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Technical Memorandum

Instream Flow Assessment of Icicle Creek, Washington

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Prepared by

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Executive Summary

The purpose of this study was to characterize the relationship between stream flow and fish habitat on Icicle Creek, Washington, downstream from the Leavenworth National Fish Hatchery to its mouth at the Wenatchee River. The stream exhibits a very flat slope and is characterized by a meandering pattern. Peak flows occur during late spring and low flows occur during late summer and fall. Flows between 2000 and 2004 ranged from 58 cfs to 3,610 cfs. Chinook salmon, steelhead trout, and bull trout are federally listed species in the Wenatchee basin and were selected by the Wenatchee Watershed Planning Unit as the species of interest for this study. Rearing and spawning life stages of these species were addressed in this study.

The method used was the U.S. Fish and Wildlife Service (USFWS) Physical Habitat Simulation System (PHABSIM) application of the Instream Flow Incremental Methodology (IFIM). The PHABSIM method is based on the premise that stream dwelling fish prefer a certain range of depths, velocities, substrates and cover types, depending on the species and life stage, and that the availability of these preferred habitat conditions varies with flow. Weighted Usable Area (WUA) is the primary product of PHABSIM. Weighted usable area is an index of habitat availability or quantity for the selected species/life stage at each simulated flow. Weighted usable area was calculated for a range of flows between 20 and 800 cfs. Graphs and tables of WUA versus flow are presented for each life stage and species of interest. This technical information can be used by the Planning Unit as the basis for instream flow recommendations in Icicle Creek.

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Introduction

The Bureau of Reclamation (Reclamation) (in coordination with the WRIA 45 Instream Flow Subcommittee) conducted an instream flow study on Icicle Creek near Leavenworth, Washington during 2004 and 2005. The purpose of this study was to characterize the relationship between stream flow and fish habitat on Icicle Creek, downstream from the Leavenworth National Fish Hatchery to its mouth at the Wenatchee River. This technical information can be used by the Wenatchee Watershed Planning Unit as the basis for instream flow recommendations that will be included in the final Wenatchee Watershed Plan by April 2006.

Study Area

The Icicle Creek study area extended from its confluence with the Wenatchee River (RM 0.0) upstream to the Leavenworth National Fish Hatchery (RM 2.7) (Figure 1). This area of the stream exhibits a very flat slope and is characterized by a meandering pattern. Chinook salmon (*Oncorhynchus tschawytscha*), steelhead trout (*O. mykiss*), coho salmon (*O. kisutch*), and bull trout (*Salvelinus confluentus*) utilize this area as a transportation corridor for both upstream and downstream movement, migration, and juvenile rearing. This area is recognized as prime spawning and incubation habitat for spring Chinook salmon as well as steelhead trout. Adult spring Chinook salmon returning to the hatchery are targeted by both sport and tribal fishers in Icicle Creek from mid May through July.

Hydrology

Recent stream gage records (water years 2000-2004) for Icicle Creek were retrieved from the U.S. Geological Survey (USGS) gage located above Snow Creek (Figure 2). This gage does not record real-time information. Peak flows occur during late spring and low flows occur during late summer and fall. Flows during this period ranged from 58 cfs (11/1/02) to 3,610 cfs (6/15/02). During the study, stage and discharge data were recorded periodically in Icicle Creek at the East Leavenworth Road Bridge (Figure 3). This information could be used to develop a rating curve for Icicle Creek and allow flow estimates based on stage readings.

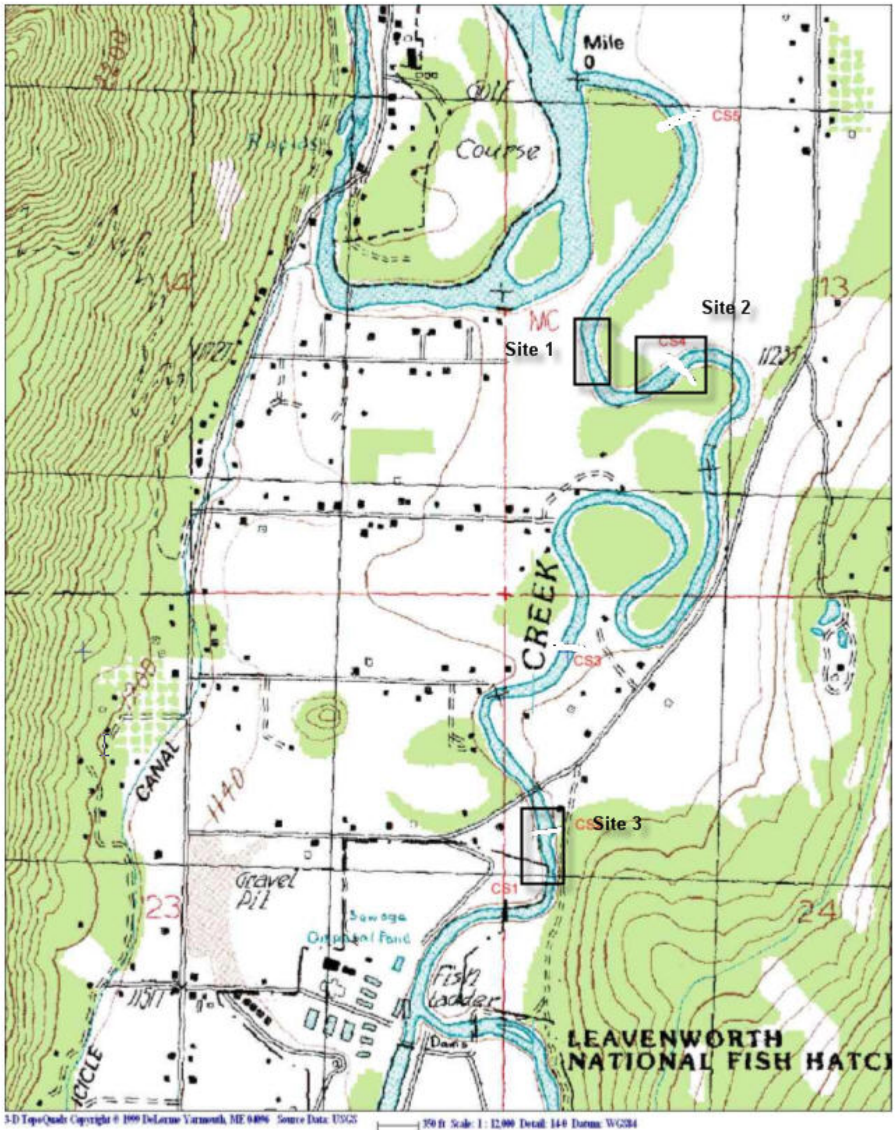


Figure 1. Study site locations on Icicle Creek for instream flow assessment.

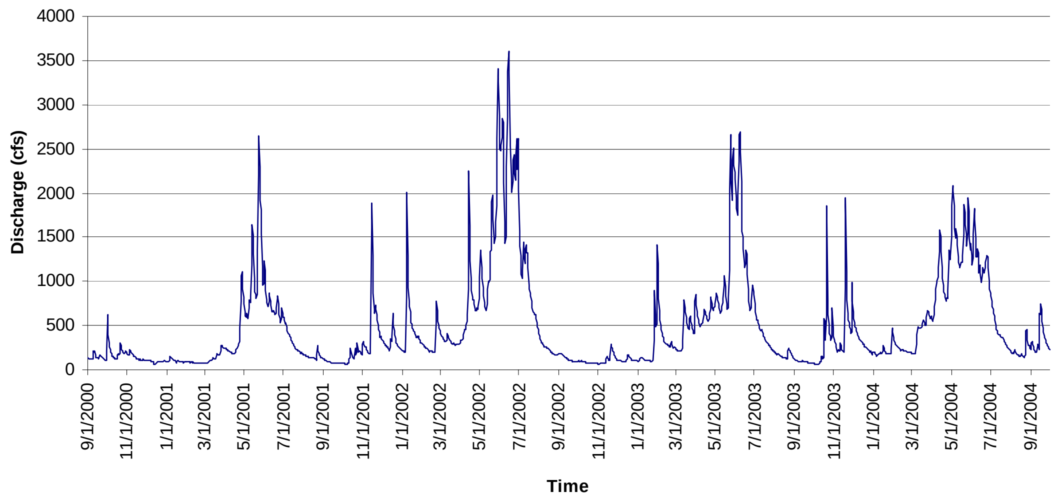


Figure 2. Recent Icicle Creek discharge records at USGS Gage number 12458000 located above Snow Creek near Leavenworth, Washington.

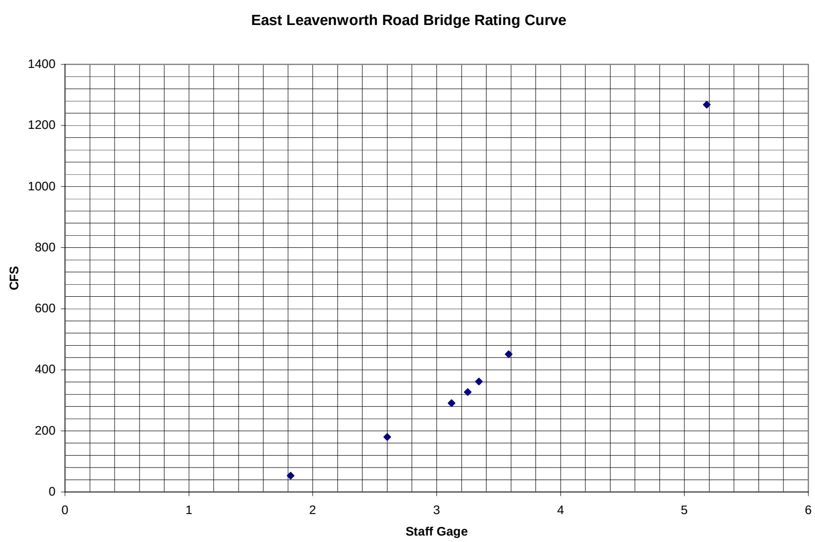
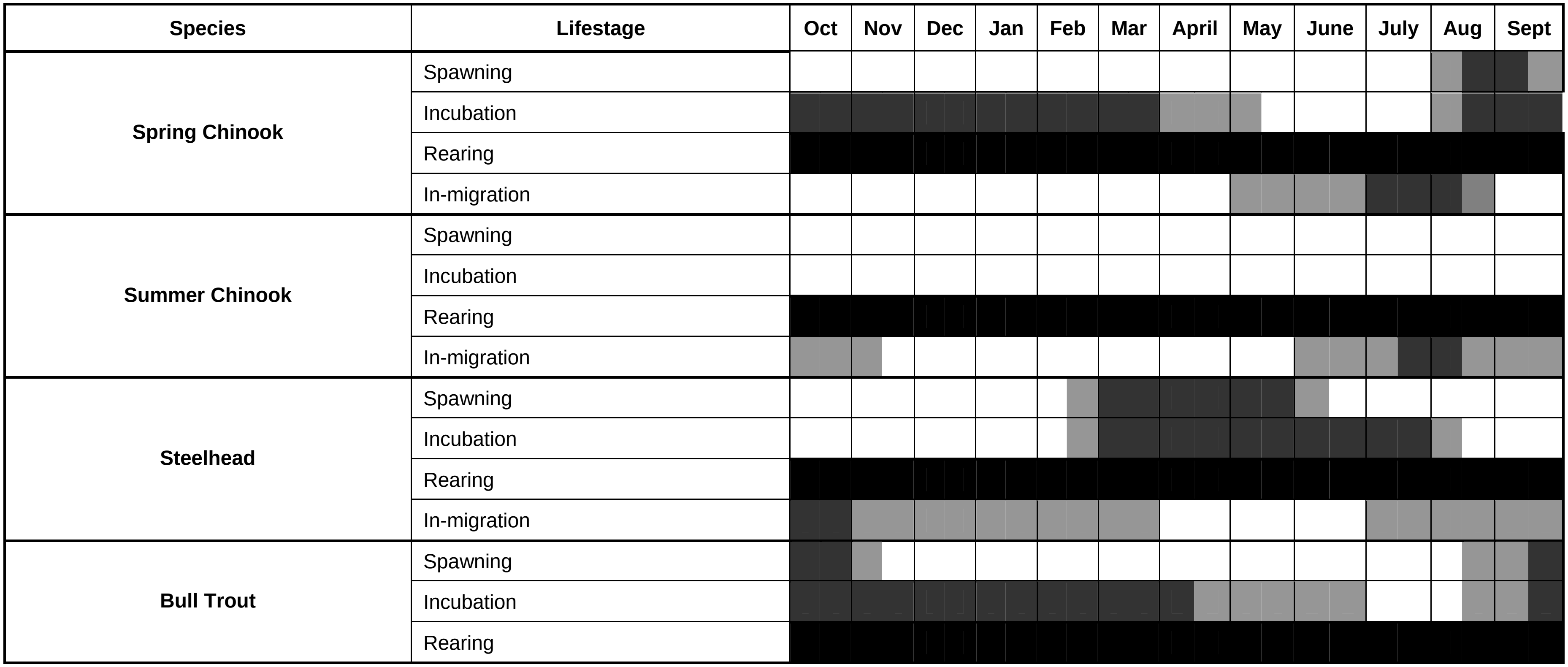


Figure 3. Stage-discharge relationship for Icicle Creek.

Affected Species and Life Stages

Chinook salmon, steelhead trout, and bull trout are federally listed species in the Wenatchee basin and were selected by the Planning Unit as the species of interest for this study. All of these species use Icicle Creek during some part of their life cycle. Figure 4 presents life-stage timing of salmonids in Icicle Creek. Anadromous fish use Icicle Creek in a variety of ways. Adults use the river as an upstream migration corridor to spawning grounds and Leavenworth Fish Hatchery. Salmonid fry and smolts use the river as a downstream migration corridor on their journey towards sea. Migration of salmonids was not addressed in this study. The analysis focused on spawning and rearing habitat for Chinook salmon, steelhead, and bull trout. Fish passage flows were not addressed.



<u>Based on:</u>

Andonaegui, C., 2001. *Salmon, Steelhead and Bull Trout Habitat Limiting Factors for the Wenatchee Subbasin (WRIA 45) and Portions of WRIA 40 within Chelan County (Squilchuck, Stemilt and Colockum Drainages).* Washington State Conservation Commission.

Comments from: USFS (Cam Thomas, Cindy Raekes), WDFW (Andrew Murdoch, Bob Vadas, Mark Cookson), USFWS (Kate Terrell) and NOAA-Fisheries (Dale Bambrick)

Key: Black indicates periods of heaviest use
Grey indicates periods of moderate use
Blank areas indicate periods of little or no use

Figure 4. Icicle Creek periodicity chart for selected fish species.

Methods

The method used to study Icicle Creek was the U.S. Fish and Wildlife Service (USFWS) Physical Habitat Simulation System (PHABSIM) application of the Instream Flow Incremental Methodology (IFIM). Generally, instream flow study procedures followed the Washington Department of Fish and Wildlife/Washington Department of Ecology (WDFW/WDOE) Instream Flow Guidelines (2004). The PHABSIM method is based on the premise that stream dwelling fish prefer a certain range of depths, velocities, substrates and cover types, depending on the species and life stage, and that the availability of these preferred habitat conditions varies with streamflow. With input from streamflow, substrate, and cover type measurements, PHABSIM quantifies habitat availability over a range of flows. It is important for the water manager to recognize that the result of the study is not a set value but a range of values to be used as a tool for determining relative amounts of habitat available at various stream flows.

PHABSIM requires hydraulic and habitat suitability data to determine the instream flow requirements for the species and/or life history stage of interest. Several hydraulic sub-models can be used with PHABSIM. Field data collection was designed to accommodate any of these models. The field methods and hydraulic analysis followed the conventional three-velocity method, or regression method, where full sets of depth and velocity data were collected at each station along the transects at the low, middle, and high flow calibration measurements. An additional calibration data set was collected in October, 2004. Water surface elevations (WSEs) were also taken at all calibration flows, and discharge measurements were made concurrently while collecting the depth and velocity information at each transect and calibration flow.

Reclamation's Technical Service Center (TSC) in Denver, Colorado, with assistance from Reclamation's Wenatchee Office and the Chelan County Conservation District, collected and compiled existing data and conducted the study. These tasks are briefly outlined below.

Transect Locations

Eleven transects were selected within three separate study sites on Icicle Creek (Figure 1) by the Wenatchee Instream Flow Subcommittee and were approved by participating resource agencies. The methodology for selecting these transects is discussed in the Draft Scoping Report prepared by EES Consulting, Inc. (2004). Transect location and descriptions are shown in Table 1 below.

Table 1. Transect descriptions for Icicle Creek instream flow assessment.

Reach	Study Site	No.	Description	River Mile
1	1	1	Riffle	0.2
		2	Glide	0.2
		3	Pool Tailout	0.2
		4	Pool	0.2
	2	1	Riffle	0.4
		2	Glide	0.4
		3	Pool Tailout	0.4
		4	Pool	0.4
	3	1	Glide	2.2
		2	Pool Tailout/glide	2.2
		3	Pool	2.4

Habitat Typing

Reclamation obtained an aerial video survey of Icicle Creek from EES Consulting. The video was used to generally characterize habitat types throughout Icicle Creek downstream from Leavenworth Fish Hatchery. In addition, Reclamation measured longitudinal lengths of each habitat type described by the transects in Table 1 (pool, pool tailout, glide, riffle) using kayaks and a laser rangefinder downstream from the boat ramp at RM 2.6 on August 17, 2005. The "cumulative-lengths" approach described by Bovee (1997) was used to determine proportions of different mesohabitat types in the Icicle Creek study area.

Depth, Velocity, and Water Surface Elevation Measurements

Field data were collected according to Bovee (1997) using standard surveying equipment at four discharges. Vertical elevations were established throughout each habitat type using a total station instrument (Bovee 1997). A benchmark was established at each study site (with rebar) and assigned the arbitrary elevation of 100.00 feet. All elevations were referenced to this benchmark and transects in each study site were "tied together" by surveying their relative elevation. Water surface elevations were measured to the nearest 0.01 ft near the water's edge along each transect at all discharges. Channel cross sections were measured (vertical and horizontal) to the nearest 0.1 ft between headpins at each transect during high discharge. Below water channel cross sections were determined by subtracting measured depths from the WSE at the high flow. Discharge measurements at each transect were taken during each survey. A temporary staff gage was installed at each site so that fluctuations in WSE could be monitored during data collection.

Depth and velocity measurements in wadeable sections of each transect were made with a USGS topset wading rod and a Marsh McBirney Model 2000 current meter. Velocity was measured at sixth tenths of the depth when depth was less than 2.5 feet and at two tenths and eight tenths of the depth at depths greater than or equal to 2.5 feet. In deeper sections, depth and velocity were made from a boat with similar equipment (i.e., 10-foot wading rod). Depths and mean column velocities were measured at various points along each transect. Stationing across transects was oriented with 0.0 on the left bank looking upstream for modeling purposes. Streambed elevations and water depths were measured to the nearest 0.1 ft. Water velocity was measured to the nearest 0.1 ft/sec. Velocity calibration sets were collected at four different time periods between October, 2004 and August, 2005 in an attempt to cover a range of flows. Velocities at the two pool transects at sites 2 and 3 were not measured in July, 2005 because shallow riffles prevented use of the available boat.

Substrate and Cover Codes

Washington agencies (WDFW/WDOE) have standard substrate and cover codes in their Instream Flow Guidelines Report (2004) (Table 2). These codes were used by Reclamation in the Icicle Creek study. Dominant and subdominant substrate types were recorded. Since PHABSIM can only accept one cover/substrate code, substrate codes were used where no cover was present and cover codes were used where cover was present, as suggested by Jim Pacheco (personal communication, 9/26/05). For the transects in this study, cover occurred primarily along the edges of the stream with silt and sand substrate. Substrate/cover codes used the format “ab.c”. For substrates, “a” was the code for the dominant particle size, “b” was the component code for the subdominant particle size, and “c” was tenths of cell area covered by the dominant (50% or greater) substrate type. For example, the code 46.8 indicated 80% medium gravel and 20% small cobble. Cover codes used the same format, but “a” and “b” were always 0 and “c” defined the type of cover. For example, 00.1 was an undercut bank, 00.2 was overhanging vegetation, etc.

Habitat Suitability Criteria (HSC)

Species habitat suitability criteria (HSCs) are required for PHABSIM analysis. Habitat suitability criteria, or curves, are interpreted using a suitability index (SI) on a scale of 0 to 1, with 0 being unsuitable and 1 being most utilized or preferred. Habitat suitability criteria that accurately reflect the habitat requirements of the species of interest are essential to developing meaningful and defensible instream flow recommendations. The recommended approach is to develop site-specific criteria for each species and life stage of interest. An alternative involves using existing curves and literature to develop suitability criteria for the species of interest. Limited site-specific HSC data are available in Icicle Creek and time and budgetary constraints precluded developing HSCs specific to Icicle Creek. Thus, Reclamation used the established spawning and rearing HSCs for Washington State (Jim Pacheco, personal communication, 9/26/05) and summarized in Appendix A, including updated bull trout criteria (EES Consulting 2005).

Table 2. Substrate and cover coding systems used for Icicle Creek instream flow study (derived from WDFW/WDOE Instream Flow Guidelines (2004).

Substrate Code	Description
1	Silt, clay, organic
2	Sand
3	Small gravel (0.1-0.5”)
4	Medium gravel (0.5-1.5”)
5	Large gravel (1.5-3”)
6	Small cobble (3-6”)
7	Large cobble (6-12”)
8	Boulder (>12”)
9	Bedrock

Cover Code	Description
0.1	Undercut
0.2	Overhang
0.3	Rootwad
0.4	Logjam/submerged brush pile
0.5	Log (s) parallel to bank
0.6	Aquatic vegetation
0.7	Short (<1’) terrestrial grass
0.8	Tall (>3’) dense grass
0.9	Vegetation beyond bank-full waters edge

Hydraulic Model Selection and Calibration

Reclamation used the USGS Windows version of PHABSIM (Waddle 2001) for the analysis of Icicle Creek data. PHABSIM has several submodels available for hydraulic simulations. These include STGQ (IFG4), WSP, and MANSQ (Waddle 2001), with STGQ being the most rigorous in terms of data requirements. The WSP model is used for backwaters (e.g., pools). Each hydraulic model requires multiple flow measurements to extend the predictive range. Depending on model performance, the predictive range may be restrictive or wide ranging (i.e., 0.1 to 10 times the measured discharges) (Waddle 2001). Field sampling was designed to collect data in formats suitable for application in any of the hydraulic models identified above. The following approach was used:

- Enter field data into appropriate format for water surface simulations
- Calibrate simulated WSEs using STGQ, MANSQ, or WSP (depending on site specific conditions) to measured WSEs
- Simulate a range of flows to predict WSEs
- Simulate depths and velocities for range of flows that occur during the irrigation season
- Calibrate velocities using velocity adjustment factors (VAF’s) and velocity regression (simulated within 0.2 ft/sec of measured velocities-Jim Pacheco, personal communication, 9/22/05)
- Evaluate simulation range based on VAF’s and other calibration sub-models

- Document acceptable range of simulations
- Conduct velocity simulation production run for applicable range of flows that may occur during the irrigation season.

Development of Flow vs. Habitat Functions

The TSC utilized the PHABSIM suite of programs developed by USGS to compute Weighted Usable Area (WUA) as a measure of available habitat. Weighted usable area (WUA) was calculated for each discharge of interest between 20 and 800 cfs. Weighted usable area is an index of habitat availability or quantity for the selected species/life stage at each simulated flow. After the hydraulic models were calibrated, transect weighting and lengths to simulate a 1,000 foot reach were added as shown in Table 4. Final hydraulic model runs produced input for the HABTAE habitat sub-model of PHABSIM. The WUAs for selected life stages and species were computed in HABTAE using the standard multiplicative computation option (Jim Pacheco, personal communication, 11/22/05) to multiply the depth, velocity, and substrate/cover HSC values at predicted hydraulic conditions, and cell surface area. The output from the HABTAE simulation was habitat area, expressed as WUA (ft^2/ 1000 ft). WUA versus flow relationships were computed for each study site separately and as a composite (all study sites combined). For presentation purposes, WUA was also normalized as a percentage of maximum habitat. It should be noted that there is a level of uncertainty associated with WUAs. Sources of uncertainty include errors in HSCs, hydraulic simulations, or selection of options to simulate microhabitat (e.g., geometric versus multiplicative means). Recognition that there is uncertainty in these sources is important in the interpretation and use of PHABSIM model results (Bovee et al. 1998).

Results

Transect weighting for habitat modeling was based on the proportions of habitat types in Icicle Creek. Individual study site transects were weighted empirically using results from the "cumulative-lengths" analysis (Table 3). Since Study Site 3 only included glide, pool tailout, and pool transects, weights were based on cumulative lengths of only these three habitat types at this site. Table 4 summarizes transect weights for each study site separately and as a composite (all study sites combined).

Table 3. Proportions of habitat types in Icicle Creek.

Habitat type	Cumulative length (ft)	Proportion (%)
Pool	6,497	46.9
Pool tailout	388	2.8
Riffle	1,912	13.8
Glide	5,064	36.5
Total	13,861	100

Table 4. Transect weights for each study site and composite (all transects).

Study Site 1 transect no.	Habitat Type	Weight (%)
1	Riffle	13.8
2	Glide	36.5
3	Pool Tailout	2.8
4	Pool	46.9
Study Site 2 transect no.		
1	Riffle	13.8
2	Glide	36.5
3	Pool Tailout	2.8
4	Pool	46.9
Study Site 3 transect no.		
1	Glide	42.40
2	Pool Tailout/glide	3.20
3	Pool	54.40
Composite transects numbered from downstream to upstream		
1	Riffle	6.90
2	Glide	12.16
3	Pool Tailout	0.93
4	Pool	15.63
5	Riffle	6.90
6	Glide	12.16
7	Pool Tailout	0.93
8	Pool	15.63
9	Glide	12.16
10	Pool Tailout/glide	0.93
11	Pool	15.63

Four sets of calibration flow data were developed from the field measurements. Actual measured flows surveyed in Icicle Creek are summarized in Table 5. The October, 2004 calibration data set was considered appropriate to use based on a comparison of cross sectional profiles among sample dates that showed very little change in stream channel morphology between October, 2004 and August, 2005. This was possibly a result of a drought and a subsequent unusually low spring (2005) peak flow that did not scour the channel.

Table 5. Calibration flows measured from lowest to highest at the Icicle Creek study sites.

Flows (cfs)	**Survey Dates**
47-59	August 16, 2005
178-195	July 6-7, 2005
240-244	October 26-27, 2004
327-362	June 14-15, 2005

Results of the PHABSIM analysis are summarized below. Photos and coordinates (NAD 83) of the study sites during the July, 2005 survey are shown in Figure 5.

Study Site 1- July, 2005- N 47º34'57.3"; W 120º39'29.5"

Study Site 2-July, 2005- N 47º34'25.3"; W 120º39'45.7"

Study Site 3-July, 2005- N 47º33'48.1"; W 120º40'03.4"

Figure 5. Photos of each study site in Icicle Creek, July, 2005.

Hydraulic WSE model calibration results are summarized in Table 6. The best WSE calibration occurred using STGQ (glides and riffles) and WSP (pools) sub-models. Simulated WSEs were within 0.05 ft of measured WSEs for all transects. The PHABSIM IFG4 input file with all 11 transects combined is located in Appendix B.

Multiple velocity calibration data sets were used as independent data sets for velocity modeling purposes. The velocity adjustment factor (VAF) is an index used by the velocity simulation model to adjust individual cell velocities/cell discharges. The VAF is the ratio of the flow requested for simulation and the flow calculated from velocity simulations. The VAF adjusts individual cell velocities by multiplying the VAF times the initial velocity to give a new velocity. Generally, the relationship between discharge and VAF is such that at simulated flows lower than the velocity calibration flows, the VAF is less than 1.0 and at simulated flows greater than the velocity calibration flow, VAF is greater than 1.0 (Waddle 2001). Table 7 presents VAFs for all transects over a range of simulated flows. The apparent "breaks" in VAF (i.e., occasional declines in VAF as flows increase) are due to using different velocity calibration sets to produce the velocity templates used for velocity simulation. Within the range of discharges for which a particular set of calibration velocity measurements were used to develop the velocity template, ascending VAF versus flow relationships indicated the expected outcome of velocity simulations. Although WDOE suggests an acceptable VAF range of 0.8-1.2 (Jim Pacheco, personal communication, 9/22/05), there is no basis for judging the "validity" or quality of the hydraulic simulations based strictly on the magnitude of the range in computed VAF values (i.e., no specific set of envelope values that the VAF should absolutely lie within) (Waddle 2001). The "shape" of the VAF versus discharge plot is a better indicator of model performance than the VAF magnitude. Based on this criterion, examination of Table 7 indicates that VAFs increase with discharge for each velocity calibration set, suggesting good model performance. Also, measured velocities across each transect closely matched simulated velocities at the calibration flows (i.e., within ± 0.2 ft/sec).

Table 6. Water surface elevation calibration results for Icicle Creek study sites.

Transect	Distance from next downstream transect (ft)	Water surface elevations (ft)											
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
Study Site 1			47.0 cfs			178.2 cfs			244.4 cfs			358.6 cfs	
1	0	87.02	87.01	-0.01	87.53	87.56	0.03	87.73	87.71	-0.02	87.90	87.90	0.00
2	84	87.04	87.02	-0.02	87.51	87.56	0.05	87.73	87.71	-0.02	87.91	87.89	-0.02
3	250	87.68	87.68	0.00	88.18	88.18	0.00	88.43	88.43	0.00	88.62	88.62	0.00
4	56	87.69	87.68	-0.01	88.17	88.20	0.03	88.50	88.46	-0.04	88.65	88.67	0.02
Study Site 2			53.5 cfs			195.4 cfs			240.6 cfs			361.8 cfs	
1	0	91.07	91.06	-0.01	91.39	91.43	0.04	91.54	91.51	-0.03	91.67	91.67	0.00
2	105	91.41	91.40	-0.01	91.85	91.88	0.03	91.97	91.97	0.00	92.17	92.16	-0.01
3	56	91.44	91.44	0.00	91.88	91.88	0.00	92.05	92.05	0.00	92.22	92.22	0.00
4	38	91.44	91.44	0.00	91.89	91.89	0.00	92.05	92.06	0.02	92.24	92.24	0.00
Study Site 3			58.5 cfs			186.8 cfs			239.7 cfs			327.1 cfs	
1	0	90.41	90.41	0.00	91.08	91.10	0.02	91.35	91.30	-0.05	91.56	91.58	0.02
2	204	90.88	90.88	0.00	91.53	91.53	0.00	91.74	91.74	0.00	91.99	91.99	0.00
3	406	90.92	90.89	-0.03	91.51	91.56	0.05	91.83	91.78	-0.05	92.05	92.05	0.00

Table 7. Velocity adjustment factors for transects at each study site at simulated flows in Icicle Creek.

Flow (cfs)	Study Site 1 Transect Number 1	2	3	4	Flow (cfs)	Study Site 2 Transect Number 1	2	3	4	Flow (cfs)	Study Site 3 Transect Number 1	2	3
20	0.5	0.4	0.5	0.7	20	0.8	0.7	0.5	0.5	20	1.2	0.8	0.4
30	0.7	0.6	0.7	1.0	30	0.9	0.8	0.7	0.7	30	1.0	0.9	0.6
40	0.8	0.7	0.8	1.2	40	0.9	0.9	0.8	0.9	40	1.0	1.1	0.8
47.0*	0.9	0.7	0.8	1.4	50	0.9	1.0	1.0	1.1	50	0.9	1.2	1.0
50	0.4	0.4	0.5	0.5	53.5*	0.9	1.0	1.0	1.2	58.5*	0.9	1.2	1.1
60	0.5	0.4	0.6	0.5	60	0.7	0.6	0.5	0.3	60	1.0	0.6	0.3
70	0.5	0.5	0.6	0.6	70	0.7	0.6	0.5	0.3	70	1.0	0.6	0.3
80	0.6	0.5	0.6	0.7	80	0.7	0.7	0.6	0.4	80	1.0	0.7	0.4
90	0.6	0.6	0.7	0.7	90	0.7	0.7	0.6	0.4	90	1.0	0.7	0.4
100	0.6	0.6	0.7	0.8	100	0.7	0.7	0.6	0.4	100	1.0	0.7	0.4
120	0.7	0.7	0.8	0.9	120	0.8	0.8	0.7	0.5	120	1.0	0.8	0.5
140	0.8	0.8	0.8	1.0	140	0.8	0.8	0.8	0.6	140	1.0	0.9	0.6
160	0.8	0.8	0.9	1.1	160	0.8	0.9	0.9	0.7	160	1.0	0.9	0.6
178.2*	0.9	0.9	1.0	1.2	180	0.9	0.9	1.0	0.7	180	1.0	1.0	0.7
180	0.8	0.8	0.7	0.9	195.4*	0.9	1.0	1.1	0.8	186.8*	1.0	1.0	0.7
200	0.9	0.8	0.8	1.0	200	0.9	0.9	0.9	0.8	200	1.1	0.9	0.8
244.4*	1.0	0.9	0.8	1.1	240.6*	0.9	1.0	1.0	1.0	239.7*	1.1	1.0	0.9
250	0.8	0.8	0.8	0.9	250	0.9	0.9	0.8	0.8	250	1.0	0.9	0.8
300	0.9	0.9	0.9	1.0	300	0.9	1.0	0.9	0.9	300	1.0	1.0	0.9
350	0.9	1.0	1.0	1.1	350	1.0	1.0	1.0	1.0	327.1*	1.0	1.0	0.9
358.6*	1.0	1.0	1.0	1.1	361.8*	1.0	1.0	1.1	1.1	350	1.0	1.1	1.0
400	1.0	1.1	1.1	1.2	400	1.0	1.1	1.1	1.2	400	1.0	1.1	1.1
450	1.1	1.2	1.1	1.3	450	1.0	1.2	1.2	1.3	450	1.0	1.2	1.2
500	1.2	1.3	1.2	1.4	500	1.1	1.2	1.3	1.4	500	1.1	1.3	1.3
550	1.3	1.4	1.2	1.5	550	1.1	1.3	1.4	1.5	550	1.1	1.3	1.4
600	1.3	1.4	1.3	1.6	600	1.2	1.3	1.5	1.7	600	1.1	1.4	1.5
650	1.4	1.5	1.4	1.7	650	1.2	1.4	1.6	1.8	650	1.1	1.5	1.6
700	1.5	1.6	1.4	1.8	700	1.2	1.4	1.7	1.9	700	1.1	1.5	1.7
750	1.5	1.7	1.5	1.9	750	1.3	1.5	1.8	2.0	750	1.1	1.6	1.8
800	1.6	1.7	1.5	1.9	800	1.3	1.5	1.8	2.1	800	1.1	1.6	1.9

* Calibration flow

Figures 6-17 show WUA versus flow graphs for rearing and spawning life stages. Actual WUA values are presented in Tables 8-11.

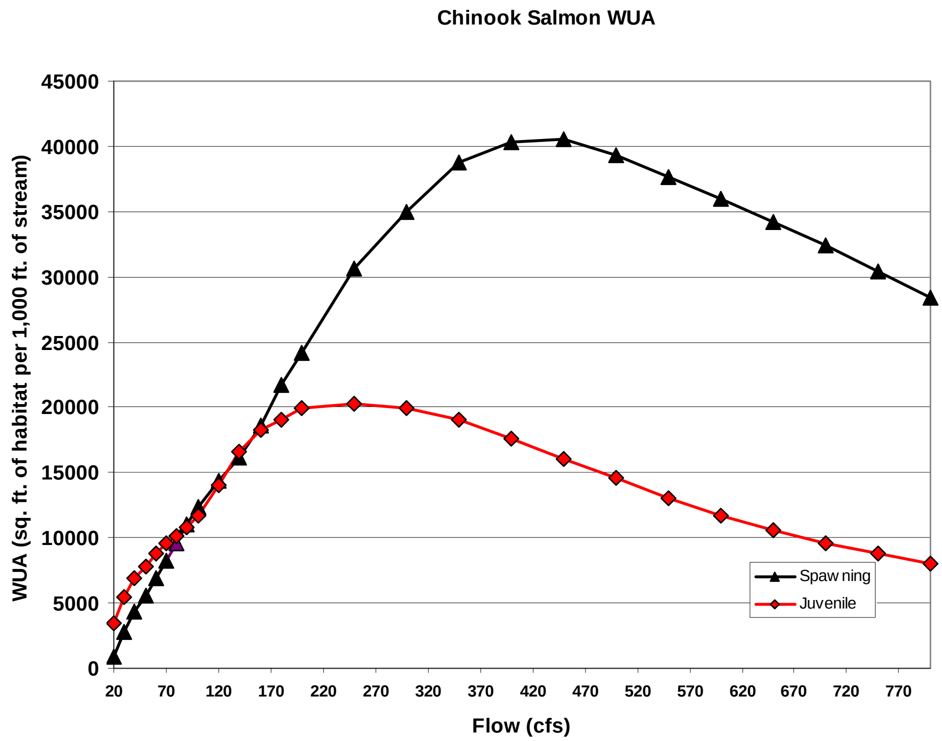


Figure 6. Weighted usable area versus flow relationships for Chinook salmon in Icicle Creek, Study Site 1.

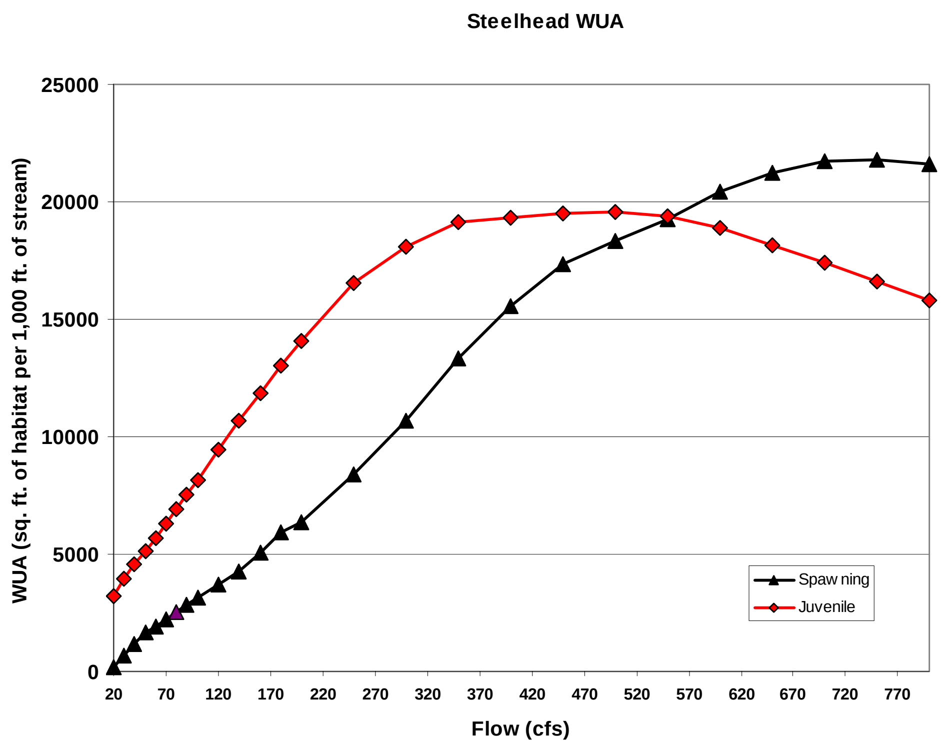


Figure 7. Weighted usable area versus flow relationships for steelhead in Icicle Creek, Study Site 1.

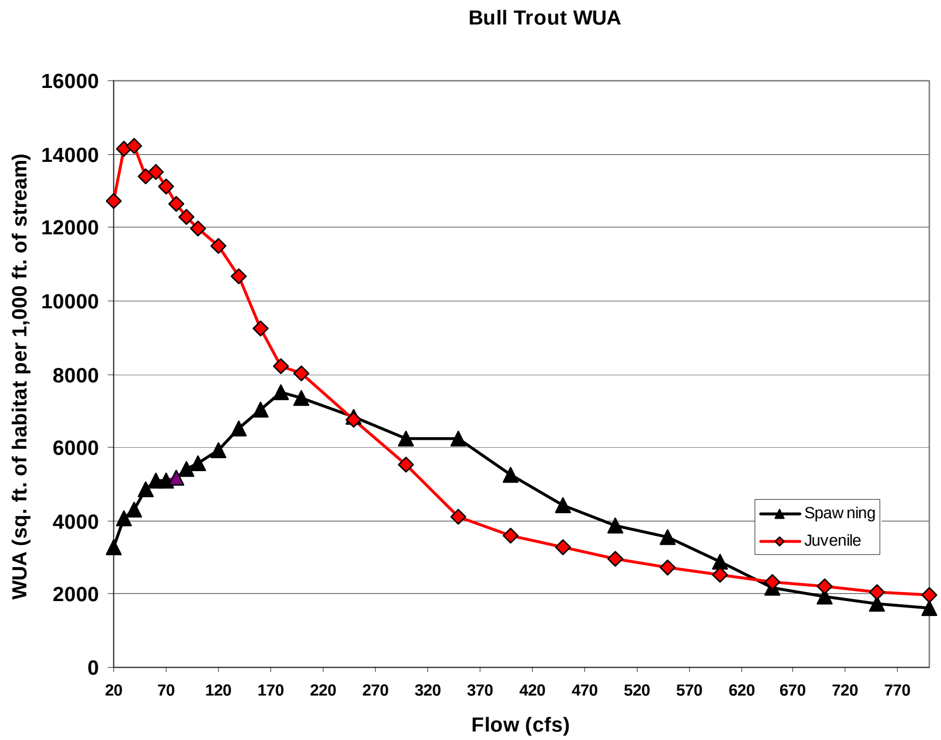


Figure 8. Weighted usable area versus flow relationships for bull trout in Icicle Creek, Study Site 1.

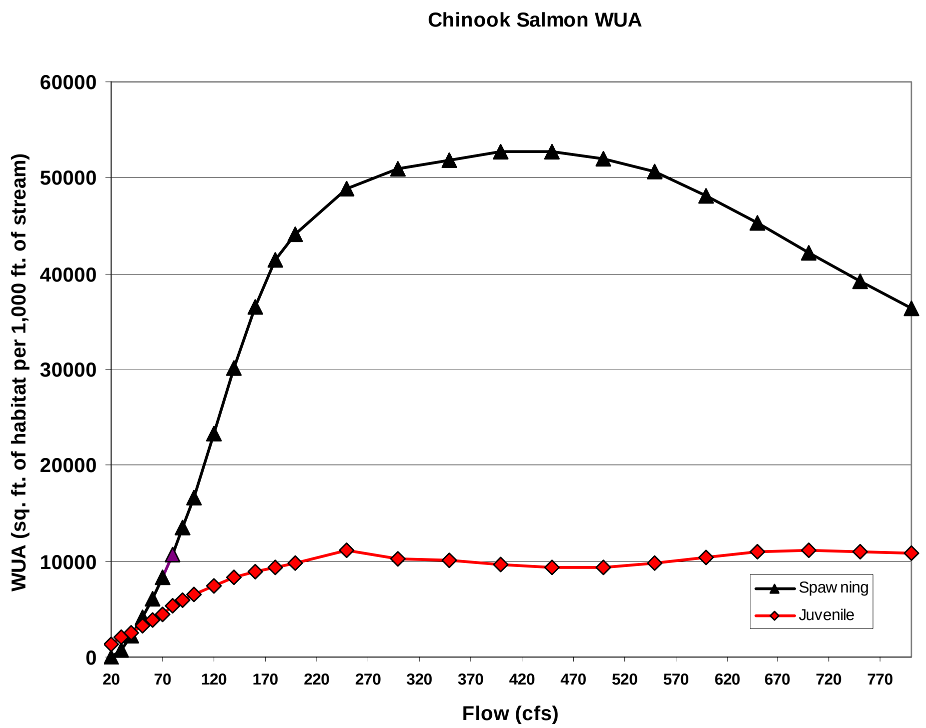


Figure 9. Weighted usable area versus flow relationships for Chinook salmon in Icicle Creek, Study Site 2.

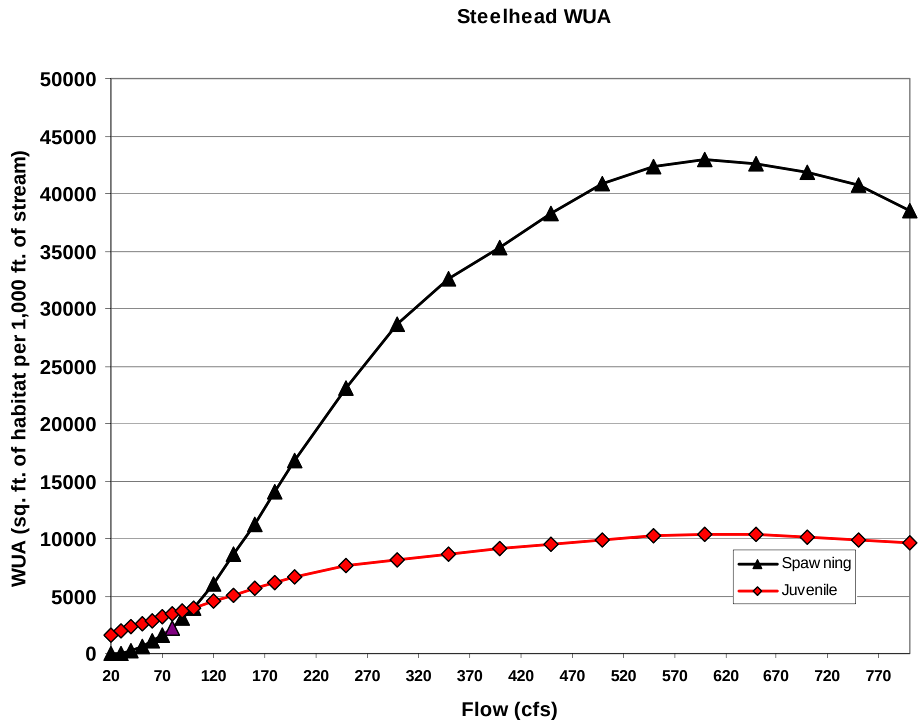


Figure 10. Weighted usable area versus flow relationships for steelhead in Icicle Creek, Study Site 2.

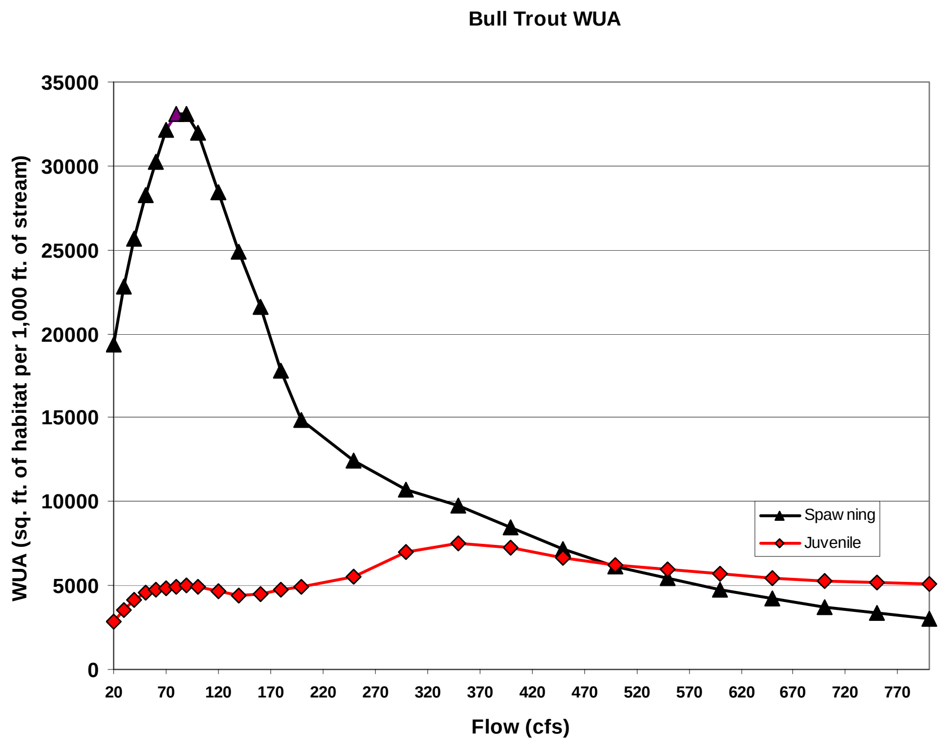


Figure 11. Weighted usable area versus flow relationships for bull trout in Icicle Creek, Study Site 2.

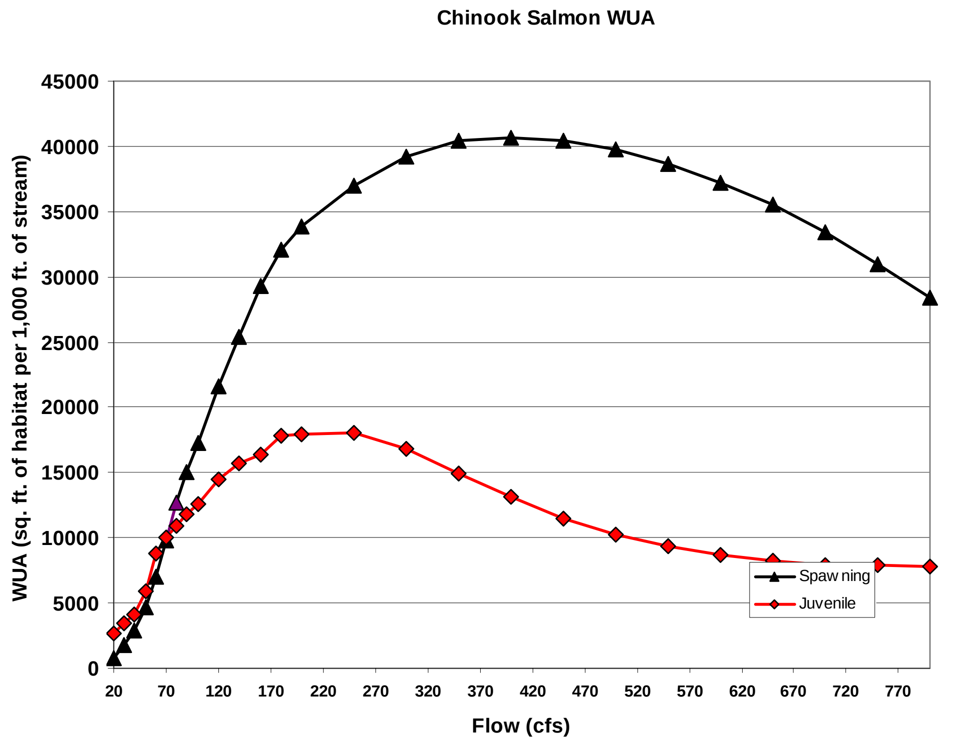


Figure 12. Weighted usable area versus flow relationships for Chinook salmon in Icicle Creek, Study Site 3.

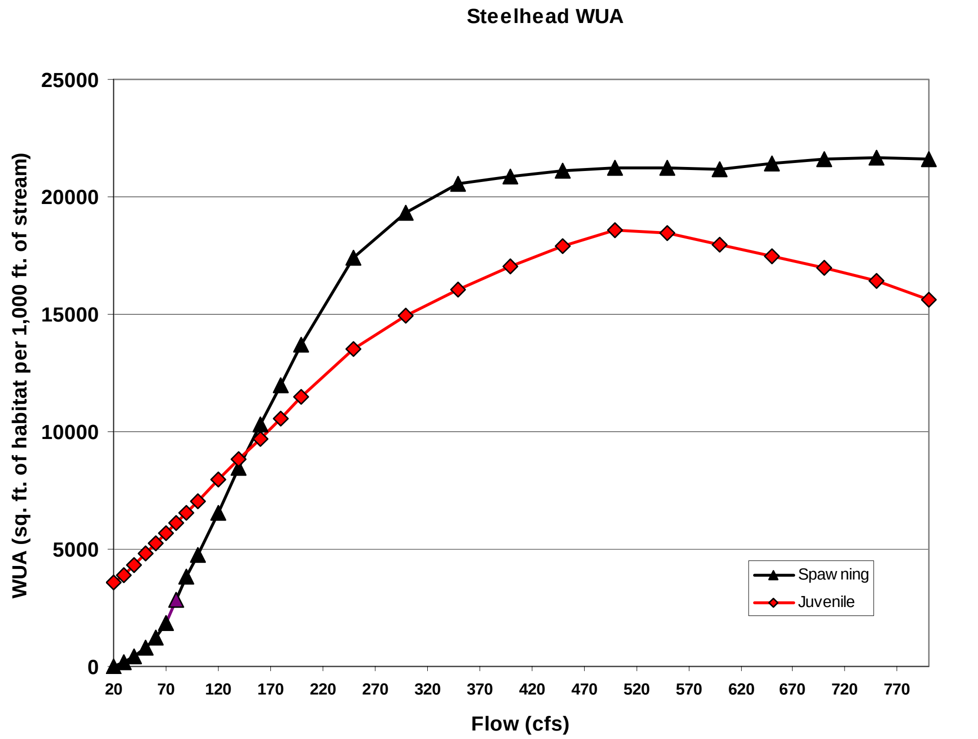


Figure 13. Weighted usable area versus flow relationships for steelhead in Icicle Creek, Study Site 3.

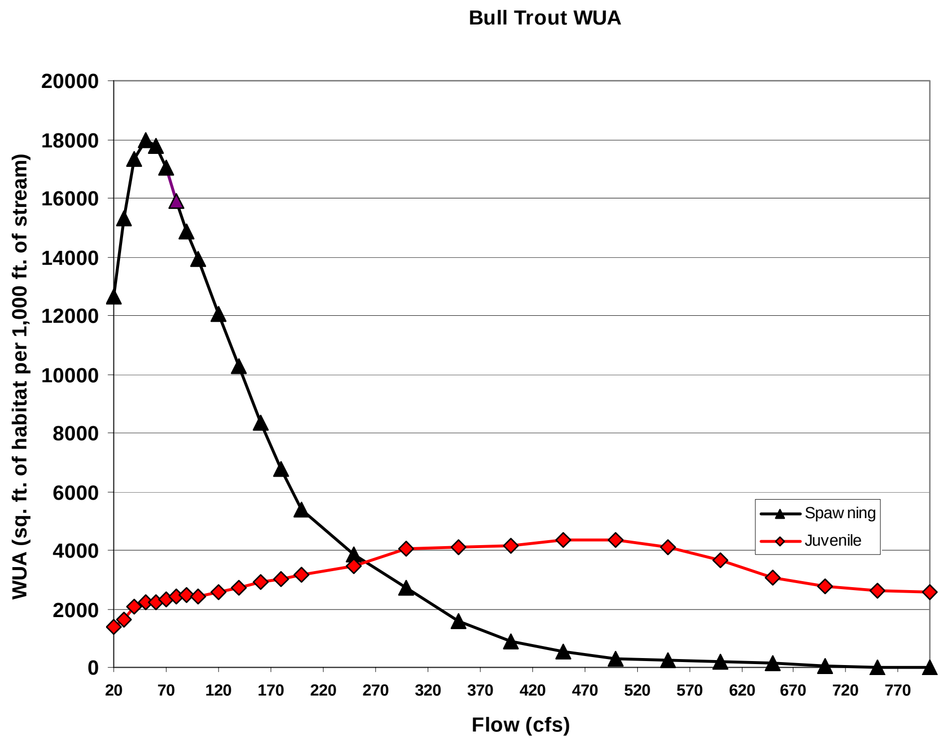


Figure 14. Weighted usable area versus flow relationships for bull trout in Icicle Creek, Study Site 3.

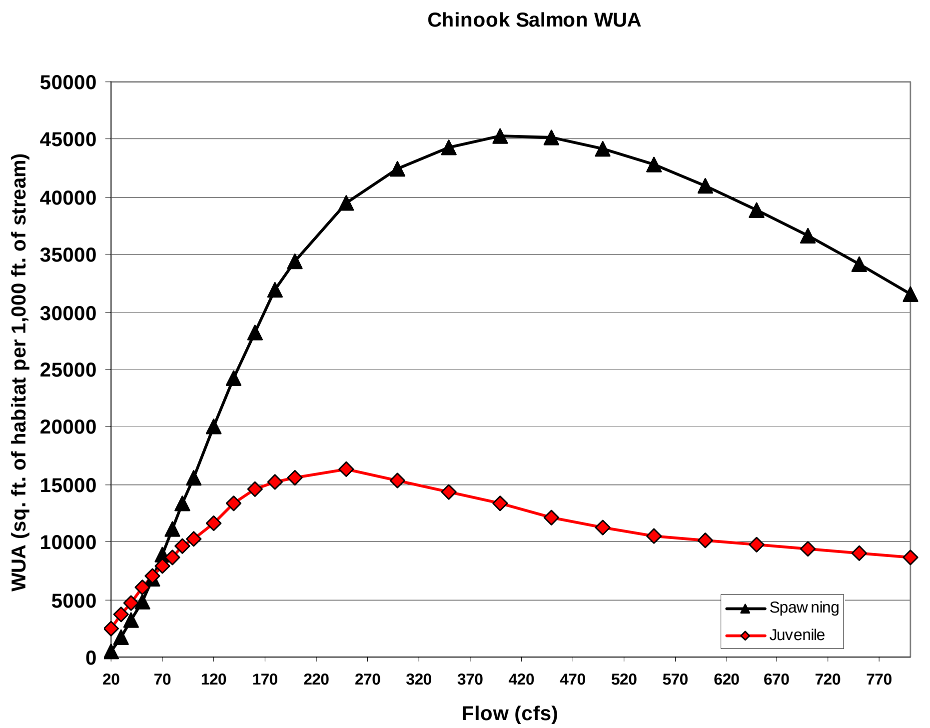


Figure 15. Weighted usable area versus flow relationships for Chinook salmon in Icicle Creek, Composite.

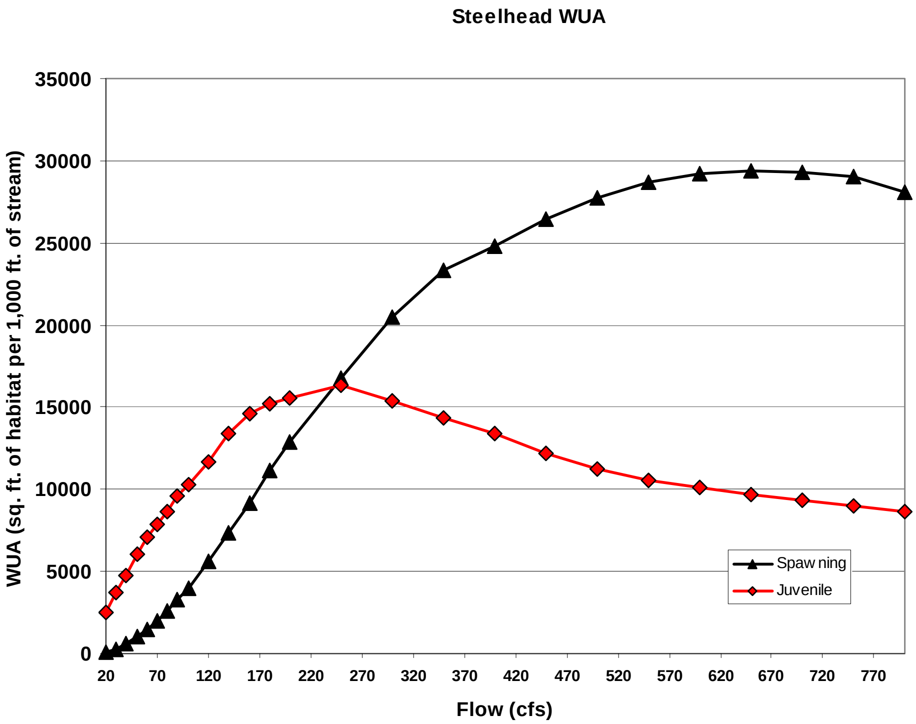


Figure 16. Weighted usable area versus flow relationships for steelhead in Icicle Creek, Composite.

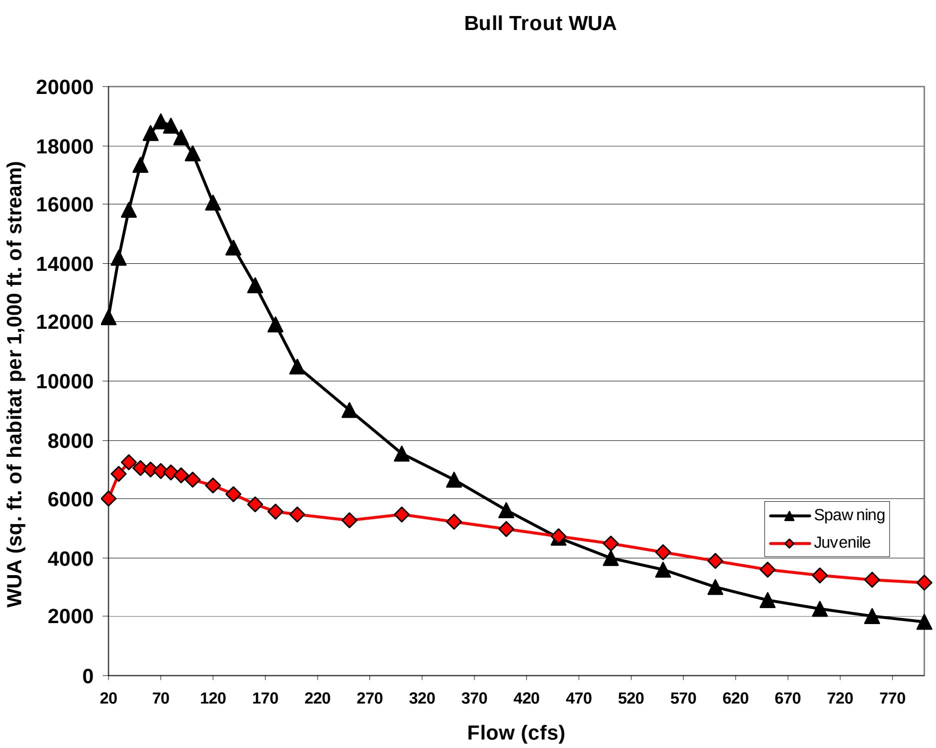


Figure 17. Weighted usable area versus flow relationships for bull trout in Icicle Creek, Composite.

Table 8. Weighted usable area (WUA) (ft^2/1,000 ft) versus flow in Icicle Creek, Study Site 1.

Flow (cfs)	Total Area	Chinook Salmon WUA		Percent of maximum WUA		Steelhead WUA		Percent of maximum WUA		Bull Trout WUA		Percent of maximum WUA	
		Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile
20	103,107	934	3,439	2.3	16.9	182	3,222	0.8	16.5	3,267	12,704	43.4	89.3
30	106,958	2,782	5,424	6.9	26.7	649	3,926	3.0	20.1	4,089	14,135	54.4	99.4
40	108,775	4,333	6,925	10.7	34.1	1,192	4,545	5.5	23.2	4,289	14,220	57.0	100.0
50	108,340	5,542	7,810	13.7	38.4	1,640	5,135	7.5	26.2	4,869	13,391	64.7	94.2
60	113,059	6,887	8,790	17.0	43.3	1,923	5,699	8.8	29.1	5,096	13,527	67.7	95.1
70	114,028	8,207	9,538	20.2	46.9	2,208	6,296	10.1	32.2	5,102	13,108	67.8	92.2
80	114,955	9,583	10,106	23.6	49.7	2,519	6,914	11.6	35.3	5,190	12,654	69.0	89.0
90	115,850	11,024	10,771	27.2	53.0	2,824	7,547	13.0	38.6	5,417	12,269	72.0	86.3
100	116,670	12,367	11,721	30.5	57.7	3,121	8,165	14.3	41.7	5,574	11,981	74.1	84.3
120	117,962	14,343	14,064	35.4	69.2	3,690	9,424	16.9	48.2	5,911	11,491	78.6	80.8
140	118,847	16,102	16,631	39.7	81.8	4,281	10,667	19.7	54.5	6,518	10,654	86.7	74.9
160	119,522	18,566	18,236	45.8	89.7	5,035	11,877	23.1	60.7	7,037	9,242	93.6	65.0
180	116,012	21,720	19,058	53.6	93.8	5,899	13,032	27.1	66.6	7,522	8,224	100.0	57.8
200	120,297	24,204	19,991	59.7	98.4	6,378	14,054	29.3	71.8	7,345	8,036	97.6	56.5
250	121,098	30,677	20,320	75.7	100.0	8,399	16,517	38.6	84.4	6,851	6,742	91.1	47.4
300	121,816	35,018	19,967	86.4	98.3	10,656	18,087	48.9	92.4	6,239	5,516	82.9	38.8
350	122,766	38,716	19,089	95.5	93.9	13,359	19,163	61.3	97.9	6,230	4,099	82.8	28.8
400	123,320	40,322	17,604	99.5	86.6	15,578	19,332	71.5	98.8	5,240	3,606	69.7	25.4
450	123,692	40,530	16,069	100.0	79.1	17,337	19,488	79.6	99.6	4,422	3,282	58.8	23.1
500	124,030	39,264	14,622	96.9	72.0	18,334	19,565	84.2	100.0	3,852	2,964	51.2	20.8
550	124,345	37,613	13,050	92.8	64.2	19,290	19,367	88.6	99.0	3,567	2,725	47.4	19.2
600	124,639	35,927	11,663	88.6	57.4	20,412	18,878	93.7	96.5	2,900	2,518	38.6	17.7
650	124,914	34,185	10,568	84.3	52.0	21,215	18,157	97.4	92.8	2,178	2,331	29.0	16.4
700	125,175	32,360	9,629	79.8	47.4	21,715	17,382	99.7	88.8	1,923	2,195	25.6	15.4
750	125,419	30,412	8,785	75.0	43.2	21,780	16,607	100.0	84.9	1,757	2,074	23.4	14.6
800	125,655	28,372	7,995	70.0	39.3	21,579	15,815	99.1	80.8	1,615	1,977	21.5	13.9

Table 9. Weighted usable area (WUA) (ft^2/1,000 ft) versus flow in Icicle Creek, Study Site 2.

Flow (cfs)	Total Area	Chinook Salmon WUA		Percent of maximum WUA		Steelhead WUA		Percent of maximum WUA		Bull Trout WUA		Percent of maximum WUA	
		Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile
20	103,289	21	1,411	0.0	12.6	0	1,662	0.0	15.9	19,353	2,826	58.5	37.4
30	110,897	780	2,017	1.5	18.0	47	1,984	0.1	19.0	22,819	3,566	68.9	47.2
40	118,633	2,263	2,587	4.3	23.1	256	2,288	0.6	21.9	25,708	4,190	77.7	55.4
50	126,993	4,152	3,216	7.9	28.7	632	2,583	1.5	24.8	28,224	4,554	85.2	60.2
60	127,722	6,113	3,867	11.6	34.5	1,100	2,873	2.6	27.5	30,254	4,715	91.4	62.4
70	128,293	8,265	4,511	15.7	40.3	1,627	3,160	3.8	30.3	32,129	4,824	97.0	63.8
80	128,775	10,697	5,293	20.3	47.3	2,277	3,438	5.3	33.0	33,107	4,939	100.0	65.3
90	129,212	13,455	6,001	25.5	53.6	3,051	3,720	7.1	35.7	33,105	4,975	100.0	65.8
100	129,747	16,582	6,570	31.4	58.7	3,922	4,001	9.1	38.4	31,985	4,923	96.6	65.1
120	130,749	23,316	7,406	44.2	66.2	6,107	4,563	14.2	43.7	28,399	4,683	85.8	61.9
140	131,538	30,079	8,293	57.0	74.1	8,641	5,110	20.1	49.0	24,911	4,397	75.2	58.2
160	132,176	36,473	8,908	69.2	79.6	11,284	5,632	26.2	54.0	21,611	4,514	65.3	59.7
180	132,725	41,423	9,369	78.6	83.7	14,086	6,122	32.8	58.7	17,795	4,741	53.7	62.7
200	133,099	44,048	9,769	83.5	87.3	16,846	6,610	39.2	63.4	14,822	4,942	44.8	65.4
250	133,827	48,870	11,195	92.7	100.0	23,082	7,613	53.7	73.0	12,484	5,517	37.7	73.0
300	134,430	50,978	10,302	96.7	92.0	28,613	8,160	66.5	78.2	10,754	6,981	32.5	92.3
350	134,955	51,762	10,060	98.2	89.9	32,539	8,634	75.7	82.8	9,807	7,560	29.6	100.0
400	135,430	52,651	9,665	99.9	86.3	35,302	9,122	82.1	87.5	8,510	7,252	25.7	95.9
450	135,773	52,727	9,340	100.0	83.4	38,216	9,518	88.9	91.2	7,194	6,640	21.7	87.8
500	136,087	52,025	9,365	98.7	83.7	40,893	9,938	95.1	95.3	6,141	6,237	18.5	82.5
550	136,378	50,654	9,775	96.1	87.3	42,386	10,306	98.6	98.8	5,449	5,935	16.5	78.5
600	136,634	48,103	10,433	91.2	93.2	42,997	10,431	100.0	100.0	4,732	5,719	14.3	75.7
650	136,873	45,261	10,933	85.8	97.7	42,557	10,312	99.0	98.9	4,194	5,479	12.7	72.5
700	137,100	42,228	11,100	80.1	99.2	41,856	10,084	97.3	96.7	3,702	5,275	11.2	69.8
750	137,315	39,231	10,984	74.4	98.1	40,786	9,837	94.9	94.3	3,375	5,155	10.2	68.2
800	137,520	36,317	10,846	68.9	96.9	38,459	9,645	89.4	92.5	3,043	5,084	9.2	67.2

Table 10. Weighted usable area (WUA) (ft^2/1,000 ft) versus flow in Icicle Creek, Study Site 3.

Flow (cfs)	Total Area	Chinook Salmon WUA		Percent of maximum WUA		Steelhead WUA		Percent of maximum WUA		Bull Trout WUA		Percent of maximum WUA	
		Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile
20	71,360	743	2,679	1.8	14.9	3	3,562	0.0	19.2	12,640	1,382	70.3	31.7
30	73,865	1,729	3,411	4.3	18.9	184	3,903	0.8	21.0	15,307	1,622	85.1	37.2
40	75,691	2,946	4,149	7.2	23.0	430	4,346	2.0	23.4	17,356	2,084	96.5	47.8
50	76,931	4,631	5,855	11.4	32.5	792	4,811	3.7	25.9	17,989	2,242	100.0	51.4
60	82,456	7,064	8,827	17.4	48.9	1,224	5,246	5.7	28.2	17,774	2,199	98.8	50.5
70	85,775	9,857	9,974	24.2	55.3	1,852	5,677	8.6	30.6	17,048	2,331	94.8	53.5
80	87,264	12,687	10,897	31.2	60.4	2,832	6,122	13.1	33.0	15,880	2,439	88.3	56.0
90	88,114	15,072	11,800	37.1	65.4	3,824	6,563	17.7	35.3	14,859	2,447	82.6	56.2
100	88,355	17,219	12,541	42.3	69.5	4,729	7,012	21.8	37.7	13,941	2,430	77.5	55.8
120	88,791	21,603	14,439	53.1	80.0	6,562	7,933	30.3	42.7	12,027	2,562	66.9	58.8
140	89,182	25,440	15,720	62.6	87.1	8,446	8,851	39.0	47.6	10,267	2,726	57.1	62.5
160	89,405	29,311	16,417	72.1	91.0	10,281	9,707	47.5	52.3	8,327	2,898	46.3	66.5
180	89,600	32,091	17,870	78.9	99.1	11,991	10,571	55.4	56.9	6,781	3,020	37.7	69.3
200	89,775	33,824	17,942	83.2	99.5	13,683	11,467	63.2	61.7	5,393	3,174	30.0	72.8
250	90,163	36,997	18,038	91.0	100.0	17,428	13,524	80.5	72.8	3,876	3,458	21.5	79.3
300	90,507	39,209	16,780	96.4	93.0	19,328	14,925	89.2	80.3	2,719	4,039	15.1	92.7
350	135,110	40,451	14,943	99.5	82.8	20,529	16,050	94.8	86.4	1,591	4,112	8.8	94.3
400	91,513	40,664	13,162	100.0	73.0	20,875	17,051	96.4	91.8	907	4,131	5.0	94.8
450	92,111	40,381	11,446	99.3	63.5	21,140	17,911	97.6	96.4	536	4,358	3.0	100.0
500	93,068	39,746	10,259	97.7	56.9	21,260	18,576	98.1	100.0	290	4,332	1.6	99.4
550	93,629	38,683	9,369	95.1	51.9	21,240	18,487	98.0	99.5	245	4,079	1.4	93.6
600	94,163	37,158	8,735	91.4	48.4	21,179	17,966	97.8	96.7	176	3,643	1.0	83.6
650	94,668	35,506	8,228	87.3	45.6	21,405	17,460	98.8	94.0	127	3,048	0.7	69.9
700	95,153	33,398	7,906	82.1	43.8	21,630	16,970	99.8	91.4	71	2,778	0.4	63.7
750	95,616	30,963	7,873	76.1	43.6	21,663	16,427	100.0	88.4	18	2,620	0.1	60.1
800	96,060	28,433	7,806	69.9	43.3	21,584	15,643	99.6	84.2	4	2,576	0.0	59.1

Table 11. Weighted usable area (WUA) (ft^2/1,000 ft) versus flow in Icicle Creek, composite of all sites.

Flow (cfs)	Total Area	Chinook Salmon WUA		Percent of maximum WUA		Steelhead WUA		Percent of maximum WUA		Bull Trout WUA		Percent of maximum WUA	
		Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile	Spawning	Juvenile
20	93,122	536	2,493	1.2	15.2	63	2,760	0.2	17.3	12,177	6,013	64.7	82.9
30	98,455	1,715	3,719	3.8	22.7	283	3,251	1.0	20.4	14,193	6,871	75.4	94.7
40	102,564	3,169	4,760	7.0	29.1	606	3,719	2.1	23.3	15,816	7,257	84.1	100.0
50	106,249	4,853	6,038	10.7	36.9	1,030	4,186	3.5	26.2	17,340	7,034	92.1	96.9
60	109,816	6,794	7,062	15.0	43.1	1,462	4,652	5.0	29.1	18,430	7,013	97.9	96.6
70	111,322	8,938	7,887	19.7	48.2	1,964	5,102	6.7	31.9	18,817	6,942	100.0	95.7
80	112,228	11,128	8,683	24.6	53.1	2,570	5,561	8.7	34.8	18,687	6,896	99.3	95.0
90	112,901	13,420	9,598	29.6	58.6	3,286	6,012	11.2	37.6	18,260	6,793	97.0	93.6
100	113,466	15,606	10,324	34.5	63.1	3,987	6,466	13.6	40.5	17,756	6,647	94.4	91.6
120	114,442	20,064	11,694	44.3	71.5	5,612	7,399	19.1	46.3	16,063	6,463	85.4	89.1
140	115,167	24,209	13,389	53.5	81.8	7,384	8,339	25.1	52.2	14,548	6,177	77.3	85.1
160	115,708	28,264	14,626	62.4	89.4	9,180	9,225	31.2	57.8	13,266	5,820	70.5	80.2
180	116,109	31,936	15,190	70.6	92.8	11,112	10,078	37.8	63.1	11,908	5,567	63.3	76.7
200	116,397	34,356	15,591	75.9	95.3	12,864	10,876	43.7	68.1	10,516	5,465	55.9	75.3
250	117,038	39,437	16,366	87.1	100.0	16,782	12,676	57.1	79.4	9,038	5,293	48.0	72.9
300	117,624	42,445	15,408	93.8	94.1	20,458	13,824	69.6	86.6	7,553	5,460	40.1	75.2
350	118,239	44,317	14,348	97.9	87.7	23,341	14,652	79.4	91.7	6,643	5,224	35.3	72.0
400	118,780	45,263	13,377	100.0	81.7	24,762	15,202	84.2	95.2	5,609	4,992	29.8	68.8
450	119,197	45,192	12,170	99.8	74.4	26,432	15,635	89.9	97.9	4,658	4,728	24.8	65.1
500	119,701	44,187	11,256	97.6	68.8	27,742	15,961	94.3	99.9	3,994	4,461	21.2	61.5
550	120,080	42,859	10,551	94.7	64.5	28,667	15,970	97.5	100.0	3,588	4,188	19.1	57.7
600	120,438	41,007	10,098	90.6	61.7	29,174	15,695	99.2	98.3	3,021	3,906	16.1	53.8
650	120,766	38,875	9,721	85.9	59.4	29,411	15,187	100.0	95.1	2,540	3,580	13.5	49.3
700	121,076	36,574	9,347	80.8	57.1	29,300	14,648	99.6	91.7	2,245	3,387	11.9	46.7
750	121,379	34,120	9,020	75.4	55.1	28,999	14,102	98.6	88.3	2,032	3,253	10.8	44.8
800	121,648	31,514	8,666	69.6	53.0	28,116	13,461	95.6	84.3	1,844	3,165	9.8	43.6

Discussion

The results presented in this report summarize the hydrology and habitat in Icicle Creek. PHABSIM analysis of the data collected and compiled for this study resulted in graphs that illustrate the relation between WUA and discharge. The highest point on the curves represents the discharge at which habitat is optimized for the life stage of interest. It should be understood that WUAs do not address water availability in any way and even the unregulated flow may commonly exceed or be less than the discharge at which maximum WUA is available. The amount of WUA available, in terms of lost or gained, can be determined by comparing to a reference or unregulated streamflow condition. Typically, the maximum, percentiles, or inflections are chosen from these curves at the level of protection desired or at points above which greater amounts of flow only provide minor gains in usable habitat.

The actual habitat experienced by fish in any river depends on the flow regime of the river. The development of habitat conditions over a period of time is an integral part of the comparison of flow regimes and developing target flows for aquatic needs. Habitat time series analysis involves interfacing a time series of streamflow data with the functional relationship between streamflow and habitat (WUA) (Bovee et al. 1998). This computational process is done for each flow regime alternative and life stage. Flow and habitat duration statistics are developed that allow a direct comparison of the changes that occur in both flow and habitat under a range of conditions. The amount of WUA available, in terms of lost or gained, can be determined by comparing WUA for an alternative flow regime to a reference or unregulated stream flow condition. The decision point in PHABSIM is a comparison of flow regimes.

The natural hydrograph needs to be considered when developing flow targets. In drought years, summer flows that provide maximum possible habitat may not be attainable because of the hydrologic limits on the stream.

Finally, it should be noted that PHABSIM was designed as a tool to provide science-based linkage between biology and river hydraulics with results to be used in negotiations or mediated settlements (Arthaud et al. 2001).

References

Arthaud, D., K. Kratz, K. Vandemoer, and M. Grady. 2001. NMFS-NWR protocol for estimating tributary streamflow to protect salmon listed under the Endangered Species Act. National Marine Fisheries Service Habitat Conservation Division-NWR. Draft. 24 p.

Bovee, K.D. 1997. Data collection procedures for the Physical Habitat Simulation System. U.S. Geological Survey, Biological Resources Division. Fort Collins, CO. 141 p.

Bovee, K.D., B.L. Lamb, J.M. Bartholow, C.D. Stalnaker, J. Taylor, and J. Henriksen. 1998. Stream habitat analysis using the instream flow incremental methodology. U.S. Geological Survey, Biological Resources Division. Information and Technical Report USGS/BRD-1998-0004. 131 p. http://www.fort.usgs.gov/products/Publications/3910/3910.asp

EES Consulting, Inc. 2004. Draft scoping report – Wenatchee River instream flow studies. Prepared for Chelan County Natural Resources Department and WRIA 45 Watershed Planning Unit. Bellingham, WA.

EES Consulting, Inc. 2005. Bull trout habitat suitability data from the upper Wenatchee River basin. Prepared for the Chelan County Natural Resources Department and WRIA 45 Watershed Planning Unit. Bellingham, WA. 39 pp. ftp://64.146.227.71/natural_resources_program/Wenatchee%20Watershed%20Planning/Instream%20Flow%20Assessment/HSI%20Report.pdf

Waddle, T.J. 2001. PHABSIM for Windows: User's Manual and Exercises. Fort Collins, Colorado. U.S. Geological Survey. Open file report 01-340. 288 p. http://www.fort.usgs.gov/products/Publications/15000/15000.asp

Washington Department of Fish & Wildlife and Washington Department of Ecology. 2004. Instream Flow Guidelines. April, 2004. http://www.ecy.wa.gov/pubs/0411007.pdf

Appendix A – Depth and Velocity Habitat Suitability Criteria for Icicle Creek

Chinook juveniles			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0.09	0	0
0.35	0.26	0.45	0
0.45	0.93	1.35	0.5
0.7	1	1.55	0.8
1.15	0.9	2.2	1
1.25	0.75	99.99	1
2.3	0.08		
3.6	0		
Chinook spawning			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0	0	0
0.5	0	0.5	0
1	0.9	1.2	1
1.75	1	3	1
2.25	1	3.5	0.5
4	0	4.5	0.07
		5	0
Steelhead juveniles			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0.23	0	0
0.25	0.3	0.25	0
0.9	0.8	1.8	0.39
1.35	1	2.65	1
1.55	1	2.95	1
2.6	0.8	4.5	0.64
2.95	0.39	99.9	0.64
3.65	0.22		
5.5	0.16		
6	0		
Steelhead spawning			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0	0	0
0.55	0	0.65	0
2.5	1	1.25	1
3.25	1	1.55	1
3.45	0.62	2.4	0.5
5	0	99.99	0.5
Bull trout juvenile/adult rearing			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0.16	0	0
0.1	1	0.45	0
0.4	1	1.3	0.56
0.8	0.2	1.5	1
1.6	0.2	2	1
2.8	0	2.1	0.67
		2.9	0.67
		3	0

Bull trout spawning			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0.03	0	0
0.35	0.48	0.1	0
0.5	1	0.3	0.18
0.95	1	0.5	1
1.1	0.4	0.7	1
2	0.13	1.3	0.29
2.1	0	2.1	0.2
		2.2	0
Coho spawning			
Velocity (ft/sec)	Preference	Depth (ft)	Preference
0	0.4	0	0
0.25	0.4	0.45	0
1.05	1	1.15	0.75
1.8	0.81	2.05	1
2.65	0.29	3.25	0.09
3.9	0	4	0.01
		5	0

Appendix B – PHABSIM Input File for Icicle Creek

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Icicle Creek Composite
Export from PHABSIM for Windows
IOC       0000000100010000100000
QARD  20.0
QARD  30.0
QARD  40.0
QARD  50.0
QARD  53.5
QARD  60.0
QARD  70.0
QARD  80.0
QARD  90.0
QARD 100.0
QARD 120.0
QARD 140.0
QARD 160.0
QARD 180.0
QARD 195.4
QARD 200.0
QARD 240.6
QARD 250.0
QARD 300.0
QARD 350.0
QARD 361.8
QARD 400.0
QARD 450.0
QARD 500.0
QARD 550.0
QARD 600.0
QARD 650.0
QARD 700.0
QARD 750.0
QARD 800.0
XSEC   1.0       0.0 1.0      84.20   0.00012
       1.0  0.0 92.0  8.2 90.9 12.4 88.4 16.1 87.9 17.4 87.5 18.5 87.3
       1.0 18.7 87.0 20.0 86.5 22.0 86.3 24.0 86.5 26.0 86.8 28.0 86.9
       1.0 30.0 87.0 32.0 87.1 34.0 87.1 36.0 87.1 38.0 87.0 40.0 87.1
       1.0 42.0 87.0 44.0 86.9 46.0 86.8 48.0 86.8 50.0 86.7 52.0 86.6
       1.0 54.0 86.6 56.0 86.5 58.0 86.4 60.0 86.3 62.0 86.3 64.0 86.2
       1.0 66.0 86.2 68.0 85.9 70.0 85.9 72.0 85.8 74.0 85.7 76.0 85.7
       1.0 78.0 85.5 80.0 85.5 82.0 85.3 84.0 85.2 86.0 85.2 88.0 85.1
       1.0 90.0 84.9 92.0 84.7 94.0 84.5 96.0 84.2 98.0 84.2100.0 84.2
       1.0102.0 84.2106.0 84.5110.0 84.7114.0 85.3118.0 85.5122.0 85.9
       1.0126.0 86.3130.0 86.7131.5 87.0133.0 87.2134.8 93.9
NS     1.0       0.9       0.9  1.0  0.7  1.0  0.2  1.0  0.2  1.0  0.4
NS     1.0  1.0  0.4  1.0 12.9      25.9      35.8      54.5      54.5
NS     1.0      45.7      54.8      54.8      45.5      45.7      45.7
NS     1.0      54.8      54.8      54.8      74.8      74.8      74.7
NS     1.0      74.5      74.8      74.8      74.8      74.8      74.8
NS     1.0      74.8      47.6      47.6      74.6      74.6      74.7
NS     1.0      74.7      74.8      74.9      76.9      76.9      76.9
NS     1.0      76.9      76.6      76.6      67.5      67.9      67.9
NS     1.0      67.9      67.9      67.9  1.0 67.9      67.9      67.9
NS     1.0      67.9      67.9      67.9       0.2       0.9
WSL    1.0      86.7      86.8      86.9      87.0      87.0      87.1
WSL    1.0      87.2      87.2      87.3      87.3      87.4      87.5
WSL    1.0      87.5      87.6      87.6      87.6      87.7      87.7
WSL    1.0      87.8      87.9      87.9      87.9      88.0      88.1
WSL    1.0      88.1      88.2      88.2      88.2      88.3      88.3
CAL1   1.0     87.90    361.80    358.60
VEL1   1.0                 0.00 0.00 0.00 0.20 0.43 0.40 0.92 1.05 1.28
VEL1   1.0 1.24 1.24 1.19 1.24 1.28 1.40 1.35 1.40 1.55 1.56 1.56 1.33
VEL1   1.0 1.58 1.57 1.77 1.60 1.71 1.70 1.65 1.48 1.38 1.43 1.49 1.55
VEL1   1.0 1.62 1.81 1.79 1.93 1.77 1.88 1.97 1.79 1.99 2.05 2.11 1.87
VEL1   1.0 2.18 2.09 1.98 1.87 1.72 1.37 1.06 0.69 0.31 0.07
CAL2   1.0     87.73    240.60    244.40
VEL2   1.0                      0.00 0.03 0.00 0.83 0.72 0.82 0.79 0.90
VEL2   1.0 0.87 0.89 0.84 1.04 1.07 0.97 1.07 1.06 0.88 0.94 1.24 1.12
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VEL2   1.0 1.40 1.22 1.30 1.28 1.27 1.45 1.43 1.28 1.21 1.33 1.43 1.48
VEL2   1.0 1.41 1.49 1.61 1.66 1.60 1.54 1.59 1.63 1.60 1.35 1.57 1.44
VEL2   1.0 1.32 1.47 1.34 1.15 0.69 0.52 0.06 0.10 0.00 0.00
CAL3   1.0     87.53    195.40    178.20
VEL3   1.0                     0.00 0.35 0.35 0.83 0.81 0.83 0.70 0.71
VEL3   1.0 0.61 0.48 0.43 0.48 0.50 0.53 0.56 0.61 0.79 0.72 0.78 0.71
VEL3   1.0 0.83 0.95 0.94 0.91 0.89 0.97 1.09 1.05 1.06 1.14 1.09 1.31
VEL3   1.0 1.22 1.43 1.46 1.36 1.50 1.36 1.55 1.57 1.37 1.50 1.34 1.40
VEL3   1.0 1.13 1.18 0.96 0.78 0.62 0.02 0.14 0.08 0.00 0.00
CAL4   1.0     87.02     53.50     47.00
VEL4   1.0                               0.00 0.43 0.51 0.55 0.23 0.00
VEL4   1.0 0.00                0.00      0.00 0.00 0.06 0.08 0.19 0.23
VEL4   1.0 0.25 0.36 0.37 0.45 0.37 0.52 0.55 0.44 0.45 0.58 0.63 0.60
VEL4   1.0 0.72 0.70 0.68 0.79 0.78 0.71 0.74 0.57 0.58 0.47 0.49 0.30
VEL4   1.0 0.38 0.30 0.20 0.00 0.04 0.19 0.04 0.10 0.00
XSEC   2.0      69.0 1.0     84.70   0.00268
       2.0  0.0 91.6  3.1 90.4  5.4 88.8  9.0 87.8 10.0 87.9 11.4 87.5
       2.0 12.0 87.2 15.0 87.0 18.0 86.6 21.0 86.3 24.0 86.0 27.0 85.6
       2.0 30.0 85.7 33.0 85.2 36.0 85.2 39.0 85.4 42.0 85.6 45.0 85.6
       2.0 48.0 85.5 51.0 85.4 54.0 85.5 57.0 85.4 60.0 85.3 63.0 85.3
       2.0 66.0 85.3 69.0 85.4 72.0 85.4 75.0 85.4 78.0 85.3 81.0 85.2
       2.0 84.0 84.8 87.0 84.7 90.0 85.1 93.0 85.6 96.0 86.0 99.0 86.5
       2.0102.0 86.8105.0 87.2108.0 87.3111.0 87.4113.0 87.5114.0 87.7
       2.0115.2 87.9118.0 89.0119.3 90.5123.2 92.5
NS     2.0     0.9         0.9      11.9      22.9      22.9      21.8
NS     2.0      21.8      21.8      25.9      26.7      62.7      62.9
NS     2.0      65.6      56.6      56.6      76.8      76.8      56.9
NS     2.0      26.7      26.7      52.8      65.6      65.6      65.6
NS     2.0      65.6      65.6      56.8      56.8      56.6      56.6
NS     2.0      56.6      65.6      65.8      67.9      67.9      67.9
NS     2.0      67.9      67.9  1.0 67.9  1.0 67.9  1.0 67.9  1.0 67.9
NS     2.0  1.0 67.9       0.8       0.8       0.9
WSL    2.0      86.7      86.9      87.0      87.1      87.0      87.1
WSL    2.0      87.2      87.2      87.3      87.3      87.4      87.5
WSL    2.0      87.5      87.6      87.6      87.6      87.7      87.7
WSL    2.0      87.8      87.9      87.9      87.9      88.0      88.1
WSL    2.0      88.1      88.2      88.2      88.3      88.3      88.3
CAL1   2.0     87.91    361.80    385.10
VEL1   2.0                0.00 0.00 0.07 0.15 0.08 0.06 0.30 0.69 1.11
VEL1   2.0 1.74 2.00 1.71 1.73 1.29 0.88 0.62 0.59 1.09 1.37 1.71 1.93
VEL1   2.0 1.99 2.29 2.63 2.74 2.79 2.41 2.64 3.03 2.36 1.68 1.48 1.17
VEL1   2.0 1.05 0.93 0.74 0.43 0.20 0.05 0.00
CAL2   2.0     87.73    240.60    260.90
VEL2   2.0                0.00 0.00 0.00 0.03 0.15 0.13 0.03 0.13 0.40
VEL2   2.0 0.78 1.15 1.72 1.80 1.38 0.76 0.75 0.69 0.85 1.11 1.49 1.93
VEL2   2.0 2.09 2.06 2.14 2.43 2.66 2.07 2.00 2.66 1.77 1.25 0.79 0.56
VEL2   2.0 0.35 0.25 0.17 0.06 0.00 0.00
CAL3   2.0     87.51    195.40    178.20
VEL3   2.0                          0.00 0.08 0.12 0.13 0.13 0.09 0.05
VEL3   2.0 0.10 0.20 0.54 0.64 0.87 0.98 0.87 0.80 0.86 0.92 1.14 1.44
VEL3   2.0 1.68 2.00 2.08 2.62 2.42 1.74 1.99 2.17 1.08 0.61 0.27 0.08
VEL3   2.0 0.02 0.06 0.18 0.00 0.00
CAL4   2.0     87.04     53.50     50.90
VEL4   2.0                                    0.00 0.08 0.11 0.06 0.05
VEL4   2.0 0.08 0.10 0.08 0.08 0.05 0.04 0.05 0.03 0.12 0.14 0.33 0.74
VEL4   2.0 0.98 1.21 2.17 1.43 1.95 0.42 0.87 0.45 0.45 0.02 0.13 0.20
VEL4   2.0
XSEC   3.0     121.6 1.0     85.40   0.00054
       3.0  0.0 94.0  2.2 93.7  3.6 88.6  4.5 88.0  5.0 88.2  7.0 87.7
       3.0  8.0 87.2 12.0 87.0 16.0 86.8 20.0 87.2 24.0 87.5 28.0 87.7
       3.0 32.0 87.6 36.0 87.3 40.0 87.1 44.0 86.9 48.0 86.8 52.0 86.9
       3.0 56.0 86.9 60.0 87.0 64.0 87.3 68.0 87.4 72.0 87.4 76.0 87.2
       3.0 80.0 87.1 84.0 86.8 88.0 86.5 92.0 86.1 96.0 85.8100.0 85.6
       3.0104.0 85.5108.0 85.4112.0 85.5116.0 85.7120.0 86.5124.0 86.5
       3.0128.0 86.9132.0 87.3136.0 87.7141.0 88.2141.5 88.2145.0 88.6
       3.0164.6 91.2171.7 95.3
NS     3.0     0.9         0.9       0.2       0.2       0.2       0.2
NS     3.0     0.2        42.8      43.6      43.8      43.8      45.8
NS     3.0      45.8      53.7      53.7      35.8      35.8      35.8
NS     3.0      35.8      35.8      54.5      54.7      54.8      54.8
NS     3.0      54.7      54.7      54.7      54.7      54.7      54.8
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NS     3.0      54.8      54.9      45.7      45.7      65.7      65.7
NS     3.0      56.8      65.9      64.8  1.0 54.9  1.0 54.9  1.0 67.9
NS     3.0      67.9      16.5
WSL    3.0      87.3      87.5      87.6      87.7      87.7      87.8
WSL    3.0      87.8      87.9      87.9      88.0      88.1      88.1
WSL    3.0      88.2      88.3      88.2      88.3      88.4      88.4
WSL    3.0      88.5      88.6      88.6      88.7      88.7      88.8
WSL    3.0      88.8      88.9      88.9      89.0      89.0      89.1
CAL1   3.0     88.62    361.80    365.20
VEL1   3.0           0.00 0.16 0.67 0.92 1.17 1.43 1.36 1.12 1.36 1.47
VEL1   3.0 1.45 1.11 1.18 1.05 1.03 1.07 0.99 1.10 1.12 1.34 1.57 1.44
VEL1   3.0 1.36 1.59 1.61 1.56 1.64 1.95 1.64 1.86 1.82 1.63 1.85 1.93
VEL1   3.0 1.92 1.72 1.45 1.00 0.54 0.00
CAL2   3.0     88.43    240.60    252.80
VEL2   3.0                0.18 0.23 0.24 0.27 1.60 1.55 1.61 1.20 1.09
VEL2   3.0 1.03 0.90 0.95 0.75 0.79 0.79 0.84 0.85 0.94 0.93 1.14 1.14
VEL2   3.0 1.58 1.50 1.44 1.43 1.60 1.61 1.26 1.55 1.63 1.68 1.74 1.67
VEL2   3.0 1.57 1.59 1.29 0.65 0.00
CAL3   3.0     88.18    195.40    171.70
VEL3   3.0                     0.00 0.45 0.91 0.88 0.74 0.64 0.58 0.44
VEL3   3.0 0.38 0.46 0.47 0.39 0.43 0.37 0.42 0.50 0.50 0.54 0.72 0.67
VEL3   3.0 1.11 1.18 1.15 1.20 1.36 1.23 1.29 1.24 1.23 1.26 1.32 1.33
VEL3   3.0 1.17 1.21 0.59 0.00 0.00
CAL4   3.0     87.68     53.50     51.30
VEL4   3.0                          0.00 0.00 0.08 0.11 0.27 0.00 0.00
VEL4   3.0 0.00 0.15 0.13 0.07 0.09 0.06 0.02 0.02 0.12 0.02 0.21 0.17
VEL4   3.0 0.47 0.60 0.65 0.56 0.59 0.97 0.67 0.75 0.65 0.64 0.64 0.60
VEL4   3.0 0.53 0.20 0.00
XSEC   4.0       9.3 1.0     85.40   0.00054
       4.0  0.0 94.5  8.3 91.0 14.0 88.5 15.0 88.2 19.0 87.2 24.0 87.3
       4.0 29.0 87.4 34.0 86.6 39.0 86.8 44.0 86.4 49.0 86.0 54.0 85.4
       4.0 59.0 85.1 64.0 84.9 69.0 84.8 74.0 85.0 79.0 84.9 84.0 84.9
       4.0 89.0 84.8 94.0 84.5 99.0 84.5104.0 84.6109.0 84.7114.0 84.7
       4.0119.0 84.6124.0 84.8129.0 84.9134.0 85.5139.0 86.2144.0 87.5
       4.0146.8 88.0147.0 87.7148.4 88.2150.2 88.7152.4 89.7156.8 94.1
NS     4.0       0.9       0.2  1.0  0.2       0.2      21.8      22.9
NS     4.0      22.9      23.9      22.9      22.9      22.9      21.9
NS     4.0      22.9      22.9      21.9      21.9      21.9      21.9
NS     4.0      21.9      22.9      25.9      25.9      24.7      24.7
NS     4.0      52.7      65.6      56.6      56.8  1.0 65.8  1.0 65.8
NS     4.0  1.0 56.8  1.0 65.5  1.0 65.5  1.0 65.5      11.9       0.9
WSL    4.0      87.4      87.5      87.6      87.7      87.7      87.8
WSL    4.0      87.8      87.9      87.9      88.0      88.1      88.1
WSL    4.0      88.2      88.3      88.2      88.3      88.5      88.4
WSL    4.0      88.6      88.6      88.7      88.7      88.8      88.9
WSL    4.0      88.9      89.0      89.1      89.1      89.2      89.2
CAL1   4.0     88.65    361.80    320.00
VEL1   4.0           0.00 0.00 0.61 0.90 0.75 0.62 0.55 0.71 0.69 0.68
VEL1   4.0 0.66 0.70 0.65 0.81 0.76 0.79 0.88 0.88 0.90 0.88 0.83 0.94
VEL1   4.0 0.82 0.69 0.86 0.74 0.77 0.62 0.37 0.28 0.19 0.00
CAL2   4.0     88.50    240.60    235.40
VEL2   4.0           0.00 0.21 0.42 0.48 0.47 0.48 0.47 0.46 0.44 0.47
VEL2   4.0 0.48 0.50 0.51 0.53 0.55 0.61 0.65 0.67 0.68 0.74 0.71 0.65
VEL2   4.0 0.65 0.70 0.58 0.66 0.55 0.33 0.00 0.00 0.00
CAL3   4.0     88.17    195.40    146.70
VEL3   4.0                0.00 0.43 0.48 0.38 0.27 0.28 0.29 0.31 0.34
VEL3   4.0 0.30 0.35 0.34 0.40 0.39 0.43 0.57 0.48 0.54 0.40 0.52 0.50
VEL3   4.0 0.49 0.51 0.41 0.47 0.37 0.31 0.01 0.00 0.00
CAL4   4.0     87.69     53.50     30.70
VEL4   4.0                     0.07 0.08 0.00 0.03 0.10 0.14 0.13 0.10
VEL4   4.0 0.08 0.07 0.05 0.08 0.11 0.10 0.13 0.12 0.20 0.13 0.32 0.14
VEL4   4.0 0.19 0.12 0.11 0.12 0.05 0.06      0.00
XSEC   5.0     156.3 1.0     90.20   0.00478
       5.0  0.0 98.7 10.0 91.7 11.0 91.5 12.3 91.1 15.0 90.8 20.0 90.9
       5.0 25.0 90.4 30.0 90.2 35.0 90.3 40.0 90.8 45.0 91.0 50.0 90.9
       5.0 55.0 91.0 60.0 91.0 65.0 91.0 70.0 90.9 75.0 90.9 80.0 91.0
       5.0 85.0 90.9 90.0 90.9 95.0 90.7100.0 90.6105.0 90.6110.0 90.4
       5.0115.0 90.4120.0 90.5125.0 90.3130.0 90.4135.0 90.3140.0 90.6
       5.0145.0 90.8150.0 90.9154.0 91.1155.0 91.2160.0 91.3162.5 91.4
       5.0163.5 91.5165.0 91.7165.2 91.9166.3 95.3177.8 97.5
NS     5.0       0.9       0.1       0.1      54.9      54.9      54.9
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NS     5.0      54.6      54.6      54.6  1.0 54.6  1.0 45.6  1.0 54.6
NS     5.0  1.0 54.6  1.0 53.8  1.0 53.8      53.8      53.8      54.9
NS     5.0      54.9      54.8      54.8  1.0 54.8  1.0 54.6  1.0 54.6
NS     5.0  1.0 54.6  1.0 45.8  1.0 45.8      45.9      45.9      45.8
NS     5.0      45.8      45.8      45.8      45.8      43.9      43.9
NS     5.0       0.2       0.1       0.1       0.9       0.9
WSL    5.0      90.8      90.9      91.0      91.0      91.1      91.1
WSL    5.0      91.1      91.2      91.2      91.2      91.3      91.3
WSL    5.0      91.4      91.4      91.4      91.4      91.5      91.5
WSL    5.0      91.6      91.7      91.7      91.7      91.8      91.8
WSL    5.0      91.8      91.9      91.9      92.0      92.0      92.0
CAL1   5.0     91.07     53.50     57.20
VEL1   5.0                0.00 0.15 0.51 0.73 1.00 0.74 0.29 0.13 0.28
VEL1   5.0 0.00 0.00 0.00 0.33 0.81 0.43 0.58 1.41 1.36 1.51 1.86 1.42
VEL1   5.0 1.75 1.45 1.51 1.43 1.69 1.01 0.69 0.41 0.00
VEL1   5.0
CAL2   5.0     91.39    195.40    212.30
VEL2   5.0           0.00 0.40 0.82 1.35 1.64 2.56 1.57 1.35 0.89 0.95
VEL2   5.0 0.62 0.30 0.82 1.02 1.61 1.97 1.97 2.65 2.93 2.42 2.77 2.51
VEL2   5.0 2.73 2.95 2.61 2.81 2.60 2.47 1.28 1.83 1.14 0.45 0.69 0.00
VEL2   5.0 0.00
CAL3   5.0     91.54    240.60    258.00
VEL3   5.0           0.00 0.50 0.99 1.87 2.35 2.60 1.78 1.27 0.98 0.93
VEL3   5.0 0.90 0.70 0.79 0.88 1.60 1.78 2.38 2.71 2.79 3.11 2.93 2.61
VEL3   5.0 3.07 2.77 3.00 2.66 3.33 3.40 1.89 1.83 1.70 1.57 0.51 0.25
VEL3   5.0 0.00
CAL4   5.0     91.67    361.80    387.80
VEL4   5.0      0.00 0.06 0.64 1.27 1.94 2.38 3.24 2.95 2.09 1.56 0.81
VEL4   5.0 0.66 0.50 0.23 0.47 1.46 1.95 2.97 3.46 3.53 3.54 3.53 3.63
VEL4   5.0 3.48 3.53 3.17 3.52 3.43 3.81 2.59 2.71 2.57 2.42 2.37 2.00
VEL4   5.0 1.55 0.00
XSEC   6.0      69.0 1.0     90.10   0.00090
       6.0  0.0 98.4  8.7 92.2 11.0 91.4 14.0 90.7 19.0 90.7 24.0 90.5
       6.0 29.0 90.5 34.0 90.9 39.0 90.8 44.0 90.6 49.0 90.4 54.0 90.5
       6.0 59.0 90.5 64.0 90.4 69.0 90.5 74.0 90.5 79.0 90.4 84.0 90.7
       6.0 89.0 90.5 94.0 90.2 99.0 90.1104.0 90.3109.0 90.3114.0 90.6
       6.0119.0 91.1124.0 91.2129.0 90.9134.0 90.7139.0 90.8144.0 90.6
       6.0149.0 90.6151.0 91.4152.0 92.0157.3 93.0160.1 93.9164.5 94.9
NS     6.0       0.9       0.2      58.8      58.8      58.8      53.8
NS     6.0      53.8      53.8      53.8      54.8      53.8      54.8
NS     6.0      53.9      53.9      53.9      52.9      52.9      52.9
NS     6.0      52.9      52.9      52.9      54.8      54.8      45.7
NS     6.0      45.7      45.7      45.9      45.9      45.9      45.9
NS     6.0  1.0 45.9  1.0 21.9      21.9       0.7       0.8       0.9
WSL    6.0      91.1      91.2      91.3      91.4      91.4      91.4
WSL    6.0      91.5      91.5      91.6      91.6      91.7      91.7
WSL    6.0      91.8      91.8      91.9      91.9      92.0      92.0
WSL    6.0      92.1      92.1      92.2      92.2      92.3      92.3
WSL    6.0      92.4      92.4      92.5      92.5      92.6      92.6
CAL1   6.0     91.41     53.50     53.50
VEL1   6.0           0.00 0.06 0.27 0.48 0.42 0.33 0.27 0.30 0.26 0.36
VEL1   6.0 0.35 0.45 0.43 0.66 0.52 0.42 0.63 0.65 0.76 0.91 0.70 0.80
VEL1   6.0 0.72 0.73 0.14 0.15 0.32 0.49 0.36 0.00
CAL2   6.0     91.85    195.40    195.40
VEL2   6.0           0.00 0.04 0.31 1.12 1.01 1.17 1.13 1.08 1.03 1.13
VEL2   6.0 1.14 1.01 1.20 1.25 0.90 1.13 1.23 1.39 1.18 1.39 1.39 1.33
VEL2   6.0 1.32 1.43 1.09 1.26 1.35 1.21 0.33 0.15
CAL3   6.0     91.97    240.60    240.60
VEL3   6.0           0.00 0.06 0.97 1.21 1.24 1.28 1.31 1.11 1.16 1.27
VEL3   6.0 1.18 1.49 1.27 1.36 1.28 1.13 1.27 1.39 1.60 1.78 1.53 1.73
VEL3   6.0 1.30 1.34 1.38 1.64 1.28 1.91 0.72 0.54 0.36
CAL4   6.0     92.17    361.80    361.80
VEL4   6.0      0.00 0.00 0.06 0.49 1.62 1.57 1.67 1.61 1.71 1.55 1.74
VEL4   6.0 1.78 1.67 1.56 1.57 1.42 1.77 1.88 1.92 1.84 1.69 1.93 1.89
VEL4   6.0 1.83 1.76 1.60 1.64 1.66 1.88 1.06 0.50 0.00
XSEC   7.0     121.7 1.0     88.80   0.00053
       7.0  0.0 96.8  5.7 92.2  6.5 91.9  7.0 91.4 10.0 90.4 15.0 89.0
       7.0 20.0 89.2 25.0 89.4 30.0 89.4 35.0 88.9 40.0 89.1 45.0 88.8
       7.0 50.0 88.8 55.0 88.8 60.0 88.8 65.0 89.0 70.0 89.0 75.0 89.1
       7.0 80.0 89.2 85.0 89.6 90.0 89.7 95.0 90.3100.0 91.0105.0 91.3
       7.0108.0 91.4110.0 91.4115.0 91.3120.0 91.1125.0 91.0130.0 90.9
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       7.0133.0 91.4134.5 91.9135.6 92.0136.0 92.2139.4 92.4144.4 95.5
       7.0156.6 97.4
NS     7.0       0.8      82.9      82.9      85.9      85.9      82.9
NS     7.0      28.9      23.5      34.5      54.5      46.7      63.7
NS     7.0      67.8      67.8      67.8      67.6      76.7      76.7
NS     7.0      67.7      67.7      65.8      56.8      56.9  1.0 56.9
NS     7.0  1.0 56.9  1.0 56.9  1.0 56.9  1.0 56.9  1.0 65.7  1.0 65.7
NS     7.0  1.0 65.7  1.0 12.7  1.0 12.7      12.7       0.2       0.8
NS     7.0       0.9
WSL    7.0      91.1      91.2      91.3      91.4      91.4      91.5
WSL    7.0      91.5      91.6      91.6      91.7      91.7      91.8
WSL    7.0      91.8      91.9      91.9      91.9      92.1      92.0
WSL    7.0      92.1      92.2      92.2      92.3      92.3      92.4
WSL    7.0      92.4      92.4      92.5      92.5      92.6      92.6
CAL1   7.0     91.44     53.50     50.90
VEL1   7.0                0.00 0.03 0.20 0.26 0.37 0.41 0.31 0.30 0.21
VEL1   7.0 0.23 0.24 0.25 0.31 0.26 0.28 0.27 0.28 0.28 0.25 0.19 0.00
VEL1   7.0 0.00 0.00 0.00 0.00 0.00 0.00 0.00 0.00
VEL1   7.0
CAL2   7.0     91.88    195.40    185.50
VEL2   7.0           0.00 0.11 0.22 0.46 0.57 0.74 0.69 0.77 0.85 0.83
VEL2   7.0 0.79 0.81 0.76 0.76 0.71 0.72 0.69 0.85 0.82 0.78 0.67 0.58
VEL2   7.0 0.55 0.51 0.43 0.42 0.48 0.65 0.30 0.00
VEL2   7.0
CAL3   7.0     92.05    240.60    232.30
VEL3   7.0           0.16 0.22 0.28 0.66 0.68 0.78 0.93 0.94 0.93 0.96
VEL3   7.0 0.87 0.90 0.89 0.95 0.94 0.83 0.91 0.84 1.00 0.79 0.78 0.80
VEL3   7.0 0.75 0.70 0.73 0.72 0.65 0.66 0.45 0.33 0.00
VEL3   7.0
CAL4   7.0     92.22    361.80    339.50
VEL4   7.0      0.00 0.21 0.32 0.42 0.73 0.88 0.95 1.02 1.26 1.20 1.47
VEL4   7.0 1.37 1.39 1.36 1.25 1.21 1.20 1.14 1.20 1.08 1.05 1.14 1.11
VEL4   7.0 1.10 1.10 0.86 0.83 0.87 0.96 0.80 0.58 0.19 0.00
VEL4   7.0
XSEC   8.0       9.3 1.0     88.80   0.00053
       8.0  0.0 97.4  7.2 92.0 11.7 91.2 12.0 91.4 13.7 90.1 18.7 88.6
       8.0 23.7 88.4 28.7 88.1 33.7 85.8 38.7 84.7 43.7 83.5 48.7 82.3
       8.0 53.7 81.7 58.7 81.2 63.7 82.2 68.7 82.7 73.7 84.7 78.7 87.2
       8.0 83.7 88.7 88.7 89.9 93.7 90.6 98.7 91.1103.7 91.3104.3 91.4
       8.0108.7 91.4113.7 91.3118.7 91.3123.7 91.4128.0 91.9129.3 92.2
       8.0144.7 96.0146.9 96.1
NS     8.0       0.7      88.9      88.9      88.9      88.9      22.9
NS     8.0      22.9      22.9      22.9      22.9      22.9      22.9
NS     8.0      22.9      22.9      27.9      27.9      62.9      62.9
NS     8.0      52.8      52.8      42.9      42.9      42.8  1.0 42.8
NS     8.0  1.0 42.8  1.0 42.6  1.0 24.7  1.0 24.7  1.0 24.7  1.0 12.9
NS     8.0       0.8       0.9
WSL    8.0      91.1      91.2      91.3      91.4      91.4      91.5
WSL    8.0      91.5      91.6      91.6      91.7      91.7      91.8
WSL    8.0      91.9      91.9      91.9      91.9      92.1      92.1
WSL    8.0      92.1      92.2      92.2      92.3      92.3      92.4
WSL    8.0      92.4      92.5      92.6      92.6      92.6      92.7
CAL1   8.0     91.44     53.50     15.20
VEL1   8.0                0.00 0.07 0.05 0.09 0.05 0.07 0.19 0.13 0.17
VEL1   8.0 0.14 0.12 0.04 0.03 0.05 0.00 0.09 0.06 0.05 0.06 0.00 0.00
VEL1   8.0      0.00 0.00
CAL2   8.0     91.89    195.40      0.00
VEL2   8.0
VEL2   8.0
VEL2   8.0
CAL3   8.0     92.05    240.60    230.70
VEL3   8.0      0.00 0.13 0.18 0.23 0.12 0.14 0.07 0.31 0.54 0.74 0.61
VEL3   8.0 0.76 0.69 0.59 0.36 0.44 0.29 0.09 0.01 0.10 0.07 0.02 0.05
VEL3   8.0 0.07 0.22 0.37 0.45 0.20
CAL4   8.0     92.24    361.80    318.50
VEL4   8.0      0.00 0.17 0.20 0.23 0.20 0.18 0.06 0.14 1.00 1.29 0.87
VEL4   8.0 1.00 0.63 0.88 0.31 0.19 0.34 0.26 0.27 0.41 0.56 0.55 0.05
VEL4   8.0 0.54 0.49 0.42 0.40 0.20 0.00
XSEC   9.0     156.3 1.0     89.30   0.00211
       9.0  0.0 96.8 13.0 93.3 24.0 91.6 24.3 91.1 24.5 89.6 30.0 89.4
       9.0 35.0 89.6 40.0 89.7 45.0 89.9 50.0 89.9 55.0 89.8 60.0 89.9
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       9.0 65.0 89.8 70.0 89.7 75.0 89.4 80.0 89.4 85.0 89.4 90.0 89.3
       9.0 95.0 89.5100.0 89.7105.0 89.9110.0 90.0115.0 90.4120.0 90.4
       9.0125.0 90.4130.0 90.6132.7 90.4134.3 91.1137.4 93.0141.5 98.1
NS     9.0       0.9       0.9      88.9      88.9      88.9      62.6
NS     9.0      34.9      45.6      45.6      53.7      53.7      54.6
NS     9.0      54.7      54.8      54.8      54.8      56.8      56.8
NS     9.0      56.8      56.8      54.8      54.8      54.8      62.8
NS     9.0      62.8  1.0 52.8  1.0 26.8  1.0 26.8       0.8       0.9
WSL    9.0      90.0      90.1      90.2      90.3      90.4      90.4
WSL    9.0      90.5      90.6      90.6      90.7      90.8      90.9
WSL    9.0      91.0      91.1      91.1      91.2      91.3      91.3
WSL    9.0      91.5      91.7      91.6      91.8      91.9      92.0
WSL    9.0      92.1      92.3      92.3      92.4      92.5      92.6
CAL1   9.0     90.41     53.50     58.50
VEL1   9.0                    0.43 0.67 0.30 0.17 0.49 0.89 1.79 1.76
VEL1   9.0 2.23 1.64 0.30 1.44 1.15 0.84 0.53 1.66 0.87 1.14 0.85 0.54
VEL1   9.0 0.59      0.00
CAL2   9.0     91.08    195.40    186.80
VEL2   9.0               0.00 1.23 1.78 1.58 1.21 0.94 0.99 1.21 1.08
VEL2   9.0 1.12 1.76 0.57 1.08 1.13 1.90 1.69 1.23 1.69 1.78 1.52 1.81
VEL2   9.0 1.34 1.34 0.67 0.00
CAL3   9.0     91.35    240.60    239.70
VEL3   9.0               0.00 0.75 1.74 1.46 1.27 1.05 1.20 1.20 1.74
VEL3   9.0 1.84 1.93 0.23 1.49 1.36 1.96 1.37 1.28 1.99 1.75 1.50 1.32
VEL3   9.0 1.54 1.14 0.57 0.00
CAL4   9.0     91.56    361.80    327.10
VEL4   9.0          0.00 0.00 0.64 1.69 1.94 1.77 1.71 1.73 1.62 1.76
VEL4   9.0 2.16 1.82 1.37 1.38 1.51 2.02 2.26 1.70 1.84 1.87 1.60 1.21
VEL4   9.0 1.19 1.24 0.62 0.11
XSEC  10.0     121.7 0.1     88.60   0.00015
      10.0  0.0 97.9  4.5 92.0  4.7 91.7  5.0 91.5  6.5 90.9  9.0 90.7
      10.0 14.0 90.4 19.0 90.4 24.0 89.8 29.0 89.3 34.0 89.2 39.0 89.2
      10.0 44.0 89.0 49.0 88.9 54.0 88.7 59.0 88.6 64.0 88.9 69.0 89.3
      10.0 74.0 89.7 79.0 89.7 84.0 89.6 89.0 89.4 94.0 89.3 99.0 89.4
      10.0104.0 89.6109.0 90.2114.0 90.6115.5 90.9117.6 91.5118.7 92.0
      10.0119.0 91.7122.5 95.8125.0 96.7
NS    10.0       0.9      12.9      12.9      12.9      25.8      25.8
NS    10.0      25.8      53.8      53.8      23.9      34.8      53.8
NS    10.0      54.8      54.8      43.8      45.8      53.8      53.8
NS    10.0      53.8      54.7      54.7      45.8      45.8      52.6
NS    10.0      56.8      56.8      56.8      56.8      21.9      21.9
NS    10.0  1.0 21.9       0.9       0.9
WSL   10.0      90.4      90.6      90.7      90.8      90.9      90.9
WSL   10.0      91.0      91.0      91.1      91.2      91.3      91.4
WSL   10.0      91.5      91.5      91.5      91.6      91.7      91.8
WSL   10.0      91.9      92.0      92.0      92.1      92.2      92.3
WSL   10.0      92.4      92.5      92.5      92.6      92.7      92.7
CAL1  10.0     90.88     53.50     46.20
VEL1  10.0                    0.00 0.14 0.09 0.10 0.25 0.28 0.37 0.45
VEL1  10.0 0.47 0.51 0.38 0.39 0.36 0.35 0.33 0.31 0.39 0.28 0.19 0.18
VEL1  10.0 0.10 0.06 0.08 0.00
CAL2  10.0     91.53    195.40    182.30
VEL2  10.0               0.00 0.04 0.07 0.30 0.52 0.66 0.81 0.94 1.05
VEL2  10.0 1.15 1.22 1.15 1.10 0.96 1.04 0.84 0.87 0.81 0.82 0.65 0.69
VEL2  10.0 0.50 0.51 0.29 0.15 0.00
CAL3  10.0     91.74    240.60    237.50
VEL3  10.0          0.00 0.07 0.11 0.14 0.46 0.59 0.83 0.97 0.91 1.29
VEL3  10.0 1.25 1.28 1.37 1.21 1.16 1.07 1.08 1.11 1.10 0.99 0.98 0.87
VEL3  10.0 0.73 0.55 0.36 0.32 0.27      0.00
CAL4  10.0     91.99    361.80    323.00
VEL4  10.0      0.00 0.02 0.18 0.28 0.38 0.65 0.88 0.84 1.11 1.25 1.44
VEL4  10.0 1.58 1.66 1.63 1.50 1.36 1.41 1.15 1.34 1.22 1.16 1.13 0.93
VEL4  10.0 0.79 0.60 0.56 0.42 0.28 0.00 0.00
XSEC  11.0     165.8 0.0     88.60   0.00015
      11.0  0.0 96.1  2.0 95.7  3.4 92.4  4.2 92.3  5.9 93.5  6.5 92.1
      11.0  7.0 90.9  9.8 90.9 11.5 88.4 14.0 86.7 17.0 89.0 20.0 85.0
      11.0 23.0 83.7 26.0 83.7 29.0 83.9 32.0 83.8 35.0 83.8 38.0 84.8
      11.0 41.0 85.4 44.0 85.9 47.0 86.3 50.0 86.8 53.0 87.1 56.0 87.7
      11.0 59.0 88.6 62.0 89.1 65.0 89.8 68.0 90.3 71.0 90.5 74.0 90.7
      11.0 76.0 90.9 77.0 91.0 78.8 91.4 80.0 92.1 82.1 93.9 86.8 94.9
NS    11.0       0.9       0.9       0.1      11.9      88.9      88.9
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NS    11.0      88.9      88.9      88.9      88.9      88.9      87.9
NS    11.0      87.6      82.9      82.9      87.9      87.9      76.8
NS    11.0      76.7      72.8      72.6      27.9      22.9      21.8
NS    11.0      25.8      25.8      25.6      21.9      21.9      21.7
NS    11.0      21.7      21.7      21.9      21.9      11.9      11.9
WSL   11.0      90.4      90.6      90.7      90.8      90.9      90.9
WSL   11.0      91.0      91.1      91.1      91.2      91.3      91.4
WSL   11.0      91.5      91.6      91.6      91.6      91.8      91.8
WSL   11.0      92.0      92.1      92.1      92.2      92.3      92.4
WSL   11.0      92.5      92.6      92.7      92.8      92.8      92.9
CAL1  11.0     90.92     53.50     43.80
VEL1  11.0                               0.00 0.02 0.04 0.05 0.06 0.05
VEL1  11.0 0.00 0.41 0.40 0.43 0.38 0.33 0.26 0.17 0.12 0.03 0.03 0.08
VEL1  11.0 0.06 0.14 0.11 0.16 0.17 0.05 0.00
CAL2  11.0     91.51    195.40      0.00
VEL2  11.0
VEL2  11.0
VEL2  11.0
CAL3  11.0     91.83    240.60    266.40
VEL3  11.0                               0.00 0.00 0.04 0.13 0.27 0.74
VEL3  11.0 1.75 1.45 1.63 1.65 1.31 1.12 0.84 0.62 0.39 0.22 0.01 0.10
VEL3  11.0 0.08 0.05 0.19 0.23 0.23 0.13 0.08 0.02 0.00
CAL4  11.0     92.05    361.80    322.50
VEL4  11.0                          0.00 0.10 0.20 0.20 0.05 0.25 1.10
VEL4  11.0 1.55 1.78 1.99 1.74 1.87 1.42 1.27 0.89 0.57 0.22 0.03 0.07
VEL4  11.0 0.23 0.23 0.15 0.37 0.37 0.34 0.06 0.03 0.00 0.00
ENDJ
```