3.8 Shuttleworth Creek

Shuttleworth Creek is a tributary to the Okanagan River, flowing from the east side of the Okanagan Basin to Okanagan River just downstream of the Skaha Lake outlet dam at Okanagan Falls, B.C. The Shuttleworth Creek drainage area is approximately 90 km^2 (OBMEP 2019). Its headwaters drain gently sloping plateaus before flowing through a steep canyon and finally over a large alluvial fan before its confluence with the Okanagan River below Okanagan Falls. A summary of creek characteristics is found in Table 3-24 and additional stream-specific data is provided in Appendix B8.

The lower reaches of Shuttleworth Creek are extremely impaired due to upstream water withdrawals and excessive urban and agricultural encroachment (Rivard-Sirois & Audy 2010). The creek has been subjected to intense urban and industrial encroachment, significant hydro-modification and riparian function impairment. Lower Shuttleworth Creek has been straightened with corresponding diking and complete bank armouring. Modifications to the streambanks eliminates the creek's ability to regularly interact with riparian areas, and riparian vegetation has been reduced to tree cover with some light shrub cover in some areas. There is a subsequent deficiency of large woody debris. The width of the riparian areas is quite narrow, usually just a thin strip of trees with houses, yards and roads directly adjacent to the stream bank, some even within the bankfull width of the stream itself. Industrial encroachment includes lumberyards, pipeline crossings, an industrial area, parking lots, gravel storage yard, gas station, and a sediment basin near the mouth.

The lowest permanent barrier to adult anadromous fish migration is believed to be 8.5 km from the mouth, which is a long, high gradient cascade in the canyon (OBMEP 2019). A previously identified weir that formed a barrier at the sediment basin near the mouth (Walsh & Long 2006a) has since been altered to allow fish passage (Sungaila 2015). The stream is known to support populations of adfluvial Rainbow. As well, returns of Spring Chinook from downstream hatchery programs have recently been reported to access the lower reaches (OBMEP 2018). The stream is also accessible to salmonid species including anadromous Steelhead, Kokanee, Sockeye and Coho Salmon. This project focused on the lowest 1 km reach of Shuttleworth Creek, just upstream of the Cedar Street Bridge and upstream of the sediment basin.

One hydrometric station was previously installed by ONA in lower Shuttleworth Creek through the OBMEP program. At present there are 15 points of diversion within the watershed and 2 pending water licence applications (Associated 2019); however, the actual volume extracted annually is unknown (OBMEP 2019). The Allendale Water Users Community (AWUC) is the main water user (B.C. Government 2019) and manages water storage at Allendale Lake and Clark Meadows headwater dams. Shuttleworth Creek is considered fully recorded for all purposes except small domestic unless storage is provided as of 1991 (FLNRORD 2016). Extensive water diversions in Shuttleworth Creek are suspected to contribute to periods of very low or no flow in the lower loosing reaches during the summer and fall. Ensuring stored water is released from the upstream reservoirs to offset downstream withdrawals, as per licence conditions, is important for ensuring that water use does not exacerbate impacts to EFNs during periods of scarcity. Streamflow measurements on the alluvial fan undertaken for this study did not provide a clear understanding whether the stream was losing streamflow to groundwater; however, losses were assumed in the flow naturalization process based on previous hydrologic models (Associated 2019).

In years when lower Shuttleworth Creek was not dry in summer months, the corresponding water temperature data gathered showed very warm conditions with temperatures well above (24°C) preferred

values for salmonid life histories in summer months (Figure B8-4, Appendix B8). Shuttleworth Creek is 'flow sensitive' during summer and winter as naturalized flows are below 20% LTMAD (Table 3-25).

Table 3-24: Shuttleworth Creek description

Drainage Area	89 km^2
Median Elevation	1543 m
WSC station	08NM006 (historic) Shuttleworth Cr near OK Falls (1921-1964) 08NM149 (historic) Shuttleworth Cr near the Mouth (1969-2010)
ONA station	08NM698 – Maple Street (2015-2018)
LTMAD	0.436 m^3/s (Associated 2019)
Fish species expected	Rainbow, Longnose Dace (ESSA & Solander, 2009), Steelhead, Chinook, Sockeye (Ernst & Vedan 2000)
Land use	Agriculture, urban development in lower reaches (Associated 2016)

Naturalized, residual and maximum licensed flow data were provided by Associated (2019) with an estimated data quality rating of C (data error between 25% and 50%). Summer and fall naturalized low flow estimates appeared quite low. Further, a suspected mismatch between residual and maximum licensed flow estimates and those observed in the field (creek dries up frequently below a point of diversion) warrants further investigation and requires continued collection of hydrometric data.

Okanagan Tennant EFNs for Shuttleworth Creek were developed in accordance with the methods outlined in Section 2.2. Fish periodicity and flow standards described in Table 2-2 to Table 2-6 were used. Weekly Okanagan Tennant EFNs were set to the lower of the naturalized flow or flow standard. WUW information from the study transects was then reviewed to determine whether final EFN recommendations needed adjustment from the Okanagan Tennant EFN. A summary of EFNs for Shuttleworth Creek is provided in Table 3-26 including the median EFN and the range of weekly EFNs, with weekly details in Figure 3-18, Figure 3-19 and Appendix B8 and flow sensitives in Table 3-25. Critical flows were calculated as described in Section 2.4. Further information regarding EFN and critical flow setting in Shuttleworth Creek is provided at the end of this section.

Table 3-25: Flow sensitivities in Shuttleworth Creek

Species & life stage	**1-in-2 yr 30-day summer low flow**		**1-in-2 yr 30-day winter low flow**	
	Flow (m^3/s)	% LTMAD	Flow (m^3/s)	% LTMAD
O. mykiss & Chinook rearing	0.049	11%		
Insect production				
Chinook spawning				
O. mykiss & Chinook overwintering			0.028	6%
Sockeye & Chinook egg incubation				

Source: Associated (2019)

Table 3-26: EFN summary table for Shuttleworth Creek

Species & life stage	Time period	Okanagan Tennant EFN		WUW EFN (m^3/s)	Recommended EFN (m^3/s)				Critical flow	
		Median (m^3/s)	% LTMAD		Median	% LTMAD	Min	Max	Flow (m^3/s)	% LTMAD
O. Mykiss parr & Chinook Fry rearing, insect production [a]	April 1 – Oct 31	0.080	18%	0.080	0.080	18%	0.045	0.340	0.022	5%
Steelhead spawning	April 1 – Jun 25	0.871	200%	0.871	0.871	200%	0.079	2.16	0.445	102%
Rainbow spawning	May 20 – Jul 10	0.871	200%	0.871	0.871	200%	0.497	2.16	0.445	102%
Chinook migration	July 1 – Aug 26	0.111	26%	n/a	0.111	26%	0.067	0.645	0.087	20%
Chinook spawning	Aug 27 – Sep 30	0.060	14%	0.200	0.060	14%	0.045	0.087	0.044	10%
Sockeye spawning	Sep 16 – Oct 31	0.053	12%	0.150	0.053	12%	0.041	0.070	0.044	10%
Overwintering salmonids	Nov 1 - March 31	0.043	10%	n/a	0.043	10%	0.032	0.081	0.022	5%

a while EFNs apply to the entire period, median values are presented for the summer low flow period from Jul 15-Sept 30.

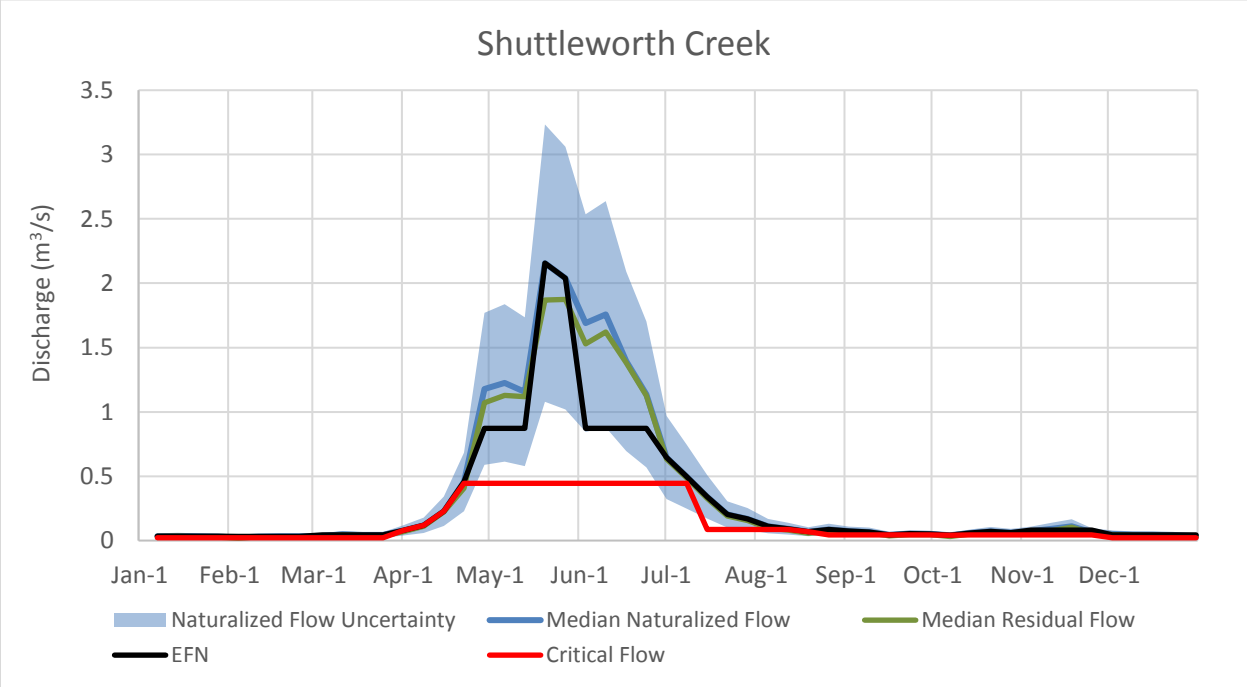


Figure 3-18: Weekly EFNs, critical flow and streamflows in Shuttleworth Creek

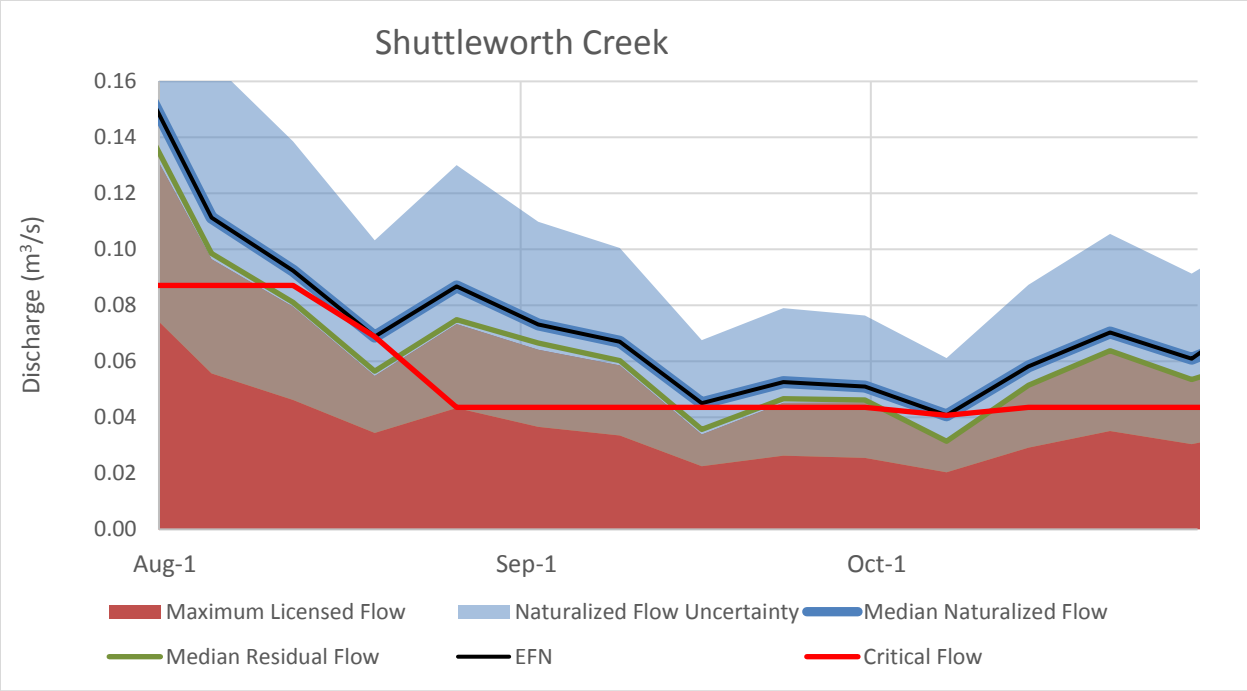


Figure 3-19: Weekly EFNs, critical flow and streamflows during the summer and fall period in Shuttleworth Creek

O. mykiss parr and Chinook fry rearing

The recommended EFN for Steelhead and Rainbow (*O. mykiss*) parr and Chinook fry rearing is the median naturalized weekly flows during the summer low flow season (0.080 m^3/s, 18% LTMAD). The recommended EFN reflects naturalized low flows occurring in September, maintains 30% of maximum WUW for *O. mykiss* parr rearing (Figure B8-5, Appendix B8) and 40% for Chinook fry rearing (Figure B8-6, Appendix B8). Insect production under these flows is somewhat marginal at 18% of maximum WUW (Figure B8-7, Appendix B8). Photos of habitat conditions in Shuttleworth Creek at the recommended EFN flows are provided in Plate 3-17. ESSA & Solander (2009) previously recommended an EFN of 0.1-0.2 m^3/s during the Rainbow parr rearing period.

Naturalized flows are generally greater than the EFN until mid-September. The WUW curves for rearing and insect production indicate that rearing conditions improve quickly at flows above the recommended EFN, and higher flows should be maintained where possible. Residual flows recorded in 2017 and 2018 were below the EFN for the entire post-freshet summer and fall period and the creek went dry during both years (Figure B8-2, Appendix B8). Major water diversions are present upstream of the station and the creek is reported dry during most summers; thus, achieving EFNs is problematic during most years.

When the creek was flowing, summer water temperatures in Shuttleworth Creek recorded at the hydrometric station generally exceeded upper temperature thresholds (20°C) for *O. mykiss* and Chinook rearing and daily maximum temperatures reached up to almost 25°C from mid-June to early August (Figure B8-4, Appendix B8). Maintaining sufficient flows is vital to maintain favorable thermal conditions in this creek though flow thresholds for temperature maintenance were not formally studied under this project.

The recommended critical flow for *O. mykiss* parr and Chinook fry rearing is 0.022 m^3/s (5% LTMAD; Table B8-2, Appendix B8), based on the LTMAD criterion (Table 2-7). While riffle width analysis indicated

slightly lower critical flows (3% LTMAD), the extremely low WUW remaining and the high stream temperatures supported leaving the critical flow recommendation at 5% LTMAD.

Steelhead and Rainbow spawning

The recommended EFN for Steelhead spawning and Rainbow spawning is 0.871 m^3/s (200% LTMAD), which is equal to the Okanagan Tennant EFN flow standard. This maintains spawning WUW over 90% for both (Figure B8-8 and B8-9, Appendix B8). ESSA & Solander (2009) previously recommended an EFN of 0.6-0.9 m^3/s. The recommended EFN also maintains near maximum *O. mykiss* parr and Chinook fry rearing (~90%) WUW during the freshet period, and maintains high (~90%) insect production from riffles. Photos of habitat conditions in Shuttleworth Creek at the recommended EFN flows are provided in Plate 3-18.

The recommended critical flow for *O. mykiss* spawning is 0.445 m^3/s (102% LTMAD) from late April to early July, based on the minimum passage depth criterion (Table 2-7). Prior to this period (early April – mid April), critical flows are defaulted to the lower naturalized median weekly flows (Table B8-2, Appendix B8).

The recommended EFN is slightly below the median naturalized flows during the Steelhead spawning period and well below median naturalized flows during the Rainbow spawning period. Flows greater than the recommended EFN are observed under naturalized flows from early May to mid-June (Figure 3-18); similar flow rates were recorded at the ONA hydrometric station from late April to late May (Figure B8-2, Appendix B8), and the recommended EFNs are thus considered achievable.

Spring Chinook migration and spawning

While spring Chinook have been observed to enter Shuttleworth Creek in the early summer (PTAGIS 2018), spawning habitat conditions in late summer are naturally constrained by the small stream size and summer low flows. If suitable conditions are to be maintained for spring Chinook spawning, it is recommended that EFNs during the entire Chinook migration and spawning period are set to naturalized flows. Estimated median naturalized flows are 0.111 m^3/s (26% LTMAD) during the migration period. The estimated median naturalized flow during the Chinook spawning period is 0.060 m^3/s (14% LTMAD). At these flows, approximately 5% spawning WUW remains and riffle passage for Chinook is likely not possible (Figure B8-10, Appendix B8). ESSA & Solander (2009) previously recommended an EFN of 0.1-0.2 m^3/s during the Chinook spawning period. Photos of habitat conditions in Shuttleworth Creek at the recommended EFN flows are provided in Plate 3-17.

The recommended critical flow for migrating Chinook is 0.087 m^3/s (20% LTMAD) and for spawning Chinook is 0.044 m^3/s (10% LTMAD; Table B8-2, Appendix B8), based on the LTMAD criteria (Table 2-7). Riffle analysis indicated much higher safe passage flows of 0.611 m^3/s (140% LTMAD) but these only occur naturally early in the migration period (early July) and would rarely occur naturally during the spawning season.

The ability of spring Chinook to successfully access Shuttleworth Creek is likely limited to the end of freshet (which coincides with the detection of PIT-tagged Chinook at the mouth of the creek in early July), or wet years with flows greater than 0.2 m^3/s during the spawning period. Any water use during mid-July to late September will have serious consequences for Chinook migration and spawning conditions in Shuttleworth Creek. Flows recorded at the ONA hydrometric station in 2017 and 2018 were above 0.2 m^3/s until mid-June, and then fluctuated wildly before dropping to zero in late July or early August (Figure B8-2, Appendix B8), rendering it unusable for Chinook.

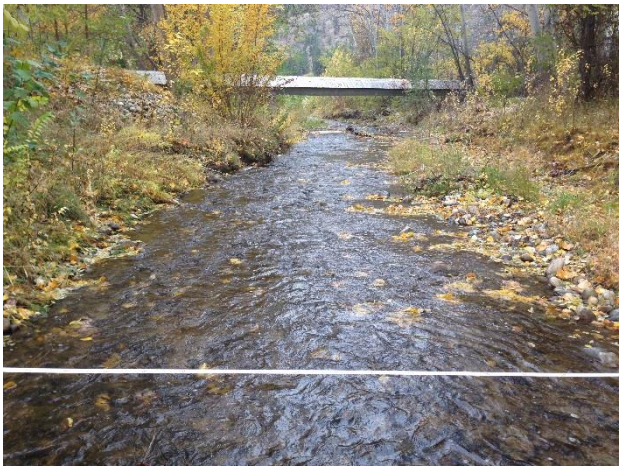
Sockeye spawning

Sockeye have been observed entering and attempting to spawn in Shuttleworth Creek although spawning habitat conditions are constrained by the small stream size and low fall flows. It is therefore recommended that EFNs during the spawning period be set to the estimated naturalized flows. Median naturalized flows during the spawning period are 0.053 m^3/s (12% LTMAD). At these flows, Sockeye spawning WUW is very marginal (2-6%) and riffle passage is likely difficult as safe riffle passage flows were estimated at 0.445 m^3/s (102 % LTMAD) (Figure B8-11 and Table B8-1, Appendix B8). ESSA & Solander (2009) previously recommended an EFN of 0.2 m^3/s during the Sockeye spawning period. Photos of habitat conditions in Shuttleworth Creek at the recommended EFN flows are provided in Plate 3-17.

The recommended critical flow for Sockeye spawning is 0.044 m^3/s (10% LTMAD, Table B8-2, Appendix B8) based on the %LTMAD criterion (Table 2-7). The ability of Sockeye to successfully spawn in Shuttleworth creek is likely limited to wet years with October flows greater than 0.15-0.2 m^3/s, which provides a moderate amount of spawning WUW (25-35%).

Any water use during mid-September to late October will have serious consequences for Sockeye spawning conditions in Shuttleworth Creek. Flows recorded at the ONA hydrometric station in 2017 and 2018 during the Sockeye spawning period were either dry (2017) or near dry (2018) (Figure B8-2, Appendix B8), rendering it unusable.

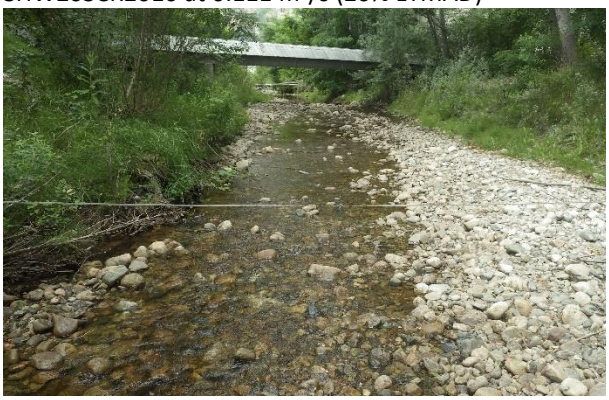
Plate 3-17: Shuttleworth Creek habitat conditions at flows near the recommended *O. mykiss* parr and Chinook fry rearing EFNs (0.08 m^3/s), and Chinook spawning (0.06 m^3/s) and Sockeye spawning (0.053 m^3/s) EFNs



SHW30GL2016 at 0.097 m^3/s (22% LTMAD)

SHW20SCR2016 at 0.111 m^3/s (26% LTMAD)

SHW40SCR2016 at 0.016 m^3/s (4% LTMAD)



SHW20SCR2016 at 0.024 m^3/s (5% LTMAD)

Plate 3-18: Shuttleworth Creek habitat conditions at flows near the recommended Steelhead and Rainbow spawning EFNs (0.871 m^3/s)

SHW30GL2016 at 0.476 m^3/s (109% LTMAD)

SHW30GL2016 at 1.25 m^3/s (286% LTMAD)