Associated Environmental

REPORT

Okanagan Basin Water Board

Okanagan Environmental Flow Needs Project Phase 1 and 2 Summary Report

MARCH 2020

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LIST OF ABBREVIATIONS

CEFT	Critical Environmental Flow Threshold (defined in the B.C. *Water Sustainability Act*)
EFN	Environmental Flow Need
FLNR	B.C. Ministry of Forests, Lands, Natural Resource Operations, and Rural Development
HSI	Habitat Suitability Index
LTMAD	Long-term mean annual discharge
OBWB	Okanagan Basin Water Board
ONA	Okanagan Nation Alliance
SEFA	System for Environmental Flow Analysis
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
WSA	B.C. *Water Sustainability Act*
WSC	Water Survey of Canada (the primary organization responsible for measuring and reporting streamflow in Canada)
WUW	Weighted usable width

1 BACKGROUND

The Okanagan region of B.C. is relatively arid, yet a large number of licences have been issued for the withdrawal of water from creeks, rivers, and lakes for municipal, agricultural, and other purposes. Until 2016, when the B.C. *Water Sustainability Act* (WSA) came into force, there was little or no legal protection for the aquatic ecosystems of B.C. streams. However, the WSA now requires that decisions on water licence applications consider the streamflows required to sustain aquatic ecosystems. This requirement applies not only to applications for water withdrawals from streams, but to water withdrawals from nearby aquifers that are likely connected to streams. These ecosystem-sustaining streamflows are referred to as Environmental Flow Needs (EFNs), and are formally defined in the WSA as "the volume and timing of water flow required for the proper functioning of the aquatic ecosystem of the stream". The Critical Environmental Flow Threshold (CEFT) is another parameter defined by the WSA – it is "the volume of water flow below which significant or irreversible harm to the aquatic ecosystem of the stream is likely to occur." The CEFT is used by the Province to manage water withdrawals during low flow periods.

Previous work has been completed to estimate the EFNs and critical low flows of Okanagan streams, but no previous study has had the necessary rigour or granularity to support well-informed water licensing decisions, or operational water management decisions in the Okanagan Basin.

Climate change is affecting Okanagan streams, and the effects have been noticeable in recent decades. The spring freshet period is starting and finishing earlier, and late summer flows are becoming lower. In addition, summers are becoming longer, hotter, and drier, which is tending to increase demand for water by municipal and agricultural users. These trends both act in the same direction - increasing the stress on aquatic ecosystems - and are expected to continue for the foreseeable future.

In 2015, in response to these issues, the Okanagan Basin Water Board (OBWB), the Okanagan Nation Alliance (ONA), and the provincial government, represented by the B.C. Ministry of Forests, Lands, Natural Resource Operations and Rural Development (FLNR), initiated the Okanagan EFN project ("the project"). Its goal is to determine the EFNs of each major stream in the Okanagan Basin. To date, the project has established EFNs and CEFT values in a subset of Okanagan streams (Figure 1-1). These particular streams were selected for the project in a collaborative analysis by the ONA, FLNR, and OBWB, based mainly on their fish habitat value and current water use pressures.

The present document (the Phase 1 and 2 Summary Report) was prepared by Associated Environmental Consultants Inc. (Associated), and summarizes the work completed to date on the project. It includes the key project reports as Appendices in electronic format, and provides links to the original reports. This document also describes next steps in the project.

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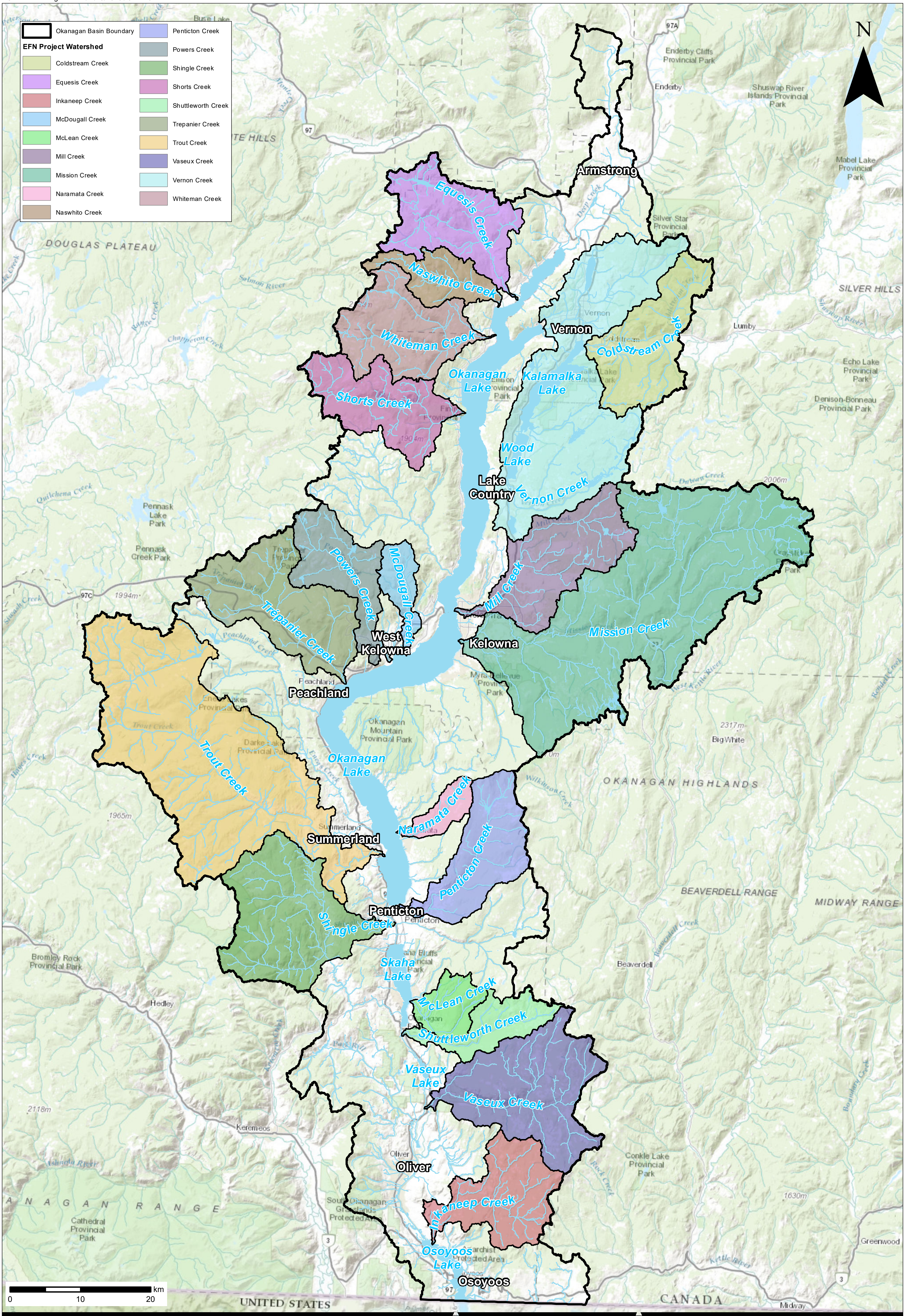

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FIGURE 1-1: STREAMS INCLUDED IN THE OKANAGAN EFN PROJECT

Okanagan Basin Water Board

EFN Summary Report

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2 OVERVIEW OF PROJECT STATUS

Two phases of the project have been completed:

- Phase 1: Development of methods to determine EFN flow regimes in Okanagan streams.
- Phase 2: Determination of EFN flow regimes (including CEFT values) for key streams in the Okanagan.

Reports have been produced for each of these two phases. The Phase 1 report (Associated 2016) is titled "Collaborative Development of Methods to Set Environmental Flow Needs in Okanagan Streams." That report recommends use of a desktop EFN-setting method (referred to as the Okanagan Tennant method) and a field-based EFN-setting method (referred to as the Okanagan Weighted Usable Width [WUW] Method) and is reproduced in Appendix A of this summary report.

The Phase 2 report (ONA 2020) is titled "Environmental Flow Needs Assessment in the Okanagan Basin" and is reproduced in Appendix D of this summary report.

Other work has been completed in support of these two project phases. The Okanagan Tennant method relies on streamflow information. Accordingly, the OBWB commissioned a report titled "Recommended Methods for the Development of Streamflow Datasets to Support the Application of the Okanagan Tennant Method in Okanagan Streams." This report is listed in the reference list as Associated (2017) and is reproduced as Appendix B of this summary report. A follow-up study titled "Streamflow Datasets to Support the Application of the Okanagan Tennant Methods in Priority Okanagan Streams" used the methods recommended by Associated (2017) to create the streamflow datasets that became the foundation of the EFN-setting work completed during Phase 2. That study report (Associated 2019) is reproduced in Appendix C of this summary report.

Finally, it became evident during Phase 2 that Okanagan streamflows have likely been influenced by climate change in the recent past. A technical memorandum (reproduced in Appendix C of Associated 2019) explains this issue and the methods adopted to account for it.

3 PHASE 1 (EFN-SETTING METHODS) SUMMARY

This section summarizes the work completed in Phase 1 of the project, which is described in detail in the Phase 1 report, reproduced in Appendix A.

The main objective of Phase 1 was to develop defensible, transparent, and robust methods for determining the EFNs of Okanagan streams. The Phase 1 report recommends two EFN-setting methods, and provides information needed to customize the methods for each of the 19 key streams shown in Figure 1-1. The work was completed by a large group of aquatic scientists representing a broad range of expertise and experience, and a large number of aquatic scientists from several levels of government provided input during the work and reviewed the finished product. The Phase 1 report reflects this broad level of engagement, contribution, and consensus.

The Phase 1 report recommends a desktop EFN-setting method for low-risk streams followed by a field-based method for higher risk streams. The desktop method is referred to as the Okanagan Tennant method, and is a variation of the B.C.-modified Tennant method that has been successfully used in the Okanagan Basin. The field-based method is also a variation of a method that has been successfully used in the Okanagan Basin, and is referred to as the Okanagan Weighted Usable Width (WUW) method. Both methods are displayed on large format flowcharts (Figures 6-1 and 6-4 of the Phase 1 report) and fully described in the Phase 1 report. They are described as "moderately prescriptive guidelines", which suggests that there is flexibility in the level of effort to apply at each step of the flowcharts, and that experience and good judgment are required to apply the methods. This is particularly applicable to the use of the Okanagan WUW method; factors such as the number of species present, the value of the aquatic habitat of the stream, and risk tolerances will determine the appropriate level of effort to apply to a particular stream.

The Okanagan Tennant method uses streamflow information to set EFNs. The basis for the method is either natural or naturalized (i.e. estimated natural) streamflows for the reaches occupied by key species. The term 'natural' is used to describe a streamflow record unaffected by human influences. When a streamflow record is affected by human influences, natural streamflow conditions must be estimated by identifying and removing the human influence. The resulting flow record is referred to as 'naturalized'.

The concept underlying the use of natural (or naturalized) streamflows as a reasonable basis for EFN-setting is that key aquatic species have become adapted to natural conditions over many centuries before direct modern anthropogenic influences such as reservoir management and water withdrawals, and indirect influences such as climate change began to affect the natural flow regimes of Okanagan streams.

The Okanagan Tennant method is intended for developing an initial understanding of the risks to aquatic habitat and ecological processes from existing and proposed water allocations relative to natural or naturalized streamflows. The method is designed to set an EFN streamflow regime that meets the WSA definition of a properly functioning ecosystem. It recommends a monthly time step for August through March and a weekly time step for April through July. EFNs should be set at the lower of the median naturalized streamflow for the time period of interest and the "instream presumptive flow standard", which is a value that has been previously estimated based on relevant similar conditions (in the absence of site-specific EFN assessments) as the portion of long-term mean annual discharge (LTMAD) required to sustain a given ecosystem, species, and life stage. Henceforth in this summary report, this value is referred to simply as the "flow standard."

The Phase 1 report provides guidance for understanding the implications of flows lower than the recommended EFNs. It acknowledges that flows in dry years will drop below EFN values, and recommends, for real-time operational management purposes (not for water licensing purposes), allowing the EFN to drop to match the natural low flow.

The Okanagan WUW method extends the Okanagan Tennant method to consider site-specific fish and fish habitat conditions in the streams and reaches of interest, and refine the EFNs recommended using the Okanagan Tennant method. The WUW is calculated using depth and velocity measurements at intervals along transects located in the appropriate habitat units for the species and life stages of interest, in conjunction with Habitat Suitability Index (HSI) curves. The Okanagan WUW method addresses the tendency to recommend optimal flows by recommending that streamflows be scaled between zero and one, where “zero” is defined as the critical environmental flow threshold (CEFT) (i.e., a flow below which severe consequences to aquatic populations are expected), and “one” is defined as the median (or suitable alternative based on stream-specific considerations) flow for the particular time period. The report provides guidance for using the information collected to judge the risks associated with flows less than EFNs. (However, during Phase 2, this WUW scaling calculation was not considered necessary for EFN-setting, as explained later in this summary report, but its usefulness for judging risks related to flows lower than EFNs is acknowledged.)

The Phase 1 report advises collecting additional relevant data on the aquatic ecosystem to inform EFN-setting. It also provides guidance on estimating CEFT values (including methods to estimate riffle passage flows), but does not provide a prescriptive approach to estimating CEFT. Finally the report recommends specifying ecological function flows.

The report includes several appendices, including one that provides information and data relevant to EFN-setting for each of 19 key streams. As noted earlier, these streams were selected collaboratively by the ONA, FLNR, and OBWB from the full set of Okanagan tributary streams, based mainly on their fish habitat value and current water use pressures.

The Phase 1 report cover identifies it as a “Working Document, Version One”, which conveys the intention of the project partners (OBWB, ONA, and the Province of B.C.) that the methods will be revised and updated based on experience gained through their use. Additionally, it was intended that the report be reviewed by ONA aquatic scientists and knowledge keepers and that additional information would be added. This contribution occurred during Phase 2 of the project, which was led by the ONA.

4 PHASE 2 (EFN-SETTING) SUMMARY

This section of the summary report summarizes the work conducted during Phase 2 of the project:

- Development of flow naturalization methods (i.e., methods for estimating natural flow when flow records are confounded by human influences) to create several streamflow datasets for use with the Okanagan Tennant method (Section 4.1);
- Creation of streamflow datasets for each of 18 streams selected for analysis in Phase 2 (Section 4.2); and
- Development of EFNs using the Okanagan Tennant method for each of the 18 Phase 2 streams, and using the Okanagan WUW method for 10 of those streams, and setting the Critical Environmental Flow Threshold (CEFT) for all 18 streams (Section 4.3).

The Phase 2 work was led by a project leadership team consisting of staff from the OBWB, ONA, and FLNR.

4.1 Streamflow Naturalization Methods

The Okanagan Tennant EFN-setting method requires the use of several streamflow datasets that have been developed in a consistent way, and which are based on the same time period. The period 1996-2010 (15 years) was adopted as the standard period for application of the Okanagan Tennant method, because streamflow information is reasonably available for this period, and water use estimates make use of information relevant to this period.

A streamflow naturalization methods report (Associated 2017) provides a 22-step method for creating streamflow datasets for Okanagan streams (for the 1996-2010 standard period), as well as stream-specific customized steps for each of the 18 Phase 2 streams. These methods are the most comprehensive ever developed for streamflow analysis in the Okanagan Basin. The 18 Phase 2 streams are:

- Coldstream Creek
- Equesis Creek
- Inkaneep Creek
- McDougall Creek
- McLean Creek
- Mill (Kelowna) Creek
- Mission Creek
- Naramata Creek
- Naswhito Creek
- Penticton Creek
- Powers Creek
- Shingle Creek
- Shorts Creek
- Shuttleworth Creek
- Trepanier Creek
- Trout Creek
- Vaseux Creek
- Whiteman Creek

These streams were the same as the streams highlighted in Phase 1, but without Vernon Creek. Vernon Creek was dropped from consideration in Phase 2 because the complexity of its water management and use significantly affected the quality of the streamflow naturalization outcomes.

For each of the 18 Phase 2 streams, the Okanagan Tennant method requires the use of LTMAD, and a streamflow dataset consisting of weekly naturalized (or natural) streamflow. In addition, for assessing the impacts of flows affected by human management, and the impacts on streams if all water under licence were to be used, two other datasets are required:

- weekly streamflow under current water use and management (i.e., residual streamflow); and
- weekly streamflow assuming maximum use of licensed storage and withdrawals (i.e., maximum licensed residual streamflow).

Accordingly, Associated (2017) provides methods for calculating LTMAD, and for developing the above-noted weekly streamflow datasets for the period 1996-2010.

4.2 Streamflow Datasets for each Priority Stream

Based on the general and stream-specific approaches for streamflow dataset development summarized in Section 4.1, a weekly natural or naturalized dataset was developed for each of the 18 streams. These results provide the foundation for Okanagan Tennant EFN-setting, and are provided in Associated (2019).

In addition, to facilitate future evaluations of the impacts of flows lower than natural or lower than recommended EFN flows, Associated (2019) provides datasets for residual flows and for flows under maximum licensed water use for streams prioritized by the project leadership team. These two datasets will be produced for the remaining streams during a future phase of the project.

The specific streamflow datasets developed for the 18 streams are listed in Table 4-1, in which the streams are listed in order from north to south.

In addition to the weekly streamflow datasets, Associated (2019) reports LTMAD and four low flow statistics for summer and winter periods for each naturalized and residual streamflow dataset available for each of the 18 streams:

- summer (July 1 to September 30) 30-day low natural and residual streamflows for 1:2, 1:5, 1:10, and 1:20-year return periods; and
- winter (November 1 to March 31) 30-day low natural and residual streamflows for 1:2, 1:5, 1:10, and 1:20-year return periods.

These low flow statistics were used in an assessment of 'flow sensitivity'. Streams for which flows naturally drop below 20% of LTMAD are considered 'flow sensitive' by the province of B.C.

The process of creating these streamflow datasets involves making adjustments to streamflow data to account for direct anthropogenic influences (such as storing and releasing water and withdrawing water from streams). During the course of this work, it became evident that climate change had a detectable influence on streamflows during the 1996-2010 standard period. The extent of the influence was investigated and an optimal approach to minimizing its influence was developed. Then all streamflow datasets were revised to become representative of climate conditions over the 43-year period 1971-2014, during which the climate change influence was smaller than it was over the 1996-2010 period. The climate change work was summarized in a memo (Appendix C of Associated 2019). The resulting streamflow datasets therefore account for direct human influences and reflect climate conditions over the period 1971-2014.

Table 4-1
Streamflow datasets developed for each Phase 2 stream

Stream	Streamflow Datasets Developed
Coldstream Creek	Naturalized
Equesis Creek	Naturalized, Residual, and Maximum Licensed
Naswhito Creek	Naturalized, Residual, and Maximum Licensed
Whiteman Creek	Naturalized, Residual, and Maximum Licensed
Shorts Creek	Naturalized, Residual, and Maximum Licensed
Mill Creek	Naturalized
Mission Creek	Naturalized and Residual
McDougall Creek	Naturalized, Residual, and Maximum Licensed
Powers Creek	Naturalized
Trepanier Creek	Naturalized
Trout Creek	Naturalized
Naramata Creek	Naturalized and Residual
Penticton Creek	Naturalized and Residual
Shingle Creek (Upper and Lower)	Naturalized
Shuttleworth Creek	Naturalized, Residual, and Maximum Licensed
McLean Creek	Naturalized
Vaseux Creek	Naturalized, Residual, and Maximum Licensed
Inkaneep Creek	Naturalized, Residual, and Maximum Licensed

Finally, to guide and inform appropriate use of these streamflow datasets, each one was assigned a combined data error / data quality rating, based on a rating framework provided in Associated (2017). These ratings are provided for each dataset in Associated (2019).

4.3 Overview of Phase 2 Report

This section summarizes the Phase 2 report (ONA 2020). The Phase 2 (EFN-setting) work was completed by ONA, with funding and technical support from the OBWB and FLNR. Other individuals and organizations also contributed, as listed in ONA (2020). The Phase 2 report was produced without prejudice to the rights and title of the *Syilx*/Okanagan Nation.

The Phase 2 report has four main sections:

- Introduction
- Methods
- Results
- Summary and Recommendations

and four Appendices:

- Appendix A: Okanagan Tennant and Okanagan WUW method flow charts
- Appendices B1 – B18: stream-specific data for the 18 Phase 2 streams
- Appendix C: SEFA analysis for Coldstream Creek (SEFA is explained in Section 4.3.2 of this summary report)
- Appendix D: HSI curves for Okanagan fish species

4.3.1 Introduction Section

The Introduction section provides a set of definitions of common technical terms used in the report, a list of acronyms, and a list of common water-related terms and fish species in both English and *nsyilxcən* (i.e., the language of the *Syilx* (Indigenous Okanagan) people.

The Introduction section highlights the importance of water in *Syilx* culture, provides a brief history of EFN-setting in the Okanagan, lists the Phase 2 project objectives, and describes the Okanagan region. The goal of the project was to produce defensible, transparent, and robust EFN values for Okanagan streams. The scope was to provide technical EFN recommendations to inform future water licensing and management decision-making activities. The Introduction includes a list of current and extirpated Okanagan fish species, and lists the species specifically targeted by the Phase 2 work, which are salmonids that use Okanagan streams for spawning and rearing. Downstream of the Okanagan Lake dam at Penticton, these species are:

- Kokanee
- Rainbow
- Sockeye
- Steelhead
- Chinook (both spring and summer run)

The Okanagan Lake Dam was the final migration barrier for upstream-moving anadromous salmonids (anadromous fish are those that move upriver from the ocean to spawn) until summer 2019; therefore, only non-anadromous species (Kokanee and Rainbow) were assessed in streams north of Penticton.

Finally, the Introduction describes the approach and criteria used to decide which EFN-setting approach was applied to each of the 18 Phase 2 streams. The Okanagan Tennant method was applied to all 18 streams, and the Okanagan WUW method was subsequently applied to 10 of these streams. Three primary criteria were used to determine which streams received Okanagan WUW analysis: fish habitat value, current water use pressure, and future water demand. The EFN-setting methods applied to each stream are listed in Table 4-2. As indicated in this table, Shingle Creek was subdivided into Lower (downstream of Shatford Creek) and Upper (upstream of Shatford Creek) sections because there are significant differences between these two sections of the creek.

Table 4-2
EFN-setting methods used for each Phase 2 stream

Stream	EFN-Setting Methods Applied
Coldstream Creek	Okanagan Tennant & Okanagan WUW
Equesis Creek	Okanagan Tennant & Okanagan WUW
Naswhito Creek	Okanagan Tennant & Okanagan WUW
Whiteman Creek	Okanagan Tennant & Okanagan WUW
Shorts Creek	Okanagan Tennant
Mill Creek	Okanagan Tennant
Mission Creek	Okanagan Tennant & Okanagan WUW
McDougall Creek	Okanagan Tennant & Okanagan WUW
Powers Creek	Okanagan Tennant
Trepanier Creek	Okanagan Tennant
Trout Creek	Okanagan Tennant
Naramata Creek	Okanagan Tennant
Penticton Creek	Okanagan Tennant
Lower Shingle Creek Upper Shingle Creek	Okanagan Tennant & Okanagan WUW
Shuttleworth Creek	Okanagan Tennant & Okanagan WUW
McLean Creek	Okanagan Tennant
Vaseux Creek	Okanagan Tennant & Okanagan WUW
Inkaneep Creek	Okanagan Tennant & Okanagan WUW

4.3.2 Methods Section

The Methods section is substantial as the methods used to complete the project are described in detail. Methods are described for:

- collection of hydrometric data;
- application of the Okanagan Tennant and Okanagan WUW EFN-setting methods;
- analysis of critical flow; and
- assessments of flow sensitivity.

In general, the methods used for EFN-setting were the same as those recommended in the Phase 1 (EFN Methods) report. The Methods section highlights any differences between the method steps recommended during Phase 1 and the steps applied during Phase 2, and notes that the experience and results obtained during Phase 2 should be used to update the Phase 1 report in future. This process of updating through experience was anticipated during Phase 1. In addition, not all method steps described in Figures 6-1 and 6-2 of the Phase 1 report were completed for all streams.

Collection of hydrometric data

Hydrometric data are required for establishing relationships between streamflow and fish habitat conditions in support of the Okanagan WUW method. At the end of Phase 1, WSC was operating hydrometric stations on 10 of the 19 Phase 1 streams (9 of the 18 Phase 2 streams), but only four were located in prime fish-bearing reaches. Accordingly, in late 2016, 18 new hydrometric stations were installed in important reaches identified for WUW field sampling in seven streams upstream of Penticton. South of Penticton, three streams had existing hydrometric stations maintained by ONA, and two new stations were installed for this project. At all hydrometric stations installed for this project, continuous water level and water temperature data are being recorded. The water level data is subsequently used to generate a continuous record of streamflow.

Application of Okanagan Tennant method

The Phase 2 report provides a summary of the Okanagan Tennant method from the Phase 1 report (a summary method flowchart from the Phase 1 report is presented in Appendix A of the Phase 2 report), a table listing the fish species and life stages of interest in each of the 18 Phase 2 streams, two tables that provide general and stream-specific life cycle timing, and three tables that provide flow standards for each of these species and each life stage. These flow standards were used in calculating Okanagan Tennant EFNs.

This section of the Phase 2 report indicates that the calculation of 'percentile flows' was recommended in Phase 1, and acknowledges that percentile flows are helpful for evaluating the impacts of flows lower than recommended EFNs. However, percentile flows for the residual streamflow datasets, and for flows under maximum licensed water usage were not computed for all 18 Phase 2 streams, because the necessary datasets were not available. With reference to the Okanagan Tennant method flowchart (Figure 6-1 of the Phase 1 report and Appendix A of the Phase 2 report), this means that steps 10, 15, 16, and 17 were not completed for all 18 streams. The report notes that this gap should be filled at a later date.

Application of Okanagan WUW method

The Okanagan WUW method flowchart is provided in Appendix A of the Phase 2 report. The report provides detailed descriptions of the steps followed to derive Okanagan WUW EFNs for 10 of the 18 Phase 2 streams.

The method description starts by outlining the concept of WUW analysis in which WUW at a particular transect and streamflow is calculated by making measurements of flow depth and velocity at several points across the transect. Transects are located in representative habitat for the species and life stage of interest. Each depth and velocity measurement is multiplied by Habitat Suitability Index (HSI) values (i.e., one value for depth and one for velocity) to generate a WUW value for that part of the transect. The HSI values range from zero to one and represent the value of the particular depth or velocity measurement to the species and life stage of interest. The sum of the WUW values across the transect is the total WUW for the transect at the particular flow. This process is repeated at several other flow levels. A relationship is then developed between streamflow and WUW (i.e., habitat) for each species and life stage at the transect. This process is integrated over several transects such that a global relationship is derived between WUW and flow for each species and life stage of interest in each stream.

WUW values are highest at flows corresponding to the preferred depth and velocity conditions for the species and life stage. However, for EFN analysis, these optimal flows are usually higher than values meeting the WSA definition of an EFN. The Okanagan WUW method addresses the potential tendency to lean towards recommending optimal flows as EFNs by focusing the assessment of flow-related habitat impacts within the range of historical or expected flows bound by the CEFT at the lower end and the median naturalized flow at the upper end. The Okanagan WUW EFN is set by examining the shape of the WUW versus flow relationship (primarily between these points) and choosing an appropriate flow level for the EFN below which there is a relatively rapid decline in habitat. Other relevant stream-specific information is also used to inform the EFN choice.

The Phase 2 report provides detailed descriptions of other methods, such as:

- how stream reaches to be sampled were selected;
- how transect locations were selected; and
- how EFN field data were collected.

Field data collection extended from summer 2016 to spring 2018, during which each transect was measured 8 to 10 times.

The Phase 2 report provides a description of the analytical methods used to calculate WUW, following completion of fieldwork. It includes a description of custom Okanagan HSI curves developed by the project leadership team for Sockeye and Chinook; specifically, a new curve for Sockeye spawning, and an alternative curve for Chinook spawning to reflect the smaller body size of the spring-run Chinook found in Okanagan River tributaries. The HSI curves are presented in Appendix D of the Phase 2 report.

This section of the Phase 2 report describes the methods used to develop the WUW versus flow relationships (i.e., combining transects on each stream, and mathematical approaches to curve fitting) and describes the factors considered in selecting a final EFN value based on the Okanagan Tennant EFN and Okanagan WUW EFN. Since the WUW analysis uses significantly more site-specific information than the Tennant analysis, the recommended EFN for the stream was generally weighted towards the Okanagan WUW EFN.

The Phase 2 report identifies one notable difference between the Phase 1 report and the work done during Phase 2. The Phase 1 report recommended scaling the WUW values between the CEFT (index = 0) and the Tennant EFN (index = 1), to avoid the tendency to prefer optimal flows, and to help evaluate the impact of flow changes between these two extremes. This step is step 14 of the Okanagan WUW analysis flowchart. However, in practice, in some streams the range between the CEFT and the Okanagan Tennant EFN was very small. The Phase 2 project team found that scaling flows in this way was not particularly informative, and accordingly it was not done. Nonetheless, the Phase 2 report notes that the scaled WUW Index is useful for comparison of impacts between naturalized, residual and maximum licensed hydrographs.

Analysis of critical flow

The WSA defines the Critical Environmental Flow Threshold (CEFT) as “the volume of water flow below which significant or irreversible harm to the aquatic ecosystem of the stream is likely to occur.” The Phase 1 (EFN Methods) report recommends assuming that CEFT is fixed at a percentage of LTMAD for each species and life stage, and also describes a field-based method for estimating the CEFT. Based on the Phase 1 report, the Phase 2 project team developed a quantitative method for estimating CEFT for each species and life stage, and applied the method to each of the 10 streams for which Okanagan WUW was completed. The method is based on criteria related to riffle widths needed for rearing life stages and minimum passage depths needed for adult life stages. However, in some of the 10 WUW streams, low flows near the CEFT were not observed during WUW fieldwork. In these cases, either WUW habitat observations were extrapolated to choose a realistic CEFT value, or an appropriate percentage of LTMAD was applied to estimate CEFT.

For the 8 streams for which only the Okanagan Tennant method was applied for EFN-setting, CEFT was assumed to be the same fixed percentages of LTMAD commonly assumed by FLNR fisheries staff for each Okanagan species and life stage.

Assessments of flow sensitivity

The concept of flow sensitivity has been used by Provincial fisheries experts for several years to assist in flow management during low flow periods of the year. In this project, the above-noted low flow statistics for each stream were calculated and reported, and streams that meet the requirement for designation as 'flow sensitive' were identified.

System for Environmental Flow Analysis (SEFA)

The project team carried out a trial application of the System for Environmental Flow Analysis (SEFA) method of providing habitat information for EFN-setting for Coldstream Creek. This method is intended for cases where gaps in the field data exist, and was applied for Coldstream Creek because no low streamflows were experienced during the data collection period. Both methods (SEFA and Okanagan WUW) produced similar habitat versus flow relationships, and similar EFNs, but slightly different CEFT values. However, the report notes that a better way of evaluating the usefulness of the SEFA method would be to compare WUW and SEFA results in a situation where field measurements have been obtained over the full range of flows. The report also notes advantages and disadvantages of SEFA analysis, and suggests that SEFA is likely most beneficial in EFN-setting projects where field measurements have been obtained over the full range of flows, but where resource constraints limit the number of field visits to less than the 8 to 10 that were completed during the present investigation.

The detailed SEFA analysis is described in Section 3.1 and Appendix C of the Phase 2 report.

4.3.3 Results Section

The Results section has 18 subsections, one for each of the 18 streams. Each subsection presents:

- a description of relevant watershed characteristics in both text and tabular formats;
- a table reporting the low flow statistics for summer and winter flows developed by Associated (2019);
- a table containing the Okanagan Tennant EFN, the Okanagan WUW EFN, the recommended EFN, and the CEFT for the creek, for each time period associated with relevant species and life stages, as well as supporting text;
- two hydrographs (one annual and one focussed on summer and fall) that show naturalized streamflow, the recommended EFN, the CEFT, and if available the residual flows and flows under maximum licensed water use; and
- photographs of the stream taken at flows close to the recommended EFNs (the flows are expressed as both absolute values and as percentages of LTMAD).

The first 10 subsections of the Results section report on those streams for which both Okanagan Tennant and Okanagan WUW analyses were completed, and the remaining 8 subsections address those streams for which only Okanagan Tennant analysis was performed. Detailed stream-specific field data and analyses are provided in 18 Appendices (B1 – B18), one for each stream.

Figure 4-1 provides an example of a WUW versus flow relationship developed using the Okanagan WUW approach, and used to determine EFNs in Whiteman Creek during the kokanee spawning period. This figure appears in Appendix B4 of the Phase 2 report. The graphic on the left shows the WUW versus flow relationship over the full range of measured flows, and the graphic on the right provides an expanded view of the leftmost portion of the curve.

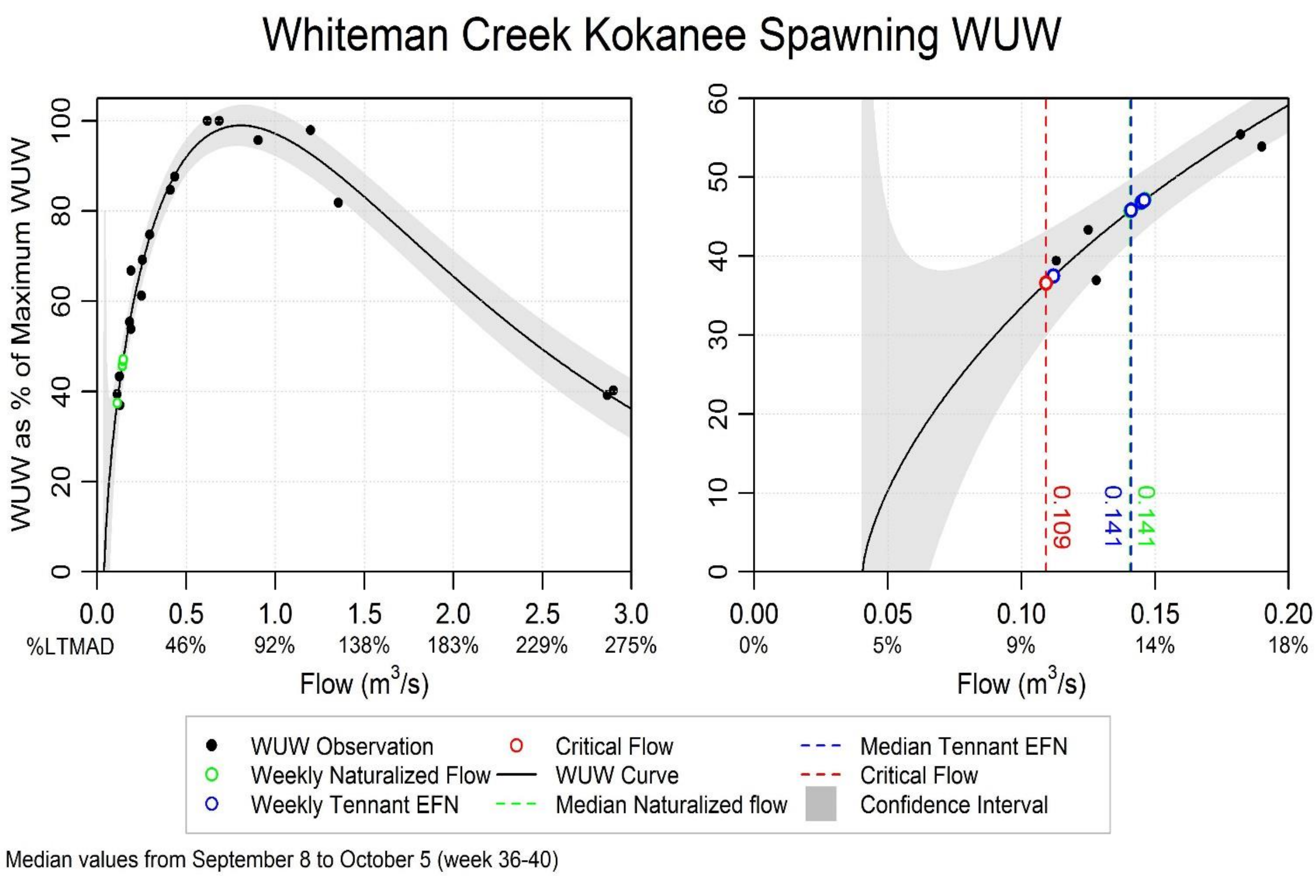

Figure 4-1
WUW curve for kokanee spawning in Whiteman Creek

4.3.4 Summary and Recommendations Section

This section of the Phase 2 report has four subsections:

- Review of EFN-setting methods and data sources
- Summary of recommended EFNs and Critical Flows
- Recommendations
- Next steps

<u>Review of EFN-setting methods and data sources</u>
This subsection provides reminders of key elements of the study methods and includes key summary observations and a comprehensive summary table. The key summary observations are summarized here.

Notwithstanding that the naturalized and residual streamflows presented in Associated (2019) (and used as the foundation for both the Okanagan Tennant and Okanagan WUW analyses) are the most comprehensive and current estimates generated for Okanagan streams, considerable uncertainty remains in these estimated flow datasets due to a lack of historical and current hydrologic and water use data. The report provides specific examples of how the lack of data increases uncertainty in the resulting flow datasets, which carries over to uncertainty in EFN estimates.

In some Okanagan watersheds, flow augmentation (via the release of water stored in upland reservoirs and/or by importing water from adjacent watersheds [e.g., the Kettle River or Nicola River watersheds]) results in flows greater than would occur naturally during summer and early fall. In some cases, flow augmentation has been ongoing for many decades, and aquatic ecosystems have adapted to the higher flows. Accordingly, EFNs and CEFT values were based on the augmented flows in these cases (Equesis, Naramata, Penticton, and Mission Creeks).

Field observations indicated that the relationship between LTMAD and channel conditions (and consequently, fish habitat characteristics) that forms the basis of the Okanagan Tennant EFN-setting approach generally holds true. However, the Okanagan WUW method is a substantial improvement because of the site-specific information that underpins its EFN recommendations. The method proved particularly useful in streams with unusual flow patters or where channels have been modified.

The Phase 2 report acknowledges that transects can be modified during freshet flows, and recommends obtaining the required field measurements within a few months following spring freshet. This recommendation is intended to help reduce a source of scatter in observational data, but the authors also note that whereas channel geometry can change during high flows, the underlying channel morphology will withstand high flows, such that the WUW-derived EFN recommendations will remain valid for multiple years.

For Coldstream and Equesis Creeks, the lowest portion of the flow range was not observed during Phase 2 fieldwork. In these cases, some extrapolation beyond the range of observed flows was necessary to fully define the WUW versus habitat relationship, and the result is greater uncertainty within the EFN range of interest. In these situations, EFNs were set using the available field observations, and informed by Okanagan Tennant EFNs and naturalized flow information.

The Phase 2 report summarizes the work done to develop relevant HSI curves for Sockeye and Chinook, the method modifications related to calculation of the WUW Index, and the SEFA analysis completed for Coldstream Creek (all of which are summarized earlier in this summary report).

A single comprehensive table (Table 4-1 of the Phase 2 report) provides stream-specific summaries of EFN uncertainties, advice for EFN implementation, and recommendations for improving EFN understanding. A portion of that table (containing information for 2 of the 18 streams) is reproduced for illustrative purposes in this summary report in Table 4-3.

<u>Summary of recommended EFNs and Critical Flows</u>

The summary of recommended EFNs and CEFT values consists of some general observations followed by two tables that list the EFNs and critical flows for each stream. These two tables are reproduced in this summary report as Tables 4-4 and 4-5.

The recommended EFNs and CEFT values have been developed, and are relevant to climate conditions of the recent past. Climate change is continuing to progressively influence both the timing and magnitude of streamflows and stream temperatures. Accordingly, the EFNs and CEFT values recommended in the Phase 2 report should be reviewed periodically and adjusted, if necessary, to reflect changing climate conditions.

In spring, naturally available streamflows are generally sufficient to produce optimum conditions for Rainbow Trout and Steelhead (these species spawn during spring). Water regulation activities during freshet should ensure that a relatively natural flow pattern is maintained with appropriate timing of high flows as described by the recommended EFNs, and that abrupt changes in flow are avoided.

Okanagan streams are most limiting to fish populations in summer, fall and winter. Streamflows are typically very low during late summer and early fall. Therefore, Okanagan Tennant EFNs in this time period were generally set according to low naturalized flows, and were mostly lower than presumptive flow standards. Following WUW analysis, the final recommended EFNs at this time of year were rarely reduced from the Tennant-derived EFNs (except for streams with naturally high baseflows from groundwater inputs). In contrast, in streams with a history of flow augmentation, WUW information was used to increase the Okanagan Tennant-derived EFNs to match residual flows to preserve the status quo. Stream temperatures were not explicitly considered in the Phase 2 analysis, but the report notes that high temperatures likely further constrain suitable rearing habitats in some streams. Critical flow recommendations are typically slightly higher than those commonly applied at this time of year by FLNR (5%), with a median of 8% and a range of 3%-10%.

The Phase 2 report provides other summary comments about EFN-setting for summer and fall EFNs for spring Chinook, Kokanee, and Sockeye spawning and for juvenile rearing.

Most of the 18 streams are naturally 'flow sensitive' during summer (Table 4-5) and without careful consideration of mitigation options (e.g., off-channel storage), any further water withdrawals may be detrimental to ecosystem health. Similarly, most of the 18 Phase 2 streams are naturally 'flow sensitive' during winter (Table 4-5). Winter low flows have the potential to negatively affect egg incubation and overwintering habitats. Water demand is generally lower during winter, and streams for which maximum licensed flow estimates were produced did not indicate significant impacts on streamflows in winter. However, care should be taken in highly regulated streams to ensure that sufficient winter flows are maintained.

In some streams, most or all fish-accessible low-gradient reaches are situated on valley-side alluvial fans, which make them sensitive to low flows as they commonly lose some streamflow to the aquifers below (e.g., Shorts Creek). Those creeks tend to experience very low baseflows. In contrast, streams with long low-gradient valley-bottom reaches (e.g., Coldstream Creek and Mill Creek) experience substantial groundwater inflows in their lower reaches and tend to have higher baseflows than average.

The nine streams for which streamflows under conditions of maximum licensed water use have been estimated (in Associated 2019) frequently show extreme impacts of water use on summer and fall streamflows, and five of the nine streams would dry up completely from mid-July to mid-September under these conditions. Interestingly, the two streams showing little estimated impact from licensed water use (Vaseux and Shuttleworth Creeks) are known to dry up most summers. These two creeks have large points of diversion upstream of the dry reaches. Monitoring of actual water use is vital to understanding whether this is a natural phenomenon or whether licensed water withdrawal amounts are being exceeded.

Table 4-3
Summary of EFN setting approach, uncertainties and data needs for 2 of the 18 Phase 2 streams (taken from Table 4-1 of EFN Phase 2 report)

Stream	EFN setting approach	Uncertainties	Considerations for EFN implementation	Recommendations
Coldstream	• Kokanee spawning and Rainbow rearing: used WUW data to adjust EFNs upwards from Okanagan Tennant EFNs because naturalized flows are much greater than flow standards and WUW declines rapidly; critical flows based on %LTMAD and reflecting naturally high baseflows • Rainbow spawning: set EFN just below Okanagan Tennant EFN; critical flows based on riffle analysis	• Lack of low flow WUW data. Greater uncertainty in low end of WUW curve for Kokanee spawning and Rainbow rearing. EFNs were set conservatively just below the lowest WUW measurement but well below naturalized flows and residual flows	• Significant groundwater contributions produce higher baseflows than most other streams; however, the water balance completed for this EFN did not consider withdrawals from hydraulically connected aquifers. The demands from this and other wells could be considered in future water balance work • EFNs and critical flows are relatively attainable due to comparatively high naturalized and residual flows • Large amount of high quality fish habitat remains due to low degree of channel modifications • Highly important Kokanee stream	• Collect low flow WUW data from riffle transects to confirm critical flow recommendations • Obtain residual and maximum licensed flow data estimates • Continue operating the hydrometric station near McClounie Road and upgrade to real-time to provide flow information in high quality fish habitats • Consider protecting available water resources and fish habitat
Mission	• Kokanee spawning and Rainbow rearing: used WUW data to adjust EFNs upwards from Okanagan Tennant EFNs because of long-term flow augmentation stipulated by Water Use Plan. Residual flows used for EFN setting. Critical flows based on riffle analysis. Passage conditions highly variable due to the wide range of channel modifications • Rainbow spawning: set EFN at Okanagan Tennant EFN; critical flows based on riffle analysis	• Channel conditions highly variable due to channelization • Moderate scatter in some WUW curves because of varying transect characteristics (i.e., lower gradient near the mouth to higher gradient near the canyon) • Some transects unsuitable for critical riffle analysis due to lack of measurements over the required range of flows	• Highly important Kokanee and adfluvial Rainbow stream • Habitat availability in the lower reaches impacted by channel modifications • EFNs and critical flows are relatively attainable due to extensive headwater storage • Water Use Plan implementation is lacking during some years • High water temperatures likely impair Rainbow rearing in the lower reaches	• Work with water managers to implement flow releases to meet EFNs • Continue operating the real-time hydrometric station near the mouth to monitor flows in key Kokanee spawning habitats • Re-establish real-time hydrometric station on Pearson Creek • Estimate maximum licensed flows • Develop safe ramping rates to provide protection to fish during adjustments in reservoir releases

Table 4-4
Recommended EFNs for the 18 study streams (Table 4-2 of EFN Phase 2 report)

Stream	Drainage Area (km^2)	LTMAD (m^3/s)	Median 30-Day summer naturalized low flow in m^3/s (%LTMAD)	Naturalized flow Data Quality Rating (Error Range)	Median recommended EFNs in m^3/s (%LTMAD)						
					Juvenile over-winter	Juvenile rearing	Steelhead spawning	Rainbow spawning	Chinook spawning	Kokanee spawning	Sockeye spawning
Coldstream	206	0.748	0.360 (48%)	B (>10% and ≤25%)	0.250 (33%)	0.250 (33%)	x	0.995 (133%)	x	0.250 (33%)	x
Equesis	204	0.700	0.059 (8%)	B (>10% and ≤25%)	0.137 (20%)	0.174 (25%)	x	1.10 (157%)	x	0.180 (26%)	x
Naswhito	87	0.363	0.045 (12%)	C (>25% and ≤50%)	0.054 (15%)	0.090 (25%)	x	0.774 (213%)	x	0.090 (25%)	x
Whiteman	203	1.09	0.108 (10%)	B (>10% and ≤25%)	0.138 (13%)	0.158 (14%)	x	1.10 (101%)	x	0.141 (13%)	x
Mission	845	6.35	1.10 (17%)	B (>10% and ≤25%)	0.925 (15%)	1.40 (22%)	x	4.83 (76%)	x	1.40 (22%)	x
McDougall	54	0.132	0.024 (18%)	C (>25% and ≤50%)	0.026 (20%)	0.026 (20%)	x	0.363 (274%)	x	0.028 (21%)	x
Lower Shingle	299	0.641	0.109 (17%)	B (>10% and ≤25%)	0.073 (11%)	0.128 (20%)	1.12 (174%)		0.125 (19%)	0.127 (20%)	0.126 (20%)
Upper Shingle	118	0.272	0.036 (13%)	B (>10% and ≤25%)	0.023 (9%)	0.064 (24%)	0.900 (331%)		0.041 (15%)	x	x
Shuttleworth	90	0.436	0.049 (11%)	C (>25% and ≤50%)	0.043 (10%)	0.080 (18%)	0.871 (200%)		0.060 (14%)	x	0.053 (12%)
Vaseux	294	1.29	0.042 (3%)	C (>25% and ≤50%)	0.070 (5%)	0.15 (12%)	1.50 (117%)		0.200 (16%)	x	0.150 (12%)
Inkaneep	179	0.362	0.081 (22%)	C (>25% and ≤50%)	0.082 (23%)	0.136 (38%)	0.771 (213%)		0.100 (28%)	x	x
Shorts	186	1.01	0.029 (3%)	B (>10% and ≤25%)	0.057 (6%)	0.100 (10%)	x	1.49 (148%)	x	0.140 (14%)	x
Mill	224	0.744	0.266 (36%)	C (>25% and ≤50%)	0.250 (34%)	0.250 (34%)	x	1.23 (165%)	x	0.250 (34%)	x
Powers	145	0.643	0.137 (21%)	C (>25% and ≤50%)	0.143 (22%)	0.141 (22%)	x	1.12 (174%)	x	0.141 (22%)	x

Stream	Drainage Area (km²)	LTMAD (m^3/s)	Median 30-Day summer naturalized low flow in m^3/s (%LTMAD)	Naturalized flow Data Quality Rating (Error Range)	Median recommended EFNs in m^3/s (%LTMAD)						
					Juvenile over-winter	Juvenile rearing	Steelhead spawning	Rainbow spawning	Chinook spawning	Kokanee spawning	Sockeye spawning
Trepanier	260	1.28	0.263 (20%)	B (>10% and ≤25%)	0.257 (20%)	0.257 (20%)	x	1.73 (135%)	x	0.257 (20%)	x
Naramata	42	0.157	0.012 (8%)	C (>25% and ≤50%)	0.028 (16%)	0.090 (52%)	x	0.492 (285%)	x	0.056 (32%)	x
Trout	747	2.17	0.512 (24%)	B (>10% and ≤25%)	0.441 (20%)	0.520 (24%)	x	2.44 (112%)	x	0.520 (24%)	x
Penticton	180	1.16	0.104 (9%)	B (>10% and ≤25%)	0.373 (32%)	0.497 (43%)	x	1.63 (142%)	x	0.417 (36%)	x
McLean	63	0.167	0.023 (14%)	C (>25% and ≤50%)	0.021 (13%)	0.032 (19%)	0.428 (256%)	0.471 (282%)	x	0.026 (15%)	x

x = fish species and life stages not present in the stream

Table 4-5
Critical flows and flow sensitivities for the 18 study streams (Table 4-3 of EFN Phase 2 report)

Stream	LTMAD (m^3/s)	1 in 2 yr 30-Day naturalized summer low flow **%LTMAD (Sensitive (red) if <20%)**	1 in 2 yr 30-Day naturalized winter low flow **%LTMAD (Sensitive (red) if <20%)**	Critical flows in m^3/s (%LTMAD)						
				Juvenile over-winter	Juvenile rearing	Steelhead spawning	Rainbow spawning	Chinook spawning	Kokanee spawning	Sockeye spawning
Coldstream	0.748	48%	33%	0.075 (10%)		x	0.419 (56%)	x	0.164 (22%)	x
Equesis	0.700	8%	7%	0.035 (5%)		x	0.380 (54%)	x	0.070 (10%)	x
Naswhito	0.363	12%	11%	0.031 (9%)		x	0.502 (138%)	x	0.06 (17%)	x
Whiteman	1.09	10%	9%	0.052 (5%)		x	0.361 (33%)	x	0.109 (10%)	x
Mission	6.35	17%	11%	0.662 (10%)		x	1.12 (18%)	x	0.662 (10%)	x
McDougall	0.132	18%	17%	0.010 (8%)		x	0.161 (122%)	x	0.013 (10%)	x
Lower Shingle	0.641	17%	10%	0.053 (8%)		0.493 (77%)		0.125 (19%)	0.064 (10%)	0.064 (10%)

Stream	LTMAD (m^3/s)	1 in 2 yr 30-Day naturalized summer low flow %LTMAD (Sensitive (red) if <20%)	1 in 2 yr 30-Day naturalized winter low flow %LTMAD (Sensitive (red) if <20%)	Critical flows in m^3/s (%LTMAD)						
				Juvenile over-winter	Juvenile rearing	Steelhead spawning	Rainbow spawning	Chinook spawning	Kokanee spawning	Sockeye spawning
Upper Shingle	0.272	13%	7%	0.020 (7%)		0.306 (113%)		0.027 (10%)	x	x
Shuttleworth	0.436	11%	6%	0.022 (5%)		0.445 (102%)		0.044 (10%)	x	0.044 (10%)
Vaseux	1.29	3%	0%	0.064 (5%)		0.477 (37%)		0.129 (10%)	x	0.129 (10%)
Inkaneep	0.362	22%	20%	0.030 (8%)		0.468 (129%)		0.100 (28%)	x	x
Shorts	1.01	3%	3%	0.050 (5%)		x	0.503 (50%)	x	0.101 (10%)	x
Mill	0.744	36%	35%	0.037 (5%)		x	0.372 (50%)	x	0.074 (10%)	x
Powers	0.643	21%	18%	0.032 (5%)		x	0.321 (50%)	x	0.064 (10%)	x
Trepanier	1.28	20%	17%	0.064 (5%)		x	0.642 (50%)	x	0.128 (10%)	x
Naramata	0.157	8%	6%	0.009 (5%)		x	0.086 (50%)	x	0.017 (10%)	x
Trout	2.17	24%	18%	0.109 (5%)		x	1.09 (50%)	x	0.217 (10%)	x
Penticton	1.16	9%	7%	0.058 (5%)		x	0.576 (50%)	x	0.115 (10%)	x
McLean	0.167	14%	10%	0.008 (5%)		0.084 (50%)		x	0.017 (10%)	x

x = fish species and life stages not present in the stream

Recommendations

The Phase 2 report contains many recommendations specific to EFN-setting in the Okanagan Basin, as well as for future EFN projects in south-central B.C. It also identifies knowledge gaps. These recommendations and knowledge gaps are summarized in Section 5 of this summary report.

Next steps

As recommended in the Phase 2 report, next steps in the project include:

- The EFN and CEFT recommendations contained in the Phase 2 report should be reviewed by key organizations, and by Okanagan Bands for streams within their area of responsibility.
- The Phase 1 report (Associated 2016) should be updated with the method adjustments and other experience gained during Phase 2.

- The EFN and CEFT recommendations contained herein are credible and scientifically defensible. A collaborative approach should be developed for using these recommendations in water licensing and management in B.C.

Finally, this section notes that the ONA Natural Resource Council and Chiefs Executive Committee will be engaged in implementation planning with the long-term goal of using EFNs for Okanagan (*Syilx*) water law development, and concludes by quoting two statements in both English and *nsyilxcən*, as follows:

> kʷu‿yʕayʕát iʔ‿kʷu‿sqilxʷ kscpútaʔstm áłiʔ yl̓mixʷmtət iʔ‿siwłkʷ.
> Water must be treated with reverence and respect.
>
> áłiʔ iʔ nx̌ʷlx̌ʷlt̓ant̓ət lut kstanm̓úsmnt̓m, áłiʔ ksctxtṡtim yʕayʕat iʔ‿stim.
> Our relationship with water is not taken lightly, we are responsible to ensure that our relation can continue to maintain the health and resiliency of our land and animals.
> *-Excerpt, Okanagan Water Declaration, July 31, 2014*

5 KEY LEARNINGS AND NEXT STEPS

The project has produced the most comprehensive estimates of streamflow conditions and both desktop and field-based EFN recommendations ever assembled for the Okanagan Basin. The EFN recommendations are credible, as they have been developed using standard methods that have been collaboratively customized for the Okanagan. The EFN recommendations have a strong scientific foundation, and were developed by a leadership team of senior scientific staff of ONA, OBWB, and FLNR. ONA staff managed and conducted the EFN-setting work.

5.1 Key Learnings

Key learnings of the Phase 2 work include:

- Human intervention has physically modified many Okanagan streams and their streamflows, generally causing reduced flows in the critical summer and early fall period, but in some cases causing increased flows at this time of year.
- Use of the full currently licensed water allocations would dry up many Okanagan creeks in summer and fall.
- Higher levels of government have historically provided insufficient resources for monitoring streamflows, water diversions, and fish habitat conditions.
- Flow naturalization is uncertain where insufficient data on streamflows and water withdrawals exist. In data-poor streams, naturalized flow estimates may lack the accuracy and precision needed for EFN-setting. In these cases, the field-based WUW approach should be used for EFN-setting.
- The Okanagan Tennant EFN-setting approach has been judged to be valid for the Okanagan, based on field observations of fish habitat conditions over a range of flows in 10 of the 18 streams where Okanagan Tennant EFN analysis had been applied. However, the Okanagan WUW EFN-setting approach provides more credible EFN information because it makes use of site-specific observational data.
- In some streams, most or all fish-accessible low-gradient reaches are situated on valley-side alluvial fans, which make them sensitive to low flows as they commonly lose some streamflow to the aquifers below (e.g., Shorts Creek). Those creeks tend to experience very low baseflows. In contrast, streams with long low-gradient valley-bottom reaches (e.g., Coldstream Creek and Mill Creek) experience substantial groundwater inflows in their lower reaches and tend to have higher baseflows than average.
- The project has identified priority streams for streamflow restoration (where a relatively large amount of habitat could be gained by restoring heavily depleted streamflows).
- The EFNs and CEFT values recommended herein are valid for relatively recent climate conditions. As the climate continues to change, the work will need to be reviewed on an approximately decadal scale.
- The project has allowed the compilation of a significant volume of scientific information related to fish, fish habitat, and aquatic ecosystem needs.
- Addressing many streams in one project has helped to efficiently leverage methodological learnings among streams.

5.2 Next Steps

Next steps recommended in the Phase 2 report (ONA 2020) are listed in Section 4.3.4 of this summary report and repeated here:

- The EFN and CEFT recommendations contained in the Phase 2 report should be reviewed by key organizations, and by ONA Bands for creeks within their area of responsibility.

- The Phase 1 report (Associated 2016) should be updated with the method adjustments and other experience gained during Phase 2.
- The EFN and CEFT recommendations contained herein are credible and scientifically defensible. A collaborative approach should be developed for using these recommendations in water licensing and management in B.C.
- The Phase 2 report notes that the ONA Natural Resource Council and Chiefs Executive Committee will be engaged in implementation planning with the long-term goal of using EFNs for Okanagan (*Syilx*) water law development.

Next steps for future Okanagan EFN work as recommended in the Phase 2 report are summarized here:

- **Collect hydrometric data**. Continue operation of existing hydrometric stations in both natural and managed streams, and install additional stations as outlined in Table 4-1 of the Phase 2 report (a small portion of that table is provided in Table 4-3 of this summary report for illustrative purposes). In addition to its site-specific benefits, the additional hydrometric data will help improve hydrologic models that are used for estimating streamflows at ungauged locations for future EFN studies.
- **Refine water use estimates and measure reservoir releases.** Water diversions and releases from reservoirs should be monitored and these requirements should be specified within the water licensing process.
- **Create or update operational plans for reservoirs.** This will permit inclusion of EFN needs into such plans.
- **Obtain residual and maximum licensed flow estimates**. Residual and maximum licensed flow datasets are not yet available for all 18 Phase 2 streams. These datasets should be completed and WUW Index percentile plots should be prepared. The impact of water use on fish habitat under residual and maximum licensed conditions can then be determined and compared among streams, which will help to identify problem areas and opportunities for streamflow restoration efforts.
- **Address over-allocation**. Over-allocation in some streams is evident (through estimates of streamflows under conditions of maximum licensed water use). The licensed amounts either need to be reduced to levels that balance the needs of water users and the ecosystem, or need to be supported 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.
- **Develop HSI curve for Okanagan spring Chinook.** An HSI curve should be developed for spring Chinook that spawn in small tributary streams. Similarly, confirmation of the Sockeye HSI curve in small tributaries would be useful.
- **Determine EFNs and critical flows for Okanagan Lake tributaries.** EFNs and critical flows for all Okanagan Lake tributaries should be determined for Sockeye and Chinook spawning. Fish passage at the outlet of Okanagan Lake was implemented in fall 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.
- **Analyze stream temperature**. Stream temperature data collected during the study should be analyzed to determine whether EFNs and CEFT values warrant adjustment to mitigate the impact of high stream temperatures, recognizing that potential EFN increases are relatively limited without exceeding naturally available flows.
- **Confirm critical flows and EFNs with fish observations**. Critical flows and, in some cases, EFNs 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.

- **Expand the climate monitoring network**. Climate data in conjunction with hydrometric data will improve our understanding of how climate change affects streamflow and the ability to meet EFNs in 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.

Next steps intended more generally for future EFN studies in south-central B.C. are summarized here:

- **Prioritize streams.** Highly modified streams with high fisheries value or potential value should be prioritized for field-based EFN setting.
- **Examine reliance on naturalized flows**. Uncertainty in naturalized flow estimation can be high and often habitat conditions change rapidly particularly at low flows. Thus, 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.
- **Determine potential for flow augmentation**. Early identification of the potential for flow augmentation and resultant effects on habitat suitability assists with focusing data collection and estimation efforts.
- **Incorporate Traditional Ecological Knowledge (TEK)**. 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.
- **Observe conditions at the lowest flows**. Where resources are limited, focusing WUW assessments on moderate and low flows is a reasonable trade-off because in the B.C. Interior, there is more pressure on the aquatic environment during the summer low flow period than at any other time of year – and this is when water demand is highest. Observing stream conditions during the lowest flows is necessary to properly define the lower end of the WUW curve and to determine critical flows.
- **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.
- **Analyze water temperatures and flows**. Conduct analysis of stream water temperatures and flows to guide EFN and critical flow setting.
- **Consider short-term flow fluctuations**. 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.

- **Define habitats**. Habitat types selected for analysis should be carefully defined to ensure consistency in transect positioning within a habitat unit.
- **Confirm that transects are representative.** The number of study transects on each stream for this project was determined from stream length, variability between reaches, logistics and time constraints, and was intended to produce results representative of each stream. The degree to which this study produced representative results should be tested in one or two streams.

Next steps to fill the knowledge gaps identified in the Phase 2 report are as follows:

- **Determine flow ramping rates**. The EFNs presented herein do not contain specific ramping rates. More research is recommended on ramping rates resulting from "point of diversion" withdrawals and water storage release rates.
- **Obtain fish life history information.** Further information is required for Kokanee juvenile migration timing and on locally-applicable flow standards for overwintering juvenile Steelhead, Chinook and Coho, for all life stages of Sockeye, and for small-bodied Rainbow Trout adult migration.
- **Confirm actual fish population health and abundance.** 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.
- **Quantify groundwater-surface water interactions.** Groundwater-surface water interactions on alluvial fans, in particular stream losses to groundwater, should be quantified to assist with naturalized flow estimation. Further, effects of channelization, groundwater pumping and urbanization on these interactions should be considered.
- **Determine channel maintenance flows**. More research is needed on determining the flows required to maintain stable channel form.

Finally, other future EFN-related activities should include:

- Ensure wide distribution of the project reports, including this summary report.
- Educate water managers and provincial permitting staff on the derivation and use of these EFNs.
- Clarify how provincial and *Syilx* fisheries staff will collaborate in enhanced water allocation decision-making in light of both the WSA and the provincial UNDRIP legislation (i.e., *Declaration on the Rights of Indigenous Peoples Act*) adopted in November 2019.
- Develop a method of tracking EFN decision-making and how operational flow management uses the EFNs and CEFTs provided herein.
- Make use of the photographic record of habitat conditions at known locations and flows for educational purposes.
- Integrate EFNs in future hydrologic modelling exercises in the Okanagan Basin.
- Host a national EFN conference in the Okanagan with a focus on action.
- Integrate EFNs in local government water planning.
- Seek collaborative funding from all levels of government for fish habitat restoration and enhancement.

REFERENCES

Each of these reports is available at the following link: http://www.obwb.ca/EFN.

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APPENDIX A - EFN PHASE 1 REPORT

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APPENDIX B - STREAMFLOW DATASET DEVELOPMENT METHODS REPORT

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APPENDIX C - STREAMFLOW DATASET REPORT

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APPENDIX D - EFN PHASE 2 REPORT

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