2015-16 Hanford Reach Fall Chinook Protection Program Report for the 2015 – 2016 Protection Season

Prepared for:

Priest Rapids Coordinating Committee
Hanford Reach Working Group
and
Signatories to the Hanford Reach Fall Chinook Protection Program Agreement

To fulfill the requirements of:
Section 401(a)(5) of the Public Utility District No. 2 of Grant County, Washington's FERC Operating License
Section 6.2(1) of Public Utility District No. 2 of Grant County, Washington Water Quality Certification
Section C.6(c) of the Hanford Reach Fall Chinook Protection Program Agreement

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Executive Summary

This report details the annual implementation of the Hanford Reach Fall Chinook Flow Protection Program Agreement (HRFCPPA). The HRFCPPA establishes the obligations of the signatories to the protection of fall Chinook in the Hanford Reach by managing discharge into the Hanford Reach.

The 2015-2016 flow protection program began on October 15, 2015 with the implementation of the reverse load factoring. On October 18, October 25, and November 22, 2015 spawning ground surveys were conducted on Vernita Bar. The peak count of 702 redds was the highest number of redds counted since surveys began in 1988. The elevational distribution of the redds established the protection level flow for the 2015-2016 season at 70 kcfs. During the entirety of 2015-2016 Post-Hatch and Emergence Periods discharge from Priest Rapids Dam was maintained above 70 kcfs. On December 7, 2015 the USGS gage downstream of Priest Rapids Dam recorded one 15-minute discharge reading at 50.2 kcfs. We believe this was an erroneous data recording at the gage.

River temperatures in the Hanford Reach were considerably warmer than the long-term mean during most of the protection period, particularly the spring rearing period. Spawn timing was similar to previous years, but the warmer water temperatures from March through May resulted in the Emergence and Rearing periods beginning earlier than the long-term means and the earliest end date (May 30, 2016) for the Rearing Period since the program began. Project operational constraints intended to reduce mortality during the Emergence and Rearing periods were in effect for 96 days in 2016 (February 25-May 30). During the 96 days of the 2016 Emergence and Rearing periods, Grant PUD met all of the flow fluctuation constraints established with the HRFCPPA.

The 2016 weekend-minimum discharge constraints began on the weekend of April 9 and continued through the weekend of April 30. On three of the four the CJAD II weekends the minimum constraint was met. On April 24 (the third Sunday of the CJAD II protections) discharge from Priest Rapids Dam dropped 4 kcfs below the minimum flow constraint of 173.3 kcfs for approximately 5 hours.

Flow management operations during the 2015-2016 season were highly successful. While the minimum flow requirement during one CJAD II weekend was exceeded by a small amount, all remaining discharge constraints were met during the Spawning, Pre-Hatch, and Emergence periods. This continues the trend of high performance that began with the 2006 brood year and is significantly greater than the historical mean under the HRFCPPA.

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1.0 Background

The dams located above the Hanford Reach of the Columbia River have the potential to influence the fall Chinook salmon population that spawn in the Hanford Reach. The main mechanisms that could influence the fall Chinook salmon in the Hanford Reach are management of flows associated with hydropower production. Priest Rapids Dam, at the head of the Hanford Reach, is part of the seven dam hydroelectric complex on the mid-Columbia River that includes Wanapum, Rock Island, Rocky Reach, Wells, Chief Joseph, and Grand Coulee dams. This seven dam complex is operated under a load following strategy to meet electrical demand in the Pacific Northwest. Hydropower generation through these projects largely governs stream flow in the Hanford Reach. The mid-Columbia projects are part of the larger Columbia River hydropower system and are operated under the terms of an international treaty and other agreements that affect river flows and natural resources. These include the Columbia River Treaty between the United States and Canada, the Pacific Northwest Coordination Agreement, Mid-Columbia Hourly Coordination Agreement (HCA), and the Hanford Reach Fall Chinook Protection Program Agreement (HRFCPPA). The HRFCPPA contains constraints on dam operations designed to provide protections for fall Chinook salmon (*Oncorhynchus tshawytscha*) that spawn and rear in the Hanford Reach of the Columbia River. This report describes the implementation of the HRFCPPA for the 2015-2016 season.

The Hanford Reach is located on the Columbia River in southeast Washington State. The Reach extends from Priest Rapids Dam at river kilometer (Rkm) 639 (and below the Priest Rapids Project Boundary) downstream for 82 kilometers to the head of McNary Pool (Rkm 557) near Richland, Washington (Figure 1). On June 9, 2000, Presidential Proclamation 7319 established the 78,900 hectare (195,000 acre) Hanford Reach National Monument, which includes the Columbia River. The monument boundary is about 3 miles downstream of Priest Rapids Dam. This designation continues the protection of the Hanford Site and Reach that began during World War II when the Hanford Nuclear Reservation was established for the production of nuclear weapons. The U.S. Fish and Wildlife Service (USFWS) co-manages the Monument under existing agreements with the Department of Energy.

The Hanford Reach is the most productive mainstem spawning area for fall Chinook salmon in the entire Columbia River basin and supports the largest spawning population of fall Chinook salmon in the Pacific Northwest (Huntington et al. 1996; Dauble and Watson 1997; Harnish et al. 2012). This productivity is particularly significant considering nearly all of the formerly large, naturally spawning anadromous fish populations of the Columbia River Basin have drastically declined.

Priest Rapids Dam (PRD) at the head of the Hanford Reach is part of the seven dam hydroelectric complex on the mid-Columbia River that also includes Wanapum, Rock Island, Rocky Reach, Wells, Chief Joseph, and Grand Coulee dams (Figure 1). This seven dam complex is operated under a power-peaking or load-following mode to meet electrical demand in the Pacific Northwest. Hydropower generation through these projects largely governs discharge in the Hanford Reach. The mid-Columbia projects are part of the larger Columbia River hydropower system and are operated under the terms of an international treaty and other agreements that affect river flows and fish resources. These include the Columbia River Treaty between the United States and Canada, the Pacific Northwest Coordination Agreement, Mid-Columbia Hourly Coordination Agreement (HCA), and the HRFCPPA.

Before the construction of major dams and water storage projects, Columbia River discharge at PRD was lowest during the winter (Niehus et al. 2012). Snowmelt increased flows in the spring and early summer and peak flows normally occurred in June. Discharge then decreased through the fall and into the winter. Little daily or hourly fluctuation in discharge occurred under pre-dam conditions. Completion of the Columbia River hydropower and flood control system has altered the annual hydrograph by reducing peak spring flows, increasing average minimum flows, and shifting the period of lowest flow from winter to autumn (Niehus et al. 2012).

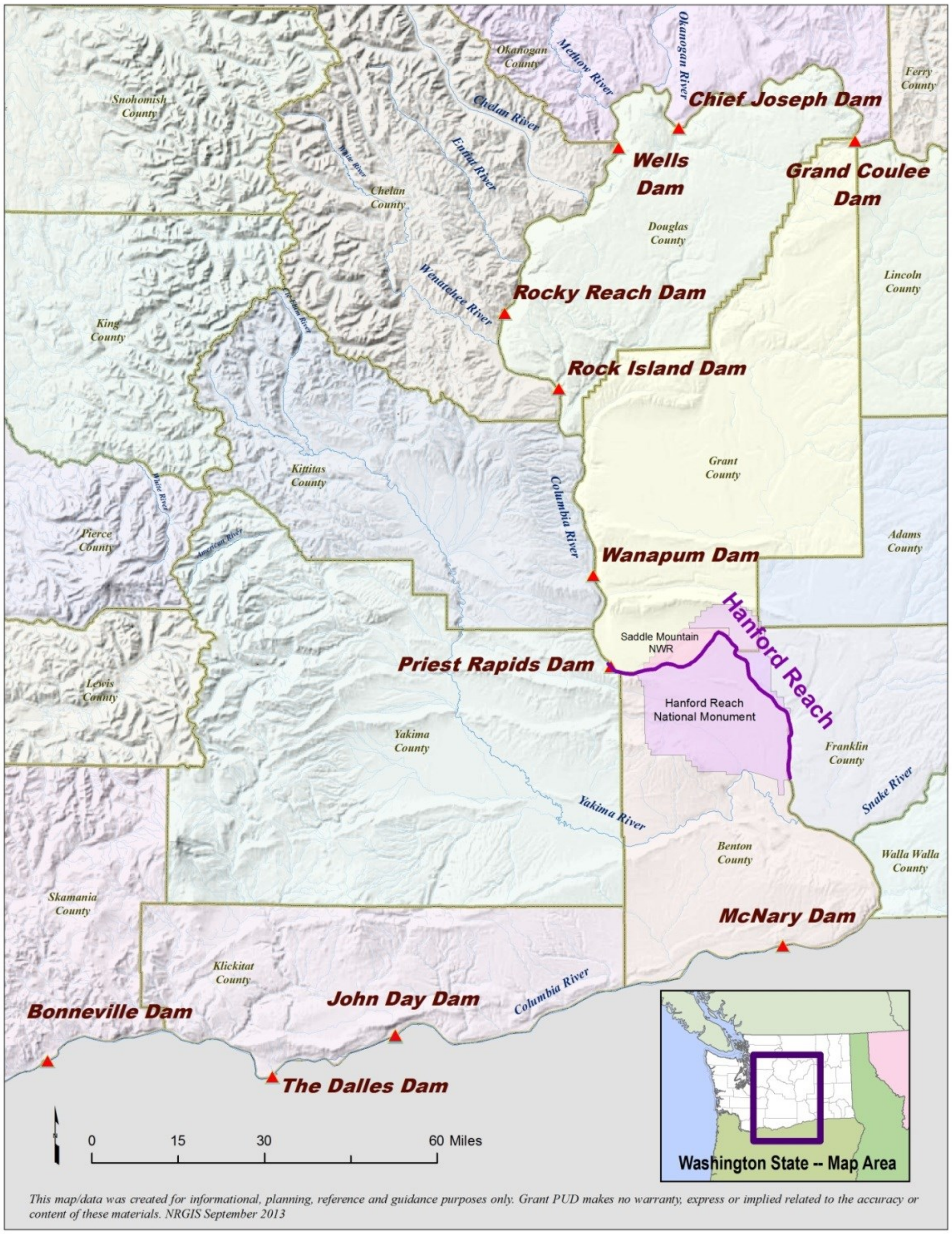

Figure 1 **Major dams in the United States portion of the Columbia River. The Hanford Reach of the Columbia River extends from the Priest Rapids Dam downstream through the Hanford Reach National Monument.**

Operation of the mid-Columbia River projects to meet power demand (load following) results in large hourly and daily fluctuations in discharge, which can lead to dewatering of redds and stranding or entrapment of juvenile fall Chinook salmon in the Hanford Reach. Fall Chinook salmon generally spawn in November and prior to implementation of the Vernita Bar Settlement Agreement (VBSA) and subsequently the HRFCPPA, load-following operations during the fall and winter seasons resulted in variable and sporadic fluctuating flows. Some salmon redds can be dewatered and cause mortality of incubating eggs and alevins as discharge decreases when electrical demand is low (e.g., nights and weekends). Repeated observations of dewatered redds motivated efforts to develop an operating agreement to reduce the impacts of flow fluctuations on fall Chinook salmon spawning and egg incubation. In 1988, the VBSA was signed by the power-producing entities, fishery agencies (with the exception of the USFWS), and Native American tribes. The VBSA was the first major formal operation to "protect" fall Chinook salmon that spawn in the Hanford Reach.

2.0 Hanford Reach Fall Chinook Protection Program

The Vernita Bar Settlement Agreement was approved by Federal Energy Regulatory Commission (FERC) Order issued December 9, 1988 and established obligations and procedures for the protection of fall Chinook salmon at Vernita Bar. The primary objective was to minimize fall Chinook salmon spawning above the water elevation occurring at a flow of 1,982 m^3/sec (70 kcfs) at Vernita Bar, which is the first major spawning area downstream of PRD (Figure 2). Discharge is manipulated by using the Mid-Columbia Hourly Coordination Agreement and reverse load factoring (RLF) at the Priest Rapids Project. The intent of reverse load factoring is to limit Chinook salmon spawning (which was thought to occur mainly during daylight hours) to lower elevations on Vernita Bar by reversing the normal load following pattern and providing low flows during the day and higher flows at night.

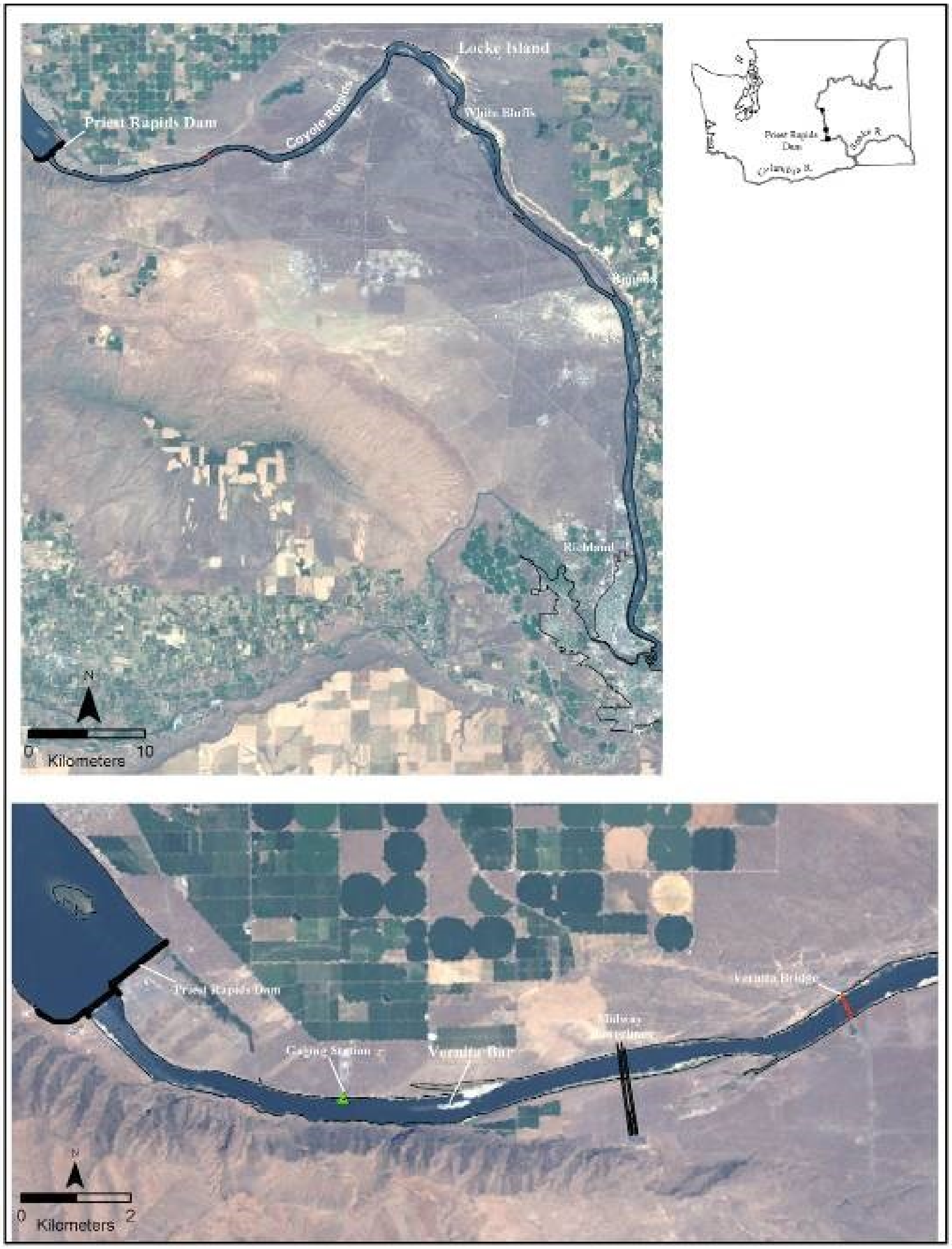

Figure 2 Vicinity of Priest Rapids Dam and Vernita Bar of the Columbia River.

The VBSA provided protection for incubating fall Chinook salmon in the Hanford Reach by maintaining sufficient discharge from PRD to prevent desiccation of eggs and hatching fry, but it did not provide protection for or enhance survival of emergent and rearing fry. In 1998, WDFW and the joint fishery managers recommended that operations at PRD create no fluctuations and/or steadily increase flows on the Hanford Reach of the Columbia River throughout the juvenile fall Chinook salmon emergence and rearing period. This recommendation was provided to the power managers, but analyses indicated that stable flows and ramping-rate constraints were not feasible. An interim protection program was proposed to meet the following criteria: 1) substantially more protection for juvenile fall Chinook salmon fry than occurred pre-1998, 2) preservation of some opportunity for load-following/power peaking operations, 3) allow system-coordinated river operations, 4) provide ability to monitor and evaluate in-season and adaptively manage operations to reduce stranding and entrapment. This led to development of the Interim Hanford Fall Chinook Protection Plan (IHFCPP) in 1999, which was implemented on a trial basis in an attempt to safeguard rearing juvenile fall Chinook salmon in the Hanford Reach. The IHFCPP set operational constraints on flow fluctuations in the Hanford Reach during the fall Chinook salmon Emergence and Rearing periods. Managing flow fluctuations in the Hanford Reach required the coordination of the seven dams upstream from Priest Rapids to Grand Coulee. From 1999 to 2003 the Hanford Reach Stranding Policy Group met annually to develop and refine an interim plan to protect emergent and rearing juvenile fall Chinook salmon in the Hanford Reach.

Refinements to the IHFCPP led to development and implementation of the Hanford Reach Fall Chinook Protection Program Agreement (HRFCPPA; Appendix A). The HRFCPPA contains provisions for measures that meet or exceed all protection measures covered under the original VBSA and additional provisions to improve survival of juvenile fall Chinook salmon after emergence. Parties to the Agreement include Grant PUD, Public Utility District No. 1 of Chelan County (Chelan PUD), Public Utility District No. 1 of Douglas County (Douglas PUD), Bonneville Power Association (BPA), NOAA Fisheries, WDFW, USFWS, Confederated Tribes and Bands of the Yakama Nation, and the Confederated Tribes of the Colville Indian Reservation.

Section C.6(c) of the HRFCPPA requires annual reporting of activities related to the HRFCCPA including 1) Vernita Bar redd counts, 2) dates on which the Hatching, Emergence, and End of Emergence and End of Rearing Periods occur, 3) a record of Columbia River flows through the Hanford Reach based on Priest Rapids discharges, and 4) a description of the actual flow regimes from Initiation of Spawning through the Rearing Period based on the availability of data. This requirement was incorporated in the Grant PUD's FERC license under section 401(a)(5) and Water Quality Certification under section 6.2(1). The following report is intended to meet these reporting requirements.

3.0 Biological Monitoring of Hanford Reach Fall Chinook

Grant PUD produces and releases 5.6 million subyearling fall Chinook salmon smolts from Priest Rapids Hatchery (PRH) as part of its mitigation for the construction and operation of Priest Rapids and Wanapum dams. The Washington Department of Fish & Wildlife operates PRH which is owned, maintained, and funded in by the Grant PUD. In addition to the production and release of subyearling fall Chinook into the Hanford Reach, Grant PUD funds a hatchery monitoring and evaluation program (M&E program). The M&E program associated with PRH is intended to evaluate the performance of the program in meeting hatchery and natural production goals. A cooperative effort between Grant PUD, Douglas PUD, Chelan County PUD, and WDFW has resulted in an updated Monitoring and Evaluation Plan for PUD Hatchery Programs (Hillman et al. 2013). This document provides guiding principles and approaches for the monitoring and evaluation (M&E) of PRH. Objectives, hypotheses, measured and derived variables, and field methods that will be used to collect data are listed in this document.

The PRH M&E program produces an annual report that reports on both monitoring within the hatchery as well as monitoring of the fall Chinook population in the Hanford Reach. Readers interested in either the PRH or biological monitoring of the fall Chinook population in the Hanford Reach should refer to the most recent PRH M&E program annual report. For reference, the primary contents of the 2015-2016 PRH Annual Report is provided below.

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4.0 2015-2016 Monitoring and Operations under the HRFCPPA

4.1 Vernita Bar Surveys

The Hanford Reach Fall Chinook Protection Program establishes a Monitoring Team[1] to determine the Initiation of Spawning, End of Spawning, and Critical Elevation. The Critical Elevation is the elevation on Vernita Bar (Figure 2) at which Protection Level Flows must be maintained during the Post Hatch and Emergence Periods. The Critical Elevation is determined annually as follows:

(a) The Monitoring Team will survey redds on Vernita Bar in the specified area (Exhibit A) for the purpose of determining the Initiation of Spawning, the location of redds, and the extent of spawning. The Monitoring Team will also provide a concurrent aerial survey of the Hanford Reach on the same weekend(s). The aerial survey(s) will be utilized to determine if Initiation of Spawning in areas of the Hanford Reach below the 36 kcfs level and/or outside the area specified

[1] Monitoring Team - a group of three individuals composed of one fishery biologist designated by each of the following: (1) Grant PUD; (2) Washington Department of Fish and Wildlife; and (3) a signatory fishery agency or tribe.

occurs prior to Initiation of Spawning set on Vernita Bar. Once an Initiation of Spawning date has been determined, based upon the presence of 5 or more redds in an individual survey, the aerial surveys maybe discontinued for that year. The surveys will be conducted on weekends beginning on the weekend prior to October 15 of each year.

(b) The Monitoring Team will perform a final redd survey the weekend prior to Thanksgiving to determine the Critical Elevation. The Monitoring Team may also make a supplemental redd survey the weekend after Thanksgiving to determine if additional redds are present above the 50 kcfs elevation. A preliminary estimate of the Critical Elevation will be made following the final redd survey and will be confirmed or adjusted based on the supplemental survey. The Critical Elevation will be set as follows: (Elevations must be in 5 kcfs increments beginning at the 40 kcfs elevation.)

> If 31 or more redds are located above the 65 kcfs elevation, the Critical Elevation will be the 70 kcfs elevation.
>
> If there are 15 to 30 redds above the 65 kcfs elevation, the Critical Elevation will be the 65 kcfs elevation.
>
> If there are fewer than 15 redds above the 65 kcfs elevation, then the Critical Elevation will be the first 5 kcfs elevation above the elevation containing the 16th highest redd within the survey area on Vernita Bar.

(c) Additional activities of the Monitoring Team will include calculation of temperature units, determination of the dates of Initiation of Spawning, Hatching, Emergence, the end of the Emergence Period, and the end of the Rearing Period. The Monitoring Team may also make non-binding recommendations to any of the Parties to this Agreement, including non-binding recommendations to protect redds above the Critical Elevation or to address special circumstances.

Under the Vernita Bar Settlement Agreement, redd counts were limited to areas on Vernita Bar that could be surveyed from the ground. The HRFCCPA expanded the survey area for establishing the Initiation of Spawning and could include aerial surveys of the mainstem river adjacent to Vernita Bar. The Hanford Reach Working Group (HRWG) adopted SOA_2007_HR04, "Protocol for the setting the Initiation of Spawning" on August 17, 2007 (Appendix B). This Agreement stipulates that aerial or ground survey(s) may be utilized to set the Initiation of Spawning. If the presence of 5 or more redds is observed in an individual survey within Exhibit A by either ground surveys or aerial surveys, the Initiation of Spawning shall be established as the Wednesday immediately prior to that survey. The HRWG agreed that Exhibit A shall be understood to include those shoreline spawning areas both upstream and downstream of Vernita Bar, including both Vernita Bar and Columbia River shorelines, within the geographic area shown approximately in Exhibit A of the HRFCPPA.

In accordance with the HRFCPPA, the first spawning ground survey for redds on Vernita Bar was to be conducted the Sunday prior to October 15th. A modification was proposed to (SOA_2010_HR01; Appendix B) and approved by the HRWG, which moved the start date to the first Sunday after October 15. In 2015, redd surveys on Vernita Bar were conducted on October 18th, October 25th, and November 22nd (Table 1). One redd was observed on the first survey (October 18th). One week later, on October 25th, a total of 67 redds were observed with 16 counted above the 50 kcfs elevation. In accordance with the HRFCPP, the Initiation of Spawning date was set as October 21st for the both above and below the 50 kcfs elevation zone. The third and final survey was conducted on November 22nd. A total of 68 redds were counted at or above the 65 kcfs elevation zone, setting the Critical Elevation for the 2015 – 2016 season at 70 kcfs. The Monitoring Team consisted of Paul Hoffarth (WDFW)and Peter Graf (GCPUD). During the November 22nd survey, flows from Priest Rapids Dam at Vernita Bar were approximately 51 kcfs. During the November 22nd survey, the Monitoring Team agreed that the fish spawning season had ended and that November 22nd be identified as the End of Spawning date. Therefore, a follow-up supplemental ground redd count was not required.

Table 1 Summary of redd counts from ground surveys, 2015.

Date	Redd Count by Flow Level (kcfs)						Total
	36–50	50 – 55	55 – 60	60 – 65	65 – 70	Above 70	
18-Oct	1	0	0	0	0	0	1
25-Oct	51	12	3	1	0	0	67
22-Nov	---	265	213	156	36	32	702
Peak	51	265	213	156	36	32	702

Final ground redd counts are generally conducted to confirm the Critical Elevation, so they are frequently not conducted in the 36-50 kcfs zone. A total of 702 redds were counted above 50 kcfs elevation on Vernita Bar during the final ground survey, which was well above the mean observed under the VBSA and HRFCPPA (i.e., 180; Figure 3), and the highest on record since 1988.

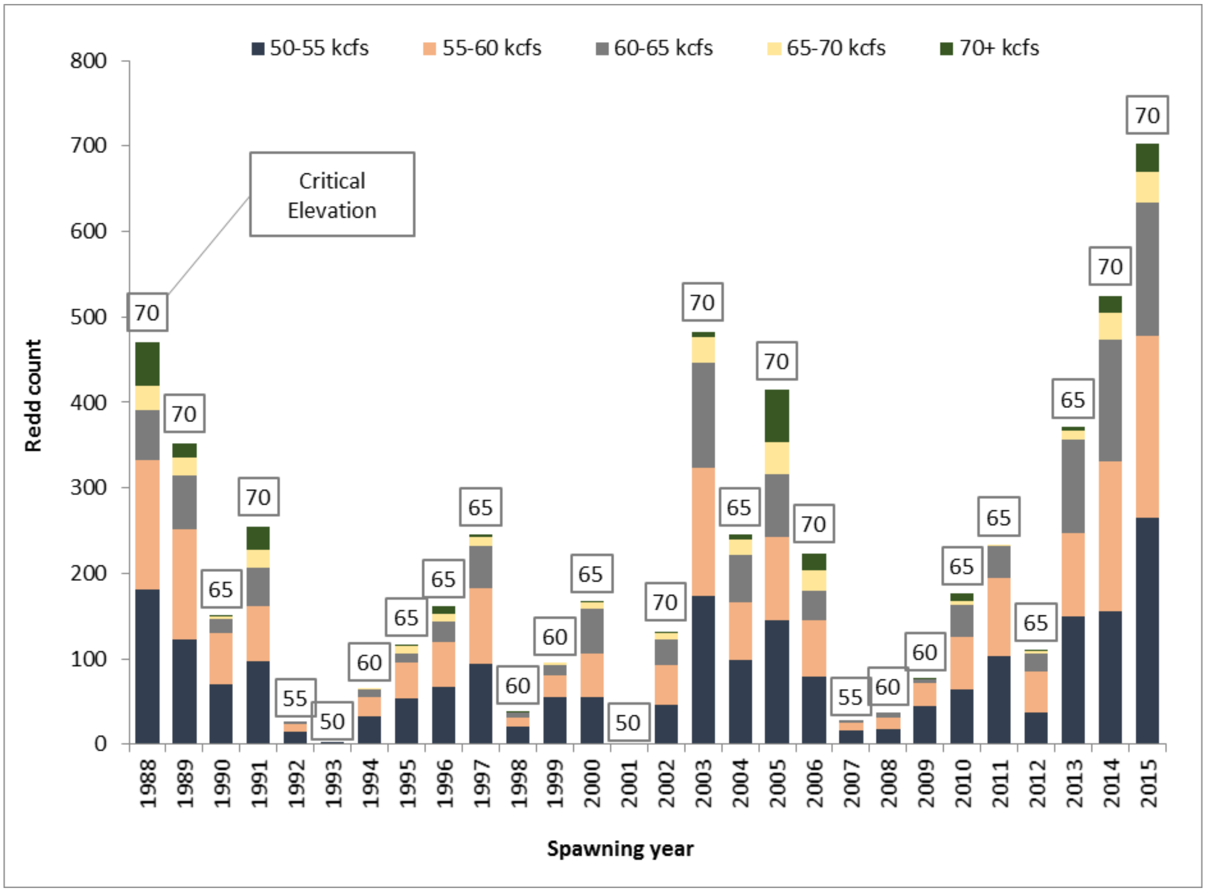

Figure 3 Final redd abundance and distribution from ground surveys on Vernita Bar, 1988-2015. Final redd counts are not consistently conducted in the 36-50 kcfs zone and are not included in this figure. The Critical Elevation for each year is listed above the bars.

Since 1988, the abundance and distribution of redds within the ground survey area on Vernita Bar has been highly variable (Figure 3 and Appendix E). Redd abundance on Vernita Bar is positively correlated with Hanford Reach adult escapement (Figure 4). The 2013 - 2015 adult returns provided a unique opportunity to observe redd construction and site selection at unprecedented levels of escapement (Figure 4). Escapements of this size provided an opportunity to potentially identify the spatial capacity of redd construction within the survey area at Vernita Bar. For example, in 2013 the redd per escapement was well below the 23-year redd per escapement line of best fit. Large negative residuals at high levels of escapement could indicate that the carrying capacity of redd construction on Vernita Bar is being met. However, the age-3 component of the 2013 return was disproportionately large, 85% of which was male. This demographic composition of the 2013 return may explain the relatively low number of redds per escapement. For example, in 2014 the adult return was nearly equal to the return in 2013, but consisted of a higher number of age-4 adults and a more balanced ratio of males to females. Accordingly, the redd per escapement relationship fell closer to the 23-year line of best fit, suggesting less influence from spatial density dependence on Vernita Bar. Additional years with high escapement to the Hanford Reach will help clarify this relationship.

Redd abundance and the elevational distribution of redds is positively correlated with escapement, particularly at the lower elevational bands (Figure 5). The relatively flat-sloped relationship between redd counts and escapement at the 65-70 kcfs and 70+ kcfs elevational bands suggest that reverse load factoring has been effective at limiting redd construction above the 65k elevation, even at the highest escapements (Figure 5).

The annual Critical Elevation, which is set by the elevational distribution of redds on Vernita Bar, is positively correlated with both escapement and discharge during peak spawning (Figure 6).

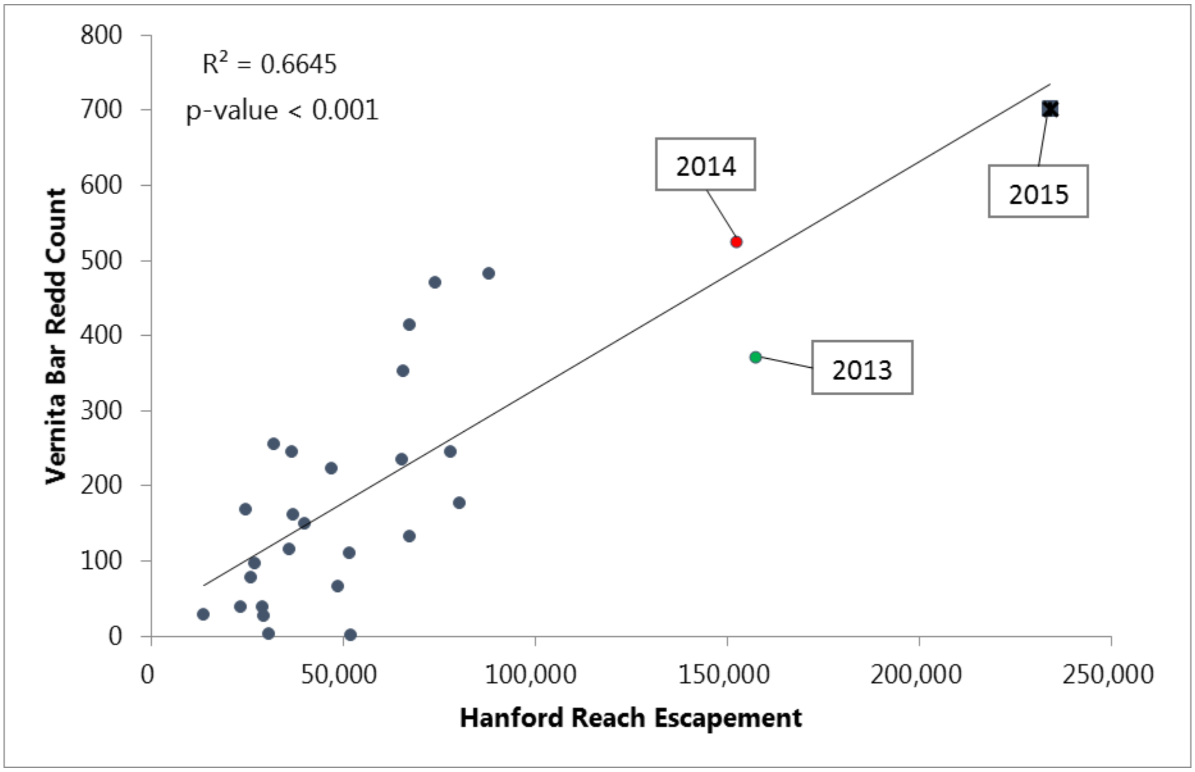

Figure 4 **Relationship between Hanford Reach adult escapement and redds above the 50 kcfs elevation observed during the Vernita Bar spawning surveys (1988-2015).**

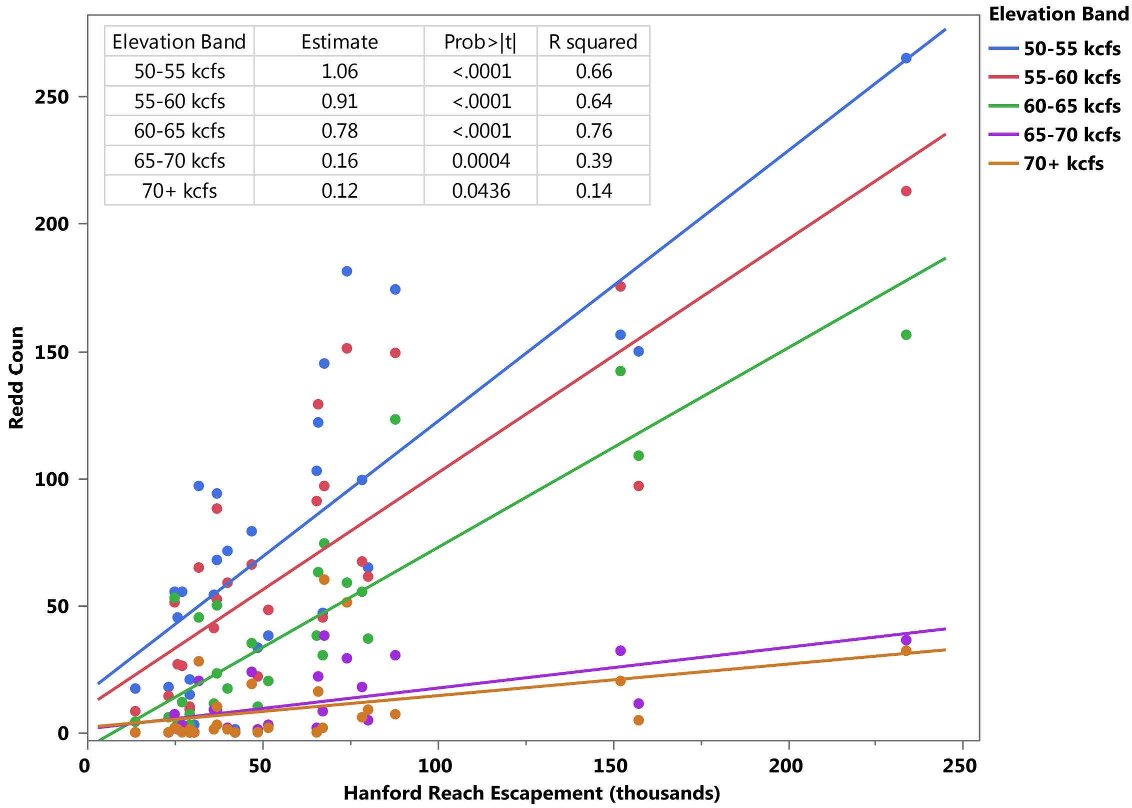

Figure 5 **Relationship between Hanford Reach escapement and redd counts on Vernita Bar by kcfs elevation bands.**

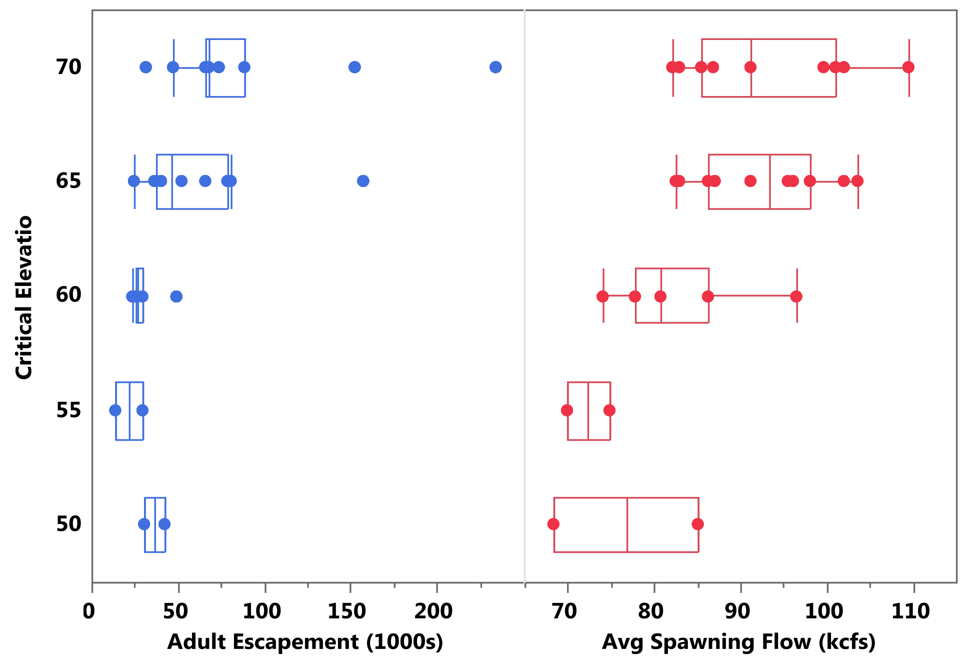

Figure 6 Relationship between Hanford Reach adult escapement and the Critical Elevation (left) and Priest Rapids Dam average discharge during peak spawning and Critical Elevation (right) (1988-2015).

4.1.1 Protections for Emergent and Rearing Fall Chinook salmon

During the Emergence and Rearing periods, the HRFCCPA establishes criteria for determining the acceptable magnitude of daily fluctuations in discharge from Priest Rapids Dam (i.e., discharge delta or minimum discharge; Table 2). Variability in power demand, water withdrawal (irrigation and urban), and weather events prevent precise prediction of daily average discharge at Priest Rapids Dam. Therefore, flow constraints are based on prior daily inflow[2] to Wanapum Dam or BPA forecasted weekend flows for Chief Joseph Dam, including side flows (i.e. tributary inflows). Criteria in the HRFCPPA requires that protections for emergent fry begin at the estimated start of emergence and continue until 400 accumulated temperature units (°C; ATU) from the end of emergence.

[2] "Previous Day's Average Weekday Wanapum Inflow" – the total volume of water discharged into the Wanapum project area measured as a daily average discharge from Rock Island Dam. This measure is used from Monday to Friday to determine the allowable flow fluctuation during the Rearing Period and will be calculated based on data reported on the Corps of Engineers website [http://nwd-wc.usace.army.mil/report/projdata.htm].

Table 2 Daily operational constraints established for the Hanford Reach Fall Chinook Protection Program.

Wanapum Weekday Inflow or Chief Joseph Weekend Forecast (kcfs)	Discharge Constraint [A]
36 - 80	Delta < 20 kcfs
80 - 110	Delta < 30 kcfs
110 - 140	Delta < 40 kcfs
140 - 170	Delta < 60 kcfs
> 170	Minimum Discharge > 150 kcfs

[A] Discharge Delta (max-min) and minimums are calculated during the 24-hour period from hour ending 1:00 AM to midnight.

In addition to PRD daily delta constraints, additional minimum flow constraints apply during a portion of the Rearing Period. On four consecutive weekends, after 800 ATU from the end of the Spawning Period, Priest Rapids outflow will be maintained to at least a minimum flow calculated as the average of the daily hourly minimum flow from Monday through Thursday of the current week. Detailed discharge, water temperature, and performance data related to the HRFCPPA can be found in the monthly summary files on the GCPUD website (http://grantpud.org/environment/water-quality/monitoring-data).

4.2 Implementation Timing and Operations

Embryonic development and growth of fall Chinook salmon is highly dependent on water temperature. Accumulated temperature units can be used to predict the rate of development (i.e., hatching and emergence timing) of fall Chinook salmon in the Hanford Reach. Fall Chinook salmon reach eyed stage at approximately 250 ATU after spawning, hatch at approximately 500 ATU, and emerge at approximately 1,000 ATU. The VBSA used these ATU milestones to determine when Emergence Period protections would end. In addition to emergence timing, ATUs can be used to predict susceptibility of fall Chinook salmon to stranding and entrapment. The HRFCPPA extended the ATU milestones beyond emergence to include protections during the Rearing Period. Based on data from the eight years of evaluation and monitoring, juvenile fall Chinook salmon susceptibility to stranding and entrapment appears to decrease substantially by 1400 ATU after the end of spawning (Hoffarth 2006).

Under the Interim Hanford Fall Chinook Protection Plan, Rearing Period protections would begin when more than 50 fall Chinook salmon fry were collected by beach seine from six designated shoreline locations in the Hanford Reach. This proved to be an unreliable and unpredictable indicator for the start of protections because hourly changes in discharge from Priest Rapids Dam can greatly alter the abundance and location of fall Chinook salmon fry in near-shore areas of the Hanford Reach. Monitoring ATU to estimate emergence timing proved to be reliable and accurate. Fall Chinook salmon fry were captured prior to the estimated start of emergence during more than five years of monitoring, but abundance was relatively low at roughly one percent of the total production (range 0-2.0%) (Hoffarth 2003; Hoffarth et al. 2012). In addition to reliability and accuracy, the ATU milestones in the HRFCPPA provide predictable dates that can be used to coordinate activities between agencies and hydroelectric projects.

For brood year 2015 river temperatures in the Hanford Reach were considerably warmer than the long-term mean (1988-present) during most of the protection period, particularly the spring rearing period (Figure 7). Spawn timing was similar to previous years, but the warmer water temperatures from March through May resulted in the Emergence and Rearing periods beginning earlier than the long-term means and the earliest end date (5/30/2016) for the Rearing Period since the program began (Figure 8 and Appendix F). Project operational constraints intended to reduce mortality during the Emergence and Rearing periods were in effect for 96 days in 2016 (February 25-May 30). Project operational constraints established by the IHFCPP and HRFCPPA to reduce mortality during the Emergence and Rearing periods have been in effect for a period of 71 to 114 days annually since the inception of the IHFCPP in 1999.

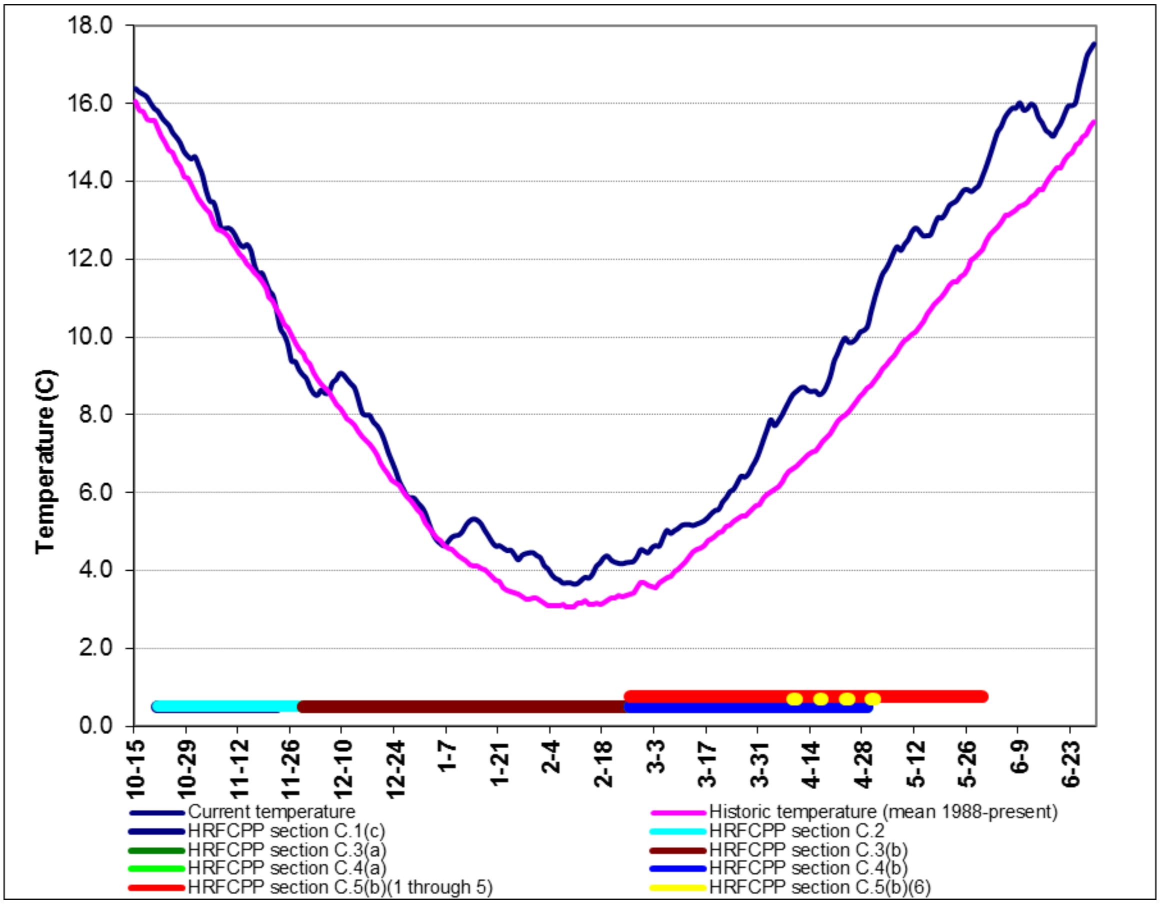

Figure 7 Mean daily river temperatures on the Hanford Reach of the Columbia River and estimated timing of fall Chinook salmon protections based on accumulated temperature units (ATU), 2015-16.

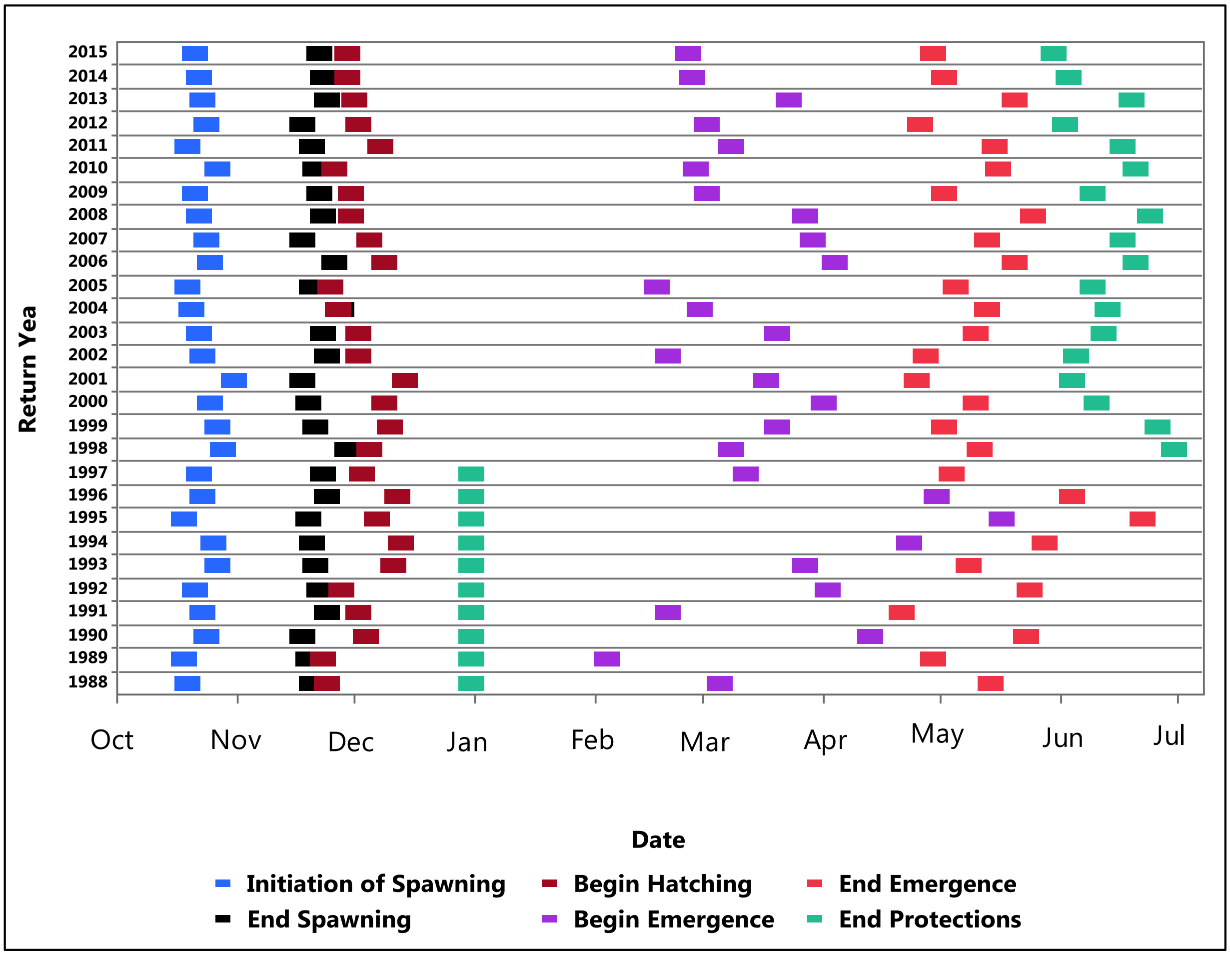

Figure 8 **Timing and duration of protection periods under the Vernita Bar Settlement Agreement and the HRFCPPA, 1988-2015 return year.**

5.0 Discharge and Daily Fluctuations in the Hanford Reach

Total discharge and discharge fluctuations influence rearing conditions throughout the Hanford Reach. A 17 kcfs change in discharge equates to a vertical change in river elevation of approximately 0.3 m (1.0 ft) at Priest Rapids Dam. Discharge from Priest Rapids Dam during the 2016 HRFCPPA Emergence and Rearing periods was similar to the 10-year mean, with the exception of mid-April which saw higher than average flows (Figure 9). As defined in the HRFCPPA, the Outflow Delta (aka, daily delta or flow fluctuation) is the difference between minimum Priest Rapids Outflow and maximum Priest Rapids Outflow over a 24 hr period beginning at 0001 hrs and extending to 2400 hrs. The mean Outflow Delta from PRD during the 2016 Emergence and Rearing periods was 31.9 kcfs, which was lower than the overall mean under the HRFCPPA (37.2 kcfs) (Appendix G). Daily fluctuations, as a percentage of mean daily discharge, were slightly less than the mean from previous years with Rearing Period protections (22.0 vs. 26.9%). Overall, the magnitude of daily discharge fluctuations have decreased and the relative frequency of smaller fluctuations has increased (Figure 10).

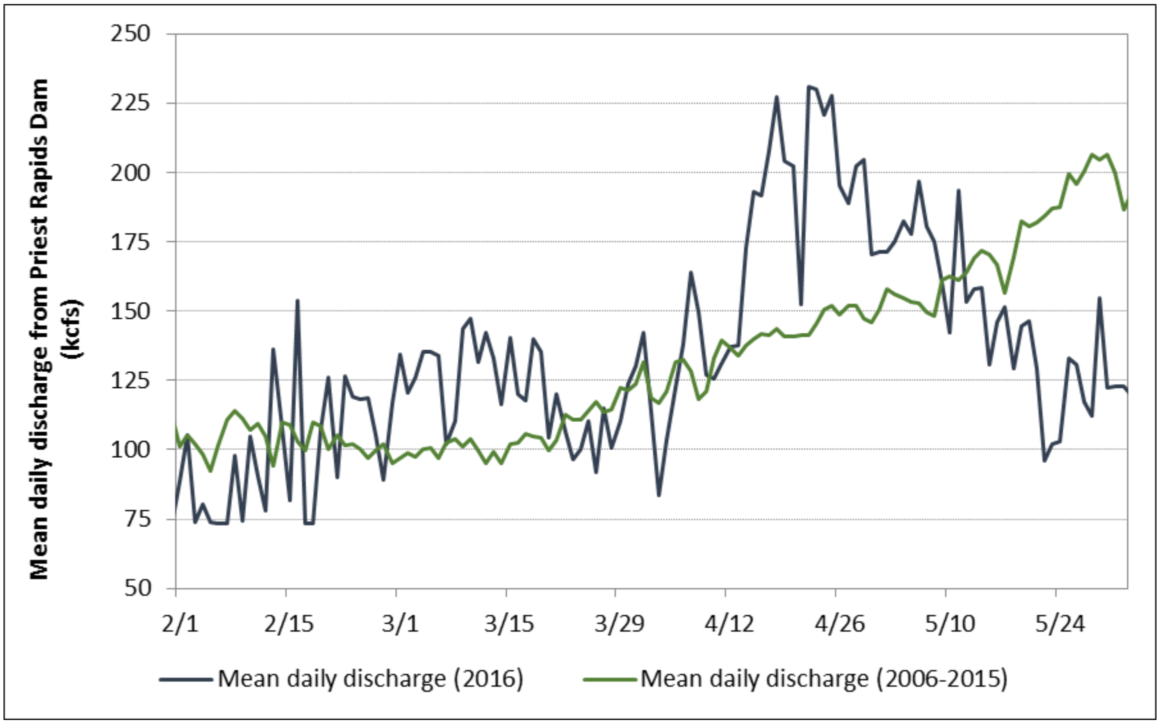

Figure 9 **Mean daily discharge from Priest Rapids Dam during the Emergence and Rearing Periods in 2016 and the mean from previous 10 years under the VBSA and HRFCPPA.**

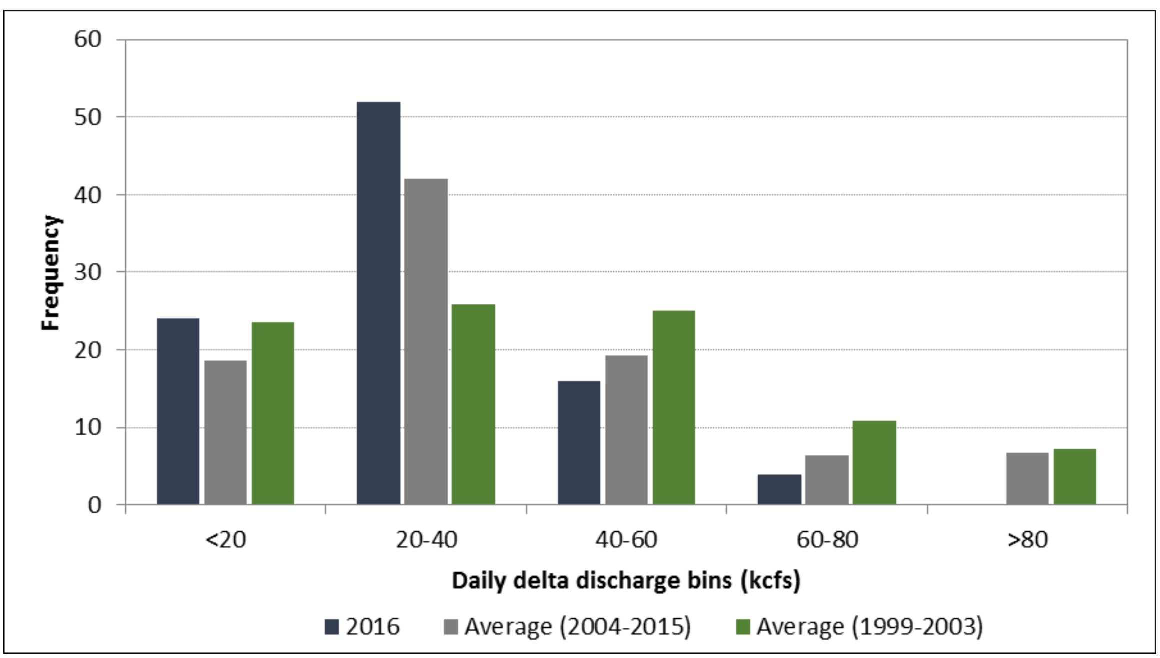

Figure 10 **Histogram of daily Outflow Deltas from Priest Rapids Dam. Some constraints restricting discharge fluctuations were initially implemented for brood year 1998. Rearing Period protections under the HRFCPPA were fully implemented for brood year 2004.**

5.1 Critical Elevation and Discharge Minimums

Minimum discharge constraints are implemented at Priest Rapids Dam to prevent desiccation of fall Chinook salmon prior to emergence. Minimum discharge constraints are based on inter-gravel water levels during the Post-Hatch Period and the Critical Elevation during the Emergence Period. For brood year 2015, the Critical Elevation for the Post-Hatch Period (11/29/2015) through the emergence period (4/29/2015) was 70 kcfs. Minimum discharge from Priest Rapids Dam during the Post-Hatch Period, measured at the USGS gage 12472800 below Priest Rapids Dam, must maintain an inter-gravel water level to no less than 15 cm below the Critical Elevation. At 70 kcfs, a 15 cm change in stage equates to approximately 5 kcfs (unpublished data). Consequently, the minimum discharge requirement for the Post-Hatch Period equates to approximately 65 kcfs at the USGS gage. During the entirety of 2015-2016 Post-Hatch and Emergence Periods discharge from Priest Rapids Dam was maintained above 70 kcfs. However, on December 7, 2015 the USGS gage downstream of Priest Rapids Dam recorded one 15-minute discharge reading at 50.2 kcfs (Figure 11). We believe this was an erroneous data recording at the gage. Figure 12shows the discharge readings around December 7. At the time of this sudden drop recorded at the USGS gage, discharge from Priest Rapids Dam remained stable and above 70 kcfs.

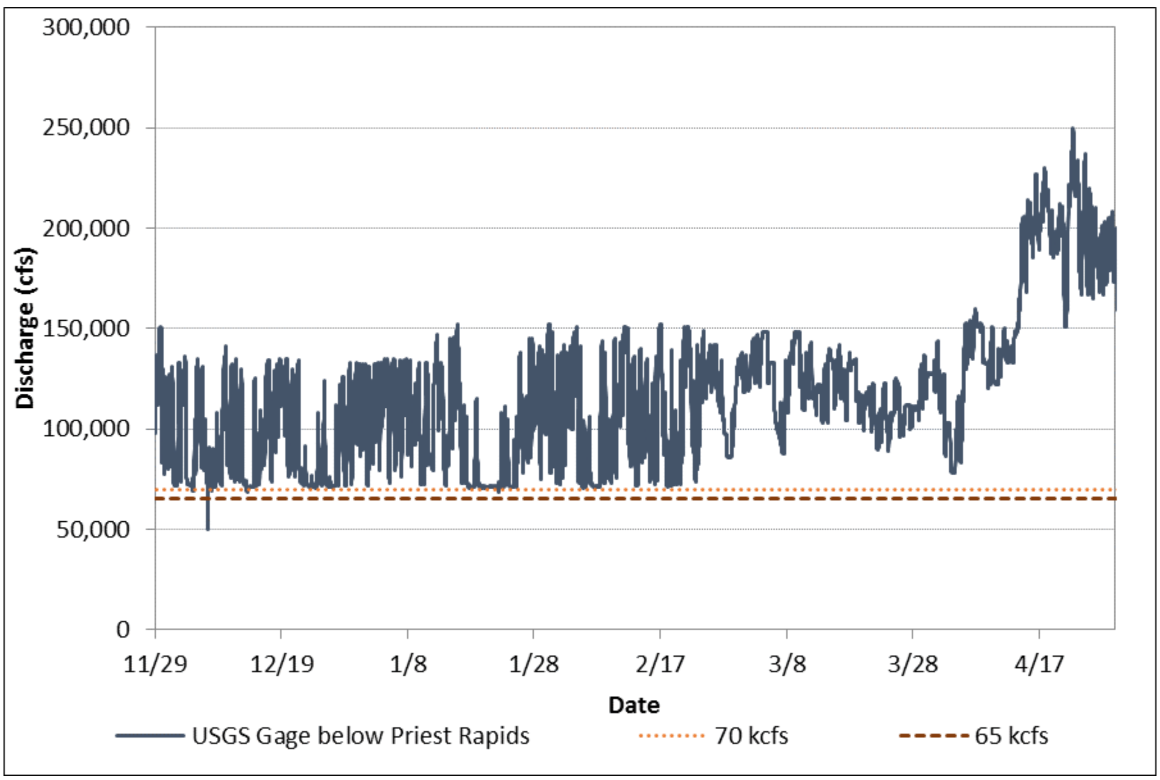

Figure 11 Discharge during the 2015-2016 Post Hatch and Emergence and Rearing periods measured at USGS Gage 12472800 below Priest Rapids Dam with the Critical Elevation (70 kcfs, dotted line) and the minimum discharge requirement for the Post Hatch Period (65 kcfs, dashed line).

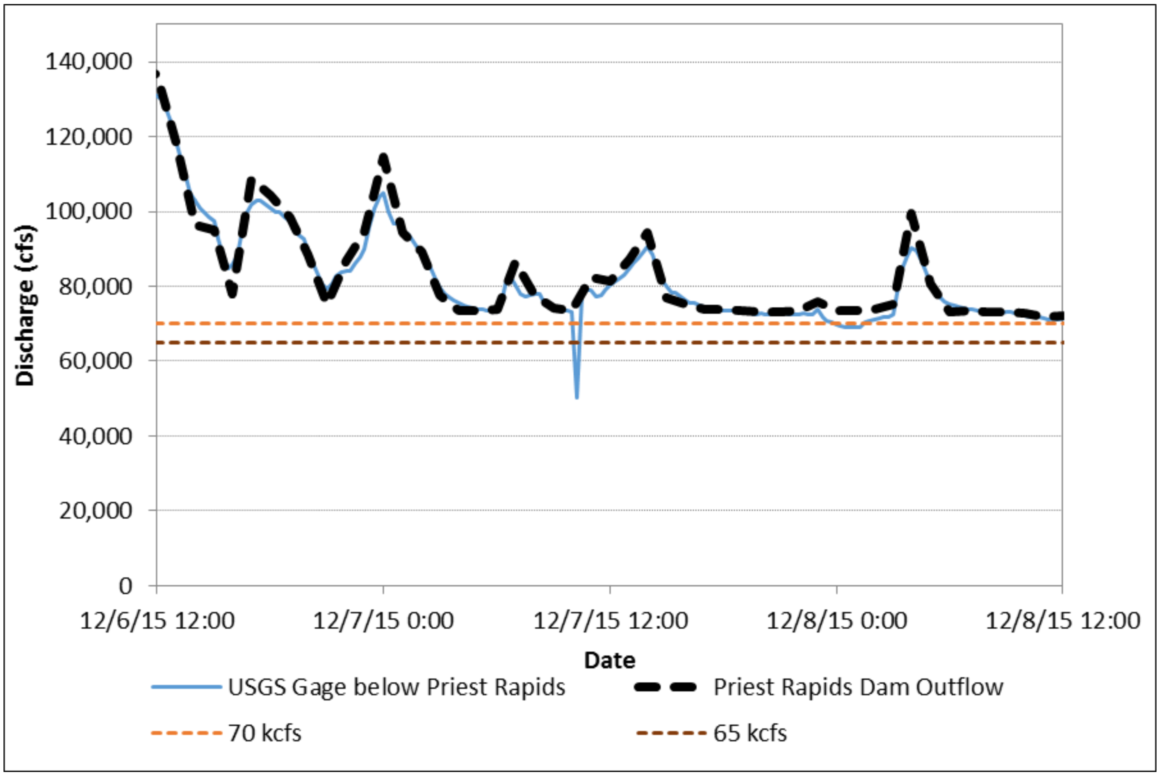

Figure 12 River flow measured at the USGS gage and discharge from Priest Rapids Dam in December 2015. The USGS gage recorded one 15-minute reading below 65 kcfs while discharge from Priest Rapids Dam remained stable.

5.2 Assessment of Flow Fluctuations and Targets

The Hanford Reach Fall Chinook Protection Program establishes operational criteria to minimize daily fluctuations in PRD discharge during fall Chinook salmon Emergence and Rearing periods. During the 96 days of the 2016 Emergence and Rearing periods, Grant PUD met all of the flow fluctuation constraints established with the HRFCPPA (Figure 13, Figure 14, Figure 15, and Figure 16). This continues the trend of significant performance improvements over the years prior to 2007 (Appendix H).

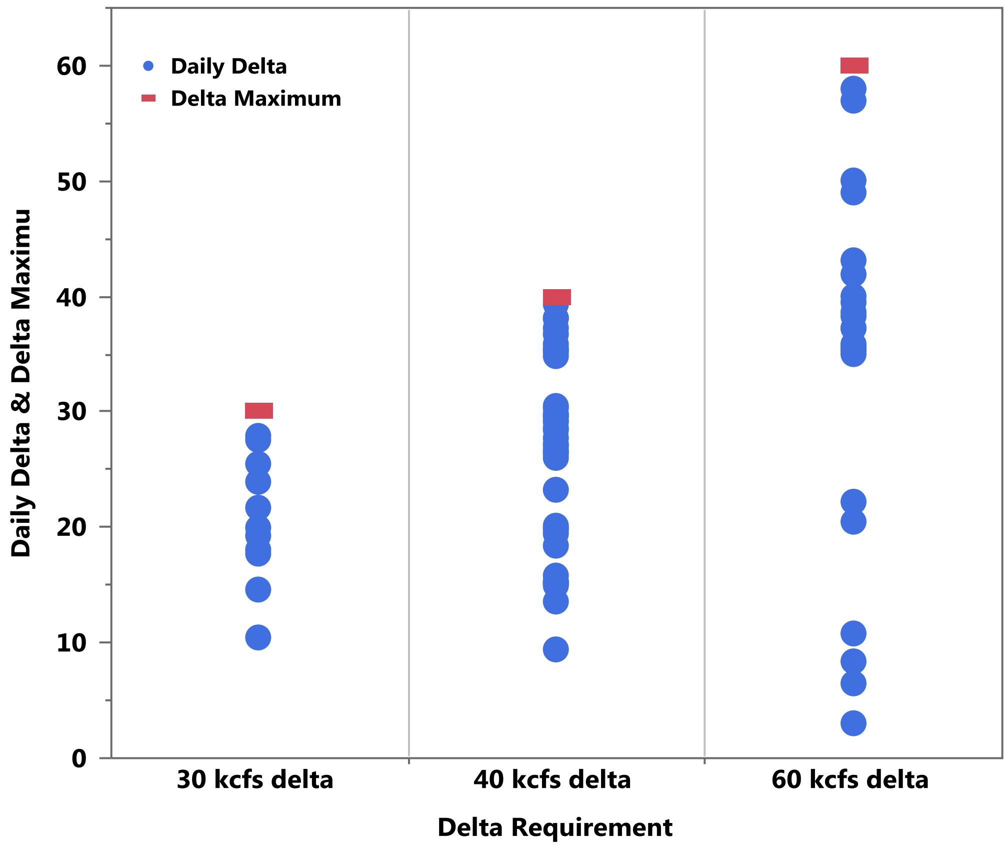

Figure 13 Summary of 2016 Priest Rapids Dam daily discharge deltas and delta maximum by constraint category.

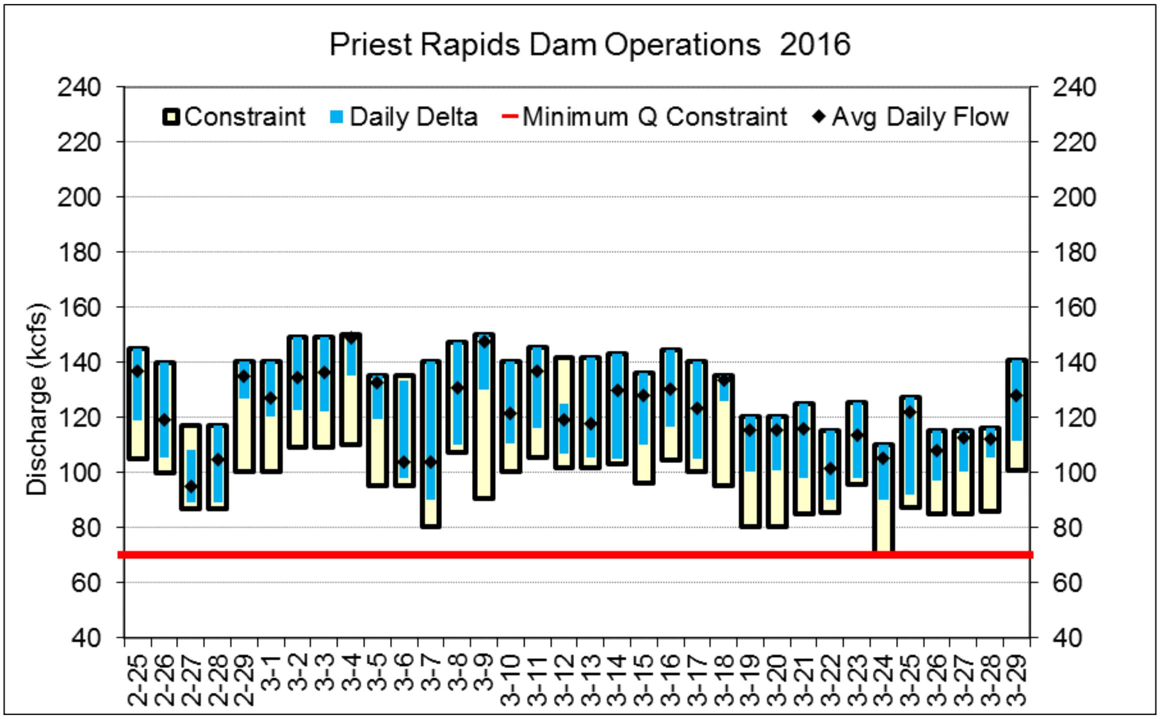

Figure 14 **Mean, minimum, maximum hourly discharge and daily fluctuation from Priest Rapids Dam, February 25 – March 29, 2016.**

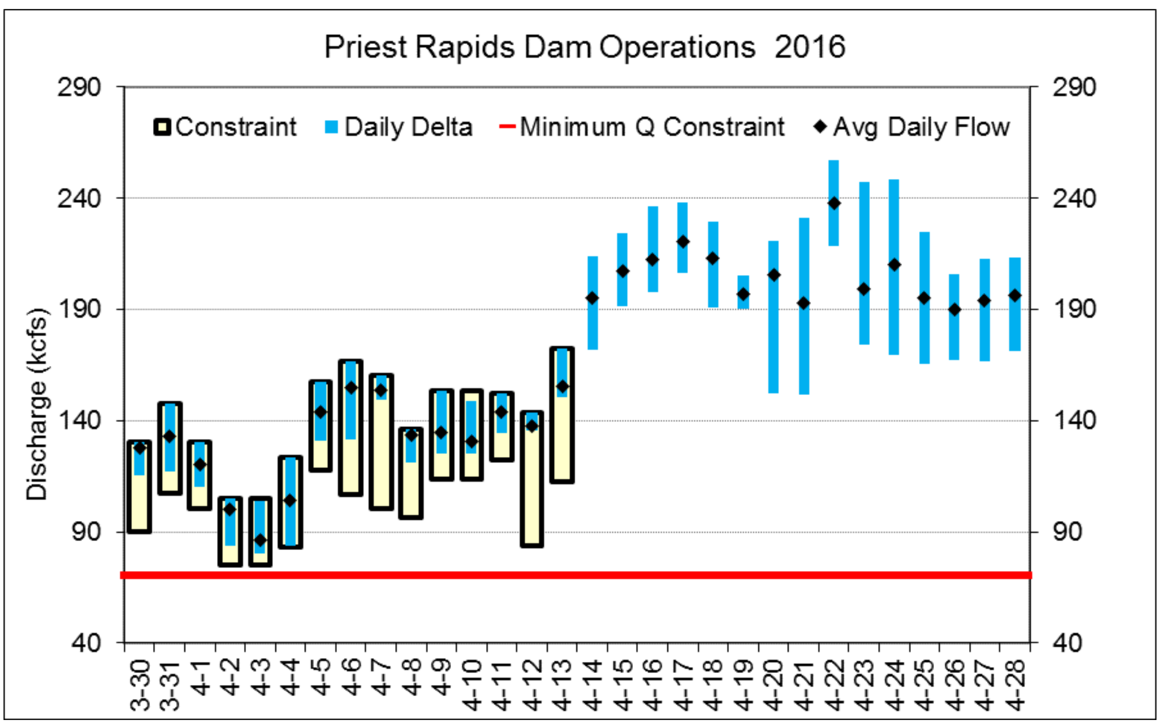

Figure 15 **Mean, minimum, maximum hourly discharge and daily fluctuation from Priest Rapids Dam, March 30 – April 28, 2016.**

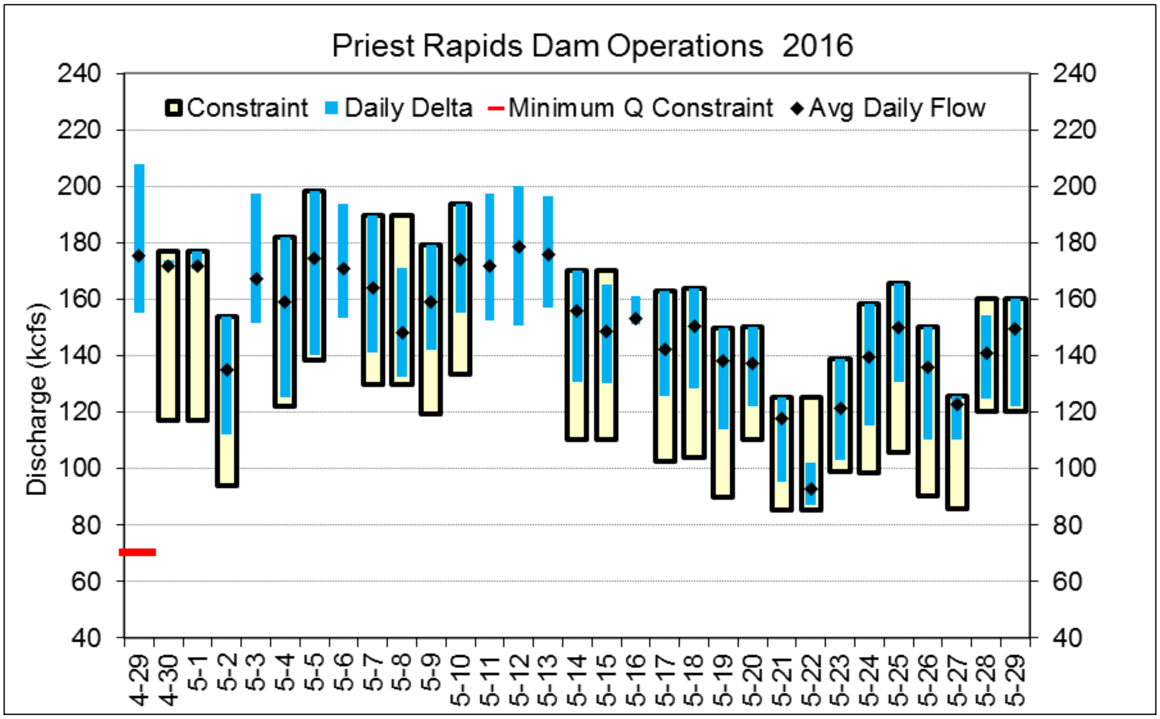

Figure 16 Mean, minimum, maximum hourly discharge and daily fluctuation from Priest Rapids Dam, April 29 – May 29, 2016.

Power demands are typically lower on weekends than on weekdays. The reduced demand for power typically leads to large reductions in discharge at hydroelectric projects. Large decreases in discharge and the resulting drop of river levels has the potential to strand and/or entrap large numbers of juvenile fall Chinook salmon. River levels can remain low throughout the weekend (48 to 56 hours) resulting in the increased likelihood of mortality from entrapments reaching lethal water temperatures or draining. Additional provisions were included in the HRFCPPA to reduce fall Chinook salmon mortality on weekends during peak susceptibility (Section C.5(b)(6), aka CJAD II protections). On four consecutive weekends that occur after 800 ATU from the end of the Spawning Period, Priest Rapids Outflow are to be maintained to at least a minimum discharge calculated as the average of the daily hourly minimum discharge from Monday through Thursday of the current week.

The 2016 weekend-minimum discharge constraints began on the weekend of April 9 and continued through the weekend of April 30. On three of the four the CJAD II weekends the minimum constraint was met (Table 3). On April 24 (the third Sunday of the CJAD II protections) discharge from Priest Rapids Dam dropped 4 kcfs below the minimum flow constraint of 173.3 kcfs for approximately 5 hours (Figure 17).

Table 3 Weekend constraints and minimum discharges from Priest Rapids Dam.

Weekend of CJAD II Minimum Flow Constraint	Weekend Minimum Constraint (kcfs)	Minimum Weekend Outflow from Priest Rapids Dam (kcfs)	Difference between constraint and Priest Rapids Dam outflow (kcfs)
April 9-10	124.0	125.1	+1.1
April 16-17	148.1	197.9	+49.8
April 23-24	173.3	169.3	-4.0
April 30-May 1	167.7	170.7	+3.0

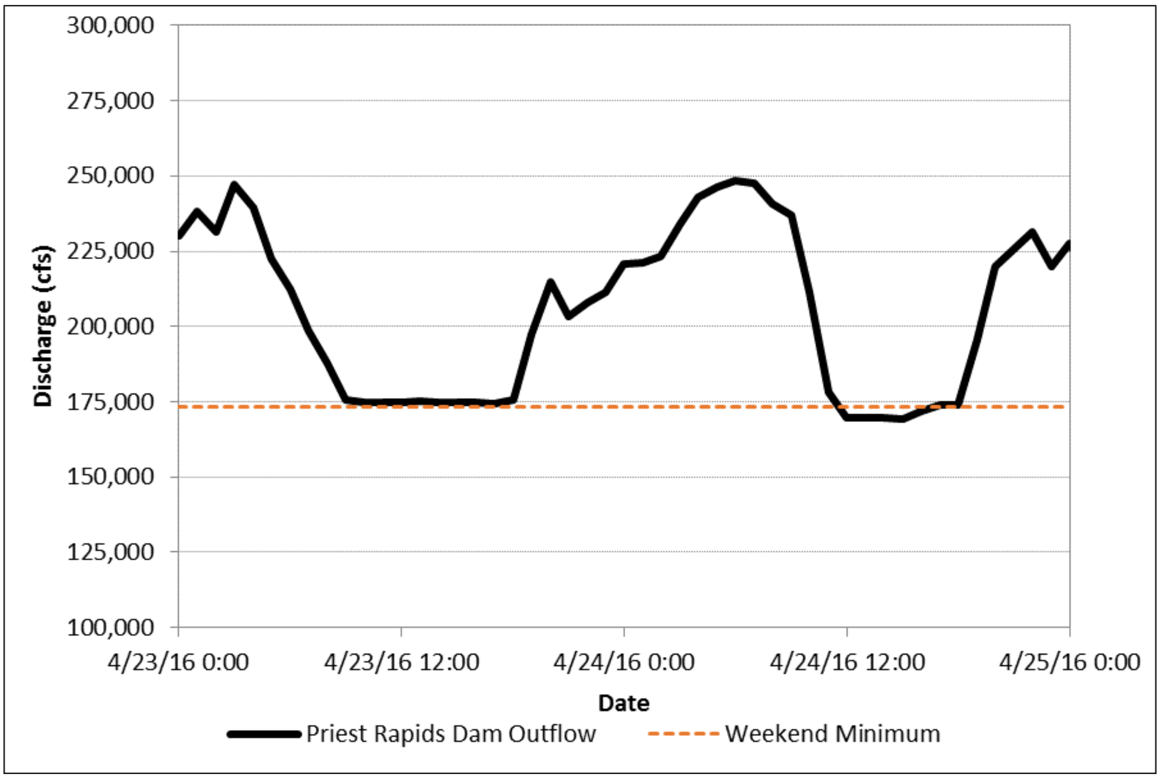

Figure 17 Priest Rapids Dam discharge and the weekend minimum flow constraint on the third CJAD II weekend. Discharge dropped below the minimum constraint of 173.3 by 4 kcfs for approximately 5 hours on Sunday, April 24, 2015.

5.3 Assessment of River Conditions During the Protection Program in Relation to Egg-to-Presmlot Survival

In an analysis of the freshwater productivity of Hanford Reach fall Chinook salmon, Harnish et al. (2014) identified two river environmental variables correlated with Hanford Reach egg-to-presmolt survival (Figure 18). First, the ratio of the minimum posthatch incubation discharge to the minimum spawning discharge (PHMinQ:SpMinQ) explained the greatest variability and was positively correlated to egg-to-presmolt survival. Second, the difference between the mean spawning discharge and the minimum posthatch incubation discharge (SpAvgQ-PHMinQ) was strongly negatively correlated with egg-to-presmolt survival. For the 2015 – 2016 flow protection season the PHMinQ:SpMinQ was 1.8 and the SpAvgQ-PHMinQ was 571.7. Using the two relationships developed by Harnish et al. (2014), the estimated egg-to-presmolt survival for the 2015 broodyear was 0.50 and 0.58, respectively.

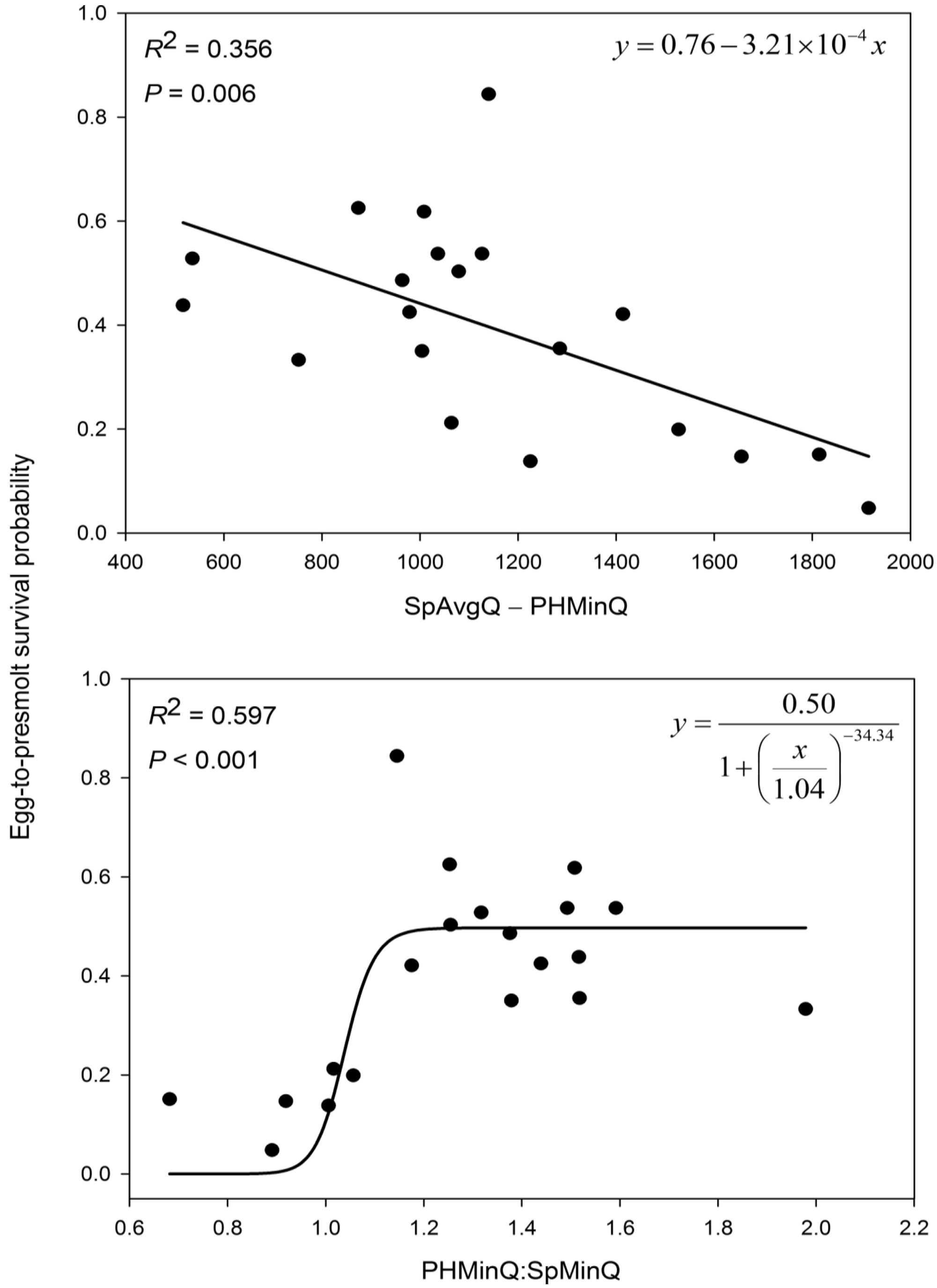

Figure 18 Figure 8 from Harnish et al. (2014). Bivariate regression relationships of river environment variables that were found to be correlated with Hanford Reach fall Chinook salmon egg-to-presmolt survival estimates. Variables included the difference between mean spawning discharge and minimum posthatch incubation discharge (SpAvgQ – PHMinQ) and the ratio between the minimum posthatch incubation discharge and the minimum spawning discharge (PHMinQ:SpMinQ).

6.0 Summary

Operations to protect the 2015 brood year of fall Chinook salmon in the Hanford Reach were highly successful. While the minimum flow requirement during one CJAD II weekend was exceeded by a small amount , all remaining discharge constraints were met during the Spawning, Pre-Hatch, and Emergence periods. This continues the trend of high performance that began with the 2006 brood year and is significantly greater than the historical mean under the HRFCPPA (93% constraints met or minor exceedances). This is particularly noteworthy given that the signatories to the HRFCPPA did not anticipate nor does the agreement require perfect compliance with constraints at all times. Section C.5(c) clearly reflects this important consideration:

(c) All Parties agree that perfect compliance with the flow constraints of C.5(b) is not possible. Conditions related to inflow, reservoir elevation, accuracy of BPA estimates, emergencies and human error can contribute to exceeding the Priest Rapids Outflow Delta or Priest Rapids Outflow dropping below minimums specified. Grant will make every effort to meet the operating constraints.

While perfect compliance is not required, it is important to recognize the performance of the operators, dispatch personal, and the hourly coordinator. Continued high performance was achieved as a direct result of their efforts and dedication.

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Appendix A
Hanford Reach Fall Chinook Protection Agreement
Excerpt of protection measures outline in Section C

C. HANFORD REACH FALL CHINOOK PROTECTION

Subject to the limitations and conditions set out in this Agreement, Grant, Chelan, Douglas and BPA shall provide the following flow regimes for the Spawning through Rearing Period for Hanford Reach fall Chinook salmon in the Hanford Reach of the Columbia River.

1. Spawning Period

(a) All Parties agree that flows maintained during the Spawning Period and escapement levels are factors influencing the placement of Redds. The flow manipulation under this subsection C.1 is directed to minimize formation of Redds above the 70 kcfs elevation. Minimizing formation of Redds above the 70 kcfs elevation in turn is a key factor influencing the success of the flow regime under subsection C.4 during the Emergence Period.

(b) During the Spawning Period(s) of 2005 and 2006, Grant will experiment with alternative operations for flow manipulation. The requirement of the alternative operations will be to ensure that Priest Rapids Outflows are not higher than 70 kcfs and not lower than 55 kcfs for a continuous period of at least 12 hours out of each day during the Spawning Period. Grant will provide continuous monitoring of Redd formation during these tests and report the results weekly. These experiments may continue as long as no more than 31 Redds are located above the 65 kcfs elevation on Vernita Bar. If Redd counts reveal that more than 31 Redds are located above the 65 kcfs elevation, Spawning Period operations will default to the procedures of C.1(c) below. If Redd counts show that alternative Spawning Period operations can limit the formation of Redds above 70 kcfs, then Grant shall be allowed to choose between use of C.1(b) or C.1(c) as guidelines for operational parameters during the Spawning Period of future years.

(c) If the experimental operations testing during C.1(b) above are unsuccessful in minimizing formation of Redds above the 70 kcfs elevation, Grant's operations will revert to the default operation specified in this paragraph. During the Spawning Period, Grant will operate Priest Rapids Project No. 2114 to the extent feasible through use of the Mid-Columbia Hourly Coordination and Reverse Load Factoring to produce a Priest Rapids Outflow during Daylight Hours that can range from 55 to 70 kcfs. The goal during the Spawning Period is to limit spawning to the area below the 70 kcfs elevation on Vernita Bar. In the event physical changes are made at the Priest Rapids Project which affect Grant's ability to provide Reverse Load Factoring, Grant agrees to meet with the Parties to this Agreement to determine what adjustments to Grant's obligation under this subsection C.1(c) shall be made, notwithstanding the provisions of subsections B.4 and B.5.

(d) The Parties agree that BPA has no obligation under this Agreement to limit fall flows to influence Redd location. This is, however, without prejudice to the rights of any Party to assert, except before the FERC prior to ten years from the effective date of this Agreement, that BPA may have an obligation apart from this Agreement to limit such flows and the rights of any Party to request cooperation of BPA, the Bureau of Reclamation and the Corps of Engineers to limit such flows. The Parties agree to work together to obtain the cooperation of BPA, the Bureau of Reclamation and the Corps of Engineers to achieve the desired flow regime.

2. Pre-Hatch Period

During the Pre-Hatch Period the Priest Rapids Outflow may be reduced to 36 kcfs for up to 8 hours on weekdays and 12 hours on weekends (with no two consecutive minimum periods). All Parties recognize that utilization of the 36 kcfs minimum may have to be limited to achieve the Priest Rapids Outflow goal during the Spawning Period.

3. Post-Hatch Period

(a) After Hatching has occurred at Redds located in the 36 to 50 kcfs zone, the Protection Level Flow shall be maintained over Vernita Bar so that the intergravel water level is no less than 15 cm below the 50 kcfs elevation.

(b) After Hatching has occurred at Redds located in the zone above the 50 kcfs elevation, the Protection Level Flow shall be maintained over Vernita Bar through the Post Hatch Period so that the intergravel water level is no less than 15 cm below the Critical Elevation.

4. Emergence Period

(a) During the Emergence Period, after Emergence has occurred in the 36 to 50 kcfs zone, the Protection Level Flow shall not be less than necessary to maintain water over Vernita Bar at the 50 kcfs elevation.

(b) During the Emergence Period, after Emergence has occurred above the 50 kcfs elevation, the Protection Level Flow shall be maintained at or above the Critical Elevation.

5. Rearing Period

(a) All Parties recognize that flow fluctuations during the Rearing Period may impact juvenile Hanford Reach fall Chinook. The Parties also recognize that elimination of all flow fluctuations is not physically possible without severely impacting the ability of Mid-Columbia Operators to produce a reliable supply of electricity. The goal during the Rearing Period is to provide a high level of protection for juvenile Hanford Reach fall Chinook rearing in the Hanford Reach by limiting flow fluctuations while retaining operational flexibility at each of the seven dams on the Mid-Columbia River.

(b) During the Rearing Period, Grant will operate Priest Rapids Project No. 2114 to the extent feasible through use of the Mid-Columbia Hourly Coordination to produce a Priest Rapids Outflow that limits flow fluctuations according to the following criteria:

> (1) When the Previous Day's Average Weekday Wanapum Inflow is between 36 and 80 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 20 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 36 and 80 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 20 kcfs.
>
> (2) When Previous Day's Average Weekday Wanapum Inflow is between 80 and 110 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 30 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 80 and 110 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 30 kcfs.
>
> (3) When Previous Day's Average Weekday Wanapum Inflow is between 110 and 140 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 40 kcfs. When the

average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 110 and 140 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 40 kcfs.

(4) When Previous Day's Average Weekday Wanapum Inflow is between 140 and 170 kcfs limit Priest Rapids Weekday Outflow Delta to no more than 60 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is between 140 and 170 kcfs limit the Priest Rapids Weekend Outflow Delta to no more than 60 kcfs.

(5) When Previous Day's Average Weekday Wanapum Inflow is greater than 170 kcfs Priest Rapids Outflow for the following weekday will be at least 150 kcfs. When the average of BPA's Friday Chief Joseph Outflow Estimates plus side flow estimates for Saturday and Sunday is greater than 170 kcfs, Priest Rapids Outflow for Saturday and Sunday will be at least 150 kcfs.

(6) On four consecutive Saturdays and Sundays that occur after 800 TUs have accumulated after the end of the Spawning Period, Priest Rapids Outflow will be maintained to at least a minimum flow calculated as the average of the daily hourly minimum flow from Monday through Thursday of the current week.

(c) All Parties agree that perfect compliance with the flow constraints of C.5(b) is not possible. Conditions related to inflow, reservoir elevation, accuracy of BPA estimates, emergencies and human error can contribute to exceeding the Priest Rapids Outflow Delta or Priest Rapids Outflow dropping below minimums specified. Grant will make every effort to meet the operating constraints.

(d) On Monday, following lower flows from the weekend it is not considered a violation of the provisions in C.5(b) when Monday inflows require increasing the Priest Rapids discharge above the upper limit established at midnight on Sunday. If the upper limit is raised on Monday, the lower limit must be raised to allow the difference between the maximum and new minimum flow to remain within the applicable Priest Rapids Weekday Outflow Delta limit.

(e) Problems can be expected from time to time. Grant will detail the circumstances associated with its inability to meet these constraints in the annual report described under C.6(c). In addition to annual reporting, the Parties agree to use the dispute resolution process described under E.9 whenever any Party claims excessive non-compliance.

<u>6. Monitoring Team</u>

For purposes of determining the Protection Level Flow during the Post Hatch and Emergence Periods, a Critical Elevation shall be determined each year as follows:

(a) The Monitoring Team will survey Redds on Vernita Bar in the area specified on Exhibit A for the purpose of determining the Initiation of Spawning, the location of Redds and the extent of spawning. The Monitoring Team will also provide a concurrent aerial survey of the Hanford Reach on the same weekend(s). The aerial survey(s) will be utilized to determine if Initiation of Spawning in areas of the Hanford Reach below the 36 kcfs level and/or outside the area specified on Exhibit A occurs prior to Initiation of Spawning within the Exhibit A area above the 36 kcfs level. Once an initiation of Spawning date has been determined, based upon the presence of 5 or more redds in an individual survey, the aerial surveys maybe discontinued for that year. The surveys will be conducted on weekends beginning on the weekend prior to October 15 of each year.

(b) The Monitoring Team will make a final Redd survey the weekend prior to Thanksgiving to determine the Critical Elevation. The Monitoring Team may also make a supplemental Redd survey the weekend after Thanksgiving to determine if additional Redds are present above the 50 kcfs elevation. A preliminary estimate of the Critical Elevation will be made following the final Redd survey and will be confirmed or adjusted based on the supplemental survey. The Critical Elevation will be set as follows: (Elevations must be in 5 kcfs increments beginning at the 40 kcfs elevation.)

(1) If 31 or more Redds are located above the 65 kcfs elevation, the Critical Elevation will be the 70 kcfs elevation.

(2) If there are 15 to 30 Redds above the 65 kcfs elevation, the Critical Elevation will be the 65 kcfs elevation.

(3) If there are fewer than 15 Redds above the 65 kcfs elevation, then the Critical Elevation will be the first 5 kcfs elevation above the elevation containing the 16th highest Redd within the survey area on Vernita Bar (see Table 1 below for examples of the application of these counts).

Table 1. Examples illustrating theoretical final Vernita Bar Redd counts and the resulting Critical Elevations, elevations are provided in kcfs ranges.

	36-50 kcfs	50-55 kcfs	55-60 kcfs	60-65 kcfs	65-70 kcfs	70+ kcfs	Resulting Critical Elevation
Example 1	836	418	148	71	48	34	70
Example 2	283	94	65	28	16	4	65
Example 3	105	35	10	3	1	0	55

(c) Additional activities of the Monitoring Team will include calculation of Temperature Units, determination of the dates of Initiation of Spawning, Hatching, Emergence, the end of the Emergence Period and the end of the Rearing Period. The Monitoring Team may also make non-binding recommendations to any of the Parties to this Agreement, including non-binding recommendations to protect Redds above the Critical Elevation or to address special circumstances. By September 1 of the following year, Grant will submit an annual report to the Monitoring Team and BPA. The annual report will include, but not be limited to: 1) Vernita Bar Redd Counts, 2) dates on which the Hatching, Emergence, End of Emergence and End of Rearing Periods occurred, 3) a record of Columbia River flows through the Hanford Reach based on Priest Rapids discharges, and 4) a description of the actual flow regimes from the Initiation of Spawning through the Rearing Period based on available data. During the rearing period, Grant will provide a weekly operations report to the Parties. After review by the Monitoring Team, the final report will be sent to all Parties. During the Rearing Periods of 2011, 2012 and 2013, the Parties will also meet to develop a follow-up monitoring program to estimate fry losses. This monitoring program will be designed according to protocols developed from 1999 to 2003 or alternatively with different methods developed by the Parties.

(d) If from time to time, disputes arise regarding activities of the Monitoring Team, the Parties agree to use the dispute resolution process described under E.9 below.

<u>7. Redds Above Critical Elevation</u>

This Agreement is not intended either to preclude or require protection of Redds above the Critical Elevation. The Parties shall meet annually to determine if there are measures that, in the joint discretion of Grant, Chelan, Douglas and BPA, can be taken to protect any Redds located above the Critical Elevation.

Appendix B
Statement of Agreement for the HRFCPPA developed by the Hanford Reach Work Group

SOA 2007-HR01: Hanford Reach Working Group Statement of Agreement on Documentation of Hanford Reach Working Group Agreements

Submitted to Hanford Reach Working Group: July 11, 2007 Approved: September 6, 2007
Statement:

"The Hanford Reach Working Group (HRWG) agrees that the process of documenting agreements reached by consensus of the HRWG will consist of the distribution of a draft Statement of Agreement at least 10 days prior to a request for a vote by all Parties 1. Modifications to the draft Statement of Agreement may occur at any time prior to a vote on the Statement of Agreement. Statements of Agreement shall be as brief as possible. Relevant background information should be included below the Statement of Agreement as warranted."

SOA 2007-HR03: Hanford Reach Working Group Statement of Agreement on Development of a Single Hanford Reach Fall Chinook Protection Program Annual Report

Submitted to Hanford Reach Working Group: July 11, 2007 Approved: September 6, 2007
Statement:

"The Hanford Reach Working Group (HRWG) agrees a single Hanford Reach Fall Chinook Protection Program Annual Report jointly developed, coordinated between the Public Utility District No. 2 of Grant County and the Washington Department of Fish & Wildlife, and submitted to the Hanford Reach Monitoring Team and the Bonneville Power Administration (BPA) by September 1 of each year."

SOA 2007-HR04: Protocol for the setting the Initiation of Spawning

Submitted to Hanford Reach Working Group: July 11, 2007 Approved: August 17, 2007
Statement:

“The Hanford Reach Working Group (HRWG) agrees that for the purposes of the Hanford Reach Fall Chinook Protection Program, Exhibit A shall be understood to include those shoreline spawning areas both upstream and downstream of Vernita Bar, including both Vernita Bar and Columbia River shorelines, within the geographic area shown approximately in Exhibit A of the Hanford Reach Fall Chinook Protection Program (HRFCPP).

Furthermore, the HRWG agrees that pursuant to subsection C.6 of the HRFCPP, aerial survey(s) may be utilized to determine if the presence of 5 or more redds in an individual survey in areas of the Hanford Reach below the 36 kcfs level, within Exhibit A and/or outside the area specified on Exhibit A, occurs prior to the identification of the presence of 5 or more redds in an individual survey within the Exhibit A area above the 36 kcfs level. If the presence of 5 or more redds is established in an individual survey by either ground surveys or aerial surveys, Initiation of Spawning shall be established as per the definition of Initiation of Spawning in Section A of the HRFCPP. Aerial redd count surveys that occur on weekdays rather than on weekends shall be valid redd count surveys. If the presence of 5 or more redds is established in an individual, weekday, aerial and/or ground survey, the Initiation of Spawning shall be established as that Wednesday immediately prior to that survey."

SOA 2007-HR06: Hanford Reach Working Group Statement of Agreement on Protocol for Requesting an Additional Weekend of Protection Flows

Submitted to Hanford Reach Working Group: July 11, 2007 Approved: September 6, 2007

"The Hanford Reach Working Group (HRWG) agrees that, on a case-by-case basis, an additional weekend of protection flows in the Hanford Reach will be considered, provided four (4) days' notice is provided to Grant PUD Operators in writing. If conditions warrant an additional weekend of protection flows, Grant PUD will coordinate with other operators and make every effort to meet the weekend minimum operating constraints."

SOA 2010-HR01: Hanford Reach Working Group Statement of Agreement on Protocol for Conducting the First Vernita Bar Ground Survey and Concurrent Aerial Redd Count

Submitted to Hanford Reach Working Group: September 3, 2010 Approved: November 2, 2010

"The Hanford Reach Working Group (HRWG) agrees that the first Vernita Bar ground survey and the first aerial redd counts will commence on the first Sunday following October 15 annually."

SOA 2011-HR01: Hanford Reach Working Group Statement of Agreement on Water temperature data that will be used to calculate Temperature Units for the Hanford Reach Fall Chinook Protection Program

Submitted to Hanford Reach Working Group: February 25, 2011 Approved: April 5, 2011

"The Hanford Reach Working Group (HRWG) agrees that data collected at the Priest Rapids Dam (PRD) tailrace Fixed Site Monitoring station will be used to calculate Temperature Unit accumulations for the Hanford Reach Fall Chinook Protection Program."

Appendix C
Summary of Priest Rapids Dam discharge, fluctuations, and constraints (kcfs) associated with the Hanford Reach Fall Chinook Protection Program, February 25 – May 30, 2016

Date	Mean daily PRD discharge	Minimum daily PRD discharge	Maximum daily PRD discharge	Daily Delta	Daily Delta constraint	Daily mean RIS discharge	Mean weekend inflows	CHJ prediction	Sideflow estimate
25-Feb-16	136.9	118.8	145.0	26.2	40	121.7		0	0
26-Feb-16	119.4	105.3	140.0	34.7	40	119.4		0	0
27-Feb-16	94.9	89.1	108.3	28.0	30	101.6	108.2	95	15.7
28-Feb-16	104.6	89.2	117.1	27.9	30	121.4	108.2	90	15.7
29-Feb-16	134.9	126.8	140.3	13.5	40	120.6		0	0
1-Mar-16	127.3	120.4	140.3	19.9	40	129.9		0	0
2-Mar-16	134.8	122.7	149.3	26.6	40	134.1		0	0
3-Mar-16	136.4	122.4	149.3	26.9	40	130.9		0	0
4-Mar-16	149.0	135.4	150.4	15.0	40	143.0		0	0
5-Mar-16	132.8	119.7	135.4	15.7	40	114.6	113.7	100	13.7
6-Mar-16	104.0	98.2	133.4	37.2	40	95.7	113.7	100	13.7
7-Mar-16	103.8	90.2	140.2	50.0	60	126.1		0	0
8-Mar-16	130.7	110.3	147.4	37.1	40	143.0		0	0
9-Mar-16	147.4	130.0	150.4	20.4	60	131.2		0	0
10-Mar-16	121.8	110.5	140.3	29.8	40	123.7		0	0
11-Mar-16	136.8	116.4	145.4	29.0	40	137.5		0	0
12-Mar-16	119.1	106.8	125.1	35.2	40	119.2	110.2	95	17.7
13-Mar-16	117.8	105.3	142.0	36.7	40	123.7	110.2	90	17.7
14-Mar-16	130.0	105.2	143.3	38.1	40	125.7		0	0
15-Mar-16	128.3	110.3	136.2	25.9	40	127.7		0	0
16-Mar-16	130.6	116.9	144.6	27.7	40	119.5		0	0
17-Mar-16	123.2	105.1	140.2	35.1	40	129.2		0	0
18-Mar-16	133.8	125.9	135.3	9.4	40	120.2		0	0
19-Mar-16	115.6	100.5	120.2	19.8	40	111.4	110.7	100	13.2
20-Mar-16	115.5	100.9	120.3	19.4	40	111.6	110.7	95	13.2
21-Mar-16	116.0	98.0	125.2	27.2	40	108.5		0	0
22-Mar-16	101.3	90.0	115.4	25.4	30	94.3		0	0
23-Mar-16	113.7	98.1	125.6	27.5	30	113.4		0	0
24-Mar-16	105.4	90.1	110.2	20.1	40	110.5		0	0
25-Mar-16	122.0	91.8	127.3	35.5	40	106.6		0	0
26-Mar-16	108.0	97.3	115.2	17.9	30	122.1	102.9	95	12.9
27-Mar-16	112.7	100.6	115.2	14.6	30	87.7	102.9	85	12.9
28-Mar-16	112.2	105.6	116.0	10.4	30	124.4		0	0
29-Mar-16	128.1	111.5	141.0	29.5	40	129.7		0	0
30-Mar-16	127.9	115.3	130.3	15.0	40	124.5		0	0
31-Mar-16	133.1	117.1	147.6	30.5	40	96.6		0	0
1-Apr-16	120.4	110.3	130.2	19.9	30	115.5		0	0
2-Apr-16	100.1	83.6	105.2	21.6	30	91.7	89.8	70	14.8
3-Apr-16	86.5	80.2	104.1	25.0	30	101.8	89.8	80	14.8
4-Apr-16	104.4	83.9	123.2	39.3	40	129.9		0	0
5-Apr-16	144.2	131.1	157.5	26.4	40	143.6		0	0

6-Apr-16	154.9	131.5	166.9	35.4	60	147.3		0	0
7-Apr-16	153.8	149.5	160.2	10.7	60	129.3		0	0
8-Apr-16	133.5	121.1	136.3	15.2	40	107.2		0	0
9-Apr-16	134.5	125.1	153.7	28.6	40	117.1	122.2	85	27.2
10-Apr-16	130.5	125.4	148.6	28.3	40	135.6	122.2	105	27.2
11-Apr-16	143.7	134.6	152.2	17.6	30	151.4		0	0
12-Apr-16	137.5	135.4	143.7	8.3	60	164.3		0	0
13-Apr-16	155.4	150.5	172.7	22.2	60	170.0		0	0
14-Apr-16	195.4	171.7	214.1	42.4	150	185.9		0	0
15-Apr-16	207.3	191.5	224.4	32.9	150	193.8		0	0
16-Apr-16	212.4	197.9	236.4	40.1	148.1	199.3	190.9	155	35.9
17-Apr-16	220.3	206.2	238.0	31.8	148.1	209.1	190.9	155	35.9
18-Apr-16	213.0	191.1	229.5	38.4	150	198.0		0	0
19-Apr-16	197.0	190.3	205.0	14.7	150	187.6		0	0
20-Apr-16	205.7	152.2	220.8	68.6	150	187.6		0	0
21-Apr-16	193.2	151.7	231.1	79.4	150	194.1		0	0
22-Apr-16	237.6	218.5	256.9	38.4	150	221.5		0	0
23-Apr-16	199.3	174.4	247.3	74.0	171.3	188.6	188.4	135	48.4
24-Apr-16	210.4	169.3	248.4	79.1	171.3	195.6	188.4	145	48.4
25-Apr-16	195.3	165.5	225.1	59.6	150	185.6		0	0
26-Apr-16	190.1	167.5	206.1	38.6	150	182.4		0	0
27-Apr-16	193.8	166.7	212.8	46.1	150	186.2		0	0
28-Apr-16	196.5	171.1	213.2	42.1	150	190.0		0	0
29-Apr-16	175.5	155.1	207.8	52.7	150	169.3		0	0
30-Apr-16	172.0	170.9	173.8	6.4	60	147.7	167.7	115	47.7
1-May-16	171.8	170.9	177.3	6.4	60	163.9	167.7	125	47.7
2-May-16	135.0	112.1	153.9	41.8	60	173.6		0	0
3-May-16	167.2	151.6	197.7	46.1	150	161.6		0	0
4-May-16	159.3	125.4	182.2	56.8	60	156.9		0	0
5-May-16	174.7	140.5	198.4	57.9	60	173.6		0	0
6-May-16	171.2	153.3	193.9	40.6	150	166.7		0	0
7-May-16	164.0	141.0	190.0	49.0	60	159.0	154.9	105	49.9
8-May-16	148.3	132.4	171.0	57.6	60	143.8	154.9	105	49.9
9-May-16	159.3	142.2	179.3	37.1	60	152.7		0	0
10-May-16	174.1	155.5	193.7	38.2	60	171.8		0	0
11-May-16	171.8	152.6	197.3	44.7	150	170.1		0	0
12-May-16	178.6	150.8	200.1	49.3	150	173.7		0	0
13-May-16	175.8	157.2	196.5	39.3	150	170.7		0	0
14-May-16	156.0	130.7	170.1	39.4	60	147.0	144.4	105	46.9
15-May-16	148.6	130.5	165.4	39.6	60	137.9	144.4	90	46.9
16-May-16	153.2	151.3	161.4	10.1	150	145.6		0	0
17-May-16	142.2	125.7	162.8	37.1	60	150.7		0	0
18-May-16	150.3	128.6	164.0	35.4	60	146.8		0	0
19-May-16	138.1	114.1	149.9	35.8	60	117.3		0	0
20-May-16	137.3	122.0	150.3	28.3	40	125.1		0	0
21-May-16	117.8	95.2	125.4	30.2	40	105.5	113.1	75	35.6
22-May-16	92.8	87.2	102.0	38.2	40	77.8	113.1	80	35.6
23-May-16	121.3	103.0	138.8	35.8	40	142.1		0	0

24-May-16	139.5	115.2	158.3	43.1	60	153.1		0	0
25-May-16	150.2	130.6	165.9	35.3	60	143.9		0	0
26-May-16	135.9	110.4	150.4	40.0	60	130.1		0	0
27-May-16	122.9	110.5	125.7	15.2	40	137.5		0	0
28-May-16	141.0	125.0	154.5	35.3	40	151.2	132	105	27
29-May-16	149.8	122.2	160.3	38.1	40	121.7	132	105	27
30-May-16	128.9	120.8	150.0	29.2	40	126.3		0	0

Appendix D
Summary of Vernita Bar ground survey, 1998-present.

Brood Year	Final count by spawning elevation (kcfs)						Total
	36-50	50-55	55-60	60-65	65-70	70+	
2015		265	213	156	36	32	702
2014	--	156	175	142	32	20	525
2013	--	150	97	109	11	5	372
2012	--	38	48	20	3	2	111
2011	--	103	91	38	2	0	234
2010	--	65	61	37	5	9	177
2009	---	45	27	4	1	1	78
2008	---	18	14	6	0	0	38
2007	---	17	8	4	0	0	29
2006[a]	---	79	66	35	24	19	223
2005	---	145[B]	97[B]	74	38	60	172
2004	---	99[B]	67[B]	55	18	6	79
2003	---	174	149	123	30	7	483
2002	152	47	45	30	8	2	284
2001	41	1	0	0	0	0	42
2000	231	55	51	53	7	2	399
1999	49[B]	55	26	12	3	0	96
1998	162[B]	21	10	7	0	1	39
1997	342	94	88	50	10	3	587
1996	299	68	52	23	9	10	461
1995	---	54	41	11	9	1	116
1994	142	33	22	10	1	0	208
1993	95	3	0	0	0	0	98
1992	99	15	9	3	0	0	126
1991	---	97	65	45	20	28	255
1990	---	71	59	17	2	1	150
1989	---	122	129	63	22	16	352
1988	---	181	151	59	29	51	471

- - - data not collected, [A] Data from November 19 survey, only 2 of 5 transects surveyed on final survey (11/26), [B] Counts from previous week because area not counted on final survey

Appendix E

Critical life stage milestones and periods of protection for fall Chinook salmon fry rearing in the Hanford Reach of the Columbia River

Dates for life-stage milestones are estimated with ATU and mean values are presented as Julian dates. Beginning in 1999, early rearing protections were extended beyond the Emergence Period. The dates for protections under the HRFCPPA (2004-present) are based on ATU and dates under the IHFCPP (1999 – 2003) are based on fall Chinook salmon fry presence in near-shore areas and encountered in random sampling by WDFW.

Brood Year	Initiation of Spawning			End of Spawning	Beginning Hatch	Start of Emergence	End of Emergence	End of Rearing Period	Duration of Emergence	Duration Emergence and Rearing protections
	<36 kcfs	36-50 kcfs	>50 kcfs							
2015	10/21/2015	10/21/2015	10/21/2015	11/22/2015	11/29/2015	2/25/2016	4/29/2016	5/30/2016	65	96
2014	10/22/2014	10/28/2014	10/28/2014	11/23/2014	11/29/2014	2/26/2015	5/2/2015	6/3/2015	66	98
2013	10/23/13	10/23/13	10/23/13	11/24/13	12/1/13	3/23/14	5/20/14	6/19/14	58	88
2012	10/24/12	10/24/12	10/31/12	11/18/12	12/2/12	3/2/13	4/26/13	6/2/13	56	93
2011	10/19/11	10/26/11	10/26/11	11/20/11	12/8/11	3/8/12	5/15/12	6/17/12	69	102
2010	10/27/10	10/27/10	11/3/10	11/21/10	11/26/10	2/27/11	5/16/11	6/20/11	79	114
2009	10/21/09	10/28/09	11/4/09	11/22/09	11/30/09	3/2/10	5/2/10	6/9/10	62	100
2008	10/22/08	10/29/08	10/29/08	11/23/08	11/30/08	3/27/09	5/25/09	6/24/09	60	90
2007	10/24/07	10/31/07	11/7/07	11/18/07	12/5/07	3/29/08	5/13/08	6/17/08	46	81
2006	10/25/06	10/25/06	11/1/06	11/26/06	12/9/06	4/4/07	5/20/07	6/20/07	47	78
2005		10/19/05	10/19/05	11/20/05	11/25/05	2/17/06	5/5/06	6/9/06	78	113
2004		10/20/04	10/27/04	11/28/04	11/27/04	2/28/05	5/13/05	6/13/05	75	106
2003		---	10/22/03	11/23/03	12/2/03	3/20/04	5/10/04	6/12/04	52	85
2002		10/23/02	10/30/02	11/24/02	12/2/02	2/20/03	4/27/03	6/5/03	67	106
2001		10/31/01	---	11/18/01	12/14/01	3/17/02	4/25/02	6/4/02	40	80
2000		10/25/00	10/25/00	11/19/00	12/9/00	4/1/01	5/10/01	6/10/01	40	71
1999		10/27/99	10/27/99	11/21/99	12/10/99	3/20/00	5/2/00	6/26/00	44	99
1998		10/28/98	11/11/98	11/29/98	12/5/98	3/8/99	5/11/99	6/30/99	65	115
1997		10/22/97	10/22/97	11/23/97	12/3/97	3/12/98	5/4/98		54	
1996		10/23/96	10/23/96	11/24/96	12/12/96	4/30/97	6/4/97		36	
1995		10/18/95	10/25/95	11/19/95	12/7/95	5/17/96	6/22/96		37	
1994		10/26/94	11/2/94	11/20/94	12/13/94	4/23/95	5/28/95		36	
1993		10/27/93	---	11/21/93	12/11/93	3/27/94	5/8/94		43	
1992		10/21/92	10/28/92	11/22/92	11/28/92	4/2/93	5/24/93		53	
1991		10/23/91	10/23/91	11/24/91	12/2/91	2/20/92	4/21/92		62	
1990		10/24/90	10/24/90	11/18/90	12/4/90	4/13/91	5/23/91		41	
1989		10/18/89	10/25/89	11/19/89	11/23/89	2/4/90	4/29/90		85	
1988		10/19/88	10/26/88	11/20/88	11/24/88	3/5/89	5/14/89		71	

Appendix F

Summary of discharge from Priest Rapids Dam, during the fall Chinook salmon Emergence and Rearing periods under the IHFCPP and HRFCPPA, 1999-present.

Brood Year	Emergence and Rearing Period Dates	Total Days	Mean Daily Discharge (kcfs)	Mean Daily Discharge Delta (kcfs)	Daily Delta/ Daily Discharge (%)	Daily Discharge Delta (kcfs)				
						<20	20-40	40-60	60-80	>80
2015	Feb 25-May 30, 2016	96	145.8	31.9	21.9	24	52	16	4	0
2014	Feb 26-Jun 3, 2015	98	128.9	29.3	22.7	18	72	8	0	0
2013	Mar 23-Jun 19, 2014	88	173.3	42.4	24.4	5	42	31	7	4
2012	Mar 2-Jun 2, 2013	93	147.2	34.7	23.6	23	30	22	10	2
2011	Mar 8-Jun 17, 2012	102	194.6	68.0	34.9	5	21	31	12	33
2010	Feb 27-Jun 20, 2011	114	196.7	31.9	16.2	5	50	31	17	11
2009	Mar 2-Jun 9, 2010	100	93.6	22.1	23.6	37	45	4	0	0
2008	Mar 28-Jun 25, 2009	89	132.0	40.2	30.4	11	37	17	4	7
2007	Mar 29-Jun17, 2008	81	148.1	38.1	25.7	18	37	11	9	6
2006	Apr 4-Jun 20, 2007	78	171.7	34.8	20.3	15	34	23	6	0
2005	Feb 13-Jun 9, 2006	117	146.2	41.3	28.2	21	48	26	10	12
2004	Feb 28-Jun 13, 2005	106	109.0	27.2	25.0	34	59	8	2	3
2003	Mar 21-Jun 12, 2004	84	110.4	28.0	25.4	32	30	20	0	2
2002	Feb 20-Jun 5, 2003	98	117.0	33.3	28.5	32	28	26	10	2
2001	Mar 21- Jun 4, 2002	76	131.2	47.1	35.9	19	9	26	11	11
2000	Mar 26-Jun 10, 2001	77	70.6	23.2	32.9	45	11	12	8	1
1999	Mar 21-Jun 26, 2000	98	148.2	50.0[A]	33.7	9	30	34	13	12
1998	Mar 10-Jun 30, 1999	113	161.4	42.1	26.1	13	51	27	12	10
mean		94.9	140.4	36.9	26.6	36.9	20.3	38.1	20.7	7.5

[A] Interim protection plan called for rewetting of dewatered areas during eight days. Mean Daily Discharge Delta was 39.5 kcfs without the rewetting operations

Appendix G
Summary of constraints and performance under the HRFCPPA, 2004-present.

Migration year	Weekday Constraint		Weekend Constraint		Combined			CJAD II weekends – difference between minimum discharge and constraints (kcfs)				
	Targets	Met	Targets	Met	Targets	Met	%	1	2	3	3	5
2016	68	68	28	27	96	97	99.0	1.1	49.8	-4.0	3.0	
2015	70	69	28	28	98	97	99.0	1.1	3.2	7.6	10.3	
2014	64	64	25	25	89	89	100.0	4.6	6.0	20.1	21.9	
2013	65	64	14	13	79	77	97.5	10.9	36.4	4.5	-27.0	
2012	72	72	15	15	87	87	100.0					
2011	81	80	17	15	98	95	96.9					
2010	72	68	14	14	86	82	95.3					
2009	63	57	13	11	76	68	89.5					
2008	57	57	12	9	69	66	95.7					
2007	56	55	11	8	67	63	94.0					
2006	84	66	16	11	100	77	77.0					
2005	76	60	15	7	91	67	73.6					
2004	60	39	13	8	73	47	64.4					
Mean	68.3	62.6	16.0	13.6	84.4	76.2	90.2					