4.3 Recommendations

This section contains recommendations specific to this study and the Okanagan as well as for future EFN projects in general. Further, knowledge gaps and potential research topics are discussed.

Specific recommendations for the Okanagan EFN project are:

- **Collect hydrometric data**. Continue operation of existing hydrometric stations and install additional stations as outlined in Table 4-1. This information is useful for continued validation of naturalized flow estimates and EFNs, as well as monitoring the status of EFN implementation and alerting to potential flow problems.
- **Refine water use estimates and obtain information on reservoir management.** Water diversions and releases from reservoirs and their impact on flows should be documented through field observations (audit), particularly where there appears to be a mismatch between estimated and observed water use (Table 4-1). This has been trialed in Trout Creek where actual use was greater than projected use. Locations of water diversions should be confirmed prior to conducting field monitoring, followed by collection of the necessary streamflow and diversion information to help inform the streamflow naturalization process. Consider the requirement of diversion monitoring within the water licensing process.
- **Support development of operational plans for reservoirs.** Creating new or updating existing operational plans will permit inclusion of EFN needs and support meeting EFNs in the future.
- **Obtain residual and maximum licensed flow estimates**. Residual and maximum licensed flow datasets are not yet available for all 18 study streams. These datasets should be completed and the WUW Index percentile plots, as described in the Phase I report, should be prepared when all datasets are available. The impact of water use on fish habitat under residual and maximum licensed conditions can then be compared between streams which will help to identify problem areas and opportunities for streamflow restoration efforts.
- **Address over-allocation**. Over-allocation is evident in the maximum licensed flow estimates provided by Associated (2019), which indicate dry streambeds in five of nine creeks. Streamflow restoration efforts are needed to reduce the licensed amounts to realistic levels that balance the needs of water users and the ecosystem, or support the licensed amounts from off-channel storage. The increasing tendency for lower summer baseflows in recent decades revealed in the flow naturalization analysis should be considered during this exercise.
- **HSI curve for Okanagan spring Chinook.** An HSI curve should be developed for spring Chinook who spawn in small tributary streams. WUWs produced by the HSI curve from the Nicola River yielded WUWs so low that spring Chinook spawning EFNs were set to naturalized flows throughout the migration and spawning period. While it is likely that small stream sizes and naturally low flows do require Chinook spawning EFNs at or near naturalized flows, it is recommended to develop an HSI curve for spring Chinook that spawn in smaller streams. Okanagan spring Chinook spawners may currently be too low in abundance to derive HSI curves as few spawners are observed annually and monitoring is sporadic. Smaller streams with spring Chinook populations in nearby watersheds, such as Bessette Creek, Salmon River, and Coldwater River would serve as useful proxies. Similarly, confirmation of the Sockeye HSI curve in small tributaries would be useful.
- **Okanagan Lake tributaries.** EFNs and critical flows for Okanagan Lake tributaries should be determined for Sockeye and Chinook spawning. Fish passage at the outlet of Okanagan Lake was

implemented in the fall of 2019 and these species now have access to Okanagan Lake tributaries. Efforts should be focused on larger tributaries with potential to support these large-bodied species.

- **Temperature analysis**. Stream temperature data were collected at hydrometric stations operated by the ONA, however they were not explicitly analyzed due to resource and technique/method limitations, but were considered during EFN and critical flow setting. Streams with problematic thermal conditions were noted in the results section and in Table 4-1. For these streams, it is recommended that the already-collected data be further analyzed, using methods such as quantile regression, to determine whether EFNs and critical flows warrant adjustment to mitigate the impact of high stream temperatures. However, possible EFN increases are likely very limited without exceeding naturally available flows.

- **Confirm critical flows and EFNs**. Critical flows and, in some cases, EFNs (specific recommendations in Table 4-1) should be confirmed with actual field-based fish observation data to assess the effectiveness of this approach. In particular, critical flows for juvenile fish rearing should be further investigated to confirm that the recommended critical flows are sufficient. Passage flows should be verified with fish movement information from the study streams to confirm they are appropriate.

- **Collect climate data**. Climate data in conjunction with hydrometric data will improve climate change modeling and provide information on the ability to meet EFNs in the future.

- **Restore and enhance fish habitats.** Many Okanagan streams have experienced physical impacts which have reduced the quantity and quality of available fish habitat. In addition, ongoing climate change may progressively restrict the ability of the managers of Okanagan Lake dam to provide flows to the Okanagan River that fully supply anadromous fish spawning needs, which in turn could negatively impact fish populations in streams throughout the Okanagan. Accordingly, instream work to restore physical and biological functioning in areas of degraded fish habitat should be a priority throughout the Okanagan - particularly where the degradation is most severe and in areas of potentially high fisheries value. In addition to stream restoration, enhancing fish habitat to provide greater benefits than currently exist should also be considered.

Additionally, the following recommendations are made for consideration in future EFN studies:

- Highly modified streams with high fisheries value or potential value should be prioritized for field-based EFN setting as habitat-flow relationships highly depend on channel configuration within each stream. Thus, highly altered streams should be prioritized for WUW analysis in future studies.
- Information on naturalized flows is useful for constraining EFNs to realistically achievable flows. However, uncertainty in naturalized flow estimation can be high and often habitat conditions change rapidly particularly at low flows. Thus, the reliance on naturalized flows as a constraint on EFNs should be examined on a stream-by-stream basis. In the absence of recent field data, historical information on channel conditions, fish populations, and flow regimes can provide useful context for verifying naturalized flows and EFNs.
- Early identification of potential flow augmentation and resultant effects on habitat suitability assists with focusing data collection and estimation efforts (e.g., development of naturalized vs. residual streamflow datasets).
- Traditional Ecological Knowledge (TEK) should be incorporated into naturalized hydrograph development where available. TEK on historical ecosystem flow characteristics (predominantly wetland or side channel inundations levels) and the magnitude of the flow standards needed, as well

as summer and fall low flows, could provide useful contributions and context to naturalized flow development and EFNs.

- Collaborative projects such as this, with representatives from the provincial government, regional water stewardship agencies, First Nations organizations, and local experts, are likely to lead to increased support for recommended EFNs and success in future EFN implementation.
- Where resources are limited, focusing WUW assessments on moderate and low flows is a reasonable adjustment because in the B.C. Interior, summer low flows are typically most limiting to EFNs and occur when water demand is highest. Springtime migration, spawning and rearing EFNs were not typically limited by low flows; thus, setting those EFNs with the Okanagan Tennant approach carries relatively low risk except in highly regulated watersheds. Potential transects should be selected pre-freshet, and WUW measurements should be focused on moderate (~75% LTMAD) to very low flows from post-freshet to early fall. Capturing the lowest flows is key to properly define the bottom of the WUW curve and to determine critical flows.
- It is recommended to collect all WUW measurements in one season; minor channel geometry changes during freshets can bias the habitat-flow relationship leading to uncertainty. However, average conditions in a given stream or reach should persist between years if representative transects are chosen.
- Conduct analysis of stream temperatures and flows to guide EFN and critical flow setting.
- The impacts of very short term (i.e., days or hours) flow fluctuations within the weekly EFN time steps cannot be addressed within the EFN setting exercise, but could / should be considered in licensee-specific operating plans to make better use of water supplies (Associated 2016). This is a serious issue in some regulated streams or those experiencing very high water use.
- Habitat types selected for analysis should be carefully defined to ensure consistency when it comes to transect positioning within a habitat unit (e.g., glide). For instance, habitat conditions at a pool tailout may be different than mid-glide though both may be used for spawning by certain species. During this study, care was taken to position transects in the center of each habitat unit (e.g., mid-riffle, mid-glide) to ensure consistency between transects and represent average conditions.
- The number of study transects on each stream was chosen from stream length, variability between reaches, logistics and time constraints. While some authors recommend a higher number of study transects (e.g. 18-20, Payne et al. 2004), there is a direct tradeoff between the number of streams that can be sampled and the number of transects on each stream when resources are limited. Conducting detailed habitat mapping to determine average conditions by habitat unit and reach, and then installing transects representative of average conditions, was expected to produce representative results even with a lower number of transects. Ideally, this assumption should be verified in future studies.

During the course of this project, several knowledge gaps were identified. More research is recommended in the following areas to better refine:

- **Flow ramping rates**. The EFNs presented herein do not contain specific ramping rates. Ramping guidelines for fish below hydroelectric facilities are provided by Knight Piesold (2005). Current ramping standards in B.C. are noted as ignoring several key stream functions and also need to be site specific. More research is recommended on ramping rates resulting from "point of diversion" withdrawals and water storage release rates at all times of the year. In addition, ramp down rates should be studied in relation to impacts on riparian vegetation rejuvenation (Richter & Richter 2000;

Mahoney & Rood 1998), in particular in Cottonwood ecosystems which are an endangered Okanagan ecosystems with very poor modern regeneration rates (BC MELP 1997; Lea 2008).

- **Fish life history information.** Further information on Kokanee juvenile migration timing in Okanagan streams should be compiled or collected to create a more robust and locally derived timing window. Further, research on locally-applicable flow standards is required for the following;
  - overwintering juvenile Steelhead, Chinook and Coho
  - all life stages of Sockeye, and
  - small bodied Rainbow Trout adult migration.
- **Confirm fish population health and abundance in contrast to summer baseflows and habitat models.** Fish population response to a variety of flows above and below the recommended EFNs and critical flows should be confirmed with actual fish abundance and/or health data. While the literature suggests increased fish abundance with greater minimum flows in some cases, the response is not unequivocal and local verification is recommended (Bradford & Heinonen 2008).
- **Groundwater-surface water interactions.** Groundwater-surface water interactions on alluvial fans, in particular losses to groundwater, should be quantified where possible to assist with naturalized flow estimation. Further, effects of channelization, groundwater pumping and urbanization of the lower reaches on these interactions should be considered.
- **Channel maintenance flows**. The flood stage where the stream reaches bankfull discharge is the dominant channel form flow (Newbury 2010, Leopold et al. 1964). These bankfull discharges maintain average rates of sediment transport, bankfull widths and depths, pool-riffle ratios, and the average rates of bank migration (Leopold et al. 1964), thus stable bed and bank erosion that creates fish habitat. The bankfull discharge is derived from a flood exceedance assessment and is always a greater number than the median spring flows calculated in the Okanagan Tennant method. More research is needed on;
  - testing the validity of estimates derived on channel stability and fish habitat, and
  - how to create flow estimates within the Okanagan Tennant method that protect channel forms.