IDAHO POWER
An IDACORP Company

Proposal to Initiate Negotiated Rule Making for Site Specific Temperature Criteria for Fall Chinook Salmon Spawning in the Hells Canyon Reach of the Snake River

Final

Idaho Power Company

June 2010

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

This page left blank intentionally

1. INTRODUCTION

In 2006, Idaho Power Company (IPC) submitted a proposal for Site Specific Criteria (SSC) to the Idaho Department of Environmental Quality (IDEQ) for fall Chinook salmon (*Oncorhynchus tschawytscha*) spawning temperature for the Snake River below the Hells Canyon Complex (HCC). The purpose of the proposal was to initiate an informal forum to discuss SSC preliminary to a formal petition for a rulemaking. The proposal was submitted for review to IDEQ only because the Oregon Department of Environmental Quality (ODEQ) indicated it preferred to participate in the process as an observer. IPC proposed a Snake River fall Chinook salmon spawning criteria not greater than 16.5 C as a daily maximum temperature on October 23 and subsequent daily maximum temperatures not to exceed levels equal to a 0.2 °C daily rate of decline through November 10. From November 11 through April 15, the daily maximum temperature was not to exceed 13 °C. These SSC were to be applied to the Hells Canyon Reach, the Snake River from Hells Canyon Dam [river mile (RM) 247.6] to the Oregon/Washington border (RM 176.1)[1].

The IDEQ held a meeting to discuss the technical merits of IPC's SSC proposal. In attendance were: IDEQ, ODEQ, U.S. Environmental Protection Agency (EPA), National Marine Fisheries Service (NOAA), U.S. Fish and Wildlife Service (USFWS), Idaho Department of Fish and Game (IDFG), Columbia River Inter-Tribal Fish Commission (CRITFC), Nez Perce Tribe (NPT), Idaho Rivers United (IRU), and American Rivers (AR). The group raised several issues including a concern that the proposed SSC was at the "edge of the envelope" for fall Chinook salmon and that the proposal would result in a standard with no inherent added protection, particularly when the resource is a species protected under the Endangered Species Act (ESA). Specifically, one concern was temperature changes downstream relative to the compliance location of Hells Canyon Dam. If water temperatures were to increase in a downstream direction, then compliance may not ensure that fall Chinook salmon embryos would not be exposed to temperatures higher than the standard. Further inquiry was made about accuracy of equipment used to measure temperature both in the river and at the compliance point and the accuracy of the temperature equipment involved in the Battelle study used as primary supportive information of the proposed SSC (discussed later in this document). Others also noted a desire to include an explicit margin of safety to ensure protection of the resource.

IPC has considered the comments and concerns expressed in reaction to the first proposal and continues to believe that the available information warrants a SSC greater than the existing Idaho and Oregon numeric criteria of 13 °C maximum weekly maximum and 13 °C seven-day average maximum,

[1] This Proposal, at times, refers to the Hells Canyon Reach. This is intended to reference the Snake River from Hells Canyon Dam to the Oregon/Washington border.

respectively, (standards which IPC believes are functionally similar), but that a sufficient margin of safety could be incorporated. The purpose of this document is to provide technical support for a proposed SSC for temperature for Snake River fall Chinook salmon spawning and incubation below Hells Canyon Dam that is protective of the resource consistent with IDAPA 58.01.02.070.07 and OAR 340-041-0028(13).

The proposed SSC in Idaho and Oregon that would be protective of Snake River fall Chinook salmon spawning are:

Proposed Amendment to Idaho IDAPA 58.01.02

286. SNAKE RIVER, SUBSECTION 130.01, HUC 17060101, UNIT S1, S2, AND S3; SITE-SPECIFIC CRITERIA FOR WATER TEMPERATURE

A maximum weekly maximum temperature of fourteen and an half degrees (14.5C) applies from October 23rd through October 31 st and a maximum weekly maximum of thirteen degrees C (13C) applies from November 1st through April 15th to protect fall chinook spawning and incubation in the Snake River from Hell's Canyon Dam to the Salmon River.

Proposed amendment to Oregon OAR 340-041-0028(4)

(g) The seven-day-average maximum temperature of a stream identified as having fall Chinook salmon spawning use may not exceed 14.5 degrees Celsius (58.1 degrees Fahrenheit) at the times indicated on Table 121B. The seven-day-average maximum temperature is the mean of daily maximum temperatures measured over a consecutive seven (7) day period ending on the day of calculation.

While the main focus of this proposal is the spawning life-stage, effects on other life stages as a result of the standard are also part of the consideration. This document is structured to provide technical information relative to concerns raised about the prior proposal as well as to provide an overview of the information specific to fall Chinook salmon. In 2007, IPC developed a Temperature White Paper that provided a comprehensive review of the effects of the HCC on fall Chinook salmon (Groves et al. 2007; Appendix 1). Much of the information presented in this document is summarized from this white paper. Subsequent to the submittal of the White Paper, the NPT filed, on August 30, 2007, with the Federal Energy Regulatory Commission (FERC) a review of the white paper conducted by the CRITFC (Appendix 2). In December, 2007, IPC filed a response with FERC to the CRITFC review that evaluated the principal criticisms made by CRITFC of the white paper (Appendix 3). Further, as part of evaluating the temperature requirements of fall Chinook salmon, IPC commissioned a study through Battelle that investigated the effects of different thermal regimes on fall Chinook salmon. The findings of this study are also summarized in the white paper. This study was accepted for publication in the Transactions of the American Fisheries Society where it received full peer review (Geist et al. 2006).

2. BACKGROUND

The HCC consists of the Brownlee, Oxbow, and Hells Canyon hydroelectric projects, located from RM 343.0 to RM 247.6 on the Snake River. The Snake River is boundary water between Oregon and Idaho. IPC operates the three hydroelectric projects in the HCC pursuant to FERC license, Project No. 1971, which expired in 2005, and continues under an annual license. IPC filed an application with the FERC to re-license the HCC in July 2003. That application is currently pending before the FERC. In conjunction with the licensing process, IPC has also applied for Section 401 water-quality certification from Idaho and Oregon. IPC has also developed the technical documentation necessary for the IDEQ and ODEQ to consider the SSC proposed in this document. Because the Snake River is boundary water, IPC anticipates that the IDEQ and ODEQ will develop a coordinated process to address the issues raised by this proposal.

In July 2003, and revised in June 2004, the IDEQ and ODEQ (2004) issued the Snake River–Hells Canyon TMDLs (SR–HC-TMDLs) that cover the mainstem Snake River from RM 409 near the town of Adrian, Oregon, to the inflow of the Salmon River at RM 188.2; this river reach includes the HCC. IPC received load allocations through the SR–HC-TMDLs for temperature, dissolved oxygen (DO), and total dissolved gases. The EPA approved the bacteria, pH, pesticides, and total dissolved gases TMDLs in March 2004 and nutrients, nuisance algae, DO, and temperature in September 2004.[2]

2.1. Site Specific Criteria Process

By Idaho statute, the IDEQ may develop new or modified criteria through site specific analysis that effectively protect designated and existing beneficial uses. IDAPA 58.01.02.275. Specifically, IDAPA recognizes that temperature criteria as they relate to specific water bodies are appropriate for adjustment when doing so will fully support the designated aquatic life at a higher temperature. IDAPA 58.01.02.070.07. Likewise, Oregon regulations provide that the ODEQ may establish, by separate rulemaking, alternative SSC for all or a portion of a water body that fully protects the designated use. OAR 340-041-0028 (13). The EPA must approve any final SSC implemented by the states. 40 CFR 131.20(c). While Idaho, Oregon, and the EPA regulations provide the authority to promulgate SSC, they do not fully prescribe the procedure. Therefore, IPC proposes that IDEQ and ODEQ, jointly or separately,

[2] Although EPA has approved the TMDLs, IPC has filed a petition for judicial review of those portions of the TMDLs that impose a temperature load allocation on the HCC. That petition is pending in Baker County, Oregon. This petition is independent of that pending legal proceeding.

engage in a negotiated rulemaking to establish a revised SSC for temperature in the Snake River from Hells Canyon Dam to the Salmon River.

The negotiated rulemaking process for Idaho would include public notice of negotiated rulemaking, two public meetings, publication of the proposed rule on the Administrative Bulletin for public comment, submission of the proposed rule to the Idaho Board of Environmental Quality, review by the Idaho legislature, and submission of the revised rule to EPA for review. This process is expected to take approximately one year.

The collaborative rulemaking process under Oregon rules is similar to the Idaho process, but the resulting rule does not require legislative approval. Any interested person may petition for a SSC rulemaking. ODEQ may hold a public hearing, but regardless must within 90 days approve or deny the petition, or initiate a rulemaking process. If ODEQ proceeds with a rulemaking, it may appoint a collaborative rulemaking committee or advisory committee to develop the rule. Public notice is given in inviting comment on the proposed rule; ODEQ may hold a public hearing to receive comment. Once the rulemaking record is complete, ODEQ may adopt the rule and file it with the Secretary of State. The SSC rule is then sent to EPA for review. This process is likely to take about one year.

2.2. Snake River Fall Chinook Status

Snake River fall Chinook salmon were listed as a threatened species in 1992 under the ESA. Many factors led to their protected status, including development on the lower Snake and Columbia rivers and the corresponding necessity for the species to migrate through eight federal hydroelectric projects below the HCC. The HCC's effects on temperature below Hells Canyon Dam are not indicated as factors that contributed to the population decline.[3] However, as NOAA Fisheries has observed, Snake River fall Chinook salmon returns have been significantly higher since 2000 than had been observed in the two preceding decades (Declaration of D. Robert Lohn, Case No. CV01-00640-RE, June 12, 2003). While IPC has not changed project operations in a manner that would alter its effects on temperature, Snake River fall Chinook salmon returns and the number of redds constructed below Hells Canyon Dam have been steadily increasing (Figure 1), with 2009 having the highest redd count (3,476 redds) for Snake River fall Chinook salmon above Lower Granite Dam since intensive surveys began in 1991. Adult numbers have increased from 336 in 1990 to over 15,000 in 2009. While much of this increase can be attributed to increased hatchery supplementation, the number of natural adults contributing to spawning

[3] The IDEQ in its comments to the IPC's draft license application indicated that it has not identified any evidence that the fall Chinook salmon population below Hells Canyon Dam is impaired by the temporal shift in water temperatures influenced by the HCC. (See the FLA, Consultation Appendix [T. Dombrowski, 2002, "Idaho Department of Environmental Quality Comments on Idaho Power Hells Canyon Complex Draft Application," FERC]).

has also increased substantially and has ranged from a low of 78 in 1990 to a high estimated in 2001 of over 5,000 (Debbie Milks, WDFW, personal communication).

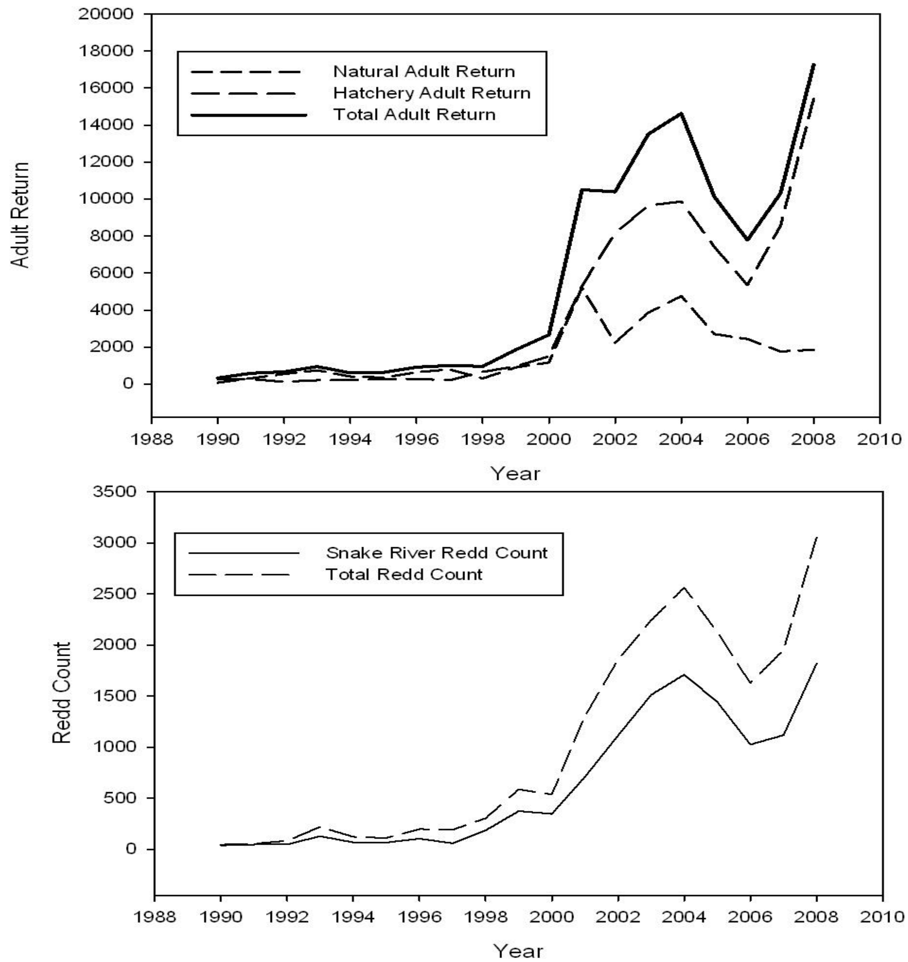

Figure 1. (*Top*) Hatchery and Natural Snake River adult returns (*Bottom*) Total redd counts and Snake River redd counts, 1990-2008.

2.3. Existing Idaho and Oregon Water Quality Standards[4]

As noted, Idaho and Oregon have salmonid spawning temperature criteria applicable to the Snake River (Table 1). IDAPA 58.01.02.250.02.286 and OAR 340-041-0028(4)(a). In addition, Oregon has species-specific and life-stage specific criteria.

Table 1. Idaho and Oregon salmonid spawning temperature criteria applicable to the Snake River below Hells Canyon Dam.

	Criteria
Idaho	Maximum Weekly Maximum of 13 °C
Oregon	Seven-Day Average Maximum of 13 °C

Each state also has exclusions for natural conditions and air temperature. The natural conditions standards generally provide that should the IDEQ or ODEQ determine that the natural background temperatures exceed any biologically-based numeric criteria, that the natural background temperatures supersede the biologically-based criteria. IDAPA 58.01.02.053.04 and OAR 340-041-0028(8). Exceedences of biologically-based numeric temperature criteria that are attributable to maximum air temperatures that exceed the 90th percentile of a yearly series of temperatures specific to the State's criterion collected over specified periods of data are not violations of the standard. IDAPA 58.01.02.080.03. and OAR 340-041-0028(12)(c). Oregon's rules further provide that "the seasonal thermal pattern in Columbia and Snake Rivers must reflect the natural seasonal thermal pattern." OAR 340-041-0028(4)(d). Each state also allows anthropogenic temperature increases. Oregon allows a cumulative increase of no more than 0.3 °C. OAR 340-041-0028(12)(b)(B). Idaho allows a similar increase applicable to point source wastewater receiving waters. IDAPA 58.01.02.401.03.a.v. The SR–HC-TMDLs established a salmonid spawning temperature target of a maximum weekly maximum temperature of 13 °C, or if the natural thermal potential is greater, an allowable cumulative increase of no more than 0.14 °C (IDEQ and ODEQ 2004).[5]

The IDEQ and ODEQ have interpreted the seven-day average maximum temperature to be the mean of daily maximum temperatures measured over a consecutive seven day period ending on the day of calculation. When used seasonally, as for spawning periods, the first applicable seven-day average occurs on the seventh day of the period. This interpretation is part of IDEQ water quality standards. IDAPA 58.01.02.010.52. The ODEQ has issued an Internal Management Directive with similar calculation

[4] Because the Snake River is boundary water and IPC seeks the development of consistent standards by each state, IPC references the applicable water quality standards of both Idaho and Oregon in this petition.

[5] Oregon has revised the anthropogenic temperature allowance standard to no more than 0.3 °C since the submission and the EPA approval of the SR–HC-TMDLs.

protocol (ODEQ 2008). Both follow the EPA recommended guidance (USEPA 2003). The salmonid spawning temperature criterion below the HCC starts on October 23. Applying the criterion in accordance with IDEQ and ODEQ interpretation and EPA's recommended guidance, the seven-day average maximum temperature is first calculated on October 29.

2.3.1. Snake River Fall Chinook Salmon Spawning Period

Idaho has a basin-specific period of October 23 through April 15 for fall Chinook salmon spawning and incubation for the mainstem Snake River from RM 188.2 to RM 247.6 (Table 2). IDAPA 58.01.02.286. Oregon has a basin-specific period of October 23 through April 15 for salmon and steelhead spawning through fry emergence for the mainstem Snake River from RM 188.2 to RM 247.6 and a period of November 1 through May 15 from RM 176.1 to RM 188.2. OAR 340-041-0028(4)(a) Figure 151B. OAR 340-041-0121 Table 121B only identifies the October 23 through April 15 salmon and steelhead through fry emergence period. The SR–HC-TMDLs, authored by both the IDEQ and ODEQ, utilized salmonid spawning criterion of a maximum weekly maximum no greater than 13 °C that applies from October 23 through April 15 from Hell's Canyon Dam to the Salmon River (IDEQ and ODEQ 2004).

Table 2 Idaho and Oregon salmonid spawning period and waters to be protected criteria applicable to the Snake River below Hells Canyon Dam.

	Criteria
Idaho	October 23–April 15 in the Snake River from Hell's Canyon Dam (RM 247.6) to the Salmon River (RM 188.2)
Oregon	October 23–April 15 in the Snake River from Hell's Canyon Dam (247.6) to the Salmon River (RM 188.2) and November 1 through May 15 in the Snake River the Salmon River (RM 188.2) to the Oregon/Washington borderRM 176.1

2.3.2. Snake River Fall Chinook Salmon Spawning Location

Idaho has identified waters of the Snake River that must support salmonid spawning (Table 2). IDAPA 58.01.02.130.01. Similarly, Oregon has identified a specific geographic location in which salmon and steelhead spawning through fry emergence must be protected for the mainstem Snake River. OAR 340-041-0028(4)(a) Figure 151B and OAR 340-041-0121 Table 121B. However, IPC believes the geographic extent identified in Table 121B is incorrect. Oregon identifies the Oregon/Washington border to be RM 169. This is near the confluence of the Grande Ronde River in Washington. The correct river mile for the Oregon/Washington border is RM 176.1. Additionally, OAR 340-041-0121 Table 121B sets a period of salmon and steelhead spawning through fry emergence different than Figure 151B. The SR–HC-TMDLs established that salmonid spawning must be protected in the Snake River from Hells Canyon Dam to the confluence with the Salmon River (IDEQ and ODEQ 2004).

2.4. Existing Conditions

Hydrology, inflowing warm water from sources upstream of the HCC, reservoir operations, and air temperatures all affect the magnitude and timing of seasonal warming and cooling in the Hells Canyon Reach. The SR–HC-TMDLs concluded that the hot, arid climate and non-quantifiable influences, such as upstream impoundments, upstream tributaries, water withdrawals, channel straightening, dikes, and removal of streamside vegetation, were the dominant causes of increased water temperatures in the Snake River (IDEQ and ODEQ 2004).

The HCC impoundments are uniquely located within a relatively narrow and steep-walled canyon. The HCC impoundments are not a heat source, but they do affect the flow of water, which correspondingly affects the timing of seasonal water temperatures exiting the Hells Canyon Dam. In the spring and summer, the HCC has an overall cooling effect because, as upstream water temperatures increase, outflow from Hells Canyon Dam remains cooler than the inflow to Brownlee Reservoir. This trend reverses in the fall as upstream water temperatures decline and outflow from the HCC is warmer than inflow. A comparison of existing temperature conditions at Hells Canyon Dam in 1992, 1995, and 1997, which may be considered low, medium, and high flow years, respectively, to current salmonid spawning criteria show that Idaho's maximum weekly maximum criterion of no greater than 13 °C was exceeded on October 29 in 1992 and 1995 and was 13.3 °C, which is the numeric criterion and allowable anthropogenic increase, in 1997 (Figure 2). While the calculation of a maximum weekly maximum temperature, by definition (IDAPA 58.01.02.003.64), is different than Oregon's seven-day average maximum temperature (OAR 340-041-0002(54)), attainment of the criteria, not to exceed 13 °C on the most critical consecutive seven-day period, are similar. Therefore, Oregon's seven-day average maximum (13.0 °C) was also exceeded in 1992 and 1995 (Figure 2). The largest magnitude of numeric criterion exceedance on October 29 occurred in 1992 (2.8 °C), while there was no numeric criterion and allowable anthropogenic increase exceedance in 1997 (Table 3).

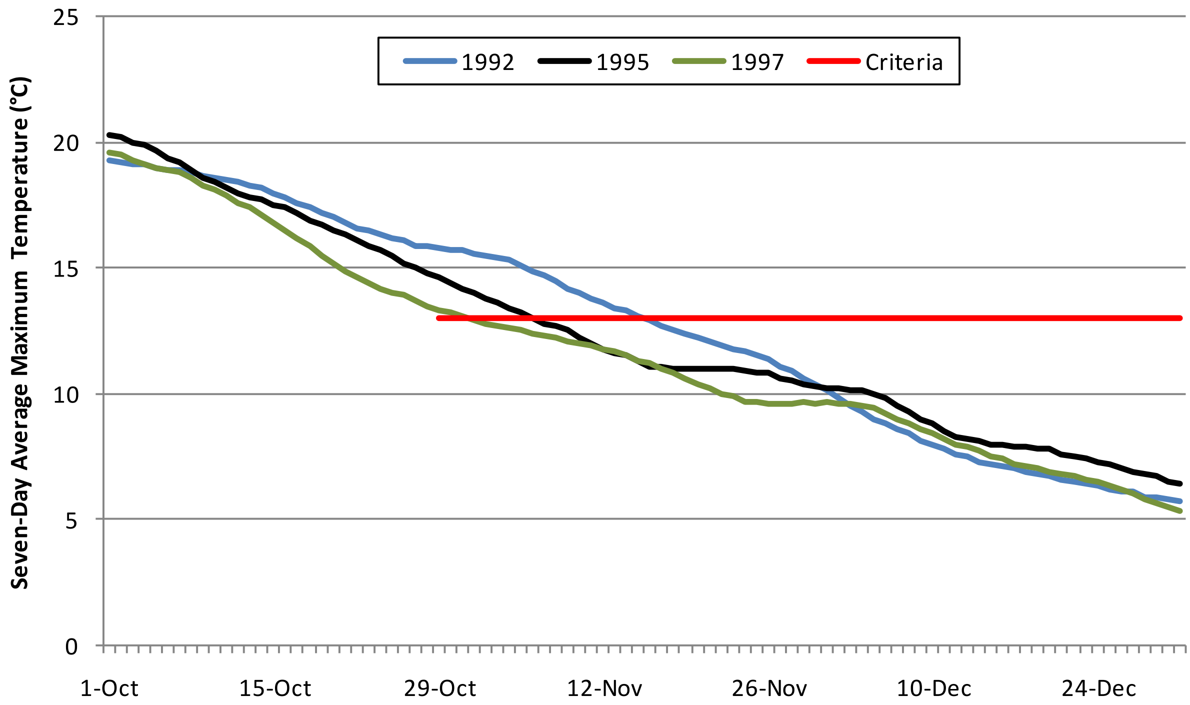

Figure 2. Snake River 7-day average maximum temperature at Hells Canyon Dam (RM 247.6) in 1992, 1995, and 1997 compared with maximum weekly maximum and 7-day average maximum criteria of 13.0 °C. These years may be considered representative of low, medium, and high flow years, respectively.

Table 3. Measured maximum weekly maximum temperature from October 23 at Hells Canyon Dam and comparison of the level of exceedance of the 13 °C maximum weekly maximum from October 23 fall Chinook salmon spawning temperature criteria in 1992, 1995, and 1997. These years may be considered representative of low, medium, and high flow years, respectively.

		1992		1995		1997	
Date	**Criteria**	**7-Day Average Maximum**	**Magnitude of Exceedance**	**7-Day Average Maximum**	**Magnitude of Exceedance**	**7-Day Average Maximum**	**Magnitude of Exceedance**
10/23							
10/24							
10/25							
10/26							
10/27							
10/28							
10/29	13.0	15.8	2.8	14.6	1.6	13.3	0.3
10/30	13.0	15.7	2.7	14.4	1.4	13.2	0.2
10/31	13.0	15.7	2.7	14.2	1.2	13.1	0.1
11/1	13.0	15.6	2.6	14.0	1.0	12.9	--
11/2	13.0	15.5	2.5	13.8	0.8	12.8	--
11/3	13.0	15.4	2.4	13.6	0.6	12.7	--
11/4	13.0	15.3	2.3	13.4	0.4	12.6	--
11/5	13.0	15.1	2.1	13.2	0.2	12.5	--
11/6	13.0	14.9	1.9	13.0	0.0	12.4	--
11/7	13.0	14.7	1.7	12.8	--	12.3	--
11/8	13.0	14.5	1.5	12.7	--	12.2	--
11/9	13.0	14.2	1.2	12.5	--	12.1	--
11/10	13.0	14.0	1.0	12.2	--	12.0	--
11/11	13.0	13.8	0.8	12.0	--	11.9	--
11/12	13.0	13.6	0.6	11.8	--	11.8	--
11/13	13.0	13.4	0.4	11.6	--	11.7	--
11/14	13.0	13.3	0.3	11.5	--	11.5	--
11/15	13.0	13.1	0.1	11.3	--	11.3	--

Note: "--" indicates no exceedance occurred.

Water temperatures downstream of Hells Canyon Dam mostly decline during the fall and early winter months providing inherent additional protection of the resource further downstream if criteria compliance was not achieved at Hells Canyon Dam (Figure 3). Julian day average (1991-2009) seven-day average maximum temperatures were generally 0-0.5 °C cooler nearer the Salmon River confluence than immediately below Hells Canyon Dam. Further, the Snake River would not be warmed by Salmon River inflows as the seven-day average maximum temperature in the Salmon River is on average approximately 5.5 °C cooler than the Snake River above the confluence during the same period of record (Figure 4).

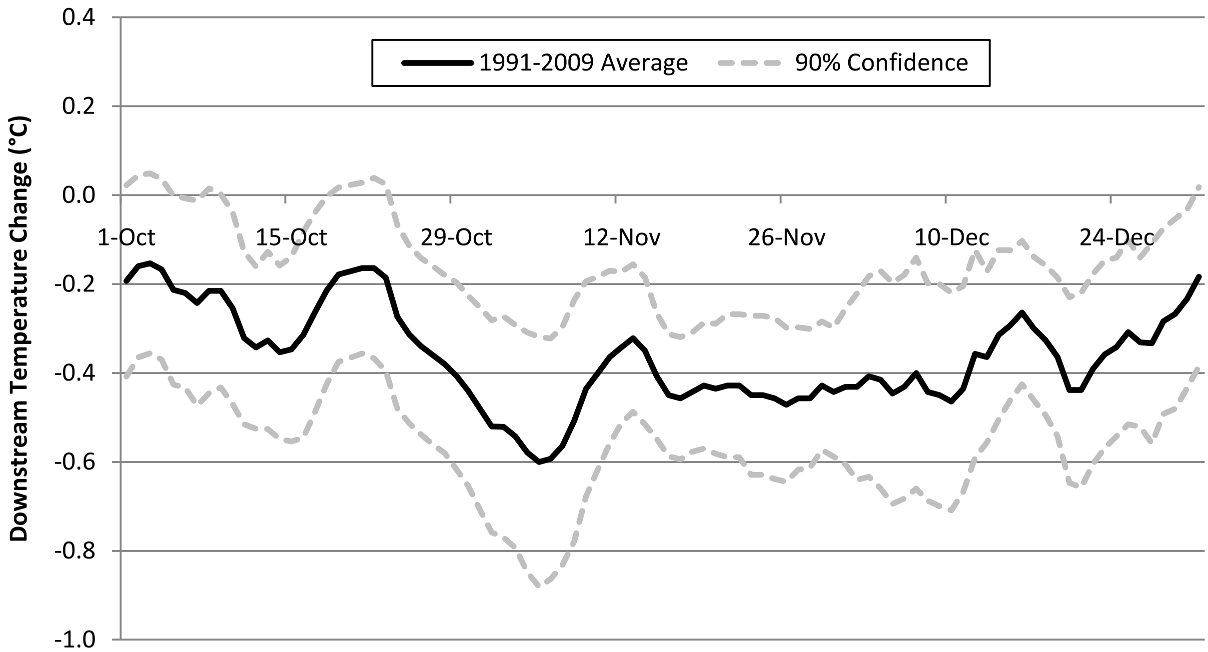

Figure 3. Summarized temperature differences from 1991-2009 between Hells Canyon Dam (RM 247.6) and just above the Salmon River confluence (RM 192). The temperature difference represents the Julian Day average temperature change through the reach. Negative numbers indicate cooling. (Note: Data from all years were not available for all dates. Actual N for each day ranged from 12-15 for the 19years.).

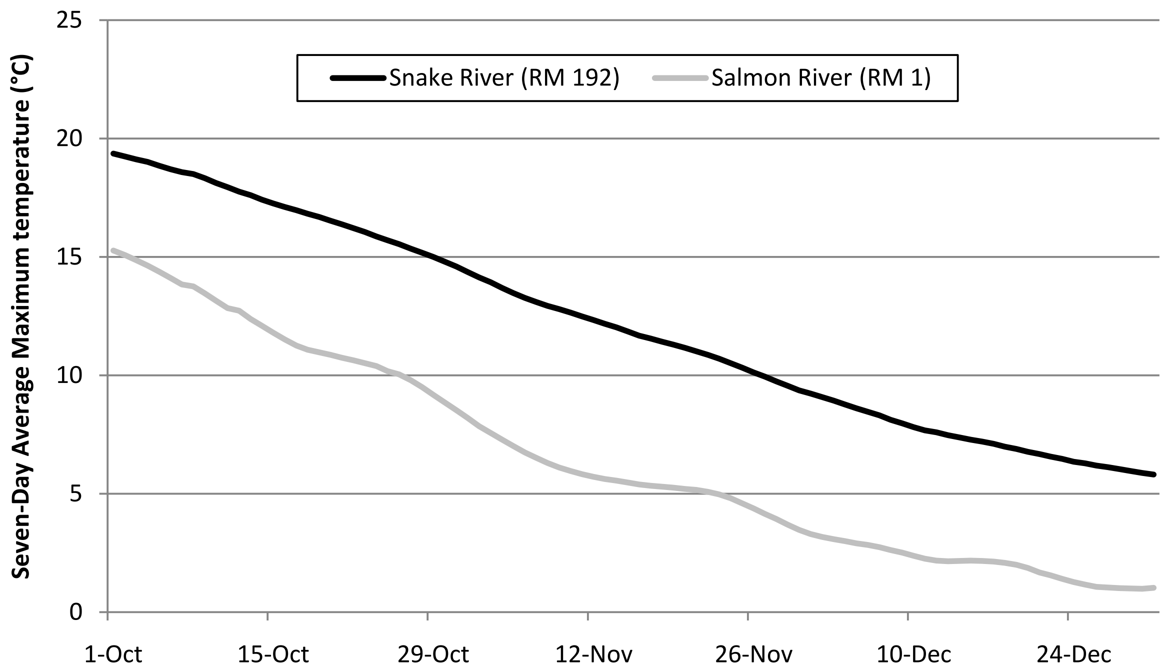

Figure 4. Julian Day seven-day average maximum temperatures of the Snake River (RM 192) just above the confluence with the Salmon River and the Salmon River (RM 1.5) recorded from 1991 through 2009.

3. PROPOSED SNAKE RIVER FALL CHINOOK SALMON SITE SPECIFIC TEMPERATURE CRITERIA

IPC proposes the following SSC in Idaho and Oregon that would be protective of Snake River fall Chinook salmon spawning.

Proposed Amendment to IDAPA 58.01.02

286. SNAKE RIVER, SUBSECTION 130.01, HUC 17060101, UNIT S1, S2, AND S3; SITE-SPECIFIC CRITERIA FOR WATER TEMPERATURE

A maximum weekly maximum temperature of fourteen and an half degrees C (14.5C) applies from October 23rd through October 31st and a maximum weekly maximum of thirteen degrees C (13C) applies from November 1st through April 15th to protect fall chinook spawning and incubation in the Snake River from Hell’s Canyon Dam to the Salmon River.

Proposed amendment to OAR 340-041-0028(4)

(g) The seven-day-average maximum temperature of a stream identified as having fall Chinook salmon spawning use may not exceed 14.5 degrees Celsius (58.1 degrees Fahrenheit) at the times indicated on Table 121B. The seven-day-average maximum temperature is the mean of daily maximum temperatures measured over a consecutive seven (7) day period ending on the day of calculation.

Table 121B

BENEFICIAL USE DESIGNATIONS – FISH USES

MAINSTEM SNAKE RIVER

Geographic Extent of Use	Salmon and Steelhead Migration Corridors (20°C)	Redband or Lahontan Cutthroat Trout (20°C)	Fall Chinook Salmon Spawning through Fry Emergence (14.5°C)	Salmon and Steelhead Spawning through Fry Emergence (13°C)
Mainstem Snake River				
Oregon/Washington Border to Salmon River (RM 176.1 to RM 188.2)	X			November 1-May 15
Salmon River to Hells Canyon Dam (RM 188.2 to RM 247.6)	X		October 23-October 31	November 1-April 15
Hells Canyon Dam to Idaho Border (RM 247.6 to RM 409)		X		

4. Rationale for Snake River Fall Chinook Salmon Spawning Temperature Site Specific Criteria

A single salmonid spawning temperature criterion is not equally appropriate for all waters, for all species, or even for the entire spawning season in a single year. The current temperature criteria are based on available literature largely consisting of exposing incubating embryos to constant temperature regimes (see Davis 1975 and McCullough et al. 2001). However, thermal regimes in the natural environment are rarely constant and in the case of fall Chinook salmon and other fall spawning fish are under a declining regime. IPC seeks to establish a SSC that more closely reflects the temperature requirements of the Snake River fall Chinook salmon.

Idaho regulations provide the Director with discretion to recognize that higher temperature criteria, that are protective of the beneficial uses, are appropriate in particular water bodies.

> **07. Temperature Criteria.** In the application of temperature criteria, the Director may, at his discretion, waive or raise the temperature criteria as they pertain to a specific water body. Any such determination shall be made consistent with 40 CFR 131.11 and shall be based on a finding that the designated aquatic life use is not an existing use in such water body or would be fully supported at a higher temperature criteria. For any determination,

> the Director shall, prior to making a determination, provide for public notice and comment on the proposed determination. For any such proposed determination, the Director shall prepare and make available to the public a technical support document addressing the proposed modification.

Hells Canyon reach, with its declining thermal regime in the fall, is just such a water body.

The EPA Region 10 Guidance (USEPA 2003) reflects the Agency's current analysis of temperature considerations for Pacific Northwest salmonid species. Specifically, it does not require strict compliance with the guidance; however, EPA intends to consider it when reviewing or promulgating temperature standards.

> "…this guidance does not preclude States or Tribes from adopting temperature WQS different from those described. . . EPA would approve any temperature WQS that it determines are consistent with the applicable requirements of the CWA [protection and propagation of fish, shellfish, and wildlife] and its obligations under the ESA."[6]

The supporting science available at the time of the development of the EPA Region 10 Guidance (USEPA 2003) is not as applicable to the natural spawning of fall Chinook salmon as more recent published literature (e.g., Geist et al. 2006). Further, the guidance over-simplifies the complex issue of temperatures necessary to support designated beneficial uses (IPC 2002).

4.1. Information Supportive of Fall Chinook Salmon Spawning Site Specific Temperature Criteria

4.1.1. Current Science Supporting Fall Chinook Salmon Site Specific Temperature Criteria

Numerous research studies report that temperatures greater than the current Oregon and Idaho salmonid spawning criteria of 13°C have comparable survival levels. Some of these studies are cited in the EPA Region 10 Guidance document. The most instructional research relative to SSC are those specific to fall Chinook salmon and those that evaluate naturally varying thermal regimes as opposed to constant thermal regimes (see Groves et al. 2007 for a complete review). Different species of Pacific salmon and even different races of Chinook salmon can differ substantially in their thermal tolerances and preferences (Beacham and Murray 1990, Beacham and Withler 1991).

There are three studies most applicable to the fall Chinook salmon: Olson and Foster (1955), Olson et al. (1970) (which includes results of Olson and Nakatani (1968)), and Geist et al. (2006). Each study

6 NOAA Fisheries' response to the EPA Region 10 Guidance included a statement that while the guidance provides a good general overview, the Agency cannot pre-judge the effects of any proposed standard with respect to the Endangered Species Act or Essential Fish Habitat consultations. EPA and NOAA Fisheries expect to consult on each set of standards that EPA proposes to approve under the CWA.

mimicked variants of a naturally declining thermal regime. The Olson and Foster (1955) and the Olson et al. (1970) studies were conducted using fall chinook salmon from the Hanford Reach of the Columbia River, and the Geist et al. (2006) study used Snake River fall Chinook salmon. All three studies indicate a sharp change in mortality after a threshold in temperature was reached. Geist et al. (2006) reported an initial incubation temperature threshold value of 16.5°C, where mortality begins to sharply increase, whereas Olson and Foster (1955) reported a value before eggs could begin incubation without significant loss of 16.1°C. The Olson et al. (1970) did not report a threshold value, but rather looked at incremental temperature increases above the base Columbia River temperature during the fall chinook salmon spawning period. Generally, the studies are comparable to each other, but have some differences that warrant consideration. The Geist et al. (2006) study used a 0.2°C daily rate of decline comparable with data from the Snake River, whereas the Olson and Foster (1955) used a daily rate of decline of 0.18°C and the Olson et al. (2006) had what appears to be a more variable rate of decline ranging from 1.1°C/d to 1.7°C/d estimated from figures in the report. The two Hanford Reach studies used Columbia River water, whereas the Geist et al. (2006) study used well water. The Hanford Reach studies monitored survival to a point past emergence whereas the Geist et al. (2006) monitored survival to emergence. Olson et al. (1970) was conducted over four spawning dates, whereas the Olson and Foster (1955) and the Geist et al. (2006) was one spawn time. These differences may be factors in the higher threshold reported by Geist et al. (2006) than observed by Olson and Foster (1955). However, the three studies are similar enough that a combined analysis of the three studies is warranted relative to the determination of a threshold value.

Using segmented regression analysis on the combined data, a spline model was created with two line segments. The point where the two lines come together is referred to as the join point, which could also be thought of as the threshold temperature where mortality begins to change. The join point from the combined data is estimated at 16°C, with 95% confidence intervals (CI) ranging from 15.3°C to 16.6°C (Figure 5). [7] Below this temperature threshold, incubation mortality does not significantly differ (i.e., a line segment with a slope not significantly different from zero). Above the join point, mortality increases with a slope of 27.8 (i.e., mortality increases by this percentage with each 1°C increase in temperature). Using the estimated join point of 16°C as the initial incubation temperature, the associated MWM would equal 15.4°C. Based on the 15.3°C (the lower 95% CI around the join point) as the most conservative initial incubation temperature where mortality would begin to increase with increasing temperature, the associated MWM temperature would be 14.7°C (0.2°C greater than the proposed SSC).

[7] Data from the third spawning series in the Olson et al. (1970) report were excluded from the pooled study analysis consistent with the author's recommendations. Exclusion did not significantly affect the findings from the combined data analysis.

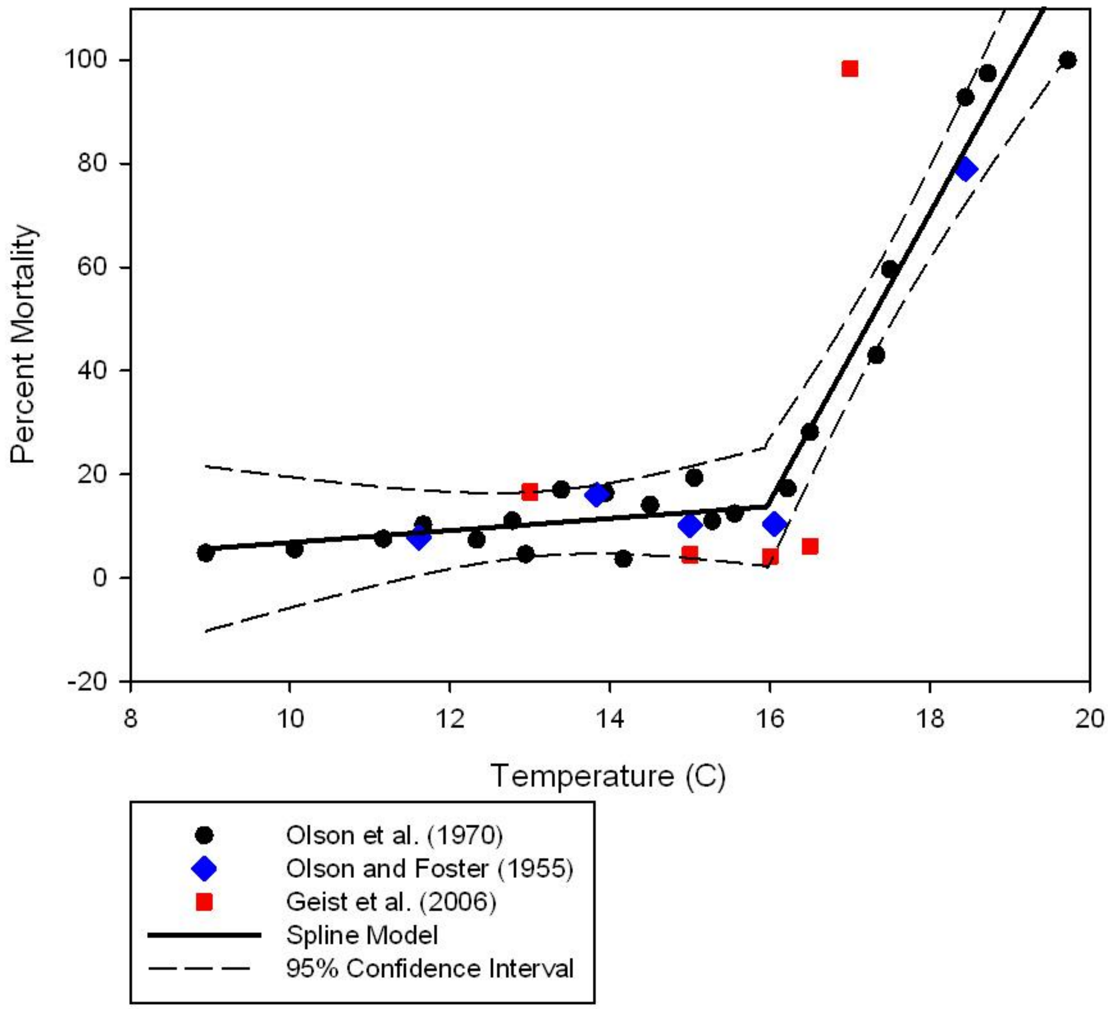

Figure 5. Combined data from three studies (Olson and Foster 1955, Olson et al. (1970) and Geist et al. (2006)) of fall Chinook salmon initial incubation temperatures and associated mortality to fry emergence under a declining thermal regime. Two line segments form a single spline model that estimates the join point (threshold value) of 16°C, with a 95% confidence interval ranging from 15.3°C to 16.6°C.

4.1.2. Reasonable Assurance

Understanding thermal requirements of aquatic organisms invariably requires laboratory experiments where temperature can be isolated from other often confounding or synergistic factors. Many factors can influence the applicability of a laboratory study to a natural environment such as the Snake River. These can include flow through the redd environment, differences in redd temperatures relative to water column temperatures and potential synergies between DO levels, temperature and survival.

The Geist et al. (2006) study is the most relevant study specific to SSC for Snake River fall Chinook salmon. The study evaluated survival, development and growth of fall Chinook salmon embryos during the incubation period that were exposed to both variable temperature and DO regimes. This study allows an examination of potential synergies between temperature and DO that might influence a SSC. The results showed that the mortality of incubating fall Chinook salmon exposed to variable temperature and DO conditions was not affected by DO levels as low as 4 mg O_2/L from initial temperatures of 15°C to 16.5°C, the temperature range at which DO was varied. Further, mean wet weight and mean fork length at emergence did not differ among any of the temperature and DO treatments. There are periods in the late summer and early fall when DO levels can be near 4 mg O_2/L in Hells Canyon, primarily in the upper portion of the Hells Canyon Reach. However, DO levels increase during the fall months and with distance downstream as many of the larger rapids aerate the water. The SSC proposal of a MWM of 14.5°C is within the variable temperature and DO ranges evaluated in the Geist et al. (2006) evaluation[8], and therefore it is reasonable to conclude that a synergistic affect relative to DO at levels as low as 4 mg O_2/L would not occur.

Another factor that could influence applicability of the lab study to the natural environment is the potential that temperatures experienced in the redd environment in some systems can differ from those in the surface water, which because it can be readily measured is the basis of measuring compliance with state standards. Groves et al. (2008) compared temperatures within artificial redds and surface water and found no significant differences between the two environments in the Snake River. This is indicative that flow of surface water through the redd environment in the Snake River is relatively high, which allows for direct applicability of the lab study to the natural environment. This conclusion is also supported by DO levels and egg survival within artificial redds in the Hells Canyon Reach. The DO levels measured in artificial redds in the Hells Canyon Reach were consistently above 9 mg/l and generally < 2 mg/l different from the surface water further suggesting high surface water through the redd environment (see Chandler 2007 for a complete summary of artificial redd and egg survival in the Hells Canyon Reach).[9]

These findings suggest that the results of the laboratory studies can reasonably be applied to the natural environment and provide reasonable assurance that a MWM temperature of 14.5 °C is protective of fall Chinook salmon spawning and incubation based on the current science available. Primary among the reasonable assurance of this determination of beneficial use protection are the combined data analysis discussed above (see Section 4.1.1; Figure 5). IPC's proposed SSC of a MWM temperature of 14.5 °C is distinguishable, using the reported accuracy of temperature instrumentation of 0.2 °C, from the calculated

[8] A MWM of 14.5°C would have an initial daily maximum temperature on October 23 of 15.1°C, assuming a 0.2°C/d rate of decline.
[9] No change in the DO standards are proposed in this SSC proposal.

MWM temperature of 14.7 °C that is associated with the initial daily maximum of 15.3 °C (the lower 95% CI around the join point). That is, the MWM of 14.7 °C would be considered the most conservative value that would define a threshold where mortality would begin to increase and statistically there is no lower survival of fall Chinook salmon embryos through spawning and incubation as compared to the current criteria of no greater than 13 °C. Additionally, IPC has illustrated (see Section 2.4; Figure 3) temperature decreases downstream of Hells Canyon Dam; further adding assurance that proposed SSC will not be exceeded. This weight of evidence is strongly supportive that IPC's proposed SSC provides reasonable assurance that the resource is protected.

4.2. A Comparison of Regional Fall Chinook Salmon Spawning Thermal Regimes

Evaluations of a declining temperature regime in the Columbia River demonstrate that healthy fall Chinook salmon populations initiate spawning at temperatures above 13 °C. Fall Chinook salmon begin spawning in October when ambient air and water temperatures are declining. Temperature at the initiation of fall Chinook salmon spawning in the natural environment is typically near 16 °C (Healey 1991). Exposure to higher temperatures is typically for short periods at the beginning of the spawning season as the thermal regime begins to decline. For example, Chandler et al. (2001) estimated that 2% or less of redds are constructed below Hells Canyon Dam early enough to experience temperatures greater than 16 °C. Similar observation of fall Chinook salmon spawning above 16 °C have been reported for the Hanford Reach of the Columbia River (Dauble and Watson 1990) and for the lower Columbia River (Van der Naald et al. 2000).

IPC compared the thermal conditions and spawn timing of the Snake River below the HCC (1991 -2003) and the Hanford Reach of the Columbia River (1974-1992; IPC unpublished information) based on available data. The timing of spawning was compared using data from 1991-2002 for Hells Canyon Reach and 1949 to 2002 for the Hanford Reach. Although initial spawning in the Hanford Reach was slightly earlier than Hells Canyon Reach, the peak and final spawning times were not different (Table 4). The thermal regime of the Hanford Reach of the Columbia River and the Hells Canyon Reach upstream of the Salmon River are also very similar (Table 5). During the initiation of fall Chinook salmon spawning, the daily mean temperature of the Snake River upstream of the confluence with the Salmon River to the Hells Canyon Dam (14.7 °C) was not statistically different than that of the Hanford Reach (15.6 °C). Both were statistically warmer than the Snake River downstream of the confluence with the Salmon River (12.6 °C). Similar results were reported through peak spawning (occurring in early November). Both the upper Hells Canyon Reach and the Hanford Reach had daily mean temperatures of 12.5 °C.

Table 4. Julian date corresponding to specific spawning phases observed within the Hanford Reach of the Columbia River (HAN), and the lower and upper Snake River sub-reaches (LSR and USR, respectively). (Julian day 285 is 11 October; different letters within each row indicate significant differences at α=0.05.)

Spawning Phases	Julian date of occurrence within reaches		
	HAN	LSR	USR
Initial	289 $_A$	298 $_B$	297 $_B$
Peak	313 $_A$	312 $_A$	310 $_A$
Final	326 $_A$	330 $_A$	335 $_A$

Table 5. Mean water temperature (°C) present during specific spawning phases within the Hanford Reach of the Columbia River (HAN), and the lower and upper Snake River sub-reaches (LSR and USR, respectively). (Different letters within each row indicate significant differences at α=0.05.)

Spawning phases	Reach water temperature (°C)		
	HAN	LSR	USR
Initial	15.6 $_B$	12.6 $_A$	14.7 $_B$
7 days pre-initial	16.0 $_B$	13.5 $_A$	15.3 $_B$
Peak	12.5 $_B$	9.8 $_A$	12.5 $_B$
7 days pre-peak	12.9 $_B$	10.2 $_A$	13.0 $_B$
Final	10.5 $_C$	7.1 $_A$	8.7 $_B$
7 days pre-final	10.9 $_C$	7.6 $_A$	9.1 $_B$

A comparison of maximum weekly maximum temperatures was also made using recent information from the Hells Canyon Dam(RM 247.6),the Upper Hells Canyon Reach upstream of the Salmon River confluence (RM 192.3) the Lower Hells Canyon Reach downstream of the Grande Ronde River (RM 165.7) and the Hanford Reach using provisional data available from the Grant County PUD from the tailrace of Priest Rapids Dam, the first dam on the Columbia River upstream of the Hanford Reach[10]. Data were available for 2006, 2008 and 2009. The comparison is consistent with the previous

[10] (http://www.gcpud.org/resources/resLandWater/waterQuality.htm)

comparison, and demonstrates a very similar thermal regime between the Upper Hells Canyon Reach and the Hanford Reach (Table 6).

Table 6. A comparison of the Maximum Weekly Maximum temperature (°C) from October 23 between the Hanford Reach of the Columbia River (as measured at Priest Rapids Dam tailrace), Hells Canyon Dam penstock, RM 192.3 (upstream of Salmon River confluence) and RM 165.7 (downstream of Grande Ronde River in lower Hells Canyon) for the years 2006, 2008 and 2009 (2007 data not available for Priest Rapids tailrace).

Year	Priest Rapids Tailrace	Hells Canyon Dam	RM 192.3	RM 165.7
2006	15.0	15.3	15	12.8
2008	14.3	14.9	14.8	12.6
2009	14.2	14.8	14.4	12.3

Several authors have estimated favorable ranges for large mainstem river Chinook salmon incubation including fall Chinook salmon. Boles et al. (1988) determined that initial spawning temperatures under a declining temperature regime could be as high as 15.5 °C for Sacramento fall-run Chinook salmon. Bell (1986), as cited in Bjornn and Reiser (1991), estimated favorable incubation conditions for fall Chinook salmon to occur between 5.0–14.5 °C. Raleigh et al. (1986) recommended a range of between 6.0–14 °C. Comb and Burrows (1957) estimated upper temperature thresholds for incubation to occur between 14.2–15.5 °C. McCullough et al. (2001) suggested daily maximums during the incubation period not exceed 13.5–14.5 °C. The studies specific to declining thermal regimes for fall Chinook salmon suggest favorable upper initial temperatures as high as 16.1 to 16.5 (Olson et al. (1955); Geist et al. (2006)).

Geist et al. (2006) showed that, as initial incubation temperature increased under a declining thermal regime, the time to hatching and emergence decreased. The inverse relationship between temperature and development time observed in this study is common among all salmon species (reviewed in Weatherly and Gill 1995). This earlier emergence has significant implications for Snake River fall Chinook salmon in the maintenance of an Age-0 life history. Survival of sub-yearling fall Chinook salmon that begin moving downstream the first week of July (after flows begin to decline and downstream reservoirs heat up) survive at rates of only 5–20%, whereas those that initiate movement in late May survive at rates of 65–90% (Connor et al. 2003; Smith et al. 2003). Many late emerging fall Chinook salmon, typical of the colder incubation thermal regime of the Clearwater River adopt an Age-1 life history, where they over-summer in the mainstem Snake and Columbia rivers before entering the ocean the following spring (Connor et al. 2002).

Because of the implications of earlier spawn timing relative to emergence timing, there is some thought that cooling river temperatures might promote earlier spawning and earlier emergence. Groves et al. (2007) compared initiation of spawning between the Upper Hells Canyon Reach (upstream of the salmon river confluence), the Lower Hells Canyon Reach (downstream of the salmon river confluence), and the Grande Ronde River. These systems all have different thermal regimes, with the Upper Hells Canyon Reach being the warmest. Groves et al. (2007) concluded that there is no clear pattern of initiation of spawning and water temperature. Groves et al. (2007) also compared reports of spawn timing in the early 1950's (Zimmer 1950) upstream of the HCC site to spawn timing distribution today. Spawning was initiated in early October and extended over a relatively prolonged period through early December, with peak spawning occurring around the first week of November (Zimmer 1950). This is very similar to what has been observed today in the spawning area below Hells Canyon Dam. This initiation of spawn timing does not seem strongly tied to a specific water temperatures with the exception that spawning generally takes place when temperature begin to drop below 16ºC and that temperatures are on a declining limb associated with fall cooling (Healey 1991).

4.3. Other Life Stage Considerations

The applicable aquatic life criterion for the state of Oregon for a stream identified as having a migration corridor use for salmon and steelhead is the seven-day average maximum temperature not to exceed 20.0 °C. OAR 340-041-0028(4)(d). This criterion is applicable to the Snake River from the Oregon/Washington border to Hells Canyon Dam (RM 176.1-247.6). In addition, there must be sufficiently distributed coldwater refugia to allow salmon and steelhead migration without significant adverse effects from higher water temperatures elsewhere in the water body. Finally, the seasonal thermal pattern in Columbia and Snake Rivers must reflect the natural seasonal thermal pattern. For the state of Idaho, the protection of cold water aquatic life are a daily maximum not to exceed 22 ºC with a maximum daily average of no greater than 19 ºC. IDAPA 58.01.02.250.02.b..

Although the focus of this proposal is for a SSC specific to fall Chinook salmon spawning, concern raised by some in the initial IPC proposal was relative to the effect of an SSC on other life-stages of fall Chinook salmon and the warmer fall environment associated with the HCC. Specific concern is that a higher initial salmonid spawning temperature may influence spawning success because gametes may be less viable under warmer conditions. A similar concern is that warmer pre-spawn and initial spawn temperatures may be associated with a high pre-spawn mortality of adults or a delay in spawn timing. The aquatic life criteria identified for a migratory corridor of anadromous fish for Oregon and Idaho presumably was established to be protective of the pre-spawn environment. Other life stages of fall

Chinook salmon have been reviewed by Groves et al. (2007; Appendix 1). The findings from this review are summarized as follows:

- *Adult migration* – There has been no apparent shift in adult migration timing compared to the pre HCC environment. Adult fall Chinook salmon experience a similar period of exposure to temperatures elevated above 20 ºC between mid-August and mid-September as they did pre-HCC, but experience a lower maximum temperature than occurred historically. This is based on water temperatures present at Central Ferry in the early to mid-1950's, prior to construction of the HCC or the lower Snake River reservoirs.
- *Pre-spawn mortality* – Some level of pre-spawning mortality among anadromous salmonids is common. There is evidence that adult salmon in hatchery holding environments exposed to prolonged periods of water temperatures > 19 ºC could be subject to significant pre-spawn mortality. In hatchery holding situations, the mortality is usually associated with increased susceptibility to disease. However, fish-to-redd ratios documented in the Snake River do not suggest excessive pre-spawn mortality of fall Chinook salmon. It may be that the non-confined environment of a large river under a naturally declining thermal regime and the availability of cold water refugia make fish less susceptible to disease and mortality. In addition, the HCC has cooled late summer outflows relative to levels associated with the inflow temperature and the operations of Dworshak Reservoir substantially cool areas associated with Lower Granite Reservoir and create thermal refugia during the early pre-spawn environment such that conditions prevalent today are better than conditions prior to the HCC.
- *Gamete viability* – Studies often cited to suggest reduced gamete viability as a result of prolonged exposure to warmer temperatures should not be cited as supporting literature. The studies typically were not designed to address the question. One study that could be cited as supporting evidence (Jensen et al. 2006) did not hold adult Chinook salmon in a declining thermal regime typical of a riverine environment, but rather exemplified relatively long-term (40-days) exposure to elevated water temperatures. In addition, the control group held fish in a constant thermal environment of between 8 and 9 ºC, which cannot be compared to a declining thermal regime under more normative environments. Based on the available information, there is no evidence that the HCC has had an adverse effect on development of gametes in returning adult fall Chinook salmon.
- *Spawn timing* – There is no evidence that spawn timing has been greatly altered in the Snake River when comparing pre-HCC spawn distribution to that of the present-day Hells Canyon Reach spawn distribution.

5. SUPPORT STATUS OF THE BENEFICIAL USE

Snake River fall Chinook salmon returns have continued to increase since the early 1990s (Figure 1). There are several reasons for the increased abundance. Increased hatchery supplementation is a primary factor; however, increasing returns of non-hatchery salmon and steelhead, including Snake River spring Chinook salmon and Snake River steelhead, over the last several years suggest improvements in migration survival and/or ocean conditions. With the increased fall Chinook salmon returns, there has been a corresponding increase in the number of redds constructed in the Hells Canyon Reach of the Snake River as well as a corresponding increase in abundance of naturally produced fall Chinook salmon, indicating that Snake River fall Chinook salmon are spawning successfully (Figure 1). Recent studies demonstrate sufficient habitat in the Snake River to support further increasing numbers of fall Chinook salmon (Groves and Chandler 2001; Connor et. al. 2001). Recent studies (Geist et al. 2006) also demonstrate that the fall thermal regime with initial spawning temperatures <16.5 °C does not impair survival of incubating fall Chinook salmon.

As indicated above, many factors influence the support status of Snake River fall Chinook salmon. Among these are global ocean conditions, regional management decisions on hatchery supplementation as well as migration survival and harvest levels, and the quantity and quality of habitat. Local water quality also undoubtedly influences support of fall Chinook salmon. However, the IDEQ in its comments to IPC's draft license application indicated that it has not identified any evidence that the Snake River fall Chinook salmon population below Hells Canyon Dam is impaired by the temporal shift in water temperatures influenced by the HCC (Dombrowski 2002).

Reference conditions should represent the best range of conditions or desirable conditions that can be achieved in similar waters in a particular ecological region. Reference conditions can be established using a combination of methods, including reference sites when known reference sites exist, historical data, paleoecological data, experimental laboratory data, quantitative models, and best professional judgment. Because there are few waters of similar watershed size, hydrologic characteristics, and similar biologic communities as the Snake River below the HCC, few comparable sites exist. The Hanford Reach of the Columbia River is one of those comparable sites. The Hanford Reach is considered an important production area for fall Chinook salmon; this stock of the most inland fall Chinook population is the most robust and healthy remaining in the Columbia River Basin and is not protected under the ESA (Huntington et al. 1996; Dauble and Watson 1997; Dauble and Geist 2000). The high level of fall Chinook salmon production in the Hanford Reach suggests that, among other conditions effecting beneficial use support, temperature-related conditions during immigration, spawning, and fry emergence is favorable for fully supporting an ocean-type life history. As described in section 3.2., the thermal conditions experienced by fall Chinook salmon using the Snake River Hells Canyon Reach and the Hanford Reach of the Columbia River are generally similar.

6. SITE SPECIFIC CRITERIA WARRANTED

Based on the body of scientific literature and research available as well as the conditions observed in other fall Chinook salmon populations, specific to Snake River fall Chinook salmon, SSC is warranted. Fall Chinook salmon spawn in lower elevation large mainstem rivers where warmer temperatures are prevalent. Initial spawning at temperature ≥ 16°C is the norm for fall Chinook salmon, even in systems other than the Snake River (Healey 1991). They spawn in a period of declining temperatures. The Age-0 life history and the timing of their arrival to the spawning grounds all suggest that they cannot be compared to other races of Chinook salmon (e.g., spring /summer Chinook salmon, *Oncorhynchyus tschawytscha*) or other species of Pacific salmon (e.g., sockeye salmon, *O. nerka*).

The Age-0 life history is dependent upon conditions that promote early emergence. Warm fall and overwinter temperatures promote early emergence and the Age-0 life history. The primary historic spawning area of Snake River fall Chinook salmon was upstream of Swan Falls Dam (see Chandler 2007 for a review of historic conditions). This area is highly influenced by large volumes of spring flow into the Snake River that moderates fall and winter cooling and historically allowed for early emergence. Historically, the area below Hells Canyon Dam did not support a significant amount of spawning and was a cold over-winter environment. The moderated temperatures associated with construction of the HCC warmed fall and winter conditions and allowed continuation of the Age-0 life history. The habitat upstream of the HCC today is too degraded to support fall Chinook salmon (Groves and Chandler 2005). The Hells Canyon Reach of the Snake River, especially upstream of the Salmon River is the closest habitat available today to that of the historic environment and should be maintained. This proposed SSC protects and supports the beneficial use and is more reflective of this large river environment and the life history of this fish.

7. SIGNATURE

For the reasons stated above, IPC respectfully submits this proposal to initiate the process to establish negotiated rulemaking for SSC for temperature as described in Section 2.1. herein.

IDAHO POWER COMPANY

Date: June 3, 2010

BY: ________________________________

Title: Director, Environmental Affairs

8. LITERATURE CITED

Beacham, T.D. and C.B. Murray. 1990. Temperature, egg size, and development of embryos and alevins of five species of pacific salmon: a comparative analysis. Transactions of the American Fisheries Society 119:927-945

Beacham, T.D. and R.E. Withler. 1991. Genetic variation in mortality of Chinook salmon, *Oncorhynchus tshawytscha* (Walbaum), challenged with high water temperatures. Aquaculture Fisheries Management 22:125-133.

Bell, M.C. 1986. Fisheries handbook of engineering requirements and biological criteria. U.S. Army Corps of Engineers, Office of the Chief of Engineers, Fish Passage Development and Evaluation Program, Portland, Oregon.

Bjornn, T. C., D. W., and Reiser. 1991. Habitat requirements of salmonids in streams. American Fisheries Society Special Publications 19:83-138.

Boles, G. L., S. M. Turek, C. D. Maxwell, and D. M. McGill. 1988. Water temperature effects on Chinook salmon (*Oncorhynchus tshawytscha*) with emphasis on the Sacramento River. California Department of Water Resources, Northern District. Sacramento, CA.

Chandler, J.A. 2007. White Paper: An evaluation of reintroduction of anadromous fish upstream of the Hells Canyon Complex. Idaho Power Company. Boise, Idaho.

Chandler, J. A., P. A. Groves, and P. Bates. 2001. Existing habitat conditions of the mainstem Snake River habitat formerly used by anadromous fish. In: J. A. Chandler, editor. Chapter 5. Feasibility of reintroduction of anadromous fish above or within the Hells Canyon Complex. Technical appendices for Hells Canyon Complex Hydroelectric Project. Idaho Power, Boise, ID. Technical Report E.3.1-2.

Combs, B. D., and R. E. Burrows. 1957. Threshold temperatures for the normal development of Chinook salmon eggs. Progressive Fish-Culturist 19:3-6.

Connor, W. P., H. L. Burge, J. R. Yearsley, and T. C. Bjornn. 2003. Influence of flow and temperature on survival of wild subyearling fall Chinook salmon in the Snake River. North American Journal of Fisheries Management 23:362–375.

Connor, W.P., H.L. Burge, R. Waitt, and T.C. Bjornn. 2002. Juvenile life history of wild fall chinook salmon in the Snake and Clearwater rivers. North American Journal of Fisheries Management 22:703-712.

Connor, W. P., A. P. Garcia, A. H. Connor, E. O. Garton, P. A. Groves, and J. A. Chandler. 2001. Estimating the carrying capacity of the Snake River for fall Chinook salmon redds. Northwest Science 75(4).

Dauble, D. D., and D. R. Geist. 2000. Comparison of mainstem spawning habitats for two populations of fall Chinook salmon in the Columbia River Basin. Regulated Rivers: Research and Management 16: 345–361.

Dauble, D. D., and D. G. Watson. 1990. Spawning and abundance of fall Chinook salmon (*Oncorhynchus tshawytscha*) in the Hanford Reach of the Columbia River, 1948–1988. Report from Pacific Northwest Laboratories Prepared for the U. S. Department of Energy, Contract DE-AC06-76RLO 1830.

Dauble, D. D., and D. G. Watson. 1997. Status of fall Chinook salmon populations in the mid-Columbia River 1948–1992. North American Journal of Fisheries Management 17: 283–300.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. Journal of the Fisheries Research Board of Canada 32:2295-2332.

Dombrowski, T. 2002. Idaho Department of Environmental Quality comments on Idaho Power Company Hells Canyon Complex draft application. In: Hells Canyon Hydroelectric Project Final License Application—Consultation Appendix. Idaho Power Company, Boise ID.

Geist, D.R., C. S. Abernathy, K.D. Hand, V.I. Cullinan, J.A. Chandler, and P.A. Groves. 2006. Survival, development, and growth of fall Chinook salmon embryos, alevin, and fry exposed to variable thermal and dissolved oxygen regimes. Transaction of the American Fisheries Society 135:1462-1477.

Groves, P.A., J.A. Chandler and T.J. Richter. 2008. Comparison of temperature data collected from artificial Chinook salmon redds and surface water in the Snake River. North American Journal of Fisheries Management 28:766-780.

Groves, P.A., J.A. Chandler and R. Myers. 2007. White Paper: The effects of the Hells Canyon Complex relative to water temperature and fall Chinook salmon. Idaho Power Company. Boise, Idaho.

Groves, P. A., and J. A. Chandler. 2001. The quality and availability of fall Chinook salmon spawning and incubation habitat downstream of the Hells Canyon Complex. Chapter three *In* P.A. Groves, editor. Evaluation of anadromous fish potential within the mainstem Snake River, downstream of the Hells Canyon Complex of reservoirs. Technical appendices for new license application: Hells Canyon Hydroelectric Project. Idaho Power, Boise, ID. Technical Report Appendix E.3.1-3.

Groves, P.A. and J.A. Chandler. 2005. Habitat quality of historic Snake River fall Chinook salmon spawning locations and implications for incubation survival. Part 2: Intra-gravel water quality. Rivers and Research Applications 21:469-484.

Healey, M. C. 1991. Life history of Chinook salmon *(Oncorhynchus tshawytsch*a). In: C. Groot and L. Margolis, editors. Pacific salmon life histories. University of British Columbia, Vancouver, B.C. Pages 313–393.

Huntington, C. S., W. Nehlsen, and J. Bowers. 1996. A survey of healthy native stocks of anadromous salmonids in the Pacific Northwest and California. Fisheries 21(3):6-14.

Idaho Department of Environmental Quality (IDEQ) and Oregon Department of Environmental Quality (ODEQ). 2004. Snake River-Hells Canyon total maximum daily load (TMDL). IDEQ, Boise Regional Office, Boise, ID, and ODEQ, Pendleton Office, Pendleton, OR. 710 p. plus appendices.

Idaho Power Company (IPC). 2002. Letter dated December 3, 2002 to U.S. Environmental Protection Agency regarding the draft EPA Region 10 guidance for state and tribal temperature water quality standards. Idaho Power Company, Boise, ID. 3 p.

Jensen, J.O.T., W.E. McLean, T. Sweeten, W. Damon, and C. Berg. 2006. Puntledge River high temperature study: influence of high water temperatures on adult Chinook salmon (*Oncorhynchus tshawytscha*) in 2004 and 2005. Canadian Technical Report of Fisheries and Aquatic Sciences 2662.

Lohn, D. R. June 12, 2003. Declaration of National Oceanic and Atmospheric Association Fisheries to Case No. CV01-00640-RE. Seattle, WA.

McCullough, D. A., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Summary of technical literature examining the physiological effects of temperature on salmonids. Issue paper 5. EPA Region 10 Temperature Water Quality criteria guidance development project. EPA-910-D-01-005.United States Environmental Protection Agency. Seattle, WA.

Northcote, T. G. and G. L. Ennis. 1994. Mountain whitefish biology and habitat use in relation to compensation and improvement possibilities. Reviews in Fisheries Science 2:347–371.

Oregon Department of Environmental Quality (ODEQ). 2008. Temperature water quality standard implementation. A DEQ internal management directive. Oregon Department of Environmental Quality. Available at http://www.deq.state.or.us/wq/pubs/imds/ Temperature.pdf.

Olson, P.A., R.E. Nakatani and T. Meekin. 1970. Effects of thermal increments on eggs and young of Columbia River fall Chinook. Battelle Memorial Institute, Pacific Northwest Laboratories. BNWL - 1538, UC 48. Richland, Washington.

Olson, P. A., and R. E. Nakatani. 1968. Effect of elevated temperatures on mortality and growth of young Chinook salmon. Battelle Memorial Pacific Northwest National Laboratories, Richland, WA.

Olson, P. A., and R. F. Foster. 1955. Temperature tolerance of eggs and young of Columbia River Chinook salmon. Transactions of the American Fisheries Society 85:203-207.

Raleigh, R. F., W. J. Miller, and P. C. Nelson. 1986. Habitat suitability index models and instream flow suitability curves: Chinook salmon. U.S. Fish and Wildlife Service. Biological report 82 (10.122).

Smith, S. G., W. D. Muir, E. E. Hockersmith, R. W. Zabel, R. J. Graves, C. V. Ross, W. P. Connor, and B. D. Arnsberg. 2003. Influence of river conditions on survival and travel time of Snake River sub-yearling fall Chinook salmon. North American Journal of Fisheries Management 23:939–961.

U.S. Environmental Protection Agency (USEPA). 2003. EPA Region 10 guidance for Pacific Northwest state and tribal temperature water quality standards. EPA 910-B-03-002. USEPA, Region X, Office of Water, Seattle, WA. 49 p. plus attachments.

Van der Naald, W., B. Spellman, and R. Clark. 2000. Evaluation of fall Chinook and chum salmon spawning below Bonneville, the Dalles, John Day, and McNary Dams: Annual Report 2001–2002. Prepared by Oregon Department of Fish and Wildlife for Bonneville Power Administration, Portland, OR. Contract 99BI15006/99BI15007, Project 99-003-01/99-003-02.

Weatherley, A. H., and H. S. Gill. 1995. Growth. Pages 101–158 *in* C. Groot, L. Margolis, and W. C. Clarke, editors. Physiological ecology of Pacific salmon. University of British Columbia Press, Vancouver, British Columbia, Canada.

Zimmer, P.D. 1950. A three year study of fall Chinook salmon spawning areas in Snake River above Hells Canyon Dam site. Report of Fish and Wildlife Service, Region 1. Portland, Oregon.

This page left blank intentionally.

Appendix 1. Groves, P.A., J.A. Chandler, and R.Myers. 2007. White Paper: The effects of the Hells Canyon Complex relative to water temperature and fall chinook salmon. Idaho Power Company. Boise, Idaho.

Appendix 2. McCullough, D. 2007. Review of Groves, Chandler, and Myers (2007)", Columbia River Inter-Tribal Fish Commission. Portland. Oregon.

Appendix 3. Idaho Power Company. 2007. IPC's Evaluation of the Nez Perce Tribe's/CRITFC's Review of the Temperature White Paper.