasons for using CFM: 1) day-to-day comparisons of data are difficult, and 2) CFM minimizes the effect of short-term weather events. Neither of these justifications is defensible. First, there is no reason that day-to-day comparisons should be "difficult" when the model provides temperature predictions at 30-minute intervals. Second, temperature graphs based on the Box Canyon model show no evidence of time lags or effects from short-term weather events. KWM at 3, 8-9, 13.
b) Water flowing from Idaho across Stateline is warmer under existing conditions than under natural conditions on most days when there are temperature violations at the Kalispel Reservation boundary. KWM at 4, 13-17.

c) CFM underestimates the frequency and magnitude of Kalispel temperature standard violations by roughly three-fold and, in several cases, fails to recognize Kalispel standard violations completely. KWM at 3-4.
d) The average temperature reduction at Stateline necessary to protect Kalispel water quality in late summer is 0.36°C.

CFM's masking of critical temperature considerations also runs afoul of EPA's TMDL guidance regarding determination of temperature impacts in impounded river systems.

> EPA believes it is particularly important for the TMDL itself or the TMDL assessment document to address [diurnal temperature variation, seasonal temperature variation, and shifts in the annual temperature pattern] where the natural background maximum 7DADM temperature exceeds 18°C and where the river has significant hydrologic alterations (e.g., dams and reservoirs, water withdrawals, and/or significant river channelization) that have resulted in the loss of temperature diversity in the river or shifted the natural temperature pattern.

Region 10 Guidance at 38. For the reasons outlined above, CFM operates to minimize temperature variations in the Pend Oreille River and thereby fails to address them.

4. The TMDL wholly fails to consider temperature impacts on thermal refugia in contravention of EPA guidance.

Restoring historic uses to the Pend Oreille River for listed species such as bull trout relies on many different actions to incrementally recover existing degradation to the river. Pend Oreille River bull trout adapted to use waters where summer maximums can naturally exceed 20°C (18°C 7DADM) by using diurnal cooling and thermal refugia to gain as early as possible river access in 1ate summer for large prey foraging and migration. When natural thermal diversity has been reduced due to hydrologic alterations it delays use of the river during critical times of stress. As explained by EPA,

> Reservoirs, due to their increased volume of water, are more resistant to temperature change which results in reduced diurnal temperature variation and prolonged periods of warm water. For example, dams can delay the natural cooling that takes place in the late summer-early fall, thereby harming late summer-fall migration runs.

Region 10 Guidance at 7. With respect to wam1river systems such as the Pend Oreille,

> the TMDL assessment document should assess other aspects of the natural thermal regime including the spatial extent of cold water refugia ...[,and] integrate[these findings] into the TMDL and its allocations to the extent possible.... Plans to implement the TMDL should include measures to restore and protect these unique aspects of the natural condition.

Region 10 Guidance at 38. The TMDL makes no attempt to identify existing or natural locations of thermal refugia, much less analyze impacts to and restoration of these critical areas of bull trout habitat. These omissions should be addressed in the revised and republished TMDL.

The TMDL continues to be flawed for all of the reasons described above and in previous correspondence from the Tribe. Chief among these flaws is Ecology's continued reliance on the cumulative frequency method of analyzing data. CFM does not account for the frequency and magnitude of temperature violations in either Washington or Kalispel waters and therefore will not remedy the temperature problem in the Pend Oreille River. This analytical problem is further compounded by the utter lack of a nexus between the TMDL's temperature reduction targets and proposed implementation actions. Even if Ecology has the discretion to disregard these sh011comings with respect to the State's own waters, it may not foist that choice on the Tribe. Nor may Ecology determine compliance with the Tribe's water quality standards through a methodology it opposes. The TMDL should be further revised to address the Tribe's concerns.

Thank you for your consideration,

Kenneth R. Merrill
Water Resources Manager
Kalispel Tribe of Indians

Cc via email: Kelly Susewind, WA Ecology
Don Martin, EPA
Dave Croxton, EPA

Enc: June 10, 2011 Keta Waters Memorandum

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Keta Waters Memo

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MEMORANDUM

To: Ken Merrill
Water Resources Manager
Kalispel Tribe Natural Resources Department
Usk, WA 99180

From: Joel Massmann, Ph.D., P.E.

Date: June 10, 2011

Subject: Violations of temperature standards in the Pend Oreille River Kalispel Tribe Reservation boundary

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A. Introduction

This memorandum provides results of my review of temperature modeling and related analyses that have been completed as part of the temperature TMDL for the Pend Oreille River published by the Department of Ecology (Baldwin et al., 2011). The review is focused on how the Kalispel Tribe's temperature criteria were considered in the TMDL. In particular, the review compares the cumulative frequency distribution approach used by Ecology in their 2011 TMDL with a more traditional daily-comparison approach for determining compliance with the Kalispel Tribe's criteria.[1] The review also considers the relationship between the amount of heat that is transported across the Washington-Idaho Stateline and compliance with the Kalispel Tribe's temperature criteria.

The analyses described in the TMDL were used by Ecology to develop the following conclusions related to the Kalispel Tribe's temperature criteria:

- There are no violations of the Kalispel Tribe's temperature criteria in the reach of the river along the Kalispel Reservation.

[1] While the focus of this memorandum is on issues related to using the cumulative frequency approach to evaluate the Kalispel Tribe's temperature criteria, similar issues arise when using the cumulative frequency approach to evaluate the State of Washington's temperature criteria. These issues include under-estimating the magnitude and frequency of temperature violations. Findings and conclusions related to the Tribe's criteria are included in the body of this memorandum. Findings and conclusions related to the State of Washington criteria are included in Attachment A.

- There are relatively minor violations of the Kalispel Tribe's temperature criteria at the upstream boundary of the Reservation.
- Compliance with the Kalispel Tribe's criteria can be achieved at the upstream boundary of the Reservation if the one-day temperature maximum is reduced by 0.27 degrees C and if the seven-day average maximum temperature is reduced by 0.22 degrees C.
- The temperature reductions necessary to meet the Kalispel Tribe's criteria will occur through efforts to achieve the load allocation for the Box Canyon Dam forebay.
- Water flowing from Idaho across the Idaho/Washington Stateline is cooler under existing conditions than under natural conditions. Ecology provides a 0.3 degree C allocation in heat load to the river downstream of the Stateline as a result of their conclusion that water flowing from Idaho is cooler under existing conditions.

Additional conclusions from Ecology's 2011 TMDL that are relevant to the review described in this memorandum are summarized in Attachment B.

The conclusions in the TMDL listed above are based on computer modeling results that were used by the Department of Ecology to estimate temperatures under natural and existing conditions (Baldwin et al., 2011). These simulations were completed using computer models developed by Portland State University (Annear et al, 2006; Annear et al, 2007). The same model results used by the Department of Ecology in developing their temperature TMDL were used in my review to identify violations of the Tribe's temperature criteria that occur at the upstream boundary of the Kalispel Tribe Reservation.

Results and conclusions from my review include the following:

1. The Kalispel Tribe's temperature criteria include two parts. The first part considers the 1-day maximum temperature and the second part considers the 7-day average of the daily maximum temperature (7DADM).
2. The Kalispel Tribe's temperature criteria are based on a comparison of daily maximum temperatures for natural and existing conditions. Ecology's conclusions related to compliance with the Kalispel Tribe's temperature are based on a cumulative frequency distribution approach that does not consider these daily comparisons between temperatures under existing and natural conditions.
3. Ecology references computer simulations describing temperature responses in the Boundary reservoir to hypothetical weather fronts to support their selection of the cumulative frequency distribution analysis. These computer simulations were developed for Seattle City Light by Battelle and are described in Breithaupt et al. (2008) and Khangaonkar et al. (2009). The Battelle simulations for the Boundary reservoir suggest that under natural conditions the response is less than one day,

and under existing conditions (with the dam) the response is about four and a half (4.5) days. No similar analyses were provided that considers response times in locations above Box Canyon dam.

4. A review of predicted temperatures upstream of the Kalispel Tribe's Reservation shows that there are two primary temperature differences between existing and natural conditions above the Kalispel Reservation: 1) there are larger daily fluctuations under natural conditions (i.e., the maximum temperatures are higher and the minimum temperatures are lower under natural conditions), and 2) there are higher temperatures throughout the day under existing conditions for some days in late August and early September. An example is shown in Figure 1 for temperatures at the Stateline. The temperature predictions show no evidence of time lags or effects of short-term events such as weather fronts. Ecology's 2011 TMDL does not include or reference any analyses to support their assumption that effects of short-term events such as weather fronts are important in evaluating temperature simulations at the boundary of the Kalispel Reservation or within the Reservation for 2004 and 2005. These analyses would be required to conclude that the cumulative frequency distribution analysis is a necessary and valid approach for evaluating compliance with the Kalispel Tribe criteria.

5. Compliance with temperature criteria developed by the Kalispel Tribe was evaluated using a direct daily comparison of temperatures under natural and existing conditions. This comparison was made at a location immediately upstream of the Kalispel Reservation (RM 72) and at a location within the Kalispel Reservation (RM 66). All temperatures used in this comparison are the maximum temperature in the river segment. These are the same temperature values used by the Department of Ecology in their TMDL analysis (Baldwin et al., 2011).

6. There are 27 violations of the Kalispel Tribe criteria at the upstream boundary of the Kalispel Tribe Reservation, based on simulations for 2004. The maximum temperature violation at this location for the Kalispel Tribe's 1-day maximum criteria is 0.80 degrees C and the maximum violation for the 7DADM criteria is 0.36 degrees. With Ecology's cumulative frequency distribution approach, the maximum temperature violation at this location for the Kalispel Tribe's 1-day maximum criteria is 0.30 degrees C and the maximum violation for the 7DADM criteria is 0.10 degrees. These results are summarized in Table 1.

7. Ecology's cumulative frequency distribution approach under-estimates the maximum violation of the Tribe's 1-day maximum criterion at the reservation boundary by a factor of 2.7 and under-estimates the maximum violation of the Tribe's 7DADM criterion by a factor of 3.6

8. There are five violations of the Kalispel Tribe criteria at river mile 66 adjacent to the Kalispel Tribe Reservation, based on the 2004 simulations. The maximum temperature violation at this location for the Kalispel Tribe's 1-day maximum criteria is 0.28 degrees C and the maximum violation for the 7DADM criteria is 0.20 degrees. There are no calculated violations of the Kalispel Tribe's criteria at

RM 66 using Ecology's cumulative frequency distribution approach. These results are summarized in Table 1.

9. Water flowing from Idaho across the Idaho/Washington Stateline is warmer under existing conditions than under natural conditions on most days when there are temperature violations at the Kalispel Reservation boundary.

Additional details regarding these findings are provided in the sections that follow.

Table 1. Comparison of Maximum Temperature Exceedence Values using the Daily Comparison Approach and the Cumulative Frequency Distribution Approach

	Temperature exceedences (deg C)			
	Above the Kalispel Reservation (RM 72)		**Within the Kalispel Reservation (RM 66)**	
	Daily Approach	**Cumulative Approach**	**Daily Approach**	**Cumulative Approach**
Kalispel daily maximum	0.80	0.3	0.28	0
Kalispel 7DADM	0.36	0.1	0.20	0

B. Overview and approach

Three CE-QUAL-w2 models have been developed to simulate flows and temperatures in the Pend Oreille River between Lake Pend Oreille and the International Boundary. The Albeni Falls model is used to simulate river conditions between Lake Pend Oreille and Albeni Falls Dam, the Box Canyon model simulates the river between Albeni Falls Dam and Box Canyon Dam, and the Boundary model simulates the river between Box Canyon Dam and the International Boundary.

The two scenarios that were considered in this review are existing conditions and natural conditions. The existing condition scenarios were intended to simulate flow and temperatures with the existing impoundments while natural conditions were intended to simulate flow without the three dams listed above. It should be noted that existing flows into Lake Pend Oreille from the Clark Fork River were used in the natural condition simulations (i.e., the natural conditions scenario includes flow regulation from upstream dam operations on the Clark Fork River basin).

The focus of the review was on comparing simulations for natural and existing scenarios using the Box Canyon model. The model results for these scenarios were obtained from the Department of Ecology. The model runs that were compared are listed in Table 2.

Table 2. Model runs used in comparison

Model	Scenario	Model run time	Developer
Box Canyon	Existing	14:12:41 on 02/12/09	Portland State
Box Canyon	Natural	16:28:52 on 06/29/07	Portland State

Existing-condition simulations were developed for the time period 1/1/2004 to 12/31/2005 while the natural condition simulations were developed for the time period 1/14/2004 to 9/9/2005. The comparison of simulations described in this memorandum focuses on the period 1/14/2004 to 12/31/2004. Table 3 identifies locations used to compare flow and temperatures under natural and existing conditions.

Table 3. Locations used in comparing simulations

River mile	Model Segment	Approximate location
88	14	Washington/Idaho stateline
72.3	115	Kalispel Reservation upstream boundary
66	156	Kalispel Reservation

The output from the CE-QUAL-w2 model provided by the Department of Ecology includes five types of temperature statistics for each segment used to represent the river. These are 1) surface temperature (i.e., temperature in the top layer), 2) bottom temperature (i.e., temperature in the bottom layer), 3) flow-averaged temperature, 4) volume-averaged temperature and 5) maximum temperature in the segment. Unless stated otherwise, all temperatures used in this analysis are the maximum temperature in the segment. These are the same temperature values used by the Department of Ecology in their TMDL analysis (Baldwin et al., 2011).

The CE-QUAL-w2 computer simulations are used evaluate compliance with the Kalispel Tribe's temperature criteria. The Tribe's temperature criteria include two parts. The first part considers the 1-day maximum temperature and the second part considers the 7-day average of the daily maximum temperature (7DADM). The criterion for the 1-day maximum is 20.5 degrees and the criterion for the 7DADM is 18 degrees. If natural conditions are above these criteria, then human influences can raise water temperature by no more than 0.3 degrees C. These criteria, which were approved by the United States Environmental Protection Agency on June 24, 2004, are for all designated uses (Baldwin et al., 2011).

C. Summary of TMDL methodology for evaluating compliance with the Kalispel Tribe's temperature criteria

The approach used by the Department of Ecology to evaluate compliance with the Kalispel Tribe's temperature criteria is described on pages 28-30 in the 2011 TMDL and is summarized in Attachment C. Ecology's approach is based on a cumulative frequency distribution analysis to evaluate compliance with water quality standards. Ecology provides three stated reasons for adopting this cumulative frequency approach (Baldwin et al., 2011, page 26):

- The dams have altered the hydrologic characteristics of the river from the natural condition. These differences between the natural and existing conditions makes direct time-based (i.e. day-to-day) temperature comparisons difficult.
- By using a cumulative frequency analysis it is possible to determine how often temperatures occur within a specific amount of time.
- The effect of short-term events such as weather fronts are minimized using the cumulative frequency approach.

To support their selection of the cumulative frequency distribution approach, Ecology references computer simulations describing temperature responses in the Boundary reservoir to hypothetical weather fronts. These computer simulations were developed for Seattle City Light by Battelle and are described in Breithaupt et al. (2008) and Khangaonkar et al. (2009). The Battelle simulations for the Boundary reservoir suggest that under natural conditions the response to a hypothetical seven-day weather pattern is less than one day, and under existing conditions (with the dam) the response is about four and a half (4.5) days. No similar analyses were provided that considers response times in locations above Box Canyon dam.

Model segment 115 was evaluated in the TMDL to determine compliance with the Tribe's water quality criteria at their reservation boundary. This model segment is located at approximately river mile 72 and defines the upstream boundary where the Kalispel criterion applies. Model segment 172 (RM 63.6) at the downstream end of the Kalispel Reservation was also considered in the TMDL "for comparative purposes" (Baldwin et al., 2011, page 28).

Graphs showing the results of Ecology's cumulative frequency approach are included in Attachment C. These graphs have the same form as the graphs described in Appendix D in the 2011 TMDL.

The maximum and average temperature differentials between natural and existing conditions as calculated using Ecology's cumulative frequency distribution approach are summarized in Table 4. The maximum differential for the location immediately above the Kalispel Reservation (RM 72) is 0.6 degree for the daily maximum criteria and is 0.4 degrees for the 7DADM criteria (Baldwin et al., 2011, page 51).

Table 4. Results from Ecology's Cumulative Frequency Distribution Approach (from Baldwin et al., 2011, Table 7, page 52)

	Above the Kalispel Reservation (RM 72, Segment 115)		**Below the Kalispel Reservation (RM 63.6, Segment 172)**	
Criteria	**Average differential**	**Maximum differential**	**Average differential**	**Maximum differential**

Kalispel daily maximum	0.06	0.60	-0.50	0.22
Kalispel 7DADM	-0.03	0.40	-0.51	0.14

Ecology compares the maximum temperature differentials listed in Table 4 with an allowable temperature increase of 0.3 degrees C to assess compliance with temperature criteria. They conclude the following (Baldwin et al., 2011, page 51):

> *"The first part of the Kalispel criteria is based on the 7-day average of the daily maximum temperatures. When natural conditions exceed 18° C, existing temperatures conditions should remain at 0.3° C or less. In 2004, at segment 115, the maximum temperature differential reached 0.40° C, an exceedance level of 0.1° C. .... At the lower tribal boundary (segment 172), the maximum temperature differential for the 7-day average was 0.14° C, 0.16° C below the criteria threshold.*
>
> *The second part of the Kalispel temperature criteria is based on the comparison of existing and natural condition daily maximum temperatures when natural conditions exceed 20.5° C. The results of its application were similar to that found for Part 1 maximum temperatures observed in segment 115 exceed criteria, though by a slightly larger margin (0.3° C as opposed to 0.1° C), while temperature conditions in segment 172 remained within criteria."*

Based on their application of the cumulative frequency distribution approach, Ecology concludes the following (Baldwin et al., 2011, page 79):

> *"To achieve compliance with the Kalispel Tribe's criteria, the one-day temperature maximum needs to be reduced by 0.27° C, and the seven-day average maximum temperature must be reduced by 0.22° C at segment 115 or river mile 72.4 (see Table 10). As stated above, these reductions are expected to occur through efforts to achieve the load allocation for the Box Canyon Dam forebay. However, Ecology will work to ensure that implementation activities occur within the Skookum reach so that the Tribe's criteria are met."*

It is not clear why there is an apparent discrepancy in the TMDL between the magnitude of the exceedences described on Page 51 and Table 7 and the temperature reductions to achieve compliance described on page 79 and Table 10, as summarized below.

Kalispel Criteria	Magnitude of Exceedence (TMDL page 51 and Table 7)	Temperature reductions to achieve compliance (TMDL page 79 and Table 10)
1-day maximum	0.3	0.27
7DADM	0.1	0.22

Ecology also simulated the effects of removing the Box Canyon dam on temperatures using their cumulative frequency distribution approach. The conclusions that they develop based on these simulations include the following (Baldwin et al., 2011, page 67):

For segment 115, the absence of the Box Canyon facility results in an overall decrease in the existing temperature condition by 0.22° C (7-day average) to 0.27° C (1-day average). Previously, through application of Washington's temperature criteria, the reduction for the Skookum reach (segment 115 defines the lower segment of the Skookum reach) was an average of 0.21° C (Table 9). As was determined previously, this temperature reduction is large enough to result in the achievement of the temperature criteria.

The loading capacity described in the TMDL defers to the Washington State criteria as opposed to designating entirely separate ones based on the Kalispel Tribe's criteria. Ecology concludes that the application of both Washington State and Kalispel tribal criteria to Pend Oreille River temperatures identified similar heating patterns in the coincidental reaches and segments that were examined (Baldwin et al., 2011, page 72).

D. Analysis of Compliance with the Kalispel Criteria using the Tribe's Methodology

The Kalispel Tribe's temperature criteria are based on comparisons of daily maximum temperatures under natural and existing conditions. The computer models developed by Portland State and used by the Department of Ecology in their TMDL are used to generate temperature predictions at 30-minute intervals. These relatively high-frequency estimates can be used to calculate the daily maximum temperatures and the 7DADM temperatures necessary to evaluate compliance with the Kalispel Tribe's criteria.

Figure 1 illustrates example results for existing and natural conditions at the Idaho/Washington Stateline during the summer of 2004. This graph shows that there are two primary temperature differences between existing and natural conditions above the Kalispel Reservation: 1) there are larger daily fluctuations under natural conditions (i.e., the maximum temperatures are higher and the minimum temperatures are lower under natural conditions), and 2) there are higher temperatures throughout the day under existing conditions for some days in late August and early September.

As noted in Section C above, Ecology's justifications for using the cumulative frequency distribution analysis are 1) direct time-based (i.e. day-to-day) temperature comparisons are difficult, and 2) the effect of short-term events such as weather fronts are minimized. It is unclear why Ecology suggests that a day-to-day comparison is "difficult," given that the model provides temperature predictions on 30-minute intervals. Furthermore, the temperature graphs shown in Figure 1 show no evidence of time lags or effects of short-term events such as weather fronts.

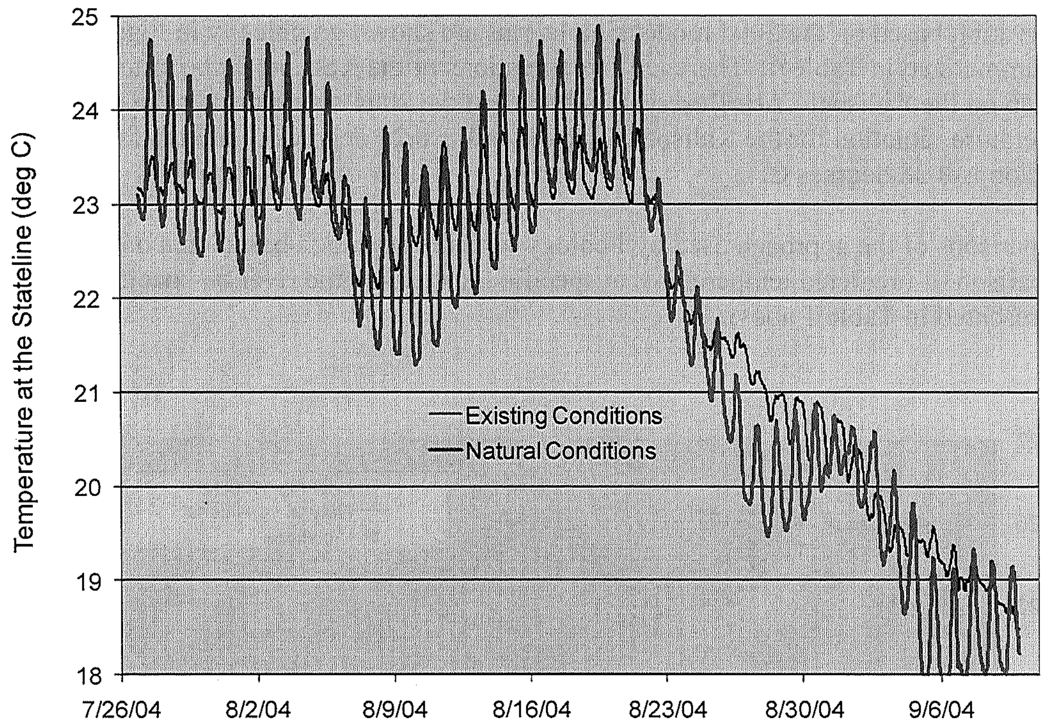

Figure 1. Temperatures at the Stateline under existing and natural conditions as predicted using the Box Canyon model

Violations of the Kalispel temperature criteria were identified by comparing directly on a one-to-one basis both daily maximum temperatures and the seven-day average of the daily maximum temperatures under existing and natural conditions. If the temperature difference between natural and existing conditions exceeds the allowable increase, a violation was noted. The magnitude of the violation is defined as the difference between the allowable temperature increase and the actual temperature increase.

Upstream of the Kalispel Reservation

The number and magnitude of violations of temperature criteria at the upstream end of the Kalispel Reservation based on the 2004 model simulations are shown graphically in Figure 2 and are summarized in Table 5.

There are 27 violations of the Kalispel Tribe criteria at the upstream boundary of the Kalispel Tribe Reservation based on the 2004 simulations. The average temperature violation for the Kalispel Tribe criteria is 0.26 degrees C and the maximum violation is 0.80 degrees C.

Adjacent to the Kalispel Reservation

The number and magnitude of violations of temperature criteria within the Kalispel Reservation based on the 2004 model simulations are shown graphically in Figures 3 and are summarized in Table 6. There are five violations of the Kalispel Tribe criteria at river mile 66 on the Kalispel Tribe Reservation based on the 2004 simulations. The average temperature violation for the Kalispel Tribe criteria is 0.21 degrees C and the maximum violation is 0.28 degrees C.

Comparisons of the approach used by Ecology with the approach based on a one-to-one comparison of predicted temperatures at specific locations in the river on specific dates are presented in Table 1 above.

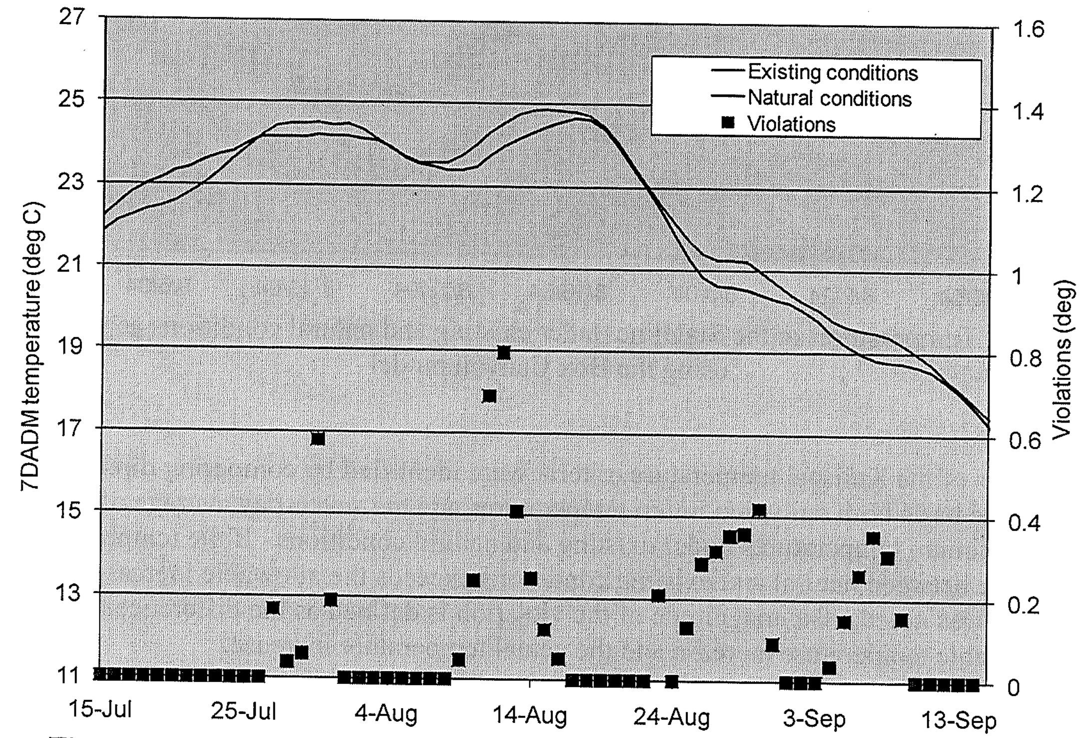

Figure 2. Violations of Kalispel 1-day Maximum Criteria immediately above the Kalispel Reservation (RM 72)

Table 5. Summary of violations of the Kalispel temperature criteria based on segment maximum temperatures at River Mile 72 (Model Segment 115). Highlighted values denote days on which heat flow at the Stateline under existing conditions is greater than under natural conditions, as described in Section E.

Date	Type of Violation	Magnitude of Violation (deg C)	Temperature under existing conditions		Warming between RM 88 and RM 72 (deg C)
			RM88	RM72	
07/27/04	Tmax	0.17	23.51	24.59	1.08
07/28/04	7DADM	0.04	23.44	24.38	0.95
07/29/04	Tmax	0.06	23.47	24.49	1.02
07/30/04	Tmax	0.58	23.34	24.50	1.16
07/31/04	Tmax	0.19	23.40	24.47	1.07
08/09/04	**7DADM**	**0.05**	**23.15**	**23.72**	**0.57**
08/10/04	**Tmax**	**0.24**	**23.43**	**24.10**	**0.67**
08/11/04	**Tmax**	**0.69**	**23.68**	**24.56**	**0.88**
08/12/04	Tmax	0.80	23.61	24.81	1.20
08/13/04	Tmax	0.41	23.65	24.80	1.15
08/14/04	7DADM	0.25	23.79	24.87	1.08
08/15/04	**7DADM**	**0.12**	**23.83**	**25.01**	**1.18**
08/16/04	**Tmax**	**0.05**	**23.92**	**25.10**	**1.18**
08/23/04	**Tmax**	**0.21**	**22.38**	**22.29**	**-0.10**
08/25/04	**7DADM**	**0.13**	**21.78**	**21.10**	**-0.69**
08/26/04	**7DADM**	**0.29**	**21.63**	**21.42**	**-0.21**
08/27/04	**7DADM**	**0.32**	**21.50**	**21.33**	**-0.18**
08/28/04	**7DADM**	**0.35**	**21.08**	**21.22**	**0.14**
08/29/04	**7DADM**	**0.36**	**20.97**	**21.24**	**0.26**
08/30/04	**Tmax**	**0.42**	**20.90**	**21.23**	**0.33**
08/31/04	7DADM	0.09	20.75	21.26	0.51
09/04/04	7DADM	0.04	19.55	19.54	-0.01
09/05/04	**7DADM**	**0.15**	**19.58**	**19.75**	**0.17**
09/06/04	**7DADM**	**0.26**	**19.38**	**19.82**	**0.44**
09/07/04	**7DADM**	**0.35**	**19.27**	**19.45**	**0.18**
09/08/04	**7DADM**	**0.31**	**19.01**	**19.72**	**0.71**
09/09/04	7DADM	0.16	18.76	19.21	0.46
Average violation:		**0.26**			
Maximum violation:		**0.80**			

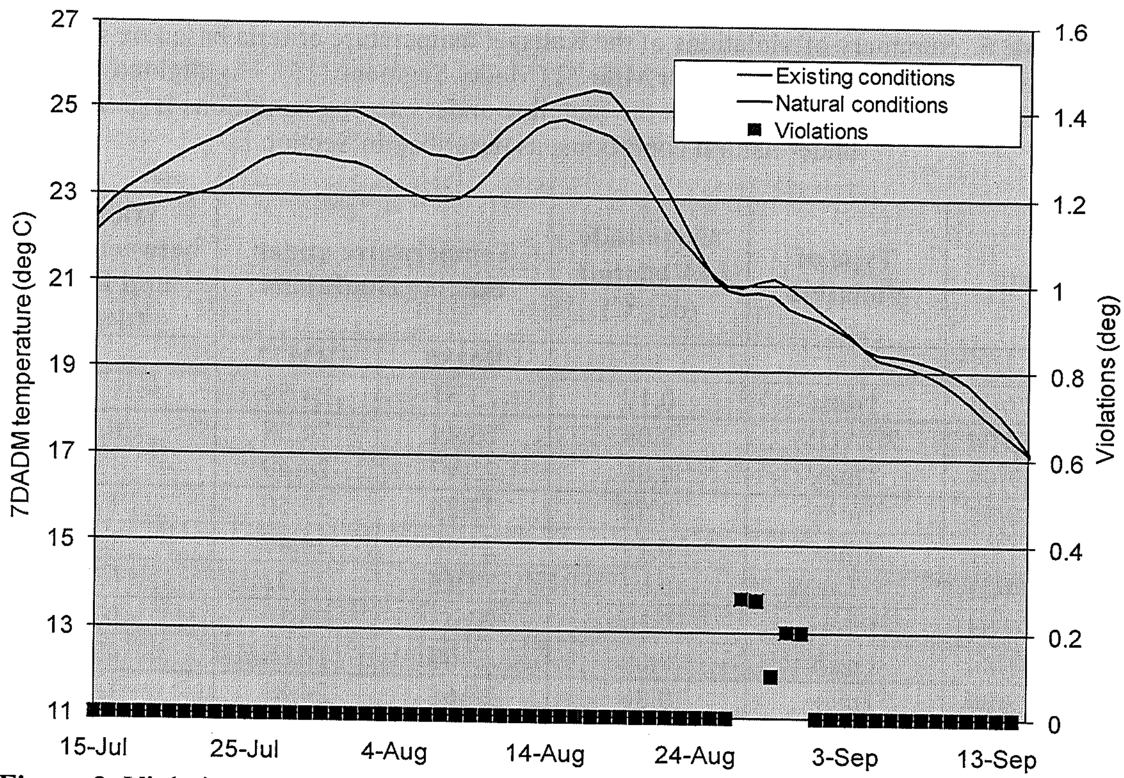

Figure 3. Violations of Kalispel 7DADM Criteria within the Kalispel Reservation (RM 66)

Table 6. Summary of violations of the Kalispel temperature criteria based on segment maximum temperatures at River Mile 66 (Model Segment 156)

Date	Type of Violation	Magnitude of Violation (deg C)	Temperature under existing conditions RM66	
			Tmax	7DADM
08/27/04	Tmax	0.277	21.174	20.964
08/28/04	Tmax	0.274	21.210	21.068
08/29/04	7DADM	0.098	21.249	21.164
08/30/04	7DADM	0.200	21.341	20.996
08/31/04	Tmax	0.199	21.367	20.707
Average violation:		**0.21**		
Maximum violation:		**0.28**		

E. Temperatures and Heat Flow at the Idaho/Washington Stateline

Temperature and flow conditions in the Pend Oreille River at the Idaho/Washington Stateline affect temperatures in the river immediately above the Kalispel Tribe reservation and within the Kalispel Reservation. The results of the computer simulations developed for the TMDL show that heat flow is greater under existing conditions on most days when the Kalispel temperature criteria are violated.

Ecology has concluded that water flowing from Idaho across the Idaho/Washington Stateline is cooler under existing conditions than under natural conditions (Baldwin et al., 2011, page 73). This conclusion is apparently a result of using the cumulative frequency distribution approach and does not consider specific time periods during the summer months when the water flow across the Stateline is warmer under existing conditions as compared to natural conditions.

Ecology's assumes that the existing river temperatures are cooler now than under natural conditions and that this will continue in the future. According to Ecology, this "stateline assumption" provides a baseline for establishing load allocations downstream (Baldwin et al., 2011, page 73). Ecology provides a 0.3 degree C allocation in heat load to the river downstream of the Stateline as a result of their conclusion that water flowing from Idaho is cooler under existing conditions (Baldwin et al., 2011, page 79).

Temperature differences between existing and natural conditions can be described using the summation of degree-hour differences and by using heat transport calculations. The two approaches give similar results, as described below. Both approaches demonstrate that temperatures and heat transport across the Idaho/Washington Stateline are greater under existing conditions than under natural conditions on most days when there are temperature violations at the Kalispel Reservation boundary. The temperature and heat flows described below are calculated using the flow-averaged temperatures provided by the Department of Ecology. These are the appropriate and correct values for estimating heat flow. Temperature predictions at the Stateline under existing and natural conditions developed using the Portland State model are shown in Figure 1.

The hourly temperature data shown in Figure 1 suggest that the time lag or time shift between temperature changes in the existing-condition and natural-condition scenarios is relatively small. There is essentially no lag for the temperature conditions at the Stateline.

Degree-hour Differences

Degree-hour differences are calculated by simply summing up the hourly temperature differences between existing and natural conditions. Figure 4 gives the degree-hour differences at the Washington/Idaho state line (RM 88). A positive slope in this figure indicates time periods when existing temperatures are warmer than natural conditions.

The results show that temperatures are warmer under existing conditions on most days when the Washington and Kalispel temperature criteria are violated. For example, the temperatures at the Stateline are warmer under existing conditions from August 6 to August 15, from August 21 to August 31, and from September 3 to September 9 of 2004, as shown in Figure 3. Violations of the Kalispel Tribe Criteria occur at the upstream end of the Kalispel Reservation (RM 72) from August 9 through August 11, from August 15 through August 30, and from September 5 through September 8, 2004, as listed in Table 4. Violations of the Washington Criteria occur at RM 72 from August 10 through August 14 and from August 14 through August 31, 2004, as listed in Table 5.

Heat Transport Differences

Heat transport calculations provide an alternative description of the amount of heat that is transported across the Stateline under existing and natural conditions. The heat flow during a time interval Δt is calculated using the following expression:

$$H = QTC\Delta t \qquad \text{Equation 1}$$

where H is the heat flow during a time interval Δt (BTU), Q is the flow rate (m^3/s), T is the water temperature (deg C), and C is the volumetric heat capacity for water (BTU/m^3/deg C). The value used for the volumetric heat capacity is 3,960 BTU/m^3/deg C. The cumulative difference in heat flow between existing and natural conditions is calculated by adding up the differences in heat flows for each time step used in the computer model. The time step size used in the Portland State model is 28.8 minutes.

Figure 5 summarizes the heat flow differences for the period between July 27 and September 9, 2009. The results show that heat flow is greater under existing conditions on most days when the Kalispel temperature criteria are violated. For example, the heat flow at the Stateline is greater under existing conditions from August 1 to August 3, from August 7 to August 11, from August 15 to August 16, on August 19, from August 22 to August 30, and from September 6 to September 8 of 2004, as shown in Figure 4. Violations of the Kalispel Tribe Criteria occur at the upstream end of the Kalispel Reservation (RM 72) from August 9 through August 11, from August 15 through August 30, and from September 5 through September 8, 2004, as listed in Table 4. Violations of the Washington Criteria occur at RM 72 from August 10 through August 14 and from August 14 through August 31, 2004, as described in Figure 5.

The primary difference between the degree-hour differences described in the Figure 4 and the heat flow calculations described in Figure 5 is that the heat flow calculations incorporate differences in flows between natural and existing conditions. Flows at the Stateline for the natural and existing scenarios are summarized in Table 7. The flows under the natural conditions are approximately 10% higher than the flows under existing conditions. The reasons for these differences have not been described.

On days when flows are higher under natural conditions than under existing conditions, the heat flow under natural conditions can actually be higher than the heat flow under existing conditions even if the temperatures are lower. This is because the heat flow is defined as the product of flow rate and temperature, as described in Equation 1 above. The heat flow results shown in Figure 5 may under-estimate the impacts of existing conditions because of the differences in flows that were used in the models.

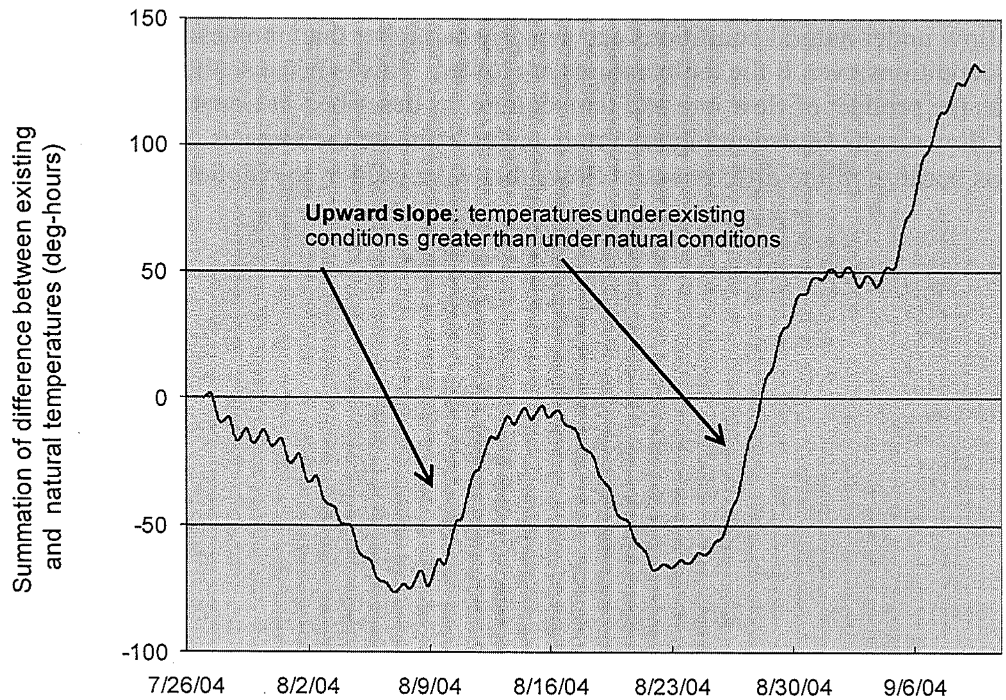

Figure 4. Summation of differences between existing and natural temperatures at the Washington/Idaho Stateline expressed in deg-hours

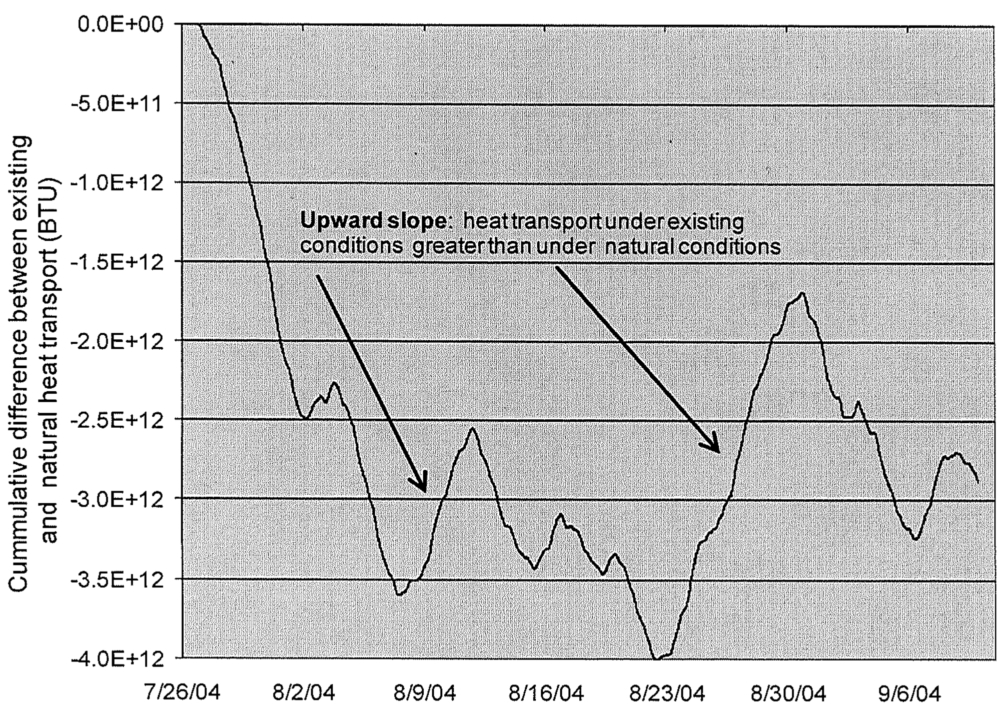

Figure 5. Summation of differences between existing and natural heat flow at the Washington/Idaho Stateline expressed in BTU's.

Table 7. Average flows between January 14, 2004 and September 9, 2005 at the Stateline in the Box Canyon model

Existing conditions	
Model	Box Canyon
Segment	10
River Mile	89
Average flow (cfs)	21,248
Natural conditions	
Model	Box Canyon
Segment	10
River Mile	89
Average flow (cfs)	23,316
Ratio of Existing/Natural	91%

F. Estimates of Required Temperature Reductions

Figure 6 provides a comparison of estimated temperatures at the Stateline and at the Kalispel Reservation on days when the Kalispel temperature criteria are violated. The temperatures shown in Figure 6 are the maximum temperature in the model segment. These are the same temperature values used by the Department of Ecology in their TMDL analysis (Baldwin et al., 2011).

The relationship between the temperatures at the Kalispel Reservation and the Stateline can be used to estimate how much the Stateline temperature would need to be reduced to achieve compliance with the Kalispel temperature criteria at the Reservation boundary. These estimates are summarized in Table 7. If no temperature reductions are required in the Box Canyon reach, then the estimates summarized in Table 7 describe what would be required to meet the Kalispel Tribe's temperature criteria at RM 72.

The dates and magnitude of the temperature violations included in Columns A and B are from Table 5 above. The allowable temperature at the Reservation boundary given in Column C is calculated by subtracting the magnitude of the violation from the estimated temperature at the Reservation under existing conditions. These estimated temperatures are included in Table 4 above. The estimated allowable temperature at the Stateline given in Column D is calculated from the allowable temperature at the Reservation using the regression equation shown on Figure 6. Finally, the required reduction in temperature at the Stateline that would be necessary to eliminate the violation at the Reservation is given in Column E. The required temperature reduction is calculated by subtracting the allowable temperature at the Stateline given in Column D from the temperature value for existing conditions at the Stateline included in Table 4 above.

The required temperature reductions range from 0.07 degrees to 0.99 degrees. The average required reduction is 0.36 degrees.

The methodology described in Figure 6 and Table 8 provide reasonable estimates for temperature reduction that would be required at the Stateline if no temperature reductions are required in the Box Canyon reach. However, it should be noted that a more accurate and reliable approach for estimating the required temperature reductions at the Stateline to achieve compliance at the upstream end of the Kalispel Reservation could be developed using the CE-QUAL-w2 models.

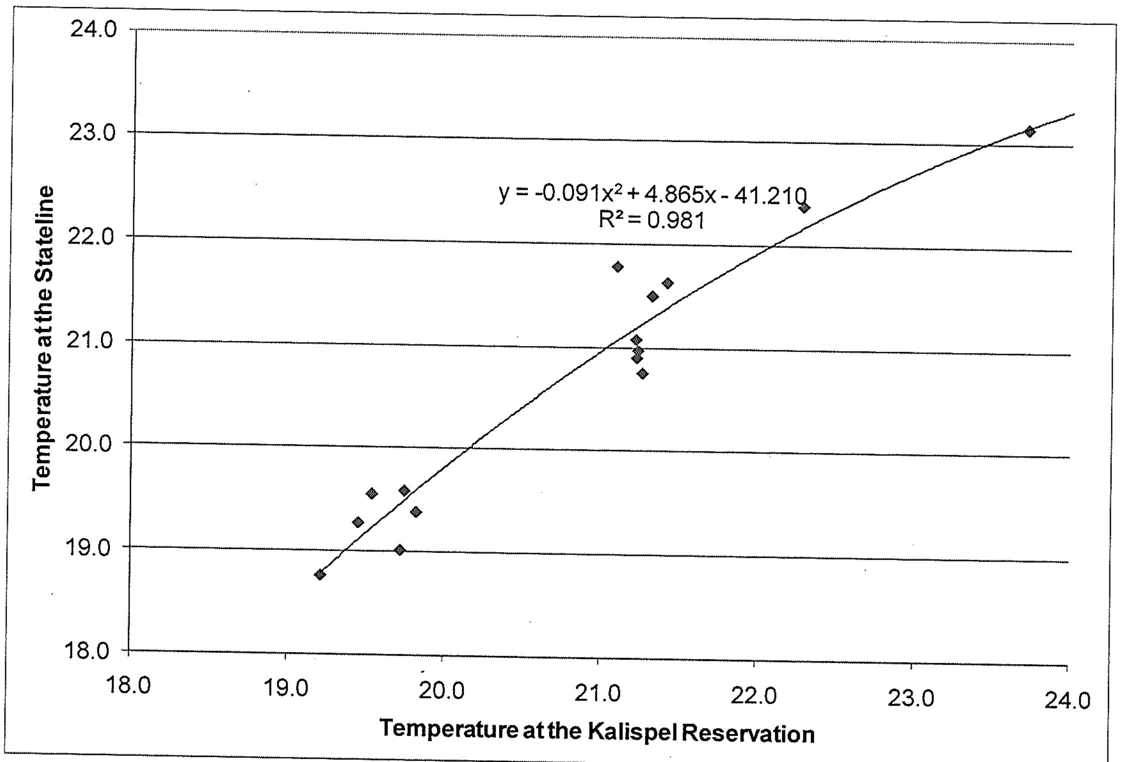

Figure 6. Comparison of estimated temperatures at the Stateline and at the Kalispel Reservation on days when the Kalispel temperature criteria are violated.

Table 8. Estimates of required temperature reductions at the Stateline to achieve compliance with the Kalispel temperature criteria at the Reservation boundary.

A	B	C	D	E
Date	**Magnitude of Violation**	**Allowable temperature at Reservation**	**Estimated allowable temperature at Stateline**	**Estimated required reduction at Stateline**
	(deg C)	**(deg C)**	**(deg C)**	**(deg C)**
07/27/04	0.17	24.42	23.33	0.18
07/28/04	0.04	24.34	23.29	0.14
07/29/04	0.06	24.43	23.33	0.14
07/30/04	0.58	23.92	23.09	0.25
07/31/04	0.19	24.28	23.27	0.13
08/09/04	0.05	23.67	22.96	0.19
08/10/04	0.24	23.86	23.06	0.37
08/11/04	0.69	23.87	23.07	0.61
08/12/04	0.80	24.01	23.14	0.47
08/13/04	0.41	24.39	23.31	0.34
08/14/04	0.25	24.62	23.41	0.38
08/15/04	0.12	24.89	23.50	0.33
08/16/04	0.05	25.05	23.55	0.37
08/23/04	0.21	22.08	21.84	0.54
08/25/04	0.13	20.97	20.79	0.99
08/26/04	0.29	21.13	20.96	0.67
08/27/04	0.32	21.01	20.83	0.67
08/28/04	0.35	20.87	20.68	0.39
08/29/04	0.36	20.88	20.70	0.28
08/30/04	0.42	20.81	20.62	0.28
08/31/04	0.09	21.17	21.00	-0.25
09/04/04	0.04	19.50	19.06	0.49
09/05/04	0.15	19.60	19.18	0.40
09/06/04	0.26	19.56	19.14	0.24
09/07/04	0.35	19.10	18.51	0.76
09/08/04	0.31	19.42	18.94	0.07
09/09/04	0.16	19.06	18.45	0.30
			Average:	**0.36**

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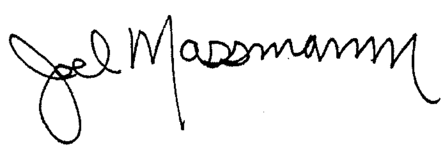

Joel Massmann, Ph.D., P.E.
Keta Waters LLC

EXPIRES December 28, 2011

ATTACHMENT A

Analysis of Compliance with the State of Washington's Temperature Criteria

This attachment provides results of my review of temperature modeling and related analysis that have been completed as part of the temperature TMDL for the Pend Oreille River (Baldwin et al., 2011). The attachment focuses on temperature criteria developed by the State of Washington. The temperature criteria developed by the Kalispel Tribe is described in the main body of this memorandum.

Results and conclusions from my review include the following:

1. Compliance with temperature criteria developed by the State of Washington was evaluated using a direct daily comparison of temperatures under natural and existing conditions. This comparison was made at a location immediately upstream of the Kalispel Reservation (RM 72) and at a location within the Kalispel Reservation (RM 66). All temperatures used in this comparison are the maximum temperature in the river segment. These are the same temperature values used by the Department of Ecology in their TMDL analysis (Baldwin et al., 2011).

2. There are 21 violations of the State of Washington criteria at the upstream boundary of the Kalispel Tribe Reservation based on the 2004 simulations. The average temperature violation criteria is 0.32 degrees C and the maximum violation is 0.80 degrees C.

3. There are eight violations of the State of Washington criteria at river mile 66 within the Kalispel Tribe Reservation based on the 2004 simulations. The average temperature violation is 0.25 degrees C and the maximum violation is 0.53 degrees C.

4. The magnitude of the exceedence at RM 72 is 0.3 degrees for the State of Washington criteria using Ecology's cumulative frequency distribution approach. There are no calculated violations at RM 66 on the Kalispel Reservation using Ecology's cumulative distribution approach.

A. Analysis of Compliance using the Tribe's Methodology

Compliance with State of Washington Criteria Upstream of the Kalispel Reservation

The number and magnitude of violations of State of Washington temperature criteria at the upstream end of the Kalispel Reservation based on the 2004 model simulations are summarized in Table A1 and are shown graphically in Figure A1.

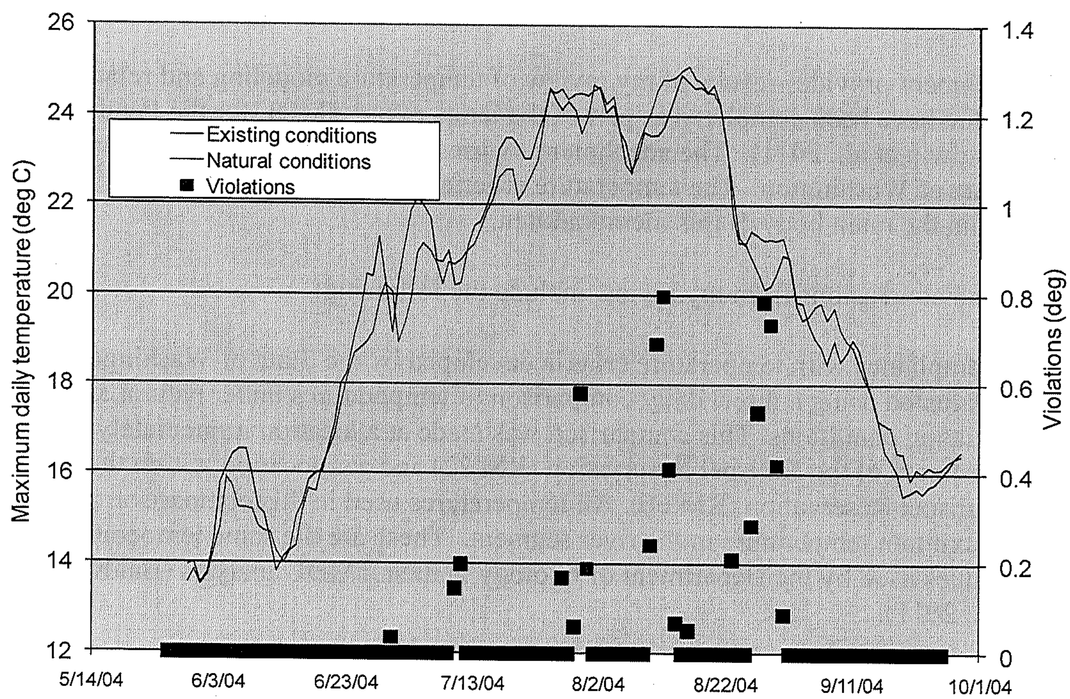

Figure A1. Violations of Washington Criteria immediately above the Kalispel Reservation (RM 72).

Table A1. Summary of violations of the Washington temperature criteria based on segment maximum temperatures at River Mile 72 (Model Segment 115). Highlighted values denote days on which heat flow at the Stateline under existing conditions is greater than under natural conditions, as described in Section C.

Date	**Magnitude of Violation (deg C)**	**Temperature under existing conditions**		**Warming between RM 88 and RM 72 (deg C)**
		RM88	**RM72**	
05/07/04	0.10	10.89	12.43	1.54
06/30/04	0.03	18.66	20.03	1.38
07/10/04	0.14	20.60	20.66	0.06
07/11/04	0.20	20.41	20.77	0.36
07/27/04	0.17	23.51	24.59	1.08
07/29/04	0.06	23.47	24.49	1.02
07/30/04	0.58	23.34	24.50	1.16
07/31/04	0.19	23.40	24.47	1.07
08/10/04	**0.24**	23.43	24.10	0.67
08/11/04	**0.69**	23.68	24.56	0.88
08/12/04	0.80	23.61	24.81	1.20
08/13/04	0.41	23.65	24.80	1.15
08/14/04	**0.07**	23.79	24.87	1.08
08/16/04	**0.05**	23.92	25.10	1.18
08/23/04	**0.21**	22.38	22.29	-0.10
08/26/04	**0.28**	21.63	21.42	-0.21
08/27/04	**0.54**	21.50	21.33	-0.18
08/28/04	**0.78**	21.08	21.22	0.14
08/29/04	**0.73**	20.97	21.24	0.26
08/30/04	**0.42**	20.90	21.23	0.33
08/31/04	0.09	20.75	21.26	0.51
Average violation:	**0.32**			
Maximum violation:	**0.80**			

<u>Compliance with State of Washington Criteria within the Kalispel Reservation</u>

The number and magnitude of violations of temperature criteria within the Kalispel Reservation based on the 2004 model simulations are summarized in Table A2 and are shown graphically in Figure A2.

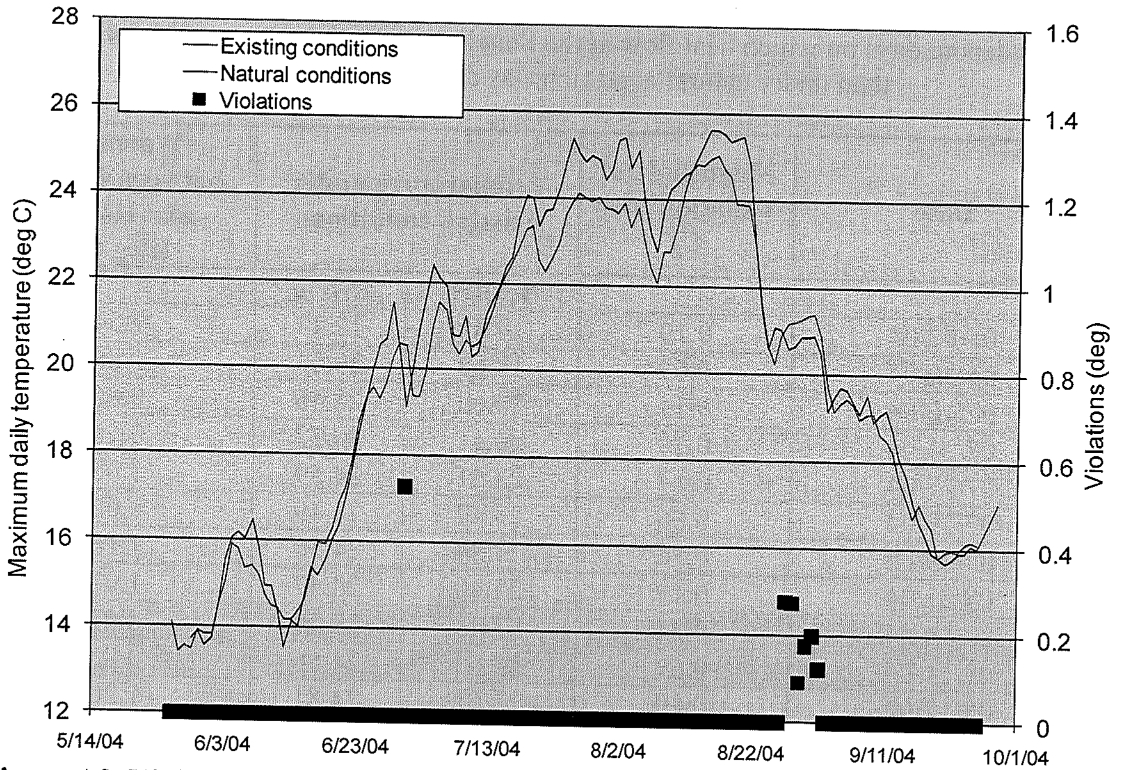

Figure A2. Violations of Washington Criteria within the Kalispel Reservation (RM 66).

Table A2. Summary of violations of the Washington temperature criteria based on segment maximum temperatures at River Mile 66 (Model Segment 156)

Date	Magnitude of Violation (deg C)	Temperature under existing conditions
		RM66
05/07/04	0.36	13.019
06/30/04	0.53	20.529
08/27/04	0.28	21.174
08/28/04	0.27	21.21
08/29/04	0.09	21.249
08/30/04	0.18	21.341
08/31/04	0.20	21.367
09/01/04	0.12	20.922
Average violation:	**0.25**	
Maximum violation:	**0.53**	

B. Analysis of Compliance using the Department of Ecology's Cumulative Frequency Distribution Approach

Comparisons of the cumulative frequency distribution approach used by Ecology with the approach based on a daily comparison of predicted temperatures at specific locations in the river on specific dates are presented in Table A3 below. Figures C3 and C6 in Attachment C give results in graphical form.

Ecology compares the maximum temperature differentials calculated using the cumulative frequency distribution approach with an allowable temperature increase of 0.3 degrees C to assess compliance with temperature criteria. The results of this approach are summarized in Table A4. The maximum differentials for the location immediately above the Kalispel Reservation (RM 72) is 0.6 degree. Ecology calculates the level of criteria exceedence by subtracting 0.3 degrees from the maximum differential. With this approach, the magnitude of the exceedence at RM 72 is 0.3 degrees for the State of Washington criteria. There are no calculated violations at RM 66 on the Kalispel Reservation using Ecology's cumulative distribution approach.

Table A3. Results from Ecology's Cumulative Frequency Distribution Approach for the State of Washington Criteria

Above the Kalispel Reservation (RM 72, Segment 115)		Within the Kalispel Reservation (RM 66, Segment 156)	
Average differential	**Maximum differential**	**Average differential**	**Maximum differential**
0.05	0.60	-0.60	0.07

Table A4. Comparison of Maximum Temperature Exceedence Values using the Daily Comparison Approach and the Cumulative Frequency Distribution Approach for the State of Washington Criteria

Temperature exceedences (deg C)			
Above the Kalispel Reservation (RM 72)		**Within the Kalispel Reservation (RM 66)**	
Daily Approach	**Cumulative Approach**	**Daily Approach**	**Cumulative Approach**
0.80	0.3	0.53	0

ATTACHMENT B

Overview of Ecology's TMDL Conclusions and Findings

Conclusions described in the March 2011 TMDL that are relevant to the discussions in this memorandum include the following:

TMDL Objectives

- Both Washington State and the Kalispel Tribe have developed water quality criteria related to temperature for the Pend Oreille River. These criteria reference both an existing and a natural temperature condition designed to protect salmonids. (page 7-8)
- The TMDL analysis of water temperatures within the Pend Oreille River was developed in response to observations of chronically elevated temperatures at levels exceeding the river's specific criteria. Elevated temperatures result in impacts to salmonid spawning, rearing, and migration, which is the designated use established for the river and protected by the water quality standards. (p. ix)
- The focus of the TMDL study is the 72-mile section of the Pend Oreille River from its entrance into Washington, near the city of Newport, to its northern exit into British Columbia, Canada. The Kalispel Indian Tribe Reservation is located along an 8.6-mile stretch between river miles 72.3 to 63.7. (p. x)

Kalispel Tribe Temperature Criteria

- The Kalispel Tribe has temperature criteria that apply to the Pend Oreille River for the section under its jurisdiction. The United States Environmental Protection Agency approved the Kalispel Tribe's water quality standards on June 24, 2004. (p. 8)

- The Kalispel's temperature criteria for the Pend Oreille River are designated to meet the use of adult salmonid migration. The criteria are
  - Seven-day average of the daily maximum of 18 degrees C.
  - One-day maximum of 20.5 degrees C.

  If natural conditions are above these criteria, then human influences can raise water temperatures by no more than 0.3°C. (p. 8)
- The Kalispel Tribe's temperature criteria refer to a natural condition. Natural conditions are those that occurred prior to altered levels of shade-producing vegetation along the mainstem and its tributaries, point source discharges, and the dams and their collective influence on river hydraulics. (p. 16)

Natural conditions and temperatures

- Because of the current changes to the river as a consequence of the dams, the natural temperature condition can only be estimated through the application of a water quality model. (p. x)
- Results of computer simulations indicate that both the Pend Oreille Public Utility District's Box Canyon Dam and Seattle City Light's Boundary Dam increase the heat load to the Pend Oreille River to levels that result in the exceedance of the temperature criteria. (p. xi)
- The Pend Oreille River's natural channel flow characteristics were narrower and shallower and subject to greater gains and losses in heat which, in turn, affected the range in temperature. The daily range of temperatures was larger under natural conditions than under existing conditions. (p. xi)

Hydroelectric Facilities

- Box Canyon Dam is owned by the Pend Oreille Public Utility District. Box Canyon is a run-of-the-river dam with very little active storage capacity. The reservoir inundates areas along the banks and floodplain of the original river. At times, the head of the reservoir can extend to the foot of Albeni Falls Dam. (p. 14)
- Boundary Dam is owned by Seattle City Light. Boundary Dam is operated for peak load-following and providing operating reserves. Water is typically released during the day and the reservoir refills at night. Currently, reservoir water levels fluctuate ten feet during the summer and 20 feet the remainder of the year. (p. 14)

Computer Simulations

- A computer model was required to evaluate the temperature criteria for the Pend Oreille River. The water quality model CE-QUAL-W2 was developed for two sections of the Pend Oreille River in Washington:
  - The Box Canyon Model describes the river from the Albeni Falls Dam to the Box Canyon Dam tailrace

    - The Boundary Model describes the river from the Box Canyon tailrace to the Boundary Dam tailrace (p. 16)

- Portland State University developed the Box Canyon model for Ecology and Battelle-Pacific Northwest Division created the Boundary model for Seattle City Light. (p. 16)
- All natural condition temperatures were generated from the CE-QUAL-W2 model since temperature data does not exist from before the dams were completed. (p. 17)
- Both the Box Canyon and Boundary models generated predictions of water temperature through the analysis period (January 1, 2004 through Sept. 8, 2005) based on a 30-minute frequency. (p. 22)
- The daily maximum temperature for each model segment was used for the TMDL analysis. This data consideration follows from the temperature criteria that apply to the Pend Oreille River, which are based on daily maximum temperatures. (p. 22)

<u>Cumulative Frequency Distribution Analysis</u>

- Ecology chose a cumulative frequency distribution analysis approach to evaluate compliance with water quality standards in the TMDL. (p. 26)
- Ecology provided three stated reasons for adopting this cumulative frequency distribution approach:
    - The dams have altered the hydrologic characteristics of the river from the natural condition. These differences between the natural and existing conditions makes direct time-based (i.e. day-to-day) temperature comparisons difficult.
    - By using a cumulative frequency distribution analysis it is possible to determine how often temperatures occur within a specific amount of time.
    - The effect of short-term events such as weather fronts are minimized using the cumulative frequency distribution approach. (p. 26)
- Ecology references computer simulations describing temperature responses to weather fronts in the Boundary reservoir to support their selection of the cumulative frequency distribution analysis. These computer simulations are described in Breithaupt et al. (2008). The simulations for the Boundary reservoir suggest that under natural conditions the response is less than one day, and under existing conditions (with the dam) the response is about four and a half (4.5) days. (p. 26)
- No similar analyses were provided that considers response times in locations above Box Canyon dam. (p. 26)

<u>Compliance with Kalispel Tribe's Temperature Criteria</u>

- Analysis of the Kalispel Tribe's temperature criteria is necessary to determine compliance at the reservation boundary. The Tribe's temperature criteria are based on two parts. Both parts are directed at peak temperature conditions and both parts are based on the comparison between natural and existing conditions. (p. 28)
- Model segment 115 was evaluated in order to determine compliance with the Tribe's water quality criteria at their reservation boundary. Model segment 115 is located at approximately river mile 72 and defines the upstream boundary where the Kalispel criterion applies. (p. 28)
- The cumulative frequency distribution analysis of peak temperatures at segment 115 under existing conditions show that both parts of the Kalispel tribal temperature criteria are exceeded. (page 51)
- The first part of the Kalispel criteria is based on the 7-day average of the daily maximum temperatures. When natural conditions exceed 18 degrees C, the existing temperatures should not be greater than 0.3 degrees C above the natural condition. In 2004, at segment 115, the maximum temperature differential reached 0.40 degrees C, an exceedance level of 0.1 degrees C. (page 51)
- The second part of the Kalispel temperature criteria is based on the comparison of existing and natural condition daily maximum temperatures when natural conditions exceed 20.5degrees C. The results of its application were similar to that found for Part 1. Maximum temperatures observed in segment 115 exceed the criteria, though by a slightly larger margin (0.3 degrees C as opposed to 0.1 degrees C). (p. 51)
- To achieve compliance with the Kalispel Tribe's criteria, the one-day temperature maximum at segment 115 needs to be reduced by 0.27 degrees C, and the seven-day average maximum temperature must be reduced by 0.22 degrees C. These reductions are expected to occur through efforts to achieve the load allocation for the Box Canyon Dam forebay. (page 79)

Effects of the Hydroelectric Facilities

- The results of the TMDL study indicate that the operations of the Pend Oreille Public Utility District's Box Canyon Dam and Seattle City Light's Boundary Dam are associated with increased heat loads in the Pend Oreille River. In both cases the increase is significant enough to result in the exceedance of the Pend Oreille River temperature criteria. (page 78)
- The TMDL study results indicate that the criteria exceedances observed at the upstream end of the Kalispel Reservation are associated with the operation of the Box Canyon facility. (p. 79)
- The computer simulations described in the TMDL show that removing the Box Canyon dam would results in an overall decrease in the existing temperature condition in river segment 115 by 0.22 degrees C (7-day average) to 0.27 degrees C (1-day average). (page 67)

- Ecology anticipates measures, actions, and efforts will need to be taken or made throughout the reservoirs and in the tributaries to achieve water quality standards in the forebays. By taking actions to reduce temperatures along the entire river and in the tributaries, impairments in the forebays and upstream reaches will be addressed. (page 79)

TMDL Allocations

- Ecology assumes river temperatures entering Washington at the Idaho-Washington state line in the future will be no warmer than 2004 observed temperatures during low flow and warm weather conditions. (page 73)
- Ecology assumes that the existing river temperatures at the Stateline are cooler now than under natural conditions. This conclusion is apparently a result of using the cumulative frequency distribution approach and does not consider specific time periods during the summer months when the water flow across the Stateline is warmer under existing conditions as compared to natural conditions. (p. 73)
- Ecology also assumes that temperatures at the Stateline in the future will be cooler than under natural conditions. According to Ecology, this "stateline assumption" provides a baseline for establishing load allocations downstream (page 73).
- Ecology provides a 0.3 degree C allocation in heat load to the river downstream of the Stateline as a result of their conclusion that water flowing from Idaho is cooler under existing conditions and that this will continue in the future. (page 79)
- Temperatures under existing conditions are 1.25 degrees warmer in Box Canyon forebay than under natural conditions. (p. 41)
- When natural condition river temperatures are greater than 20 degrees C (July and August), load allocations have been set equivalently at 0.12 degrees C above the natural temperature condition for the Box Canyon and Boundary facilities. (p. xii)
- The temperature reduction required to achieve the load allocations for Box Canyon and Boundary is 1.13 degrees C and 0.88 degrees C, respectively. These reductions apply during July and August in the forebays of the dams, which are the areas of maximum temperature impairment. (p. xii)

ATTACHMENT C

Graphical Results from the Department of Ecology's Cumulative Frequency Distribution Approach

The approach used by Ecology to identify violations of the Washington and Kalispel temperature criteria is described in the "*Methods*" section of the 2011 TMDL. Ecology's approach for identifying violations of the Washington temperature criteria is summarized.[2] The page references refer to page numbers in the 2011 TMDL (Baldwin et al., 2011).

Step 1. Data Filtering (page 48)

Daily maximum temperatures less than or equal to 20.5 deg C and 7DADM temperatures less than or equal to 18 degrees were removed from the model output. The natural temperatures at the same locations and times that exceed the 20.5 or 18 degree criteria are also identified in Ecology's approach. Only temperature output for 2004 was used. The reason for this is that the output in 2005 ended early September, when daily maximum temperatures (and 7-day averages) remained above 18 degrees C.

Step 2. Cumulative Frequency Distribution (page 48)

The second step in Ecology's approach is to plot the existing and natural temperatures on cumulative frequency distribution (CFD) graphs. An example for the 1-day maximum temperatures is shown in Figure C1a and an example for the 7DADM is shown in Figure C2a . Ecology's approach involves using 100 data points to define the CFD for both the existing and natural distributions.

Step 3. Calculation of Temperature Differentials (page 48)

[2] A detailed and full description of the Ecology approach is not included in the TMDL document. The description provided in this memorandum represents my best interpretation of their approach based on the information included in the TMDL

The third step involves calculating what Ecology defines as "temperature differentials." The rationale for this step is summarized in the excerpt below from Page 32 of the 2011 TMDL:

> *The cumulative frequency distributions (CFD) derived for the existing condition (Scenario 1) and associated natural condition (Scenario 8) were compared to examine compliance with the Pend Oreille River temperature criteria. To determine compliance with criteria, the existing condition temperature CFD was subtracted from the associated natural condition temperature CFD, based on similar percentiles, to derive what is referred to as a temperature differential. The temperature differential presents the change in temperature from the existing condition in relation to the natural condition.*

An example diagram of temperature differentials for the 1-day maximum temperature is shown in Figure C1b and example for the 7DADM is shown in Figure C2b. Ecology also calculates a "full temperature profile differential" by taking the average of the 100 differentials calculated from the CFD graphs.

Figures C1 through C6 describe the results of Ecology's cumulative frequency distribution approach in graphical form for RM 72 and RM 66. Figures C1 and C4 give results for the Kalispel daily maximum criteria, Figure C2 and C4 give results for the Kalispel 7-day average criteria, and Figures C3 and C6 give results for the State of Washington Criteria.

Figure C1. Results from the Department of Ecology's cumulative frequency distribution approach for the river segment immediately above the Kalispel Reservation (Model Segment 115, RM 72) for the Kalispel daily maximum criteria.

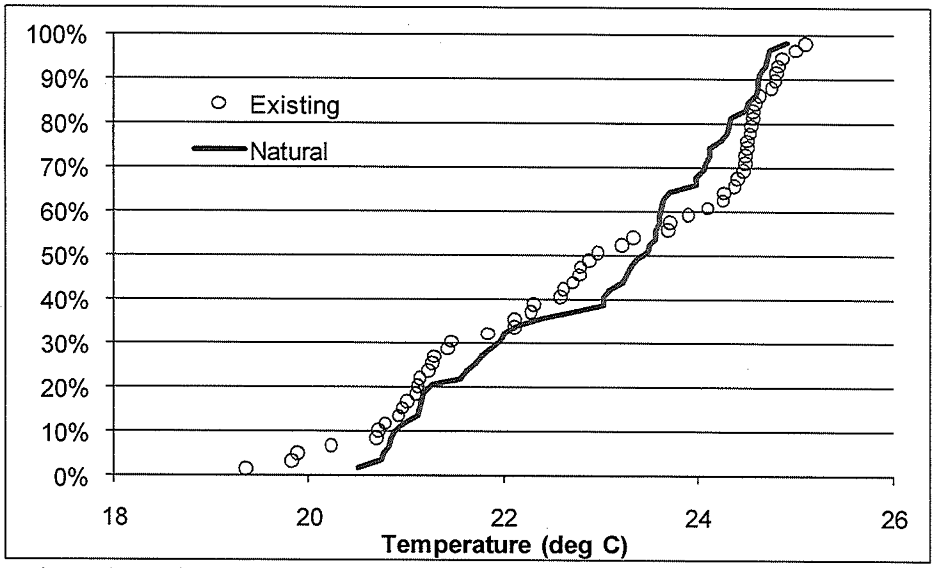

Figure C1a. Cumulative distributions for temperatures when existing daily maximum temperatures exceed 20.5 degrees C.

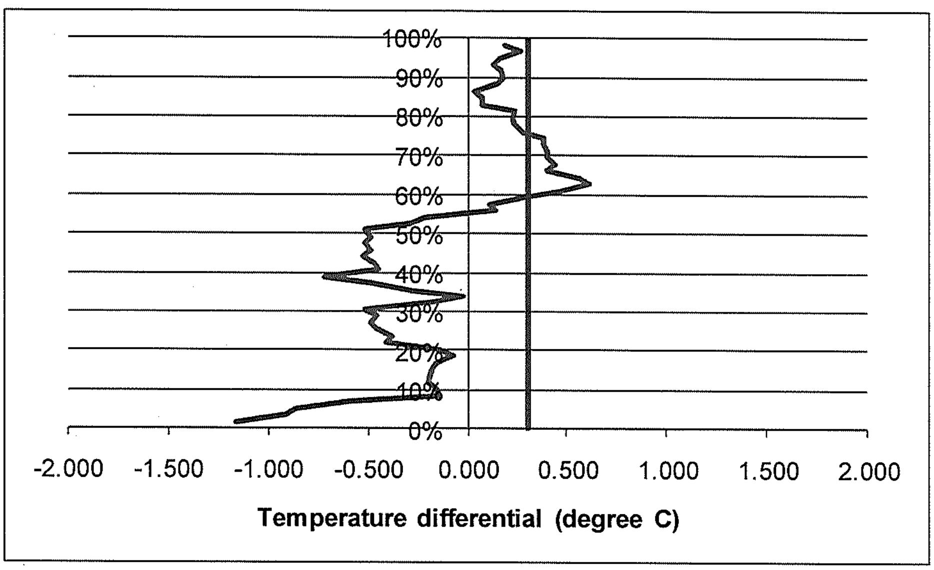

Figure C1b. Temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 20.5 degrees C.

Figure C2. Results from the Department of Ecology's cumulative frequency distribution approach for the river segment immediately above the Kalispel Reservation (Model Segment 115, RM 72) for the Kalispel 7DADM criteria.

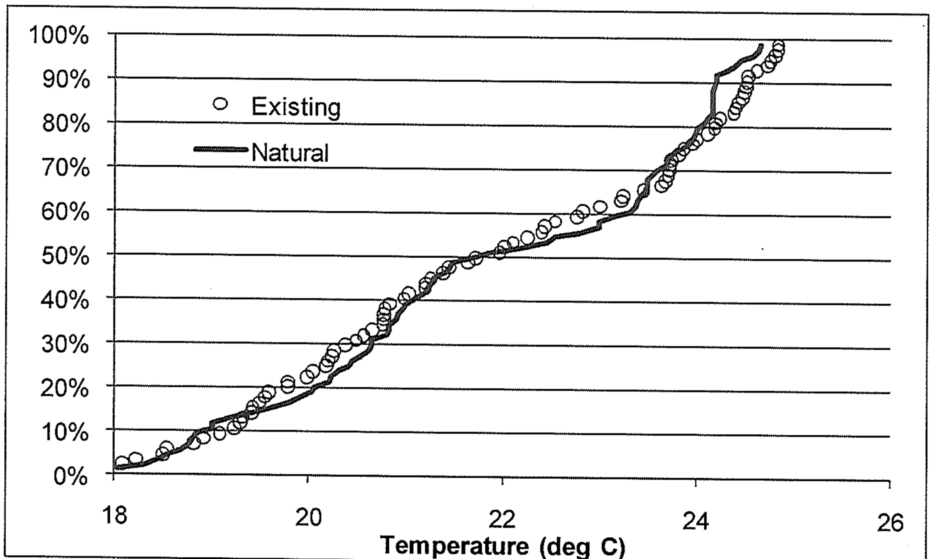

Figure C2a. Cumulative distributions for temperatures when existing daily maximum temperatures exceed 18 degrees C.

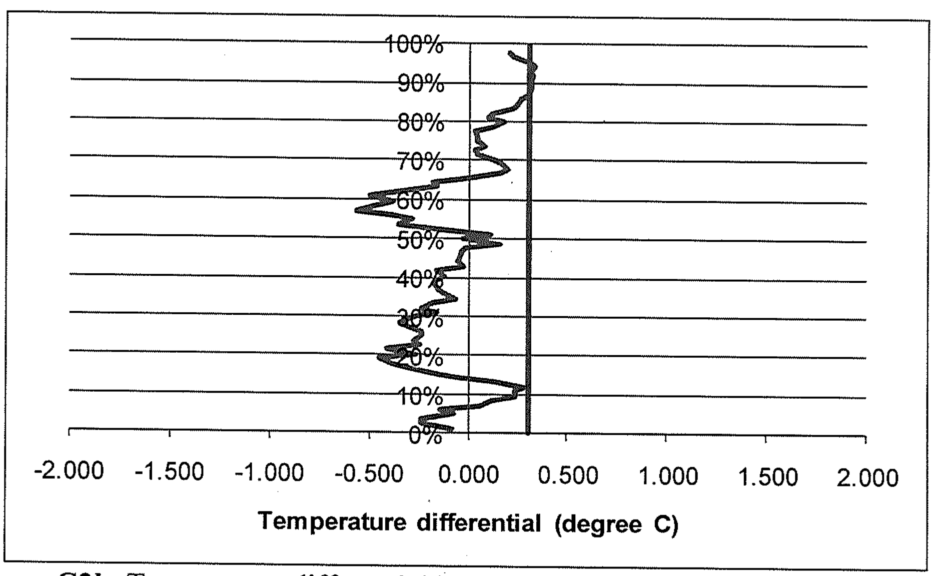

Figure C2b. Temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 18 degrees C.

Figure C3. Results from the Department of Ecology's cumulative frequency distribution approach for the river segment immediately above the Kalispel Reservation (Model Segment 115, RM 72) for the State of Washington criteria.

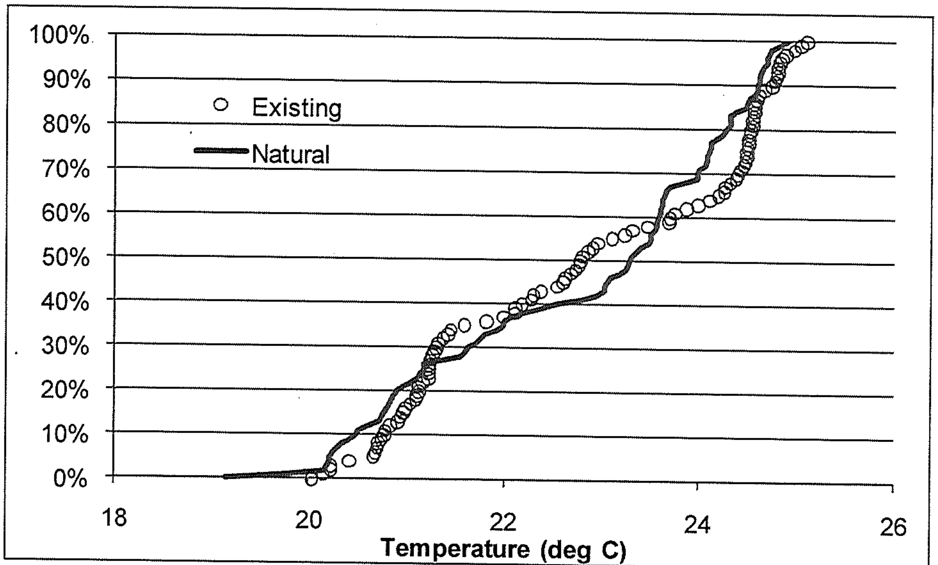

Figure C3a. Cumulative distributions for temperatures when existing daily maximum temperatures exceed 20 degrees C.

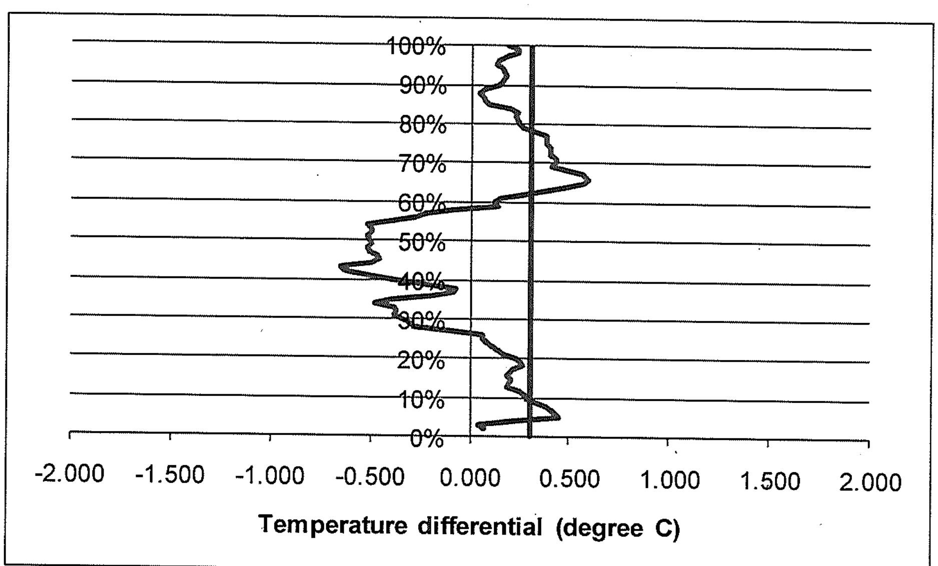

Figure C3b. Temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 20 degrees C.

Figure C4. Results from the Department of Ecology's cumulative frequency distribution approach for the river segment immediately within the Kalispel Reservation (Model Segment 156, RM 66) for the Kalispel daily maximum criteria.

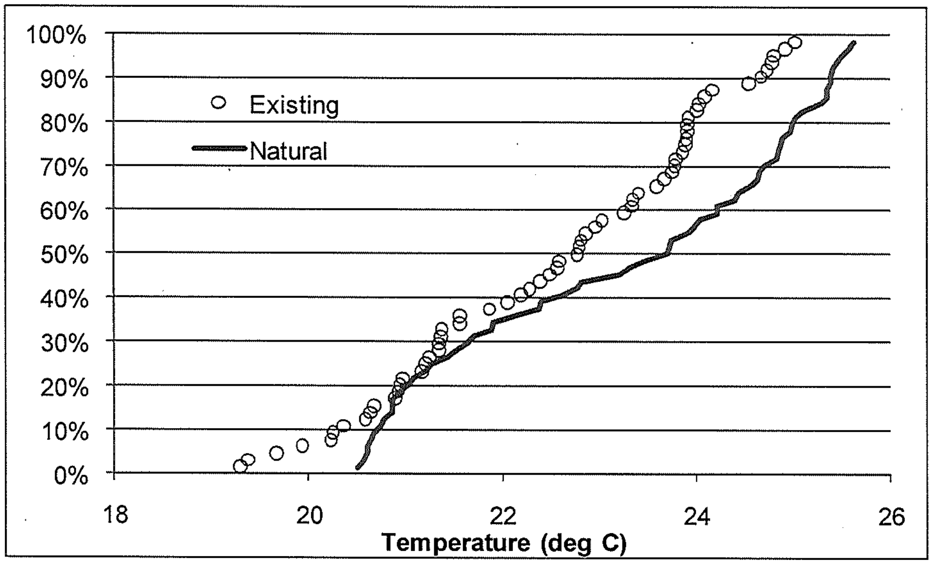

Figure C4a. Cumulative distributions for temperatures when existing daily maximum temperatures exceed 20.5 degrees C.

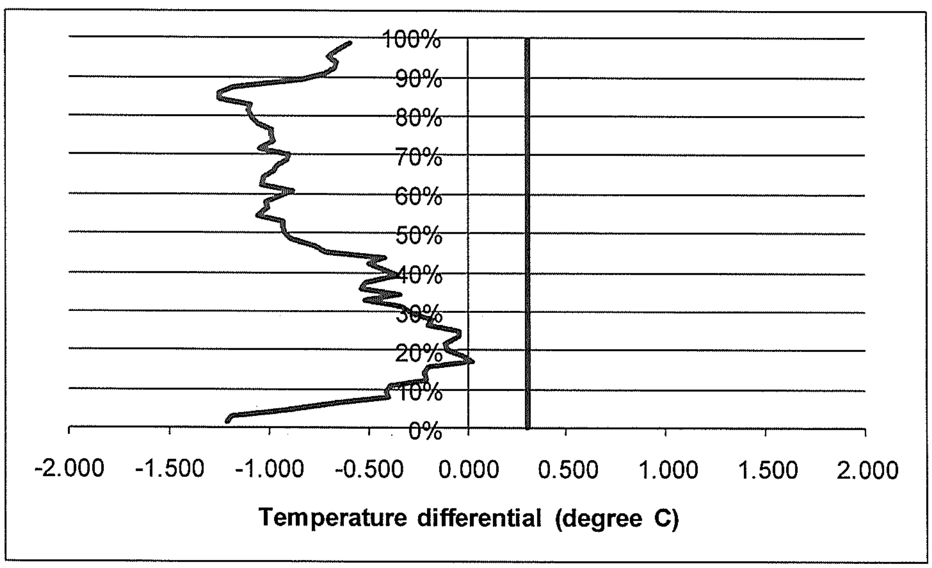

Figure C4b. Temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 20.5 degrees C.

Figure C5. Results from the Department of Ecology's cumulative frequency distribution approach for the river segment immediately above the Kalispel Reservation (Model Segment 156, RM 66) for the Kalispel 7DADM criteria.

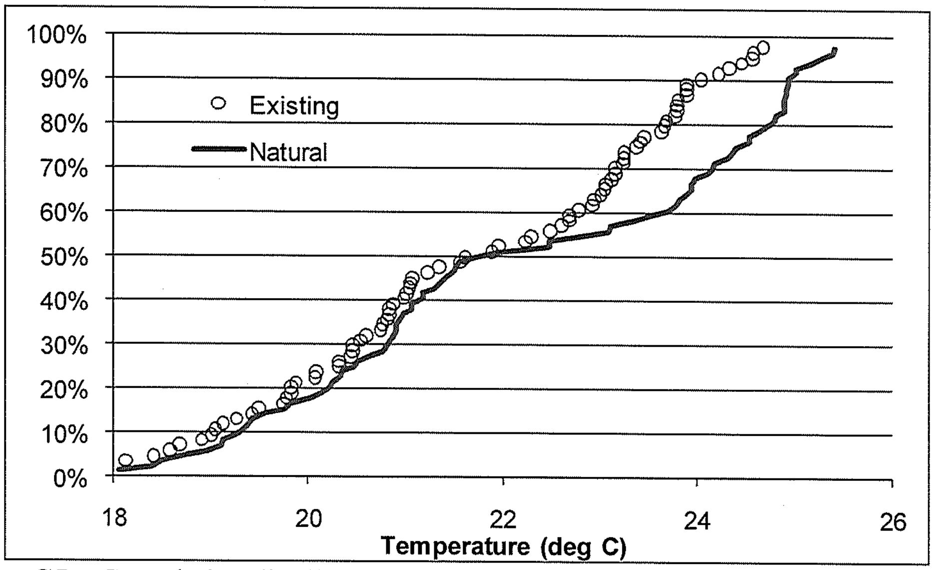

Figure C5a. Cumulative distributions for temperatures when existing daily maximum temperatures exceed 18 degrees C.

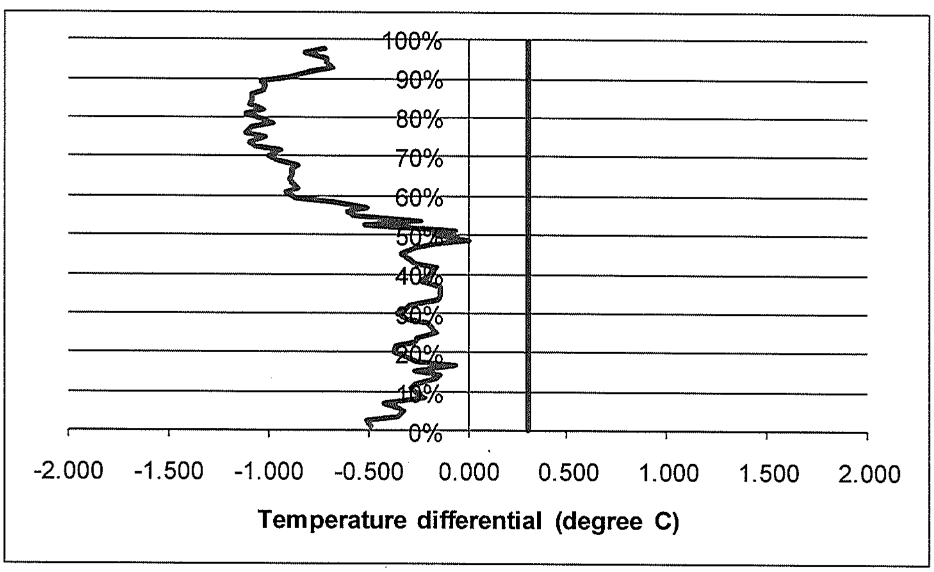

Figure C5b. Temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 18 degrees C.

Figure C6. Results from the Department of Ecology's cumulative frequency distribution approach for the river segment within the Kalispel Reservation (Model Segment 156, RM 66) for the State of Washington criteria.

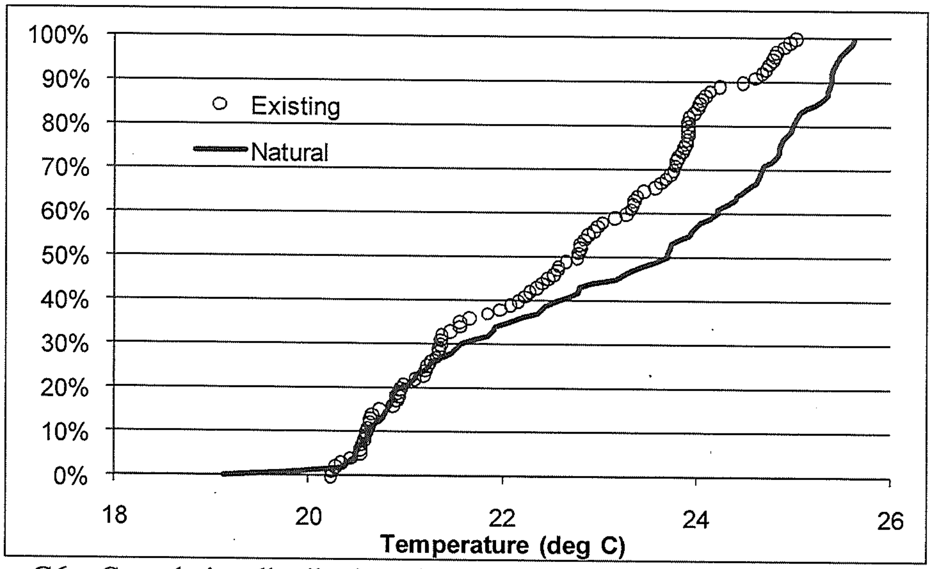

Figure C6a. Cumulative distributions for temperatures when existing daily maximum temperatures exceed 20 degrees C.

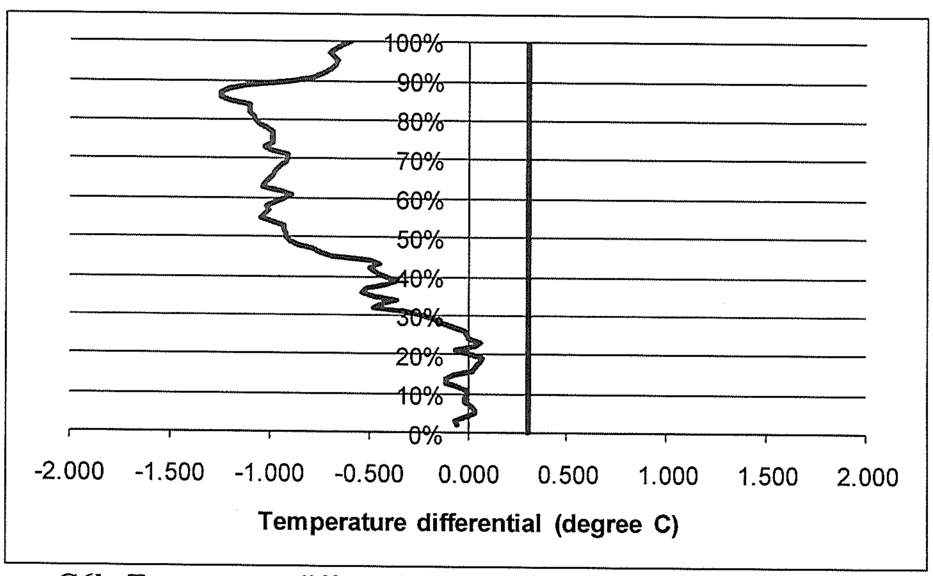

Figure C6b. Temperature differential between existing and natural conditions, by percentile, when natural conditions exceed 20 degrees C.

Pend Oreille County Public Utility District

Administrative Offices- P.O. Box 190 • Newport, WA 99156 • (509) 447-3137 • FAX (509) 447-5824
Box Canyon Hydro Project- P.O. Box 547 •lone, WA 99139 • (509) 446-3137 • FAX (509) 447-6790

September 29, 2011

David Moore
Washington Department of Ecology
Water Quality Program- Eastern Regional Office
4601 North Monroe Street
Spokane, Wi\ 99205-1295

RE: Errata Document Comments
Pend Oreille River TMDL-Temperature

Dear Mr. Moore:

Ecology has requested comments on proposed changes to the Pend Oreille Temperature TMDL as called for by the Ecology Director's "Decision" regarding the TMDL Dispute Resolution process. The proposed changes are provided in an "Errata" document dated September 2011. While the District does not fully agree with the results and conclusions in the Decision, the District respectfully submits the following comments.

One of the District's primary concerns with the "Errata" is that Ecology does not refer to or acknowledge the increased level of uncertainty regarding model calibration and results, and the related load allocations that was addressed in the Decision. The District requests that Ecology add references in the Errata that show the analyses contained in the Decision, including:

1. The current calibration based on measured profile data has a bias on the high side with modeled temperatures above temperatures indicated by monitoring data.
2. The "maximum" water temperatures predicted in the model and used to develop the allocations are higher than the available measured data indicate.
3. The "maximum" water temperatures used in the TMDL are not verifiable at this time.
4. Model calibration was "re-assessed" based on a more "average" temperature time series measured at 3-meters depth.
5. 1\nalyses of3-meter depth model data indicate the Box Canyon TMDL allocation of 1.13°C, which is based on maximum model data, may be substantially lower.

As an alternative to these requested changes, the District requests that Ecology adds reference in the TMDL that indicates increased model and allocation uncertainty as expressed in the Decision, and include the "Directors Decision" as an attachment to the TMDL. This seems appropriate considering Ecology's analyses show the Box Canyon TMDL allocation could be substantially lower, or that violations may not occur. And more importantly, this acknowledged uncertainty can influence future decisions as we move forward with efforts to develop a "reasonable and feasible" Water Quality Attainment Plan, as recently discussed.

Finally, the District requests that Ecology add language to the Errata document showing that Ecology will consider new data if it becomes available in the future.

These comments do not constitute the District's agreement with the Director's Decision or a waiver by the District of any claims the District may have with respect to the Pend Oreille River TMDL. By submitting these comments, the District is reserving all of its rights.

Thank you for the opportunity to comment on the Errata document of the TMDL. We look forward to working with Ecology on the efforts to develop the Water Quality Attainment Plan.

Sincerely,

Mark Cauchy
Director, Regulatory & Environmental Affairs
Public Utility District No. 1 of Pend Oreille County

Seattle City Light document

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City of Seattle
Michael Patrick McGinn, Mayor

Seattle City Light
Jorge Carrasco, Superintendent

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DEPARTMENT OF ECOLOGY
EASTERN REGIONAL OFFICE

September 29, 2011

David Moore
Washington State Department of Ecology
Water Quality Program - Eastern Regional Office
4601 North Monroe Street
Spokane, WA 99205-1295
Email: david.moore@ecy.wa.gov

VIA E-MAIL AND US MAIL

RE: SCL's Comments on Proposed Changes to Pend Oreille River Temperature TMDL

Dear Mr. Moore:

This letter and its attachments provide Seattle City Light's ("SCL") comments on Ecology's draft Errata for the Pend Oreille River Temperature Total Maximum Daily Load: Water Quality Improvement Report ("TMDL") that you provided to us on September 14, 2011.

SCL very much appreciates the opportunity to review this document before finalization and transmittal to EPA. SCL's comments and accompanying rationale are provided in the attached document titled "Seattle City Light's Comments on Ecology's Proposed Changes to Pend Oreille Temperature TMDL," which shows in redline/strikeout format SCL's proposed changes to Ecology's text. We are also providing, in the attached document titled "Proposed Changes to Pend Oreille Temperature TMDL," text that incorporates SCL's proposed changes and that can be inserted directly into Ecology's Errata sheet for transmittal to EPA.

Please let me know if you would like the opportunity to discuss any of SCL's comments or proposed changes, and again, thank you for the opportunity to review this document.

Sincerely,

B Greene

Barbara Greene
Boundary Relicensing Project Manager

Attachments

cc: Marci Mangold, Ecology

Proposed Changes to Pend Oreille Temperature TMDL

(Ecology 9/14 Errata with SCL Proposed Revisions)

The following sections are intended to replace corresponding sections in Ecology's September 14 draft Errata for the TMDL.

- Introduction, Second bullet point

  The temperature reduction target in the Boundary Dam forebay needs to reflect the temperature signal from the PUD's Box Canyon Dam. The required temperature reduction in the Boundary forebay should be 0.76°C, not the 0.88°C listed in the TMDL. However, the load allocation value for each dam remains unchanged at 0.12°C above the natural temperature condition, for a total of 0.24°C of the 0.3°C allowance. Therefore, the cumulative temperature reduction from both the PUD and SCL is a temperature reduction of 0.76°C in the Boundary Dam forebay, which would achieve the target temperature of natural conditions +0.24°C.

- Page 87, second paragraph

  The approach the Pend Oreille PUD and Seattle City Light will use to meet the load allocations in this TMDL will be consistent with requirements found in the state water quality standards [Washington Administrative Code (WAC) 173-201A-510(5)], which assigns a ten-year compliance schedule to dams. This rule requires dam owners to develop a Water Quality Attainment Plan. The water quality attainment plan provides a detailed approach for achieving compliance and must contain five elements specific to temperature:

  - A schedule to achieve compliance that does not exceed ten years.
  - The identification of all reasonable and feasible improvements that could be used to meet standards, or if meeting the standards is not attainable, then achieve the highest attainable level of improvement.
  - A description of the methods used to evaluate the reasonable and feasible improvements.
  - A plan to conduct water quality monitoring to be used by Ecology in tracking progress in achieving compliance with state water quality standards.
  - The benchmarks and reporting requirements that will be used to track the progress of implementing the water quality attainment plan and meeting water quality standards.

- Page 87, fifth paragraph

  After the Water Quality Attainment Plan is implemented, Ecology and the dam operator will decide what the next steps are (whether completed actions meet water quality standards; another compliance schedule is appropriate; or evaluate other alternatives to achieve compliance with the standards). ~~If after the Pend Oreille PUD or Seattle City Light complete all reasonable and feasible improvements under WAC 173-201A-510(5)(g), and their load~~

~~allocation is still not met by the timeline set in this TMDL, then the dam owner would take the following steps to achieve compliance with the standards:~~

~~• Evaluate new reasonable and feasible technologies or other options.~~

~~• Develop a new compliance schedule to evaluate and incorporate any new technology.~~

~~• If no new reasonable and feasible technologies are identified, propose other alternatives as allowed by WAC173-201A-510.~~

- Page 92, paragraph four, *Pend Oreille Public Utility District (PUD)*:

  Pend Oreille Public Utility District (PUD): The Pend Oreille PUD is responsible for implementing provisions of their license for Box Canyon Dam that FERC issued in July 2005. In February 2003, Ecology issued a water quality certification which is included as part of the FERC license.

  Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispel Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreille PUD to implement a Trout Habitat Restoration Program (THRP). The THRP calls for the restoration and maintenance of 164 miles of tributary habitat, of which 66 miles will occur in the first ten years, 66 in the second ten years, and 32 in the remaining five year period. The THRP will include a combination (some or all) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:

  • Channel improvements (limited to geomorphologic improvements and barrier removal)

  • Floodplain restoration

  • Riparian corridor restoration

  • Conservation easements and/or purchases

  Ecology will use current actions from Pend Oreille PUD settlement agreement as evidence demonstrating that the PUD is moving toward meeting applicable temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the ten-year compliance schedule.

  The Pend Oreille PUD should keep the public; Kalispel Tribe; Idaho DEQ; Ecology; the Tri- State Water Quality Council; and the EPA informed of the status of the project. A copy of the license for Box Canyon Dam can be found on the PUD's website: www.popud.com/license.htm.

- Page 93, second paragraph, *Seattle City Light*:

  Seattle City Light: Seattle City Light is working on relicensing Boundary Dam. Studies conducted to identify and understand the environmental and other effects of the dam will help identify water quality conditions that may be incorporated into Ecology's 401 certification. Seattle City Light will be responsible for implementing requirements of its water quality attainment plan and provisions of its new FERC license.

  Seattle City Light has a settlement agreement that was signed on March 23, 2010, by the Bureau of Indian Affairs; National Park Service; United States Fish and Wildlife Service; Untied States

Department of Agriculture Forest Service; Washington Department of Fish and Wildlife; Washington Department of Ecology; Kalispel Tribe; Public Utility District No. 1 of Pend Oreille County, Washington; American Whitewater; Selkirk Conservation Alliance; and the Lands Council. Seattle City Light developed a temperature Water Quality Attainment Plan that Ecology approved. The Plan will rely on all actions in the settlement agreement that may improve temperatures in the mainstem and tributaries. Under the Plan, the first ten years of the 401 compliance schedule includes the following activities:

- Mill Pond Dam Removal and Stream Channel Restoration.
- Stream and Riparian Improvements in Sullivan Creek and North Fork Sullivan Creek.
- Large woody debris placement and Road improvements in Sullivan Creek and selected tributaries upstream of the confluence with Outlet Creek.
- Habitat protection, riparian improvement, and stream channel enhancement in Sullivan Creek.
- Cold water release structure at Sullivan Dam.
- Mainstem large woody debris at tributary deltas; two at Sullivan, one at Sweet, Slate, and Linton Creeks.
- Mainstem erosion control measures and riparian plantings.

Under the Plan, monitoring will be required in the tributaries where improvements are expected and in the mainstem of the river.

Seattle City Light should keep the public; Kalispel Tribe; Ecology; the Tri-State Water Quality Council; and the EPA informed of the status of its progress in addressing specified water quality conditions. The format and venue for sharing information regarding compliance may be detailed in the water quality attainment plan. Information about Seattle City Light's relicensing efforts is available on the Web at: www.ci.seattle.wa.us/light/news/isssues/bndryRelic/br_document.asp.

- Page 95, Table 17. Interim and final targets after completion of the WQIP.

Target (years)	NPDES permit holders	Box Canyon Dam	Boundary Dam	Tributary shade	Mainstem Canopy Cover
1	meet permit conditions	water quality attainment plan submitted to Ecology	water quality attainment plan submitted to Ecology	n/a	n/a
5	n/a	0.5°C reduction	0.5°C reduction	n/a	n/a
10	n/a	natural conditions + 0.12 °C	natural conditions + ~~0.12~~0.24 °C	10% increase	7% increase
20	n/a	n/a	n/a	15% increase	10% increase
30	n/a	n/a	n/a	25% increase	13% increase
40	n/a	n/a	n/a	40% increase	17% increase
50	n/a	n/a	n/a	potential natural vegetation (see Table 14)	potential natural vegetation (See Table 13)

Seattle City Light's Comments on

Ecology's Proposed Changes to Pend Oreille Temperature TMDL

SCL respectfully submits the following comments on Ecology's proposed Errata sheet for the Pend Oreille Temperature TMDL to implement the changes required by Director Sturdevant's August 26, 2011 decision letter. As requested by Ecology in its September 14 transmittal, SCL is not commenting on claims denied by Director Sturdevant. However, SCL's lack of comment on these claims does not reflect its agreement with the decision or waiver by SCL of any claims it may have with respect to the Pend Oreille River TMDL.

For each comment below, SCL's recommended revision is marked as redline/strikeout against Ecology's proposed new language. For clarity, Ecology's redline/strikeouts are not shown below. An explanation of SCL's rationale follows each recommended revision.

- Introduction, Second bullet point

  The temperature reduction target in the Boundary Dam forebay needs to reflect the temperature signal from the PUD's Box Canyon Dam. The required temperature reduction in the Boundary forebay should be 0.76°C, not the 0.88°C listed in the TMDL. However, the load ~~SCL's~~ allocation value for each dam remains unchanged at ~~natural conditions +~~ 0.12°C above the natural temperature condition, for a total of 0.24°C of the 0.3°C allowance. ~~The distinction is that the PUD's efforts to implement the TMDL will result in reduced temperatures flowing into Boundary Dam's forebay.~~ Therefore, the cumulative temperature reduction from both the PUD and SCL is a temperature reduction of 0.76°C in the Boundary Dam forebay, which would achieve the target temperature of natural conditions +0.24°C.

  ***Explanation:** SCL recommends revising the bullet point as shown above to better track the language of Director Sturdevant's August 26 letter, and to better track the language of the TMDL at p. 79.*

  The recommended revisions are necessary to ensure that the temperature reduction now required by the TMDL (0.76°C) is internally consistent with the load allocation compliance metric to be used at the Boundary forebay (which must be natural condition +0.24°C – see comments below re Table 17). If the compliance metric for Boundary forebay is not corrected in the TMDL, then the proposed change to the required temperature reduction would become meaningless because the temperature reduction is based on historic conditions (i.e., 2004), whereas future assessments will be based upon the comparison to natural conditions, without regard to historic conditions.

Finally, SCL recommends deleting the statement about the PUD's efforts as unnecessary and potentially confusing because, even if the PUD achieves compliance with the TMDL, it will still be passing water into the Boundary reservoir that is up to 0.12°C above natural conditions.

- Page 87, second paragraph

The approach the Pend Oreille PUD and Seattle City Light will use to meet the load allocations in this TMDL will be consistent with requirements found in the state water quality standards [Washington Administrative Code (WAC) 173-201A-510(5)], which assigns a ten-year compliance schedule to dams. This rule requires dam owners to develop a Water Quality Attainment Plan. The water quality attainment plan provides a detailed approach for achieving compliance and must contain five elements specific to temperature:

- A schedule to achieve compliance that does not exceed ten years.
- The identification of all reasonable and feasible improvements that could be used to meet standards, or if meeting the standards is not attainable, then achieve the highest attainable level of improvement.
- A description of the methods used to evaluate the reasonable and feasible improvements.
- A plan to conduct water quality monitoring to be used by Ecology in tracking progress in achieving compliance with state water quality standards~~after activities are implemented with appropriate adaptive management steps~~.
- The benchmarks and reporting requirements that will be used to track the progress of implementing the water quality attainment plan and meeting water quality standards.

Explanation: SCL recommends the above revision to better track the relevant regulation (WAC 173-201A-510(5)(b)(v)).

- Page 87, fifth paragraph

After the Water Quality Attainment Plan is implemented, Ecology and the dam operator will decide what the next steps are (whether completed actions meet water quality standards; another compliance schedule is appropriate; or evaluate other alternatives to achieve compliance with the standards~~or surface water quality standards should be changed~~).

Explanation: SCL recommends the above revision to better track the relevant regulation (WAC 173-201A-510(5)(g)(ii)).

- Page 92, paragraph four, *Pend Oreille Public Utility District (PUD)*:

Pend Oreille Public Utility District (PUD): The Pend Oreille PUD is responsible for implementing provisions of their license for Box Canyon Dam that FERC issued in July 2005. In February 2003, Ecology issued a water quality certification which is included as part of the FERC license.

Pend Oreille PUD reached a settlement agreement and amended their FERC license on February 19, 2010. The settlement agreement was between the Department of Interior, United States Forest Service, the Kalispel Tribe of Indians, and Ponderay Newsprint. Article 406 of the FERC License requires Pend Oreille PUD to implement a Trout Habitat Restoration Program (THRP). The THRP calls for the restoration and maintenance of 164 miles of tributary habitat, of which 66 miles will occur in the first ten years, 66 in the second ten years, and 32 in the remaining five year period. The THRP will include a combination (some or all) of the following measures that will also make up parts of the Pend Oreille PUD's Temperature Water Quality Attainment Plan:

- Channel improvements (limited to geomorphologic improvements and barrier removal)
- Floodplain restoration
- Riparian corridor restoration
- Conservation easements and/or purchases

~~Similar to Seattle City Light's Water Quality Attainment Plan (see next bulleted item),~~, Ecology will use current actions from Pend Oreille PUD settlement agreement as evidence demonstrating that the PUD is moving toward meeting applicable temperature criteria. We will also require monitoring to inform us on what steps need to take place at the end of the ten-year compliance schedule.

> ***Explanation: SCL recommends the above revision because the deleted text it is unnecessary and could potentially confuse the two separate plans being developed by SCL and the PUD.***

- Page 93, second paragraph, *Seattle City Light*:

Seattle City Light: Seattle City Light is working on relicensing Boundary Dam. Studies conducted to identify and understand the environmental and other effects of the dam will help identify water quality conditions that may be incorporated into Ecology's 401 certification. Seattle City Light will be responsible for implementing requirements of its water quality attainment plan and provisions of its new FERC license.

Seattle City Light has a settlement agreement that was signed on March 23, 2010, by the Bureau of Indian Affairs; National Park Service; United States Fish and Wildlife Service; Untied States Department of Agriculture Forest Service; Washington Department of Fish and Wildlife; Washington Department of Ecology; Kalispel Tribe; Public Utility District No. 1 of Pend Oreille County~~;~~, Washington; American Whitewater; Selkirk Conservation Alliance; and the Lands Council. Seattle City Light developed a temperature Water Quality Attainment Plan that Ecology approved. The ~~plan~~ Plan will rely on all actions in the settlement agreement that may improve temperatures in the mainstem and tributaries. Under the Plan, ~~T~~the first ten years of the 401 compliance schedule includes the following activities:

- Mill Pond Dam Removal and Stream Channel Restoration.
- Stream and Riparian Improvements in Sullivan Creek and North Fork Sullivan Creek.
- Large woody debris placement and Road improvements in Sullivan Creek and selected tributaries upstream of the confluence with Outlet Creek.
- Habitat protection, riparian improvement, and stream channel enhancement in Sullivan Creek.
- Cold water release structure at Sullivan Dam.
- Mainstem large woody debris at tributary deltas; two at Sullivan, one at Sweet, Slate, and Linton Creeks.
- Mainstem erosion control measures and riparian plantings.

Under the Plan, ~~Monitoring~~ monitoring will be required in the tributaries where improvements are expected and in the mainstem of the river.

Seattle City Light should keep the public; Kalispel Tribe; Ecology; the Tri-State Water Quality Council; and the EPA informed of the status of its progress in addressing specified water quality conditions. The format and venue for sharing information regarding compliance may be detailed in the water quality attainment plan. Information about Seattle City Light's relicensing efforts is available on the Web at: www.ci.seattle.wa.us/light/news/isssues/bndryRelic/br_document.asp.

***Explanation:** SCL recommends revisions to Ecology's proposed new text as marked above to clarify that the stated activities and monitoring will be as provided in the Plan.*

- Page 95, Table 17. Interim and final targets after completion of the WQIP.

***Explanation:** SCL recommends that the cell entry for "Boundary Dam" at "Target Year 10" in Table 17 be revised to read "natural conditions + 0.24°C". SCL made this request in its letter initiating the dispute resolution process (April 16, 2011 letter to Director Sturdevant, at p. 4), so this recommendation is within the scope of comments on the Errata requested by Ecology.*

The recommended change is necessary to make Table 17 consistent with Table 15 and with the text changes proposed by the Errata sheet, all of which clarify that the temperature reduction at Boundary forebay (0.76°C) needs to reflect the temperature signal from the PUD's Box Canyon Dam, and that the cumulative allocation to the two dams is 0.24°C above natural conditions. The value currently stated in the table ("natural conditions + 0.12°C") is based on the old required temperature reduction 0.88°C.

To clarify, the proposed new text for p. 79 of the TMDL calculates the required reduction needed to achieve compliance at Boundary forebay (0.76°C) as follows: start with the historic maximum temperature differential between natural and existing conditions (i.e., from 2004, when existing = natural +1.0°C), then subtract 0.12°C each for both Box Canyon and Boundary dams. If the 0.76°C temperature reduction had been achieved in 2004, then the existing condition at Boundary forebay would have been natural condition + 0.24°C. Accordingly, for purposes of Table 17, which sets the metrics against which future conditions will be measured, the compliance metric for Boundary forebay must be natural conditions + 0.24°C.