COUGAR

BioAnalysts

Memo

To: Al Giorgi

From: Kevin Malone

cc: Alden

Date: March 17, 2014

Re: Cougar Dam Turbine Survival Rates

Proposed Turbine Survival Rates for Chinook

Juvenile Chinook survival rates through Cougar Dam have been collected using multiple methods and for varying turbine operations. The methods and turbine operations are as follows:

Methods- PIT Tags, Radio-Tags and HI-Z Balloon Tags[1]

Turbine Operations- Minimum Wicket, Peak Efficiency, Maximum Wicket

Turbine survival estimates for juvenile Chinook have been developed for fish > or < 150 mm and fish condition (malady and malady-free)

Beeman et al (2012) radio-tag data was used as the initial estimate of turbine survival rates for Chinook. The Beeman et al data was selected for the following reasons:

1. Collected using similar methods as the RO survival rate data
2. Survival estimates include both direct and indirect mortality as measured at SF McKenzie Bridge and Leaburg Hatchery.
3. Tagged fish size ranged from 95 mm to 166 mm which is the expected size of subyearling and yearling migrants.
4. Confidence intervals for the data set span almost the entire range of survival estimates developed in other studies.

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[1] HI-Z balloon tag estimates of survival were available for Cougar but because of issues with premature inflation of the balloons these data were not used. The data indicated that direct survival rates may be twice as high as the Beeman et al (2012) estimates. However, all indirect (or delayed) mortality from treatment effects may not have been observed over the time period the measurements were collected.

The Beeman et al (2012) data are summarized in Table 1.

Table 1. Turbine survival rates and 95% CI for Chinook (Beeman et al (2012)

Turbine Survival Rate	Point Estimate	95% CI
Release to SF McKenzie	36.8%	15.01%-63.71%
Release to Leaburg Dam	21.55%	8.63%-38.85%
Non-weighted Average	29%	
Range	8.63%-63.71%	

I am suggesting that for the initial analysis we use the non-weighted average survival rate in Table 1 for subyearlings/yearlings and the high end of the 95% CI for fry (release to SF McKenzie). This approach is consistent with that used in the development of RO survival (i.e. smaller fish have higher survival rates). Similar survival rates were proposed for subyearlings and yearlings because 1) the range being modeled likely encompasses the survival rate for each life stage and 2) the size of each overlaps to some extent dependent on the month of migration[2].

For fry, the end result is an assumption that survival rates between the turbines and RO at gate opening of 1.2-3.5 ft are very similar (Table 2). This approach is deemed adequate for making relative comparisons between alternatives.

Table 2. Proposed Turbine and RO survival rates for juvenile Chinook

	Survival Rate		
	Fry (<60mm)	Subyearlings	Yearlings
Turbine	63.71%	29%	29%
RO 1.2 ft	56.59%	45.9%	45.9%
RO 3.5 ft	59.18%	51.76%	51.76%
RO 7.5 ft	96.4%	73.89%	73.89%

Sensitivity Analysis

Proposed values for the sensitivity analysis is presented in Table 3. The rationale used for the analysis is also presented in Table 3.

Table 3. Proposed Turbine survival rates for sensitivity modeling of juvenile Chinook

	Survival Rate			
	Fry (<60mm)	Subyearlings	Yearlings	Notes
Point Estimate	63.71%	29%	29%	Used Low and High 95% CI values from Table 1 for the high and low range for subyearlings/yearlings For fry, simply selected a wide range of values that would allow us to test model sensitivity
Low	20%	8.63%	8.63%	
High	80%	63.71%	63.71%	

[2] Because fish that rear in the reservoir are expected to be larger than riverine reared fish, future analysis may want to consider adding another life stage category to the Fish Benefits Workbook.

References

Beeman, J.W., Hansen, A.C., Evans, S.E., Haner, P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile Chinook salmon through the powerhouse and regulating outlet at Cougar Dam, Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p.

BioAnalysts

Memo

To: Al Giorgi

From: Kevin Malone

cc: Alden

Date: March 17, 2014

Re: Cougar Fish Benefits Workbook Regulating Outlet Survival Rate for Juvenile Chinook

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Proposed RO Survival Rates for Chinook

I am proposing the following approach for defining RO survival values by life stage for the Cougar Dam RO.

RO survival rates will vary by gate opening with higher gate settings corresponding to higher survival (Table 1).

Table 1. RO baseline survival rate data for Chinook by gate opening for Cougar Dam (Beeman et al 2013).

RO Gate Opening (ft)	Point Estimate	Range	Notes
1.2	45.94%	33.53%-56.59%	Data is for the reach extending from the Temperature Control Tower to Marshall Island (105.8 km). Beeman reports this is the minimum length of reach for expression of treatment effects. Note that > 80 percent of the fish passed the project at night when gate openings were set at 3.2 ft. Survival values for the 1.2 ft gate setting may actually be lower.
3.2	51.76%	44.34%-59.18%	Data is for the reach extending from the Temperature Control Tower to Leaburg Dam (40.2 km). These data were selected to allow for an increase in fish survival between gate openings of 3.2 and 7.5 ft. Note that > 80 percent of the fish passed the project at night when gate openings were at 3.2 ft.
7.5	73.89%	51.15%-96.64%	Data is for the reach extending from the Temperature Control Tower to Marshall Island (105.8 km). Beeman reports this is the minimum length of reach for expression of treatment effects

The data in presented in Table 1 are from Beeman et al 2013. I used the exact numbers from the report only as a means to track the data over time (i.e. link data to the source report). I selected these data as they are relative survival estimates (compared to a control) calculated to reaches below the dam. Therefore, it's assumed that delayed mortality from RO passage has been accounted for in the estimates.

At the June 20, 2013 FBW meeting it was agreed that RO survival rates (by gate opening) would be the same for all passage alternatives.

Fish Size Adjustment

HI-Z balloon tag data indicated that fish <160mm in length had higher survival rates than fish >160mm (Table 3). The data indicated that smaller fish may have higher survival rates at the lower gate openings but not for larger gate openings.

Table 3. RO survival rates for two sizes of Chinook under two gate openings (averages). (Monyzk et al 2010).

Fish Size	RO Gate Opening	% Survival	Survival Improvement for <160mm versus > 160mm fish
<160mm	1.5	94.1%	20.6%
>160mm	1.5	78.1%	
<160mm	3.7	82.8%	-3.6%
>160mm	3.7	85.9%	

Based on the data in Table 2 and Table 3, I propose that we use the survival rates by life stage shown in Table 4. I selected the Beeman et al data as it included all delayed mortality. RO survival rates for subyearlings and yearlings use the point estimate from Table 2 while the fry estimate will use the upper end of the CI range; based on the assumption that the smaller fry (<60mm) will have higher survival at all gate openings.

Similar survival rates were proposed for subyearlings and yearlings because 1) the range being modeled likely encompasses the survival rate for each life stage and 2) the size of each overlaps to some extent dependent on the month of migration[1].

Table 4. Proposed Fish Benefits Workbook RO Chinook survival rates by life stage and gate opening at Cougar Dam.

Gate Opening (ft)	Fry (<60mm)	Subyearlings	Yearlings
1.2	56.59%	45.94%	45.94%
3.2	59.18%	51.76%	51.76%
7.5	96.4%	73.89%	73.89%

Sensitivity Analysis

Values to be used in the sensitivity analysis are shown in Table 5. The values were selected as follows:

[1] Because fish that rear in the reservoir are expected to be larger than riverine reared fish, future analysis may want to consider adding another life stage category to the Fish Benefits Workbook.

Subyearlings/Yearlings

- The lower and upper bounds of the 95% CI values from Table 1 are used for modeling the low and high survival rates for subyearlings and yearlings, respectively.

Fry

- The low value for fry uses the point estimate for subyearlings/yearlings at each gate opening.
- The high value for fry at a gate opening of 7.5 ft. is set slightly above the high end estimate for subyearlings/yearlings.
- The high value for fry at the 3.2 ft. gate opening is based on the point estimate for subyearlings/yearlings at a gate opening of 7.5 ft.
- The high value for the 1.2 ft. gate opening is based on the point estimate for subyearlings/yearlings at a gate opening of 3.2 ft.

Table 5. RO survival rate values proposed for sensitivity analysis.

	Low Value			High Value		
Gate Opening	**Fry (<60mm)**	**Subyearlings**	**Yearlings**	**Fry (<60mm)**	**Subyearlings**	**Yearlings**
1.2	45.94%	33.53%	33.53%	51.76%	56.59%	56.59%
3.2	51.76%	44.34%	44.34%	73.89%	59.18%	59.18%
7.5	73.89%	51.15%	51.15%	98%	96.64%	96.64%

References

Beeman et al 2013. Passage and Survival Probabilities of Juvenile Chinook salmon at Cougar Dam, Oregon, 2012

Monzyk et al 2010. Multi-method Assessment of Direct Mortality for the Regulating Outlet and Turbines at Cougar Dam, South Fork McKenzie River, OR.

BioAnalysts

Memo

To: Al Giorgi

From: Kevin Malone

cc: Alden

Date: March 17, 2014

Re: Cougar Dam Passage Efficiency (DPE)

Proposed DPE values for baseline and passage alternatives are provided below.

Baseline

Estimates of dam passage efficiency (DPE) for Cougar Dam are presented in Table 1. This data was collected and reported by Beeman et al (2012 and 2013) for migration years 2011 and 2012. Estimates wherein the number of tagged fish released were less than 20 were not included in the table (Beeman et al 2012)[1].

The data in Table 1 indicate that DPE increases as reservoir elevation decreases. The highest DPE (70.4%) was observed at reservoir elevation ~1500-1550 ft. The second highest DPE value (70.10%) was measured when average reservoir elevation was 1550.8. However, in this latter example reservoir elevation was decreasing over time to 1504 ft and discharge was high which may have affected results. Beeman et al (2012) indicated that dam passage rate was greatest during low reservoir elevation, at night, and during high discharge. The FBW is not set up to adjust DPE based on discharge or time of day.

[1] Reports are draft- will need to confirm final dates of publication. Note that the DPE estimate for elevation 1571-1690 for wild fish during the spring sample period was not used in the analysis as there was less than 20 fish.

Table 1. Summary of Chinook DPE data for Cougar Dam

Elevation	Point Estimate	95% CI	Notes:
1500+	70.4%		Flows averaged 562 cfs (day) and 585 cfs (night). Elevation range 1500.7 to 1569
1532-1571	10%	3%-17.3%	Wild fish-Low sample size
1532-1571	16.3%	11.2%-21.5%	Hatchery fish
1532-1571	33%	23.3%-42.6%	Wild fish
1532-1571	29.6%	24.5%-34.7%	Hatchery
1550.8	70.10%		Forebay decreasing, range from 1595-1504 and averaged 1550.8; Discharge from 910-6,780 cfs (day) average of 2325 and 780--4040 (average 2,306 cfs) (night).
1571-1690	29.9%	19.7%-40.01%	Wild fish
1571-1690	20.9%	16.1%-25.6%	Hatchery fish
1571-1690	13.5%	10%-17%	Hatchery fish

Because the reservoir fluctuated greatly during the periods when the higher DPE values (~70 percent) were observed, we looked at Project physical data to see the location of the RO and turbines (Figure 1). The data indicated that the opening of the RO was at elevation 1500 ft. It is assumed that all flow will be passed through the gate and will provide excellent surface attraction to migrating juveniles. Under these conditions, DPE is expected to readily achieve 70 percent DPE.

Based on the data in Table 1, Figure 1 and conclusion of the authors that collected the DPE data, proposed DPE values for Cougar are presented in Table 2.

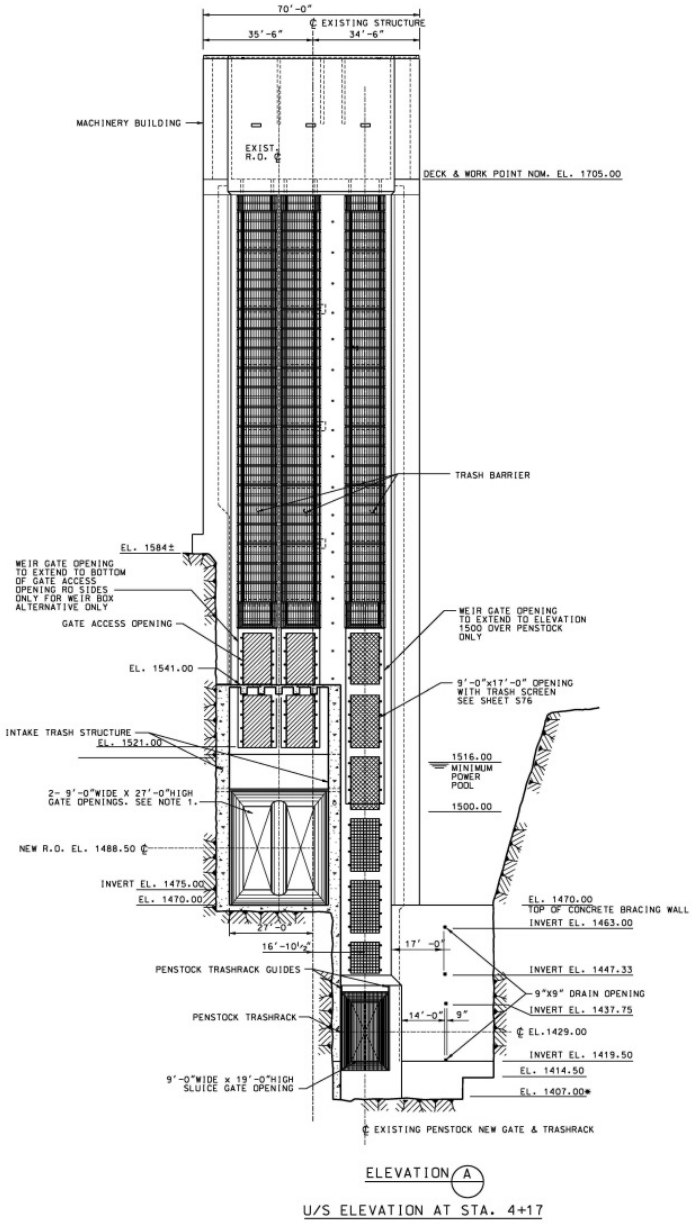

Figure 1. Elevation levels for Cougar Dam, turbines, RO and other structures.

Table 2. Proposed baseline DPE values for Chinook (all life stages) at Cougar Dam.

Elevation (ft)	Point Estimate	Low	High	Rationale
1500-1544	70.4%	60%	80%	Only data for this elevation. The low and high CI were set by subtracting/adding ~10 percentage points to the point estimate. Its assumed that the RO will act lie a surface collector at this elevation.
1545-1584	58%	48%	68%	Point estimate based on Beeman's conclusion that the higher elevation range (1670-1690) was ~50% of the 1545-1584 range. The low and high CI were set by subtracting/adding ~10 percentage points to the point estimate.
1585-1669	44%	34%	54%	Point estimate based on a simple average of the 1545-1584 and 1670-1690 ranges in this table (value rounded). The low and high CI were set by subtracting/adding ~10 percentage points to the point estimate
1670-1690	29.9%	3%	40%	Used the data for wild fish from Table 1 for elevation 1571-1690. Set the low and high CI based on the low and high CI values for data collected between 1532-1571 and 1571-1690, respectively

It should be noted that the DPE values measured at each elevation are affected by the amount of time the reservoir is operated at each elevation. The shorter the period of operation the less time fish are exposed to the condition which likely result in lower estimates of DPE.

Proposed DPE Values for Passage Alternatives

The rationale used for setting DPE values for the passage alternatives is described below.

Elevation 1500 Drawdown

As this is an operational alternative, no changes are proposed to the baseline DPE values as fish behavior is expected to be similar to the baseline for each reservoir elevation.

Delayed Refill

As this is an operational alternative, no changes are proposed to the baseline DPE values as fish behavior is expected to be similar to the baseline for each reservoir elevation.

FSS above 1571 and FSS above 1552

Under these two alternatives, the floating screen structure (FSS) will skim surface flow (up to 1,000 cfs) from the near forebay as the reservoir fluctuates from 1552 to 1690 ft. The structure will be designed with fish-friendly entrance conditions that should readily attract and pass juvenile Chinook. Thus, DPE is expected to be greater than the baseline under the FSS alternatives for most reservoir levels.

The DPE values proposed for these alternatives were based on data from the projects presented below (ENSR 2007).

Rocky Reach Forebay Collector

This system had an entrance, discovery and collection efficiency of 89%, 41% and 37%, respectively. The data was for sockeye salmon.

Lower Granite SBC

Table 3. Lower Granite SBC data

Species	Entrance Efficiency	Fish Collection Efficiency	Fish Collection Effectiveness
Run-at large Spring	0.76	0.43	11
Yearling Chinook	0.84	0.29	6.7
Steelhead Wild	0.60	0.27	6.2
Steelhead Hatchery	0.42	0.18	3.6

Lower Granite RSW

Table 4. Lower Granite RSW data

Species	Discovery Efficiency	Entrance Efficiency	Fish Collection Efficiency	Fish Collection Effectiveness
Run-at large Spring			0.43	9.99
Run-at large Summer			0.25	3.27
Subyearling Chinook			0.64	
Yearling Chinook	0.55	0.92	0.45	7.38
Steelhead Wild	0.68	0.92	0.59	8.33
Steelhead Hatchery	0.70	0.94	0.50	8.53

Cowlitz Falls

Table 5. Cowlitz Falls data

Species	Discovery Efficiency	Entrance Efficiency	Fish Collection Efficiency
Chinook (primarily subyearlings)	59%	66%	39%
Coho	81%	72%	58%

*90 percent conceptual design report.

The data presented in Tables 3-5 on discovery and entrance efficiency support an assumption that a well-designed FSS, with adequate attraction flow, is likely to have a DPE ranging from 60-80%. This assumption is supported by the 70% DPE estimate for Cougar Dam operating at lower reservoir elevations (1500-1550). At lower reservoir elevations the RO operates similar to a surface bypass system.

Based on data collected at Cougar and surface collector/bypass systems at other projects, the values in Table 6 are proposed for FBW modeling of the two FSS alternatives. Note that the range is identical to that used for the baseline at elevation 1500-1544 ft.

Table 6. Proposed DPE values for FSS above 1571 and FSS above 1552 (all life stages).

Elevation (ft)	Point Estimate	Low	High
1500-1544	70%	60%	80%
1545-1584	70%	60%	80%
1585-1669	70%	60%	80%
1670-1690	70%	60%	80%

References

Beeman, J.W., Hansen, A.C., Evans, S.E., Haner, P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile Chinook salmon through the powerhouse and regulating outlet at Cougar Dam, Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p.

Beeman 2013. Behavior and Dam Passage of Juvenile Chinook salmon at Cougar Reservoir and Dam, Oregon, March 1011-February 2012.

ENSR 2007. Surface Bypass Program Comprehensive Review Report. Prepared for the U.S. Army Corps of Engineers. Portland District.

ROUTE EFFECTIVENESS

Baseline

Applies to all life stages as no data/rationale are available to make adjustments

All flow is skimmed from the surface over the tower weirs and distributed inside the tower to the RO and turbine intake down to el 1571 ft. Below el. 1571 ft, the RO bypass gate is opened.

Recommended	Route Effectiveness				
Flow Ratio	Spillway	Fish Passage	RO	Turbine	Rationale and Reference
0.00	1.00	n.a.	1	1	The values were derived by using Beeman et al (2012 and 2013) data for RO
0.10	1.00	n.a.	2.50	0.50	Effectiveness (see internal memo for summary). The overall value from 2011
0.20	1.00	n.a.	2.50	0.39	and 2012 were averaged to obtain an RO efectiveness value of 91.45%. The
0.30	1.00	n.a.	2.50	0.26	estimate applies for flows ranging from 48% to 73% as this was the range of
0.40	1.00	n.a.	2.13	0.19	flows the data was collected over. Values for flows above and below the range
0.50	1.00	n.a.	1.84	0.16	were shaped based on professional opinion. The use of professional opinion
0.60	1.00	n.a.	1.54	0.25	should have little effect as the project should operate within these ranges very
0.70	1.00	n.a.	1.32	0.36	often.
0.80	1.00	n.a.	1.15	0.63	
0.90	1.00	n.a.	1.06	0.83	
1.00	1.00	n.a.	1.00	1.00	

Low

Flow Ratio	Spillway	Fish Passage	RO	Turbine	
0.00	1.00	n.a.	1	1	
0.10	1.00	n.a.	2.00	0.75	
0.20	1.00	n.a.	2.25	0.77	
0.30	1.00	n.a.	2.33	0.58	
0.40	1.00	n.a.	1.88	0.46	
0.50	1.00	n.a.	1.54	0.42	
0.60	1.00	n.a.	1.28	0.43	
0.70	1.00	n.a.	1.10	0.69	Used the Lower 95%CI value of 76.87 Beeman, J.W., Hansen, A.C., Evans, S.E.,
0.80	1.00	n.a.	1.06	0.89	Haner, P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile
0.90	1.00	n.a.	1.00	1.00	Chinook salmon through the powerhouse and regulating outlet at Cougar Dam,
1.00	1.00	n.a.	1.00	1.00	Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p.

High

Flow Ratio	Spillway	Fish Passage	RO	Turbine	
0.00	1.00	n.a.	1	1	
0.10	1.00	n.a.	3.00	0.10	
0.20	1.00	n.a.	2.50	0.12	
0.30	1.00	n.a.	2.67	0.08	
0.40	1.00	n.a.	2.25	0.06	
0.50	1.00	n.a.	1.95	0.05	
0.60	1.00	n.a.	1.63	0.17	
0.70	1.00	n.a.	1.39	0.29	Used the 97.65 UP 95% CI from: Beeman, J.W., Hansen, A.C., Evans, S.E., Haner,
0.80	1.00	n.a.	1.22	0.63	P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile
0.90	1.00	n.a.	1.11	0.78	Chinook salmon through the powerhouse and regulating outlet at Cougar Dam,
1.00	1.00	n.a.	1.00	1.00	Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p

Additiional Recommendation

Recommend that the relationship between effectiveness and flow ratio be modified to allow effectiveness to be varied with the reservoir elevation. Once the reservoir reaches el 1571 ft, if all flow enters the tower through the RO bypass gates, they are directly in line with the RO openings and provide a direct path to the ROs. RO effectiveness in this case should be at least equivalent to the best Surface Flow Outlets (SFOs), which have an effeciveness on the order of 6.0 per ENSR, 2007. Surface Bypass Program Comprehensive Review Report, Contract No. W9127N-06-D-0004, TO 001. prepared for CENWP.

Observatioin

Spillway effectivness numbers are essentially irrelevant since the average spill for the RES-SIM period of record is 0 except in late December, where it briefly reaches 100 cfs.

Cougar Alternative: MK-DSP-17-CGR Applies to all life stages as no data/rationale are available to make adjustments

Operational Assumption: All flow is skimmed from the surface over the tower weirs and distributed inside the tower to the RO and turbine intake down to el 1571 ft. Below el. 1571 ft, the RO bypass gate is opened. In December, RO is given priority within its capacity and an attempt is made to drawdown the reservoir to el 1500 ft. However, the average elevation over the RE{-SIM period of record only drops to el 1530 ft.

Recommended	Route Effectiveness				
Flow Ratio	Spillway	Fish Passage	RO	Turbine	Rationale and Reference
0.00	1.00	n.a.	1	1	Simply used baseline data. There is no rationale to adjust these values, other
0.10	1.00	n.a.	2.50	0.50	than the recommendation below to vary effectiveness with reservoir elevation.
0.20	1.00	n.a.	2.50	0.39	Note: We will want to determine if the water velocities change into the RO
0.30	1.00	n.a.	2.50	0.26	versus turbines when flow is entering using the RO Bypass gates...this could
0.40	1.00	n.a.	2.13	0.19	affect RO effectiveness.
0.50	1.00	n.a.	1.84	0.16	
0.60	1.00	n.a.	1.54	0.25	
0.70	1.00	n.a.	1.32	0.36	
0.80	1.00	n.a.	1.15	0.63	
0.90	1.00	n.a.	1.06	0.83	
1.00	1.00	n.a.	1.00	1.00	

Low

Flow Ratio	Spillway	Fish Passage	RO	Turbine	
0.00	1.00	n.a.	1	1	
0.10	1.00	n.a.	2.00	0.75	
0.20	1.00	n.a.	2.25	0.77	
0.30	1.00	n.a.	2.33	0.58	
0.40	1.00	n.a.	1.88	0.46	
0.50	1.00	n.a.	1.54	0.42	
0.60	1.00	n.a.	1.28	0.43	Used the Lower 95%CI value of 76.87 Beeman, J.W., Hansen, A.C., Evans, S.E.,
0.70	1.00	n.a.	1.10	0.69	Haner, P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of
0.80	1.00	n.a.	1.06	0.89	juvenile Chinook salmon through the powerhouse and regulating outlet at
0.90	1.00	n.a.	1.00	1.00	Cougar Dam, Oregon, 2011: U.S. Geological Survey Open-File Report 2012-
1.00	1.00	n.a.	1.00	1.00	1250, 26 p.

High

Flow Ratio	Spillway	Fish Passage	RO	Turbine	
0.00	1.00	n.a.	1	1	
0.10	1.00	n.a.	3.00	0.10	
0.20	1.00	n.a.	2.50	0.12	
0.30	1.00	n.a.	2.67	0.08	
0.40	1.00	n.a.	2.25	0.06	
0.50	1.00	n.a.	1.95	0.05	
0.60	1.00	n.a.	1.63	0.17	
0.70	1.00	n.a.	1.39	0.29	Used the 97.65 UP 95% CI from: Beeman, J.W., Hansen, A.C., Evans, S.E., Haner,
0.80	1.00	n.a.	1.22	0.63	P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile
0.90	1.00	n.a.	1.11	0.78	Chinook salmon through the powerhouse and regulating outlet at Cougar Dam,
1.00	1.00	n.a.	1.00	1.00	Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p

Additiional Recommendation

Recommend that the relationship between effectiveness and flow ratio be modified to allow effectiveness to be varied with the reservoir elevation. Once the reservoir reaches el 1571 ft, if all flow enters the tower through the RO bypass gates, they are directly in line with the RO openings and provide a direct path to the ROs. RO effectiveness in this case should be at least equivalent to the best Surface Flow Outlets (SFOs), which have an effeciveness on the order of 6.0 per ENSR, 2007. Surface Bypass Program Comprehensive Review Report, Contract No. W9127N-06-D-0004, TO 001. prepared for CENWP.

Draw down to 1500 in Dec and RO Priority

Cougar Alternative: MK-DSP-06-CGR

Applies to all life stages as no data/rationale are available to make adjustments

Operational Assumption: All flow is skimmed from the surface over the tower weirs and distributed inside the tower to the RO and turbine intake down to el 1571 ft. Below el. 1571 ft, the RO bypass gate is opened. Upon reaching the minimum flood control pool, the beginning of refill is delayed until May 1 and the RO is given priority.

Recommended	Route Effectiveness				
Flow Ratio	Spillway	Fish Passage	RO	Turbine	Rationale and Reference
0.00	1.00	n.a.	1	1	Simply used baseline data. There is no rationale to adjust these values, other
0.10	1.00	n.a.	2.50	0.50	than the recommendation below to vary effectiveness with reservoir elevation.
0.20	1.00	n.a.	2.50	0.39	
0.30	1.00	n.a.	2.50	0.26	
0.40	1.00	n.a.	2.13	0.19	
0.50	1.00	n.a.	1.84	0.16	
0.60	1.00	n.a.	1.54	0.25	
0.70	1.00	n.a.	1.32	0.36	
0.80	1.00	n.a.	1.15	0.63	
0.90	1.00	n.a.	1.06	0.83	
1.00	1.00	n.a.	1.00	1.00	

Low

Flow Ratio	Spillway	Fish Passage	RO	Turbine	
0.00	1.00	n.a.	1	1	
0.10	1.00	n.a.	2.00	0.75	
0.20	1.00	n.a.	2.25	0.77	
0.30	1.00	n.a.	2.33	0.58	
0.40	1.00	n.a.	1.88	0.46	
0.50	1.00	n.a.	1.54	0.42	
0.60	1.00	n.a.	1.28	0.43	
0.70	1.00	n.a.	1.10	0.69	Used the Lower 95%CI value of 76.87 Beeman, J.W., Hansen, A.C., Evans, S.E.,
0.80	1.00	n.a.	1.06	0.89	Haner, P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile
0.90	1.00	n.a.	1.00	1.00	Chinook salmon through the powerhouse and regulating outlet at Cougar Dam,
1.00	1.00	n.a.	1.00	1.00	Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p.

High

Flow Ratio	Spillway	Fish Passage	RO	Turbine	
0.00	1.00	n.a.	1	1	
0.10	1.00	n.a.	3.00	0.10	
0.20	1.00	n.a.	2.50	0.12	
0.30	1.00	n.a.	2.67	0.08	
0.40	1.00	n.a.	2.25	0.06	
0.50	1.00	n.a.	1.95	0.05	
0.60	1.00	n.a.	1.63	0.17	
0.70	1.00	n.a.	1.39	0.29	Used the 97.65 UP 95% CI from: Beeman, J.W., Hansen, A.C., Evans, S.E., Haner,
0.80	1.00	n.a.	1.22	0.63	P.V., Hansel, H.C., and Smith, C.D., 2012, Passage probabilities of juvenile
0.90	1.00	n.a.	1.11	0.78	Chinook salmon through the powerhouse and regulating outlet at Cougar Dam,
1.00	1.00	n.a.	1.00	1.00	Oregon, 2011: U.S. Geological Survey Open-File Report 2012-1250, 26 p

Additiional Recommendation

Recommend that the relationship between effectiveness and flow ratio be modified to allow effectiveness to be varied with the reservoir elevation. Once the reservoir reaches el 1571 ft, if all flow enters the tower through the RO bypass gates, they are directly in line with the RO openings and provide a direct path to the ROs. RO effectiveness in this case should be at least equivalent to the best Surface Flow Outlets (SFOs), which have an effeciveness on the order of 6.0 per ENSR, 2007. Surface Bypass Program Comprehensive Review Report, Contract No. W9127N-06-D-0004, TO 001. prepared for CENWP.

Observatioin

Spillway effectivness numbers are essentially irrelevant since the average spill for the RES-SIM period of record is 0 except in late December, where it briefly reaches 100 cfs.

Delay Refill

Cougar Alternative: MK-DSP-19-CGR

Applies to all life stages as no data/rationale are available to make adjustments

Operational Assumption: All flow is skimmed from the surface , with the first 1,000 cfs through the FSS and the remainder over the tower weirs and distributed inside the tower to the RO and turbine intake down to el 1571 ft. Below el. 1571 ft, the RO bypass gate is opened. The RO is given operational priority for forebays lower than el 1561 ft.

Recommended Route Effectiveness

Flow Ratio	Spillway	Fish Passage (FSS)	RO	Turbine	
0.00	1.00	4.00	1	1	
0.10	1.00	4.00	2.50	0.50	
0.20	1.00	4.00	2.50	0.39	
0.30	1.00	4.00	2.50	0.26	
0.40	1.00	4.00	2.13	0.19	
0.50	1.00	4.00	1.84	0.16	
0.60	1.00	4.00	1.54	0.25	
0.70	1.00	4.00	1.32	0.36	
0.80	1.00	4.00	1.15	0.63	
0.90	1.00	4.00	1.06	0.83	Assume that the FSS is intermediate in effectiveness to the spillway and other
1.00	1.00	4.00	1.00	1.00	SFO's in the region. See maximum above wrote-up

Low Route Effectiveness

Flow Ratio	Spillway	Fish Passage (FSS)	RO	Turbine	
0.00	1.00	0.00	1	1	The high performing SFOs pull from the surface ~ 40 ft as compared to
0.10	1.00	2.50	2.00	0.75	withdrawal from the competing turbines at depths of ~40-90 ft. The Cougar FSS
0.20	1.00	2.50	2.25	0.77	will draw from the surface 15 ft as compared to the competing weir flows from
0.30	1.00	2.50	2.33	0.58	the surface 10 ft. Since there is no vertical separation from the competing flow,
0.40	1.00	2.13	1.88	0.46	the effectiveness may not be as great as other SFOs. The assumption is that the
0.50	1.00	1.83	1.54	0.42	effectiveness of the SFO will be similar to the RO under the baseline condition.
0.60	1.00	1.52	1.28	0.43	Thus, the baseline RO values were used for the FSS. This results in reduction in
0.70	1.00	1.31	1.10	0.69	turbine passage of ~2%.
0.80	1.00	1.14	1.06	0.89	
0.90	1.00	1.06	1.00	1.00	
1.00	1.00	1.00	1.00	1.00	

High Route Effectiveness

Flow Ratio	Spillway	Fish Passage (FSS)	RO	Turbine	Rationale and Reference
0.00	1.00	6.00	1	1	The RO and turbine effectiveness values are as derived from the baseline. There
0.10	1.00	6.00	3.00	0.10	is no rationale to adjust these values, other than the additional
0.20	1.00	6.00	2.50	0.12	recommendation below to vary effectiveness with reservoir elevation.
0.30	1.00	6.00	2.67	0.08	In plan view the Cougar FSS has a concentrating flow pattern similar to the
0.40	1.00	6.00	2.25	0.06	Rocky Reach or Bonneville 2nd Powerhouse Corner Collector.The best possible
0.50	1.00	6.00	1.95	0.05	effectiveness for the FSS might be equivalent to a good Surface Flow Outlet
0.60	1.00	6.00	1.63	0.17	(SFO) with an adjacent concentrating eddy, which according to ENSR (2007) is
0.70	1.00	6.00	1.39	0.29	appproximately 6.0.
0.80	1.00	6.00	1.22	0.63	
0.90	1.00	6.00	1.11	0.78	
1.00	1.00	6.00	1.00	1.00	

Additional Recommendation

Recommend that the relationship between effectiveness and flow ratio be modified to allow effectiveness to be varied with the reservoir elevation. Once the reservoir reaches el 1571 ft, if all flow enters the tower through the RO bypass gates, they are directly in line with the RO openings and provide a direct path to the ROs. RO effectiveness in this case should be at least equivalent to the best Surface Flow Outlets (SFOs), which have an effeciveness on the order of 6.0 per ENSR, 2007. Surface Bypass Program Comprehensive Review Report, Contract No. W9127N-06-D-0004, TO 001. prepared for CENWP.

FSS above 1571

Cougar Alternative: MK-DSP-10-CGR Applies to all life stages as no data/rationale are available to make adjustments

Operational Assumption: All flow is skimmed from the surface , with the first 1,000 cfs through the FSS and the remainder over the tower weirs and distributed inside the tower to the RO and turbine intake down to el 1552 ft. Below el. 1552 ft, the RO bypass gate is opened. The RO is given operational priority for forebays lower than el 1561 ft.

Recommended Route Effectiveness

Flow Ratio	Spillway	Fish Passage (FSS)	RO	Turbine	
0.00	1.00	4.00	1	1	
0.10	1.00	4.00	2.50	0.50	
0.20	1.00	4.00	2.50	0.39	
0.30	1.00	4.00	2.50	0.26	
0.40	1.00	4.00	2.13	0.19	
0.50	1.00	4.00	1.84	0.16	
0.60	1.00	4.00	1.54	0.25	
0.70	1.00	4.00	1.32	0.36	
0.80	1.00	4.00	1.15	0.63	
0.90	1.00	4.00	1.06	0.83	
1.00	1.00	4.00	1.00	1.00	Assume that the FSS is intermediate in effectiveness to the spillway and other SFO's in the region.

Low Route Effectiveness

Flow Ratio	Spillway	Fish Passage (FSS)	RO	Turbine	
0.00	1.00	0.00	1	1	The high performing SFOs pull from the surface ~ 40 ft as compared to
0.10	1.00	2.50	2.00	0.75	withdrawal from the competing turbines at depths of ~40-90 ft. The Cougar FSS
0.20	1.00	2.50	2.25	0.77	will draw from the surface 15 ft as compared to the competing weir flows from
0.30	1.00	2.50	2.33	0.58	the surface 10 ft. Since there is no vertical separation from the competing flow,
0.40	1.00	2.13	1.88	0.46	the effectiveness may not be as great as other SFOs. The assumption is that the
0.50	1.00	1.83	1.54	0.42	effectiveness of the SFO will be similar to the RO under the baseline condition.
0.60	1.00	1.52	1.28	0.43	Thus, the baseline RO values were used for the FSS. This results in reduction in
0.70	1.00	1.31	1.10	0.69	turbine passge of ~2%.
0.80	1.00	1.14	1.06	0.89	
0.90	1.00	1.06	1.00	1.00	
1.00	1.00	1.00	1.00	1.00	

High Route Effectiveness

Flow Ratio	Spillway	Fish Passage (FSS)	RO	Turbine	Rationale and Reference
0.00	1.00	6.00	1	1	The RO and turbine effectiveness values are as derived from the baseline.
0.10	1.00	6.00	3.00	0.10	There is no rationale to adjust these values, other than the additional
0.20	1.00	6.00	2.50	0.12	recommendation below to vary effectiveness with reservoir elevation.
0.30	1.00	6.00	2.67	0.08	In plan view the Cougar FSS has a concentrating flow pattern similar to the
0.40	1.00	6.00	2.25	0.06	Rocky Reach or Bonneville 2nd Powerhouse Corner Collector.The best possible
0.50	1.00	6.00	1.95	0.05	effectiveness for the FSS might be equivalent to a good Surface Flow Outlet
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0.70	1.00	6.00	1.39	0.29	appproximately 6.0.
0.80	1.00	6.00	1.22	0.63	
0.90	1.00	6.00	1.11	0.78	
1.00	1.00	6.00	1.00	1.00	

Additional Recommendation

Recommend that the relationship between effectiveness and flow ratio be modified to allow effectiveness to be varied with the reservoir elevation. Once the reservoir reaches el 1571 ft, if all flow enters the tower through the RO bypass gates, they are directly in line with the RO openings and provide a direct path to the ROs. RO effectiveness in this case should be at least equivalent to the best Surface Flow Outlets (SFOs), which have an effeciveness on the order of 6.0 per ENSR, 2007. Surface Bypass Program Comprehensive Review Report, Contract No. W9127N-06-D-0004, TO 001. prepared for CENWP.

FSS with Tower Bypass