FISH PASSAGE CENTER

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MEMORANDUM

TO: Tom Rien, ODFW

FROM: Michele DeHart

DATE: October 31, 2014

RE: Summary of Surface Passage Structures Effectiveness Analyses

In response to your request the Fish Passage Center (FPC) staff completed an update of the FPC memorandum titled *Review of RSW and TSW Studies* (January 15, 2010, #05-10). Our review of available reports (see Appendix A) indicates that no additional evaluations of surface spill structure effectiveness, when compared to traditional spill, were conducted by the U.S. Army Corps of Engineers at hydroelectric projects beyond those summarized in the memorandum dated January 15, 2010. The only recent analysis that provides an indication of the effectiveness of the operation of surface spill structures is the development of the spill efficiency metric through the Comparative Survival Study (CSS) analysis. Although no additional at-project marking studies were conducted to evaluate surface passage structures versus traditional spill, the FPC staff again reviewed all of the available reports evaluating surface spill structures, in order to explore your specific questions regarding the conclusion that:

> *"More fish (as many as 4X more) pass through surface passage spill than conventional spill using less water volume".*

The first component in developing the requested summary was completing reviews of all the surface passage structure evaluations conducted. However, public availability of U.S. Army Corps of Engineers mainstem passage studies reports presented a potential obstacle to the requested review. The attached list of studies was reviewed. However, because of the difficulty of accessing reports, this review list may not be comprehensive.

The second component of the updated review is a summary of the CSS analyses. These analyses were completed in response to recommendations from NOAA Fisheries to develop a spill metric that includes the effect of operation of surface structures on spill passage efficiency. The new spill metric, spill passage efficiency (SPE), will be used in CSS analyses. The CSS analyses evaluate SPE at the projects before and after installation of surface passage structures, therefore describing the effectiveness of surface passage structures in actual Federal Columbia River Power System operations.

Our summary conclusions are listed below, followed by a detailed discussion of the surface passage evaluation studies review and the CSS analyses.

- Surface passage structures do not allow spill volumes to be reduced without resulting in reduction of project SPE.
- Surface passage structures are most effective when flows are low, because the surface structure spill volume is a larger proportion of the total project flow.
- The effectiveness of surface passage structures is variable and is dependent on species and river flow conditions.
- CSS analyses of pre- and post-installation of surface passage structures indicate that some benefit is provided for steelhead passage, but limited benefit is provided for spring/ summer Chinook. Further, CSS analyses indicate that flow and spill are the primary variables influencing spill passage efficiency, with and without surface passage structures.
- The statement that surface passage structures pass 4x more fish than conventional spill is unfounded and cannot be substantiated by the available data and research reports

Review of evaluations of surface passage structures

- Justifications of using surface passage to reduce spill should result from tests directly comparing fish passage with and without surface passage structures in place under similar flows and spill operations. To date, this type of study has not been conducted at any site under the U.S. Army Corps of Engineers evaluations. For further detail on the closest possible comparisons to operations with and without surface passage structures, see the FPC Memo from January 15, 2010 (attached).
- Existing data, though incomplete, indicate that the effects of surface passage are not spread equally across sites and species.

Lower Granite Dam

There have been no studies at Lower Granite Dam to directly compare SPE and smolt survival with and without surface passage. In 2002, a study was completed attempting to compare high spill levels without the removable spillway weirs (RSW) and low spill levels with the RSW. Although similar SPEs were observed with and without the RSW, the operations were completed on significantly different time frames, alternated with periods of no spill, which confounds fish passage timing. Additionally, the volume of spill varied between treatments as well as over the course of the study. This study also included many unplanned operations of varying times, making the results difficult to compare directly, and most operations showed no statistical difference in SPE. Flow and spill in 2002 were largely uncontrolled and are not representative of other years, and direct comparisons of the number of fish passing during each operation are not accurate.

It is possible that the above mentioned statement that four times more fish pass via surface pass structures with less spill volume than conventional spill is a misinterpretation or misunderstanding of the 2002 study. In fact, because the surface passage structure was tested at a very different spill operation, it is impossible to know the rate of fish passage through conventional spill at the same spill level and directly compare the two operations. The potential benefits of surface passage cannot be deduced from the 2002 study at Lower Granite Dam.

None of the SPE estimates prior to the installation of the RSW include spill operations similar to the current required 24-hour spill. No studies have tested similar spill levels, and none have accounted for varying flow; therefore any perceived benefits to surface passage at Lower Granite have not been accurately assessed. Studies in 2003, 2005, and 2007 compared varying spill operations with the RSW, but involved no comparisons of RSW and non-RSW spill. Therefore there is no evidence that the RSW provides equal fish protection with reduced spill.

Little Goose Dam

As with Lower Granite Dam, no studies have directly compared the SPE values with and without the use of the temporary spillway weirs (TSW) at Little Goose Dam. However, there are SPE estimates prior to the installation of the TSW with operations similar to those used after its installation. With 30% spill in a low flow year (2007) without the TSW, SPE estimates for yearling Chinook were higher than estimates generated during a mid-flow year (2009) with the TSW. For the same years and operations, steelhead SPEs were equivalent.

Because direct comparisons cannot be made between different flow years, it is impossible to determine if differences in SPE between 2007 and 2009 were due to TSW operations or differing flows. A study in 2009 compared varying spill operations with the TSW in place, but involved no comparisons of TSW and non-TSW spill. So the benefits of the TSW remain unclear.

Lower Monumental Dam

At Lower Monumental Dam, SPE was estimated in consecutive years, with similar flow and spill operations, one year (2008) with and one year (2007) without the RSW. In comparing 2007 and 2008, SPE for yearling Chinook decreased after installation of the RSW. In contrast, SPE for steelhead increased slightly. When comparing 2006 (without RSW) and 2009 (with RSW), similar flow years with similar operations, it was observed that both yearling Chinook and steelhead SPE increased.

Studies in 2008 and 2009 compared bulk and uniform spill, but both operations utilized the RSW. There have been no direct comparisons of RSW and non-RSW operations. The benefits of the RSW at Lower Monumental Dam are inconclusive and not distributed equally across species.

Ice Harbor Dam

In 2005, bulk spill without the RSW was compared to reduced spill while using the RSW. It is clear from this study that use of the RSW did not compensate for the reduction in spill. Reduced spill with use of the RSW resulted in lower SPE, lower spillway passage, and increased forebay delay for both yearling Chinook and steelhead. No studies have been conducted to use similar spill operations with and without the RSW, as recommended in the 2005 report. Instead, all studies at Ice Harbor since 2005 have included the RSW for all spill operations.

Studies in 2006, 2007, and 2008 at Ice Harbor have tested SPE at 30% spill compared to 45 Kcfs daytime/gas cap night. Even with the RSW in use for all operations, reduced spill levels have resulted in lower estimates of SPE for yearling Chinook, subyearling Chinook, and steelhead.

McNary Dam

Studies measuring SPE at McNary Dam have varied considerably in flow and spill operations, even within a single year. This makes informative comparisons between TSW and non-TSW operations impossible. However, it should be noted that with the TSW in place, higher spill has resulted in higher SPE. In 2007 and 2008, the recommended SPE performance standard was met under 60% spill with the TSW in place, but was not met at 40% spill with the TSW in place. This indicates that the TSWs at McNary Dam have not compensated for reductions in spill.

In 2007, 2008, and 2009, studies were conducted to compare spill levels and operations, but all studies included the use of two TSW units, and none involved comparisons with non-TSW operations.

John Day Dam

As at other sites, no comparisons have been done of TSW and non-TSW operations under conditions of similar flow and spill. In 2008 and 2009, the two TSWs at John Day Dam were tested under 30% and 40% spill. For yearling and subyearling Chinook, increased spill increased SPE with the TSWs in place. Steelhead results were inconclusive, as increased spill increased SPE in 2009 but not in 2008.

CSS analyses indicate that RSWs and TSWs provide limited benefit for steelhead and even less benefit for spring/summer chinook. The original objective of TSW and RSW development was to allow reductions in spill for fish passage without reductions in spill passage efficiency. This original objective has not been realized. TSWs and RSWs do not allow reductions in spill without resulting in reductions in spill passage efficiencies.

In response to recommendations from NOAA Fisheries at the 2011 CSS workshop, the CSS Oversight Committee defined a modified spill metric that includes the effect of the operation of surface passage structures (TSWs and RSWs) on project passage. The CSS Oversight Committee agreed that the benefits to project spill passage efficiencies from the installation of RSWs and TSWs should be included in CSS analyses of mainstem passage and adult returns. The goal of developing a new spill metric was to account for the benefit of RSWs and TSWs. A new metric was introduced to characterize spill in a way that is more relevant to fish survival, and thus improves how spill is represented in survival models. Previously, the CSS used percent spill or functions of percent spill (e.g., N_powerhouse) to quantify spill effects on fish survival through the hydrosystem, and spill effects on delayed mortality. During the 2011 CSS Workshop, reviewers suggested that a metric such as SPE (the proportion of total fish passing the dam that pass via the spillway) would be a better approach given different flow and spill levels and dam-specific physical configurations including the operation of surface passage structures. In response to those suggestions, the CSS developed models that accounted for the effects of flow and spill levels, along with RSW/TSW installations, on spill passage efficiency at each dam for spring/summer Chinook salmon and steelhead. These models were based on PIT-tag detection probabilities (and in some cases radio/acoustic tags) collected over a range of flow and spill levels, and in years prior to and following RSW/TSW installations. Model validations showed that the developed CSS models accurately estimated SPE for both Chinook salmon and steelhead across a range of flow and spill levels, as well as prior to and following RSW/TSW installations. All of the models included flow and spill as the primary factors influencing SPE, with SPE increasing as spill levels increased. Approximately half of the models included an interaction for flow and spill, showing that spill was particularly effective at increasing SPE when flows were low. Only two of the Chinook models and five of the steelhead models included RSWs/TSWs as a factor influencing SPE.

The development of the new spill metric successfully incorporates the operation of surface passage structures into the analyses presented at the 2013 CSS Workshop, and this metric will be used in future CSS analyses. In addition, the CSS analysis indicates that the benefits of RSWs and TSWs is limited and varies by species and by flow conditions. At most projects some improved steelhead passage was indicated. However, at most projects the benefits for spring/summer Chinook passage identified in these analyses were limited. There is an indication that surface spill is particularly effective at low flow levels. The initial objective of development of surface spillway structures, to reduce spill volume without reducing SPE, has not been achieved. Reductions in spill volume will certainly reduce spillway passage efficiency even with surface passage structures in place.

Appendix A: Literature Reviewed

Lower Granite

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Perry, R.W., T.J. Kock, M.S. Novick, A.C. Braatz, S.D. Fielding, G.S. Hansen, J.M. Sprando, T.S. Wilkerson, G.T. George, J.L. Schei, N.S. Adams, D.W. Rondorf. 2007. Survival and migration behavior of juvenile salmonids at Lower Granite Dam, 2005. Final Report of Research by the U.S. Geological Survey to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV50498133, Walla Walla, Washington

Plumb, J.M., A.C. Braatz, J.N. Lucchesi, S.D. Fielding, J.M. Sprando, G.T. George, N.S. Adams, D.W. Rondorf. 2003. Behavior of radio-tagged juvenile Chinook salmon and steelhead and performance of a removable spillway weir at Lower Granite Dam, Washington, 2002. Report of Research by the U.S. Geological Survey to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV00104592, Walla Walla, Washington

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Puls, A.L. T.D. Counihan, C.E. Walker, J.M. Hardiman, I.N. Duran. 2008. Survival and migration behavior of subyearling Chinook salmon at Lower Granite Dam, 2007. Final report of research by the U.S. Geological Survey to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV70198655, Walla Walla, Washington

Little Goose

Beeman, J.W., A.C. Braatz, H.C. Hansel, S.D. Fielding, P.V. Haner, G.S. Hansen, D.J. Shurtleff, J.M. Sprando, O.W. Rondorf. 2010. Approach, passage, and survival of juvenile salmonids at Little Goose Dam, Washington: Post-construction evaluation of a temporary spillway weir, 2009: U.S. Geological Survey Open-File Report 2010-1224, 100p.

Skalski, J.R., R. Townsend. 2009. Estimates of injury and survival of juvenile Chinook salmon passing through a spillway equipped with a temporary spillway weir and a spillway with a new spill deflector at Little Goose Dam, 2009. Prepared by Normandeau Associates, Inc. to the U.S. Army Corps of Engineers, Walla Walla District, Contract W912EF-08-D-0005, Walla Walla, Washington.

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Dumdei, N., R.F. Absolon, E.E. Hockersmith, G.A. Axel, M. G. Nesbit, J.J. Lamb, B.J. Burke, K.E. Frick, B.P. Sandford. 2010. Passage behavior and survival of radio-tagged subyearling Chinook salmon at Lower Monumental Dam, 2009. Report of research by Northwest Fisheries Science Center to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV80438584, Walla Walla, Washington

Ham, K.D., P.S. Titzler, C.I.I. Arimescu. 2009. Hydroacoustic evaluation of fish passage distributions at the temporary spillway weirs at Lower Monumental Dam in 2009. Prepared by Battelle for the U.S. Army Corps of Engineers, Walla Walla District, Contract W912EF-08-D-0004, Walla Walla, Washington.

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Hockersmith, E.E., G.A. Axel, R.F. Absolon, B.J. Burke, K.E. Frick, J.J. Lamb, M.G. Nesbit, N.D. Dumdei, B.P. Sandford. 2010. Passage behavior and survival for radio-tagged yearling Chinook salmon and juvenile steelhead at Lower Monumental Dam, 2009. Report of research by Northwest Fisheries Science Center to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV80438584, Walla Walla, Washington

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Ice Harbor

Axel, G.A., E.E. Hockersmith, D.A. Ogden, B. Burke, K. Frick, B.P. Sandford. 2006. Passage behavior and survival for radio-tagged yearling Chinook salmon and steelhead at Ice Harbor Dam, 2005. Report of research by Northwest Fisheries Science Center to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV92844866, Walla Walla, Washington

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Axel, G.A., E.E. Hockersmith, B. Burke, K. Frick, B.P. Sandford, W.D. Muir, R.F. Absolon, N. Dumdei, J.J. Lamb, M.G. Nesbit. 2010. Passage behavior and survival of radio-tagged yearling Chinook and subyearling Chinook salmon and juvenile steelhead at Ice Harbor Dam, 2009. Report of research by Northwest Fisheries Science Center to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV83306729, Walla Walla, Washington

Ogden, D.A., E.E. Hockersmith, G.A. Axel, B. Burke, K. Frick, B.P. Sandford. 2007. Passage behavior and survival for river-run subyearling Chinook salmon at Ice Harbor Dam, 2005. Report of research by Northwest Fisheries Science Center to the U.S. Army Corps of Engineers, Walla Walla District, Contract W68SBV92844866, Walla Walla, Washington

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Skalski, J.R. 2006. Comparative direct survival and injury rates of juvenile salmon passing the new removable spillway weir (RSW) and a spillbay at Ice Harbor Dam, Snake River, Washington. Report prepared by Normandeau Associates, Inc. for the U.S. Army Corps of Engineers, Walla Walla District, Washington.

McNary

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MEMORANDUM

TO: Michele DeHart

FROM: Brandon R. Chockley

DATE: January 15, 2010

RE: Review of RSW and TSW studies

In response to your request, I have reviewed Corps of Engineers (COE) reports pertaining to the performance of surface passage routes (RSWs and TSWs) at various projects throughout the FCRPS. The purpose of this review was to: 1) determine what types of tests have been conducted at each site, 2) compare spill passage efficiency (SPE) at these projects with and without surface passage routes, and 3) determine whether the tests conducted so far are adequate enough to say that spill can be reduced while still maintaining desired SPE levels. Below is a brief summary of my findings, followed by a more detailed explanation of the tests conducted at each of the FCRPS projects with surface passage routes.

- Not all sites have estimates of SPE under recent spill operations (i.e., spill volumes and durations) without surface passage devices in operation. This prevents a direct comparison of current SPE estimates with surface passage routes to what might be accomplished without surface passage devices.
- To date, tests of surface passage routes are mostly inadequate towards determining whether spill can be reduced while still maintaining high SPE because very few tests have been conducted to measure SPE with and without a surface passage route in operation, in the same year.
    - No tests have been conducted to compare SPE with and without surface passage devices while operating at the same levels of spill.

    - Tests at Ice Harbor in 2005 showed that spill of ~35-46% with an RSW in operation resulted in lower SPE than spill of ~82-84% without an RSW for yearling Chinook, steelhead, and subyearling Chinook
- Several studies have found that decreasing spill levels with a surface passage device in operation still causes a reduction in SPE.
- Changes in SPE with or without surface passage devices seem to be sensitive to the flow regime for a particular year. In low flow years where spill is provided, SPE without surface passage routes is similar to that in high flow years with surface passage routes.
- When spill is provided and current levels, surface passage routes seem to be more effective at passing juvenile steelhead than yearling or subyearling Chinook.
- Recommended SPE levels (Attachment B of Tribal MOA) at some projects are not being met with current surface passage devices in operation. Recent results at MCN suggest that increased spill may be necessary to meet these recommended "performance standards" for yearling Chinook and steelhead.

Lower Granite Dam

An RSW was installed at Lower Granite Dam (LGR) in 2002. Estimates of SPE at LGR prior to the installation of the RSW are based on old operations, which consisted of 12-hr of 60 Kcfs spill at night. Recent operations call for 24-hour of 20 Kcfs spill at LGR. No estimates of SPE are available at this spill level without the RSW in operation. Therefore, it is not possible to compare SPE estimates at LGR with the RSW in operation versus those without the RSW in operation. However, estimates of SPE under the 12-hour operation without the RSW are similar to those of 24-hour spill with the RSW. Furthermore, no tests have been conducted at LGR to determine what SPE might be at different spill levels with the RSW in operation. Without such tests, it is impossible to determine whether spill can be reduced at LGR while still maintaining desired levels of SPE.

Little Goose Dam

A modified TSW was installed at Little Goose Dam (LGS) in 2009. Since the installation of the TSW at LGS, there have been no tests to compare the SPE with and without the TSW in operation in the same year. When comparing SPE estimates with and without a TSW, the best we can do is compare different years with similar spill operations (Table 1). While the years where SPE data are available for LGS had similar spill operations (~30% bulk spill), they differ substantially in their flow regimes.

In a low flow year without a TSW (2007), bulk spill of 30% resulted in an SPE of 0.82-0.83 for yearling Chinook and 0.51-0.59 for steelhead (Table 1). In a high flow year without a TSW (2006), bulk spill of 30% resulted in an SPE estimate of 0.61 for yearling Chinook and 0.37 for steelhead (Table 1). These data indicate that spill in a low flow year is extremely effective at passing juvenile Chinook and steelhead through the spillway. With an average daily flow of 97.5 Kcfs, water year 2009 was intermediate compared to what was seen in 2006 and 2007. The estimates of SPE in 2009 (with a TSW) were 0.72 for yearling Chinook and 0.57 for steelhead (Table 1). It appears that the TSW may have improved SPE for both species when compared to 2006 but no improvement was seen when compared to 2007 (Table 1). Given the sensitivity of SPE to flow regimes (i.e., 2006 vs. 2007) it is difficult to determine whether the higher SPE in

2009 (versus those for 2006) are due to the operation of the TSW or the lower flow seen in 2009 compared to 2006.

Table 1. Estimates of SPE for yearling Chinook and steelhead at LGS in years with RSW and without RSW (shaded in grey)

	2006	2007	2009
Average Flow (Kcfs)	124.7	68.4	97.5†
Average Spill (%)	~30%	30%	30%
Spill Pattern	Bulk	Bulk	
RSW	No	No	Yes
CH1 SPE	0.61	0.82-0.83	0.72
ST SPE	0.37	0.51-0.59	0.57

† Average daily flow for study period (Apr 18-May 21, 2009)

Lower Monumental Dam

An RSW was installed at Lower Monumental Dam (LMN) in 2008. Since the installation of the RSW at LMN, there have been no tests to compare the SPE with and without the RSW in operation in the same year. When comparing SPE estimates with and without an RSW, the best we can do is compare different years with similar spill operations (Table 2). As with LGS, the years where SPE data are available for LMN were similar in their spill operations (~26-29% bulk spill) but differed substantially in their flow regimes.

Based on comparisons of SPE estimates between years with an RSW in operation and years without an RSW in operation, the results are inconclusive as to whether the RSW improves passage efficiency at LMN. For example, 2006 (no RSW) and 2009 (with RSW) were relatively high flow years and both operated under bulk spill of 26-27%. Comparisons of estimates of SPE between these two years reveal that the RSW may have improved SPE at LMN for both yearling Chinook and steelhead (Table 2). Water year 2007 (no RSW) and 2008 (with RSW) were both relatively low flow years, at least during the period when the study was conducted, and both operated under bulk spill of 29%. Comparisons of estimates of SPE between these two years reveal that the operation of the RSW only improved SPE for steelhead (Table 2). Estimates of SPE decreased for yearling Chinook with the operation of the RSW in 2008 (Table 2).

Table 2. Estimates of SPE for yearling Chinook and steelhead at LMN in years with RSW and without RSW (shaded in grey)

	2006	2007	2008	2009
Average Flow (Kcfs)	139	79	68	101.6
Average Spill (%)	26%	29%	29%	27%
Spill Pattern	Bulk	Bulk	Bulk	Bulk
RSW	No	No	Yes	Yes
CH1 SPE	0.60	0.75	0.66	0.73
ST SPE	0.49	0.67	0.83	0.69

Ice Harbor Dam

An RSW was installed at Ice Harbor Dam (IHR) in 2005. Prior to the installation of the RSW, tests were conducted that allow for the comparison of SPE estimates at two spill patterns and two levels of spill (bulk spill at Gas Cap/Gas Cap vs. flat spill at 45 Kcfs/Gas Cap). After the RSW was installed at IHR, tests were conducted that allow for the comparison of SPE estimates without the RSW in operation (at 82% bulk spill) and with the RSW in operation (at 34% bulk spill). However, tests of the same level of spill with and without the RSW in operation were not conducted. From 2006 to 2008, tests were conducted at IHR that allow for comparison of SPE estimates between two different spill operations (30%-40% spill versus 45 Kcfs/Gas Cap) with the RSW in operation for yearling Chinook and steelhead. Finally, a test was conducted at IHR in 2007 that allows for the comparison of SPE estimates under reduced spill (44% spill) versus BiOp spill (~77%), both with the RSW in operation for subyearling Chinook.

In 2004 (no RSW), the Gas Cap/Gas Cap (bulk) spill operation resulted in higher estimates of SPE than the 45 Kcfs/Gas Cap (flat) spill operation for yearling Chinook (Table 3). The 2005 tests showed that ~34% bulk spill with RSW had lower SPE than ~82% bulk spill without the RSW, for both yearling Chinook and steelhead (Table 3). These same tests also showed that 46% bulk spill with the RSW resulted in lower SPE estimates than 84% bulk spill without the RSW for subyearling Chinook (Table 4). The tests conducted in 2006 through 2008 (all with RSW) revealed that the reduced spill levels (30-40% spill) resulted in lower estimates of SPE than the higher spill operations (45 Kcfs/ Gas Cap) for both yearling Chinook and steelhead. The 2007 test on subyearling Chinook also revealed that reduced spill levels with the RSW (44% spill) resulted in lower estimates of SPE than did higher spill levels with the RSW (73% spill) (Table 4).

Finally, Attachment B of Tribal MOA has a recommended “performance standard” of 0.84->0.90 SPE for subyearling Chinook at IHR. SPE estimates for subyearlings in 2008 did not meet this recommended standard.

Table 3. Estimates of SPE for yearling Chinook and steelhead at IHR in 2006, 2007 and 2008 under different spill levels.

	2004	**2004**	**2005**	**2005**	**2006**	**2006**	**2007**	**2007**	**2008**	**2008**
Spill Operation	Bulk GC/GC	Flat 45Kcks/GC	Bulk	Bulk RSW	30-40%	45Kcfs/ GC	30-40%	45Kcfs/ GC	30-40%	45Kcfs/ GC
Avg. Flow (Kcfs)	85.6	89.5	105.0	96.0	120	145	75	79	103	123
Avg. Spill (%)	76.2%	54.2%	82%	34%	33%	58%	31%	68%	35%	63%
RSW	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
CH1 SPE	0.98	0.88-0.91	0.98	0.78	0.61	0.81	0.75	0.93	0.56	0.77
ST SPE			0.97	0.77	0.61	0.81	0.86	0.95	0.77	0.89

Table 4. Estimates of SPE for subyearling Chinook at IHR in 2006, 2007 and 2008 under different spill levels.

	2005	**2005**	**2006**	**2007**	**2007**	**2008**
Spill Operation	Bulk	Bulk RSW		Reduced Spill	BiOp Spill	
Average Flow (Kcfs)	49	50	56	37	39	96
Average Spill (%)	84%	46%	54%	44%	73%	56%
RSW	No	Yes	Yes	Yes	Yes	Yes
CH0 SPE	0.98	0.87	0.94	0.84	0.97	0.66

McNary Dam

Two TSWs were installed at McNary Dam (MCN) in 2007. Since the installation of the TSWs at MCN, there have been no tests that allow for a comparison of SPE with and without the TSWs in operation in the same year. When comparing SPE estimates with and without the

TSWs, the best we can do is compare different years with similar spill operations (Table 5). Unlike LGS and LMN, there are few years where SPE data are available for MCN that have similar spill operations. In 2006, tests were conducted at MCN that allow for the comparison of SPE estimates without TSWs in operation, under two different spill patterns (same spill levels) for yearling Chinook and steelhead. Also in 2006, a test was conducted that allows for the comparison of SPE estimates at two different spill levels (without TSWs) for subyearling Chinook. In 2007, tests were conducted at MCN that allows for the comparison of SPE estimates for subyearling Chinook under two different spill operations (40% versus 60%) with the TSW in operation. In 2008, there was a test at MCN that allows for the comparison of SPE estimates (with TSWs) under two different spill levels (40.2% versus 52.8% for yearling Chinook and steelhead and 40% versus 60% for subyearling Chinook). Unfortunately, during this period the flow regimes were also different (Table 5). Finally, there were no tests in place for yearling Chinook and steelhead in 2007 and 2009, but there was research that allowed for the estimation of SPE for these two species under a single spill operation.

The tests conducted prior to the installation of the TSWs revealed that SPE estimates were slightly lower under the proposed TSW spill pattern (south loading), compared to the FPP spill pattern (north loading) (Table 5). This was true for both yearling Chinook and steelhead. The 2006 tests also revealed that SPE estimates under 60% spill (no TSW) were higher than those under 40% spill (no TSW) for subyearling Chinook (Table 6). The 2008 tests with yearling Chinook and steelhead revealed that with TSWs in operation, spill of 52.9% resulted in higher estimates of SPE than spill of 40.2%, for both species (Table 5). However, it should be noted that these two spill treatments occurred under substantially different flow regimes (Table 5). The 2007 and 2008 tests with subyearling Chinook revealed that spill of 60% resulted in substantially higher estimates of SPE than did spill of 40% (Table 6). This pattern was true regardless of where the TSWs were placed.

Finally, Attachment B of Tribal MOA has a recommended SPE "performance standard" of 0.45-0.57 for yearling Chinook and 0.52-0.78 for steelhead at MCN. It should be noted that spill of 42.7% in 2009 did not meet these standards. However, spill of 52.9% in 2008 did meet these standards. Furthermore, the recommended SPE "performance standard" of 0.61-0.64 for subyearling Chinook was not met at MCN under the 40% spill operation in 2007 or 2008. However, spill of 60% in 2007 and 2008 resulted in SPE estimate that met (2007) or nearly met (2008) this standard.

Table 5. Estimates of SPE for yearling Chinook and steelhead at MCN in 2006 (No TSW) and 2007-2009 (with TSW)

	2006 FPP[A]	**2006 TST**[B]	**2007**	**2008 Early**	**2008 Late**	**2009**
Average Flow (Kcfs)	334.1[C]	334.1[C]	247.6	211.3	352.5	271.2
Average Spill (%)	50%	50%	~40%	40.2%	52.9%	42.7%
TSW location	No TSW	No TSW	Bays 20 & 22	Bays 19 & 20	Bays 19 & 20	Bays 4 & 20
CH1 SPE	0.66	0.61	0.57	0.32	0.72	0.41
ST SPE	0.68	0.60	0.78	0.25	0.58	0.35

[A] FPP – spill primarily on North end of spillway
[B] TST – spill primarily on South end of spillway (similar to proposed TSW spill pattern)
[C] Average daily flow for entire study period (Apr. 26-June 3). Average flows for each treatment were not available in report

Table 6. Estimates of SPE for subyearling Chinook at MCN in 2006 (No TSW) and 2007-2008 (with TSW)

	2006	2006	2007	2007	2008	2008
Average Spill (%)	~40%	~60%	~40%	~60%	~40%	~60%
TSW location	No TSW	No TSW	Bays 20 & 22	Bays 20 & 22	Bays 19&20	Bays 19&20
CH0 SPE	0.46	0.67	0.48	0.73	0.33	0.60

John Day Dam

Two TSWs were installed at John Day Dam (JDA) in 2008. As with other FCRPS sites, there have been no tests that allow for comparison of SPE estimates with and without the operation of the TSWs in same year. Therefore, the best we can do to compare SPE estimates is to compare different years with similar operations. However, as with the other projects, when spill operations are comparable, the flow regimes of the different years may differ. The only year where SPE estimates are available for JDA prior to the installation of the TSWs was 2000. In 2000, a test was conducted that allows for the comparison of SPE estimates at two different spill levels (0/60% versus 30%/60%) for yearling Chinook and steelhead. In 2008 and 2009, tests were conducted at JDA that allow for the comparison of SPE estimates with TSWs operating at two different spill levels (30% versus 40%) for yearling Chinook, steelhead, and subyearling Chinook.

The 2000 test revealed that the 30%/60% spill treatment resulted in higher estimates of SPE than the 0/60% treatment for yearling Chinook (Table 7). However, the improvement in SPE for steelhead was marginal in this year (Table 7). The 2008 and 2009 tests (with TSWs) revealed that reduced spill levels at JDA resulted in slightly reduced estimates of SPE for yearling and subyearling Chinook. However, these tests are inconclusive for steelhead. For steelhead, lower spill levels resulted in higher SPE estimates in 2008 and lower estimates of SPE in 2009.

Table 7. Estimates of SPE for yearling Chinook and steelhead at JDA in 2006 (No TSW) and 2008-2009 (with TSW)

	2000	2000	2008	2008	2009	2009
Average Spill (%)	0/60%	30%/60%	~30%	~40%	~30%	~40%
TSW location	None	None	Bays 15 & 16	Bays 15 & 16	Bays 15 & 16	Bays 15 & 16
CH1 SPE	0.75	0.86	0.76	0.77	0.76	0.85
ST SPE	0.61-0.79	0.64-0.83	0.76	0.72	0.72	0.81
CH0 SPE			0.66	0.71		