Appendix D - Supplemental Information on the Okanagan WUW Method

The EFN-setting method proposed in Appendix C is a desktop based method that can be used to set initial EFN values for Okanagan streams, and help to understand the implications of flows that are lower than the EFNs set with this method. This method will be useful for an initial understanding of the risks to aquatic habitat and ecological processes from existing and proposed water allocations relative to natural (or naturalized) flows.

Inevitably though, there will be applications for water allocation from streams with higher risks due to existing and/or proposed water allocation. More detailed methods are required to fine tune the EFN recommendations and to provide additional information for consideration of EFNs in the water allocation process, and to further evaluate the impacts of reducing flows below EFN values.

Adaptation of the Weighted Useable Width method to create an “Okanagan Weighted Useable Width (WUW) method” is recommended as the more detailed EFN-setting technique for the Okanagan Basin. An overview of the Okanagan WUW method is provided in Section 5 of the main report. This appendix provides supplemental information (including examples) to facilitate a better understanding of the method.

Mission Creek WUW Example

To illustrate the proposed method, we present a “simplified” example using data from Mission Creek. The example is considered simplified because:

- it uses data from only one transect, across multiple years;
- it scales the habitat Index from zero at 5% LT mad as an example critical environmental flow threshold rather than an actually defined critical environmental threshold, and
- it uses residual flows as opposed to naturalized flows.

In practice, the analysis would be done using multiple transects (and the multiple transects would be integrated and error bars included on the graphical outputs), and it would use naturalized flows.

Weighted Useable Width analyses were conducted from 2005 to 2009 at several transect locations in Mission Creek, with WUW calculated for Kokanee spawning and Rainbow Trout rearing. The example provided herein uses data from 2006 to 2009 for a single transect on lower Mission Creek, approximately 200 m upstream of the Gordon Road Bridge. The site was classified as a riffle, but is really more of a run in this dyked section of the creek. A number of Kokanee redds were observed on this transect during Kokanee spawning, confirming that it represented high quality Kokanee spawning habitat. Figure D1 shows the typical WUW results curve, with a 3rd order polynomial regression and equation, and optimal flow as indicated by the highest point at a flow that approximates 50% LT mad at about 3.6 m^3/sec, and an inflection point on the curve that would represent about 80% of optimal flow at about 2.0 m^3/s. Note that this figure is intended to simply illustrate the method, and specific models for each different transect would need to be generated depending upon the data.

Next, monthly flow data for WSC station Mission Creek at East Kelowna (08NM116) were used to calculate percentile flows for each month from minimum to median, in 5th percentile increments. As indicated above, this data set was not naturalized for this demonstration, as it's intended for illustration purposes only. In practice, flows would be naturalized prior to proceeding with the analysis. All of the streams with existing WUW data are regulated, with Mission Creek flow data likely being closest to natural for the summer and fall months due to most of the water use being supported during that time from BMID and SEKID storage reservoirs.

The example focuses on October, but the analysis would be completed for each month, or each week if a weekly times step is used for the EFNs. Mission Creek flows in October range from a minimum (of the series of mean monthly flows) of 0.533 m^3/s to a median of 1.79 m^3/s, and an example critical environmental flow threshold (CEFT) was set at 5% LT mad which corresponds to 0.310 m^3/s for this data set. The weighted useable width for Kokanee spawning for each percentile flow for October was calculated using the formula from the weighted useable width curve in Figure D-1. The widths for October ranged from 3.7 m at CEFT to 15.6 m at median flow. The index values were then calculated by subtracting the CEFT useable width (3.7 m) from all of the useable width values and then dividing by the median flow useable width minus the CEFT useable width (15.6 - 3.7) to create index values that range from 0.0 at CEFT to 1.0 at the median flow. The index indicates the proportion of the median useable width that is available at any percentile flow. Note that use of the index is not constrained by the values chosen to represent 0 and 1 for the index - flows higher than the median flow would return an index value greater than 1, while flows lower than the CEFT will return negative index values.

To further demonstrate how this could be used in a water allocation exercise, an arbitrary 5% LT mad (i.e., a constant rate of 0.310[6] m^3/s) was subtracted from each of the percentile flows, then weighted useable widths were recalculated and new index values were calculated (by dividing each of the adjusted widths - CEFT useable width by the original median useable width - CEFT useable width- i.e., 15.6 m - 3.7 m). This demonstrates how useable width changes in response to a water allocation that does not vary with the flow, and results in an index value of -0.08 at minimum flow as the residual flow after this allocation would be less than the CEFT in this example.

[6] The rate of 0.310 m^3/s is actually 5% of the mean annual “net” flow of 6.19 m^3/s used in this simplified example in place of LT mad (i.e. the mean of the long term natural flows).

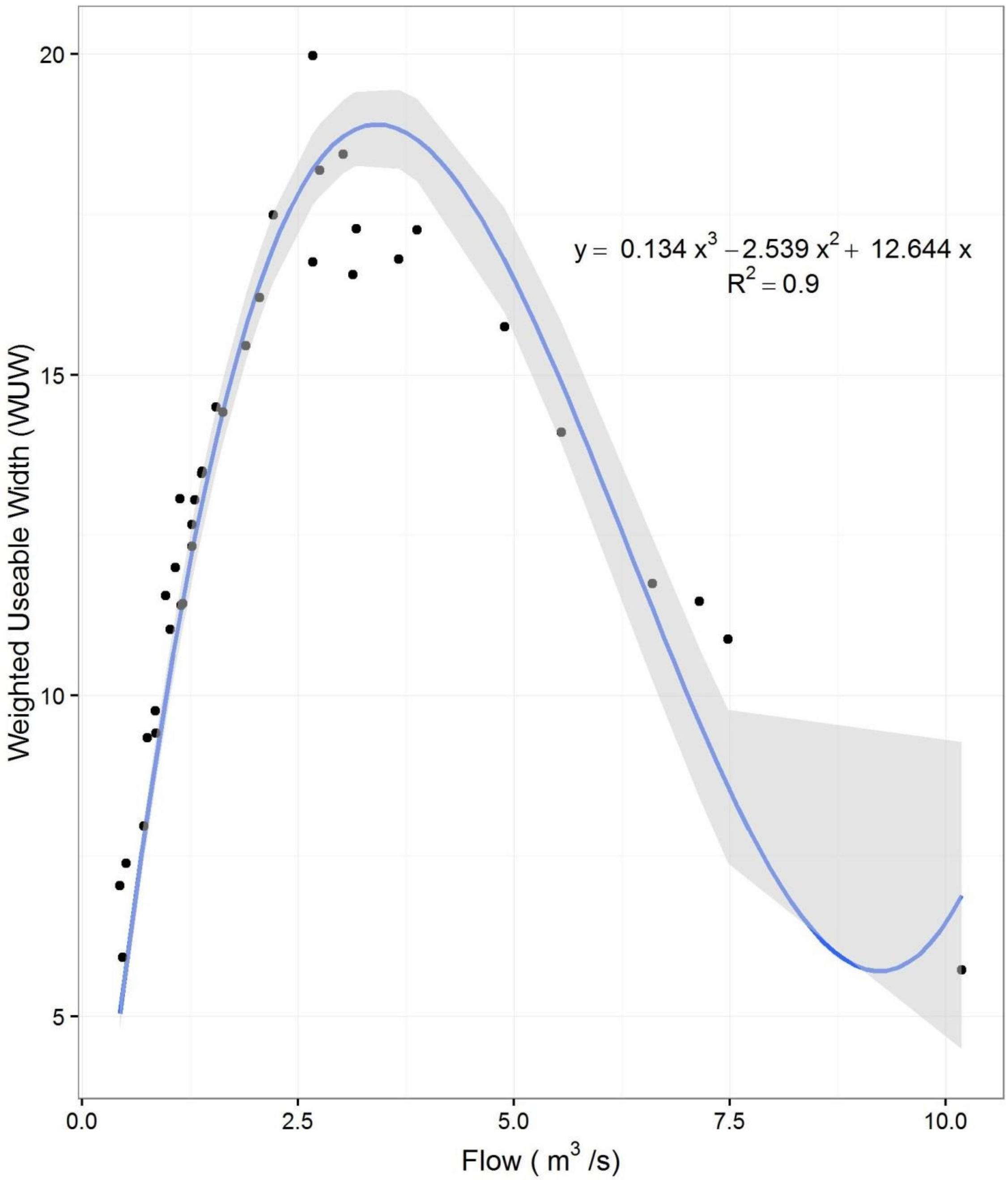

Figure D-1
Weighted Useable Width Curve for Kokanee Spawning in Mission Creek

This was repeated using an arbitrary 10% reduction of each percentile flow reduction (i.e., flow reduction ranges from 0.179 m^3/s at median to 0.053 m^3/s at minimum) to demonstrate how useable width changes in response to water allocation at a rate that reduces in proportion to lower natural flows. Results are summarized in Table D-1 and charted in Figure D-2.

Table D-1
October flows, Weighted Useable Width, and Index Values

	Flow (m^3/s)			Weighted Useable Width (m)			Index		
Percentile	Oct Flow	Flow less 5% LT mad	Flow less 10%	Oct Flow	Flow less 5% LT mad	Flow less 10%	Oct Flow	Flow less 5% LT mad	Flow less 10%
CEFT	0.310			3.72			0.00		
Min	0.533	0.224	0.480	6.12	2.73	5.57	0.20	-0.08	0.16
P5	0.874	0.565	0.787	9.34	6.441	8.56	0.47	0.23	0.41
P10	0.983	0.674	0.885	10.3	7.51	9.43	0.55	0.32	0.48
P15	1.06	0.751	0.954	10.9	8.23	10.0	0.60	0.38	0.53
P20	1.08	0.777	0.977	11.1	8.47	10.2	0.62	0.40	0.55
P25	1.23	0.921	1.11	12.2	9.74	11.2	0.71	0.51	0.64
P30	1.28	0.975	1.16	12.5	10.2	11.6	0.74	0.55	0.67
P35	1.37	1.06	1.23	13.1	10.9	12.2	0.79	0.60	0.71
P40	1.47	1.16	1.32	13.8	11.6	12.8	0.85	0.67	0.77
P45	1.70	1.39	1.53	151	13.2	14.1	0.96	0.80	0.88
Median	1.79	1.48	1.61	15.6	13.8	14.6	1.00	0.85	0.92

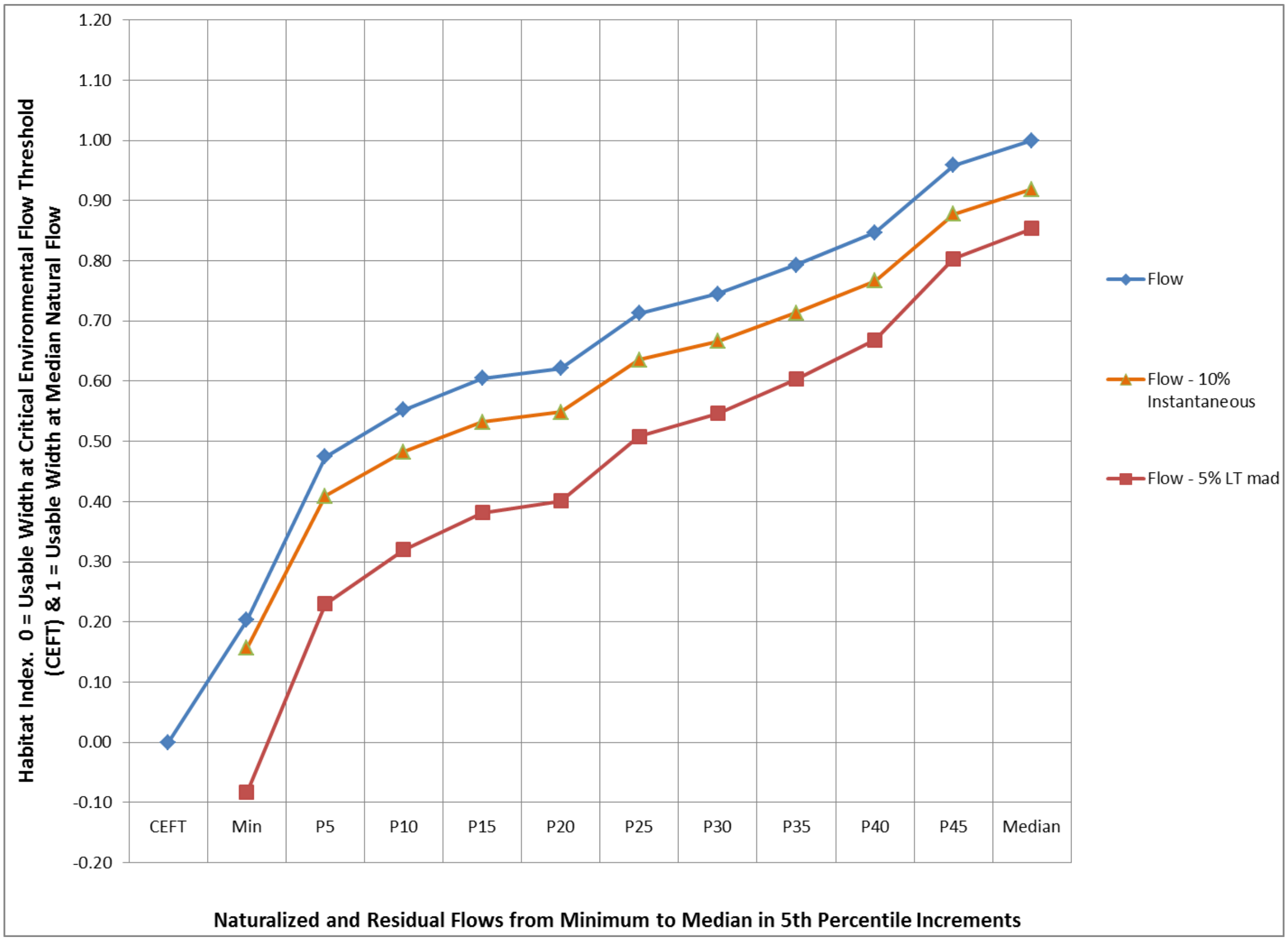

Figure D-2
WUW index results for Kokanee Spawning in October at Residual (i.e. "net") and Reduced Flows in Mission Creek.

The results in Figure D-2 are plotted against the percentile flows before reduction and then with the two different allocation volume examples. The flow line demonstrates how much the useable width is reduced naturally between median and minimum monthly flows. Comparing vertically, the "flow - 10% instantaneous" and "flow - 5% LT mad" demonstrate how much further the useable width would be reduced by those volumes due to allocation.

Comparing the three curves horizontally allows comparison of water allocation flow reductions to the useable widths available in the natural flow regime. For example, the width remaining after reduction of median flow by 5% LT mad (see the upper right portion of the curves in Figure D-2) equates to the 40th percentile naturalized flow – i.e. the index value for the "flow – 5% LT mad" (red line) at median is 0.85, the same as the index value of 0.85 for the P40 unreduced flow (blue line). Comparisons can be made visually in Figure D-2, or numerically in Table D-2.

The illustrations using 5%LT mad and 10% reductions are entirely arbitrary, but demonstrate the type of comparison that can be made using the WUW Index concept. In practice, a number of charts would likely be produced to demonstrate several species and life stages during the applicable months or weeks. Also, the charts would be used to demonstrate naturalized flow, existing net flow and the impact of a range of hypothetical water allocations, rather than just the net flow (which is shown in this example as the naturalized flow).

The WUW Index only demonstrates the frequency and magnitude of reduction in habitat width at flows below the reference flow (in this example median) habitat width due to resulting from both natural variability and the even lower flows that result from water allocation. This in itself does not define how much (if any) habitat reduction below EFN value could be reduced or if any reduction due to allocation is acceptable. Determining modifications to the EFN and commenting on acceptable reduction in habitat due to allocation would be the responsibility of the expert panel with additional input from the advisory panel contemplated herein.

Use of the WUW index is strictly applicable to quantifying habitat reductions for the species and life stages with HSI curves - i.e. Kokanee, trout, and salmon spawning and rearing.

Flow Exceedance Data for Evaluating Ecological Function Flows

The Tennant method targets, fish periodicity tables (Table B-1 and B-2) and the instream presumptive flow standards (Table C-1) all make reference to short term (days to weeks) high flows of 100% to more than 400% LT mad that should be met during spring freshet. Preliminary analyses of Mission Creek data provide a potential method for evaluating the effects of water allocation on the magnitude, timing, duration and frequency of high flows.

Flow exceedance calculated for Mission Creek using the daily flow data from 1949 to 2013 is shown in Table D-2. The exceedance data was calculated using the COUNTIF[7] function in Excel to show the number of days in each year in the 65 year record that exceed flows ranging from 100% LT mad to 800% LT mad, based on a LT mad value of 7.5 m^3/s. Early years in the data record have only seasonal data, but were included as long as the record contained the complete freshet period. Years with incomplete freshet data (1961, 1962 and 1966) were omitted. Percentiles were then applied to annual exceedance data to demonstrate the minimum to maximum number of days that exceed various %LT mad flows. The minimum exceedance ranges from only 28 days exceeding 100% LT mad (1987) to no days exceeding 400% LT mad, while the maximum exceedance ranges from 90 days exceeding 100% LT mad to 9 days exceeding 800% LT mad (1972).

[7] COUNTIF is an Excel function that returns the count (number) of values that meet the IF argument criteria. For this example, the arguments were set to >7.5 (100%LT mad), 11.25 (150%LTmad), 15.0 (200%LT mad), etc.

Table D-2
Number of days per year for which flows exceed various percentages of LT mad (where LT mad = 7.5 m^3/s based on 65 years of daily data)

	Min	P2	P5	P10	P15	P20	P25	P30	P35	P40	P45	P50	P55	P60	P65	P70	P75	P90	p95	Max
100%LT mad	28	41	45	49	53	54	56	58	59	62	63	65	67	68	70	72	73	78	85	90
150%LT mad	19	25	31	38	42	47	48	50	51	52	53	54	56	57	59	60	63	72	75	84
200%LT mad	11	16	21	28	29	30	34	36	39	41	43	47	48	49	50	52	52	63	65	72
250%LT mad	8	12	15	18	24	25	26	28	30	31	33	37	41	44	45	46	47	51	56	70
300%LT mad	5	6	9	10	12	17	18	19	22	24	25	26	30	34	35	38	40	45	50	58
350%LT mad	2	3	5	6	9	10	12	14	14	16	18	21	23	24	25	29	33	40	43	50
400%LT mad	0	2	2	4	5	5	6	7	8	11	13	15	16	18	18	20	25	36	39	48
500%LT mad	0	0	0	0	0	1	1	1	2	3	4	5	8	9	10	11	12	20	25	41
600%LT mad	0	0	0	0	0	0	0	0	0	0	1	1	2	2	3	4	7	12	17	25
700%LT mad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	7	10	16
800%LT mad	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	4	6	9

The flows used for this example are the residual (i.e. net) flows in Mission Creek with substantial storage by BMID and SEKID reducing the freshet flows somewhat, particularly in years with lower freshet flows. The results indicate that the ecosystem function flows of 100% LT mad are met a minimum of 28 days (4 weeks) with P25 flows providing 56 days (8 weeks) which would cover May and June or an equivalent period. Channel maintenance flows of 400% are met at the P2 flows, and almost met at the Minimum which exceeds 350%LT mad.

Flow exceedance can be calculated for naturalized flows, residual flows and residual flows minus proposed allocation and then compared to quantify the impacts of allocation based flow reduction. The residual data for Mission Creek shows that the 400% LT mad channel maintenance flows are being met now at 2nd percentile and above flows, while 8 weeks of 100% LT mad flows for off-channel connectivity and riparian functions are met by 25th percentile and above flows. Re-calculating with lower freshet flows due to future proposed diversions to storage during freshet would indicate if there was a significant reduction in the number of days meeting the 400% target in the lower flow years. Comparison on the basis of before and after percentiles is recommended for evaluating impacts. For example, if the 2nd percentile flows no longer met the 400% channel maintenance target, but the 5th percentile flows did, it could be considered low impact. Alteration to not meeting the maintenance target at 10th or 20th percentile flows would be a significantly greater impact.

Flow exceedance works best with very short duration criteria like the channel maintenance flows which are required for 1 or 2 days. The flow exceedance calculations could be used to quantify a range of flow related targets including spawning flows, but need to be used with caution when flows need to exceed a target for a contiguous period of time such as required for adfluvial Rainbow Trout migration upstream, spawning, and then migration back downstream.