Draft
EPA Region 10 Guidance
for
Pacific Northwest State and Tribal Temperature Water Quality Standards

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I. Introduction

This guidance describes an approach States and authorized Tribes (Tribes) in the Pacific Northwest may use to adopt water quality standards (WQS) for temperature that EPA believes will protect cold water salmonid species and meet the requirements of the Clean Water Act (CWA) and Endangered Species Act (ESA). This guidance specifically addresses the following cold water salmonid species in the Pacific Northwest: chinook, coho, sockeye, chum, and pink salmon; steelhead and coastal cutthroat trout; and bull trout. This guidance may also be useful for States and Tribes to protect other cold water salmonid species that have similar temperature tolerances but are not explicitly addressed in this guidance.

Because this is a guidance document and not a regulation, EPA cannot bind itself to approve a WQS submission that conforms to this guidance. Furthermore, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service (the Services) cannot bind themselves to future consultation determinations (i.e. a "no jeopardy" determination). Indeed, the EPA and the Services must examine the appropriateness of every WQS submission on a case-by-case basis. However, States and Tribes that adopt temperature WQS consistent with this guidance can expect an expedited review by EPA and the Services.

It is also important to note that this guidance does not preclude States or Tribes from adopting temperature WQS different from those described here. EPA would approve any such temperature WQS where EPA determined that its approval would be consistent with the CWA and ESA. Because this guidance reflects the most recent scientific information on temperature tolerances for Pacific Northwest salmonids species, EPA intends to consider it when reviewing Pacific Northwest State and Tribal temperature WQS or promulgating federal temperature WQS in Idaho, Oregon, or Washington.

This guidance was developed with the assistance of representatives of the Pacific Northwest States, the Services, and the Columbia River Inter-Tribal Fish Commission (CRITFC) Tribes. As part of developing this guidance, EPA, with the assistance of technical experts from Federal, State, and Tribal organizations, developed five technical issues papers and a technical synthesis report summarizing technical issues related to water temperature and salmonids. These reports represent the technical foundation of this guidance and summarize the latest literature related to temperature and salmonids.

II. Regulatory Background

The goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters and, where attainable, to achieve water quality that provides for the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water. As a means of meeting this goal, section 303(c) of the CWA requires States and Tribes to adopt WQS that include designated uses and the water quality criteria to protect those designated uses. In addition, Federal WQS regulations require States and Tribes to adopt a statewide antidegradation policy and methods to implement such policy. See 40 C.F.R. § 131.12. States and Tribes may also adopt into their standards policies generally affecting the application and implementation of WQS, such as mixing zones and variances. See 40 C.F.R. § 131.13.

EPA is required to approve or disapprove new or revised State and Tribal WQS under section 303(c) of the CWA to ensure they are consistent with the requirements of the CWA and EPA's implementing regulations. See CWA section 303(c)(3). New or revised State and Tribal WQS are not in effect for CWA purposes until they are approved by EPA. If EPA disapproves a new or revised WQS submitted by a State or Tribe, or if the EPA Administrator determines that a new or revised WQS is necessary to meet the requirements of the CWA, EPA must propose and promulgate appropriate WQS itself, unless appropriate changes are made by the State or Tribe. See CWA section 303(c)(4).

Where EPA's approval of State or Tribal WQS may affect threatened or endangered species or their critical habitat, the approval action is subject to the procedural and substantive requirements of section 7(a)(2) of the ESA. Section 7(a)(2) of the ESA requires EPA to ensure, in consultation with the Service(s), that any action it takes is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction of critical habitat. For actions that are likely to adversely affect listed species, the ESA regulations require EPA to engage in formal consultation, which results in the issuance of a biological opinion by the Service(s). If the Service(s) anticipate that "take" will occur as a result of the action, the opinion in most cases will include required reasonable and prudent measures and associated terms and conditions to minimize such take, along with an incidental take statement providing EPA legal protection from ESA section 9 take liability for its approval action. Section 7(a)(1) of the ESA requires EPA to use its authorities to carry out programs for the conservation of endangered and threatened species. The ESA, however, does not expand EPA's authorities under the CWA. EPA approval or disapproval decisions regarding State and Tribal WQS must be based on the CWA and EPA's implementing regulations.

In addition, EPA has a federal trust relationship with federally recognized Pacific Northwest tribes. In the Pacific Northwest, federal courts have affirmed that certain tribes reserved through treaty the right to fish at all usual and accustomed fishing places and to take a fair share of the fish destined to pass through such areas. EPA's approval of a State or Tribal WQS, or promulgation of its own WQS, may directly impact the habitat that supports the treaty fish. EPA must ensure that its WQS actions do not violate treaty fishing rights.

Water Quality Standards set the water quality goals for a specific water body and serve as a regulatory basis for other programs, such as National Pollutant Discharge Elimination System (NPDES) permits, listings of impaired water bodies under CWA section 303(d), and total maximum daily loads (TMDLs). In general, NPDES permits contain effluent limitations to meet WQS; 303(d) lists identify those water bodies where the WQS are not being met; and TMDLs are mathematical calculations indicating the pollutant reductions needed to meet WQS.

III. Relationship of Guidance to EPA's 304(a) Criteria for Water Temperature

Under CWA section 304(a), EPA issues national criteria recommendations to guide States and Tribes in developing their WQS. When EPA reviews a State or Tribal WQS submission for approval under section 303(c) of the CWA, it must determine whether the adopted designated uses are consistent with the CWA requirements and whether the adopted criteria protect the designated uses. EPA's regulations encourage States and Tribes, when adopting water quality criteria as part of their WQS, to use EPA's section 304(a) criteria guidance, to modify EPA's section 304(a) guidance to reflect site-specific conditions, or to use other scientifically defensible methods to derive criteria to protect the designated uses.

EPA develops its section 304(a) criteria recommendations based on a uniform methodology that takes into account a range of species' sensitivities to pollutant loadings using certain general assumptions; therefore, the national recommendations are generally protective of aquatic life. However, these criteria recommendations may not be protective of all aquatic life designated uses in all situations. It may be appropriate for States and Tribes to develop different criteria using current data concerning the species present, and site-specific or regional conditions. EPA approval or disapproval would not depend on whether the criterion adopted by a State or Tribe is consistent with a particular guidance document, such as this guidance or the national 304(a) criteria recommendations, but rather, whether the State or Tribe demonstrates that the criterion protects designated uses, as required by section 303(c) of the CWA and EPA's WQS regulations.

EPA's current 304(a) criteria for temperature can be found in *Quality Criteria for Water 1986*, known as the "gold book." The freshwater aquatic life criteria described in this 1986 document were first established in 1977, and were not changed in the 1986 document. In summary, EPA's temperature criteria for salmonids and other fish consist of formulas to calculate the protective temperatures for short term exposure and a maximum weekly average exposure. Protective short term temperature exposure is based on subtracting 2°C from the upper incipient lethal temperature (the temperature at which fifty percent of the sample dies). Protective weekly average temperature exposure is based on the optimal growth temperature plus 1/3 the difference between the optimal growth temperature and the upper incipient lethal temperature. Using these formulas and EPA data for coho and sockeye salmon, the 1986 document calculates suggested temperature criteria for short term exposure as 22°C (sockeye) and 24°C (coho) and a maximum weekly average exposure of 18°C for both species.

Based on extensive review of the most recent scientific studies, EPA Region 10 and the Services have concluded that there are a variety of chronic and sub-lethal effects that are likely to occur to Pacific Northwest salmonid species exposed to the maximum weekly average temperatures calculated using the current 304(a) recommended formulas. These chronic and sub-lethal effects include: reduced juvenile growth, increased incidence of disease, reduced viability in gametes in adults prior to spawning, increased susceptibility to predation and competition, and suppressed smoltification. It may be possible for healthy fish populations to endure some of these chronic impacts with little appreciable loss in population size. However, for vulnerable fish populations, such as the endangered or threatened salmonids of the Pacific Northwest, these chronic effects can impact the overall health and size of the population.

For these reasons, the national assumptions made when developing the section 304(a) criteria recommendations for temperature may not necessarily protect the vulnerable cold water salmonids in the Pacific Northwest. EPA Region 10, therefore, has developed this guidance to assist Pacific Northwest States and Tribes in developing temperature criteria that protects the cold water salmonids in the Pacific Northwest identified above.

IV. Water Temperature and Salmonids

IV.1. Importance of Temperature for Salmonids

Water temperatures significantly affect the distribution, health, and survival of native salmonids in the Pacific Northwest. Since salmonids are ectothermic (cold-blooded), their survival is dependent on external water temperatures and they will experience adverse health effects when exposed to temperatures outside their optimal range. Salmonids have evolved and thrived under the water temperature patterns that historically existed (i.e. prior to significant anthropogenic impacts that altered temperature patterns) in Pacific Northwest streams and rivers. Although evidence suggests that historical water temperatures exceeded optimal conditions for salmonids at times during the summer months on some rivers, the temperature diversity in these unaltered rivers provided enough cold water during the summer to allow salmonid populations as a whole to thrive.

Pacific salmon populations have historically fluctuated dramatically due to climatic conditions, ocean conditions, and other disturbances. High water temperatures during drought conditions likely affected the historical abundance of salmon. In general, the increased exposure to stressful water temperatures and the reduction of suitable habitat caused by drought conditions reduce the abundance of salmon. Human-caused elevated water temperatures significantly increase the magnitude, duration, and extent of thermal conditions unsuitable for salmonids.

The freshwater life histories of salmonids are closely tied to water temperatures. Cooling rivers in the autumn serve as a signal for upstream migrations. Fall spawning is initiated when water temperatures decrease to suitable temperatures. Eggs generally incubate over the winter or early spring when temperatures are coolest. Rising springtime water temperatures may serve as cue for downstream migration.

Because of the overall importance of water temperature for salmonids in the Pacific Northwest, human-caused changes to natural temperature patterns have the potential to significantly impact the abundance of salmonid populations. Of particular concern are human activities that have led to the excess warming of rivers and the loss of temperature diversity.

IV.2. Human Activities That Can Contribute to Excess Warming of Rivers and Streams

Rivers and streams in the Pacific Northwest naturally warm in the summer due to increased solar radiation and warm air temperature. Human changes to the landscape have magnified the degree of river warming, reducing the number of river segments that are thermally suitable for salmonids and causing adverse effects to salmonids exposed to elevated temperatures. Human activities can increase water temperatures by increasing the amount of heat load into the river, by reducing the river's capacity to absorb heat, and by eliminating or reducing the amount of groundwater flow which moderates temperatures and provides cold water refugia. Specific ways in which human development has caused excess warming of rivers are presented in Issue Paper 3 and are summarized below:

1) Removal of streamside vegetation reduces the amount of shade that blocks solar radiation and increases solar heating of streams. Examples of human activities that reduce shade include forest harvesting, land clearing and grazing for agriculture, and urban development.

2) Removal of streamside vegetation also reduces bank stability, thereby causing bank erosion and increased sediment loading into the stream. Bank erosion and increased sedimentation results in wider and shallower streams, which increases the stream's heat load by increasing the surface area subject to solar radiation and heat exchange with the air.

3) Water withdrawals from rivers for purposes such as agricultural irrigation and urban/municipal and industrial use result in less river volume and generally remove cold water. The temperature of rivers with smaller volumes equilibrate faster, which leads to higher maximum water temperatures in the summer.

4) Water discharges from industrial facilities, wastewater treatment facilities and irrigation return flows can add heat to rivers.

5) Channeling, straightening, or diking rivers for flood control and urban and agricultural land development reduces or eliminates cool groundwater flow in a river that moderates summertime river temperatures. Two forms of groundwater flow can be reduced from the above human actions. One form is groundwater that is created during over bank flooding and is slowly returned to the main river channel to cool the water in the summer.

A second form is water that is exchanged between the river and the riverbed (i.e. hyporheic flow). Hyporheic flow is plentiful in fully functioning alluvial rivers systems.

6) Removal of upland vegetation along with soil compaction and increased storm runoff reduces the amount of groundwater that is stored in the watershed and that slowly filters back to the stream in the summer to cool water temperatures. Examples of upland vegetation removal include forest harvesting and agricultural and urban development.

7) Dams and their reservoirs can affect thermal patterns in a number of ways. They can increase maximum temperatures by holding waters in reservoirs to warm, especially in shallow areas near shore. 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 negatively impacting late summer-fall migration runs. Reservoirs also inundate alluvial river segments, thereby, eliminating the groundwater exchange between the river and the riverbed (i.e. hyporheic flow) that cools the river and provides cold water refugia during the summer. Further, dams significantly reduce the river flow rate causing juvenile migrants to be exposed to high temperatures for a much longer time than they would under a natural flow regime.

It should also be noted that some human development can create water temperatures colder than an unaltered river. The most significant example of this occurs when cold water is released from the bottom of a thermally stratified reservoir behind a dam.

IV.3. Human-Caused Elevated Water Temperature As A Factor in Salmonid Decline

Many reports issued in the past decade have described the degradation of freshwater salmonid habitat, including human-caused elevated temperatures, as a major factor in salmonid decline. The following provides a brief summary of some of these reports:

National Marine Fisheries Service's Listing and Status Reviews for Pacific Northwest Salmonids

The National Marine Fisheries Service (NMFS) identified habitat concerns (including alteration of ambient stream water temperatures) as one of the factors for decline of listed west coast steelhead (NMFS 1996), west coast chinook (NMFS 1998), and Snake River spring/summer chinook salmon (Mathews and Waples 1991). Specific effects attributed to increased temperatures by NMFS include increased juvenile mortality, increased susceptibility and exposure to diseases, impaired ability to avoid predators, altered migration timing, and changes in fish community structure that favor competitors of salmonids. NMFS included high water temperatures among risk factors related to the listings under the ESA of the following evolutionarily significant units (ESUs) of chinook salmon: Puget Sound, Lower Columbia River, Snake River spring/summer, and Upper Willamette (Myers et al. 1998). NMFS also noted high water temperatures in its analyses of risk factors related to the ESA listings of Upper Willamette River steelhead and Ozette Lake sockeye.

U.S. Fish and Wildife Service Listing and Status Reviews for Bull Trout

When listing bull trout in the Columbia River and Coastal-Puget Sound population segments, USFWS identified activities such as forestry, agriculture, and hydropower that have impacted bull trout habitat and specifically have resulted in increased stream temperatures. Bull trout are found primarily in colder streams, although individual fish are found in larger river systems. Water temperature above 15°C is believed to limit bull trout distribution and this may partially explain their patchy distribution within a watershed. The strict cold water temperature requirements of bull trout make them particularly vulnerable to activities that warm spawning and rearing waters. At the time of listing for the Coastal-Puget population segment, at least 30 stream reaches within habitat occupied by 13 bull trout subpopulations were included on the Washington State proposed 1998 303(d) list for temperature exceedances.

Return to the River Reports by the Independent Science Group

The Independent Scientific Group (ISG) is a group of scientists chartered by the Northwest Power Planning Council to provide independent scientific advice to the Columbia River Basin Fish and Wildlife Program. In their 1996 Return the River report (updated in 2000), they include a separate section discussing the impacts elevated temperature have on salmonids as part of their overall discussion on freshwater habitats. The report states:

> "Temperature is a critical habitat variable that is very much influenced by regulation of flow and impoundments. The mainstem reservoirs are relatively shallow and heat up in late summer causing concern for salmon survival. The lower reaches of some key tributaries also are very warm in late summer because they are dewatered by irrigation withdrawals. Due to the extreme importance of temperature regimes to the ecology of salmonids in the basin, temperature information merits special attention as a key habitat descriptor (Coutant 1999)."
>
> "Water temperatures in the Columbia River basin have been altered by development and are, at times, suboptimal or clearly detrimental for salmonids. High temperatures alone can be directly lethal to both juvenile and adult salmonids in the Snake River in summer under recent conditions based on generally accepted thermal criteria and measured temperatures."

Oregon Coastal Salmon Restoration Initiative

The Oregon Coastal Salmon Restoration Initiative (1997) included water temperature as a factor for decline in populations of Oregon coastal coho salmon, noting that:

> "Water temperatures are too warm for salmonids in many coastal streams. Altered water temperatures can adversely affect spawning, fry emergence, smoltification, maturation period, migratory behavior, competition with other aquatic species, growth and disease resistance."

Summer Chum Salmon Conservation Initiative

The Summer Chum Salmon Conservation Initiative (2000) for the Hood Canal and Strait of Juan de Fuca region listed elevated water temperature in its limiting factor analysis, noting that:

> "Elevated temperatures impede adult passage, cause direct mortality, and accelerate development during incubation leading to diminished survival in subsequent life stages."

Interior Columbia Basin Ecosystem Management Project

The aquatic habitat assessment for the Interior Columbia Basin Ecosystem Management Project (Lee et al. 1997) indicates that:

1. Changes in riparian canopy and shading, or other factors influencing stream temperatures, are likely to affect some, if not most, bull trout populations.
2. In desert climates, the loss of riparian canopy has been associated with excessive water temperature and reduced redband trout abundance.
3. Loss of vegetation has resulted in stream temperatures that have far exceeded those considered optimal for Lahontan Cutthroat Trout.
4. Water temperatures in reaches of the John Day, upper Grande Ronde, and other basins in eastern Oregon commonly exceed the preferred ranges and often exceed lethal temperatures for chinook salmon.

Northwest Indian Fisheries Commission - Critical Habitat Issues by Basin for Natural Chinook Stocks in the Coastal and Puget Sound Areas of Washington State

In this report, the Northwest Indian Fisheries Commission reviewed the habitat issues for the basins in the coastal and Puget Sound areas of Washington State, and identified elevated temperature as a critical habitat issue in 12 out of 15 basins reviewed.

Other Basin and Watershed Studies

Numerous scientific studies of habitat and elevated water temperature impacts on salmon, steelhead and resident native fish have been completed in the Pacific Northwest over the past two decades. The Northwest Power Planning Council is in the process of developing habitat assessments and restorations strategies for all the sub-basins of the Columbia River Basin. In many of these sub-basin summaries (e.g. Okanogan, Methow, Wenatchee, Yakima, Tucannon, Grande Ronde, Umatilla, and John Day draft summaries - see www.cbfwa.org) elevated temperatures are cited as a major factor contributing to salmonid decline. These and other studies elsewhere in the Pacific Northwest provide a consistent view of the importance of restoring temperatures suitable for cold water salmonds to aid in their recovery.

One specific study worth noting is by Theurer et al. (1985) in the Tucannon River in southeastern Washington. This study shows how human-caused changes in riparian shade and channel morphology contributed to increased water temperatures, reduced available spawning and rearing space, and diminished production of steelhead and chinook salmon. Using a physically-based water temperature model, the authors concluded that approximately 24 miles of spawning and rearing habitat had been made unusable in the lower river due to temperature changes. If the temperatures were restored, they estimated chinook adult returns would increase from 884 that currently exist to 2240 (near historic levels) and that chinook rearing capacity would increase from 170,000 to 430,000. The authors state that the change in temperature regime caused by the loss of riparian vegetation alone is sufficient to explain the reduction in salmonid population in the Tucannon River, while noting that increased sediment input also has played a subsidiary role.

Another similar analysis was done by Oregon Department of Environmental Quality (ODEQ, 2000) for the upper Grande Ronde River as part of their TMDL for this river. ODEQ modeling showed that restoration of riparian shade, channel width and depth, and water flow would drastically reduce maximum temperatures. As shown in Figure 1 (Figures 11 and 12 in ODEQ 2000), over 90% of the river currently exceeds 68°F (20°C), but with full restoration that percentage drops to less than 5%. Similarly, the percentage of the river that exceeds 64°F (18°C) is reduced from over 90% to less than 50% with full restoration. This represents nearly 50 additional miles that are colder than 18°C, which is a very large increase in available rearing habitat. Although actual estimates of increased fish production were not calculated in this study, one might expect similar results as those calculated for the Tucannon River.

Although temperature is highlighted here as a factor in the decline of native salmonid populations, it by no means is the only factor in their decline. Certainly, degradation of habitat unrelated to temperature (e.g. impassable barriers to spawning and rearing areas and physical destruction or inundation of spawning grounds), fishing harvest, and hatchery operations have all played a role in their decline. However, as described above, elevated temperatures are an important factor in the decline of salmonids and restoring suitable temperature regimes for salmonids is a critical element in protecting salmonid populations.

Figure 11. Grande Ronde River Temperatures at Current Conditions and Site Potential

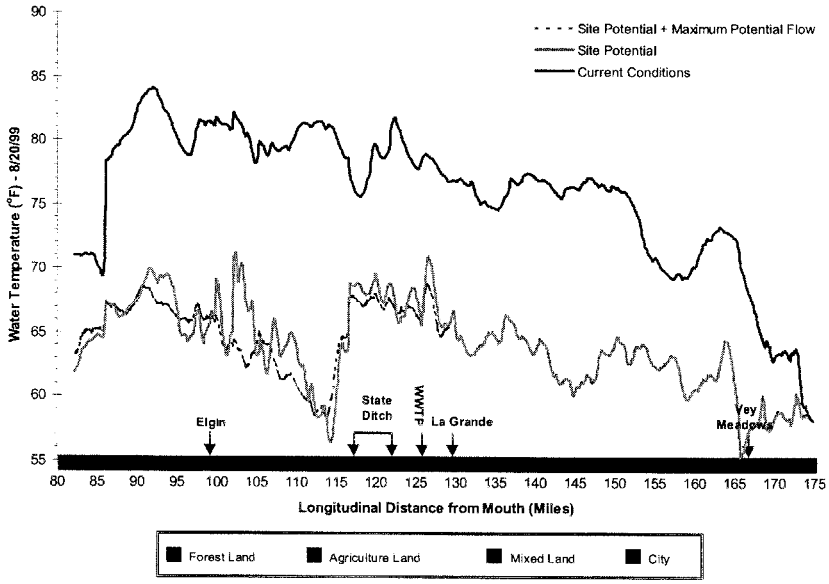

Figure 12. Percent of River Temperatures Below Specified Temperature

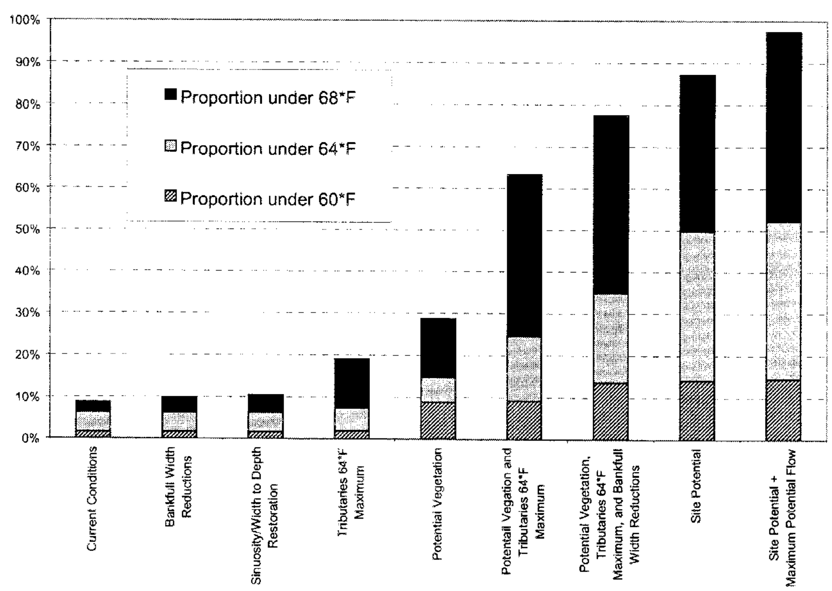

Figure 1. Grande Ronde River temperature modeling using ODEQ's Heat Source Model, showing site potential.

IV.4. General Life Histories of Salmonids and When Human-Caused Elevated Water Temperatures May Be A Problem

Different salmonid species have evolved to take advantage of the Pacific Northwest's cold water environment in different ways. Each species has a unique pattern of when and where they use the rivers, and even for a specific species there is a range of time for this pattern of use. This diversity in freshwater life history is a critical evolutionary trait that has allowed salmonids to persist in a freshwater environment that naturally fluctuates and has natural disturbances.

Below is a general summary of the freshwater life history strategies for some the cold water salmonids. This summary is intended to provide a "big picture" understanding of how each of these fish use Pacific Northwest rivers and to highlight when and where human elevated water temperatures have impacted these fish. As noted above, because of their life history diversity, the discussion below may be an over generalization for some situations.

Chinook Salmon

Adult spring chinook salmon generally leave the ocean and enter Pacific Northwest rivers in the spring (April - June) and swim upstream to hold and spawn in the mid-to-upper reaches of river basins. Spawning generally occurs in late summer and fall (August - October). Egg and alevin incubation extends over the winter and fry generally emerge in the early spring (March - May). Juveniles rear in their natal streams and lower in the basin for a year, then migrate out to the ocean the following spring. Human-caused elevated temperatures can adversely affect spring chinook when adults hold and begin to spawn in the late-summer/early fall and throughout the summer when juveniles rear. Human-caused elevated temperatures in these mid-to-upper reaches can "shrink" the available habitat for adult holding/spawning and juvenile rearing limiting spring chinook to habitat higher in the watershed.

Adult fall chinook salmon generally enter Pacific Northwest rivers in the summer (July - August) and swim upstream to hold and spawn in the lower reaches of mainstem rivers and large tributaries. Spawning generally occurs in the fall (October - December). For example, Snake River fall chinook migrate past Bonneville dam from August-October and spawn in the Snake River below Hells Canyon Dam and the lower reaches of the Clearwater, Grand Ronde, Imnaha, and Tucannon rivers. Fry emerge from March through April and begin their downstream migration several weeks after emergence. Downstream migration occurs mainly in the spring under existing conditions, but may extend throughout the summer in some areas (e.g. Columbia River). Historically, juvenile fall chinook out-migrated throughout the summer months, but today human-caused elevated temperatures have made this impossible in some rivers (e.g. Yakima river). Human-caused elevated temperatures can adversely affect fall chinook in lower river reaches during the summer months when the adults are migrating upstream and holding to spawn and when juveniles are migrating downstream. Human-caused elevated temperatures in the early fall may also delay spawning.

Coho Salmon

Adult coho salmon generally enter Pacific Northwest rivers in the fall (late September through October) and spawn in low gradient 4th and 5th order streams in fall-winter. Fry emerge in the spring. Juvenile coho will rear for 1 to 2 years prior to migrating to sea during the spring. Juvenile coho salmon may migrate considerable distances upstream to rear in lakes or other river reaches suitable for rearing. Coho salmon are most predominant in the rivers of the coastal mountains of Washington and Oregon and the west-slopes of the Washington Cascades. Wild coho populations were extirpated years ago in the Umatilla and Yakima rivers but they are now being introduced in these rivers. Human-caused elevated temperatures can adversely affect coho salmon in the summer months when juveniles are rearing and in early fall when adults start migrating. Human-caused elevated temperatures may render waters unsuitable for rearing thereby "shrinking" the amount of available habitat.

Sockeye Salmon

Adult sockeye salmon generally enter freshwater from mid summer through early fall and migrate up to lakes and nearby tributaries to spawn in the fall. Juveniles generally rear in lakes from 1 to 3 years, then migrate to the ocean in the spring. Pacific Northwest lakes that support sockeye include: Redfish (Idaho), Okanogan, Wenatchee, Baker, Washington, Sammamish, Quinault, and Osoyoos. Human-caused elevated temperatures can adversely affect sockeye adult salmon as they migrate upstream in the mid-to-late summer.

Chum

Adult chum salmon generally enter freshwater in late-summer and the fall and spawn (October - December) in the low reaches and side channels of major rivers just upstream from tidewater areas. Upon emergence, juveniles begin their short migration to saltwater that generally occurs between March and June. Juveniles will rear in estuaries for a while prior to entering the ocean. Human-caused elevated temperatures can adversely affect adult chum salmon as they migrate upstream in the late summer.

Pink Salmon

Adult pink salmon generally enter freshwater in late summer and spawn in the lower reaches of large rivers in late summer and early fall. Like Chum, juveniles will migrate to saltwater soon after emerging in the late winter. Human-caused elevated temperatures can adversely affect adult pink salmon as they migrate upstream in the late summer.

Steelhead Trout

Adult steelhead enter Pacific Northwest rivers throughout the year, but can generally be divided into a summer run (May - October) and a winter run (November-June). Both runs typically spawn in the spring. Summer steelhead enter freshwater sexually immature and generally travel greater distances to spawn than winter steelhead, which enter freshwater sexually mature (i.e. with well-developed gonads). All steelhead runs upstream of the Dalles Dam are summer steelhead. Fry generally emerge from May through July and juvenile steelhead will rear in the mid-upper reaches of river basins for 1-2 years (sometimes 3 or 4 years) before migrating to the ocean in the spring. Human-caused elevated temperatures can adversely affect steelhead in the summer months when the juveniles are rearing in the mid-upper reaches. Human-caused elevated temperatures may render waters unsuitable for rearing thereby "shrinking" the amount of available habitat. Human-caused elevated temperatures also can adversely affect summer run adults as they migrate upstream during the summer and eggs and fry that incubate into July in some watersheds.

Bull Trout

Bull trout generally are freshwater fish (although the adults of a few populations enter saltwater estuaries). Adult bull trout generally migrate upstream in the spring and summer from their feeding grounds (lower reaches in a basin for migrating fluvial forms or a lake for adfluvial forms) to their spawning grounds higher in the basin. Bull trout generally spawn in September-October, but in some watersheds spawning can occur as early as July. Bull trout have a long incubation time with fry emergence generally from March through May. Juveniles will rear in their natal streams for 2-4 years, then the migratory forms will migrate downstream to more productive feeding grounds (i.e. lower river reaches or lakes) in the spring, but some fall downstream migration has also been noted. Human-caused elevated temperatures can adversely affect summer juvenile rearing in the upper reaches where elevated temperatures have rendered water unsuitable for rearing thereby "shrinking" the amount of available habitat. Adults migrating upstream to spawn in the summer can also have adverse effects from human-elevated temperatures. Additionally, migratory adults can be adversely affected by the loss of cold water refugia due to human activities.

V. EPA Region 10 Recommendations for Pacific Northwest State and Tribal Temperature WQS to Facilitate Expedited CWA and ESA Review

EPA Region 10 offers the following recommendations to assist States and Tribes in adopting temperature WQS that fully support cold water salmonids in the Pacific Northwest and meet the requirements of the CWA and the ESA. As noted in Section I, Pacific Northwest States and Tribes that adopt temperature WQS consistent with these recommendations can expect an expedited review by EPA and the Services.

In order to receive an expedited review by EPA and the Services, State and Tribal WQS need to include the following three items, which are discussed in more detail below:

1) Adoption of Cold Water Salmonid Uses And Numeric Criteria To Protect Those Uses

2) Adoption Of Regulatory Provisions To Protect Existing Water Temperature That Is Colder Than The Numeric Criteria

3) Adoption Of Mixing Zone Provisions To Protect Salmonids

V.1. Cold Water Salmonid Uses And Numeric Criteria To Protect Those Uses

Tables 1 and 2 provide a condensed summary of the important water temperature considerations for each life stage for salmon and trout and bull trout: spawning, egg incubation, and fry emergence; juvenile rearing; and adult migration. Each temperature consideration and associated temperature values noted in Tables 1 and 2 includes a reference to the relevant technical issues papers prepared in support of this guidance (or other studies) that provide a more detailed discussion of the supporting scientific literature. The temperatures noted in Tables 1 and 2 form the scientific basis for EPA's recommended numeric criteria to protect cold water salmonids, which are presented in Tables 3 and 4.

In addition to Tables 1 and 2, there are a number of other general factors that EPA considered in recommending cold water salmonid uses and numeric criteria to protect those uses. These factors and EPA's recommended approach for considering these factors (described below) provide the overall context for EPA's use and criteria recommendations.

Table 1 - Summary of Temperature Considerations For Salmon and Trout Life Stages

Life Stage	Temperature Consideration	Temperature & Unit	Reference
Spawning and Egg Incubation	*Temp. Range at which Spawning is Most Frequently Observed in the Field * Egg Incubation Studies - Results in Good Survival -Optimal Range *Reduced Viability of Gametes in Holding Adults	4 - 14°C (daily avg) 4 - 12°C (constant) 6 - 10°C (constant) > 13°C (constant)	Issue Paper 1; pp 17-18 Issue Paper 5; p 81 Issue Paper 5; p 16 Issue Paper 5; pp 16 and 75
Juvenile Rearing	*Lethal Temp. (1 Week Exposure) *Optimal Growth - unlimited food - limited food *Rearing Preference Temp. in Lab and Field Studies *Impairment to Smoltification *Impairment to Steelhead Smoltification *Disease (lab studies) -Severe - Elevated - Minimized	23 - 26°C (constant) 13 - 20°C (constant) 10 - 16°C (constant) 10 - 17°C (constant) < 18°C (7DADM) 12 - 15°C (constant) > 12°C (constant) 18 - 20°C (constant) 14 - 17°C (constant) 12 - 13°C (constant)	Issue Paper 5; pp 12, 14 (Table 4), 17, and 83-84 Issue Paper 5; pp 3-6 (Table 1), and 38-56 Issue Paper 1; p 4 (Table 2). Welsh et al. 2001. Issue Paper 5; pp 7 and 57-65 Issue Paper 5; pp 7 and 57-65 Issue Paper 4, pp 12 - 23
Adult Migration	*Lethal Temp. (1 Week Exposure) *Migration Blockage and Migration Delay *Disease (lab studies) -Severe - Elevated - Minimized *Adult Swimming Performance - Reduced - Optimal * Overall Reduction in Migration Fitness due to Cumulative Stresses	21- 22°C (constant) 21 - 22°C (average) 18 - 20°C (constant) 14 - 17°C (constant) 12- 13°C (constant) > 20°C (constant) 15 - 19°C (constant) > 17-18°C (prolonged exposures)	Issue Paper 5; pp 17, 83 - 87 Issue Paper 5; pp 9, 10, 72-74. Issue Paper 1; pp 15 - 16 Issue Paper 4; pp 12 - 23 Issue Paper 5; pp 8, 9, 13, 65 - 71 Issue Paper 5; p 74

Table 2 - Summary of Temperature Considerations For Bull Trout Life Stages

Life Stage	Temperature Consideration	Temperature & Unit	Reference
Spawning and Egg Incubation	*Spawning Initiation	< 9°C (constant)	Issue Paper 5; pp 88 - 91
	*Temp. at which Peak Spawning Occurs	< 7°C (constant)	Issue Paper 5; pp 88 - 91
	*Optimal Temp. for Egg Incubation	2 - 6°C (constant)	Issue Paper 5; pp 18, 88 - 91
	*Substantially Reduced Egg Survival and Size	6 - 8°C (constant)	Issue Paper 5; pp 18, 88 - 91
Juvenile Rearing	*Lethal Temp. (1 week exposure)	22 - 23°C (constant)	Issue Paper 5; p 18
	*Optimal Growth - unlimited food - limited food	 12 - 16 °C (constant) 8 - 12°C (constant)	 Issue Paper 5; p 90. Selong et al 2001. Bull trout peer review, 2002.
	*Highest Probability to occur in the field	12 - 13 °C (daily maximum)	Issue Paper 5; p 90. Issue Paper 1; p 4 (Table 2). Dunham et al., 2001. Bull trout peer review, 2002.
	*Competition Disadvantage	>12°C (constant)	Issue Paper 1; pp 21- 23

Cold Water Salmonid Uses

Under EPA's WQS regulations, States and Tribes may adopt sub-categories of uses and set appropriate criteria to protect those uses. Because Pacific Northwest salmonids have multiple freshwater life stages with differing temperature tolerances, it is appropriate to establish sub-categories of use based on life stages. In addition, EPA's WQS regulations allow States and Tribes to adopt seasonal uses where a particular use applies for only a portion of the year. EPA's recommended approach here is for States and Tribes to utilize both of these use designation options in order to more precisely describe where and when the different cold water salmonid uses occur.

Focus on Summer Maximum Conditions

In general, increased summertime temperatures due to human activities is the greatest water temperature concern for salmonids in the Pacific Northwest, although temperatures in the late spring and early fall are also a concern in some areas. EPA therefore believes it is appropriate that temperature criteria focus on the summer maximum conditions to protect the cold water salmonid uses that occur then. Generally, improving river conditions to reduce summer maximum temperatures will also reduce temperatures throughout the summer and in the late spring and early fall (i.e. shift the seasonal temperature profile downward). Thus, due to the natural annual temperature regime, we assume that providing protective temperatures during the summer maximum period will in many areas provide protective temperatures for more temperature sensitive uses that occur in the spring-early summer and late summer-fall.

In some areas, however, more temperature-sensitive salmonid uses (e.g. spawning, egg incubation, and steelhead smoltification) that occur in the spring-early summer or late summer-fall may not be protected by meeting the summer maximum criterion. Thus, in addition to summer maximum criteria, EPA also recommends criteria be adopted to protect these more temperature-sensitive uses when and where they occur. Doing so provides an added degree of protection for those situations where control of summer maximum temperatures is inadequate to protect these more temperature-sensitive uses.

In recommending protective summer maximum criteria, EPA took into consideration that meeting a criterion during the warmest period of the summer (e.g. warmest week) will result in cooler temperatures during other times in the summer. The duration of exposure to near summer maximum conditions, however, can vary from one to two weeks in some areas to over a month in other areas.

General Target for Protective Criteria

In recommending protective numeric criteria, EPA generally selected temperatures at which overall adverse effects are minimized or are unlikely to occur for each salmonid life stage. Each salmonid life stage has an optimal temperature range. Exposure to temperatures above this optimal range results in increased severity of sub-lethal adverse effects as temperatures rise until at some point they become lethal. Thus, adverse effects are minimized as long as temperatures remain within the bounds of the optimal temperature range. Note: water temperatures can also be too cold for salmonids, but that is generally a natural condition and not an issue for water quality standards.

For reasons discussed below (see *Integrating the General Factors in Selecting Protective Criteria*), most of the recommended numeric criteria reflect temperatures that are near the warm end of the optimal temperature range for the salmonid life stage uses the criteria are designed to protect. Two of the summer maximum criteria (i.e. the 18°C and 20°C numeric criteria in Table 3), however, take into account other considerations. The 18°C criterion takes into account that in a natural system some individuals will occupy sub-optimal habitat (slightly warmer than optimal). The 20°C numeric criterion takes into account the natural thermal potential and the processes that create cold water refugia of some rivers in the Pacific Northwest.

Use of the 7 Day Average of the Daily Maximum (7DADM) Unit of Measurement

The recommended metric for all of the criteria below is the maximum 7 day average of the daily maxima (7DADM). This metric is recommended because it describes the maximum temperatures in a stream, but is not overly influenced by the maximum temperature of a single day. Thus, it reflects an average of maximum temperatures that fish are exposed to over a week period. Since this metric is oriented to daily maximum temperatures, it can be used to protect against acute effects, such as lethality and migration blockage conditions.

This metric can also be used to protect for sub-lethal or chronic effects (e.g. temperature effects on growth, disease, smoltification, and competition), but the resultant cumulative thermal exposure fish experience over the course of a week or more needs to be considered when selecting a 7DADM value to protect for these effects. A general conclusion from studies on fluctuating temperature regimes (which is what fish generally experience in rivers), is that fluctuating temperatures increase juvenile growth rates when mean temperatures are colder than the optimal growth temperature derived from constant temperature studies, but will reduce growth when the mean temperature exceeds the optimal growth temperature (see Issue Paper 5, pages 51-56). When the mean temperature is near or above the optimal growth temperature, the "mid-point" temperature between the mean and the maximum is the "equivalent" constant temperature. This "equivalent" constant temperature then can be directly compared to laboratory studies done at constant temperatures. For example, a river with a 7DADM value of 18°C and a 15°C weekly mean temperature (i.e. diurnal variation of ± 3°C) will be roughly equivalent to a constant laboratory study temperature of 16.5°C (18°C - 15°C/2). Thus, both maximum and mean temperatures are important when determining a 7DADM value that is protective of chronic temperature effects, such as reduced growth rates.

For many rivers and streams in the Pacific Northwest, the maximum 7DADM temperature is about 3°C higher than the maximum weekly average (Dunham, et al. 2001; Chapman, 2002). Thus, when considering what 7DADM temperature value protects for chronic effects, EPA added 1-2°C degrees to the constant temperatures that scientific studies indicate would be protective for chronic effects (see Table 1 for summary of studies done under constant temperatures). Thus, following this general procedure takes into account the maximum and mean temperature (i.e. reflects a "mid-point") when protecting for growth and other sub-lethal effects. It is important to note that there are also studies that analyzed sub-lethal effects based on maximum or 7DADM temperature values which need not be translated for purposes of determining protective 7DADM temperatures. For example, there are field studies that assess probability of occurrence or density of a specific species based on maximum temperatures (Issue Paper 1, Haas (2001), Welsh et al. (2001)). These field studies represent an independent line of evidence for defining upper optimal temperature thresholds, which complements laboratory studies.

It is also important to note that there are confounding variables that are difficult to account for but are important to recognize. For instance, diurnal variation in rivers and streams in the Pacific Northwest varies considerably, therefore the difference between the 7DADM and the weekly mean will vary. The difference between the 7DADM temperature and the weekly mean may be less than 1°C for rivers with little diurnal variation (0-2°C) and as high as 9°C for streams with high diurnal variation (greater than12°C)(Dunham et al., 2001). Another variable is food availability. The temperature for which there is optimal juvenile growth increases when food supply is unlimited. Generally, EPA believes that laboratory studies under limited food availability are most reflective of environmental conditions fish typical experience. However, there are likely situations where food is abundant and thus upper optimal temperatures would be higher. Thus, a given 7DADM numeric criteria will be more protective in situations where there is high diurnal variation and/or abundant food and will be less protective in situations where there is low diurnal variation.

Criteria Apply to all but Unusually Warm Conditions

In order to have criteria that protect designated uses under the CWA, the criteria need to apply nearly all the time. However, EPA believes it is reasonable for a State's or Tribe's WQS to exempt unusually warm conditions in determining attainment with temperature numeric criteria. One way to do this would be to base attainment on the 90th percentile of the yearly maximum 7DADM values calculated from a yearly set of values of 10 years or more. Another way may be to exclude water temperature data when the air temperature during the warmest seven-day period of the year exceeds the 90th percentile of the seven-day average daily maximum air temperature calculated in yearly series over the historic record at the nearest weather reporting station. Thus, generally speaking, the numeric criteria would apply 9 out 10 years, or all but the hottest year.

The rationale for some type of exemption for unusually warm conditions is that infrequent peaks in water temperature, typically due to unusually hot air temperatures, is a natural component of the environment and these infrequent conditions should not drive compliance determinations. Salmonid may experience some adverse effects during these periods, but by definition, they would only be allowable 1 in 10 years.

Even provided some form of an exemption described above, attainment determinations will be based on all climatic conditions except for the extreme condition. Thus, given that river temperatures exhibit year to year variation in their maximum 7DADM values, the average maximum 7DADM value from a yearly series will need to be lower than the numeric criteria in order to meet the criteria 9 out of 10 years. Therefore, in most years, the maximum 7DADM temperature will need to be lower than the numeric criteria in order to meet the criteria in the warm years. EPA took this into consideration when it recommended the protective criteria.

Numeric Criteria Apply Upstream of the Furthest Downstream Extent of Use

Criteria apply at the lowest downstream extent of use. Because streams generally warm progressively in the downstream direction, waters upstream of the lowest downstream extent of use will generally need to be cooler in order to meet the criteria downstream. Thus, a water body that meets a criterion at the furthest downstream extent of use will in many cases provide water cooler than the criterion for the upstream extent of the use. EPA took this into consideration when recommending numeric criteria.

EPA also believes that the numeric criteria should apply upstream of the areas of actual use because temperatures in upstream waters significantly affect the water temperatures where the actual use exists and that upstream waters are usually colder. Of course, if a more sensitive use is designated upstream the more protective criterion would apply upstream.

Current versus Potential Use

It is well recognized that the current distribution of salmonids in the Pacific Northwest has significantly shrunk and is more fragmented than their historical distribution due to human development and that the current distribution is unlikely to provide for sustainable salmonid populations. EPA regulations require that, at a minimum, States and Tribes protect uses that have existed since 1975. See 40 C.F.R § 131.3(e) & 131.10(h)(1). EPA also believes that in order to meet the national goal of providing for the protection and propagation of fish wherever attainable, that salmonid use designations should be of sufficient geographic and temporal scope to support sustainable levels of use. This is because, unless the designated use specifically provides otherwise, a salmonid use reasonably implies a healthy and sustainable population. Because of the importance of restoring healthy salmonid populations in the Pacific Northwest, EPA Region 10 advises States and Tribes not to limit salmonid use designations to where and when salmonids exist today for areas with thermally degraded habitat.

EPA recommends that cold water salmonid uses be designated in waters where the use currently occurs or is suspected to occur (today), and where there is reasonable potential for that use to occur if temperatures were to be restored in areas of degraded habitat. For areas with minimal habitat degradation, current use is appropriate. In most areas of degraded habitat, temperatures have risen forcing salmonid rearing and spawning upstream to find suitable water temperatures. As a result, the downstream extent of current use is farther upstream than what it was prior to habitat degradation. EPA, therefore, recommends that use designations for rearing and spawning extend farther downstream than where they exist today in many situations.

EPA recognizes that establishing use designation based on where there is reasonable potential for that use to occur in areas of thermally degraded habitat depends on best professional judgement.
One methodology that EPA believes is appropriate to follow is to have the downstream extent of use that currently occurs during late spring-early summer and/or late summer-early fall to represent the "potential" downstream extent of use during the summer maximum condition. In many cases, distribution maps (e.g. www.streamnet.org) showing downstream extent of use may already depict this because they might not differentiate the distribution during summer maximum temperatures versus the distribution during other periods of the year.

EPA also recognizes that fish distribution information may be incomplete and that there are waters where use likely currently occurs but it is not documented. Thus, in some situations it may be appropriate to generalize uses by stream order, size, and or elevation (e.g. designating bull trout juvenile rearing use based on stream size and elevation).

Integrating the General Factors in Selecting Protective Criteria

Because the numeric criteria are intended to apply to the warmest years (except for extreme conditions), warmest times of the summer, and lowest downstream extent of use, EPA believes it is inappropriate to select criteria that reflect the mid-point of the optimal range for various salmonid uses. Adopting a numeric criterion near the warmer end of the optimal range that is applied to the above conditions (near worst case) will result in temperatures near the middle of the optimal range most of the time where most of the use occurs. Further, short durations of slightly warmer than optimal temperatures for chronic and sub-lethal effects (e.g. growth, disease, competition) will still allow for healthy growth rates overall and minimal increased risks from competition or disease.

V.1.1 EPA Recommended Salmonid Uses and Numeric Criteria

EPA's recommended cold water salmonid uses and criteria to protect those uses are presented in Tables 3 and 4. Table 3 describes uses that occur during the summer maximum temperature conditions. Designating the uses in Table 3 will result in apportioning the river into 3 to 4 salmonid use categories with associated criteria (e.g. 12°C, 16°C, 18°C, and 20°C). The colder criteria would apply in the headwaters and the warmer criteria would apply in the lower river reaches, which is consistent with the typical thermal and salmonid use patterns of rivers in the Pacific Northwest during the summer.

Table 4 describes cold water salmonid uses that generally occur other than during the summer maximum conditions, except for rare circumstances. As noted in Table 4, these criteria apply when and where these uses occur and may potentially occur.

V.1.2 Discussion of Use and Criteria Presented in Table 3

Bull Trout Juvenile Rearing

EPA's recommended 12°C maximum 7DADM criteria is designed to: 1) safely protect against lethal temperatures, 2) provide upper optimal conditions for growth under limited food during summer maximum temperature periods, 3) and provide temperatures where bull trout are not at a competitive disadvantage with other salmonids (see Table 2). 12°C 7DADM is also consistent with field studies of temperatures where bull trout have the highest probability to occur. Bull Trout waters are generally more stable (less diurnal variation due to ground water influences) than salmon rearing water downstream, so for comparison purposes, a maximum 12°C 7DADM roughly converts to a 12.5 - 13°C summer maximum and a 9 - 11°C maximum weekly mean (Dunham et al. 2001).

Note: EPA is not recommending a separate bull trout migration numeric criteria at this time because our current knowledge of bull trout migration pathways and timing is limited and the 16°C juvenile rearing summer maximum criterion will likely provide protection for this use provided cold water refugia (12°C) is available. EPA believes rivers that currently meet or are restored to meet the 16°C criterion will likely provide the cold water refugia that adult bull trout are believed to need. As more is learned about adult bull trout migration, EPA, in consultation with the U.S. Fish and Wildlife Service, may reconsider this recommendation.

Table 3. Recommended Criteria That Apply To Summer Maximum Temperatures

Notes: 1) 7DADM: Maximum 7 Day Average of the Daily Maximums; 2) "Salmon" refers to Chinook, Coho, Sockeye, Pink, and Chum salmon; 3) "Trout" refers to Steelhead and coastal cutthroat trout; 4) "may potentially occur" refers to waters that will likely support the use if temperatures are restored

Salmonid Uses During the Summer Maximum Conditions	Criteria
Bull Trout Juvenile Rearing Applies to waters where summer juvenile bull trout rearing currently occurs and may potentially occur. This use is generally in a river basin's upper reaches.	**12°C (55°F) 7DADM**
Salmon/Trout "Core" Juvenile Rearing Applies to core juvenile rearing habitat. Generally, core juvenile rearing applies to the furthest downstream extent of current summer use for areas of degraded habitat where current summer distribution is shrunken relative to historical distribution. For areas of minimally degraded habitat, this use would apply to waters of core use based on density and/or habitat features. This use also applies to juvenile rearing waters that currently meet this criteria. This use is generally in a river basin's mid-to-upper reaches, downstream from juvenile bull trout rearing areas. However, in colder climates, such as the Olympic mountains and the west slopes of the Cascades, this use may apply all the way to the saltwater estuary. This use is designed to protect high quality summertime juvenile rearing habitat for salmon and trout. Protection of these waters for juvenile rearing also provides protection for adult spring chinook salmon that hold throughout the summer prior to spawning and bull trout migration.	**16°C (61°F) 7DADM**
Salmon/Trout Juvenile Rearing and Juvenile/Adult Migration Applies to waters where summer salmon and trout juvenile rearing and juvenile/adult migration currently occurs and may potentially occur. This use extends downstream from the "core" juvenile rearing use. In many river basins in the Pacific Northwest, this use will apply all the way to river basin's terminus (i.e. confluence with the Columbia or Snake rivers or saltwater) This use is designed to protect juvenile rearing that extends beyond "core" juvenile rearing areas and migrating juveniles and adults.	**18°C (64°F) 7DADM**
Salmon/Trout Migration on Lower Mainstem Rivers Applies in the lower reaches of mainstem rivers (e.g. mid-lower Columbia river, lower Snake river, and possibly the lowest reaches of other large mainstem rivers) in the Pacific Northwest where based on best available scientific information (e.g. temperature modeling and pre-disturbance temperature data) maximum temperatures likely reached 20C prior to significant human alteration of the landscape. The narrative cold water refugia provision would require all feasible steps be taken to restore and protect the river functions (e.g,. alluvial floodplains) that could provide cold water refugia in these river segments. *Note: this recommendation is a combination of a numeric criteria (20°C) and a narrative WQS requiring effective protection of cold water refugia that together protects this use.*	**20°C (68°C) 7DADM, with a cold water refugia narrative provision**

Table 4. Other Recommended Criteria

Notes: 1) 7DADM: Maximum 7 Day Average of the Daily Maximums; 2) "Salmon" refers to Chinook, Coho, Sockeye, Pink, and Chum salmon; 3) "Trout" refers to Steelhead and coastal cutthroat trout; 4) "may potentially occur" refers to waters that will likely support the use if temperatures are restored

Salmonid Uses	Criteria
Bull Trout Spawning Applies to waters where and when bull trout spawning, egg incubation and fry emergence currently occurs and may potentially occur. This criteria is designed to protect bull trout spawning, which generally occurs in the fall in the same waters that bull trout juveniles use for summer rearing. If this criterion is met during spawning, the natural seasonal temperature pattern will likely result in protective temperatures for egg incubation (<6°) that occurs over the winter. This use is defined from the average date that spawning begins to the average date incubation ends (the first 7DADM is calculated 1 week after the average date that spawning begins).	**9°C (48°F) 7DADM**
Salmon/Trout Spawning, Egg Incubation, and Fry Emergence Applies to waters where and when salmon and trout spawning, egg incubation, and fry emergence currently occurs and may potential occur. Generally, this use occurs: a) in late spring-early summer for trout (mid-upper reaches), b) in late summer-fall for spring chinook (mid-upper reaches), c) in the fall for coho (mid-reaches), pink, chum, and fall chinook (latter three in lower reaches). This use is defined from the average date that spawning begins to the average date incubation ends (the first 7DADM is calculated 1 week after the average date that spawning begins).	**13°C (55°F) 7DADM**
Steelhead Smoltification Applies to waters where the early stages of smoltification occurs in steelhead trout. Generally applies in April and May for rivers where juvenile outmigration occurs except for the mid and lower Columbia and lower Snake rivers (e.g. the criteria would apply at the mouth of the major tributaries of the Columbia river basin). This use is designed to protect the early stages of steelhead smoltification. Smoltification of other salmonids is generally protected vis-a-vis the summer maximum criteria, but this criteria provides an added level of protection for other salmonids which can successfully smolt at higher temperatures than steelhead.	**14°C (61°F) 7DADM**

Salmon and Trout "Core" Juvenile Rearing

This use represents core salmon and trout summer rearing habitat. EPA's recommended 16°C maximum 7DADM criterion is designed to: 1) safely protect against lethal temperatures, 2) provide optimal temperatures throughout the summer months for rearing juvenile salmon and trout, 3) avoid temperatures where juveniles are at a competitive disadvantage, and 4) protect against temperature induced elevated disease rates. This criterion is consistent with temperatures which juvenile salmon and trout prefer and are found in high densities. This criterion also provides protection for adult spring chinook holding over the summer to spawn and in many cases protect for late summer salmon spawning and early summer incubating trout eggs that occur in these waters (see Table 1). Further, this criterion provides protection for adult bull trout migration that often occurs in these waters.

Salmon and Trout Juvenile Rearing and Juvenile/Adult Migration

EPA's recommended 18°C maximum 7DADM criterion is designed to protect juvenile rearing and juvenile and adult migration that exists downstream from the core juvenile rearing habitat described above. As noted in Table 3, this use generally extends all the way downstream to the river basin's terminus. This criterion is designed to: 1) safely protect against lethal conditions for both juveniles and adults, 2) prevent migration blockage conditions for migrating adults, 3) prevent adults and juveniles from prolonged exposures of 16 - 17°C that can lead to elevated disease rates, and 4) provide optimal or near optimal juvenile growth conditions (under limited food conditions) for most of the summer, except during the summer maximum conditions, which would be slightly warmer than optimal (See Table 1). Although there may be some increased risk of adverse effects during the maximum summer conditions for rivers with little diurnal variation, juvenile and adult use and exposure is likely to be limited during these periods because out-migrating juveniles have generally completed their out-migration by this time and the number of adults migrating through these waters at this time is limited and of short duration.

Salmon and Trout Migration (with cold water refugia narrative provision)

EPA's recommended 20°C maximum 7DADM criterion, in conjunction with a narrative cold water refugia WQS provision, is designed to protect juveniles and adults migrating through mainstem rivers where best available scientific information demonstrates that maximum temperatures likely reached 20°C prior to significant human alteration of the landscape. As noted in Table 3, waters with this use designation would have both an applicable numeric criterion of 20°C and an applicable narrative WQS provision requiring that all feasible steps be taken to restore and protect the river functions that could provide cold water refugia. Cold water refugia could be generally defined as waters that are 2-3C° degrees cooler than the main channel river temperature.

An example of best available scientific information demonstrating temperatures reached 20°C prior to significant human alteration of the river system, is the recent temperature modeling and review of historical temperature data as part of EPA's development of the Columbia and lower

Snake river TMDL. Similar type analysis would be required to apply this criteria to other rivers in the Pacific Northwest.

EPA does not believe 20°C as a 7DADM, by itself, is protective of migrating juveniles and adults in these lower mainstem rivers that experience little diurnal variation. Although 20°C 7DADM just barely prevents adult migration blockage and lethality, adverse effects in the form of increased disease and decreased swimming performance in adults and increased disease, impaired smoltification, reduced growth, and increased predation for late migrating juveniles (fall chinook in the Columbia and Snake) will likely occur (see Table 1). Therefore, the narrative cold water refugia WQS provision is a critical element to protect these uses.

Although some altered rivers, such as the Columbia and Snake, experience similar summer maximum temperatures today as they did historically, there is a big difference between the temperatures that fish experience today versus what they experienced historically. Unaltered rivers generally had a high degree of spatial and temporal temperature diversity with portions of the river or time periods that were colder than the maximum river temperatures. These cold portions or time periods in an otherwise warm river provided salmonids cold water refugia to tolerate such situations. The loss of this temperature diversity is likely as significant to salmon and trout in the Columbia, Snake, and their major tributaries as maximum temperatures. Therefore, in order for 20°C 7DADM to be protective of migrating salmon and trout, there must also be cold water refugia, to the extent that is if feasible, so they can migrate through these waters with minimal thermal stress.

As described in Issue Paper 3 and the Return to the River report (2000), alluvial floodplain's with a high level of groundwater exchange historically provided high quality habitat that served as cold water refugia during the summer for large rivers in the Columbia River basin (and other rivers of the Pacific Northwest). These alluvial reaches are interspersed between bedrock canyons and are like beads on a string along the river continuim. Today, most of the alluvial floodplain are either flooded by dams, altered through diking and channelization, or lack sufficient water to function.

One of the reasons EPA is recommending a 20°C criterion in conjunction with the cold water refugia WQS provision, is to direct attention to the importance of functioning alluvial system for salmonids and to restore them to the maximum extent possible. For example, state watershed restoration plans designed to meet WQS and implement TMDLs should include plans to restore and protect these areas to create cold water refugia in addition to focusing on lowering the river's maximum temperatures.

V.1.3 Discussion of Criteria Presented in Table 4

Bull Trout Spawning

EPA's recommended 9°C maximum 7DADM criterion is designed to protect the bull trout spawning. As noted in Table 4, this criterion, when applied at the onset of spawning, will likely provide protective temperatures for egg incubation (<6°) that occur over the winter. Further, in many cases the bull trout juvenile rearing numeric criterion of 12°C 7DADM, when met during summer maximum conditions, will result in temperatures below 9°C when spawning typically begins in the fall. However, EPA recommends adopting this criterion to ensure protection for those situations where bull trout spawning occurs early enough (e.g. late summer) that limiting the summer maximum temperature to 12°C 7DADM via the bull trout juvenile rearing criterion will be insufficient to protect bull trout spawning.

Salmon and Trout Spawning, Egg Incubation, and Fry Emergence

EPA's recommended 13°C maximum 7DADM criterion is designed to protect the above life stages for salmon and trout. In many situations the Table 3 numeric criteria to protect summer maximum conditions (e.g. 16°C and 18°C) will result in temperatures below 13°C when spawning typically begins in the late summer-fall for salmon and when trout fry typically emerge in the spring and early summer. However, EPA recommends adopting this criteria to ensure protection for those situations where the summer maximum criteria are insufficient to protect these life stages.

Steelhead Trout Smoltification

EPA's recommended 14°C maximum 7DADM steelhead smoltification criterion is designed to protect this sensitive life stage. As described in Table 1, steelhead smoltification can be impaired from exposure to greater than 12°C constant temperatures. The greatest risk to steelhead is during the early stages of smoltification that occurs in the spring (April and May). For the Columbia river tributaries, 90% of the steelhead smolts are typically past Bonneville dam by the end of May (Issue Paper 5, pg 59), indicating that applying this criterion at the mouths of major tributaries to the Columbia river in April and May will protect this use. Applying this criteria to the Columbia river itself is unnecessary because the more temperature sensitive early stages of smoltification occurs in the tributaries. If steelhead in the early smoltificaiton process are exposed to higher temperatures than the recommended criteria they may cease migration or migrate to the ocean undeveloped thereby reducing their estuary and ocean survival.

V.2. Adoption of Regulatory Provisions to Protect Existing Water Temperature That is Colder Than The Numeric Criteria

One of the important principles in protecting populations at risk is to first protect the existing high quality habitat and then to restore the degraded habitat that is adjacent to the high quality habitat. Further, EPA WQS regulations recognize the importance of protecting waters that are of higher quality than the criteria (i.e. colder than numeric temperature criteria). EPA, therefore, believes that for ESA-listed salmonids, it is important to have strong regulatory measures to protect waters that are currently colder than EPA's recommended criteria. These waters likely represent the last remaining strongholds for these fish. Because temperatures currently do not meet EPA's recommended summer maximum criteria for many waters in the Pacific Northwest, these high quality, thermally optimal waters are likely vital for their survival and any thermal warming to these waters will likely cause harm. Further, protection of these cold water segments in the upper part of a river basin likely plays a critical role in maintaining temperatures downstream. Therefore, if downstream temperatures are currently exceeding the numeric criteria, any upstream temperature increase will in many cases further contribute to the non-attainment downstream. Lastly, natural summertime temperatures in the Pacific Northwest were spatially diverse with areas of cold-optimal, warm-optimal, and warmer than optimal water. The 20°C criterion described in Table 3 and the natural background provisions and use attainability pathways described in Section VI are included in this guidance to address those waters that are warmer than optimal for salmonids, thus it is also appropriate to have provisions to protect waters that are at the colder end of their optimal range.

Thus, EPA recommends States and Tribes adopt strong regulatory provisions to protect existing water that has summer maximum temperatures colder than the EPA recommended numeric criteria in Table 3. EPA believes there are several ways a State or Tribe may do this. One approach would be to revise the State's or Tribe's antidegradation regulation to explicitly state that measurable summertime temperature increases are generally prohibited in waters with ESA-listed salmonids that are currently colder than the summer maximum numeric criteria. A second approach would be a narrative temperature criterion that said the same as above. A third approach would be to identify and establish high quality waters for temperature and establish numeric criteria equal to the current conditions. EPA views this third approach to be complementary to the first two approaches, unless the third approach includes a broad application to all or most of the State's or Tribe's waters that currently have maximum temperatures lower than the numeric criteria.

V.3. Adoption of Mixing Zone Provisions to Protect Salmonids

Mixing zones are limited areas or volumes of water where initial dilution of a discharge takes place and where numeric water quality criteria may be exceeded. States and Tribes may include mixing zone provisions in their WQS. See 40 C.F.R. § 131.13. EPA reviews a State's or Tribe's particular mixing zone policy on a case-by-case basis as part of its review of water quality standards. EPA's judgment about the appropriateness of the mixing zone policy is based on whether there are sufficient limitations on mixing zones to protect the designated use of the waterbody as a whole. For example, many States limit the amount of flow and the downstream length that can be used for mixing zone purposes.

EPA recommends that States and Tribes add specific provisions to their mixing zone WQS to protect salmonids from thermal plume impacts. Specifically, language should be included that ensures that mixing zones do not cause: instantaneous lethal temperatures; thermal shock; migration blockage; adverse impact on spawning, egg incubation, and fry emergence areas; and the loss of localized cold water refugia.

The following are examples from the scientific literature of potential adverse impacts that may result from temperature mixing zones, and possible limitations to avoid those impacts. Exposures of less than 10 seconds can cause instantaneous lethality at 32°C; temperatures at the edge of an zone of initial dilution (ZID) could be limited to 32°C and limited in size such that fish would not be entrained in the ZID for more than 2 seconds. Thermal shock leading to increased predation can occur when fish experience a sudden temperature increase of 10°C or greater; mixing zones could be conditioned so that portions of the river most frequently used by emigrating juveniles (e.g. shoreline areas) not subject them to temperature changes greater than 8°C relative to upstream temperatures. Adult migration blockage conditions can occur at 21°C; the maximum cross-sectional area of a river at or above 21°C could be limited to less than 25% or if upstream temperature exceeded 21°C due to natural conditions, the mixing zone could be limited such that 75% of the cross-sectional area of the river has no temperature increase. Adverse impacts on salmon and trout spawning, egg incubation, and fry emergence can occur when the temperatures exceed EPA recommended 13°C spawning criteria; mixing zones could be prohibited in active spawning and incubation areas.

VI. Approaches to Address Situations Where EPA's Recommended Numeric Criteria Are Inappropriate or Unachievable

There will be some circumstances where streams and rivers in the Pacific Northwest cannot attain EPA Region 10's recommended numeric criteria to protect salmonid designated uses, or where the recommended numeric criteria are inappropriate. The following are three WQS approaches to address these circumstances, together with descriptions of when each approach may be appropriate. These approaches are available to States and Tribes under EPA current WQS regulations. See 40 C.F.R. Part 131.

It is important to note each of these approaches will require EPA approval (either in the form of a WQS, TMDL, or 303(d) list approval) and will require a case-by-case review by EPA and the Services (if subject to ESA consultation).

VI.1. Adoption of Site-Specific Numeric Criteria that Supports The Use

This approach can be followed if it can be demonstrated that an alternative numeric criterion supports the designated salmonid use. One example may be the adoption of a 13°C 7DADM criterion to protect bull trout rearing use in areas where competition with other fish is minimal and food sources are abundant. Another example may be where there is exceptionally high natural diurnal temperature variation and where the maximum weekly mean temperature is within the optimal temperature range but because of the high diurnal variation summer maximum temperatures exceed EPA's numeric criteria. In this situation, a State or Tribe may choose to develop a site-specific numeric criterion that more accurately describes the thermal exposure that is protective of the use (e.g. a maximum weekly mean with a daily maximum cap). There may be other situations as well when alternative site-specific criteria would be appropriate. The State or Tribe would need to describe how the site-specific numeric criterion fully supports the use when it submits the criterion to EPA for approval. EPA will then make a decision whether to approve or disapprove on a case-by-case basis, after fully taking into account the demonstration made by the State or Tribe in its submission.

VI.2. Use of a State's or Tribe's "Natural Background" Provisions

A State and Tribe may, if it has not already done so, adopt narrative natural background provisions that supercede numeric criteria when natural background conditions are higher than the numeric criteria, and that under such conditions, no measurable human caused temperature increase above natural background is allowed.

One circumstance when it might be reasonable to utilize these narrative provisions is when waters exceed the numeric criteria due to natural background conditions and where human impacts are negligible (e.g. wilderness areas). For this circumstance, States and Tribes should identify these waters in their WQS. Because the water body would be meeting the narrative provisions of the WQS, it would not be considered impaired and, therefore, would not need to be listed section under 303(d).

A second circumstance when it might be reasonable to utilize these narrative provisions is when waters exceed the numeric criteria due to a combination of apparent natural background conditions and human impacts. In this situation, unlike the situation described above, the State or Tribe would need to list the waters on the 303(d) list of impaired water bodies and develop a TMDL, because the water body's temperature exceeds both the numeric criteria and the natural condition. When the State or Tribe develops the TMDL, however, the narrative natural background provisions in the WQS can be taken into account in order to calculate the loading capacity of the water and to allocate loads. In other words, *estimated* temperatures associated with natural background conditions, after all significant human impacts are removed, could serve as the water quality target for the TMDL, which is used to set TMDL allocations. Thus, the TMDL would be written to meet the WQS narrative natural background provision, and the load reductions contemplated by the TMDL would be equivalent to the removal of the human impacts. In estimating natural background conditions the best available temperature modeling techniques should be employed that capture to the greatest extent practicable all the human impacts that affect river temperatures. Those human impacts that cannot be captured in a model should be identified in the TMDL document along with rough or qualitative estimates of their contribution to elevated water temperatures. Estimates of natural conditions should be revisited periodically as our understanding of the natural system and temperature modeling techniques advance.

When using natural background conditions as TMDL targets and to set TMDL allocations, alluvial river segments that provided cold water refugia prior to human alterations of the landscape should be specifically considered, especially if the TMDL target exceeds 18°C. States should pursue ways to capture the effect of restoring alluvial river segments and the associated hyporiec flow in their estimates of natural background conditions. In the event that restoration of these river segments cannot be included in the natural background estimate (i.e. TMDL targets), the State should include in the TMDL document a rough or qualitative estimate of the effect on temperature if these areas were to be restored. Further, the State's watershed restoration plans designed to meet WQS and implement TMDLs should include measures to restore and protect these alluvial river segments to provide cold water refugia, especially in waters where natural background is estimated to exceed 18°C.

If the human impacts are determined to be irreversible, which would prevent attainment of the natural background conditions, then the State or Tribe could follow the use attainability analysis process discussed below (Section V1.3) and adopt numeric criteria that would support a less than fully supported level of use.

VI.3. Use Attainability Analysis and Numeric Criteria that Supports a "Marginal" or "Limited" Use

States and Tribes may adopt numeric criteria that supports a marginal or limited level of salmonid use if the State or Tribe can demonstrate through a use attainability analysis (UAA) that a more protective criteria is unattainable. See 40 C.F.R. § 131.10. The following are two circumstances when a State or Tribe may want to pursue this option and there may be other circumstances not described here. EPA believes that both of these examples are most applicable to the lower reaches of rivers in the Pacific Northwest.

The first circumstance is when either the adopted temperature numeric criteria or natural background conditions cannot be met due to human impacts that cannot be remedied or that would cause widespread economic and social impact if they were remedied. See 40 C.F.R § 131.10 (g). Under this circumstance, a State or Tribe could conduct an use attainability analysis describing the human impacts that prevent attainment of either the numeric criteria or natural background conditions and calculate the temperature value that could be attained provided restoration of all the reversible human impacts. This calculated temperature value then could be adopted as the numeric criteria that would support a "marginal" or "limited" salmonid use. The State or Tribe then would need to submit the new use and criterion, together with the use attainability analysis, to EPA for review and approval. This circumstance is mostly likely to arise when the State or Tribe is developing or implementing a temperature TMDL.

The second circumstance is when the State or Tribe determines that the criteria that fully protects cold water salmonid uses (e.g. EPA recommended numeric criteria) cannot be attained for some waters due to natural background conditions. See 40 C.F.R. § 131.10 (g). Under this circumstance, the State could conduct a use attainability analysis demonstrating that natural background conditions prevent attainment of the fully protective numeric criteria and calculate the temperature value that reflects the natural background conditions. This calculated temperature value then could be adopted as the numeric criteria that would support a "marginal" or "limited" salmonid use. The State or Tribe then would need to submit the new use and criterion, together with the use attainability analysis, to EPA for review and approval. Although this option could be done at anytime, a State or Tribe may wish to follow this prior to 303(d) listing and TMDL development in order to first establish a realistic numeric criteria. Following this approach prior to doing a TMDL may be most appropriate when the current temperatures are at or near natural background conditions because the natural background demonstration would likely be simpler than if there were extensive human impacts.

Lastly, if a State or Tribe chooses to follow either of the above UAA approaches, EPA strongly recommends they do so in an overall watershed context showing where within the watershed (or sub-basin) fully protective numeric criteria can be met. That is, if a UAA is done for a lower reach in the watershed, the State and Tribe should also show where within the upper part of the watershed the fully protective numeric criteria will be met.

VII. The Role of Temperature WQS in Protecting and Recovering ESA-Listed Salmonids and Examples of Actions to Restore Suitable Water Temperatures

EPA Region 10 and the Services believe that State and Tribal temperature WQS can be a valuable tool to protect and aid in the recovery of threatened and endangered salmonid species in the Pacific Northwest. The following are three important ways that temperature WQS, and measures to meet WQS, can protect salmonid populations and thereby aid in the recovery of these species. The first is to protect existing high quality waters (i.e. waters that currently attain the numeric criteria) and prevent any further thermal degradation in these areas. Second, is to reduce maximum temperatures in thermally degraded stream and river reaches immediately downstream of the existing high quality habitat (e.g. downstream of wilderness areas and unimpaired forest lands) thereby expanding the habitat that is suitable for cold water salmonid rearing and spawning. Third, is to lower maximum temperatures and protect and restore areas of cold water refugia in lower river reaches in order to improve thermal conditions for migration.

The following are examples of specific on-the-ground actions that could be done to meet temperature WQS, protect salmonid populations and also aid in the recovery of threatened and endangered salmonid species. Logically, these example actions are oriented toward reversing the human activities that can contribute to excess warming of river temperatures described in Section IV.2. See Issue Paper 3, Coutant (1999), and Return to the River (2000) for more detailed discussion.

- Replant native riparian vegetation
- Fencing to keep livestock away from streams
- Protective buffer zones to protect riparian vegetation
- Reconnect portions of the river channel with its floodplain
- Re-contour streams to follow their natural meandering pattern
- Increase flow in the river derived from more efficient use of water withdrawals
- Discharge cold water from stratified reservoirs behind dams
- Lower reservoirs to reduce the amount of shallow water in “overbank” zones
- Restore more natural flow regimes to allow alluvial river reaches to function

- Restore more natural flow regimes so that river temperatures exhibit a more natural diurnal and seasonal temperature regime

EPA and the Services acknowledge that efforts are underway on the part of some land owners, companies, non-profit organizations, tribes, local and state governments, and federal agencies in the Pacific Northwest to take actions to protect and restore suitable temperatures for salmonids and improve salmonid habitat generally. A few examples of broad-scale actions to improve temperatures for salmonids are: the Aquatic Conservation Strategy of the Northwest Forest Plan (federal lands); the State of Washington's forest protection regulations; and timber company Habitat Conservation Plans (HCPs), particularly the Simpson HCP, which was done concurrent with a temperature TMDL. Additionally, there are small-scale projects, which are too numerous to list here (e.g. tree plantings, fencing, and re-establishing the natural meandering channel of small streams), that have or will contribute to improved thermal conditions for salmonids.

EPA and the Services believe it is important to highlight these examples of on-the-ground actions to recognize their contribution to improving water temperatures, to demonstrate their feasibility, and to provide a model for others to take similar actions.

VIII. References

Technical Papers Developed in Support of EPA Region 10's Draft Temperature Guidance

Issue Paper 1: Salmonid Behavior and Water Temperature, Prepared as Part of EPA Region 10 Temperature Water Qualilty Criteria Guidance Development Project

Issue Paper 2: Salmonid Distribution and Temperature, Prepared as Part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project

Issue Paper 3: Spatial and Temporal Patterns of Stream Temperature, Prepared as Part of EPA Region 10 Temperature Water Qualilty Criteria Guidance Development Project

Issue Paper 4: Temperature Interaction, Prepared as Part of EPA Region 10 Temperature Water Quality Criteria Guidance Development Project

Issue Paper 5: Summary of Technical Literature examining the Physiological Effects of Temperature on Salmonids, Prepared as Part of EPA Region 10 Temperature Water Qualilty Criteria Guidance Development Project

Technical Synthesis: Scientific Issues Relating to Temperature Criteria for Salmon, Trout, and Char Native to the Pacific Northwest, A summary report submitted to the policy workgroup of the EPA Region 10 Water Temperature Criteria Guidance Project

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