Appendix 2
Description of Calculations Used to Address Question 1.4.B: Can Surface Bypass/Collectors Substantially Increase the Proportion of Snake River Spring/Summer Chinook Salmon Transported?

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To determine the likelihood that surface bypass collectors (SBC) may substantially increase the proportion of Snake River spring/summer chinook salmon that are collected for transportation, the following estimates were derived:

1. the proportion of salmon that can be collected with existing project configurations and operations under a range of assumptions
2. the performance of an SBC that would be necessary to change this proportion incrementally.

Because the purpose of this analysis is to bound expectations, the approach is simple and results are general approximations.

Existing Project Configuration

The first step was to define the current system configuration, without a SBC, as the 1997 collector project configurations that are described in the National Marine Fisheries Service (NMFS) March 2, 1995, biological opinion on operation of the Federal Columbia River Power System. These are:

Lower Granite Dam:	Extended-length submerged bar screens (ESBS) in all units
Little Goose Dam:	ESBS in all units
	Lower Monumental Dam:
	Standard-length submerged travelling screens (STS) in all units
McNary Dam:	ESBS in all units

To examine the potential under an operation designed to maximize collection, it was assumed that no voluntary spill would occur. To simplify calculations, periods of involuntary spill at high flows also were disregarded. This assumption was made because the proportion of the run passing each project during periods of involuntary spill will vary annually, which would greatly increase complexity of the analysis. **Therefore, an important caveat is that the proportion of listed salmon estimated to be collected in this analysis will be somewhat higher than the proportion that can actually be collected, because involuntary spill will reduce collection efficiency during a proportion of the run.**

A further simplifying assumption was that collection at McNary Dam was irrelevant, both because only a small proportion of Snake River spring/summer chinook would still be in the river at that point and because the NMFS 1995 biological opinion specifies that transportation from McNary Dam will not occur until at least 1999.

Population of Interest and Collection Metric

The hydro decision pathway considers listed Snake River spring/summer chinook salmon between the head of Lower Granite pool and the tailrace of Bonneville Dam. Therefore, the proportion of fish collected is defined relative to the number of fish first entering Lower Granite pool. Ideally, listed Snake River spring chinook salmon from the Tucannon River, which enter the Snake River between Little Goose and Lower Monumental dams, should also be included. In 1996, the number of Tucannon River salmon entering the Snake River was estimated to be approximately 36% of the number of listed spring/summer chinook salmon reaching Lower Granite Dam (Schiewe 1996; Table 4). These fish are not included in this analysis because all other comparisons and estimates of survival

goals in the hydro decision pathway include fish that pass through the entire hydro system. **An important caveat is that the proportion of listed salmon estimated to be collected in this analysis will be somewhat higher than the proportion that can actually be collected, because listed Tucannon River spring/summer chinook salmon are not included in calculations.**

The proportion of transported fish is estimated as:

$$\frac{COLLECTED_{LGR} + COLLECTEDSUBLGO + COLLECTED_{LMO}}{LGR\ POOL\ ARRIVALS}$$

where COLLECTED refers to the number collected and surviving to the point of barge or truck loading at each project, LGR is Lower Granite Dam, LGO is Little Goose Dam, LMO is lower Monumental Dam. $COLLECTED_{LMO}$ does not include listed fish from the Tucannon River. There are two possible fates of fish that are not collected for transportation. Non-collected fish may either die between the head of Lower Granite pool and the tailrace of Lower Monumental Dam or they may survive and remain in the river below Lower Monumental Dam.

Method of Estimating Current Collection Capability

A simple spreadsheet model routes fish through reservoirs and through turbines or bypasses at the first three Snake River projects.

The fish surviving through each reservoir is:

$$FOREBAY_{[DAM\ X]} = TAILRACE_{[DAM\ (X\ -\ 1)]} * SUR_{[RESERVOIR]}$$

where FOREBAY is the proportion of fish starting from the head of Lower Granite pool that arrive in the forebay of a given dam; X refers to LGR, LGO, or LMO; TAILRACE is the proportion of fish either in the tailrace below LGR or LGO dam or at the head of LGR reservoir; and $S_{[RESERVOIR]}$ is a constant survival rate expressed on a per-reservoir basis.

The collection at each dam is:

$$COLLECTION_{[DAM\ X]} = FOREBAY_{[DAM\ X]} * FGE_{[DAM\ X]} * S_{[BYPASS]}$$

where $FGE_{[DAM\ X]}$ is the fish guidance efficiency (proportion of fish approaching turbines that are bypassed) at a particular dam and $S_{[BYPASS]}$ is the survival through the bypass system (screens, gatewells, orifices, etc.) prior to barge or truck loading.

Survival of non-collected fish at each dam is:

$$TAILRACE_{[DAM\ X]} = FOREBAYSUB[DAM\ X] * (1 - FGE_{[DAM\ X]}) * S_{[TURBINE]}$$

where $S_{[TURBINE]}$ is the survival of fish passing through turbines.

The cumulative proportion of fish surviving and remaining in the river past the first three projects is $TAILRACE_{[LMO]}$.

The cumulative proportion of fish that die between the head of Lower Granite pool and the tailrace of Lower Monumental Dam is:

$$TAILRACE_{[HEAD\ OF\ LGR\ POOL]} - [COLLECTED_{[LGR,LGO,LMO]} + TAILRACE_{[LMO]}]$$

The following values were used in calculations:

$S_{[RESERVOIR]}$	0.90, 0.95	(see Section 1.6.B)
$S_{[BYPASS]}$	0.98	(see Section 1.1A)
$S_{[TURBINE]}$	0.89, 0.92	(see Section 1.6.A.1.b.1)
FGE		
LGR and LGO	0.60,0.74	(with ESBS, Ceballos 1996, Section 1.6.A.1.b.3)
LMO	0.45,0.55	(with STS, Ceballos 1996, Section 1.6.A.1.b.3)

Results: Current Collection Capability

Results are presented in Table 1. Table 1 displays results of intermediate calculations along three rows corresponding to Lower Granite, Little Goose, and Lower Monumental reservoirs and dams. The top half of the table displays results based on the lower reservoir and turbine survivals described above and the bottom half displays results based on the higher survival estimates. Within each section, the range of FGE estimates is considered.

The cumulative proportion transported at LGR, LGO, and LMO under 1997 project configuration is 0.739-0.810 under the lower survival assumptions and 0.808-0.874 under the higher survival assumptions. The full range is therefore approximately 74-87%. Cumulative mortality (10.5-21.5%) and non-collected fish surviving to the LMO tailrace (2.1-4.5%) matching the extreme transport collection estimates are also displayed.

Collection Capability With ESBS at LMO

This calculation is identical to the method described above. The FGE at LMO is increased from 0.45-0.55 to 0.60-0.74 to reflect replacement of standard screens with extended-length screens. Results are presented in Table 2. Collection increases approximately 1% under this scenario.

Collection Capability With Surface Collector: Methods

The method used to estimate the proportion of smolts entering Lower Granite pool that would be collected if a surface bypass/collector (SBC) at Lower Granite Dam was operated is similar to the method described above. The main difference is inclusion of a term for the collector in calculation of $COLLECTION_{[DAM\ X]}$ and $TAILRACE_{[DAM\ X]}$.

$COLLECTION_{[DAM\ X]}$ is calculated as:

$$COLLECTION_{[DAM\ X]} =$$

$$FOREBAY_{[DAM\ X]} * [SBC_{[COL]} + ([1 - SBC_{[COL]}] * FGE_{[DAM\ X]})] * S_{[BYPASS]}$$

where the proportion of fish arriving in the forebay at a project and entering the collector, $SBC_{[COL]}$, is a pre-defined constant ranging from 0.2-1.0 at LGR and equal to zero at other projects.

$TAILRACE_{[DAM\ X]}$ is calculated as:

$$TAILRACE_{[DAM\ X]} =$$

$$FOREBAY_{[DAM\ X]} * (1 - [SBC_{[COL]} + ([1 - SBC_{[COL]}] * FGE_{[DAM\ X]})]) * S_{[TURBINE]}$$

A spreadsheet calculated these values under the same ranges of reservoir survival, turbine survival, and FGE as the previously-described calculations. Additionally, information regarding the efficiency of a surface collector under various assumptions was calculated. SBC efficiency is defined as:

$$SBC\ EFFICIENCY = \frac{SBC_{[COL]}}{SBC\ FLOW \div TOTAL\ FLOW}$$

In other words, SBC efficiency is defined as the ratio of the proportion of fish arriving in the forebay at a project and entering the collector to the proportion of total flow passing through the SBC. SBC FLOW was assumed to be 4 kcfs, based on the flow through the prototype SBC being tested at Lower granite Dam in 1996 (COE 1996). TOTAL FLOW was evaluated at two levels, 60 kcfs and 200 kcfs, representing a large proportion of the range of flows generally occurring in the Snake River during the migration of spring/summer chinook salmon.

Collection Capability With Surface Collector: Results

Results are presented in Tables 3-8. A summary of the results follows. Parentheses indicate changes from the 1997 condition.

	Percent of Smolts Collected In Surface Collector at LGR	Percent of Smolts Arriving at LGR Pool That Are Transported
1. 1997 Condition	n/a	74-87%
2. Add ESBS at LMO	n/a	75-88%(+1%)
3. With SBC at LGR	20%	77-89%(+2-3%)
4. With SBC at LGR	40%	80-90%(+3-6%)
5. With SBC at LGR	60%	83-91%(+4-9%)
6. With SBC at LGR	80%	85-92%(+5-11%)
7. With SBC at LGR	90%	87-93%(+6-13%)
8. With SBC at LGR	100%	88-93%(+6-14%)

A 5-13% increase in the proportion transported could be achieved if a SBC collected 80-90% of the fish arriving at Lower Granite Dam. Note that, in order to achieve this performance, the efficiency (as defined above) would have to be between 12 and 45. This means that for each percentage of flow passing through the collector, 12-45% of the fish would have to pass through it. This concentration appears to be much greater than that required at Wells Dam, which collects about 90% of the fish in 6-8% of the total discharge (Johnson 1995), which translates to an efficiency of 11-15.

References

Ceballos 1995 [Internal NMFS memorandum - need full documentation]

Corps of Engineers. 1996. Lower Granite Dam surface bypass and collection system 1996 prototype test. Final Draft. April 8, 1996. U.S. Army Corps of Engineers, Walla Walla District.

Johnson, G. 1995. Fisheries research on phenomena in the forebay of Wells Dam in spring 1995 related to the surface flow smolt bypass. Draft Report. December 5, 1995. Report prepared for U.S. Army Corps of Engineers, Walla Walla District, by Pacific Northwest Laboratory, Richland, Washington.

Schiewe, M. 1996. Estimation of percentages of listed spring/summer and fall chinook and sockeye salmon smolts arriving at McNary Dam in 1996. January 23, 1996, memorandum from M. Schiewe (NMFS) to R. Bellmer (NMFS). 21 p.