State of Washington
DEPARTMENT OF FISH AND WILDLIFE
Mailing Address: 1701 S. 24th Ave - Yakima, Washington 98902 - (509) 454-4305

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TO: Aaron Penvose and Lisa Pelly**,** Washington River's Conservancy, WDFW Water Team

FROM: Jonathan Kohr and Robert Vadas, Jr., Instream flow monitoring, WDFW, Yakima/Olympia, WA

SUBJECT: Assessment of lower Wenatchee River weighted usable area (WUA) considering possible increased flow of 15 cfs.

Introduction

The eastern Washington Water Team monitoring program is tasked to determine biological benefits of increased instream-flow projects throughout the state. For this Wenatchee River assessment, the only consideration is the possible benefits from increased flow in association with Weighted Usable Area (WUA) and timing of species use for potential instream-flow transactions. The product of the habitat simulation is expressed as WUA (ft^2/1000 ft) of stream for a range of simulated stream discharges. Proportional increases of WUA will be evaluated with an arbitrary increment of increased instream flow of 15 cfs within the lower Wenatchee River. Potential future projects will likely derive better determinations for cost-to-benefit ratios to fishes from increased instream flows, based on this report.

There were formerly good runs of steelhead trout, spring chinook, and summer chinook salmon in the Wenatchee subbasin. Sockeye salmon ran into Lake Wenatchee and a good run of coho salmon spawned in the Wenatchee system (Bryant and Parkhurst 1950). Bull trout were also distributed throughout the subbasin in their various life-history forms. The three species reviewed for this assessment are summer steelhead (*Oncorhynchus mykiss*), spring chinook salmon (*O. tshawytscha*), and bull trout (*Salvelinus confluentus*). Two life stages for each species, except for bull trout (for which only rearing is evaluated), are calculated, i.e., (a) adult or spawning and (b) juvenile or rearing. The WUA numbers used in this report were derived from the consultants' PHABISM report for WRIA 45 (EESC and TRPA 2005).

It must be understood that WUA results do not show any other potential benefits of water restoration (towards normative = semi-natural flows) such as fish passage, aquatic-macroinvertebrate productivity, riparian-growth benefits, groundwater storage and recharge, and sediment/LWD (large-woody-debris) deposition. The WUA numbers focus only on the "useable area" for specific life-history stages of salmonids. Other ancillary benefits of this project becoming a pilot project on the Wenatchee River is that it could create options for future projects that might collectively have demonstrable effects on instream flow conditions for fish, habitat, and water quality, which are not discussed in this report, but should be noted. Maintenance of the diversion would also be diminished or eliminated, reducing disturbance in the Wenatchee River and the side channel that is currently being used as the diversion could be rehabilitated (if feasible).

Monthly mean statistics and low flows (Table 1) were taken from October 1962 to October 2007 from the United States Geological Survey gage, USGS 12462500 WENATCHEE RIVER AT MONITOR, WA (see http://waterdata.usgs.gov/wa/nwis/uv?station=12462500). This gage is located at RM 7.0, on right bank 1.0 mile north of Monitor. Only the months of water augmentation (restoration) from potential projects were charted during the irrigation season, i.e., April 1-October 15.

Table 1. Wenatchee River monthly mean and low flows (in cfs) since 1962.

	August	September	October
Monthly mean	1440	793	1070
*Low monthly mean	425	301	346

**August=2005, September=2005, October=1987*

For this assessment, monthly averaged flows (rounded) of 300, 500, and 800 cfs were used to calculate weighted usable area (Table 2). The 300 cfs was determined from the low flow in September of 2005 (301 cfs) and averaged. For 500 cfs, it was determined that this was a good arbitrary ("typical") flow for the low summer months (August through October). And the monthly mean flow of 793 cfs was used for the third and final evaluation, but rounded up to 800 cfs. These monthly mean flows are considered near worst case scenarios, but it should be noted that there were 28 instances when flows dropped below 300 cfs including five daily average flows between 247 and 252 cfs in August of 2005. Additionally in 2005, record low flows of 243 and 253 cfs occurred in September and October respectively as gauged.

Table 2. Lower Wenatchee River increases and decreases in WUA for three salmonid species using 300, 500, and 800 cfs.

	chinook			steelhead			bull trout
Flow (cfs)	**rearing**	**spawning**		**rearing**	**spawning**		**rearing**
300	70,868	4,421	**300**	47,599	n/a	**300**	21,102
315	71,400	5,070	**315**	48,980	n/a	**315**	20,320
Difference	532	649	**Difference**	1381		**Difference**	-782
% Difference	0.75%	14.68%	% Difference	2.90%	n/a	% Difference	-3.71%
500	70,620	15,631	**500**	61,052	n/a	**500**	14,673
515	70,190	16,600	**515**	61,720	n/a	**515**	14,370
Difference	-430	969	**Difference**	668		**Difference**	-303
% Difference	-0.61%	6.20%	% Difference	1.09%	n/a	% Difference	-2.07%
800	59,317	32,242	**800**	67,803	n/a	**800**	9,974
815	58,770	32,840	**815**	67,875	n/a	**815**	9,860
Difference	-547	598	**Difference**	72		**Difference**	-114
% Difference	-0.92%	1.85%	% Difference	0.11%	n/a	% Difference	-1.14%

Chinook rearing

For 300 cfs, chinook rearing WUA increased by 1% with the 15-cfs flow augmentation. Normally, the lower the flow drops, the higher the percent increase in WUA from instream-flow enhancement projects. For chinook rearing at 500 and 800 cfs, WUA actually decreased by less than 1% with flow restoration. See "Other considerations of effects of decreased or minimally increased WUA" below for considerations of lower WUA's. Chinook rearing Habitat Suitability Criteria (HSC) used are for all chinook species as shown in Appendix A.

Chinook spawning
These WUA tables are for chinook in general and it is realized that there are only summer chinook spawning within this lower reach. These values are assessed only for summer chinook and use Habitat Suitability Criteria (HSC) as recorded in Appendix A for all chinook species. WUA increased from flow augmentation at 300, 500, and 800 cfs. That's a 15% increase in WUA at a low flow of 300 cfs, but only a 6% vs. 2% increase at the progressively higher flows.

Steelhead rearing
Steelhead rearing WUA increased from flow augmentation by 3%, 1%, and 0.1%, respectively at the three evaluated flows.

Steelhead spawning
Steelhead spawning occurs in the Wenatchee River from April to October with peak spawning from mid to late April. Flows during this period were well above the flow averages during the summer flow assessment as above. An assessment at higher flow (3000 cfs) for steelhead is attached below in Appendix A.

Bull trout rearing
As with some chinook rearing at higher flows, bull trout rearing WUA decreased from flow augmentation, namely by 4%, 2%, and 1%, respectively at the three evaluated flows.

Other considerations of effects of decreased or minimally increased WUA
Weighted usable area isn't the only recognized benefit with additional flow to the lower Wenatchee River, but it does give a numerical benefit for flow comparisons. Reduction or minimal increases in WUA may be counteracted by other factors and benefits involved in higher-flow regimes. While some increased flows in the high water periods (April-June) may show decreases in certain WUA amounts, there may be other, less-apparent benefits of increased flow in sorting and transporting of sediments, woody debris placement, and channel maintenance to name a few (Annear et al. 2002). With severe reductions in flow, there may be concentrated, opportunistic predators that feed on young salmonids (Park 1990; Zabel et al. 2002). The effects of increased temperatures can cause disease and increased mortality of immature salmonids (Pippy and Hare 1969; Vadas 2000). Lower flow may also concentrate young salmonids into a more competitive surrounding, and thus reduce growth and condition factors (Shirvell and Morantz 1983; Vadas 2000). Such dewatering also prevents terrestrial invertebrates and leaf detritus from entering streams as food (Mathers and Rowland 1985). Therefore, with the modeled results showing little to no gains in WUA at certain flows, even slight increments of water added from restoration projects could still be beneficial. Indeed, the WUA increases above 10% for spring chinook and summer steelhead spawning when flow is augmented from 300 to 315 cfs is especially encouraging, given (a) that the flow increase is only 5%[1] and (b) the federally threatened status of these runs here (cf. Busby et al. 1996; Myers et al. 1998; NMFS 1998).

Discussion
The average (mean) monthly flows in most months show little to no improvement in WUA for some species and/or life stages, but that should not overshadow the realized benefits of the lower-water periods. In other words, even in a high or a more normative flow year, there is weekly or daily low flows that an additional 15 cfs would create improvement during the

[1]Compare the two flows by dividing by the obsolete (pre-restoration) discharge, i.e., (315-300) / 300 = (315/300) – 1 = 0.05 is 5%.

irrigation season. And during those periods of time flow could be the limiting factor, when flow needs to remain high for egg incubation, thermal modulation, macroinvertebrate reproduction, phosphorus dilution, etc. If there is a need to target flows for a specific species, or a specific life stage, this assessment could help in the determination of the timing of flow augmentation.

WUA Parameters
The parameters used for this report and a supplemental flow at 3000 cfs (for steelhead spawning purposes) is contained in Appendix A.

Notable (good bang-for-the-buck) percentage gains in WUA[2] extracted from the 2005 model for 15 cfs in September are:

- Chinook spawning at low flow – 15% (a disproportionate increase with 5% flow restoration)

- Chinook spawning at typical flow – 6% (a disproportionate increase with 3% flow restoration)

- Chinook spawning at mean flow – 2% (a proportionate increase with 2% flow restoration)

- Steelhead rearing at low flow – 3% (a disproportionate increase with 5% flow restoration)

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[2]Where feasible, even more bang-for-the-buck could be achieved if flows were restored to tributaries that flow into the Wenatchee River, i.e., putting flow restoration farther upstream to benefit both tributary and mainstem habitats that spring Chinook and summer steelhead both spawn in (cf. Blomstrom and Detrick 1980; Andronaegui 2001; CCG et al. 2003).

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CC: Robert Barwin, WDOE
David Burdick, WDOE
Brad Caldwell, WDOE
Chris Maynard, WDOE
James Pacheco, WDOE
Ken Bevis, WDFW
Perry Harvester, WDFW

APPENDIX A

Below are the Habitat Suitability Criteria (HSC) information used for the lower Wenatchee WUA curves. These data are imbedded within the EES Consulting, Inc. (EESC) final technical report for the Wenatchee River in Appendix A.

Chinook Juveniles

Vel	Pref	Depth	Pref
0.00	0.09	0.00	0.00
0.35	0.26	0.45	0.00
0.45	0.93	1.35	0.50
0.70	1.00	1.55	0.80
1.15	0.90	2.20	1.00
1.25	0.75	99.99	1.00
2.30	0.08		
3.60	0.00		
99.99	0.00		

Chinook Spawning - Large Rivers

Vel	Pref	Depth	
0.00	0.00	0.00	0.00
0.50	0.00	0.50	0.00
1.00	0.13	1.00	0.75
1.50	1.00	1.50	1.00
3.70	1.00	5.00	1.00
5.00	0.00	10.00	0.00
99.9	0	99.9	0

Chinook Spawning - Small Rivers (for Peshastin)

Vel	Pref	Depth	Pref
0.00	0.00	0.00	0.00
0.50	0.00	0.50	0.00
1.00	0.90	1.20	1.00
1.75	1.00	3.00	1.00
2.25	1.00	3.50	0.50
4	0	4.50	0.07
99.9	0	5	0
		99.9	0

Steelhead Trout Juveniles

Vel	Pref	Depth	Pref
0.00	0.23	0.00	0.00
0.25	0.30	0.25	0.00
0.90	0.80	1.80	0.39
1.35	1.00	2.65	1.00
1.55	1.00	2.95	1.00
2.60	0.80	4.50	0.64
2.95	0.39	99.9	0.64
3.65	0.22		
5.50	0.16		
6.00	0.00		
99.99	0.00		

Steelhead Spawning

Vel	Pref	Depth	Pref
0.00	0.00	0.00	0.00
0.55	0.00	0.65	0.00
2.50	1.00	1.25	1.00
3.25	1.00	1.55	1.00
3.45	0.62	2.40	0.50
5.00	0.00	99.99	0.50
99.9	0		

Bull trout Juvenile/ Adult

Vel	Pref	Depth	Pref
0.00	0.16	0.00	0.00
0.10	1.00	0.45	0.00
0.40	1.00	1.30	0.56
0.80	0.20	1.50	1.00
1.60	0.20	2.00	1.00
2.80	0.00	2.10	0.67
99.9	0	2.90	0.67
		3.00	0.00
		99.99	0.00

Coho Spawning

Vel	Pref	Depth	Pref
0.00	0.40	0.00	0.00
0.25	0.40	0.45	0.00
1.05	1.00	1.15	0.75
1.80	0.81	2.05	1.00
2.65	0.29	3.25	0.09
3.90	0.00	4.00	0.01
99.9	0	5	0
		99.9	0

Table 3 was a check of possible increases to WUA at higher flow regimes. As considered the increases are marginal at best, albeit not for WUA. In fact WUA decreased (minutely) with the addition of 15 cfs from the anticipated Pioneer diversion project. These differences are so small that they are not likely within the confidence levels for hydraulic and/or biometric models. Therefore, the evaluation at these higher flows show little to no difference with the additional 15 cfs within the lower Wenatchee River. Also recall as stated in the report that WUA's are not the "tell-all" of increased flow within streams.

Table 3. Lower Wenatchee River increases and decreases in WUA for three salmonid species using 3000 cfs.

	chinook			steelhead			bull trout
Flow (cfs)	**rearing**	**spawning**		**rearing**	**spawning**		**rearing**
3000	21924	n/a	**3000**	46994	24205	**3000**	6164
3015	21840	n/a	**3015**	46878	24167	**3015**	6159
Difference	-84		**Difference**	-116	-38	**Difference**	-5
% Difference	-.004%	n/a	% Difference	-.002%	-.002%	% Difference	-.0008%

The following page is pasted from the Wenatchee River report and explains the parameters used for the report conducted by EES Consulting, Inc. and TRPA (Thomas R. Payne & Associates) in 2005.

2.7 Field Methods

2.7.1 Mainstem Wenatchee River

The field methods and hydraulic analysis for the mainstem Wenatchee River followed the 1-velocity method as described in Payne (2003). This method uses one set of velocity measurements and a water surface elevation (WSE), usually at the high flow, and two additional stage discharge points as input to the PHABSIM model to generate hydraulic simulations for the desired range of flows. The EESC/TRPA field team obtained a high flow set of hydraulic calibration measurements at each transect. Measurements included depths and velocities at close intervals across the transect and water surface elevations at each transect at each of the three flows.

Mid-channel depth and velocity distributions at the calibration flow were measured using an acoustic doppler current profiler (ADCP) mounted on a small trimaran boat and side tied to an inflatable raft. The ADCP uses acoustic pulses to measure water velocities and depths across the channel. According to an extensive evaluation conducted by the U.S. Geological Survey (USGS), "ADCP's can be used successfully for data collection under a variety field conditions" (USGS 1996). ADCP hydraulic measurements are made from a boat by moving the ADCP across the channel while it collects vertical-velocity profile and channel-depth data. The ADCP tracks the distance traveled from the point of origin so each depth and velocity measurement is coordinated with a horizontal distance on the transect. Measurements are taken at close intervals across the transect and at multiple levels in the water column. The ADCP is connected by cable to a power source and a radio modem that is linked to a laptop computer on shore. The computer is used to program the instrument, monitor its operation, and collect and store the data.

Because the ADCP will not measure in depths less than approximately 1.5 feet, shallow depth measurements near shore and other locations were taken manually using either a Price AA meter or a Swoffer brand, propeller-type velocity meter mounted on a standard top-set USGS wading rod. Manually measured velocities were taken at sixth tenths of the depth when depths were less than 2.5 feet and at two tenths and eight tenths of the depth when depths equaled or exceeded 2.5 feet or when the expected velocity profile was altered by an obstruction immediately upstream.

An auto level was used to measure headpin elevations, water surface elevations (WSE), hydraulic controls and above water bed elevations along each transect. All measurements were referenced relative to a temporary benchmark. Bed elevations below the water surface were obtained by subtracting measured depths taken during velocity calibration from the water surface elevations for that particular transect. Except when surveying the bed profile, the surveyor attempted to measure elevations to the nearest .01 feet.

Substrate and cover were measured visually during a low-flow period in September. In the deeper portions of pool, transects substrate was measured with the aid of a mask and snorkel. Cover and substrate codes are shown in Appendix A and are according to the revised Washington State Resource Agency Instream Flow Guidelines (WDFW/WDOE, 2004).