Workshop to Investigate Solutions for Smolt Collection at or near Cowlitz Falls Dam

March 3 & 4, 2008

Background Information

Statement of Problem

The Cowlitz River historically supported abundant runs of coho, spring and fall Chinook salmon along with steelhead and sea-run cutthroat trout. In the 1960s, Tacoma Power completed the Cowlitz River project, composed of two high dams on the Cowlitz River that effectively blocked volitional migration to about 80% of the spawning habitat for anadromous fish. Initially, Tacoma Power attempted to collect out-migrating smolts upstream of the second dam with Lake Merwin type traps. However, this trapping was unsuccessful and discontinued after 1973. This effectively eliminated anadromous fish production in the Upper Cowlitz Watershed until the construction of the run-of-the-river Cowlitz Falls Dam (1994) and integral juvenile fish collection facility (1996) by Lewis County PUD, with funding from Bonneville Power Administration (BPA), enabled collection of downstream migrating smolts from the Upper Cowlitz River Basin. This smolt collection capability is essential for an opportunity to reintroduce salmon and steelhead to the historically productive 240 miles of anadromous habitat upstream of Cowlitz Falls Dam.

The current Upper Cowlitz reintroduction program began as a BPA program in 1994 with the Washington Department of Fish and Wildlife (WDFW) as the lead agency. The collection of out-migrating smolts emigrating from the Upper Cowlitz Watershed and the safe transportation of these smolts around the large reservoirs of the Cowlitz River Project has been determined to be the primary factor for the success or failure of the reintroduction effort and the efficiency of smolt collection and passage will determine the success of this effort. The habitat in the Upper Cowlitz Watershed remains capable of sustaining significant populations of naturally reproducing populations of salmon and steelhead. Although over two million smolts have been captured by the Cowlitz Falls Fish Facility (CFFF) at the Cowlitz Falls Dam and safely transported to the lower Cowlitz River since 1996, current fish collection efficiency (FCE) is insufficient to restore self-sustaining anadromous fish populations to harvestable levels in the upper Cowlitz Watershed.

Through relicensing of their Cowlitz River Project, Tacoma Power has agreed to improve downstream fish passage. Article 1 of the license issued to the Cowlitz River Project (FERC No. 2016) dated July 18, 2003 requires that the licensee prepare a plan for downstream fish passage and collection that includes "…proposed facilities and measures most likely to achieve the goal of 95% fish passage survival ("FPS"), as defined in the August 2000 Settlement Agreement, to be funded by the licensee to contribute to effective downstream passage and collection at or near Cowlitz Falls and/or to be constructed by the licensee downstream of Cowlitz Falls Dam at Riffe Lake." The emphasis of the Settlement Agreement "…is ecosystem integrity and the restoration and recovery of wild, indigenous salmonid runs, including ESA listed and unlisted stocks, to harvestable levels."

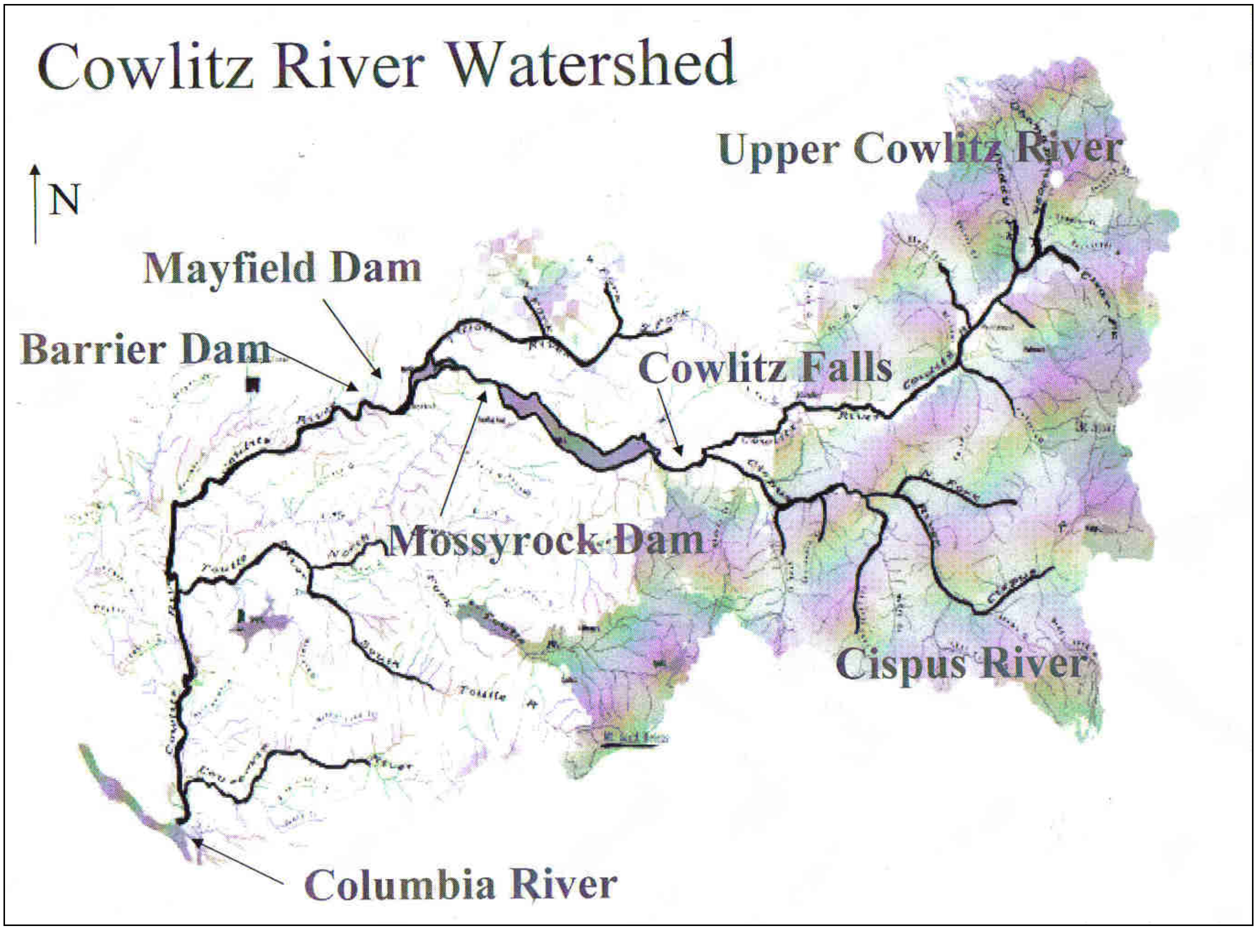

Figure 1. Cowlitz River Basin and relative location of dams and rivers. Shaded area approximately represents the drainage area of the Upper Cowlitz Watershed.

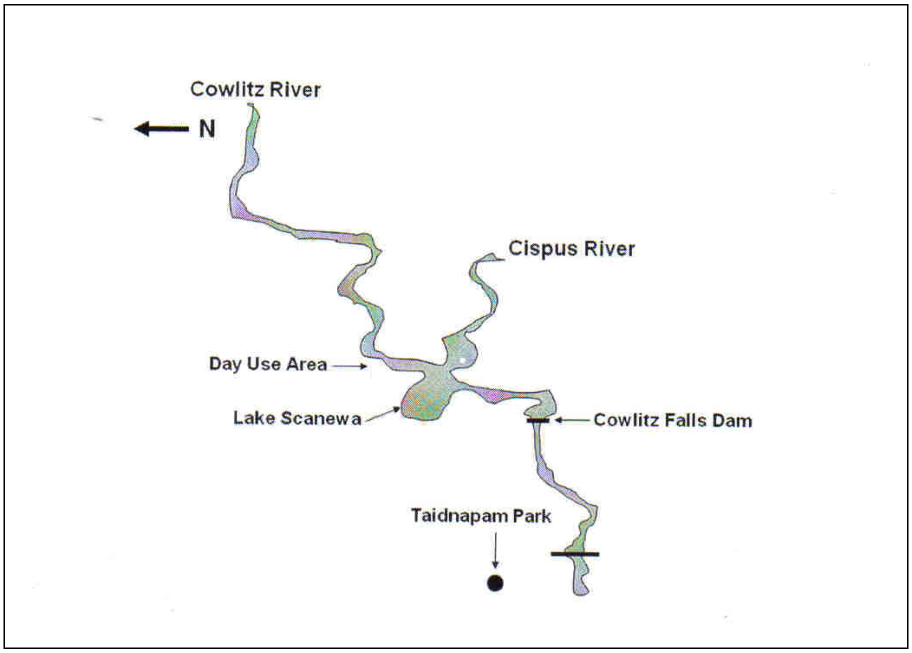

Figure 2. Layout of Lake Scanewa (Cowlitz Falls Reservoir).

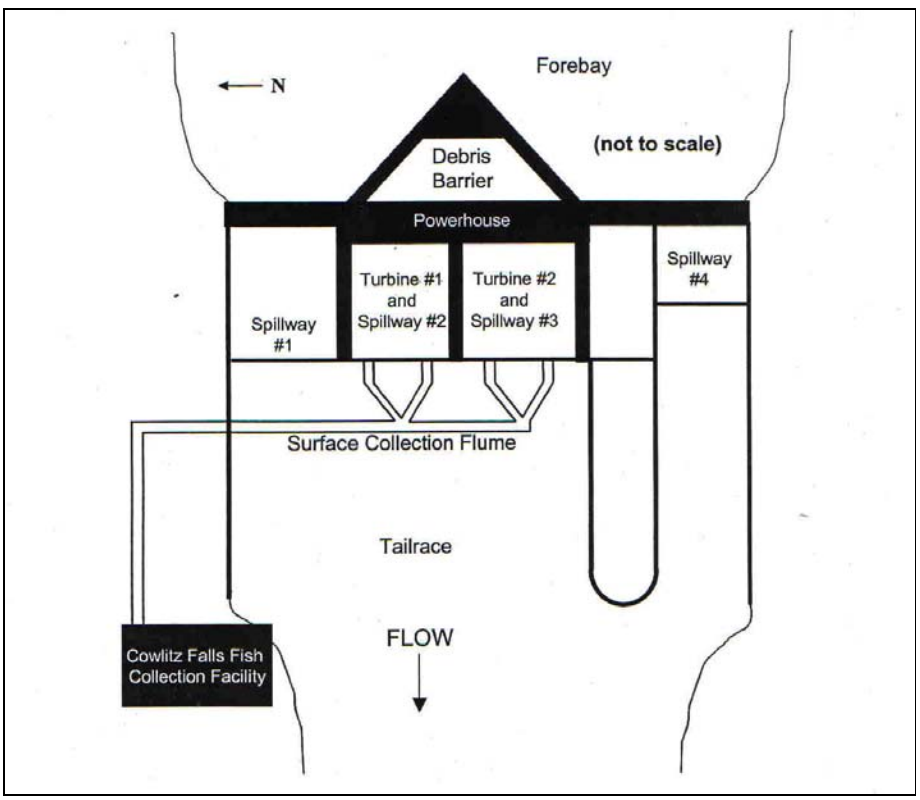

Figure 3. Plan view of Cowlitz Falls Dam and Cowlitz Falls Fish Facility.

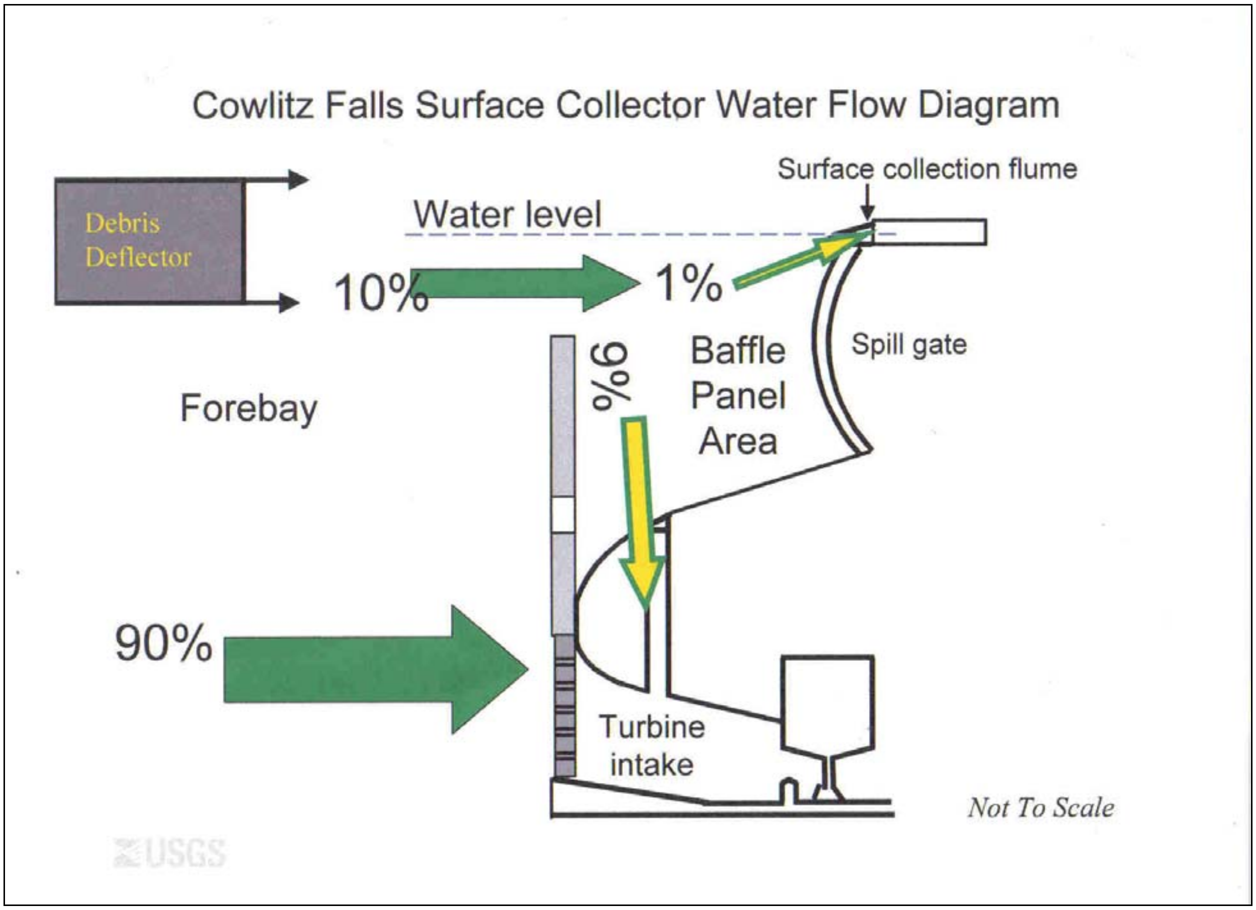

Figure 4. Cross section diagram of Cowlitz Falls Dam, showing surface collector with water flow paths and approximate distribution. The percentages are of total dam flow. The lighter, bi-colored arrows show the approximate distribution of flow entering the baffle panel area.

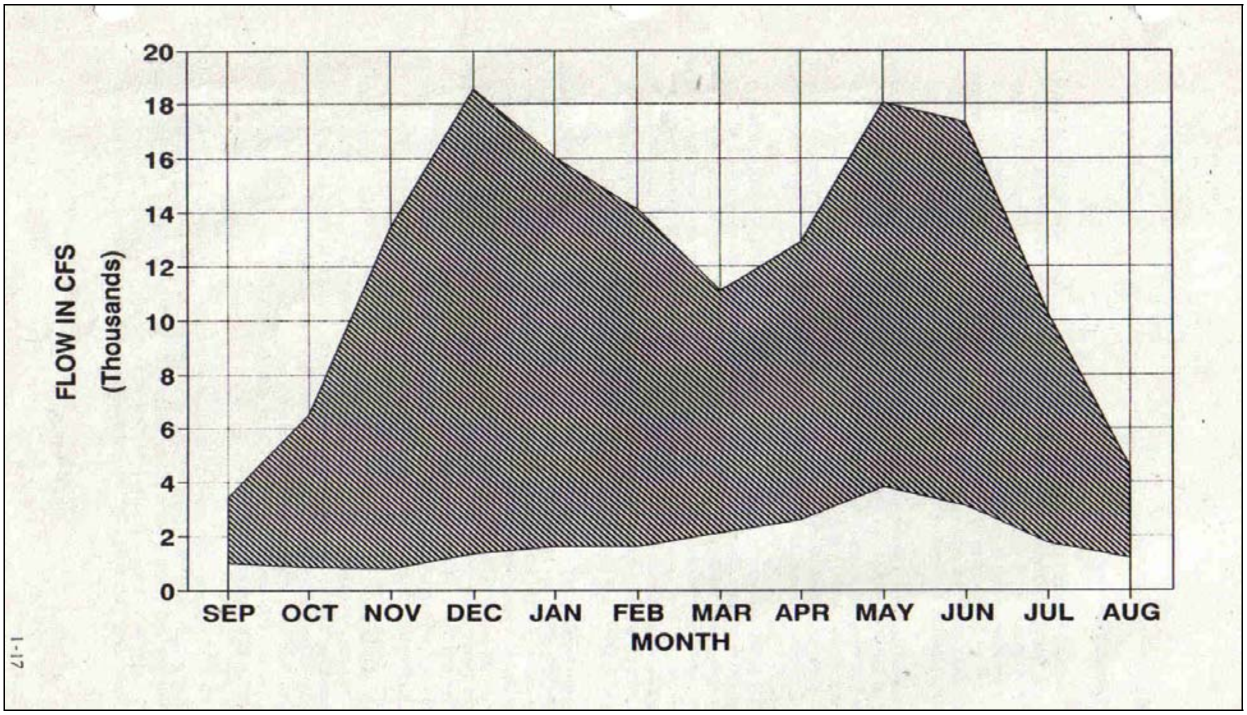

Figure 5. Probable minimum and maximum flows in the upper Cowlitz River, 5-95% Flow exceedence probability based on data from Flow-Duration, 1929-1985. (from GAIA, 1994)

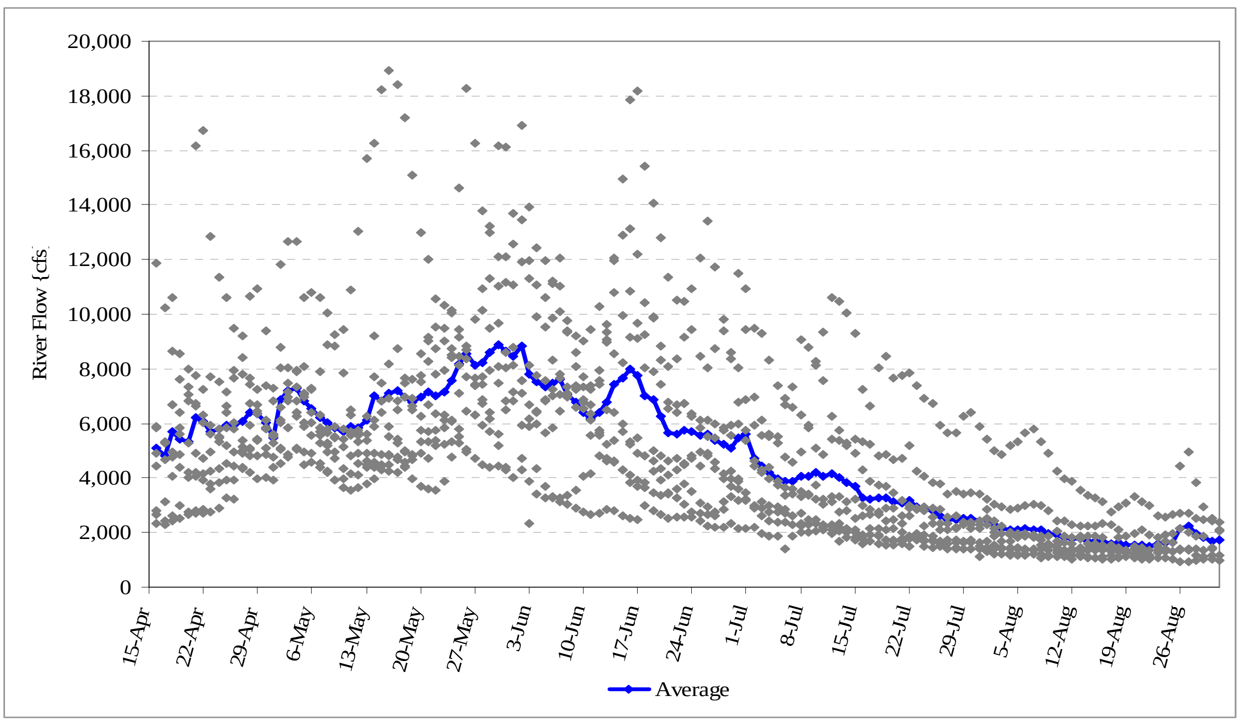

Figure 6. Cowlitz Falls Dam flow during the spring-summer smolt collection season, 1997-2005.

Project Description

The Cowlitz Falls Dam, located at RM 88.5 on the Cowlitz River, is a concrete gravity dam with spill bays located directly above the generating units (Thompson et al. 1993). The dam is 700 feet long and 140 feet high, with a head of 87.5 feet and has four radial spill gates; one ungated emergency spillway, and two sediment sluiceways. The two outer radial gates are equipped with flap gates to pass excess flows and small debris. Two Kaplan turbines are located below the two center spillways in a hydro-combine design.

The turbines are vertical-shaft, variable pitched, with elbow type draft tubes. Each has five runner blades, a turbine hub, blade servo and a runner blade operating mechanism. The runner blades are constructed of corrosion and wear resistant cast stainless steel. The discharge ring of the turbine is unique, with a spherical shape that allows constant blade tip clearance regardless of blade angle. Turbine speed is 150 RPM. Each turbine unit operates in a range from 1,700 to 5,250 cfs, for a total capacity of 10,500 cfs. Peak generation capacity from the run-of-the-river Cowlitz Falls Dam is 70 MW but average generation is less than 30 MW.

The reservoir behind the Cowlitz Falls Dam, Lake Scanewa, covers 610 surface acres with a storage capacity of 11,000 acre/feet. The license permits a maximum reservoir elevation of 862 feet, which creates a wishbone shaped lake with forks extending upstream into the Cowlitz and Cispus River valleys 10.5 miles and 1.5 miles, respectively. The water entering the reservoir exits in less than 24 hours. The average annual flow at the Cowlitz Falls Dam site is approximately 4,600 cubic feet per second (cfs). Summer low flows can decline to 1,000 cfs or less. Peak discharge recorded at the project exceeded 103,000 cfs in February 1996 during a one in one hundred year flood event. The Cowlitz Falls Dam is required by license to draw Lake Scanewa down by 9 to 20 feet when Cowlitz River flows measured at Randle WA exceed 15,000 cfs. Since dam construction on average 2 of these flood control drawdowns have occurred annually. These draw-downs cause the loss of adult and juvenile salmonids from the system primarily through fallback over Cowlitz Falls Dam and by stranding. WDFW and cooperators are currently studying the significance of these events to total watershed salmonid production. From 1996 through 2007, there were no flood control draw-downs of Lake Scanewa during the spring-summer operation of the CFFF.

Although the license for the Cowlitz Falls Project did not require fish passage, it did require that the dam be designed to allow for fish passage structures to be retrofitted if funding became available. The Cowlitz Falls Project was designed with provisions to allow for installation of submerged intake screens but also recognized the potential of a surface collection system. BPA agreed to fund the construction of these facilities and in 1992 convened a technical advisory committee, composed of state and federal resource agencies, Friends of the Cowlitz, Lewis County PUD, Tacoma Power and coordinated by Harza Northwest, inc. This group issued a report that concluded that facilities similar to those in place at Wells Dam would be the most promising collection method.

The Project’s two center gates are 45 feet wide. They are protected from debris by a large V-shaped floating “debris deflector” that was designed to steer debris to the larger (65 feet) outside gates. The debris deflector drafts nine feet into the reservoir. The two center gates were modified by cutting and installing small “fish gates” that are controlled electronically to provide calibrated flows through these entrances into the fish flumes.

Seven modifications were made to the Cowlitz Falls Dam to improve the likelihood of successful fish collection at Cowlitz Falls Dam. These modifications include:

1) Installation of four vertical baffled slots,
2) Lowering of the coffer dam and retaining wall by 4.6 meters,
3) Minimizing the use of flap gates during the fish migrations,
4) Installation of a vortex suppresser,
5) Installation of block-out in spillway number 4 pier for potential future fish attraction,
6) Modifications to power intake gate storage,
7) Building trash-racked slot covers for the induction slots.

Initial design plans also included the design, construction and installation of four ramped fish screens behind each of the vertical baffled slots.

The Cowlitz Falls Dam surface collector, fish flumes and separator were completed by mid May 1996. The surface collector was patterned after the effective hydro-combine design at Wells Dam on the mid-Columbia River. Each of the two center spillways has a pier that splits the spillway into two 22 foot wide bays configured to hold the baffle panels. The baffle panel openings were designed to provide surface attraction flows (similar to Wells Dam) that smolts would recognize and follow through the slot opening and into the surface collection flume entrances on the spill gates. The system was originally designed to provide about 10% of the project flow through the baffle panel entrances. Most of this flow would exit via the induction slot and on into the turbines to be used for power generation.

Each of the four surface collection flumes is two feet wide and operated with about four feet of water depth with the reservoir at full pool. These gates were designed to operate with 20 cfs of flow and the radial gates at the entrance to each collection flume were designed to adjust automatically to forebay elevations to maintain these flows. These gates can also be set to operate manually. An alternate mode of fish gate operation, first utilized in 2002, utilized only one gate per turbine power bay set at full open with the second gate closed. This provided over 40 cfs of water to the open fish flume, however when flows exceed 40 cfs, the excess flow spills over the flumes. To prevent fish loss, a slotted cover of PVC piping with gaps narrow enough to keep fish within the flume while allowing excess water to escape was constructed.

After the smolts enter the fish flumes, flow velocities effectively capture the smolts and direct them toward the separator and fish facility. The four collection flumes converge into a single main collection flume with a capacity of approximately 80 cfs of flow. The fish and water continue to the Cowlitz Falls Fish Facility (CFFF). The CFFF includes dewatering structures, a fry/smolt/adult separator, holding tanks, a sampling station, and transportation facilities.

Fish Collection Efficiency (FCE) Estimates and Improvement Attempts

The effectiveness of the surface collection system FCE has been measured every year since 1996 by mark-recapture methods (Table 1). Radio telemetry monitoring of smolts approach and passage has occurred since 1998. FCE is closely related to the FPS measure and can be used as an approximation for discussion purposes. FCE is calculated as the number of marked smolts recaptured at the CFFF divided by the total number of smolts released in that mark group. FPS is defined by the Settlement Agreement as "…the percentage of smolts entering the upstream end of Scanewa reservoir, and adjusted for natural morality, that are collected at Cowlitz falls Dam and Riffe Lake and Mossyrock Dam, that are transported downstream to the stress relief ponds, and subsequently leave the stress relief ponds at Barrier Dam as healthy migrants."

Table 1. Annual WDFW mark-recapture estimates of fish collection efficiency at Cowlitz Falls Dam, with average of weekly release groups and highest and lowest group returns each season.

Year	Late Winter Steelhead			Coho			Sub-Yearling Spring Chinook		
	Average	*Low*	*High*	*Average*	*Low*	*High*	*Average*	*Low*	*High*
2007[1]	**42%**	*30%*	*65%*	**36%**	*14%*	*70%*	**20%**	*10%*	*28%*
2006[1]	**47%**	*6%*	*70%*	**26%**	*3%*	*53%*	**31%**	*11%*	*48%*
2005	**42%**	*23%*	*62%*	**36%**	*19%*	*59%*	**12%**	*0%*	*33%*
2004	**48%**	*26%*	*63%*	**42%**	*8%*	*68%*	**14%**	*0%*	*28%*
2003	**68%**	*57%*	*82%*	**43%**	*20%*	*63%*	**13%**	*6%*	*20%*
2002	**56%**	*45%*	*65%*	**33%**	*5%*	*62%*	**22%**	*14%*	*30%*
2001	**58%**	*41%*	*75%*	**42%**	*13%*	*61%*	**23%**	*12%*	*29%*
2000[2]	**65%**	*55%*	*79%*	**45%**	*19%*	*76%*	**24%**	*13%*	*36%*
1999	**41%**	20%	63%	**17%**	6%	42%	**24%**	7%	46%
1998	**19%**[3]	3%	38%	**32%**	16%	53%	**18%**	11%	44%
1997	**45%**	17%	76%	**21%**	5%	50%	**17%**	10%	45%
1996	**50%**	37%	74%	**15%**	5%	25%	-	-	-

1] Tacoma Fish Screen Tested on Turbine 2. Turbine 1 baffle pannels blocked.

2] Baffle pannel configuration changed to "C-Horizontal"

3] Poor retention of the PanJet marks this year. Actual estimated at 50% by Radio Telemetry.

Chronological evaluation and improvement attempts of Cowlitz Falls Surface Collector Efficiency

1994*- Cowlitz Falls Dam Completed. Cowlitz Falls Project Fisheries Management Plan: Anadromous Fish Reintroduction Program adopted*
(Thompson, et al. 1992, GAIA 1994)

1995 *– Hydroacoustic evaluation of smolt travel at Cowlitz Falls Dam*
See publication for details of results. (HTI 1996)

1996 - *Interim Facility, Initial FCE estimates, HTI hydro-acoustics*
(HTI 1997, Serl and Morrill 1999a)
This was a partial season while the CFFF under construction. The original configuration consisted of the ramped fish screen (RFS) in slot #3. Slots #1, #2 and #4 were operated with 4'wide by 36' deep slot configuration. Mark-recapture FCE measured at 50% for steelhead and 15% for coho. Collection ended prior to Chinook migration due to construction. Hydro-acoustic sampling suggested an average of 95.8% of all fish with net movement toward the turbine intakes were observed in the area immediately in front of the two center spillways. The CFFF was finished in the winter of 1996.

1997 - *Testing of original Ramped Fish Screen (RFS)*
(Serl and Morrill 1999b)
This was the first full spring-summer season of CFFF operation. The surface collector was configured the same manner as 1996. FCE results were 45% for steelhead, 21% for coho and 17% for spring Chinook sub-yearlings. A screen-in versus screen-out study of the RFS was conducted and more smolts were collected through the non-screened fish flumes than the RFS equipped fish flume. For steelhead, cutthroat and coho over 80% were collected in the non-screened flume. Spring Chinook smolts were collected in similar numbers in slots with and without RFS. The RFS was determined to be ineffective and not used again. WDFW recommended not acquiring the three additional screens originally planned.

1998 - *Pilot radio telemetry with steelhead smolts, Turbine Fyke Net FCE testing*
(Adams et al. 1999, Serl and Morrill 1999b)
The dam was configured with all four baffle panels with the 4'wide by 36' deep slot. This was the first study with USGS-Columbia River Research Lab participation at Cowlitz Falls. This result suggests that steelhead smolts quickly travel to the dam but then delay passage at the dam. Steelhead that were not collected were found to be passing the turbines through the induction slots or were making upstream trips of several miles into the reservoir. FCE estimates were 32% for coho and 18% for spring Chinook and approximately 50% for steelhead.

1999 - *Strobe light study, Induced turbulence flow near zone w/ manifold. Forebay induced turbulent flow testing with coho.*
(Evans et al. 1999, Darland et al. 2001a, Serl and Morrill 2000a)
A strobe light system was tested to divert smolts from passing the induction slots. The results indicated that the strobe light increased induction slot passage when on. FCE estimates this year were 41% for steelhead, 17% for coho and 24% for spring Chinook. USGS conducted a near

zone directed flow by pumping a surface jet of water at the fish flumes. This had no effect on fish collection. USGS also tested the directed flow system in the forebay and demonstrated that smolts could be moved with the directed flow system. FCE estimates at the CFFF were 41% for steelhead, 17% for coho and 24% for spring Chinook.

***2000** - Baffle Panel Testing, Forebay induced turbulent flow with Debris Barrier removed.*
(Darland et al. 2001b, Serl and Morrill 2000a)
The USGS, with US Army Corps of Engineers funding, tested directed flow in the forebay with two mixer configurations and the debris barrier removed. Positive results indicated that directed flow increased collection by 17% and 34% with the two configurations. FCE estimates were 65% for steelhead, 45% for coho and 24% for spring Chinook.

***2001** - Baffle Panels reconfiguration to "C"-horizontal, Rounded Flume Entrance tested*
(Farley et al. 2002, Hausmann, et al. 2001, Normandeau Associates, Inc.2001, Serl and Morrill 200b)
After flow velocity profile testing, USGS suggested reconfiguring baffle panels to a "C" horizontal configuration that opened the top entrance to 22' wide and reduced the vortex that developed in the power bays. Radio telemetry demonstrated that the rejection that previously occurred at the 4' wide baffle panel openings was eliminated and >90% of steelhead smolts were detected within 1 meter of the flume openings. A small rounded flume entrance was constructed by Tacoma Power. Side by side sampling indicated that 80-90% of the smolts preferred the standard opening configuration. The rounded flume entrance was first painted a light gray color. When painted dark green, the proportion of smolts using this entrance doubled, but was still low. FCE estimates were 58% for steelhead, 42% for coho and 23% for spring Chinook.

Normandeau and Associates, inc. was contracted to conduct a turbine survival study by LCPUD. Survival rates of 97.3% and 97.6% were calculated for the one-hour and the 48-hour survival tests, respectively.

***2002** - 8' W x 2' D flume box tested with 40 cfs, induced turbulent flow*
(Serl and Morrill 2002, Meeting summary 2002)
Because most steelhead smolts were detected near the fish flume entrances, but delayed entering or rejected entering, we speculated that the 2' wide entrance was too narrow and began research to determine the necessary width required for effective entrance. A plywood and angle iron box with an 8' wide entrance was attached to one flume and about 40 cfs were passed through the box. The 8' opening was found to pass fish with little rejection, but the 2' entrance was still rejected. Passing 40 cfs through one gate with or without the box was found to be more effective at entraining fish than the standard 20 cfs opening. FCE estimates this year were 56% for steelhead, 33% for coho and 22% for spring Chinook.

Tacoma Power convened a meeting to explore methods to meet the downstream survival goals identified in the Settlement Agreement. "The consensus from the brainstorming meeting with agency and consultants on January 31, 2002 at the Mayfield Office is that a full exclusionary system at the upper end of Riffe Lake is necessary for the first attempt to achieve the 95% survival goal."

2003 *- High discharge Wide flume entrance box, High Velocity Orifice (Tacoma)*
(Perry et al. 2004, Serl and Morrill 2003)
We tested collection with 40 cfs through one flume per turbine, with and without a wide entrance box compared to the standard configuration. Although the results indicate that operating the flumes at 40 cfs will improve attraction and entrainment into the flume entrances, problems remain with fish guidance, attractions and collection.. FCE was measured at 68% for steelhead, 43% for coho and 13% for spring Chinook this year.

2004 *- Double Flume Box 40cfs vs 60 cfs, Lake Scanewa Merwin Trapping*
(Serl and Morrill 2004*)*
We further tested a wide opening with additional discharge created by expanding the box to cover both flumes to pull about 60 cfs though on opening. FCE this year was 48% for steelhead, 42% for coho and 14% for spring chinook. Two Lake Merwin type traps, with 185 foot long, 30 foot deep lead nets, were fished in Lake Scanewa by WDFW staff with funding from Tacoma, starting in late June, captured about 6.1% of the migrating chinook.

2005 *- Turbine Fyke Net FCE testing, Lake Scanewa Merwin Trapping*
(Serl and Morrill 2005)
Cowlitz Falls Dam was fished in the “C” horizontal configuration with no other changes this year. Two Merwin traps fished in Lake Scanewa to add supplemental collection to our spring Chinook collection effort. This added an additional 8% collection to the 12% at the dam for a total FCE of 20% spring Chinook. FCE for steelhead was 42% and 36% for coho.

2006 *- First year of testing Tacoma Fish Screen*
(Kock et al. 2006, Serl and Morrill 2006)
The surface collector was configured so that a newly designed Tacoma Fish Screen (TFS) was the only surface collection route and the baffle panels on the other turbine were blocked. FCE estimates this year were 47% for steelhead, 26% for coho and 31% for spring Chinook. The TFS results for 2006 indicated that collection was reduced for steelhead and coho, but improved for Chinook. Didson acoustic Camera footage indicated that there was a high rate of rejection within the screen. It was hypothesized that the steelhead and coho collection were reduced because of the decrease in surface attraction flow. The coho FCE estimates were 18.9% during two turbine operation and 52.1% during one turbine operation. In early May, smolts were noticed in the power bay and collection there began. About 10% of the smolts collected were collected on the turbine with the blocked up baffle panels, apparently by traveling up the induction slots.

2007 *– Second year of testing Tacoma Fish Screen with flow modifications and entrance trap.*
(Lietdke et al. 2007, Serl and Morrill 2008)
A heart type trap entrance was added to the TFS in an attempt to decrease rejection of the screen. Adjustable flow control panels were added to the TFS and the position was changed to improve hydraulic conditions within the screen. FCE estimates this year were 42% for steelhead, 36% for coho and 20% for spring Chinook. Overall, FCE was lower than in 2006, except for coho. The improvement in coho FCE was likely due to the much lower than normal flows in 2007. Screen rejection was still a problem and discovery efficiency for Chinook was very low.

***2008** – Proposed Actions*

For 2008, Tacoma Power has proposed fish collection studies at Cowlitz Falls Dam that consist of utilizing the TFS on the north slot of the south turbine as the only surface collector entrance coupled with removal of the debris barrier, electro-anesthesia trials within the fish screen, deploy bar screen into the turbine intake of the north turbine at the induction slot, and additional supplemental trapping both above and below Cowlitz Falls Dam.

Collection Summary

The key findings of WDFW, Tacoma Power and USGS research to date are:

- The steelhead and coho migration periods strongly overlap and Cowlitz Falls Dam typically operates both turbines during this time period. The sub-yearling spring Chinook migration typically takes place after the steelhead and 80% of the coho have migrated. Cowlitz Falls Dam typically only has enough water to operate one turbine during this migration.
- Most radio tagged smolts released into Lake Scanewa arrive at Cowlitz Falls Dam quickly, typically within one day. Smolts tend to favor an approach path that starts on the north side of the reservoir and move southward at they neared the dam.
- Entrance through the four foot wide baffle panels was rejected by about one third of the fish overall.
- Changing the baffle panels to the open topped configuration allowed over 90% of radio tagged steelhead to be detected within 1 meter of the fish gates.
- Rejection of the two-foot wide fish flume entrances caused delay and multiple trips upstream.
- DIDSON acoustic camera monitoring suggests that smolt behavior consists of milling in a zone within one meter of the fish gates.
- Water velocity sampling indicated that the bulk water movement inside of the baffle panel area slows and dives as the flow hits the spill gate and begins to dive towards the induction slot. Smolts are observed to be milling area where this area which is approximately one meter upstream of the fish gates.
- Fish collection is generally better with lower river flows.
- Directed flow was used to direct more fish into the power bays and was demonstrated to increase collection, however directed flow at a small scale was not able to improve fish flume entrance.
- The TFS has not improved smolt collection for steelhead and coho smolts, but has increased spring Chinook smolt collection efficiency in one of two years.

References

Full Background Documents Available at:
http://www.ci.tacoma.wa.us/power/Cowlitz_Falls_Downstream_Collection_Workshop/Review.htm
Also see Power Point Presentation for pictures of Cowlitz Falls Dam and fish collection devises.

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