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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		