2014-15 Hanford Reach Fall Chinook Protection Program Report for the 2014 – 2015 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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1.0 Background

The Hanford Reach (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 Hanford Reach Fall Chinook Protection Program Agreement (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).

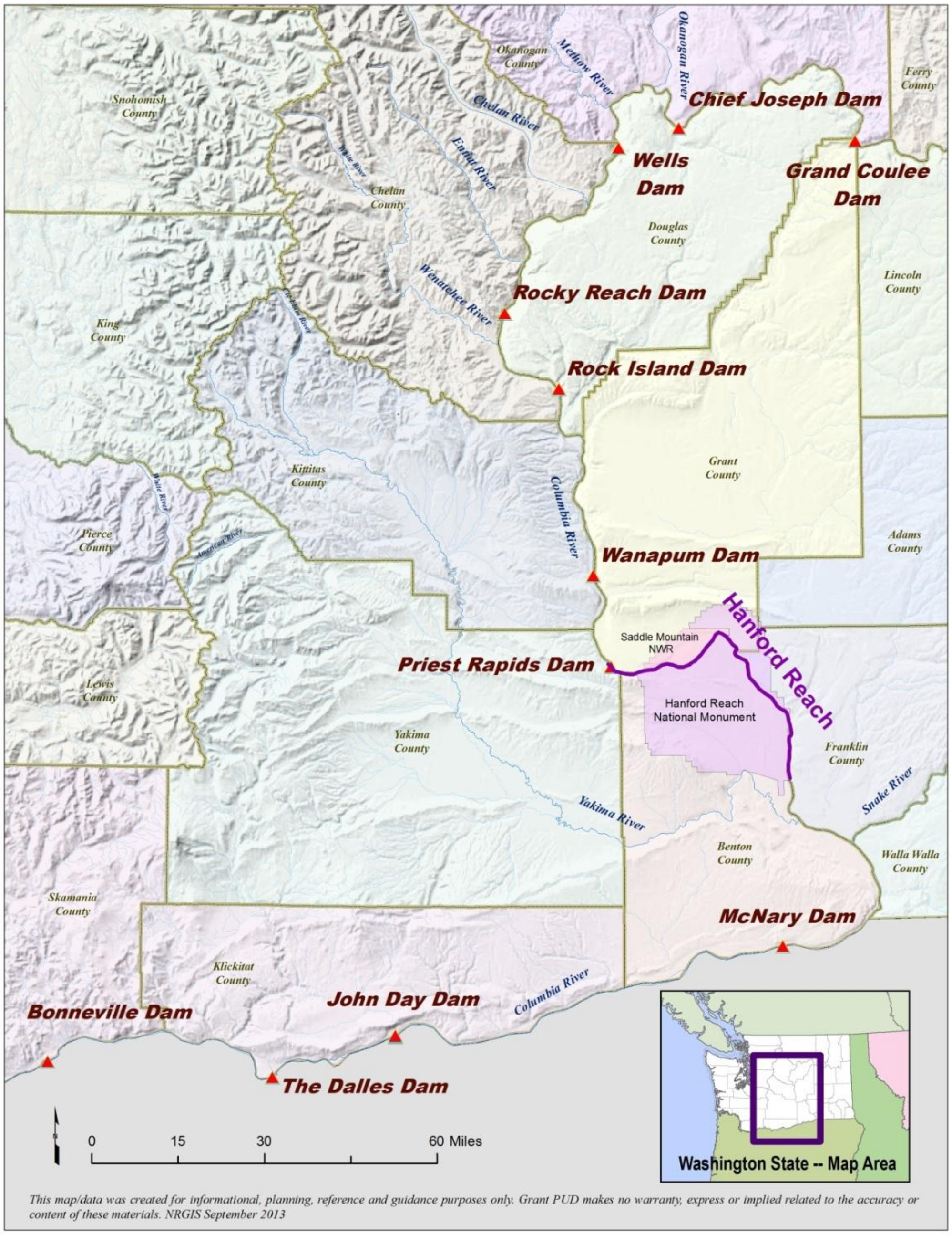

Figure 1 **Major dams in the United States portion of the Columbia River. The Hanford Reach of the Columbia River extends from the Priest Rapids Dam downstream through the Hanford Reach National Monument.**

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 Vernita Bar Settlement Agreement 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.

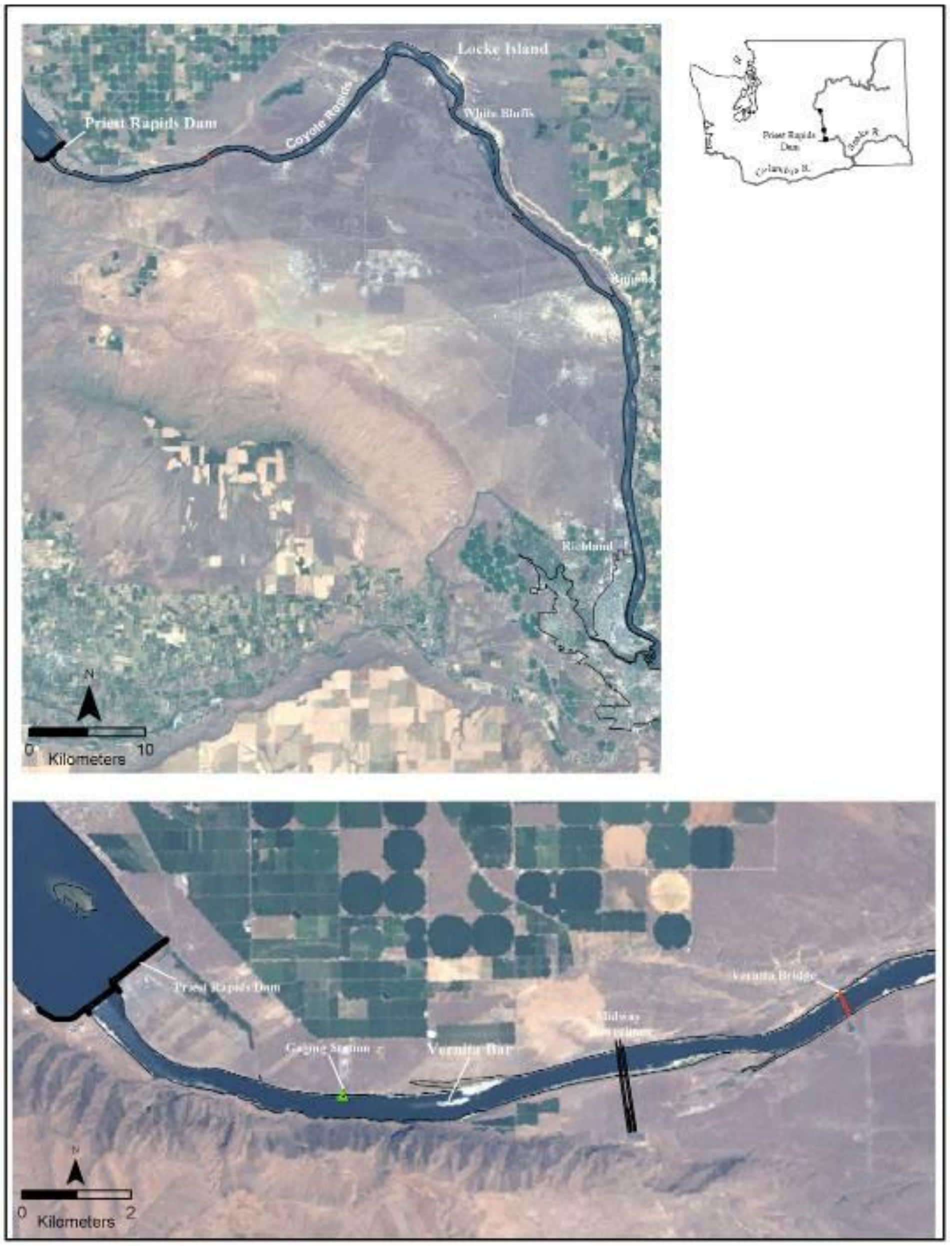

Figure 2 Vicinity of Priest Rapids Dam and Vernita Bar of the Columbia River.

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 Hanford Reach Up River Bright Fish Population Status

The Hanford Reach provides productive spawning and rearing areas for fall Chinook salmon and serves as a migratory corridor for many other species of anadromous and resident fishes. Anadromous fishes include spring, summer, and fall Chinook salmon, coho, and sockeye salmon; steelhead; shad; and Pacific lamprey. White sturgeon, formerly an anadromous species, has suffered from passage problems at Columbia River dams and is now resident in the Hanford Reach. Native resident fish species observed in or using the Reach include mountain whitefish, northern pikeminnow, sand roller, redside shiner, three-spine stickleback, suckers, and sculpins.

The population of fall Chinook salmon that spawns in the Hanford Reach is a major component of what is referred to as Upriver Bright (URB) fall Chinook salmon (ODFW and WDFW, 2003). The URB Chinook salmon produced in the Reach are heavily utilized as a fishery in the Columbia River and Pacific Ocean. The Hanford Reach stock represents the bulk of the Upper Columbia River Bright management unit (fall Chinook salmon that spawn primarily upstream of McNary Dam). This management unit is considered an indicator stock by the Pacific Salmon Commission, and is under the jurisdiction of the Pacific Salmon Treaty. The URB stock of fall Chinook salmon is a far north migrating stock and a major contributor to ocean fisheries off

Southeast Alaska and British Columbia. Between 1990 and 2012, wild Chinook from the Hanford Reach have comprised on average 14% (range 4 – 26%) of the Chinook salmon catch in southeast Alaska troll fishery and 4.5% (range 0 – 12%) of the North British Columbia catch (PSC 2015).

Within the Columbia River, tribal and non-tribal URB fisheries are set within the guidelines and limits of the Columbia River Fish Management Plan (CRFMP), the Endangered Species Act (ESA), and management agreements negotiated by Parties to the *U.S. v. Oregon* court case (ODFW and WDFW 2008). The URB stock is the backbone of the non-tribal fall season sport and commercial fisheries; and ceremonial, subsistence and commercial treaty Indian fisheries of four Native American tribes in the mainstem Columbia River.

Since 2004, an average of 35.4% (range 22%-50.3%) of the Columbia River's URB fall Chinook salmon counted at McNary Dam have escaped to the Hanford Reach. The URB population spawning in the Reach may also be considered a critical "core population" of fall Chinook salmon in the Columbia River system that may be used to re-colonize nearby tributaries and mainstem areas (ISG 1996). Returns of adult URBs to spawn in the Hanford Reach were relatively stable at low levels from the early 1960s to the early 1980s. Following the implementation of ocean harvest restrictions, spawning escapement increased to nearly 90,000 adults in the late 1980s. Throughout much of the 1990s, escapement was depressed to around 40,000 adults as a result of poor ocean productivity (Anglin et al. 2006). From 2001 to 2005, ocean productivity improved, harvest restrictions have been maintained, and escapement during 2003 rebounded to nearly 90,000 adults. In 2007, numbers fell to less than 14,000 adults, the lowest estimated adult escapement in over 30 years. Since 2007, spawning escapement has rebounded to more than 50,000 adults from 2010 – 2013, and in 2013 and 2014 reached over 150,000, the highest recorded escapements since record keeping began in 1964.

Fall Chinook salmon in the Hanford Reach typically spawn from late October through November. Eggs begin to hatch after approximately 500 (°C) temperature units have accumulated (ATU) from the date of spawning (November – December). Fry begin to emerge from the gravel at approximately 1,000 ATU, usually in March or April, with emergence typically complete by late June to early July. Spawning escapements during recent years have produced between 5 and 138 million juvenile fall Chinook salmon that rear in the Hanford Reach during spring and early summer (Harnish et al. 2012).

3.1 2008-2017 United States v. Oregon Management Agreement

The Parties to the *U.S. v. Oregon* case have negotiated agreements for the management of upper Columbia River fall Chinook salmon. In 1999, a management goal of 46,000 adult fall Chinook salmon upstream of McNary Dam was set to provide for a sport fishery in the Hanford Reach, hatchery broodstock collection above McNary Dam, and an interim spawning escapement[1] goal of 40,000 naturally spawning fall Chinook salmon (ODFW and WDFW 2000). It is recognized by fishery managers that the stock-recruitment-based interim escapement goal of 40,000 naturally spawning adult fall Chinook salmon was developed with limited data during a time frame when the Hanford Reach URB population was adjusting to significant hydrosystem management events. For example, construction of John Day Dam and filling of the reservoir in 1968 displaced a portion of this substantial, naturally spawning population from the John Day

[1] Escapement is that portion of the population that returns to naturally spawn in-river. (Total return minus natural mortality, harvest and hatchery returns).

reservoir area to the Hanford Reach and other areas. In addition, the historic escapement range of naturally spawning fall Chinook salmon used in the stock-recruitment analyses for the interim goal was relatively narrow compared to recent higher escapements, which may have biased low the interim escapement goal. It should be noted that the interim escapement goal was developed during a period when the hydrosystem was managed primarily for hydropower production, and that these conditions may not have been conducive to high productivity of the URB population during the freshwater life stage. Currently, management focuses on a balance between hydropower production and natural resources and could influence future stock-recruitment analyses.

In May of 2008, a federal judge approved a new 10-year agreement guiding salmon harvest and production on the Columbia River. The agreement, approved by U.S. District Court Judge Garr M. King in Portland, was developed by four of the Columbia Basin's treaty tribes (Umatilla, Yakama, Warm Springs and Nez Perce) and the states of Washington, Oregon and Idaho, under provisions of the *U.S. v Oregon* court judgment of 1969. The 2008 *U.S. v. Oregon* Agreement ends years of negotiation. A previous 10-year management agreement expired in 1999. Since then, Columbia River fisheries were managed under a series of interim agreements. The 2008 *U.S. v. Oregon* fisheries agreement is the result of several legal decisions by federal courts that determined tribes have a treaty right to harvest a fair share (50%) of the harvestable fish destined to reach the tribes' usual and accustomed fishing places and established the tribes as co-managers of the fisheries.

The 2008 *U.S. v. Oregon* fisheries agreement introduces a number of new approaches into the management of Columbia River fisheries. The agreement details harvest management guidelines and artificial production techniques that, working together with habitat protection authorities and other enhancement efforts, will help to ensure that Columbia River fish runs continue to provide a broad range of benefits. The 2008 *U.S. v. Oregon* Agreement provides a framework within which the tribes, states and federal government may exercise their independent sovereign powers in a coordinated and systematic manner in order to protect, rebuild, and enhance upper Columbia River fish runs while providing harvests for both treaty Indian and non-treaty fisheries.

Concerning the escapement and management objectives for fall Chinook salmon above McNary Dam the Agreement states:

> *"The Parties agree that the minimum combined Columbia River and Snake River upriver bright management goal at McNary Dam is 60,000 adult fall Chinook, which includes both hatchery and natural production for all areas above McNary Dam. The 60,000 McNary Dam goal will be used as part of the annual calculation of harvestable surplus and allocation shares. The Parties also agree that the minimum Upriver Bright adult escapement to meet the combined Hanford Reach, lower Yakima River, and mainstem Columbia River above Priest Rapids Dam natural spawning goal, as well as the current Priest Rapids Hatchery production goal is 43,500 adult fall Chinook (this historically included a minimal run to the Snake River). In the event of anticipated low returns of upriver bright fall Chinook to the Hanford Reach, notwithstanding the provisions of Table A3, ocean and in-river fisheries will be managed at the discretion of the Parties to help achieve the escapement goal. If future hatchery production is modified as a result of mitigation agreements or new production programs, then the Parties will instruct TAC to calculate appropriate adjustments to the McNary Dam*

management goal to address program adjustments and natural production needs for this area. TAC will present its recommended adjustments to the Policy Committee."

3.2 Hanford Reach Escapement Estimates

The Washington Department of Fish and Wildlife has historically estimated escapement; sampled fall Chinook salmon in the escapement; and reconstructed the return by age, sex, and stock as part of the Columbia River fall Chinook salmon stock assessment effort. The number of adult fall Chinook salmon spawning in the Hanford Reach is estimated each year by using official adult counts from the U.S. Army Corps of Engineers fish passage report for the corresponding year (U.S. Army Engineer Districts Portland and Walla Walla) and the following formula:

- HR spawners = MD – (IH+(PRD*FB)+PRH+RH+HRF+YR)
- Where:

MD : McNary Dam adult counts

IH : Ice Harbor Dam adult counts

PRD : Priest Rapids Dam adult counts

FB : Adjustment for fallback of salmon at Priest Rapids Dam. The value 0.90 is used for the estimated 10% fallback rate and 1.0 is used for unadjusted counts unless specific fallback information is available

PRH : Number of adults captured at the Priest Rapids Hatchery trap and Hatchery discharge channel (leading to Priest Rapids Hatchery trap) redd counts

RH : Number of adults captured at the Ringold Hatchery trap

HRF : Estimated number of harvested adults in the Hanford Reach fishery

YR : Estimated adult escapement for Yakima River using adult counts at Prosser Dam and Marion Drain, as well as lower Yakima River redd counts and creel surveys

Adult escapement estimates from this formula assume no natural or hooking mortality and accurate accounting of fish harvested and at the fish ladders of Priest Rapids, McNary, Ice Harbor, and Prosser dams. The final estimated Hanford Reach fall Chinook salmon spawning escapement in 2014 was 183,807 Chinook salmon, 152,517 adults and 31,290 jacks (Table 1 and Appendix D). The 2014 fall Chinook escapement estimate was the largest recorded total return and second largest adult return to the Hanford Reach on record (since 1964). Escapement to McNary in 2013 and 2014 was 224% and 215% larger than the previous highest escapement year (2012), respectively. The 2013 and 2014 escapements to the Hanford Reach were 173% and 182% larger than the previous highest escapement estimate (2003), respectively (Figure 3).

Table 1 Fall Chinook salmon adult and jack counts for 2013 and 2014

Count Source		**2014**			**2013**		
		Adult	Jack	Total	Adult	Jack	Total
Adult	**McNary**	410,786	76,110	486,896	454,991	54,367	509,358
	Wanapum	52,424	7,240	59,664	91,618	7,489	99,107

	Priest Rapids	120,099	12,321	132,420	260,962	18,363	279,325
	Fallback Adjustment	40,593	4,164	44,757	113,231	7,968	121,199
	Ice Harbor	61,389	17,944	79,333	57,850	19,133	76,983
	Prosser	7,004	654	7,658	6,823	684	7,507
Hatcheries	Priest Rapids Hatchery	64,721	11,945	76,666	38,628	3,008	41,636
	Priest Rapids Hatchery Channel	9	0	9	257	7	264
	Angler Broodstock Collection	305	0	305	402		402
	Ringold Springs Hatchery	12,205	2,049	14,254	16,358	528	16,886
Harvest	Hanford Sport Harvest	28,679	3,738	32,417	24,921	2,709	27,630
	Yakima River Sport Harvest	1,568	66	1,634	2,532	352	2,884
	Wanapum Tribal Fishery	29	1	30	69	0	69
Escapement	Yakima River (Lower)	2,854	266	3,120	1,936	194	2,130
	Hanford Reach + Priest Pool	179,599	32,207	211,806	213,597	20,263	233,860
	Priest Pool	27,082	917	27,999	56,113	2,906	59,019
	Hanford Reach	**152,517**	**31,290**	**183,807**	**157,484**	**17,356**	**174,841**

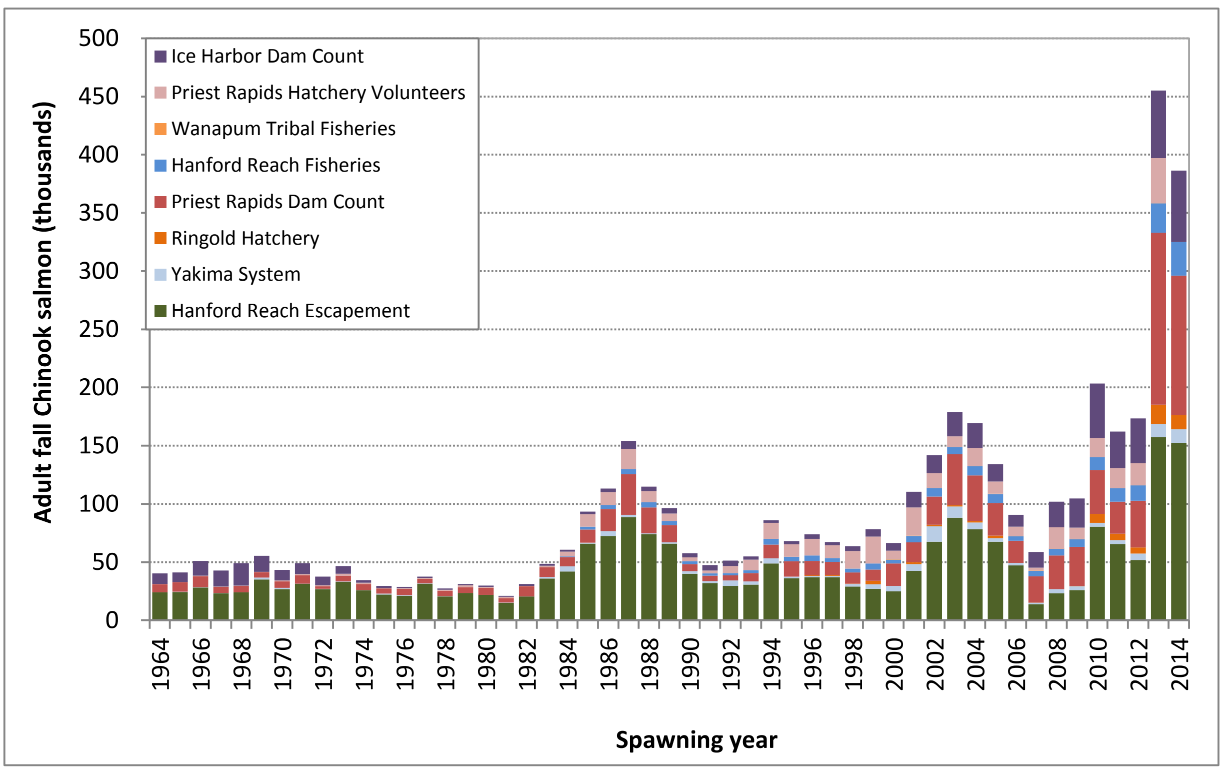

Figure 3 Adult fall Chinook salmon counts upriver of McNary Dam, 1964-present.

3.3 Fall Chinook Salmon Egg Production Estimate

Sex ratios are recorded during the sport-fishing creel survey, hatchery trapping, and carcass surveys. The sex ratio can be highly variable between methods. Of the 805 adult Chinook salmon sampled during the 2014 Hanford Reach fall Chinook salmon sport fishery, the female composition was 49.6% (Table 2; Hoffarth 2015). Female composition in carcass surveys and in volunteer returns to the Priest Rapids Hatchery (PRH) was 51.7% and 47.8%, respectively (Hoffarth 2015). The fecundity of PRH returns are used as an estimate of natural-origin fecundity. Adult female fall Chinook salmon sampled from the natural spawners in the Hanford Reach average 81cm in fork length. Comparable size Chinook salmon at Priest Rapids Hatchery had an average fecundity of 4,284 eggs per female. Spawning success was estimated to be 93.3% based on egg retention rates of 1,636 female fall Chinook salmon that were examined during carcass surveys in the Hanford Reach in 2014.

Table 2 Age and sex composition of fall Chinook salmon in the 2014 Hanford Reach sport fishery.

	Age-2	Age-3		Age-4		Age-5		Age-6		Total Adults	
	#	#	%	#	%	#	%	#	%	#	%
Male	3,738	4,164	12.8	7,822	24.1	584	1.8	39	0.1	16,346	50.4
Female	0	2,062	6.4	13,114	40.5	895	2.8	0	0.0	16,071	49.6
Total	3,738	6,226	19.2	20,935	64.6	1,479	4.6	39	0.1	32,417	

Depending on which assumptions about fallback and sex ratios are employed, fall Chinook salmon deposited 213.8 to 315.2 million eggs in the Hanford Reach during 2014 (Table 3). The wide range in the estimated egg production reflects the fact that the sheer size of the Columbia River in the Hanford Reach makes collecting accurate and precise information difficult.

Table 3 Estimates for adult escapement with and without a fallback adjustment, redds and eggs deposited in the Hanford Reach during 2014.

Source of sex ratio	Percent Females	Adult Escapement	Spawning Females	Successful Redds	Eggs Deposited (millions)	Estimated Emergent Fry (millions)
Priest Rapids Hatchery	47.8	152,517	72,903	68,019	291.4	87.4
Hanford Reach Creel	49.6	152,517	75,648	70,580	302.4	90.7
Hanford Reach Carcass	51.7	152,517	78,851	73,568	315.2	94.5
Priest Rapids Hatchery	47.8	111,924	53,500	49,915	213.8	64.2
Hanford Reach Creel	49.6	111,924	55,514	51,795	221.9	66.6
Hanford Reach Carcass	51.7	111,924	57,865	53,988	231.3	69.4
[A] Without estimated fallback rate of 33.8% for adults at Priest Rapids Dam during 2014.						

Survival estimates from egg-to-emergent fry were not available for naturally spawned fall Chinook salmon in the Hanford Reach during 2014. Healey (1998) reported that under natural conditions, 30% or less of the potential eggs deposited resulted in emergent fry or fry and fingerling migrants in the systems studied. Quinn (2005) reviewed the available literature and noted that the average egg-to-fry survival rate for Chinook salmon is about 38%. McMichael (2003) reported a mean survival of 27.8% for fall Chinook salmon from egg to fry in the Columbia River downstream from Wanapum Dam (Priest Rapids Pool). Redds monitored during the McMichael study were dewatered 3.1% of the time during the post-hatch inter-gravel rearing period. Survival from egg-to-emergent fry was estimated to be 71% during a recent study that buried cylindrical egg tubes at two locations in the Hanford Reach (Oldenburg et al. 2012). If a conservative estimate of egg-to-fry survival rate of 30% is applied to the egg production estimate for 2013, the estimated range of emergent fry in the Hanford Reach is 64.2 to 94.5 million (Table 3).

The result of calculating an estimate of fry emerging in 2014 based on the escapement estimate may be biased, as there is uncertainty about the actual spawning population in the Hanford Reach. Chinook salmon returning downstream after ascending fish ladders (fallback) reduces the accuracy of ladder counts. Natural mortality, unmonitored sport fishing, and hooking mortality that are not included in the escapement calculations within the McNary reservoir would further reduce the escapement estimate.

4.0 2014-2015 Monitoring and Operations under the HRFCPPA

4.1 Vernita Bar Surveys

The Hanford Reach Fall Chinook Protection Program establishes a Monitoring Team[2] 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 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

[2] 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.

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 2014, redd surveys on Vernita Bar were conducted on October 19th, October 26th, November 2nd, and November 23rd (Table 4). No redds were observed on the first survey (October 19th). One week later, on October 26th, a total of 13 redds were observed, but only 2 redds were counted above the 50 kcfs elevation. In accordance with the HRFCPP, the Initiation of Spawning date was set as October 22rd for the 36 – 50 kcfs elevation zone. On November 2nd a third survey was conducted. A total of 119 redds were observed above the 36 – 50 kcfs elevation zone, setting the Initiation of Spawning date for the above 50 kcfs elevation zone to October 29th. The fourth and final survey was conducted on November 23rd. A total of 52 redds at or above the 65 kcfs elevation zone, setting the Critical Elevation for the 2014 – 2015 season at 70 kcfs. The Monitoring Team consisted of Paul Hoffarth (WDFW), Peter Graf, and Mark Woodward (GCPUD). During the November 23rd survey, flows from Priest Rapids Dam at Vernita Bar were approximately 51 kcfs. During the November 23th survey, the Monitoring Team agreed that the fish spawning season had ended and that November 23rd be identified as the End of Spawning date. Therefore, a follow-up supplemental ground redd count was not required.

Table 4 Summary of redd counts from ground surveys, 2014

Date	Redd Count by Flow Level (kcfs)						Total
	36–50	50 – 55	55 – 60	60 – 65	65 – 70	Above 70	
19-Oct	0	0	0	0	0	0	0
26-Oct	11	2	0	0	0	0	13
2-Nov	---	68	37	12	1	1	119
23-Nov	---	156	175	142	32	20	525
Peak	---11	156	175	142	32	20	525

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 525 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 4), and the highest on record since 1988.

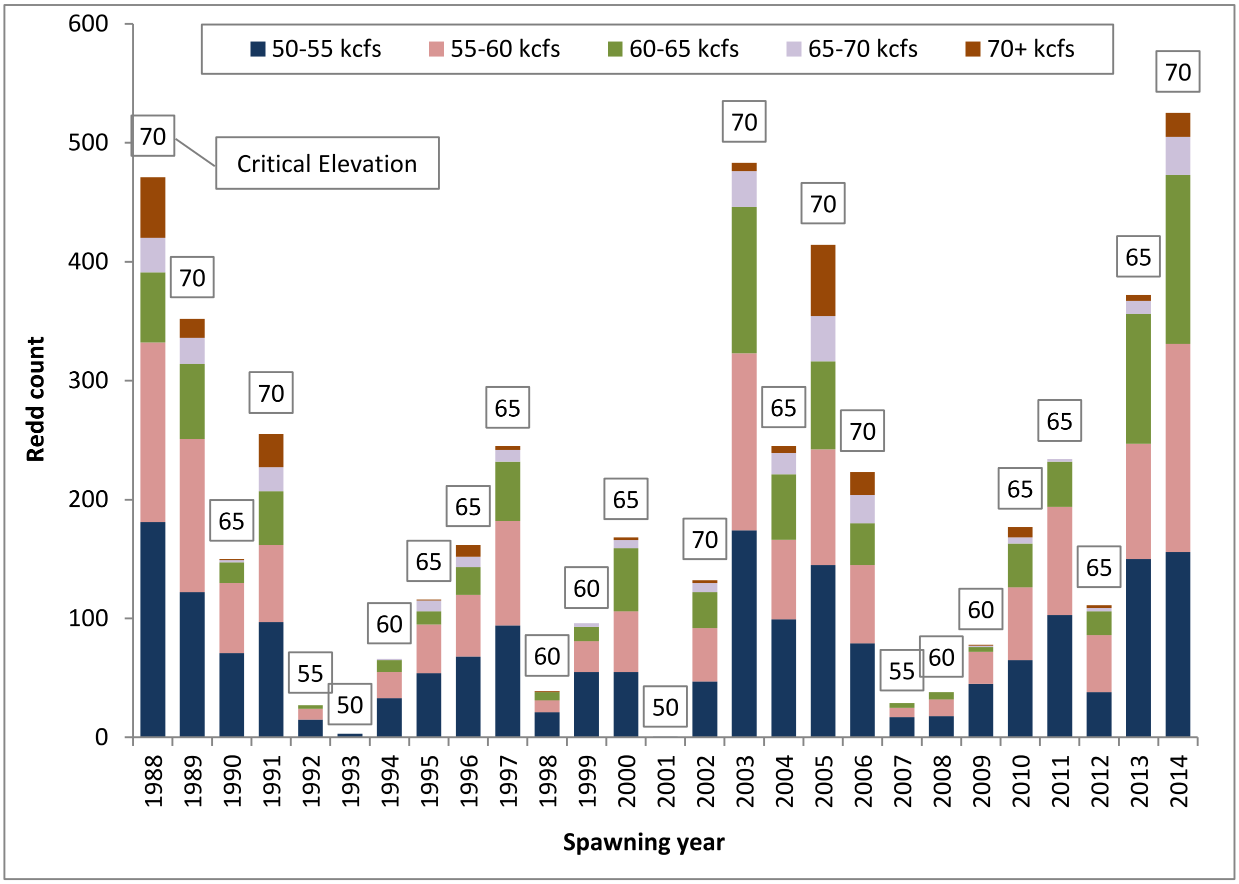

Figure 4 **Final redd abundance and distribution from ground surveys on Vernita Bar, 1988-2014. Final redd counts are not consistently conducted in the 36-50 kcfs zone and are not included in this figure. The Critical Elevation for each year is listed above the bars.**

Since 1988, the abundance and distribution of redds within the ground survey area on Vernita Bar has been highly variable (Figure 4 and Appendix E). Redd abundance is positively correlated with both Hanford Reach adult escapement and the average discharge from Priest Rapids Dam during peak spawning (Figure 5 and Figure 6). The 2013 and 2014 adult returns provided a unique opportunity to observe redd construction and site selection at unprecedented levels of escapement (Figure 3). 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 within the survey area on Vernita Bar also appears to be a function of discharge from Priest Rapids Dam during peak spawning (Oct 31 – Nov 10) (Figure 6). Higher average flows in the Hanford Reach result in increased river stage and wetted area, which in turn provides more available spawning habitat. The elevational distribution of redds is also positively correlated with escapement, particularly at the lower elevational bands (Figure 7). 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 7).

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 8). However the historically large 2013 and 2014 escapements weakened the escapement vs. Critical Elevation relationship and for now, act as outliers.

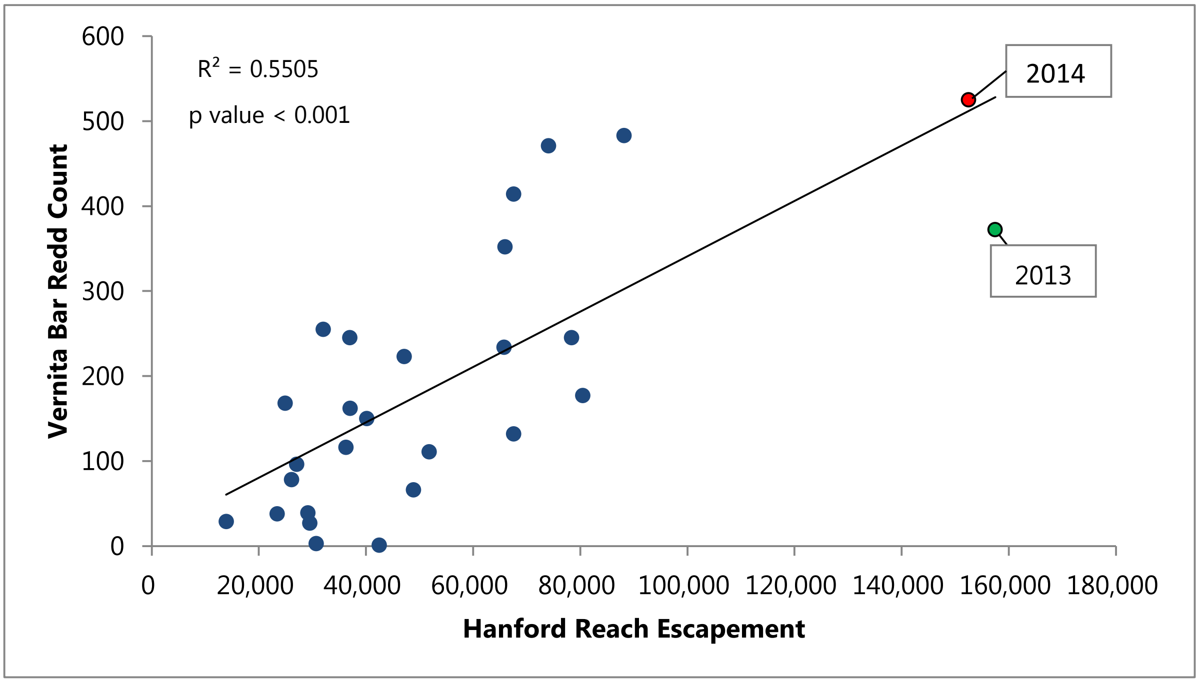

Figure 5 Relationship between Hanford Reach adult escapement and redds above the 50 kcfs elevation observed during the Vernita Bar spawning surveys (1988-2013).

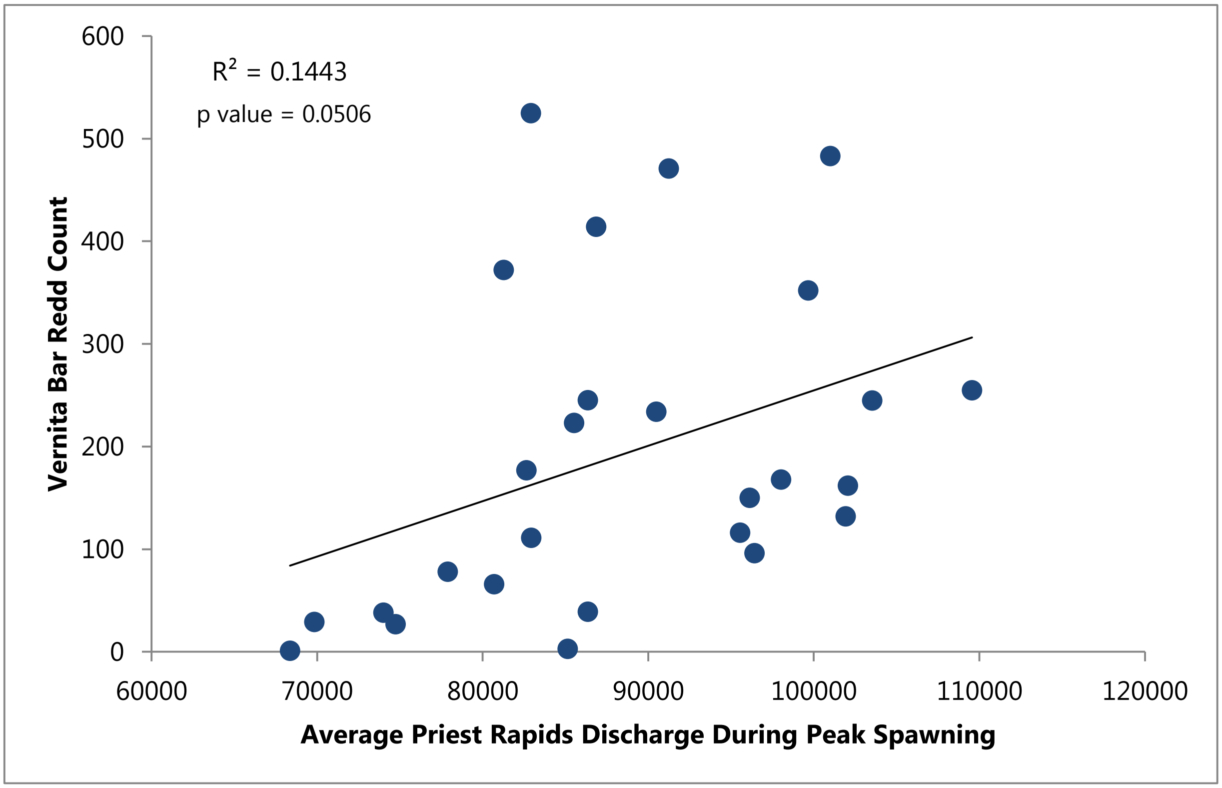

Figure 6 **Relationship between average Priest Rapids Dam discharge during peak spawning and redds above the 50 kcfs elevation observed during the Vernita Bar spawning surveys (1988-2013).**

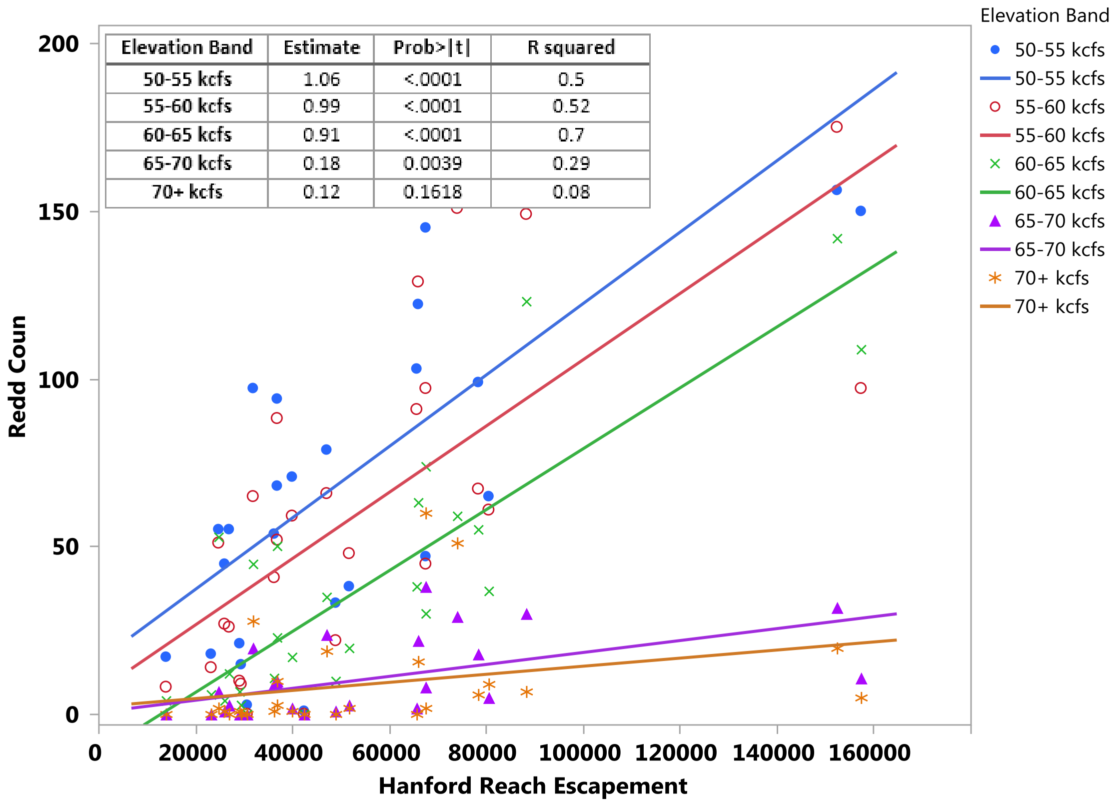

Figure 7 **Relationship between Hanford Reach escapement and redd counts on Vernita Bar by kcfs elevation bands.**

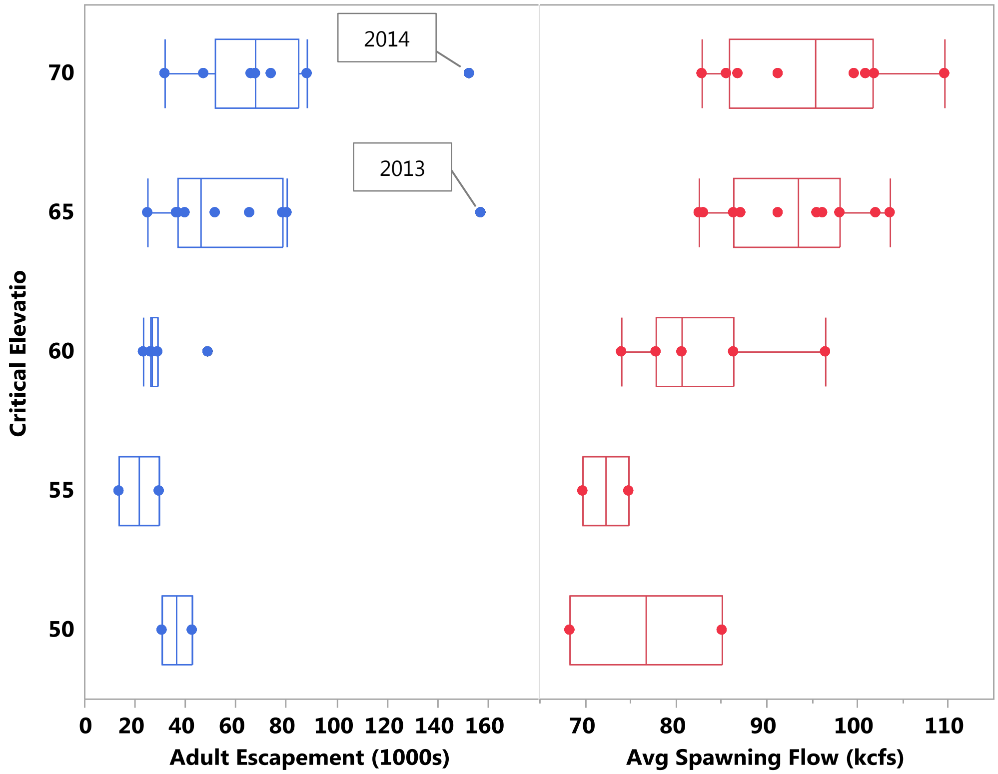

Figure 8 Relationship between Hanford Reach adult escapement and the Critical Elevation (left) and Priest Rapids Dam average discharge during peak spawning and Critical Elevation (right) (1988-2014).

4.1.1 Aerial Redd Counts

From 1948 through 2010, Pacific Northwest National Laboratory (PNNL) conducted aerial surveys to count fall Chinook salmon redds in the Hanford Reach. Environmental Assessment Services (EAS) began conducting the aerial redd counts during 2011. In 2014, aerial redd counts were conducted on October 20, November 10, November 24, and December 1.

The peak redd count for fall Chinook salmon in the Hanford Reach was 15,951in 2014 (C. Lindsey and J. Nugent 2015). This was the second highest count on record and was well above the 10-year mean of 8,100. Consistent with previous years, the primary spawning areas were Locke Island, near Islands 2, 4, 5, 6, 8, 9, and 10 and Vernita Bar (Figure 9). These areas typically account for approximately 75% of the total number of redds counted in the Hanford Reach.

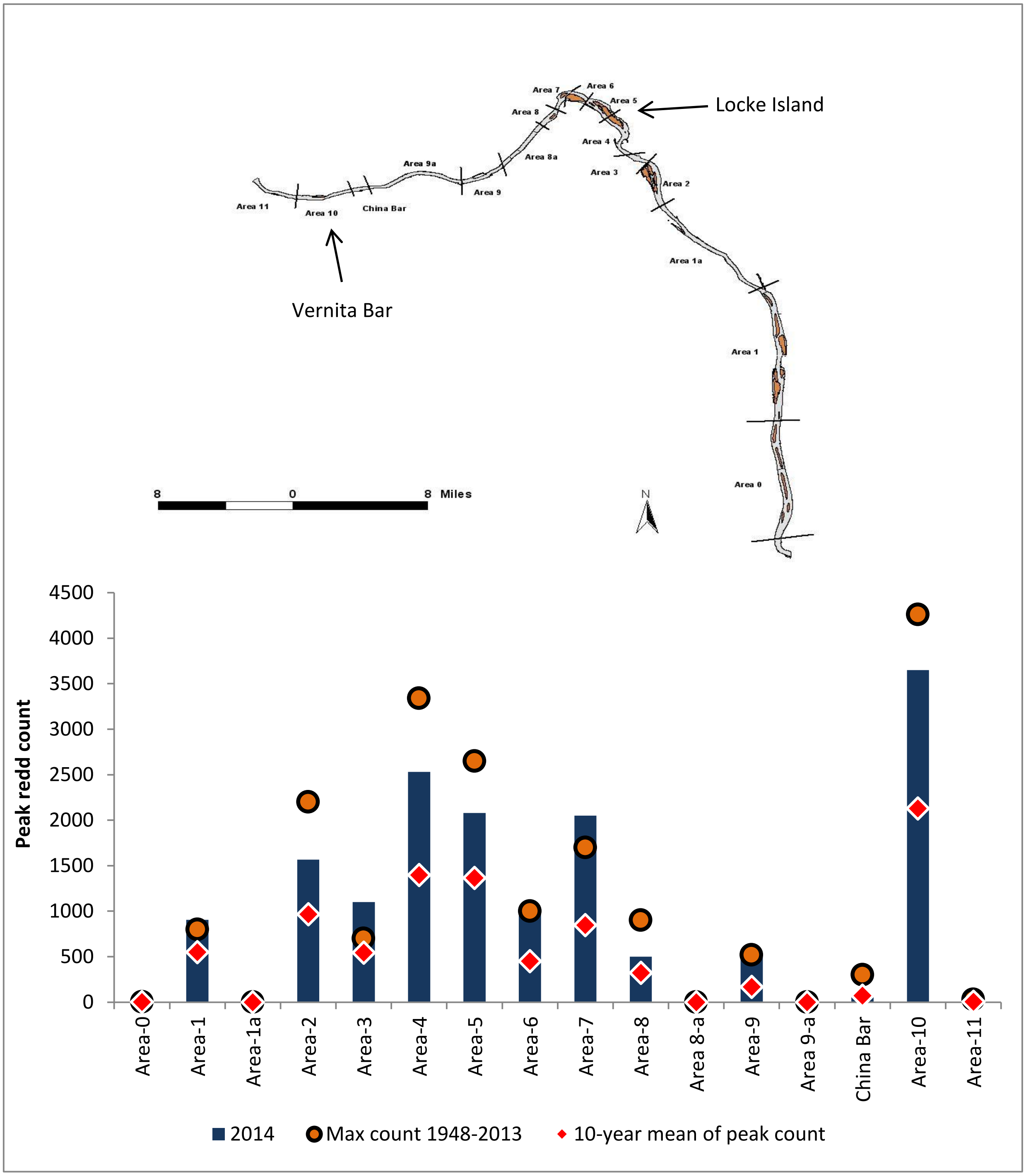

Figure 9 **Summary of peak fall Chinook salmon redd counts by location in the Hanford Reach of the Columbia River. Peak counts for 2014, the maximum for 1948-2014, and the mean peak count from the previous ten years are provided for each area. The map delineating fall Chinook salmon survey areas was provided by EAS. Vernita Bar (Area-10) and Locke Island are highlighted.**

4.1.2 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 5). 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[3] 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.

Table 5 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

[3] "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].

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 2014 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 10). Spawn timing was similar to previous years, but the warmer water temperatures from February through May resulted in the Emergence and Rearing periods beginning earlier than the long-term means (Figure 11 and Appendix F). Project operational constraints intended to reduce mortality during the Emergence and Rearing periods were in effect for 88 days in 2014 (March 23-June 19). 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.

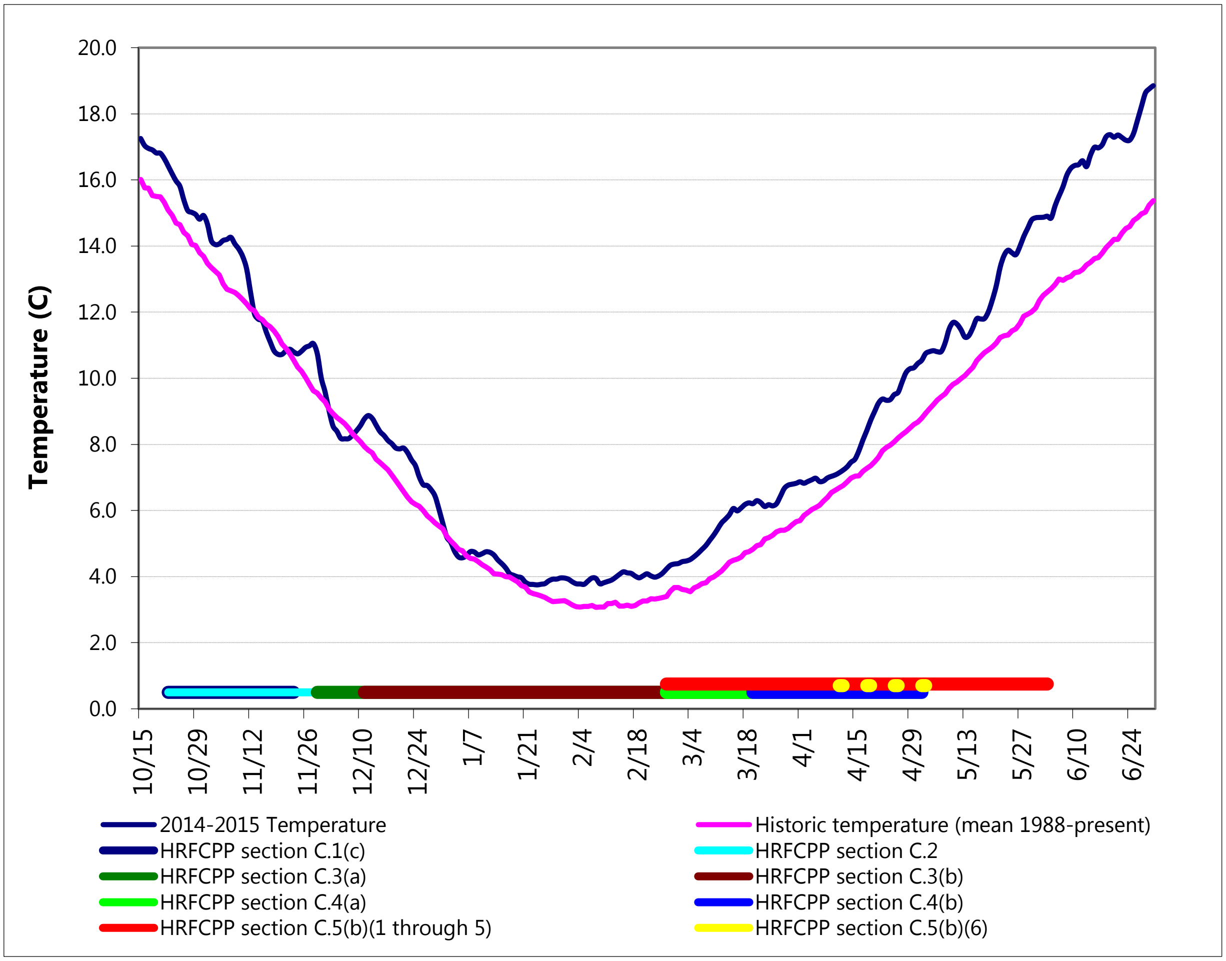

Figure 10 **Mean daily river temperatures on the Hanford Reach of the Columbia River and estimated timing of fall Chinook salmon protections based on accumulated temperature units (ATU), 2014-15.**

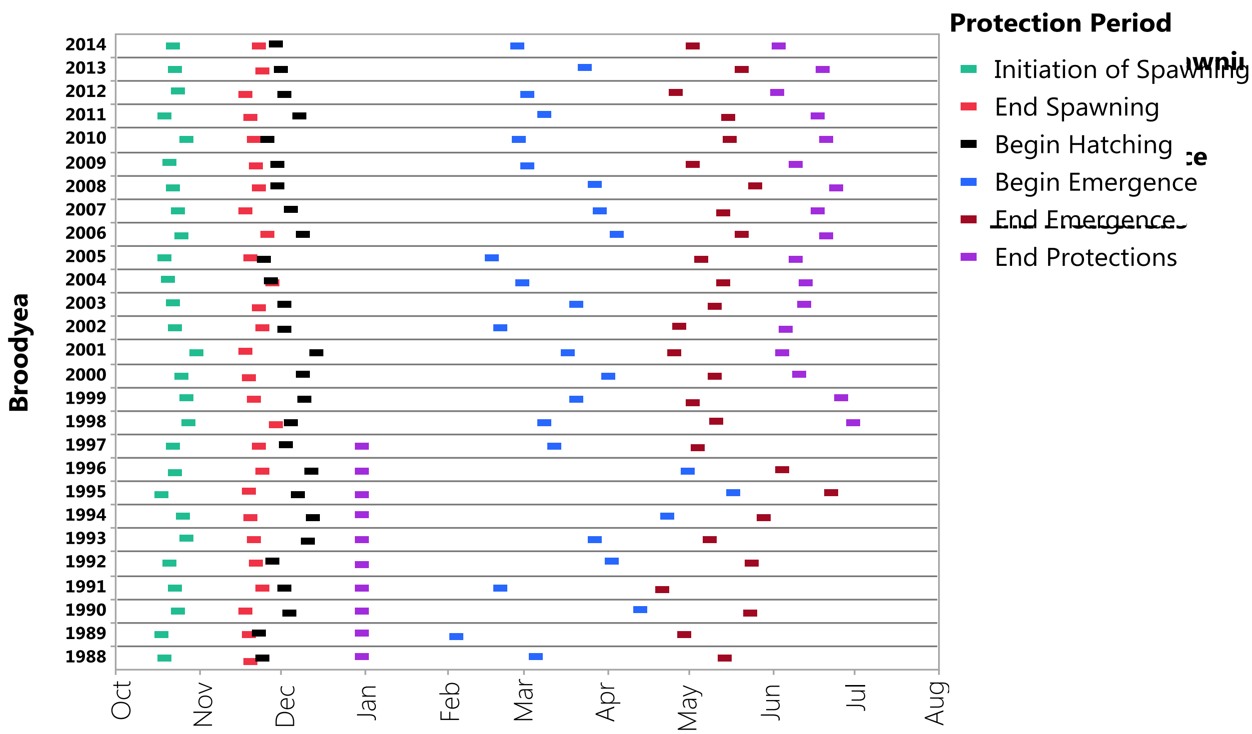

Figure 11 **Timing and duration of protection periods under the Vernita Bar Settlement Agreement and the HRFCPPA, 1988-present.**

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 2015 HRFCPPA Emergence and Rearing periods was generally greater than the 10-year mean, particularly during the early part of the Emergence and Rearing Periods (Figure 12). 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 2015 Emergence and Rearing periods was 29.3 kcfs, which was lower than the overall mean under the HRFCPPA (37.7 kcfs) (Appendix G). Even though mean daily discharge has been greater since implementation of the HRFCPPA, the magnitude of the daily fluctuations have decreased. Daily fluctuations, as a percentage of mean daily discharge, were slightly less than the mean from previous years with Rearing Period protections (23.0 vs. 27.4%). Overall, the magnitude of daily discharge fluctuations have decreased and the relative frequency of smaller fluctuations has increased (Figure 13).

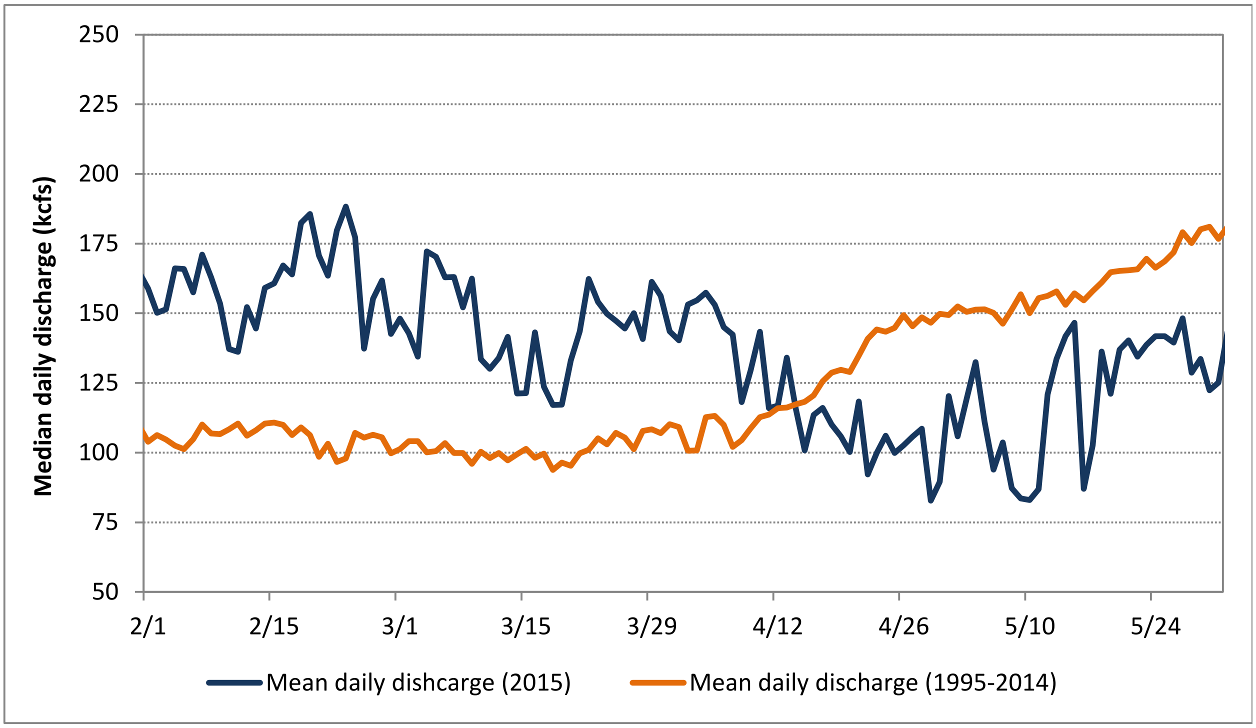

Figure 12 **Mean daily discharge from Priest Rapids Dam during the Emergence and Rearing Periods in 2014 and the mean from previous years under the VBSA and HRFCPPA.**

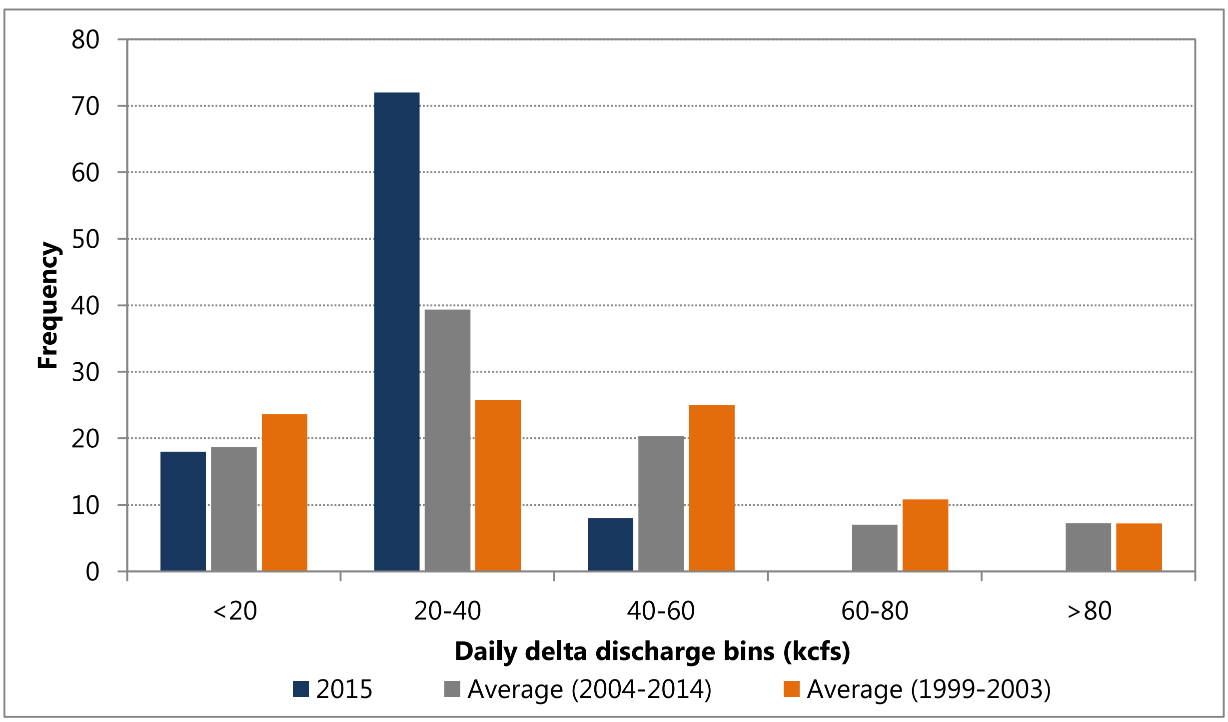

Figure 13 **Histogram of daily Outflow Deltas from Priest Rapids Dam. Some constraints restricting discharge fluctuations were initially implemented for**

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 2014, the Critical Elevation for the Post-Hatch Period (11/29/2014) through the emergence period (5/2/2015) 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 2014 Post-Hatch Period discharge at the USGS gage dropped below 65 kcfs on December 1st for eight consecutive 15-minute discharge readings (Figure 14). During the Emergence and Rearing Periods flows remained above the 70 kcfs Critical Elevation.

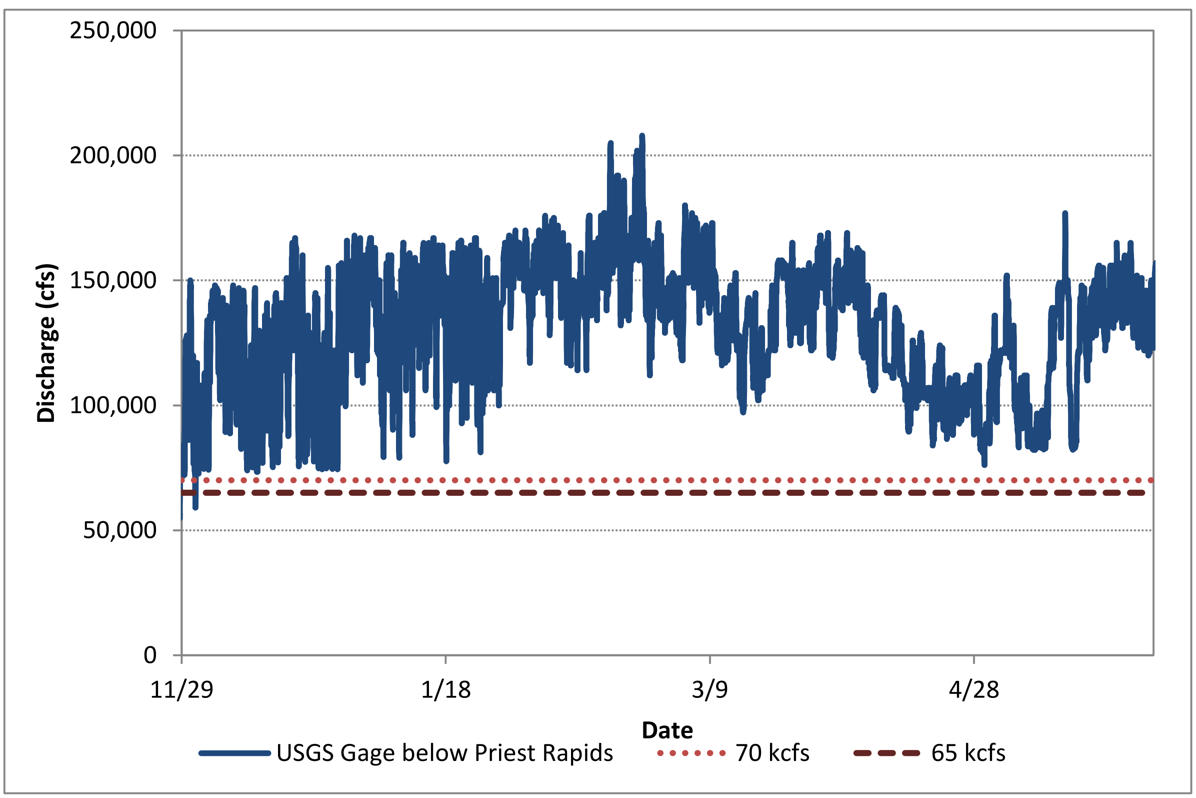

Figure 14 Discharge during the 2014-2015 Post-Hatch and Emergence and Rearing periods measured at USGS Gage 12472800 below Priest Rapids Dam with

the Critical Elevation (70 kcfs, dotted line) and the minimum discharge requirement for the Post-Hatch Period (65 kcfs, dashed line).

While any discharge readings below 65 kcfs could constitute a violation of the minimum discharge requirements, the effect on redds at or above the minimum flow elevations was likely minimal due to the short duration (two hours) that flows were below 65 kcfs. Typically, in river systems with fluctuating flows, there is a delayed response between stage change and water level within the inter-gravel spaces (Figure 15, from Oldenburg et al. 2012). For example, studies were conducted on Vernita Bar in 1984 (Grant PUD, unpublished data) on fluctuating flows and water level within the hyporheic zone. These studies demonstrated that when discharge was dropped from 100 kcfs to 50 kcfs the inter-gravel area at 15 cm below the 60 kcfs elevation remained inundated for 4 hours after the surface was dewatered. Further evidence is provided by data collected on Vernita Bar during the egg-to-fry survival study in 2010 (Oldenburg et al. 2012). Discharge at the USGS gage on December 14, 2010 was below 65 kcfs for eight consecutive hours and reached a minimum of 51.8 kcfs. Pressure sensors used in the study indicated that the minimum water surface elevation on Vernita Bar was approximately 56 kcfs. At the 70 kcfs elevation, the inter-gravel water level did not reach redd depth until the surface was dry for more than 4.5 hours.

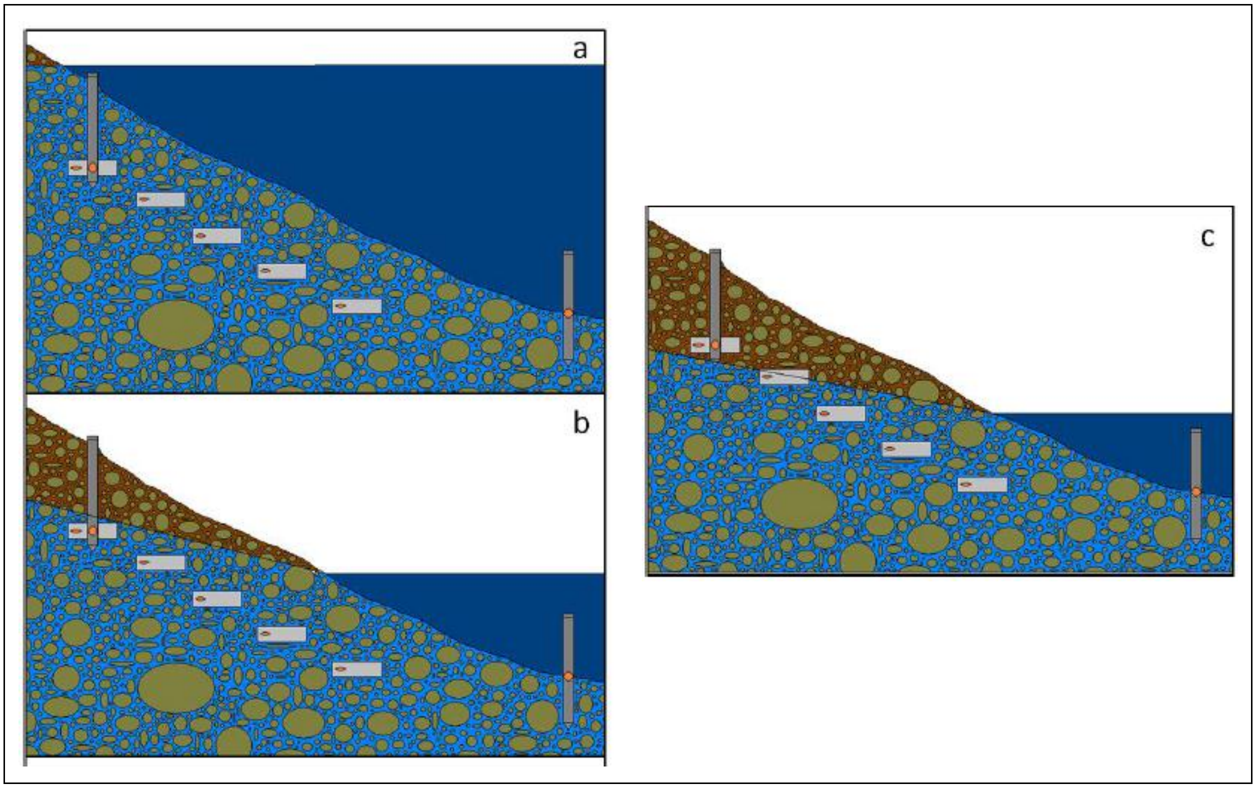

Figure 15 From Oldenburg et al. 2012, a cross section of the Columbia River and hyporheic zone under stable (panel a) and decreasing discharge (panels b and c) observed during cylindrical egg tube egg-to-fry survival studies.

Given the time lag response from reduced discharge and dewatering the inter-gravel spaces, along with the input from groundwater, it is unlikely that redds were exposed for an extended period of time to dry conditions during the December minimum flow events. Nevertheless, Grant PUD voluntarily considers these violations of the HRFCPPA until the dynamics of inter-gravel water levels are better understood. Grant PUD strives for perfect compliance of the flow constraints under the HRFCPPA and will continue to look for opportunities to improve coordination between the HRFCPPA, operational constraints, and the Mid-C Coordination to meet this goal.

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 97 days of the 2015 Emergence and Rearing periods, Grant PUD met all but one of the flow fluctuation constraints established with the HRFCPPA (Figure 16). On May 15, 2015 the daily delta from Priest Rapids Dam was 45.6 kcfs (daily maximum = 180.7 kcfs, daily minimum = 135.1 kcfs) which exceeded the daily delta constraint of 40 kcfs (previous day's inflow = 125.7) by 5.6 kcfs. This continues the trend of significant performance improvements over the years prior to 2007 (Appendix H).

Discharge in the Columbia River was high at the start of the 2015 Emergence and Rearing periods; however, by April, flow had dropped below historical norms (Figure 17). Daily delta constraints were between 30 and 60 kcfs throughout the season (Figure 18, Figure 19, and Figure 20).

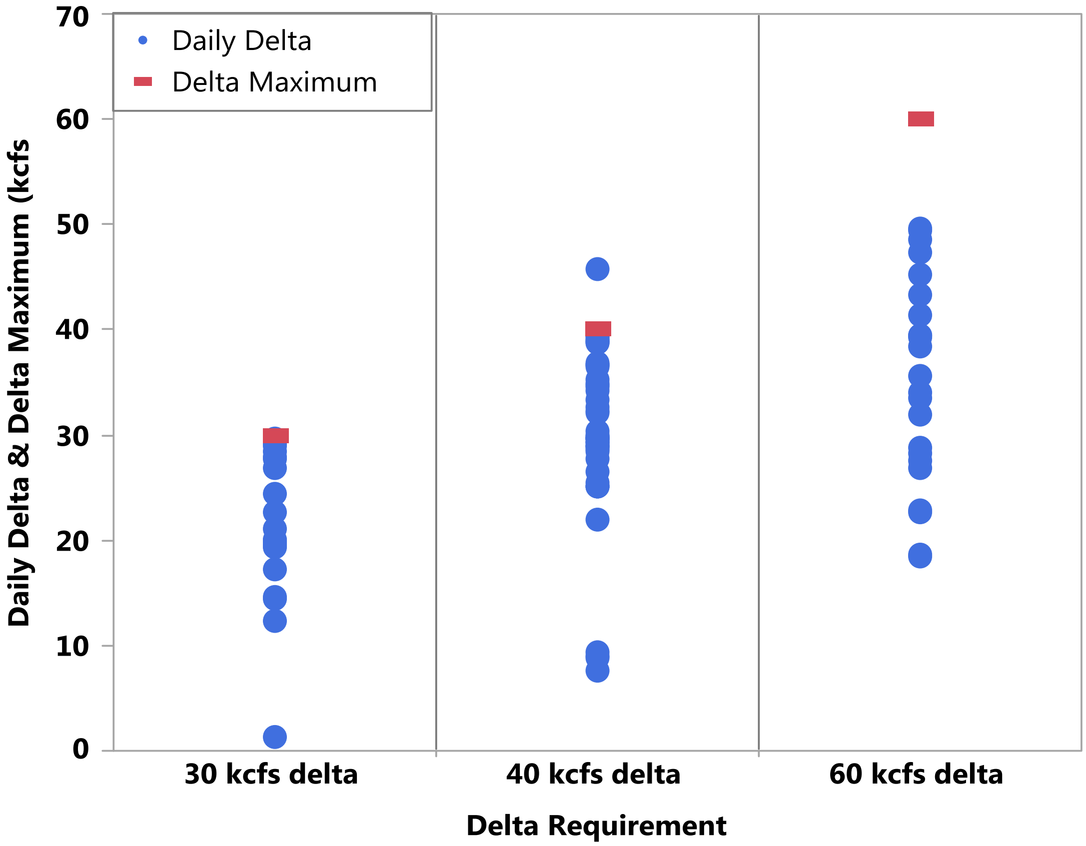

Figure 16 Summary of 2015 Priest Rapids Dam daily discharge deltas and delta maximum by constraint category.

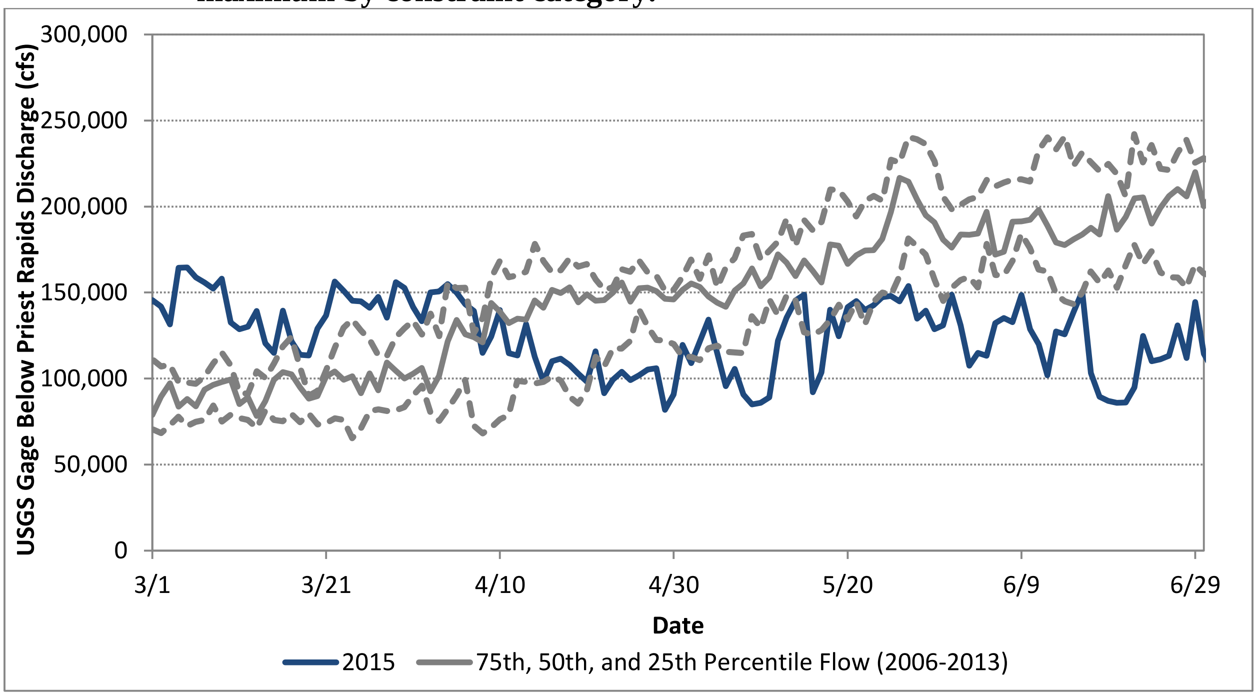

Figure 17 **Average daily discharge at the USGS Gage below Priest Rapids Dam in 2015 and the 75th, 50th, and 25th daily percentile discharge from 2006-2013.**

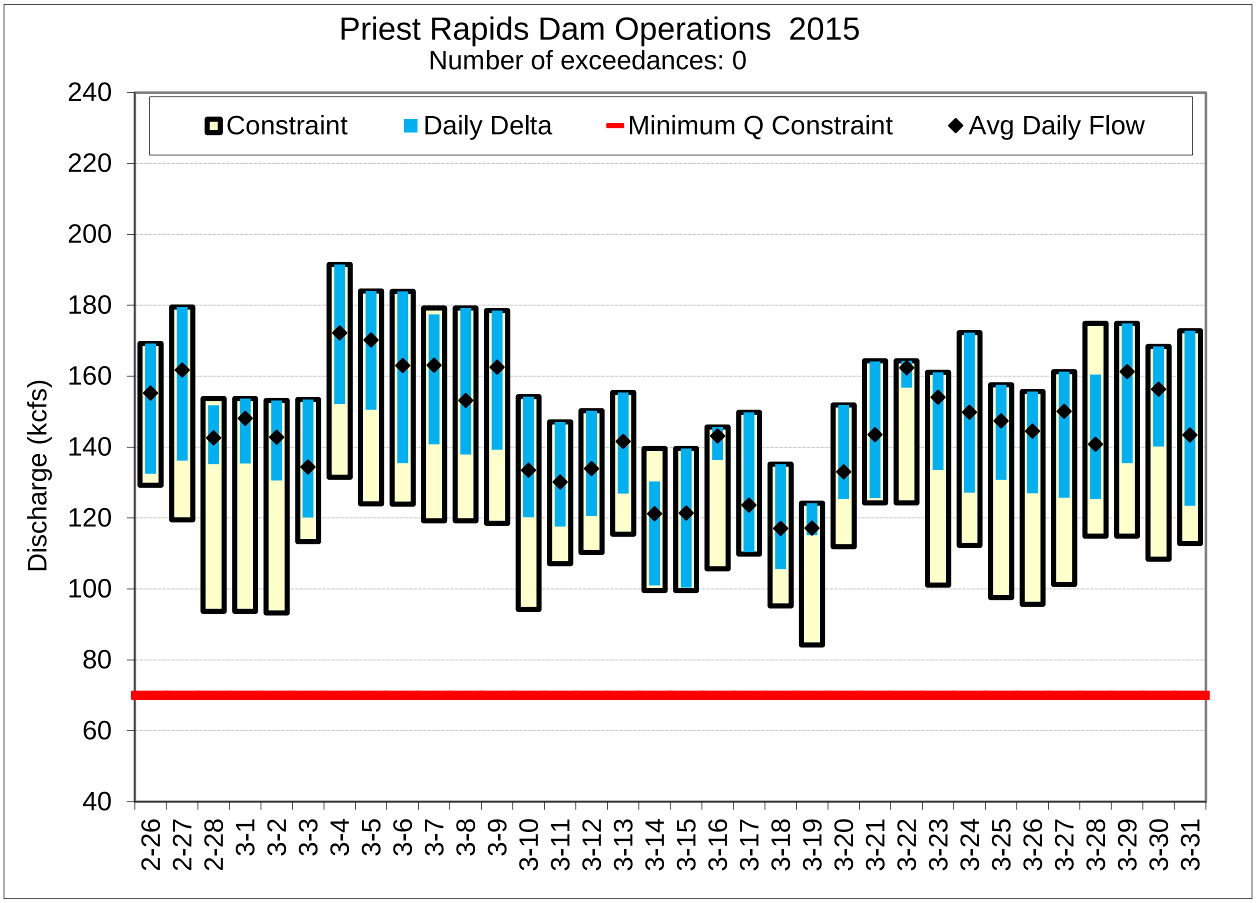

Figure 18 **Mean, minimum, maximum hourly discharge and daily fluctuation from Priest Rapids Dam, February 26 – March 31, 2015.**

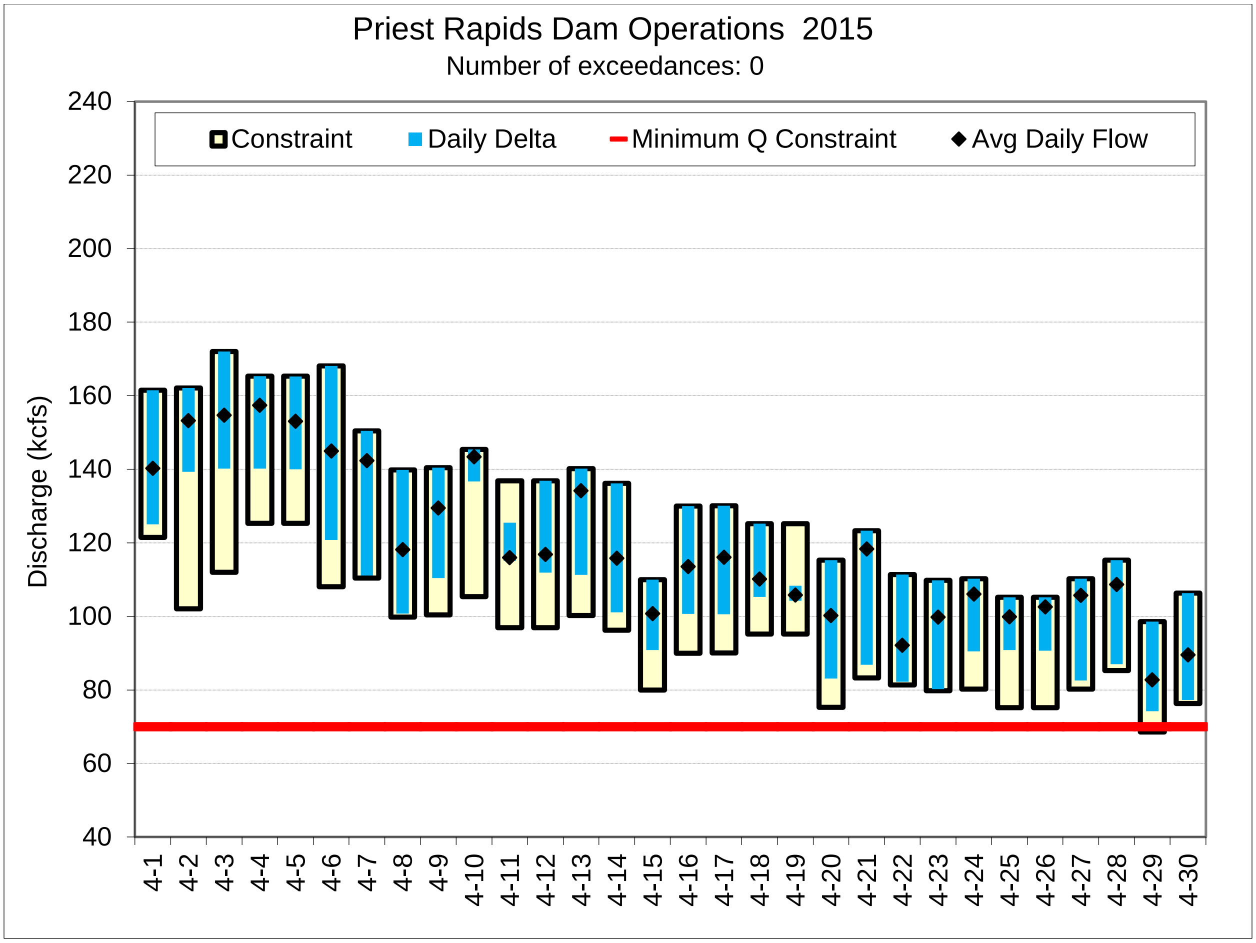

Figure 19 **Mean, minimum, maximum hourly discharge and daily fluctuation from Priest Rapids Dam, April 1 – April 30, 2015.**

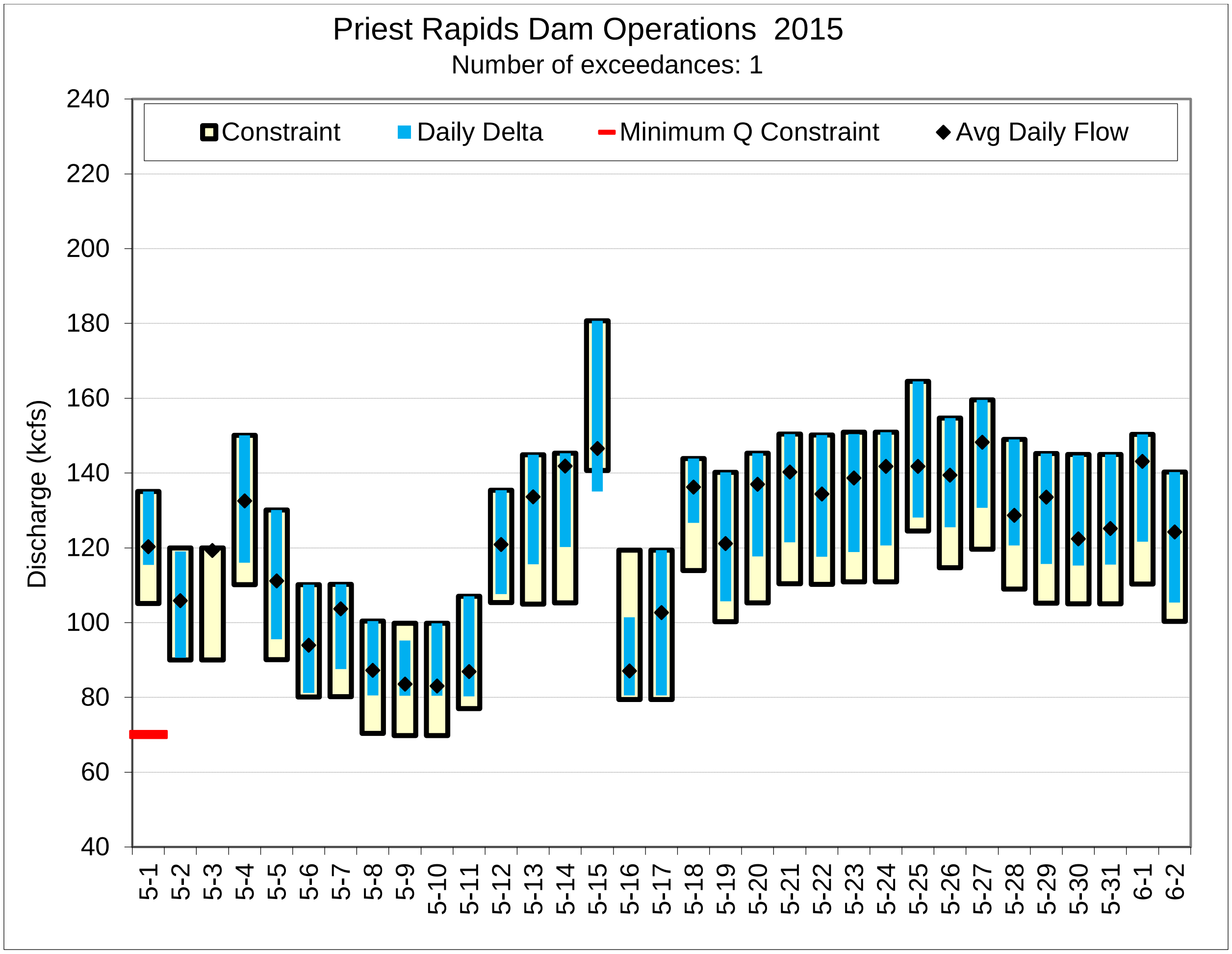

Figure 20 **Mean, minimum, maximum hourly discharge and daily fluctuation from Priest Rapids Dam, May 1 – June 2, 2015.**

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 will 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.

During 2015, the weekend-minimum discharge constraints began on the weekend of April 11 and continued through the weekend of May 3. Minimum discharge from PRD was at least 4.6 kcfs greater than minimum discharge constraints during the four weekends (Table 6).

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 21). 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 2014 – 2015 flow protection season the PHMinQ:SpMinQ was 1.9 and the SpAvgQ-PHMinQ was 497.2. Using the two relationships developed by Harnish et al. (2014), the estimated egg-to-presmolt survival for the 2014 broodyear was 0.50 and 0.60, respectively.

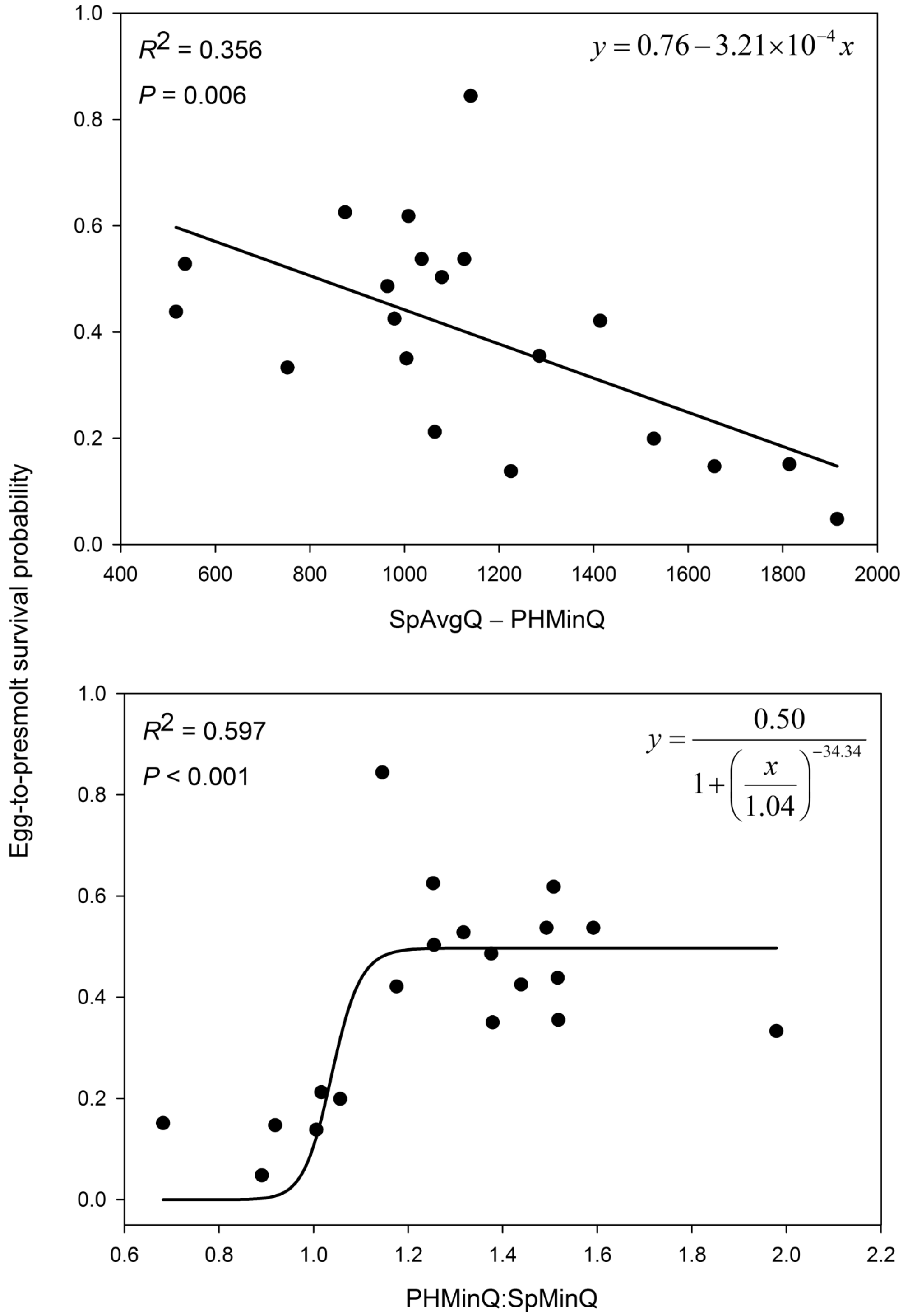

Figure 21 **Figure 8 from Harnish et al. (2014). Bivariate regression relationships of river environment variables that were found to be correlated with Hanford Reach fall Chinook salmon egg-to-presmolt survival estimates. Variables included the difference between mean spawning discharge and minimum posthatch incubation discharge (SpAvgQ – PHMinQ) and the ratio between the minimum posthatch incubation discharge and the minimum spawning discharge (PHMinQ:SpMinQ).**

Table 6 Weekend constraints and minimum discharges from Priest Rapids Dam during weekends between March 30 and April 21, 2013.

Weekend	Weekend Discharge Minimums (kcfs)		Difference (kcfs)
	Constraint	PRD Outflow	
April 11-21	110.8	111.9	1.1
April 18-19	101.0	104.2	3.2
April 25-26	83.1	90.7	7.6
May 2-3	80.3	90.6	10.3

6.0 Summary

Operations to protect the 2014 brood year of fall Chinook salmon in the Hanford Reach were highly successful. While the minimum flow requirement during the Post-Hatch Period was exceeded for one two-hour period in December and one daily delta constraint was exceeded by 5.6 kcfs, 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.

<u>1. Spawning Period</u>

(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.

6. Monitoring Team

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 16^{th} 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.

7. Redds Above Critical Elevation

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 26 – June 3, 2015

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
26-Feb-15	155.2	132.5	169.2	36.7	40	144.8		0	0
27-Feb-15	161.7	136.2	179.5	43.3	60	148.2		0	0
28-Feb-15	142.6	135.2	151.8	18.5	60	141.8	143.2	130	18.2
1-Mar-15	148.1	135.4	153.7	18.3	60	140.3	143.2	120	18.2
2-Mar-15	142.8	130.6	153.2	22.6	60	138.6		0	0
3-Mar-15	134.4	120.1	153.4	33.3	40	144.8		0	0
4-Mar-15	172.2	152.2	191.5	39.3	60	161.2		0	0
5-Mar-15	170.2	150.5	184.0	33.5	60	164.1		0	0
6-Mar-15	162.9	135.5	183.9	48.4	60	153.4		0	0
7-Mar-15	163.0	140.8	177.4	38.4	60	158.5	140.7	130	15.7
8-Mar-15	153.2	137.9	179.2	41.3	60	145.2	140.7	120	15.7
9-Mar-15	162.5	139.3	178.5	39.2	60	145.5		0	0
10-Mar-15	133.5	120.2	154.2	34.0	60	125.2		0	0
11-Mar-15	130.1	117.6	147.1	29.5	40	128.4		0	0
12-Mar-15	133.9	120.6	150.3	29.7	40	130.8		0	0
13-Mar-15	141.6	126.9	155.4	28.5	40	136.9		0	0
14-Mar-15	121.2	101.0	130.3	38.6	40	116.4	113	105	10.5
15-Mar-15	121.4	100.4	139.6	39.2	40	124.4	113	100	10.5
16-Mar-15	143.1	136.4	145.7	9.3	40	133.6		0	0
17-Mar-15	123.6	110.4	149.8	39.4	40	134.1		0	0
18-Mar-15	117.1	105.6	135.2	29.6	40	120.1		0	0
19-Mar-15	117.2	115.2	124.2	9.0	40	131.1		0	0
20-Mar-15	133.0	125.4	151.9	26.5	40	149.9		0	0
21-Mar-15	143.5	125.6	164.2	38.7	40	147.0	136.5	120	16.5
22-Mar-15	162.4	156.8	164.3	7.5	40	150.5	136.5	120	16.5
23-Mar-15	154.0	133.6	161.1	27.5	60	144.1		0	0
24-Mar-15	149.8	127.2	172.3	45.1	60	143.0		0	0
25-Mar-15	147.3	130.8	157.6	26.8	60	144.8		0	0
26-Mar-15	144.5	127.0	155.7	28.7	60	141.9		0	0
27-Mar-15	150.0	125.7	161.3	35.6	60	144.7		0	0
28-Mar-15	140.8	125.4	160.5	49.5	60	139.0	142.8	130	17.8
29-Mar-15	161.3	135.5	174.9	39.4	60	155.0	142.8	120	17.8
30-Mar-15	156.3	140.2	168.4	28.2	60	150.8		0	0
31-Mar-15	143.4	123.5	172.8	49.3	60	128.8		0	0

1-Apr-15	140.2	125.0	161.5	36.5	40	142.0		0	0
2-Apr-15	153.2	139.3	162.1	22.8	60	144.3		0	0
3-Apr-15	154.7	140.2	172.0	31.8	60	147.3		0	0
4-Apr-15	157.4	140.2	165.3	25.1	40	142.0	135.4	110	22.9
5-Apr-15	153.0	140.0	165.2	25.3	40	141.3	135.4	115	22.9
6-Apr-15	145.0	120.8	168.1	47.3	60	138.3		0	0
7-Apr-15	142.4	111.1	150.4	39.3	40	122.2		0	0
8-Apr-15	118.2	100.8	139.8	39.0	40	119.1		0	0
9-Apr-15	129.5	110.4	140.4	30.0	40	130.5		0	0
10-Apr-15	143.4	136.7	145.4	8.7	40	125.9		0	0
11-Apr-15	116.0	115.1	125.5	21.8	40	108.7	111.9	95	19.4
12-Apr-15	116.8	111.9	136.9	25.0	40	121.7	111.9	90	19.4
13-Apr-15	134.1	111.3	140.2	28.9	40	123.5		0	0
14-Apr-15	115.8	101.1	136.2	35.1	40	88.9		0	0
15-Apr-15	100.7	90.8	110.0	19.2	30	110.7		0	0
16-Apr-15	113.6	100.7	130.0	29.3	40	121.9		0	0
17-Apr-15	116.1	100.6	130.1	29.5	40	116.8		0	0
18-Apr-15	110.1	105.3	125.2	19.9	30	83.6	93.6	80	16.1
19-Apr-15	105.8	104.2	108.3	21.0	30	95.0	93.6	75	16.1
20-Apr-15	100.2	83.1	115.3	32.2	40	121.8		0	0
21-Apr-15	118.4	86.8	123.3	36.5	40	105.9		0	0
22-Apr-15	92.2	82.2	111.4	29.2	30	90.6		0	0
23-Apr-15	99.8	80.2	109.8	29.6	30	104.5		0	0
24-Apr-15	106.1	90.5	110.2	19.7	30	108.9		0	0
25-Apr-15	99.9	90.8	105.2	14.4	30	90.2	87.4	70	17.4
26-Apr-15	102.6	90.7	105.2	14.5	30	86.1	87.4	70	17.4
27-Apr-15	105.7	82.6	110.2	27.6	30	97.3		0	0
28-Apr-15	108.6	87.0	115.3	28.3	30	103.1		0	0
29-Apr-15	82.7	74.2	98.6	24.4	30	80.1		0	0
30-Apr-15	89.5	77.3	106.3	29.0	30	100.6		0	0
1-May-15	120.3	115.4	135.1	19.7	30	124.1		0	0
2-May-15	105.8	90.6	119.0	29.4	30	122.3	102.7	90	15.2
3-May-15	119.3	118.7	120.0	1.3	30	109.4	102.7	85	15.2
4-May-15	132.5	116.0	150.1	34.1	40	113.8		0	
5-May-15	111.2	95.5	130.1	34.6	40	94.6		0	
6-May-15	93.9	81.2	110.1	28.9	30	91.1		0	
7-May-15	103.6	87.6	110.2	22.6	30	87.1		0	
8-May-15	87.2	80.5	100.4	19.9	30	84.4		0	
9-May-15	83.6	80.4	95.2	19.4	30	91.0	92.9	75	
10-May-15	83.0	80.4	99.8	19.4	30	81.3	92.9	75	
11-May-15	86.9	80.3	107.0	26.7	30	103.0		0	

12-May-15	120.8	107.6	135.4	27.8	30	119.9		0	
13-May-15	133.7	115.6	144.9	29.3	40	128.7		0	
14-May-15	141.8	120.2	145.3	25.1	40	125.7		0	
15-May-15	146.6	135.1	180.7	45.6	40	105.9		0	
16-May-15	87.0	80.5	101.4	38.9	40	101.6	116	95	
17-May-15	102.6	80.5	119.4	38.9	40	126.1	116	90	
18-May-15	136.3	126.7	143.9	17.2	30	114.1		0	
19-May-15	121.1	105.7	140.2	34.5	40	127.0		0	
20-May-15	137.0	117.7	145.3	27.6	40	130.8		0	
21-May-15	140.3	121.5	150.4	28.9	40	136.8		0	
22-May-15	134.4	117.6	150.2	32.6	40	129.8		0	
23-May-15	138.7	118.9	150.4	32.0	40	138.0	132.7	105	
24-May-15	141.7	120.6	150.9	30.3	40	137.5	132.7	105	
25-May-15	141.8	128.1	164.5	36.4	40	132.6		0	
26-May-15	139.5	125.5	154.7	29.2	40	138.5		0	
27-May-15	148.2	130.7	159.6	28.9	40	128.8		0	
28-May-15	128.7	120.6	149.0	28.4	40	132.2		0	
29-May-15	133.6	115.7	145.2	29.5	40	132.6		0	
30-May-15	122.4	115.3	144.7	29.7	40	123.5	126.6	95	
31-May-15	125.2	115.5	145.0	29.5	40	125.2	126.6	105	
1-Jun-15	143.2	121.6	150.3	28.7	40	120.4		0	
2-Jun-15	124.3	105.4	140.3	34.9	40	102.0		0	
3-Jun-15	102.3	100.4	112.6	12.2	30	99.5		0	

Appendix D
Adult fall Chinook salmon dam counts and escapement, 1962 – present.

Year	McNary Dam Count	Ice Harbor Dam Count[A]		Yakima System		Ringold Hatchery[D]		Priest Rapids Dam Count		Hanford Reach Fisheries[B]		Wanapum Tribal Fisheries		Priest Rapids Hatchery Volunteers[C]		Hanford Reach Escapement		Aerial Redd Count	
		#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1962	26,200	---	---	---	---	---	---	7,863	30.0	---	---	---	---	---	---	---	---	---	---
1963	27,100	---	---	216	0.8	---	---	3,515	13.0	---	---	---	---	---	---	---	---	---	---
1964	40,400	9,100	22.5	80	0.2	---	---	6,882	17.0	---	---	---	---	290	0.7	24,048	59.5	1,477	3.7
1965	41,100	8,200	20.0	132	0.3	---	---	8,268	20.1	---	---	---	---	140	0.3	24,360	59.3	1,789	4.4
1966	51,100	12,800	25.0	270	0.5	---	---	9,479	18.5	---	---	---	---	472	0.9	28,079	54.9	3,101	6.1
1967	42,900	14,000	32.6	354	0.8	---	---	5,153	12.0	---	---	---	---	205	0.5	23,188	54.1	3,267	7.6
1968	49,200	19,500	39.6	124	0.3	---	---	5,258	10.7	---	---	---	---	251	0.5	24,067	48.9	3,560	7.2
1969	55,400	13,600	24.5	1,656	3.0	---	---	4,778	8.6	---	---	---	---	427	0.8	34,939	63.1	4,508	8.1
1970	43,200	9,000	20.8	1,268	2.9	---	---	5,334	12.3	---	---	---	---	868	2.0	26,730	61.9	3,813	8.8
1971	49,000	9,300	19.0	176	0.4	---	---	7,120	14.5	---	---	---	---	1,006	2.1	31,398	64.1	3,600	7.3
1972	37,600	7,500	19.9	272	0.7	---	---	2,327	6.2	---	---	---	---	752	2.0	26,749	71.1	876	2.3
1973	46,600	6,700	14.4	348	0.7	---	---	4,855	10.4	---	---	---	---	1,653	3.5	33,044	70.9	2,965	6.4
1974	34,600	2,400	6.9	262	0.8	---	---	5,028	14.5	---	---	---	---	1,063	3.1	25,847	74.7	728	2.1
1975	29,600	1,900	6.4	678	2.3	---	---	4,320	14.6	---	---	---	---	460	1.6	22,242	75.1	2,683	9.1
1976	28,800	1,100	3.8	494	1.7	---	---	5,473	19.0	---	---	---	---	593	2.1	21,140	73.4	1,951	6.8
1977	37,600	1,200	3.2	164	0.4	---	---	4,060	10.8	---	---	---	---	649	1.7	31,527	83.8	3,240	8.6
1978	27,300	1,100	4.0	64	0.2	---	---	4,787	17.5	---	---	---	---	771	2.8	20,578	75.4	3,028	11.1
1979	31,200	1,200	3.8	---	---	---	---	4,858	15.6	---	---	---	---	1,584	5.1	23,558	75.5	2,983	9.6
1980	29,850	1,155	3.9	22	0.1	---	---	6,031	20.2	---	---	---	---	781	2.6	21,861	73.2	1,487	5.0
1981	21,114	770	3.6	172	0.8	---	---	3,833	18.2	---	---	---	---	1,224	5.8	15,115	71.6	4,866	23.0
1982	31,103	1,627	5.2	66	0.2	---	---	8,767	28.2	0	0.0	---	---	100	0.3	20,543	66.0	4,988	16.0
1983	48,570	1,771	3.6	1,267	2.6	---	---	8,284	17.1	0	0.0	---	---	1,226	2.5	36,022	74.2	5,290	10.9
1984	60,756	1,650	2.7	4,400	7.2	---	---	7,918	13.0	577	0.9	---	---	4,229	7.0	41,982	69.1	7,310	12.0
1985	93,308	2,046	2.2	943	1.0	---	---	11,133	11.9	2,533	2.7	---	---	10,857	11.6	65,796	70.5	7,645	8.2
1986	113,265	3,104	2.7	4,047	3.6	---	---	19,015	16.8	3,426	3.0	---	---	11,114	9.8	72,559	64.1	8,291	7.3
1987	154,146	6,788	4.4	1,813	1.2	---	---	35,023	22.7	4,410	2.9	---	---	17,350	11.3	88,762	57.6	8,616	5.6
1988	114,741	3,847	3.4	757	0.7	---	---	22,162	19.3	4,343	3.8	---	---	9,598	8.4	74,034	64.5	8,475	7.4
1989	96,494	4,638	4.8	1,047	1.1	---	---	14,833	15.4	3,676	3.8	---	---	6,387	6.6	65,913	68.3	8,834	9.2
1990	57,612	3,470	6.0	2,112	3.7	---	---	6,095	10.6	2,447	4.2	---	---	3,371	5.9	40,117	69.6	6,506	11.3
1991	47,307	4,489	9.5	1,698	3.6	---	---	4,690	9.9	1,990	4.2	---	---	2,469	5.2	31,971	67.6	4,939	10.4
1992	51,189	4,636	9.1	4,863	9.5	---	---	4,354	8.5	1,790	3.5	---	---	6,097	11.9	29,449	57.5	4,926	9.6
1993	54,876	2,805	5.1	2,861	5.2	---	---	7,183	13.1	2,414	4.4	---	---	8,963	16.3	30,650	55.9	2,863	5.2
1994	85,932	2,073	2.4	4,477	5.2	---	---	11,829	13.8	4,877	5.7	---	---	13,819	16.1	48,857	56.9	5,619	6.5
1995	68,186	2,750	4.0	1,179	1.7	---	---	13,273	19.5	4,000	5.9	---	---	10,740	15.8	36,244	53.2	3,136	4.6
1996	73,929	3,851	5.2	1,166	1.6	399	0.5	12,555	17.0	4,700	6.4	---	---	14,280	19.3	36,978	50.0	7,618	10.3
1997	67,192	2,767	4.1	1,032	1.5	895	1.3	11,201	16.7	3,500	5.2	---	---	10,836	16.1	36,961	55.0	7,600	11.3
1998	63,791	4,220	6.6	2,100	3.3	281	0.4	9,662	15.1	3,328	5.2	---	---	15,074	23.6	29,126	45.7	5,368	8.4
1999	78,356	6,532	8.3	3,898	5.0	3,169	4.0	9,542	12.2	5,100	6.5	---	---	23,101	29.5	27,014	34.5	6,068	7.7
2000	66,378	6,509	9.8	4,738	7.1	0	0.0	19,127	28.8	3,435	5.2	480	0.7	7,233	10.9	24,856	37.4	5,507	8.3
2001	110,517	13,635	12.3	5,814	5.3	1,761	1.6	16,957	15.3	5,571	5.0	100	0.1	24,225	21.9	42,454	38.4	6,248	5.7
2002	141,682	15,248	10.8	13,303	9.4	1,370	1.0	24,137	17.0	7,325	5.2	144	0.1	12,640	8.9	67,515	47.7	8,083	5.7
2003	178,951	20,998	11.7	9,648	5.4	1,021	0.6	43,691	24.4	6,457	3.6	56	0.0	8,926	5.0	88,154	49.3	9,465	5.3
2004	169,348	21,104	12.5	5,804	3.4	1,139	0.7	39,162	23.1	8,082	4.8	137	0.1	15,573	9.2	78,347	46.3	8,468	5.0
2005	133,999	14,677	11.0	3,121	2.3	2,049	1.5	28,160	21.0	7,546	5.6	285	0.2	10,618	7.9	67,543	50.4	7,891	5.9
2006	90,754	10,272	11.3	2,165	2.4	117	0.1	18,851	20.8	4,055	4.5	77	0.1	8,122	8.9	47,095	51.9	6,508	7.2
2007	58,733	13,408	22.8	1,351	2.3	22	0.0	22,650	38.6	4,614	7.9	128	0.2	2,673	4.6	13,887	23.6	6,509	11.1
2008	101,869	21,896	21.5	3,360	3.3	0	0	29,018	28.5	5,638	5.5	97	0.1	18,499	18.2	23,361	22.9	5,618	5.5
2009	104,544	24,824	23.7	3,304	3.2	105	0.1	33,703	32.2	6,553	6.3	302	0.3	9,709	9.3	26,044	24.9	4,996	4.8
2010	197,721	46,541	23.5	3,435	1.7	7,641	3.9	37,771	19.1	10,985	5.6	4	0.0	16,501	8.3	80,408	40.7	8,817	4.5
2011	162,191	31,405	19.4	3,312	2.0	5,487	3.4	27,266	16.8	11,614	7.2	6	0.0	17,260	10.6	65,724	40.5	8,915	5.5
2012	173,472	38,546	22.2	5,609	3.2	5,324	3.1	40,002	23.1	13,141	7.6	7	0.0	19,069	11.0	51,774	29.8	8,368	4.8
2013	454,991	57,850	12.7	11,936	2.5	16,358	3.6	260,962	57.3	24,921	5.4	69	0.0	38,628	8.4	157,484	34.6	17,398	3.8
2014	410,786	61,389	14.9	11,469	2.8	12,205	3.0	79,506	19.4	28,679	7.0	29	0.0	65,035	15.8	152,474	37.1	NA	NA

[A] Combined adult and jack counts 1962 & 1963, [B] Incomplete data but likely less than 100 Adults prior to 1982, [C] First volunteer returns to Priest Rapids Hatchery in 1964, [D] First volunteer returns to Ringold Hatchery in 1996

Appendix E
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+	
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 F

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							
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 G

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
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		94.8	140.0	36.5	26.9	20.1	37.3	21.0	7.7	6.8

[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 H
Summary of constraints and performance under the HRFCPPA, 2004-present.

Migration year	Weekday Constraint		Weekend Constraint		Combined			Met when exceedances < 5kcfs (%)	CJAD II weekends – difference between minimum discharge and constraints (kcfs)				
	Targets	Met	Targets	Met	Targets	Met	%		1	2	3	3	5
2015	70	69	28	28	98	97	99.0	99.0	1.1	3.2	7.6	10.3	
2014	64	64	25	25	89	89	100.0	100.00	4.6	6.0	20.1	21.9	
2013	65	64	14	13	79	77	97.5	97.5	10.9	36.4	4.5	-27.0	
2012	72	72	15	15	87	87	100.0	100.0					
2011	81	80	17	15	98	95	96.9	99.0					
2010	72	68	14	14	86	82	95.3	95.3					
2009	63	57	13	11	76	68	89.5	89.5					
2008	57	57	12	9	69	66	95.7	98.6					
2007	56	55	11	8	67	63	94.0	100.0					
2006	84	66	16	11	100	77	77.0	86.0					
2005	76	60	15	7	91	67	73.6	82.4					
2004	60	39	13	8	73	47	64.4	82.2					
Mean	68.3	62.6	16.0	13.6	84.4	76.2	90.2	94.1					

Appendix I

Summary of all fall Chinook salmon redd counts from aerial surveys conducted in 2014 by location in the Hanford Reach, Columbia River (data provided by EAS).

Area	Description	Redd Count				Maximum Count
		10/20/2014	11/10/2014	11/24/2014	12/1/2014	
0	Islands 17-21 (Richland)	0	0	0	0	0
1	Islands 11-16	0	76	767	906	906
1a	Savage Island/Hanford Slough	0	0	0	0	0
2	Islands 8-10	0	427	1470	1565	1565
3	Near Island 7	0	400	1100	1100	1100
4	Island 6 (lower half)	10	1020	2230	2530	2530
5	Island 4, 5 and upper 6	25	730	2030	2080	2080
6	Near Island 3	0	100	900	1000	1000
7	Near Island 2	23	1010	2030	2050	2050
8	Near Island 1	0	200	400	500	500
8a	Upstream of Island 1 to Coyote Rapids	0	0	0	0	0
9	Near Coyote Rapids	25	255	400	500	500
9a	Upstream of Coyote Rapids to China Bar	0	0	0	0	0
China Bar	China Bar/Midway	0	20	50	60	60
10	Near Vernita Bar	55	1830	3600	3650	3650
11	Upstream of Vernita Bar to Priest Rapids Dam	0	5	10	10	10
	Total	138	6073	14987	15951	15951