TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

APPENDICES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.1 INTRODUCTION

The following Key Line of Inquiry presents the effects assessment of the Expansion Project on Trudel Creek. Trudel Creek was specifically identified in the Terms of Reference (TOR) for the Taltson Developer's Assessment Report (DAR) (Mackenzie Valley Environmental Impact Review Board; MVEIRB, 2008) as an area of concern by the MVEIRB and by various community members during the development of the TOR.

The assessment addresses effects of the Project on water quantity (Section 14.3), water quality (Section 14.4), ice (Section 14.5), wetlands (Section 14.6), aquatic resources (Section 14.7), fisheries resources (Section 14.8) and wildlife (Section 14.9). Fisheries and wildlife were identified as the key end users of Trudel Creek, whereby changes in water quantity and quality, ice regime, aquatic resources and wetlands directly affect fish and wildlife. Thus, the conclusions (Section 14.10) focused on effects of the Project on fish and wildlife. Effects of the Project on Aboriginal Groups traditional and current use – harvesting of fish and wildlife, for example – are addressed in Section 15.11.

The effects assessment followed the methodology outlined in Chapter 10 - Assessment Methods and Presentation. However, where necessary minor changes were made to the methodology based on the specifics of assessing effects on Trudel Creek. These minor changes in methodology are presented in Section 14.2.

Each effects assessment section (14.3 to 14.9) includes a summary of the existing environment and predictions of changes based on both the 36 MW and 56 MW expansion options being considered. Where possible, the quantitative and qualitative predictions of effects were presented together to minimize duplication.

14.1.1 Taltson Expansion Project and Trudel Creek

The Expansion Project proposes to add between 36 MW and 56 MW of power-generating capacity at the Twin Gorges plant. The expansion would add to the existing 18 MW capacity that was established in 1965 to provide power to the Pine Point Mine. Closure of the mine in 1986 allowed the distribution of power supply to the communities of Hay River, Fort Smith, Fort Fitzgerald and Fort Resolution, NWT. During operations at Pine Point Mine, the Twin Gorges plant was operating at or near capacity for just over 20 years. Flows on the Taltson River at Twin Gorges greatly exceed the flow required to generate the 18 MW capacity of the Twin Gorges plant. Thus, water in excess of that required for maximum power generation was spilled over the South Valley Spillway (SVS) and into the headwaters of Trudel Creek. Upon closure of Pine Point Mine, power generation dropped to between 9 MW and 11 MW. As a result, additional water was spilled into Trudel Creek. This hydrologic regime has been maintained since 1986.

With construction of the Twin Gorges power facilities and the SVS, Trudel Creek essentially became the main channel of the Taltson River from the newly-formed Forebay to Elsie Falls. This added approximately 33 km of flow routing to the

Taltson River. At the same, Twin Gorges essentially transformed into a regulated side-channel of the Taltson River.

The Expansion Project proposes to maximize the use of the currently spilled water for power production and introduce greater hydrological control to increase generating capacity. This would have the effect of reducing the flow in Trudel Creek to a flow that would be considerably lower, on average, than current conditions. Essentially, Trudel Creek would become the side channel and the Twin Gorges plant would become the main channel as most of the flow would be managed to flow through the new and existing power facilities. However, during extreme high-flow years and scheduled and unscheduled outages of the new power facilities, flows in Trudel Creek would increase markedly from average conditions. The effects of scheduled outages at the Twin Gorges plant are discussed in Chapter 14. The effects of unscheduled outages are addressed in Chapter 17 - Accidents and Malfunctions.

The hydrological changes to Trudel Creek from the Expansion Project have the potential to change the biophysical and biological components of the aquatic environment of Trudel Creek. As such, and in accordance with the Terms of Reference for the Taltson Developer's Assessment Report (DAR) (Mackenzie Valley Environmental Review Board, 2008), an assessment of the ecological changes to Trudel Creek has been conducted.

14.1.2 Trudel Creek Biophysical History

Flows over the SVS into Trudel Creek since construction of the Twin Gorges facility in 1964 have varied as a result of the operational history. In order to describe the biophysical conditions associated with Trudel Creek, the hydrology has been divided into three time periods. These time periods have been designated as Pristine (pre-1964), Pine Point (1964 to 1986), and Current (1986 to present). Throughout the historical time periods, the conditions of the watershed, hydrology, channel morphology and fish habitat availability have varied substantially. The following sections describe the biophysical conditions associated with each time period.

14.1.2.1 CURRENT BIOPHYSICAL CONDITION

The current flow conditions in Trudel Creek began with the permanent closure of Pine Point Mine in 1986, after 20 years of operation. Closure of the mine led to a reduction in water use from the Taltson River for power generation, causing increased flows over the SVS and into Trudel Creek. Since 1986, approximately 85% of the flow from the Taltson River has been diverted into Trudel Creek over the SVS. The other approximately 15% of the Taltson River flow is used for power generation at the current Twin Gorges hydro facility.

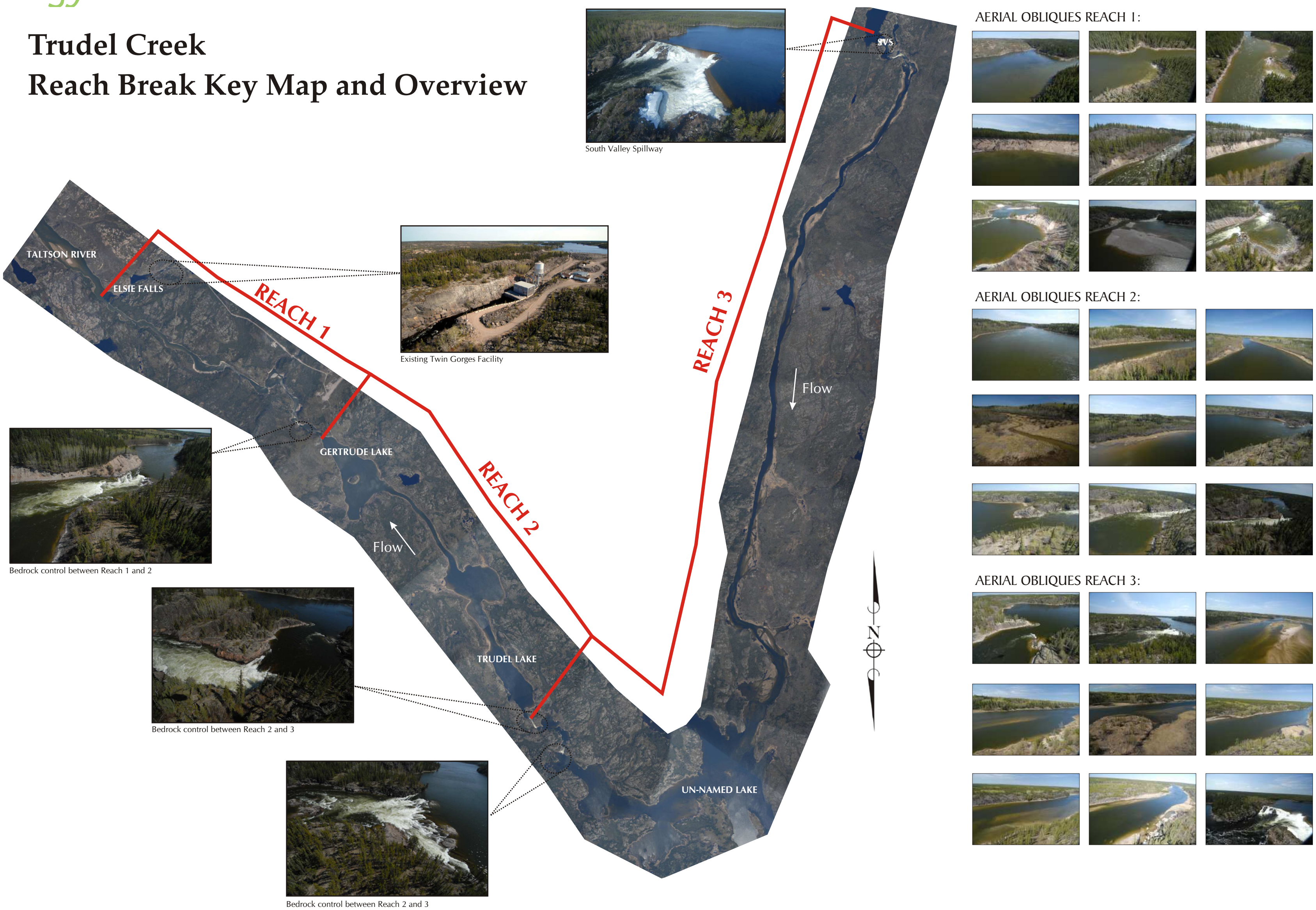
Trudel Creek in its current state is a large river with fluctuating water levels. It is characterized by low-gradient, straight-channel morphology and confined banks (Figure 14.1.1). The general homogenous, low-gradient system features three lakes held by a series of bedrock controls. Current channel widths range from 70 m to 230 m.

Overall, Trudel Creek has a very low elevation gradient and drops less than 50 m over its 33 km length from the SVS to the confluence with the Taltson River. Excluding the SVS, the elevation drop is only 25 m over approximately 32 km. This equates to an average bed slope of 0.08%. Moreover, most of the elevation drop occurs at the outflow of two lakes: Trudel and Unnamed lakes (Figure 14.1.2). The outflow controls of these lakes also control water levels within the river reaches. Modelled data presented in Section 14.3 - Alterations to Water Quantity show that even under very low flow conditions water levels are still maintained well above the bed of the river. The very low river gradient and water level controls from downstream lakes result in a low-velocity regime in the open river sections. High velocities are observed at rapids sections and lake outflow sections.

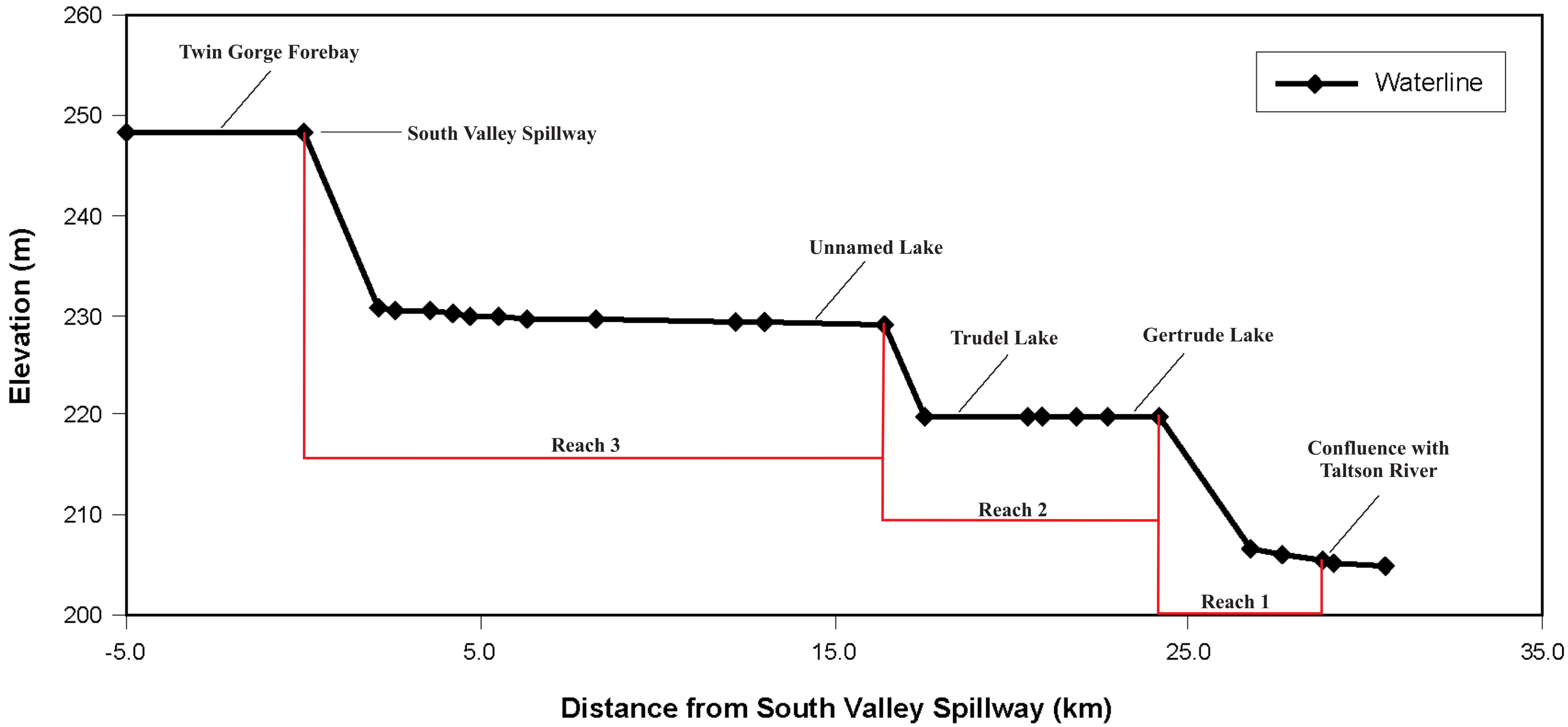
Low-level and high-level aerial photography was collected for Trudel Creek in 2008 and is provided in Appendix 14.1A. In addition to the low- and high-level aerial photographs, bathymetric maps of each of the lake systems in Trudel Creek were developed (Rescan, 2006); these are shown in Figure 14.1.3 to Figure 14.1.5.

A full description of the current biophysical conditions of Trudel Creek, such as hydrology, ice formation, water quality, aquatics, etc., are contained in the existing environmental sections of the relevant environmental disciplines in this chapter.

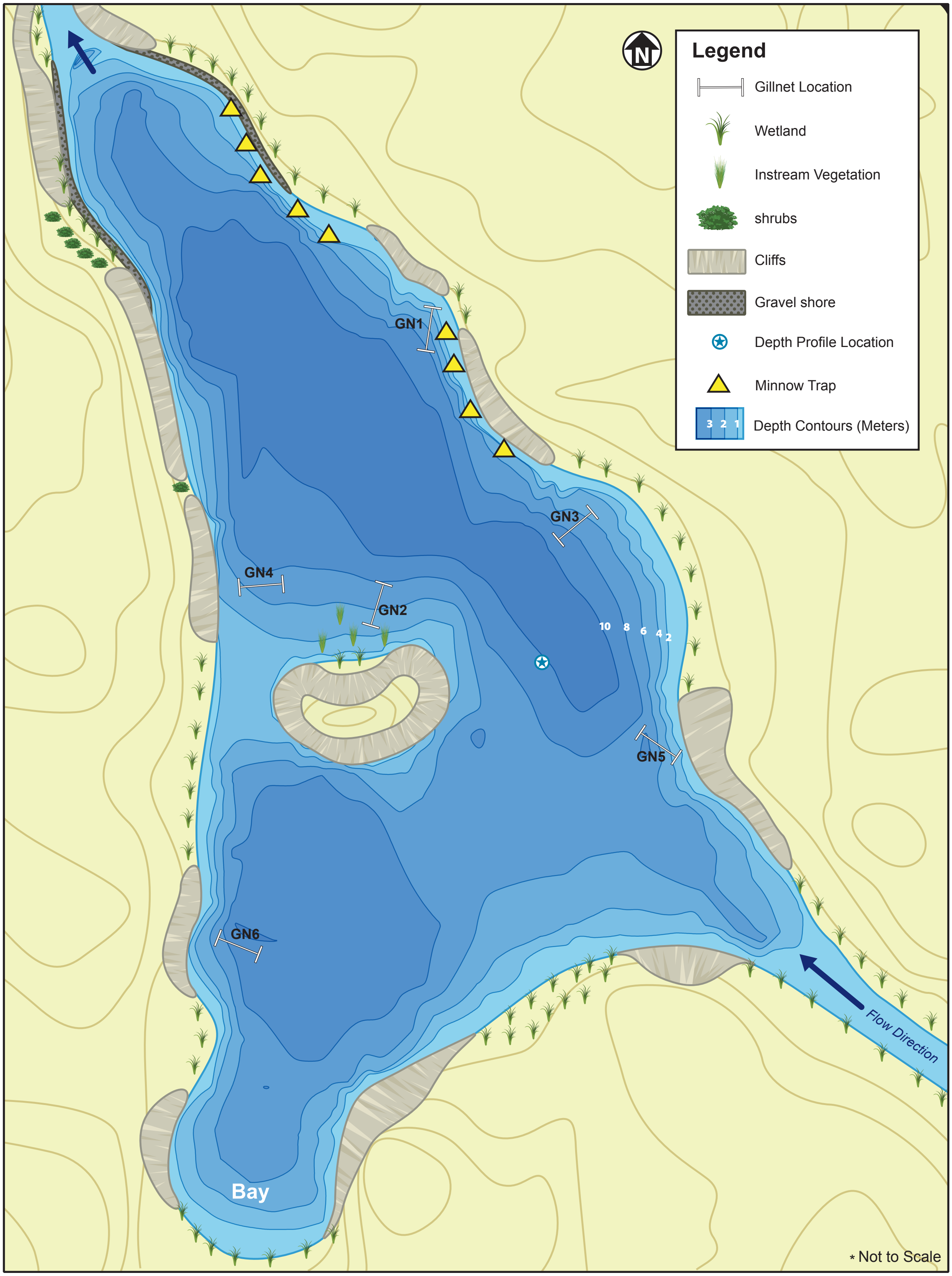
Trudel Creek
Reach Break Key Map and Overview



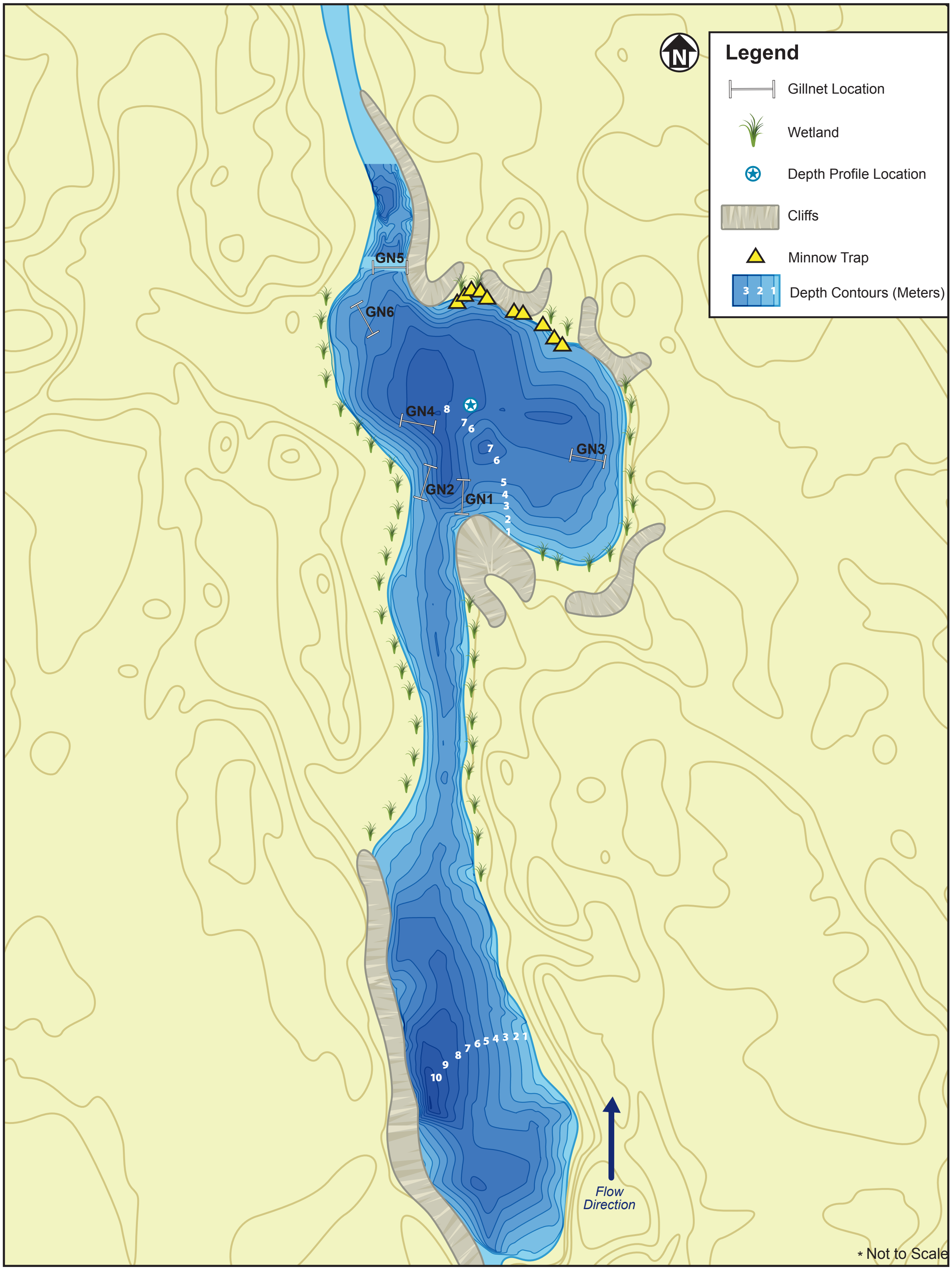
TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report** **2009**	**Trudel Creek Reach Break Key Map and Overview**	**Figure 14.1.1**



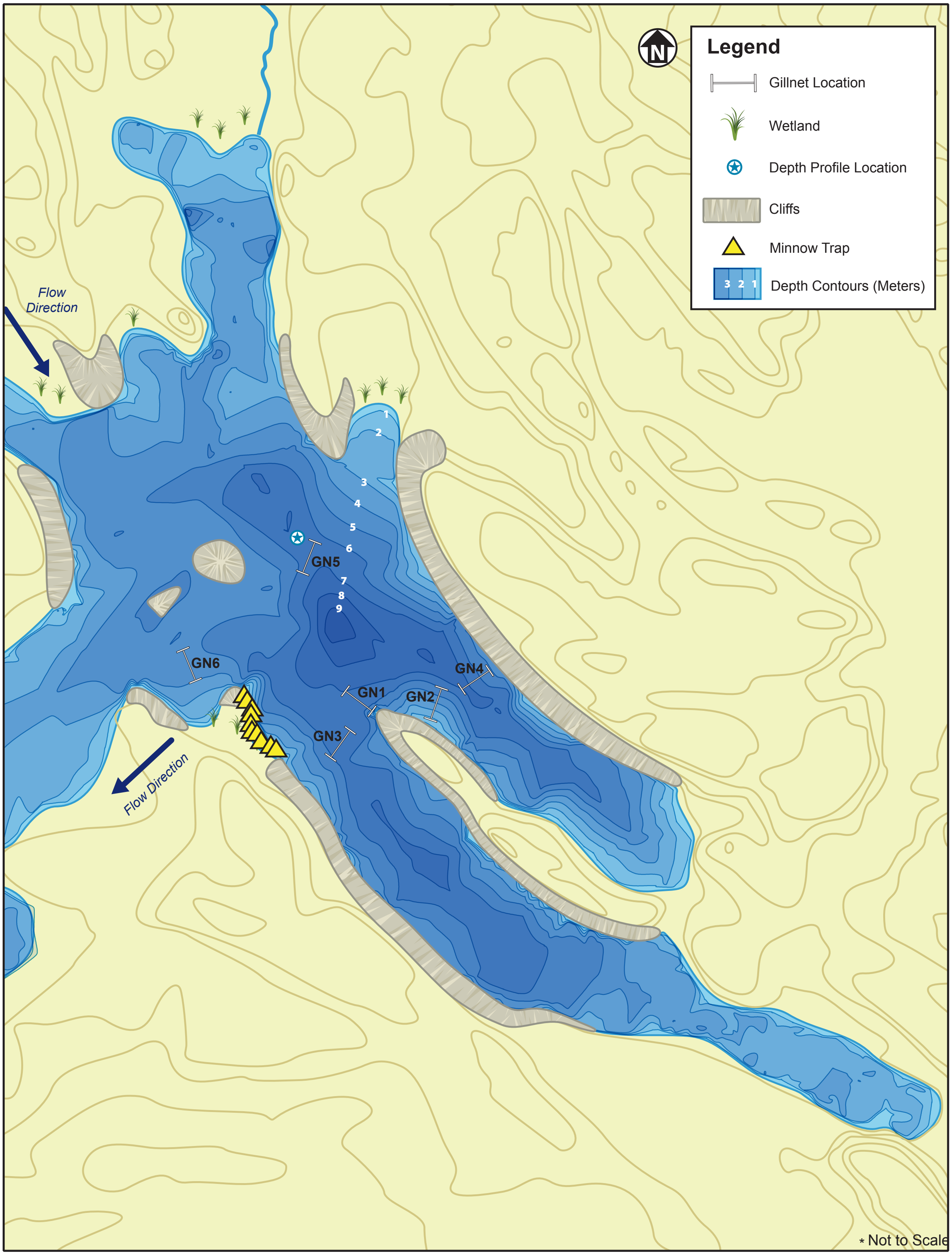
TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Trudel Creek Longitudinal Profile	Figure 14.1.2



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Gertrude Lake Bathymetric Map	Figure 14.1.3



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Trudel Lake Bathymetric Map**	**Figure 14.1.4**



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Unnamed Lake Bathymetric Map	Figure 14.1.5

14.1.2.2 PINE POINT (1964-1986) BIOPHYSICAL CONDITION

Historical air photos of Trudel Creek during operation of the Pine Point Mine are illustrated in Figure 14.1.6 and Figure 14.1.7.

14.1.2.2.1 Hydrology

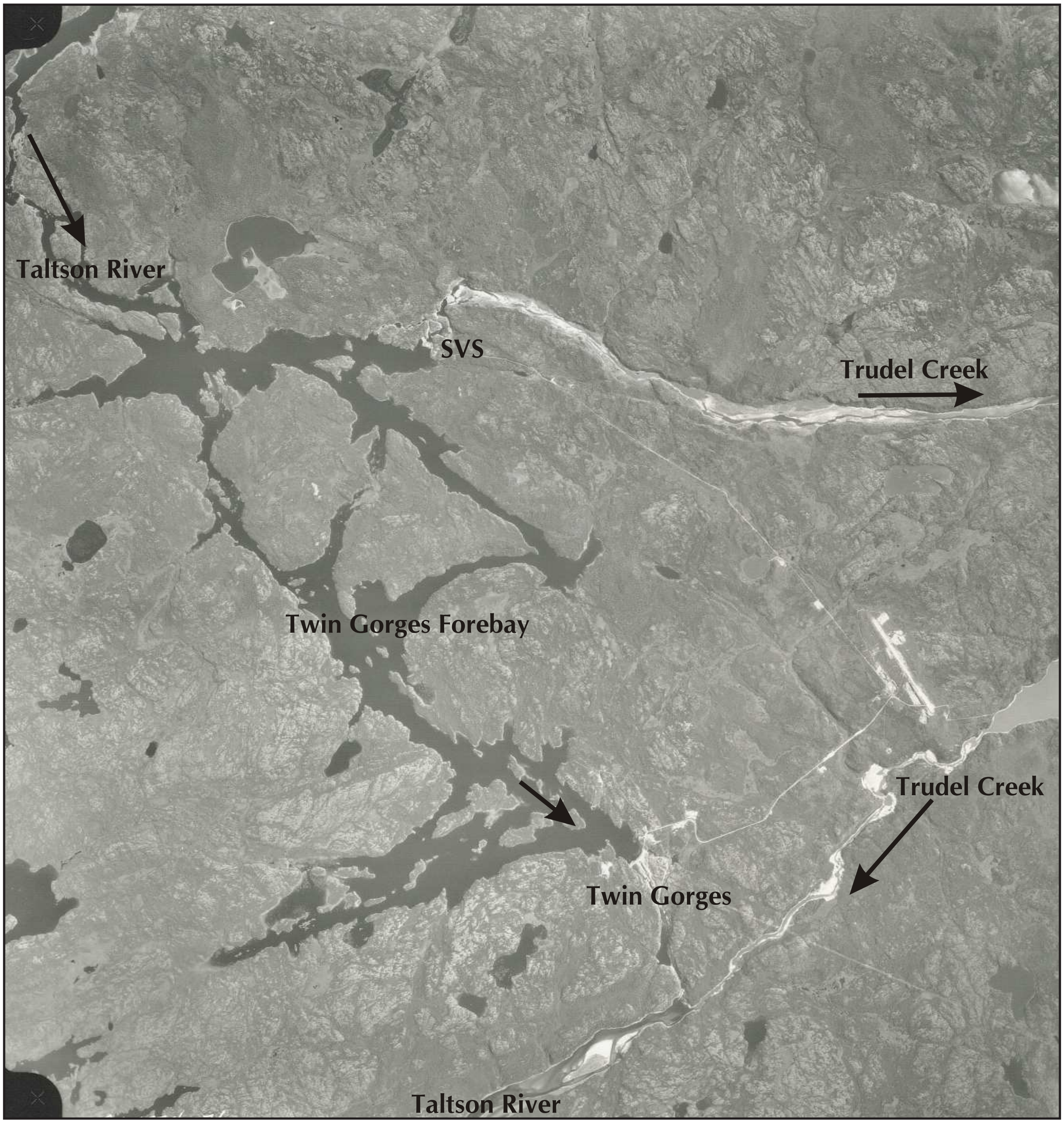
The following points highlight some of the general characteristics of the hydrological conditions in Trudel Creek during the Pine Point Mine operation:

- Mean Annual Discharge was 115.7 m^3/s.
- Discharge is typically the lowest in April and peaks in August.
- Discharge begins to increase in late April and May, first due to the melting snow and ice in the local area, and continues to rise through July and August due to melting snow and ice upstream in the Taltson River system.
- Discharge gradually declines from September, through the fall and winter.

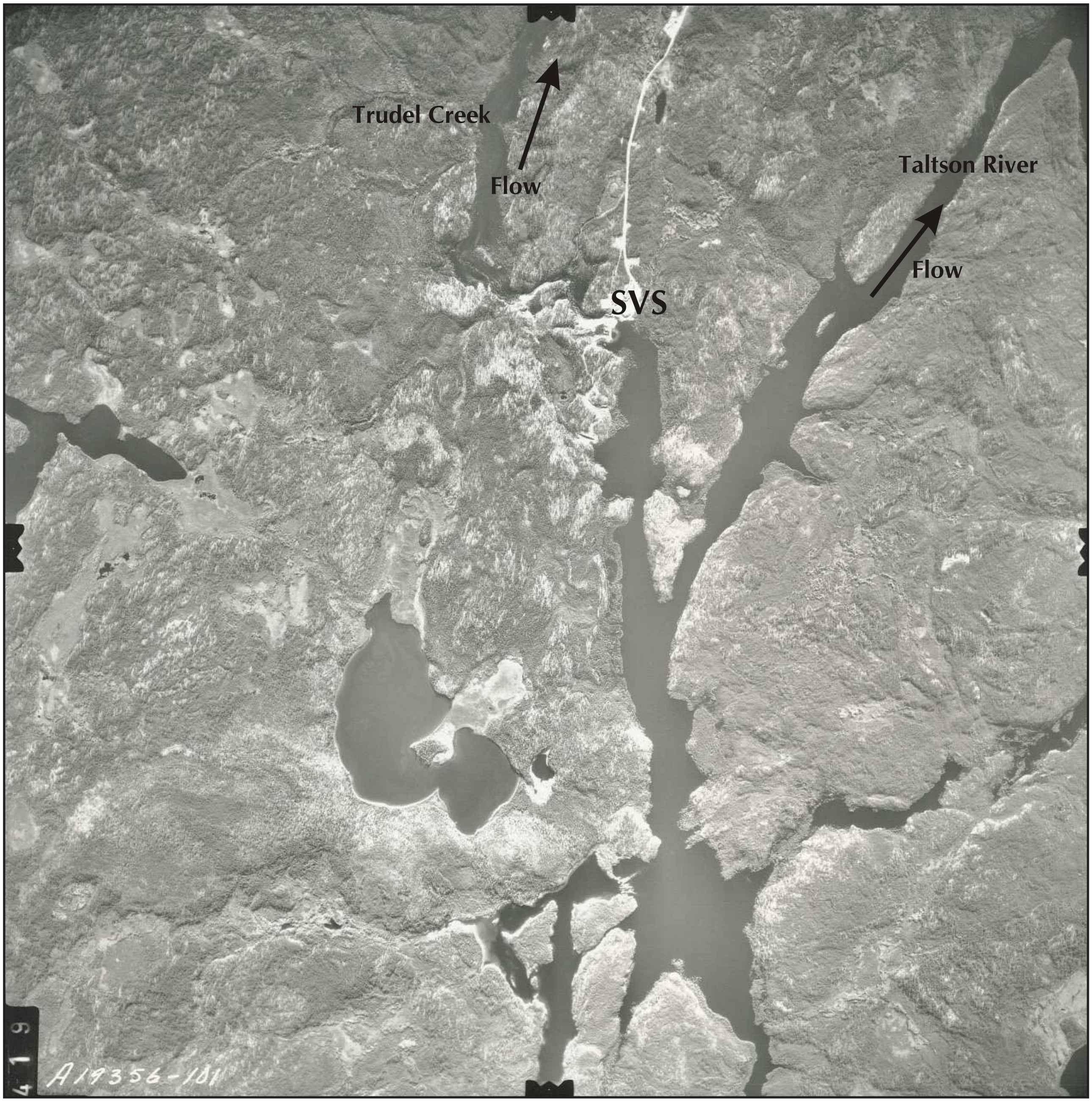
14.1.2.2.2 Channel Morphology

The construction of the Twin Gorges dam increased flows in Trudel Creek well above estimated and observed pre-Twin Gorges levels. It is evident when examining the historical air photos that the increased flows during the Pine Point era caused the channel morphology to become straighter due to flooding of the natural meanders and increased energy. The channel widths increased from approximately 15–40 m to approximately 60–230 m. The most dramatic changes are noticed downstream of Gertrude Lake (Reach 1) where, the small meandering creek present prior to 1964 became a much straighter channel with high eroded banks.

The Pine Point era stream morphology observed on aerial photos is similar to the current morphology of Trudel Creek. Comparisons of aerial photographs taken pre-1964 and during Pine Point operations illustrate the changes in channel morphology from pre-Twin Gorges conditions to post Twin Gorge conditions.



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Aerial Photo of Trudel Creek, the SVS and Twin Gorges (1980)**	**Figure 14.1.6**



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Aerial Photo of Taltson River Forebay and SVS (1980)**	**Figure 14.1.7**

14.1.2.2.3 Icing

Ice conditions during the operation of the Pine Point Mine are unknown; however, based on typical ice processes and the known hydrology, the ice regime during mine operations is assumed to be similar to that described for the current conditions (Section 14.5 – Alteration of Ice Structure in Trudel Creek), with potentially greater thermal ice cover in river sections, due to the lower flows and velocities.

14.1.2.2.4 Water Quality

Water quality is also unknown; however, also based on the known hydrology, the water quality could be considered of similar quality to current conditions. The exception to this would be turbidity and total suspended solids during the initial years of operations, when most of the erosion is thought to have occurred (Klohn Crippen Berger, 2008). During these periods, turbidity and TSS would likely have been elevated over later years of Pine Point operations or over current water quality conditions.

14.1.2.2.5 Erosion

With the current data available, erosion rates cannot be quantified but can be qualified in relative terms. The rate of erosion on Trudel Creek was greatest for several years immediately after construction of the hydro power plant in 1965 due to the dramatic increases in flows (Klohn Crippen Berger, 2008). Base flows, monthly flows, and peak flood flows increased dramatically due to the change in hydro power plant operation. It is expected that during the first 5 to 10 years of this new flow regime, the rate of erosion was very high. The erosion rate reduced as some of the banks began to self-armour and the channel widths increased. It is unlikely that an equilibrium was reached in the 21-year period from 1965 to 1986, since the creek flow regime was significantly changed i.e., some erosion was still taking place in 1986 due to the changing flow regime. Aerial photo coverage and scales are not of sufficient detail to allow mapping of this historical erosion (Klohn Crippen Berger, 2008).

14.1.2.3 PRISTINE BIOPHYSICAL CONDITION

Since the construction of the Twin Gorges facility, flows through Trudel Creek have varied as a result of operational history. Prior to development of the Twin Gorges Facility in 1964, Trudel Creek was a non-regulated system. There was no in-stream development or flow management in the Taltson River or Trudel Creek watersheds. Historical air photos of Trudel Creek pre-Twin Gorges are illustrated in Figures 14.1.8, 14.1.9 and 14.1.10.

14.1.2.3.1 Hydrology

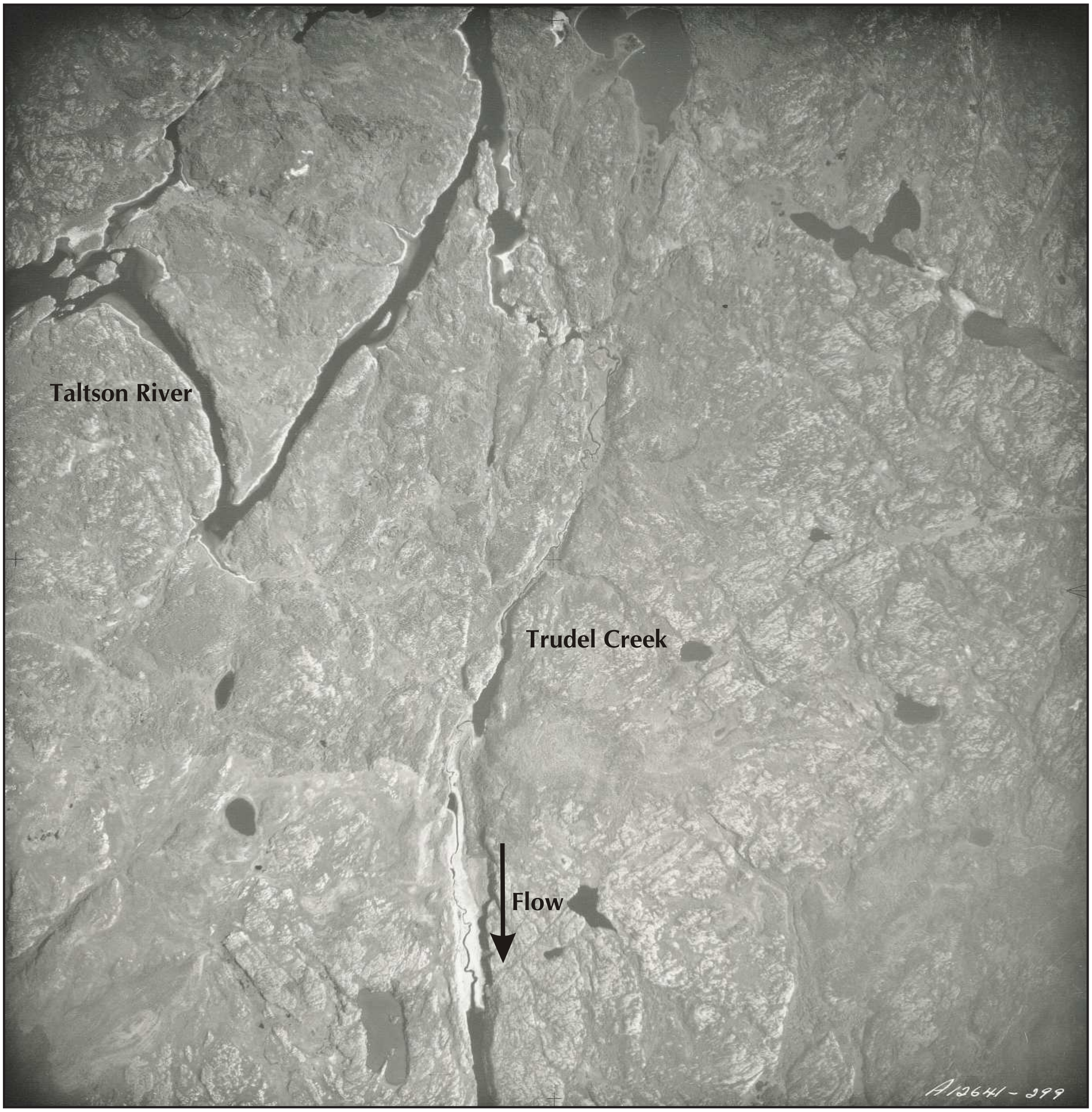
A hydrological assessment conducted in 2006 (Rescan 2006) reviewed the potential pre-Twin Gorges condition of Trudel Creek. The hydrological assessment estimated potential pre-development flows in Trudel Creek based on the hydraulic geometry of the existing channel. The results indicated that pre-development flows in Trudel Creek may have been approximately 0 to 12% of current flows.

The assessment estimated the Trudel Creek watershed to generate mean monthly flows between 0.24 m^3/s (March) and 2.37 m^3/s (May) at the confluence with the Taltson River (Rescan, 2006). Geomorphologic and photographic observations indicate that potential connectivity existed between the Taltson River and Trudel Creek prior to construction of the Twin Gorges dam and the SVS. It is likely the connectivity occurred over the natural bedrock sill upon which the SVS weir was subsequently constructed. The elevation of this natural sill is unknown; therefore, it is unclear as to the potential frequency and duration of this connectivity.

As the hydro power infrastructure did not exist pre-1965, ramping, or rapid flow increases or decreases, would have only occurred as a result of natural flow changes in the Taltson River. The extent of natural flow variations within the Trudel system prior to development is unknown, although it is suspected to have been minimal based on the pre-development morphology of Trudel Creek.

TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Aerial Photo of Trudel Creek and Twin Gorges pre-Development (1955)**	**Figure 14.1.8**

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Aerial Photo of Lower Section of Trudel Creek Pre-Development (1955)**	**Figure 14.1.9**



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Aerial Photo of Upper Section of Trudel Creek Pre-Development (1955)**	**Figure 14.1.10**

14.1.2.3.2 Channel Morphology

Pre-Twin Gorges development, Trudel Creek was predominantly a meandering stream, indicative of a low-energy, low-sediment transport regime. Aerial photos taken in 1950 show a defined stream channel located within an incised geological formation. The landform between the stream and the geological walls appears vegetated.

Gertrude and Trudel lakes both appear clearly on the aerial photos. Unnamed Lake was not included on the flight line. Both lakes have a similar shape, size, shoreline, and island configuration as is experienced under current conditions.

The pre-development condition and estimated flow regime of Trudel Creek suggest that there was minimal erosion within the system besides the natural processes associated with slow-moving meandering stream morphology. This is visible in the aerial photographs, which depict a low-energy system and a narrow meandering channel. Estimated pre-development channel widths are between 15 m and 40 m.

14.1.2.3.3 Icing

Based on the estimated hydrology and aerial photographs, thermal ice conditions would have occurred over most of the creek and lakes. Some open water may have occurred at the bedrock controls, although these may have also been iced over or de-watered due to no available re-charge flows during the winter season.

14.1.2.3.4 Water Quality

As the substrate material and vegetation conditions, which have potential to affect water quality, are unknown, it is difficult to comment on potential water quality pre-Twin Gorges; however, it is likely that the water quality conditions were similar to the water within the Taltson River. No further conclusions could be made about the pre-1964 water quality conditions due to a lack of data.

14.1.2.3.5 Erosion

Pre-Twin Gorges, Trudel Creek appeared to be a small, stable channel, with minimal erosion or deposition.

14.1.2.4 Traditional Knowledge

Traditional Knowledge has been embedded into the Project planning and design. Specific information regarding the ice regime of Trudel Creek was identified and is described below.

One respondent stated that “a lot of the creek names have changed from then to today.” He said he never heard of the Trudel Creek name and “can’t remember if it was used back in his day.” Archie is 93 years young.

Construction of the existing Twin Gorges Project changed baseline conditions in Trudel Creek. Prior to development, Trudel Creek flowed throughout the year and was smaller and narrower: “maybe 20-30 feet wide” or “half of today” [according to the interviewees, the bottom was visible and it was possible to cross the creek on foot in several places. Almost all interviewees agreed that the crossing of Trudel Creek was easy and that there were no concerns about flooding. The water flow was smooth and highest in the spring. Respondents stated that the current creek is wider and faster, carries more silt, freezes rougher, and floods out beavers with the wider water level fluctuations. One of the interviewees stated that "the dam changed everything in the creek – vegetation and furbearing animals."

All but one respondent stated that Trudel Creek was not a significant travel route but was still important to some travellers and for its jackfish, whitefish and pickerel populations. Respondents' opinions split on fishing quality along Trudel Creek and significance (if any) of Trudel Creek's history. Most interviewees used it for travelling and fishing, and one person used it "every second day for trapping, before the dam."

The Traditional Knowledge indicates that the aerial photo assessment of the historical condition of Trudel Creek is relatively accurate.

Recent observations by Johnny Desjarlais, a resident of Fort Smith (personal communication, July 2008) include:

- The lake surfaces become free of ice in June. The edges melt faster than the centre. During this time, the vegetation around the edges grows extremely fast and becomes available for pike spawning around the lake margins.
- Beaver populations are declining as they can't adapt to the changing (fluctuating) water levels. When water rises in the winter, the beavers drown, their homes become flooded and their food stashes get washed away.
- Walleye have historically been caught at the upstream end of Trudel Lake and near the downstream end of Gertrude Lake. In both locations, walleye are found in the deeper waters immediately adjacent to faster flows.

14.1.3 Mitigation and Monitoring

A number of mitigation measures, including design features and operational guidelines, have been identified to reduce the overall potential for negative effects throughout the Trudel Creek system as summarized below. Discipline-specific (water quantity, water quality, aquatic resources, etc.) mitigation measures are outlined in each discipline section.

14.1.3.1 Proposed Minimum Release Flow

The Project proposes to maximize the use of currently-spilled water for power production. This would have the effect of reducing the flow in Trudel Creek to a flow that is considerably lower than current conditions and potentially similar to pre-Twin Gorges. The developer's economic feasibility review originally proposed a flow of 4 m^3/s or less to maximize flows for power production. As a result of communications with agencies and the results of the Trudel Creek Fish and Fish Habitat Effects Assessment (Cambria Gordon Ltd. 2008), the proponent revised the Project design parameters to accommodate a minimum flow of 4 m^3/s.

14.1.3.2 Plant Maintenance and Service

As the Project would comprise multiple turbines in two separate power-generating plants, maintenance schedules would be designed to take only one turbine off-line at any one time, whenever possible. This would minimize the reduction of flow through the plant, and maintain as minimal flow increase as possible to Trudel Creek.

14.1.3.3 BYPASS STRUCTURE

The Expansion Project would incorporate a bypass spillway with 30 m^3/s capacity so that the minimum flows in the Taltson River can be maintained in event of a total generation shut-down.

14.1.3.4 OPERATIONAL GUIDELINES FOR SHUTDOWN AND START-UP

To minimize the events of sudden increases or decreases of flows in Trudel Creek (ramping), and thus negative effects on fish from displacement or stranding, operational guidelines would be established for controlled shutdowns and start-ups (all start-ups are controlled). The purpose of the guideline is to provide a gradual change to the flow at a rate designed to accommodate fisheries and other concerns. Shutdown and start-up flow guidelines are typical for hydroelectric facilities across Canada that have the potential to affect fisheries resources from ramping, and many resources are available for use in developing specific guidelines for the Project.

14.1.3.5 MULTIPLE POWER PLANT GENERATING FACILITY

A combination design of two power-generating facilities at Twin Gorges would be connected by a common substation. Power delivery from the substation would be to one of two transmission lines and to the associated communities or mines. Having two power-generating facilities decreases the potential for uncontrolled plant shutdowns from accidental generator or line outages, thereby decreasing the potential for ramping events in Trudel Creek.

14.1.3.6 FOLLOW-UP MONITORING

Potential monitoring has been identified for individual environmental components in the various disciplines in this chapter. A detailed monitoring program for Trudel Creek would be developed in consultation with the regulatory agencies to ensure the program monitors system indicators that best reflect the issues of interest. Indicators would be identified to provide an indication of effects predicted and changes to the ecosystem, particularly during the initial years of Project operations.

14.2 METHODOLOGY

Trudel Creek was clearly identified in the Terms of Reference for the Taltson Developer's Assessment Report (DAR) (MVEIRB 2008) as an area of concern if the Expansion Project is to proceed. This chapter specifically addresses Project effects on Trudel Creek. However, and as discussed in Section 14.1, Trudel Creek is not an isolated entity; it is one of two channels of the Taltson River between the Forebay and Elsie Falls. As such, during the development of the DAR, it was noted that both Project effects and the assessment endpoints of various valued components (VCs) include areas outside the geographic boundary of Trudel Creek. For example, effects on furbearers from Project activities extended beyond the downstream end of Trudel Creek when flow ramping events were considered. Moreover, the geographic extent of a population of furbearers includes habitat adjacent to Trudel Creek. Thus, assessing the overall Project effect on the assessment endpoint of furbearers ("preservation of harvesting opportunities") should include the population as a whole. For instance, if a Project activity caused a one-time direct mortality effect, individuals would be lost. However, if following this one-time activity the habitat was still suitable for occupation, furbearers adjacent to Trudel Creek could move into the area. Thus, the sustainability of the population could be maintained.

To accommodate the need to present the effects of the Project on Trudel Creek in isolation, assessment endpoints and assessment boundaries were limited to areas within Trudel Creek for this chapter. However, a holistic, or population(s) approach, was taken to complete the effects assessment for the Taltson River Watershed KLOI (Chapter 13). Assessment endpoints and assessment boundaries for the Taltson River Watershed effects assessment were based not just on potential effects from the Project but also on the geographic extent of populations listed as VCs. Thus, the determination of significance of effects on Trudel Creek fisheries resources and wildlife was presented herein (Chapter 14) and subsequently used to assess the significance of effects on the VCs within the entire Taltson River Watershed (Chapter 13).

14.2.1 Trudel Creek Assessment Methodology

The methodology used for the assessment of the ecological changes to Trudel Creek adhered to the methods outlined in Chapter 10 — Assessment Methods and Presentation. To enable this assessment, the Project components and associated activities were first identified. Next, activities that had the potential to interact with an assessment endpoint, either directly or indirectly via measurement endpoints, were identified based on a general understanding of the Project. This step was meant to identify all possible pathways from a typical hydroelectric project, and did not necessarily consider the specifics of the Expansion Project. The intent was to be conservative and include all possible pathways.

An assessment endpoint is the key component of a VC that should be assessed in order to determine if the VC is significantly affected by the proposed development. Assessment endpoints can be quantified, but it is often difficult to do so. A measurement endpoint is a quantifiable feature that the assessment endpoint depends on. For example, a measurement endpoint for aquatic resources would be loss of habitat, while the assessment endpoint would be preservation of productivity, biodiversity and community structure. Measurement endpoints were sometimes used to qualify effects to assessment endpoints when the assessment endpoints were either difficult to qualify or there was overlap between measurement and assessment endpoints.

Once all possible pathways were identified, Project mitigation was reviewed to determine if the pathways were valid, invalid or the potential effects were reduced to minor.

All valid pathways that led to effects on assessment endpoints were carried forward to the effects classification. Effects on measurement endpoints were identified and quantified where possible. A qualitative assessment of residual effects on the assessment endpoints was then completed using the following criteria: direction, magnitude, geographic extent, duration, frequency, reversibility and likelihood. An overall rating of the residual effect was also completed based on the individual criteria ratings and professional judgement. Each effect was qualified separately.

Not all components of the Trudel Creek environment took the assessment to a qualitative stage. Water quantity (Section 14.3) was only discussed quantitatively, where baseline data was presented together with predictive data from the 36 and 56 MW expansions. Water quality (Section 14.4) data was presented quantitatively and compared to various existing guidelines. A general qualitative assessment was completed as well, based on magnitude of change to specific water-quality parameters. Given the nature of ice processes and the baseline data available, the assessment of effects on the ice regime of Trudel Creek was more general and qualitative, but did not include a qualitative assessment of residual effects.

The effects assessment for aquatic resources and wetlands was both quantitative and qualitative in that both sections include residual effects classifications. The residual effects classifications and the quantitative changes in the various measurement endpoints played a key role in the assessment of fisheries resources and wildlife.

Determination of significance was only completed for fisheries resources and wildlife. The significance determination tables present all effects on a given assessment endpoint. The determination of significance was made after considering all the individual effects in summation on a given assessment endpoint.

The assessment of effects of fisheries resources deviated slightly from the above and from what is outlined in Chapter 10. The deviations from the standard methods were based on the Department of Fisheries and Oceans Canada's (DFO) Risk Assessment Framework (RAF). The RAF identifies Pathways of Effects (POE) on fisheries resources for common in-stream and land-based activities. These POEs describe "cause and effect relationships" that are known to exist, and the mechanisms by which stressors ultimately lead to effects in the aquatic environment. Each cause-and-effect relationship is represented as a line, known as a pathway, connecting the activity to a potential stressor, and a stressor to some ultimate effect on fish and fish habitat, known as an assessment endpoint.

As such, analysis of the potential effects to the fisheries resource incorporated those pathways and assessment endpoints identified by DFO. The DFO-identified pathways and assessment endpoints vary from the methodologies outlined in Chapter 10 in that the assessment endpoints are not specific to a valued component but rather to a specific parameter (i.e., water quality) that could affect the valued component. In this way, they direct and support the method used for assessment of the ecology of Trudel Creek, with various parameters acting as stressors to fish and wildlife

Where not specified, the definitions used to classify residual effects used the definitions below (Table 14.2.1), which are specific to Trudel Creek but based mainly on those definitions presented in Chapter 10.

Table 14.2.1 — Definitions of Terms Used in the Residual Effect Classification

Direction	Magnitude	Geographic Extent	Duration	Reversibility[1]	Frequency	Likelihood
Neutral: no residual effect **Adverse:** a less favourable change relative to baseline values or conditions **Beneficial:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values **Low:** effect is predicted to be within the range of baseline values **Moderate:** effect is predicted to be at or slightly exceeds the limits of baseline values **High:** effect is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions	**Small-scale:** Single reach or lake of Trudel Creek **Medium-scale:** Multiple reaches or lakes of Trudel Creek **Regional (large-scale):** All of Trudel Creek	**Short-term:** effect is reversible at end of two to three years **Medium-term:** effect is reversible after 10 years **Long-term:** effect is reversible after the assumed 40-year operation period **Indefinite:** the duration of the effect is indefinite beyond the assumed 40-year operation period	**Reversible:** effect would not result in a permanent change of state of the population compared to "similar" environments not influenced by the Project **Irreversible:** effect is not reversible (i.e., duration of impact is indefinite or permanent)	**Isolated:** confined to a specific discrete period **Periodic:** occurs intermittently but repeatedly over the 40-year assessment period **Continuous:** occurs continually over the 40-year assessment period	**Unlikely:** the effect is likely to occur less than once in 100 years **Possible:** the effect is possible within a year; or at least one chance of occurring in the next 100 years **Likely:** the effect is probable within a year; or at least one chance of occurring in the next 10 years **Highly Likely:** the effect is very probable (100% chance) within a year

[1] "similar" implies an environment of the same type, region, and time period

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

APPENDICES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

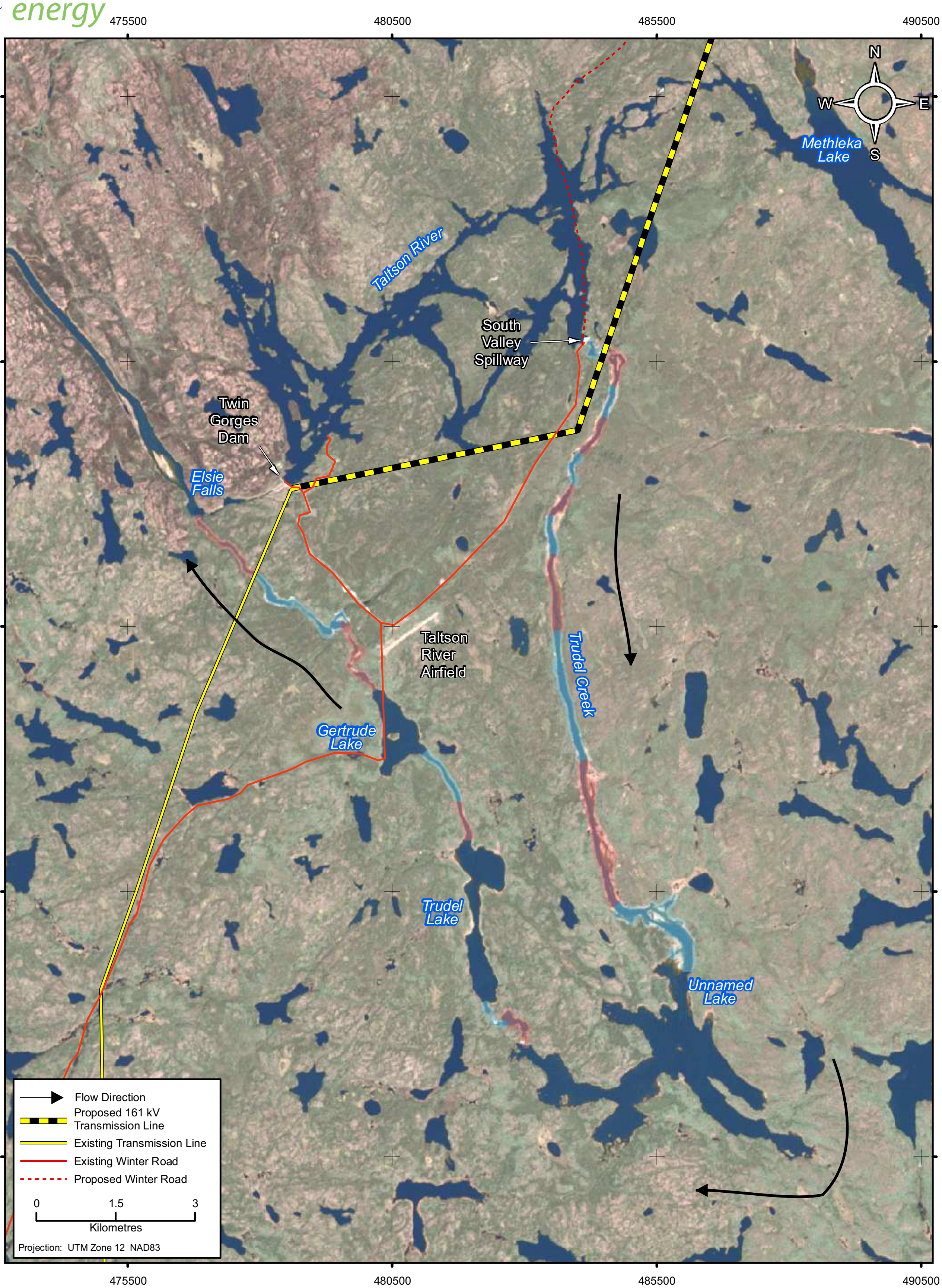
14.3 ALTERATIONS OF WATER QUANTITY

Water in excess of that needed for current power production demand discharges over the South Valley Spillway (SVS) to Trudel Creek. The creek flows in a southern direction towards Unnamed Lake and then northwards through two smaller lakes (Gertrude and Trudel lakes) before discharging back into the Taltson River below Elsie Falls (Figure 14.3.1).

Prior to the construction of the dam and SVS at Twin Gorges in 1965, Trudel Creek was normally a small meandering stream interconnecting the three lakes in this reach. Only during periods of higher runoff would Trudel Creek receive flow from the Taltson River mainstem through the natural saddle, which is the current location of the SVS (Rescan, 2006). Since the use of Trudel Creek as the spillway route for the Twin Gorges power facility, additional high flows have been routed into this watercourse. During the operational period of the Pine Point Mine (1965 to 1986) and in particular subsequent to the construction of the Nonacho Lake dam in 1968, spill flows were likely reduced compared to current conditions, and flows over the SVS relatively more intermittent. Since the closure of the Pine Point Mine in 1986, power generation has decreased along with flow through the power plant, releases from Nonacho Lake have been less structured, and approximately 75% of the annual flow has spilled over the SVS into Trudel Creek. Currently the majority of flow within Trudel Creek enters the creek at the SVS. However, runoff from the surrounding watershed does contribute a very small portion to the total flow in Trudel Creek.

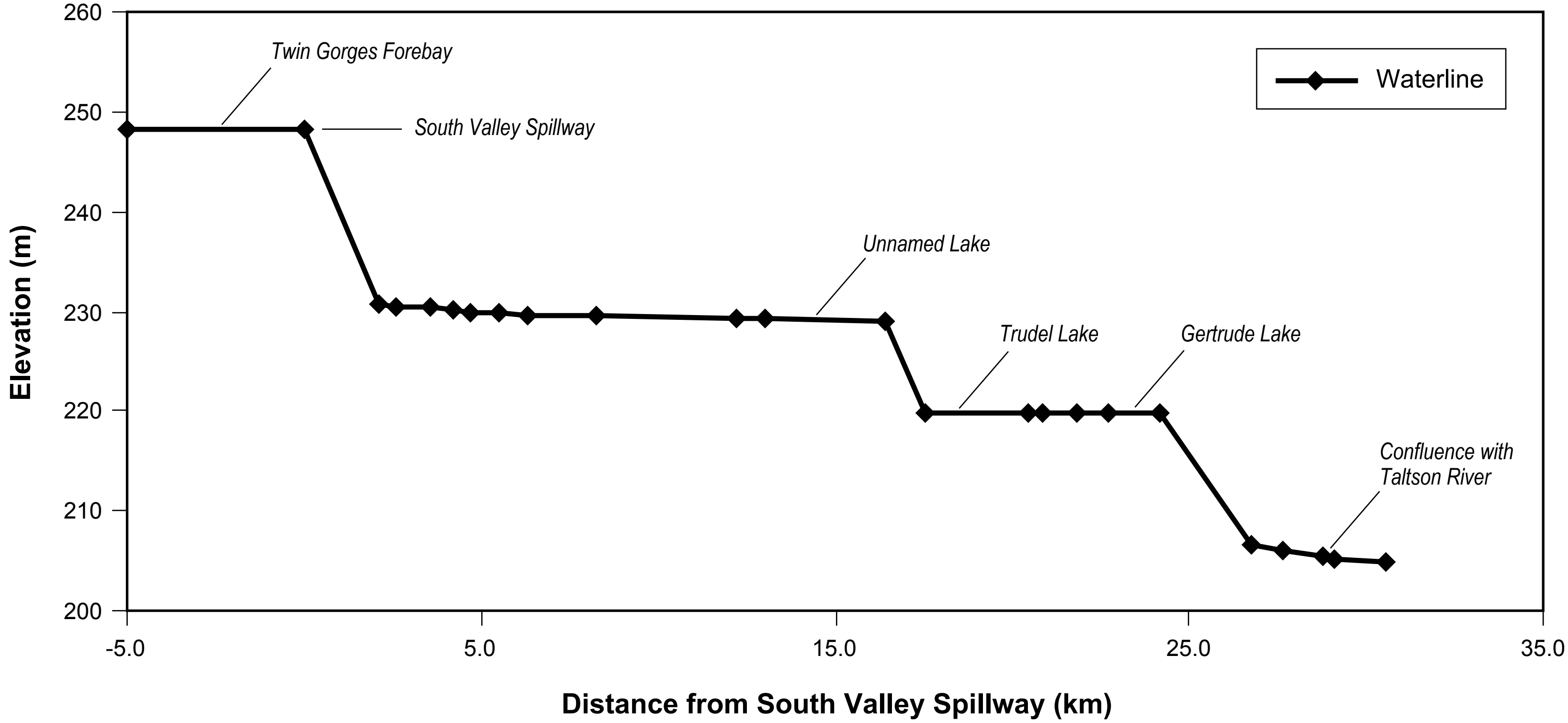
At present, the upper reaches of Trudel Creek have a fairly uniform, low-gradient channel. Lower Trudel Creek features several lakes connected by a series of rapids (Figure 14.3.2). Below Gertrude Lake, Trudel Creek has several steeper sections before it reaches the confluence with the Twin Gorges Dam outflow.

A main goal of the Expansion Project would be to maximize flow from the Taltson River through the Twin Gorges power facilities to maximize power production. Consequently, flows over the SVS would be substantially reduced. Therefore, the potential effect of decreasing flows in Trudel Creek was identified as a concern for fish, wetland, and wildlife habitat. As a result, the effect the Expansion Project would have on Trudel Creek was investigated by predicting the change in flow that would occur over the SVS under the 36 MW and 56 MW expansion scenarios. As it was anticipated that changes to the flow regime in Trudel Creek could be substantial, an additional modelling study was completed specific to Trudel Creek to detail simulated effects on hydraulic parameters throughout the creek. A HEC-RAS hydraulic model was developed of Trudel Creek to estimate and quantify the effect that the change in flows over the SVS, as simulated by the Taltson Basin Flow Model, would have on water levels, stream velocities, and stream widths throughout Trudel Creek, including Unnamed, Trudel, and Gertrude lakes.



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Trudel Creek Overview Map**	**Figure 14.3.1**

gis no. TAL-10-004DAR



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Trudel Creek Longitudinal Profile (503-005 / a21420f)	Figure 14.3.2

14.3.1 Taltson Basin Flow Model Expansion Scenarios for Trudel Creek

The Taltson Basin Flow Model is a numerical model created to simulate flows and water levels along the Taltson River between Nonacho Lake and Great Slave Lake and to predict changes in these parameters under the Expansion Project. Results provided by the model are considered for six zones (including Nonacho Lake) along this section of the Taltson River. Trudel Creek forms Zone 5 of the Taltson Basin Flow Model. The set-up of the Taltson Basin Flow Model for calibration and baseline conditions as well as model results is fully described in Section 9.3 and Appendix 9.3A of this report. The following discussion focuses on model components and results for Trudel Creek under the 36 MW and 56 MW expansion scenarios and compares these results to the baseline scenario.

14.3.1.1 Representation of Proposed Expansion Scenarios within the Taltson Basin Flow Model

To allow prediction of the flows and water levels within the model study area under the expansion scenarios, the representation of Nonacho Lake and Twin Gorges was altered to reflect the proposed Project description. This included:

- increasing the capacity of the underflow gates at the Nonacho dam control structure,
- altering the rating equation for the Nonacho dam spillway to account for an increase in the spillway elevation,
- altering the operational release decision of the Nonacho control structure to account for increased flow-through capacity of the Twin Gorges facilities, and
- increasing the flow-through capacity of the Twin Gorges power facilities to support increased power-generation capacity.

These features of the model are fully discussed in Section 13.3 and Appendix 9.3A.

In addition to the above-listed features of the Taltson Basin Flow Model and specific to flow in Trudel Creek, a minimum release from Twin Gorges at the SVS of 4 m^3/s was specified within the model. This reflected a Project design mitigation feature to maintain a minimum flow to Trudel Creek at all times over the SVS as outlined in Section 6.4.3. No other modifications to the baseline model scenario were made to Trudel Creek or the SVS.

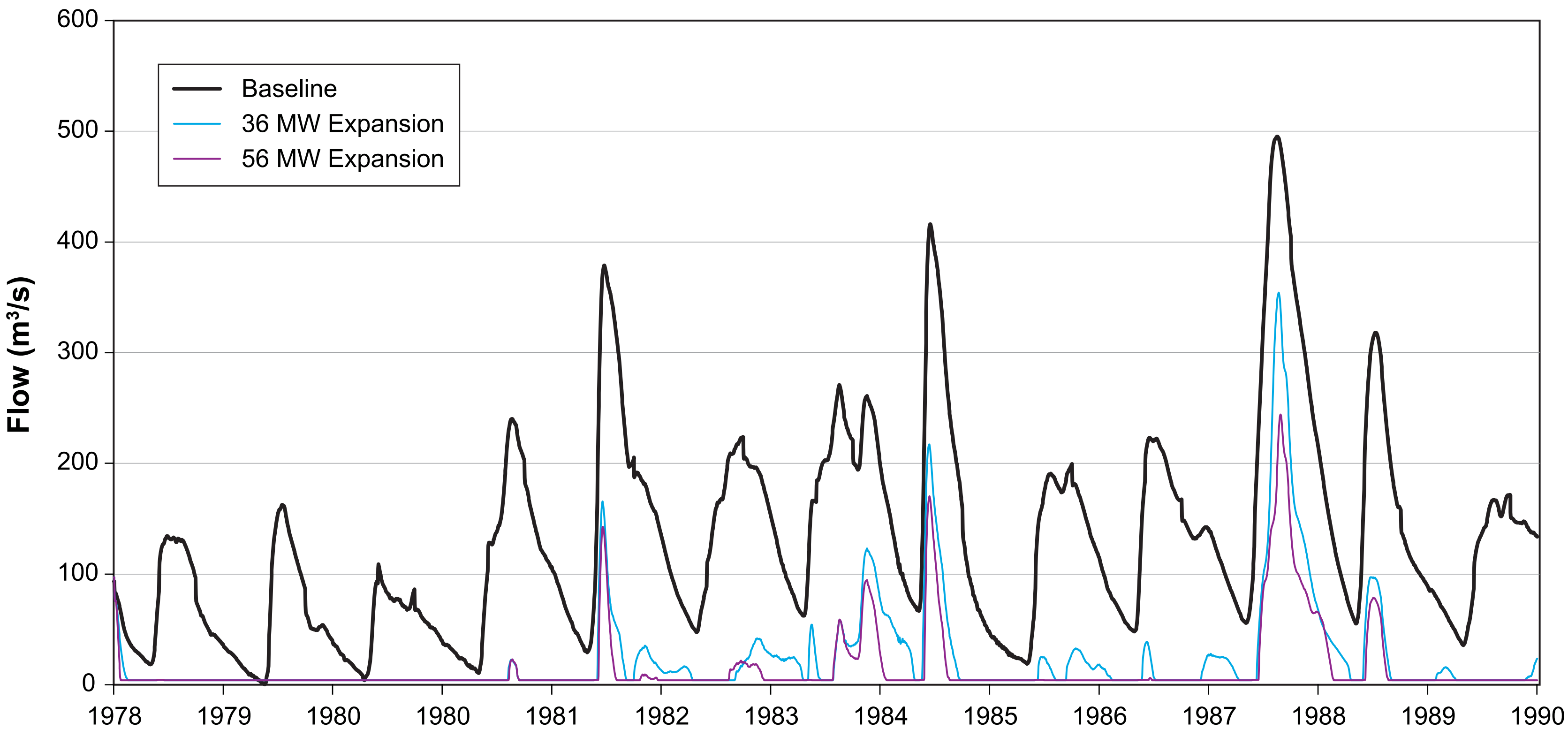
14.3.1.2 Expansion Scenario Model Results for Trudel Creek and Comparison to Baseline

The proposed changes to the operation of Nonacho Lake and increase in flow through the expansion power facilities are expected to substantially decrease the total annual flow over the SVS to Trudel Creek.

In general, the increased power production translates to water levels in the Forebay that are lower than baseline conditions (see Section 13.3). This is because the model is optimized to provide maximum power production and maintain the water level in Twin Gorges at the elevation of the crest of the SVS. When the water level is above the SVS crest, the excess water in the reservoir is spilled to Trudel Creek; otherwise, releases from Twin Gorges are used exclusively for power production.

The SVS is an uncontrolled (static) spillway; flow over the SVS (other than during periods of specified minimum release) is directly related to Forebay water levels. As water levels drop on the Forebay, so does the flow over the SVS. Flows simulated by the Taltson Basin Flow Model in Trudel Creek under baseline conditions and for the expansion scenarios are illustrated in Figure 14.3.3 and Figure 14.3.4 and Table 14.3.1.

An example of the resulting changes in water levels at one location within Trudel Creek (TRUDEL1) is provided in Figure 14.3.5 and Figure 14.3.6. Predicted water levels throughout Trudel Creek under baseline and expansion scenarios are presented in Section 14.3.2.



Note: Both expansion scenarios include a 4 m³/s minimum release from Twin Gorges over the SVS into Trudel Creek.

TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report** **2009**	**Taltson Basin Flow Model Results** **Zone 5: Trudel Creek Flow Time Series** (503-005 / a21418m)	**Figure** **14.3.3**

A. Average Monthly Flow

B. Difference in Average Monthly Flow Between Baseline and Expansion Scenarios

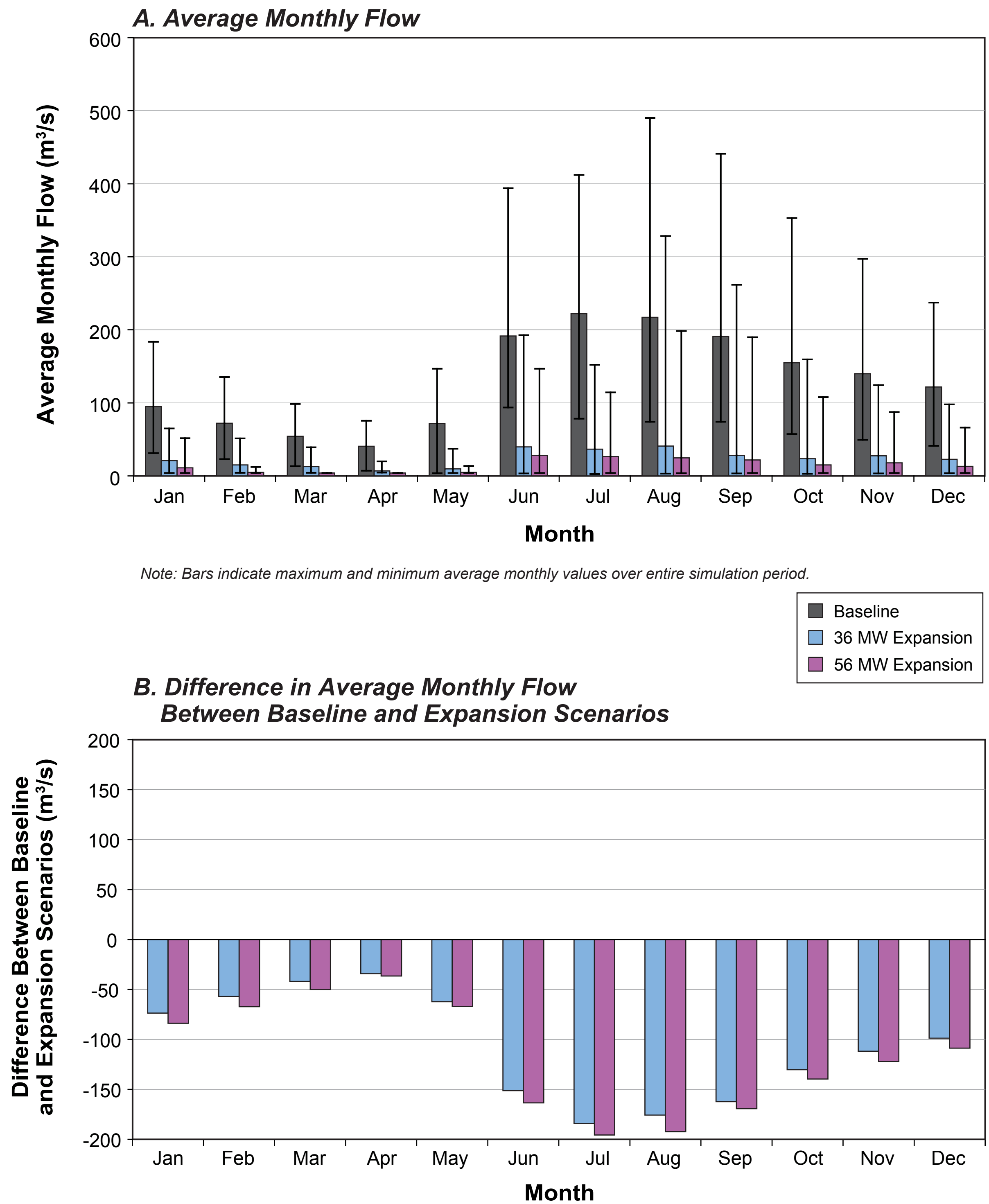


Table 14.3.1 — Taltson Basin Flow Model Results - Zone 5: Trudel Creek Flow

Scenario	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average Monthly Flow (m^3/s)												
Baseline	94.68	71.97	54.24	40.57	71.78	191.53	222.21	217.17	191.11	154.94	139.92	121.80
36 MW Expansion	21.09	14.91	12.35	6.41	9.64	40.25	38.00	41.54	28.84	24.63	28.12	23.14
56 MW Expansion	10.96	4.67	4.04	4.04	4.85	27.96	26.54	24.87	21.86	15.25	17.89	13.02
Change from Baseline (m^3/s)												
36 MW Expansion	-73.59	-57.06	-41.89	-34.16	-62.15	-151.28	-184.21	-175.64	-162.27	-130.31	-111.80	-98.66
56 MW Expansion	-83.73	-67.29	-50.20	-36.53	-66.93	-163.57	-195.68	-192.30	-169.25	-139.69	-122.04	-108.77

Overall, either of the expansion scenarios would result in less flow entering Trudel Creek. For the majority of the 13-year model simulation period, flow over the SVS would be restricted to the minimum release level of 4 m^3/s under both of the expansion scenarios. However, because of the low storage volume in Twin Gorges and uncontrolled flows from the Tazin River as well as other local watersheds between Nonacho Lake and Twin Gorges, there would be periods when high flows are experienced in Trudel Creek, although at lower magnitudes compared to baseline peak flow levels.

The peak daily flow over the 13-year simulation period would decrease by as much as 250 m^3/s under the 56 MW scenario compared to baseline (Table 14.3.2). Return period peak flows, estimated by conducting a flood frequency analysis of the modelled flows, show a similar decline in magnitude under the expansion scenarios compared to baseline.

Table 14.3.2 — Predicted Peak Flows within Trudel Creek

Peak Flow	Baseline [1] (m^3/s)	36 MW Expansion [2] (m^3/s)	56 MW Expansion [2] (m^3/s)
Maximum Daily Peak over Simulation Period	495	355	244
Return Period Flows			
Q_2	233	62	45
Q_{10}	408	208	161
Q_{50}	578	434	329
Q_{100}	655	572	427

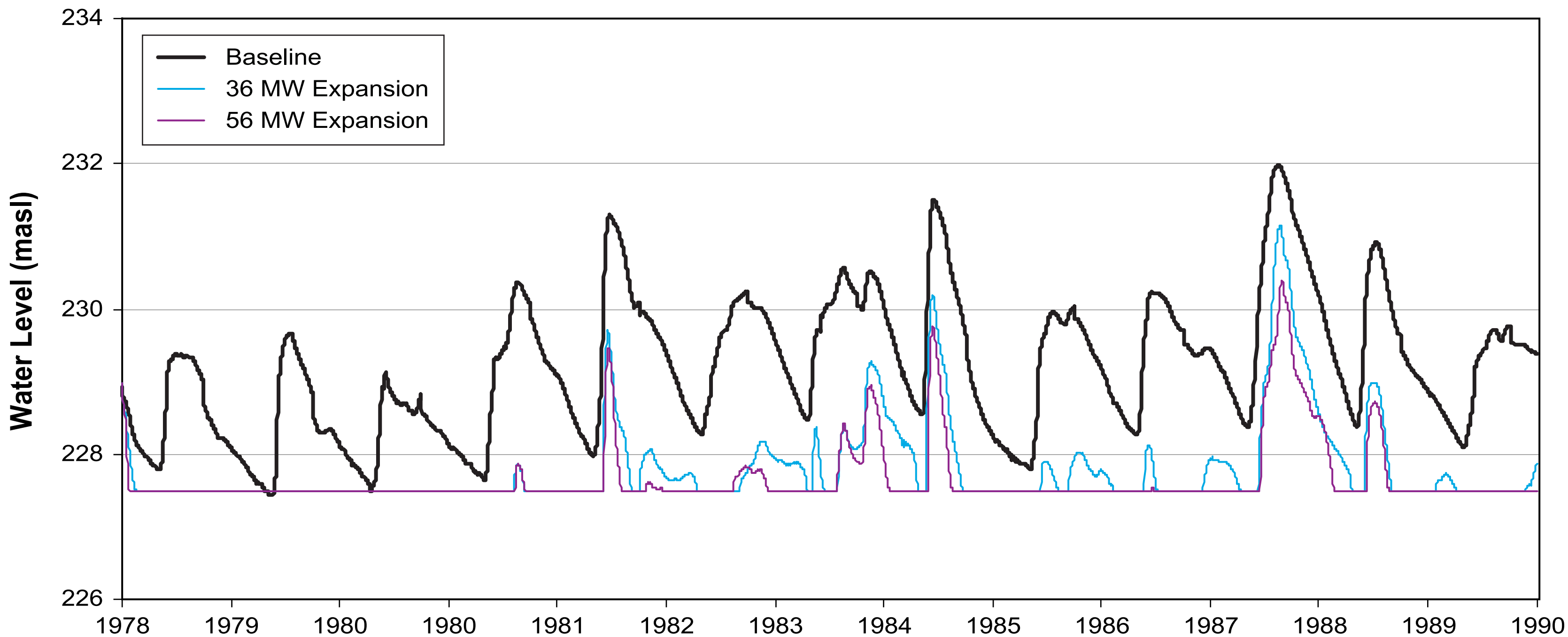
Notes:

QT is the Daily peak flow (Q) expected on average, once every (T) years.

[1] Return period flows based on Log-Pearson Type 3 distribution.

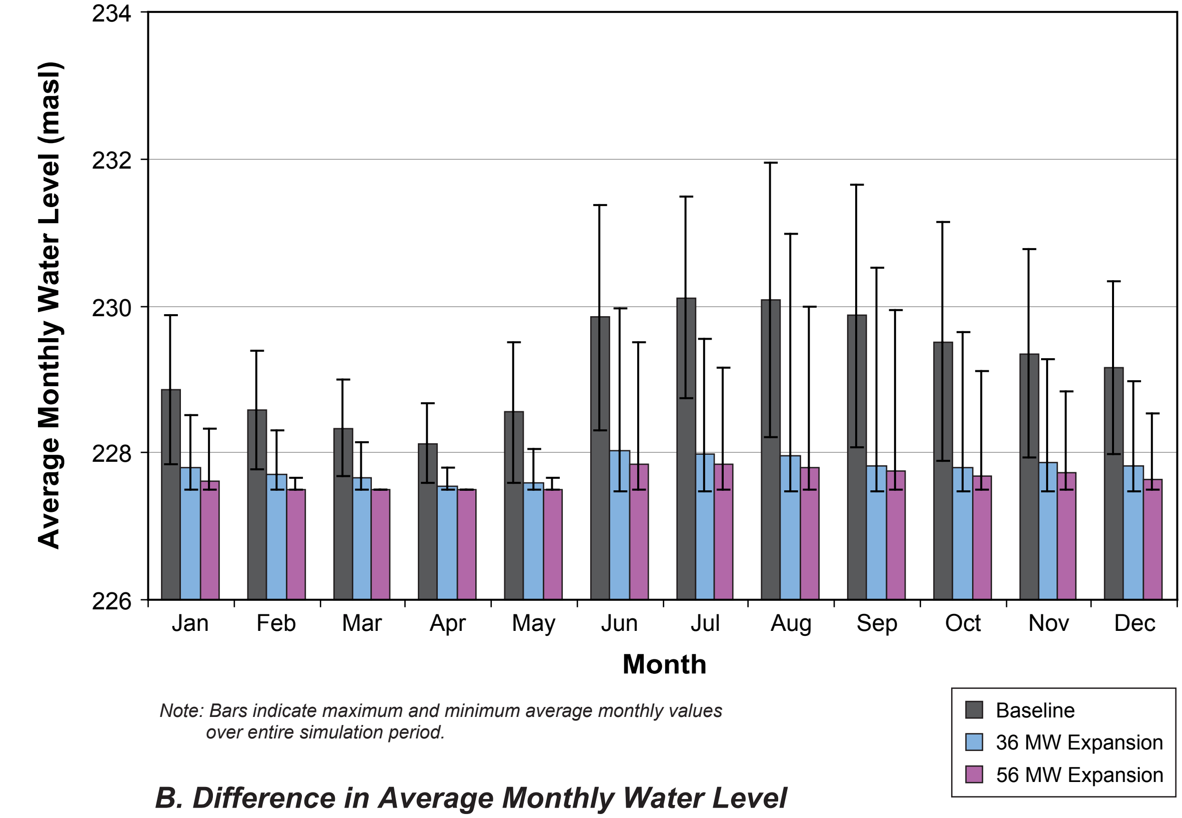
[2] Return period flows based on Generalized Extreme Value distribution.

The range of flows experienced within Trudel Creek under the expansion scenarios would decrease (Table 14.3.3). This is primarily because of the minimum specified flows over the SVS, which would occur for substantial periods of time.

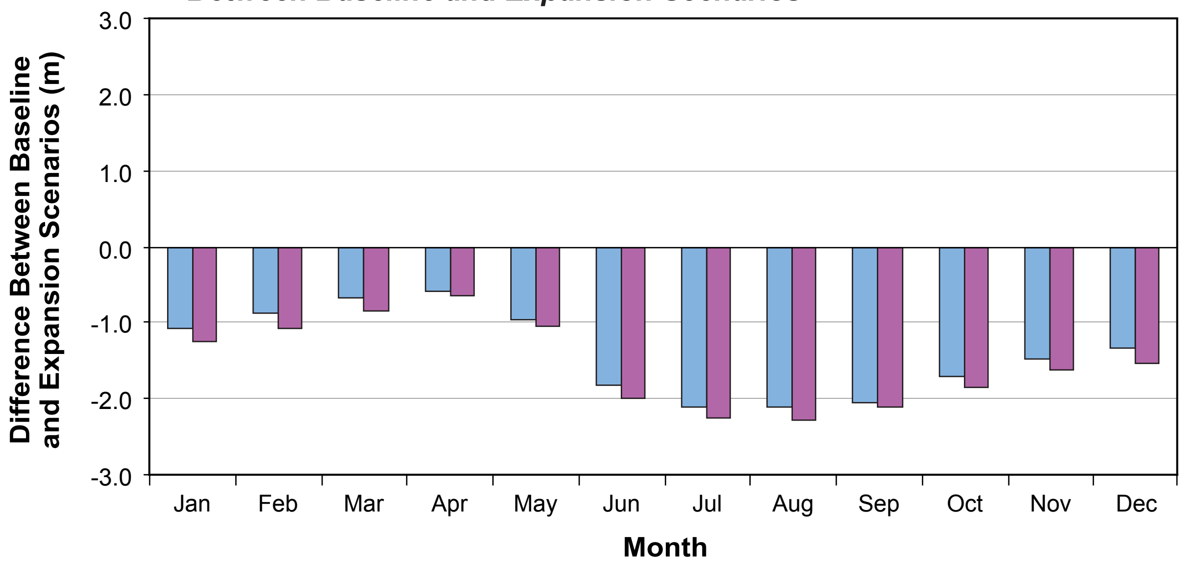


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 5: Trudel Creek at TRUDEL 1 Water Level Time Series (503-005 / a21677f)	Figure 14.3.5

A. Average Monthly Water Level



B. Difference in Average Monthly Water Level Between Baseline and Expansion Scenarios



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Taltson Basin Flow Model Results Zone 5: Trudel Creek at TRUDEL 1 Water Level Monthly Summary (503-005 / a21678f)	Figure 14.3.6

Table 14.3.3 — Predicted Annual Variation in Mean Monthly Flow within Trudel Creek

	Annual Variation in Mean Monthly Flow (m^3/s)
Baseline	181.65
36 MW Expansion	35.13
56 MW Expansion	23.92

For most flow indices, values are expected to decrease in Trudel Creek under the expansion scenarios; during extreme and prolonged dry periods minimum flow in Trudel Creek could increase because of the specified minimum release from Twin Gorges of 4 m^3/s at the SVS. The minimum flow predicted for the baseline scenario was 0.24 m^3/s, which occurred in 1979. Accounting for the uncertainty in the model, a simulated flow of 0.24 m^3/s at the SVS may be viewed as no flow at the SVS. Under the expansion scenarios the SVS would not dewater.

To further examine the expected change in the flow regime in Trudel Creek, flow exceedance curves (Figure 14.3.7) were derived based on results summarized in Table 14.3.1. Under baseline conditions, flow in Trudel Creek was predicted to be above 117 m^3/s approximately 50% of the time, whereas under the expansion conditions, this flow level is predicted to be equalled or exceeded 5% and 3% of the time for the 36 MW and 56 MW scenarios, respectively. For both of the expansion scenarios the 50% exceedance flow in Trudel Creek would be just above the minimum specified SVS release rate of 4.1 m^3/s.

Under both expansion scenarios, water levels throughout Trudel Creek would respond similarly to the predicted changes in flow. Because of the substantial change in average flow conditions within Trudel Creek, an additional modelling exercise was conducted using a one-dimensional hydraulic model to more precisely predict the changes to water levels caused by decreasing flows within Trudel Creek. The results of that modelling study are detailed in the following sections.

The Flow Model was used to address "normal operations" of the Project only. Outage scenarios were not considered. However outages would occur to allow for routine maintenance or as a result of accidents and malfunctions, see Sections 6.6 and 6.7. A discussion of scheduled outage scenarios and associated impacts to flow and water levels in the Twin Gorges Forebay and the Taltson River below Twin Gorges is provided in Section 14.3.3 (Ramping from Annual Scheduled Outages). Section 14.3.3 incorporates flows at the power facilities simulated by the Flow Model but applies the outage scenario external to the model.

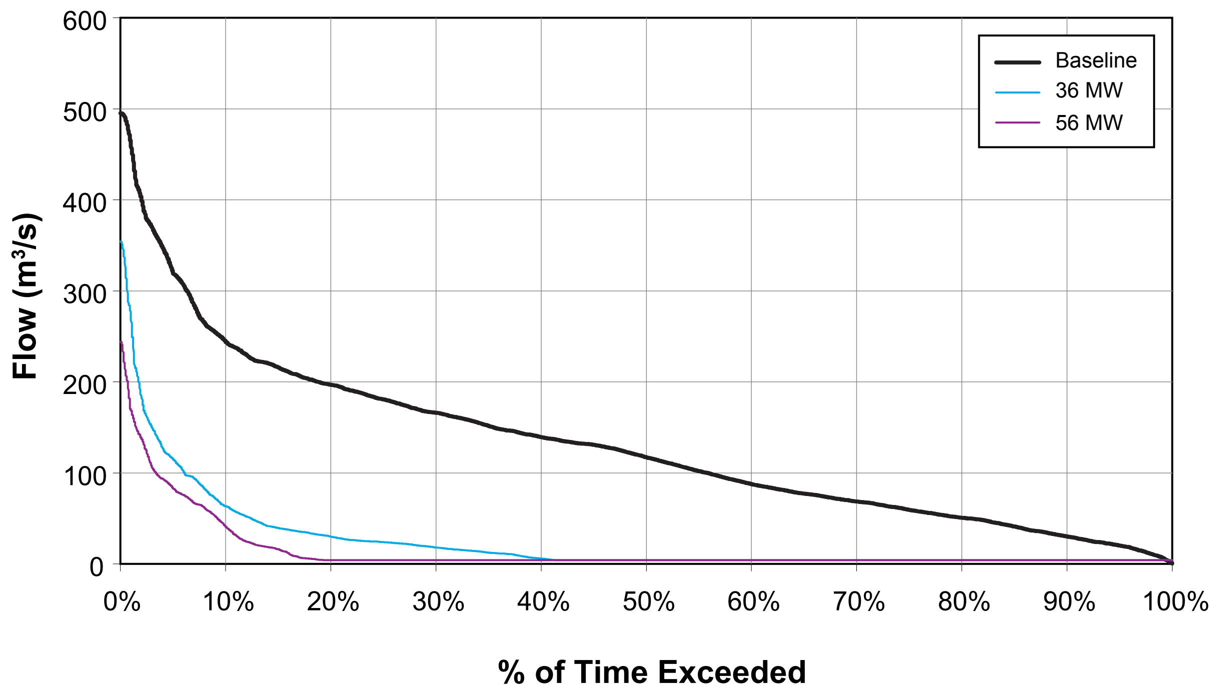
14.3.2 Trudel Creek HEC-RAS Model

14.3.2.1 Model Methodology

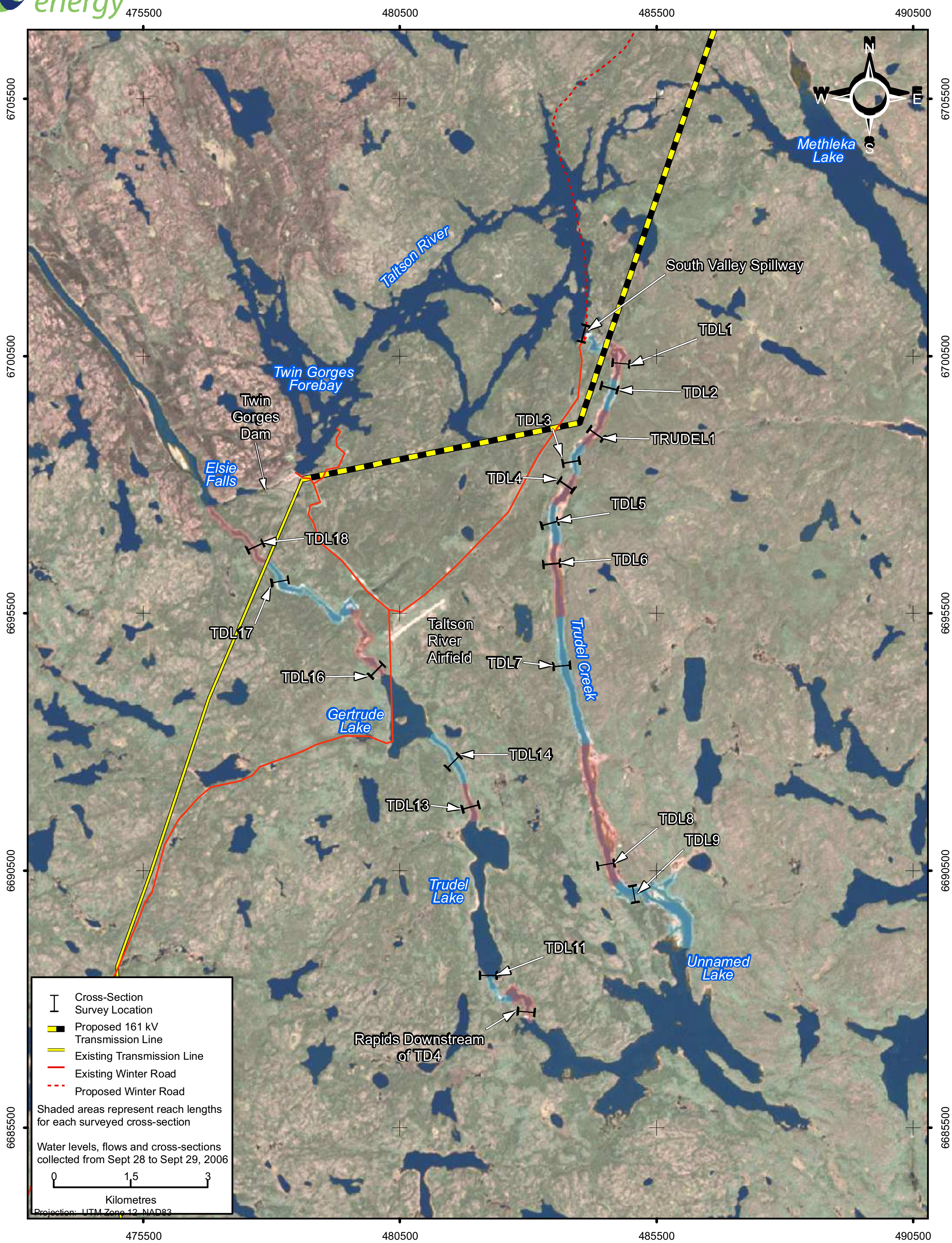
The hydraulic model of Trudel Creek was set up with HEC-RAS modelling software (version 3.1.3), which was developed by the US Army Corps of Engineers to perform one-dimensional, steady-state and unsteady-state hydraulic calculations for constructed and natural channels (US Army Corps of Engineers, 2008).

14.3.2.1.1 Cross-sections of Trudel Creek

Detailed survey data for 18 cross-sections along Trudel Creek were collected during field studies in the fall of 2006. Cross-sections were surveyed at locations where there were changes in river form that were considered representative of a given river reach (Figure 14.3.8). Rapids could not be surveyed because of safety concerns and access issues, so cross-sections for these hydrologic features were inferred based on field observations and aerial photographs. Inferred cross-sections include the outlets of Unnamed, Trudel, and Gertrude lakes, and the pinch-points and rapids sections downstream of Unnamed and Gertrude lakes.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Trudel Creek Flow Exceedance Curves (503-005 / a21400m)	Figure 14.3.7



TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report 2009**	**Trudel Creek Survey Locations and Cross-Sections Used in HEC-RAS Modelling**	**Figure 14.3.8**

gis no. TAL-10-005DAR

14.3.2.1.2 Approach to Modelling Lakes

Lakes are modelled as storage areas represented as water volume-elevation curves. Lake bathymetry data were used to construct the volume-elevation relationship (Appendix 14.3A). The water level in the lakes is controlled by storage and the geometry of the lake outlet. This modelling method approach approximates the linear reservoir or modified Puls routing method.

There is a degree of uncertainty related to the outlet geometry of the lakes. The geometry is estimated using the available bathymetry data and downstream cross-section data. It was not possible to directly measure the outlet geometry in the field because of safety and access issues. The lake outlets consist of fast-flowing rapids and/or waterfall sections that are inaccessible for measurement.

14.3.2.1.3 Model Boundary Conditions and Initial Conditions

The upstream boundary condition is the expected flow in Trudel Creek as simulated by the Taltson Basin Flow Model (Sections 9.3 and 13.3). The Taltson Basin Flow Model results for Trudel Creek include flow over the SVS as well as local inflows to Trudel Creek. As the lower reach of Trudel Creek is affected by flow through the power plants, this is also used as an upstream boundary condition for a tributary that represents the power plant tailrace. The model is run in a pseudo-unsteady state, such that each flow of interest is run within the model until water levels in the lakes and river cross-sections reach a steady-state value.

The initial water levels within the lakes and river cross-sections for the pseudo-unsteady state runs were generated by first performing a steady-state run of the system. Output from the steady-state simulation was then applied as initial conditions for the pseudo-unsteady flow analysis.

The downstream boundary condition for the model is the rating curve developed for the Taltson River downstream from the Twin Gorges existing facility.

14.3.2.1.4 Model Parameter Estimation

A key parameter used in the model is the channel friction represented as the Manning's roughness coefficient or Manning's n. Manning's n is set at 0.04 for the Trudel Creek channel and the flood plain beyond the banks is set at n = 0.09. These values were chosen based on channel bed characteristics and vegetation (Hicks & Mason, 1998). Channel friction is held constant for all cross-sections along Trudel Creek.

14.3.2.1.5 Model Calibration

Steady-state model calibration was performed using observed data for flows and water levels collected in 2006. The water levels predicted using the Trudel Creek HEC-RAS model are within 1% of measured values.

14.3.2.2 FLOW SCENARIOS

The purpose of the modelling study was to predict the water levels in Trudel Creek under the proposed 36 MW and 56 MW expansion conditions and compare these water levels with baseline conditions. The primary flow scenarios that are used as input to the HEC-RAS model are the mean monthly flows for Trudel Creek and the power plant(s) as simulated by the Taltson Basin Flow Model (Sections 9.3 and 13.3, Table 14.3.4).

Table 14.3.4 — Predicted Mean Monthly Flows Used for HEC-RAS Modelling

Month	Baseline Flow (m^3/s)		36 MW Flow (m^3/s)		56 WM Flow (m^3/s)	
	Trudel Creek	Power Plants	Trudel Creek	Power Plants	Trudel Creek	Power Plants
January	97	50	21	156	11	152
February	72	50	15	154	4.7	126
March	54	50	13	140	4.0	105
April	41	50	6.8	124	4.0	90
May	72	50	9.6	131	4.7	122
June	191	30	40	164	28	190
July	222	30	36	158	26	203
August	217	30	41	160	25	213
September	191	30	28	160	22	201
October	155	50	24	159	15	194
November	140	50	28	159	18	187
December	122	50	23	157	13	171

In addition to the monthly flows predicted using the Taltson Basin Flow Model, the predicted maximum daily flow over the 13-year simulation period for the baseline, 36 MW, and 56 MW expansion scenarios were also modelled in the Trudel Creek HEC-RAS model to provide an upper limit of water level fluctuation (Table 14.3.5).

Table 14.3.5 — Predicted Maximum Daily Flows Used for HEC-RAS Modelling

Scenario	Trudel Creek (m^3/s)	Power Plants (m^3/s)
Baseline	495	30
36 MW Expansion	355	180.6
56 MW Expansion	244	240

The model scenarios describing the proposed facility expansions include a provision that the minimum release of flow to Trudel Creek would be 4 m^3/s. However, to provide a lower limit to water level predictions in Trudel Creek, a zero flow scenario was also run in the HEC-RAS model using a flow of 0.5 m^3/s in Trudel Creek. This is the lowest flow that could be modelled using the current configuration without the results becoming unstable. Using a 0.5 m^3/s flow produces results that are similar to a zero-flow scenario in that the water slope along the creek is flat and the water levels are equal to the invert elevations of the outlet of the lake downstream of the reach.

This flow scenario provides minimum water level predictions for lakes in the Trudel system and identifies sections of Trudel Creek that are susceptible to dewatering.

14.3.2.3 RESULTS

Model predictions of hydraulic parameters including water level, average velocity, cross-sectional flow area, top width, and wetted perimeter for 18 cross-sections along Trudel Creek are summarized in Appendix 14.3B.

The predicted water levels for Trudel Creek are shown in a series of cross-sections in Figure 14.3.9 to Figure 14.3.25. Each cross-section shows the range in water levels for the predicted mean monthly flows of the baseline and expansion scenarios. Also presented in the figures are the predicted daily maximum water level for the baseline and expansion scenarios, and the water level predicted at near-zero (0.5 m^3/s) flow.

In general, the water level in Trudel Creek is controlled by the elevation of the invert of each lake outlet. If the flows were to drop to zero, the water level upstream of each lake would drop to the elevation of the lake outlet. Because the creek is low gradient, Trudel Creek would not completely dewater if it experienced a zero flow scenario; however, there is potential to lose connectivity between the lakes. The short, steep rapids sections may not maintain an appreciable depth based on model predictions.

The difference between baseline expansion scenario conditions predicted in Trudel Creek for depth, average channel velocity, channel width, and wetted perimeter averaged over the range of modelled monthly mean flows are summarized in Table 14.3.6 and Table 14.3.7. The difference between baseline and expansion scenario conditions for depth, average channel velocity, channel width, and wetted perimeter averaged over all cross-sections in Trudel Creek on a mean monthly basis are presented in Table 14.3.8 and Table 14.3.9.

The monthly average depth, surface area, and% change from baseline conditions of the three main lakes in Trudel Creek under the 36 MW and 56 MW expansion scenarios are presented in Table 14.3.10, Table 14.3.11, Table 14.3.12.

In general, the flows through Trudel Creek decrease with increased flows through the power plant and increased regulation of releases from Nonacho Lake. For cross-sections upstream of Gertrude Lake, the range in monthly predicted water levels decreases, as does the overall water level in the creek. For the 36 MW expansion scenario, the maximum monthly water level is similar to the minimum monthly water level predicted for baseline conditions. In many cross-sections for the 56 MW expansion scenario, the water level in the creek approaches the level predicted for the zero-flow scenario. The predicted maximum daily water level over the 13-year simulation period decreases for both the 36 MW and 56 MW expansion scenarios.

Downstream of Gertrude Lake (cross-sections TDL17 and TDL18), predicted water levels are affected by backwater within the Taltson River downstream of where the power plant flow enters the river. Therefore, water levels downstream of Gertrude Lake are a result of the combined flow through the power plants and flow within Trudel Creek. During baseline flows, the flow through Trudel Creek is much larger than the plant flow and water levels in this reach respond similarly to flow in upstream reaches. When flows through the plant are increased in the expansion scenarios, this creates a backwater condition in the lower reach of Trudel Creek. The variation in predicted monthly water levels decreases for the expansion scenarios, but the minimum monthly water level is at or above the baseline minimum. This would occur because the minimum monthly combined flows for Trudel Creek and the power plants under the expansion scenarios (131 m^3/s and 94 m^3/s for the 36 MW and 56 MW scenarios, respectively) would be greater than baseline conditions (91 m^3/s). The zero flow scenario water levels in this reach are higher than most of the simulated range in monthly mean water levels because the zero-flow scenarios were run in the model with maximum plant discharge (180 m^3/s and 240 m^3/s for the 36 MW and 56 MW scenarios, respectively). The velocity through this section decreases from baseline conditions for the expansion scenarios, further illustrating the backwater effect.

14.3.3 Ramping from Annual Scheduled Outages: Trudel Creek

Outages at the Twin Gorges power facility would be scheduled on an annual basis to conduct routine maintenance. The following section discusses the associated ramping of flow and water levels in Trudel Creek; ramping in the Twin Gorges Forebay and the Taltson River below Twin Gorges is discussed in more detail in Section 13.3.4 (Ramping from Annual Scheduled Outages). Outages would also occur as a result of accidents/malfunctions and effects of the environment (e.g., lightning). Ramping resulting from unplanned and unscheduled events is discussed in Chapter 17 (Accidents and Malfunctions), Sections 17.4 (Ramping Trudel Creek) and 17.5 (Taltson Basin).

Scheduled shutdowns would occur once a year for each turbine for regular maintenance. Each turbine would be inoperative for approximately one week. Maintenance of the turbines would be completed sequentially rather than simultaneously, such that as one turbine is brought back on-line another turbine would be taken off-line. Thus, a scheduled partial shutdown of the existing 18 MW and two proposed 18 MW turbines for a 36 MW expansion, or two 28 MW turbines for a 56 MW expansion, would last approximately three consecutive weeks. The preferred timing of the annual outages would be scheduled to occur just prior to the onset of freshet, which generally occurs in April or May.

During the annual outages, the aim would be to reduce any resulting ramping of flow and levels in the Forebay, the Taltson River below Twin Gorges, or in Trudel Creek. If full generation flow (180.6 m^3/s and 240 m^3/s for the 36 MW and 56 MW expansions, respectively) was not occurring at the power plants at the time of the outage, then the flow that had been conveyed through a turbine being taken off-line would be passed to the remaining two turbines. If the pre-outage flow in the Forebay was greater than the combined capacity of any two of the turbines, the South Gorge by-pass spillway would be operated to allow up to 30 m^3/s of excess flow to continue to pass to the Taltson River below Twin Gorges, rather than having it re-route through Trudel Creek. In the event the pre-outage flow was greater than the combined capacity of two of the turbines and the South Gorge spillway, staging of levels would occur in the Forebay and ramping of flows would occur in the Taltson River below Twin Gorges and in Trudel Creek.

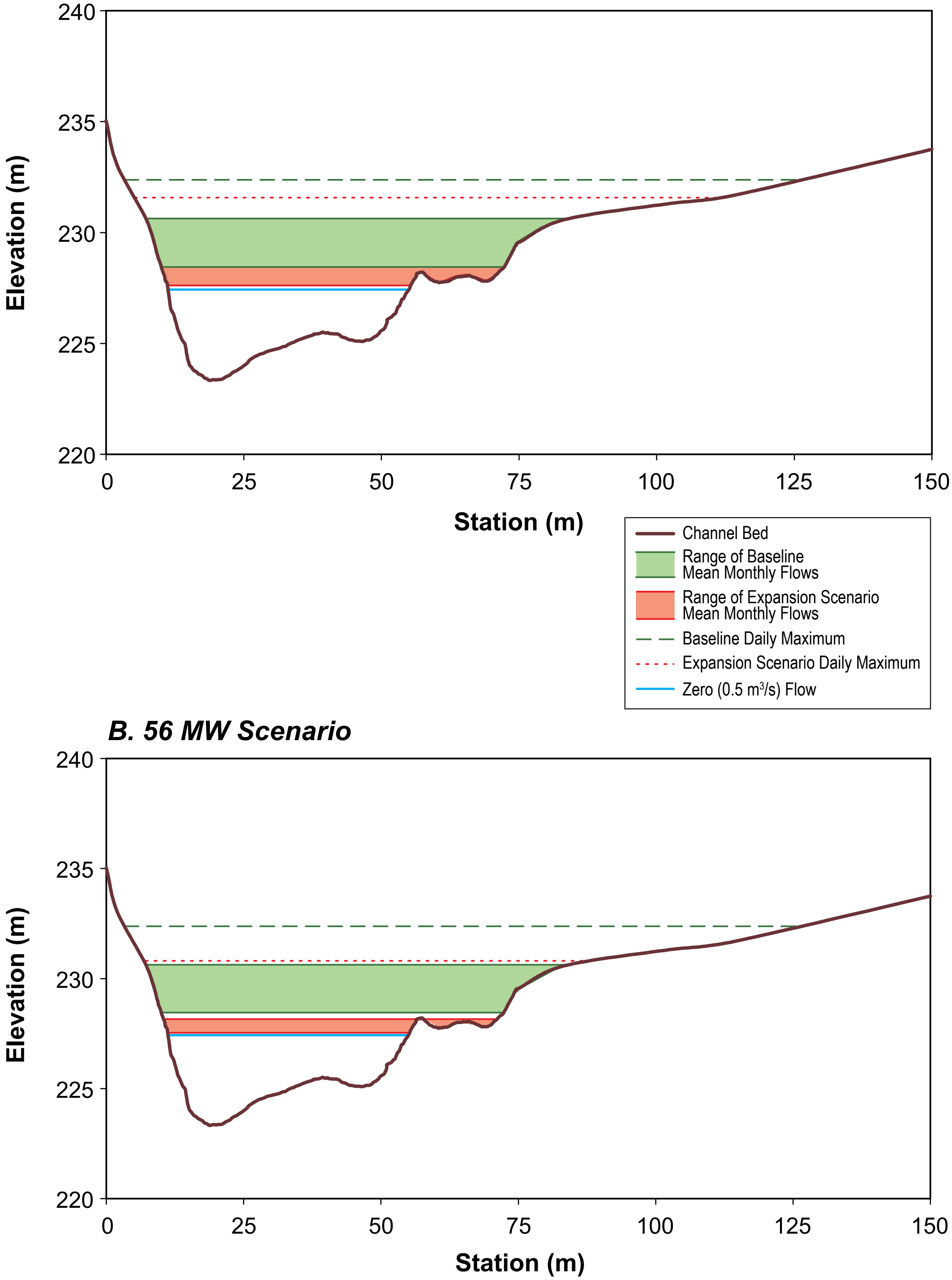
The greatest ramping of levels and flows would occur if all turbines would be running at full capacity when the outage commenced. Based on the Flow Model results, this was estimated to occur six times in April or May during the 13-year model simulation period for the 36 MW expansion scenario and once for the 56 MW expansion scenario. The 13-year model period represents historical runoff in the Taltson Basin for the period of 1978 to 1990 and is a subset of a longer period of record (see Section 9.3.3 - Taltson Basin Hydrology) available below Twin Gorges. Although the model period was limited to 13 years, it contained the highest recorded annual flow as well as the second and fourth lowest annual flow on record. Therefore, the period represents a wide range of expected hydrological conditions in the area.

Assuming full generation flow was occurring at the time of an outage, upon initial shutdown of a turbine, the level would rise in the Forebay and increase the discharge over the SVS to Trudel Creek. The South Gorge Spillway would be operated and 30 m^3/s would pass to the Taltson River below Twin Gorges, reducing the increase in flow to Trudel Creek. Discharge over the SVS would peak approximately six hours following the initial turbine shutdown and would remain elevated throughout the three-week period estimated to perform maintenance of three turbines. Through the successive re-start and shutdown of the three turbines, ramping to a lesser degree would occur as the maintenance shifts from an expansion turbine to the existing turbine and vice versa, depending on the order that the turbines are serviced. Additional ramping would not occur between the re-start of one expansion turbine and shutdown of another, as the expansion turbines would have the same flow-through capacity. Upon the re-start of the final turbine, the South Gorges Spillway would be closed, and flow over the SVS would decrease to background levels over a period of approximately six hours.

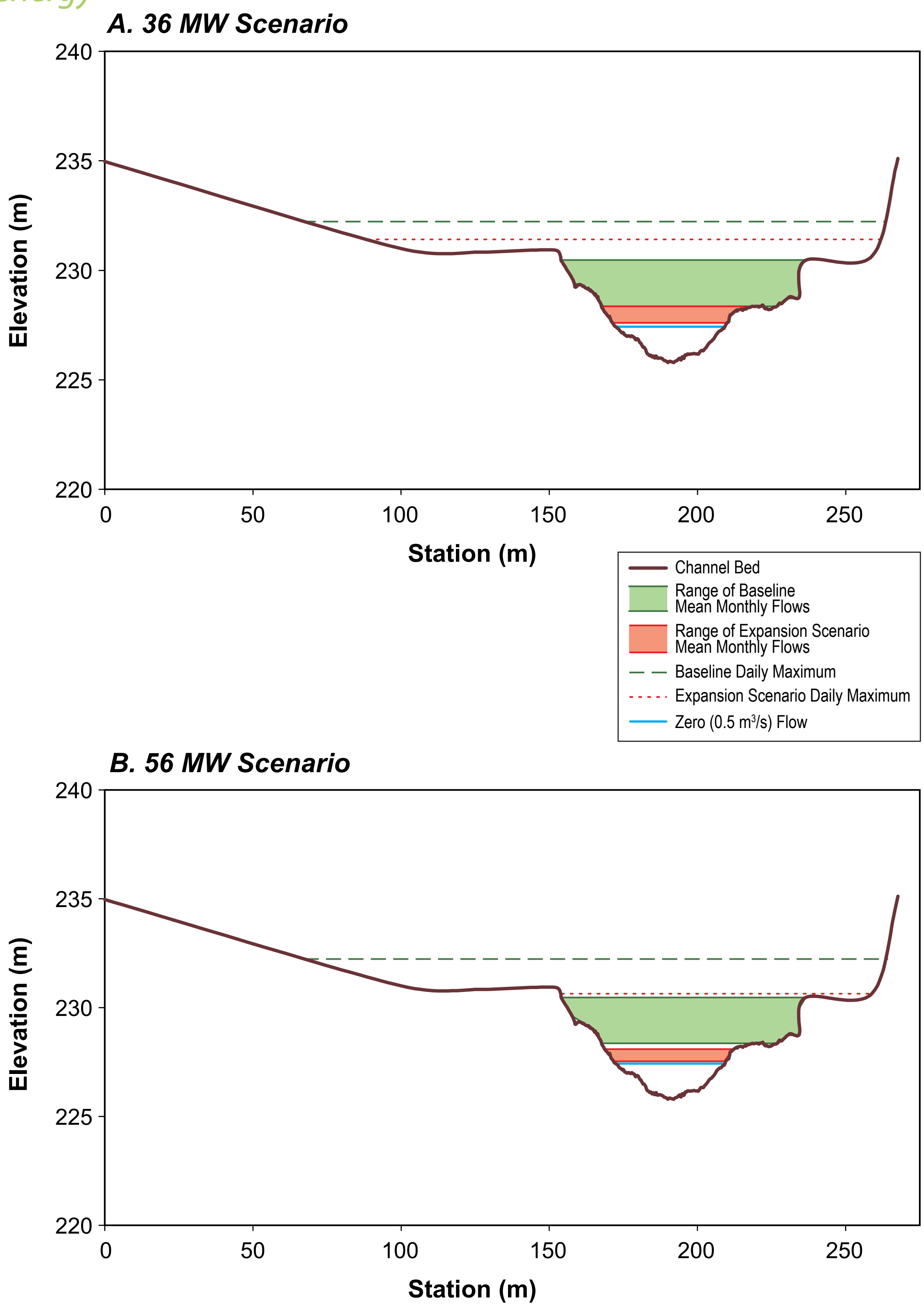
The change in flow and levels in Trudel Creek as a result of a scheduled outage would depend on the pre-outage flow in the basin as well as the final size of the Expansion Project turbines. Table 14.3.13 presents the estimated change in flow and water levels assuming that full generation is occurring prior to the outage. The estimated pre-outage flows in Trudel Creek were based on average daily Flow Model results in April and May when full generation was occurring at the power plants.

Flow in Trudel Creek would change by up to 44 m^3/s (for the existing turbine) from estimated pre-outage conditions for the 36 MW expansion and by up to 53 m^3/s (for an expansion turbine) for the 56 MW scenario. Based on average April and May background flow in Trudel Creek during periods of full generation flow at the power plants, the resulting changes in water level would be up to 0.68 m for the 36 MW expansion and up to 0.79 m for the 56 MW expansion.

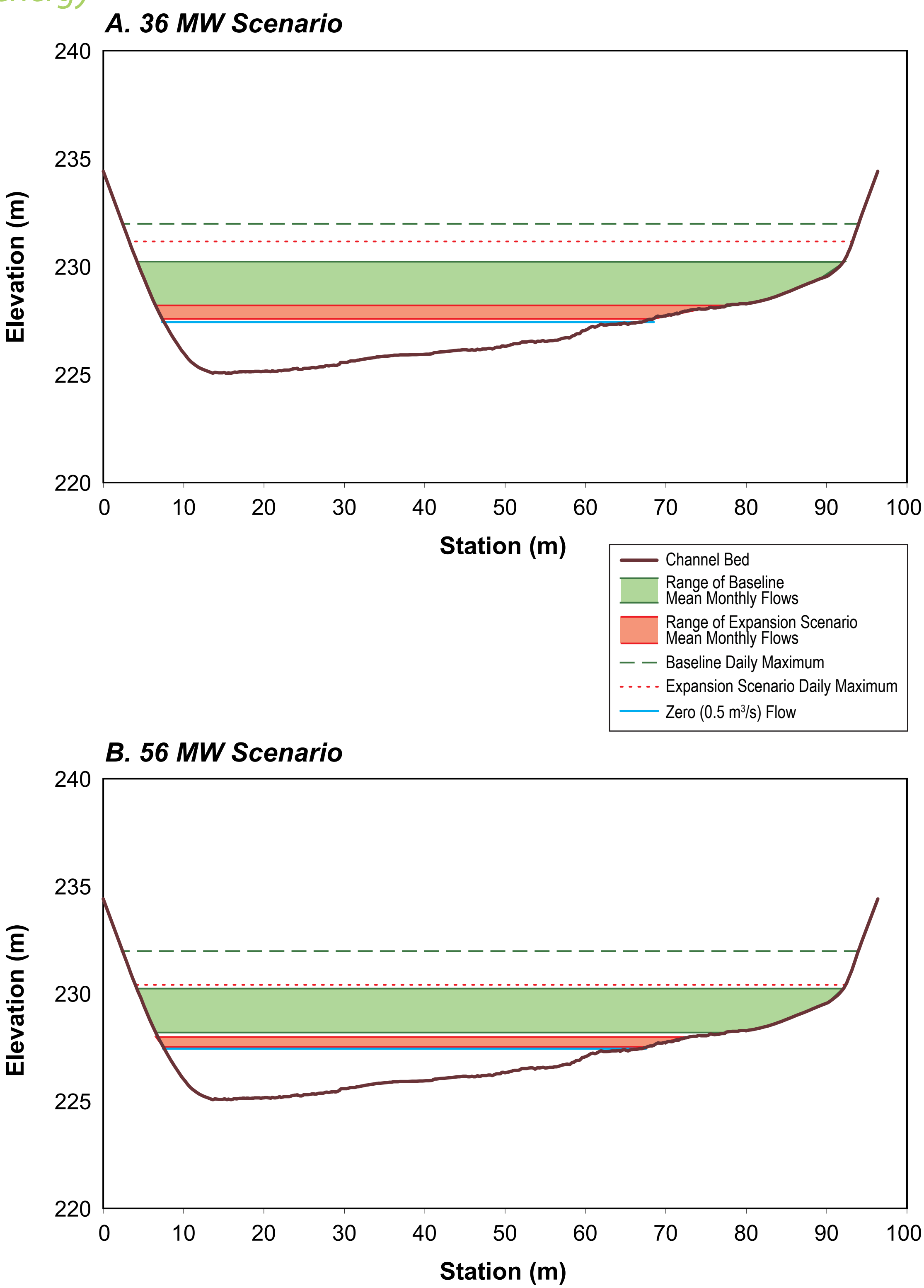
A. 36 MW Scenario



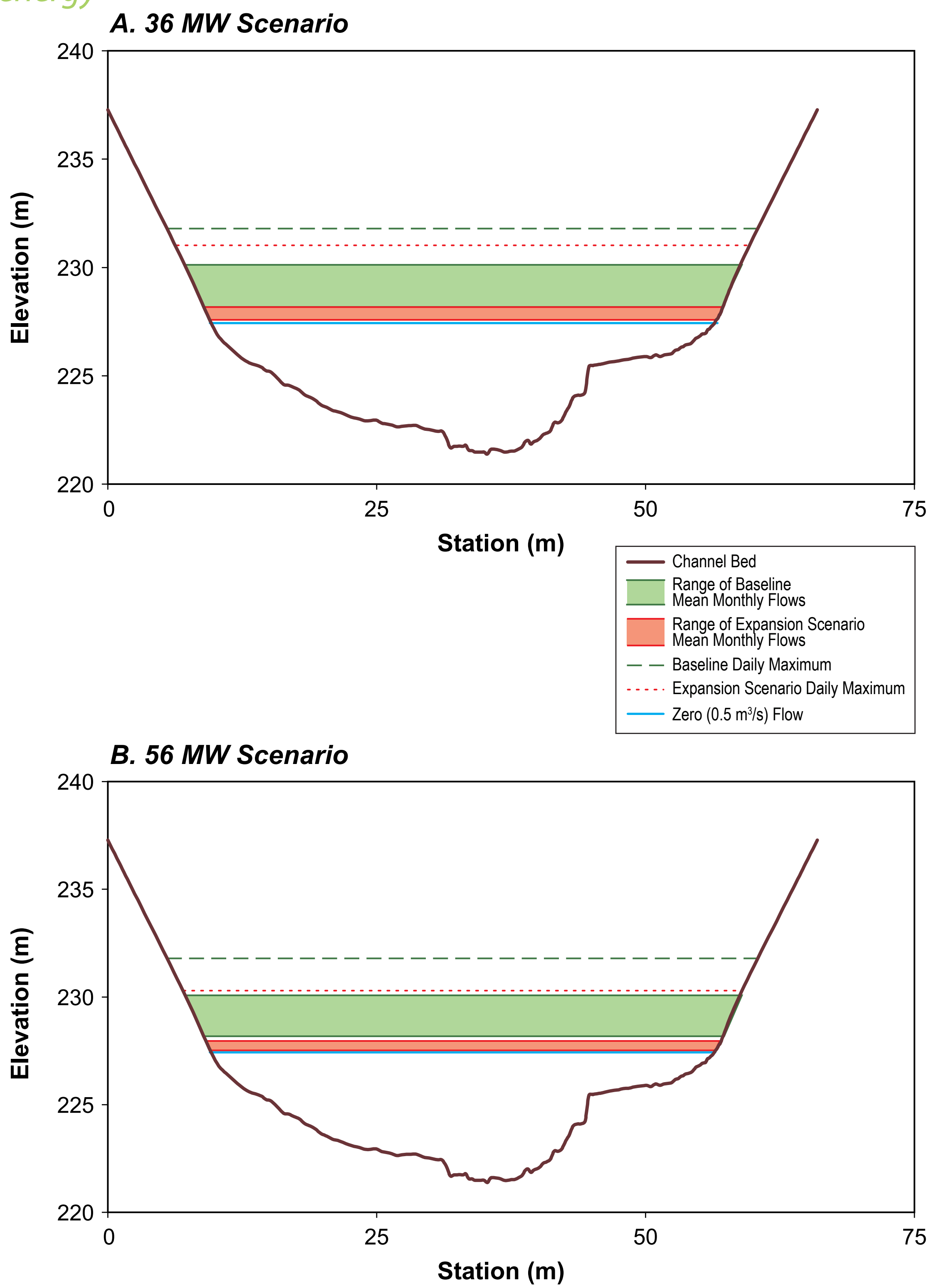
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL1 (503-005 / a21401m)	Figure 14.3.9



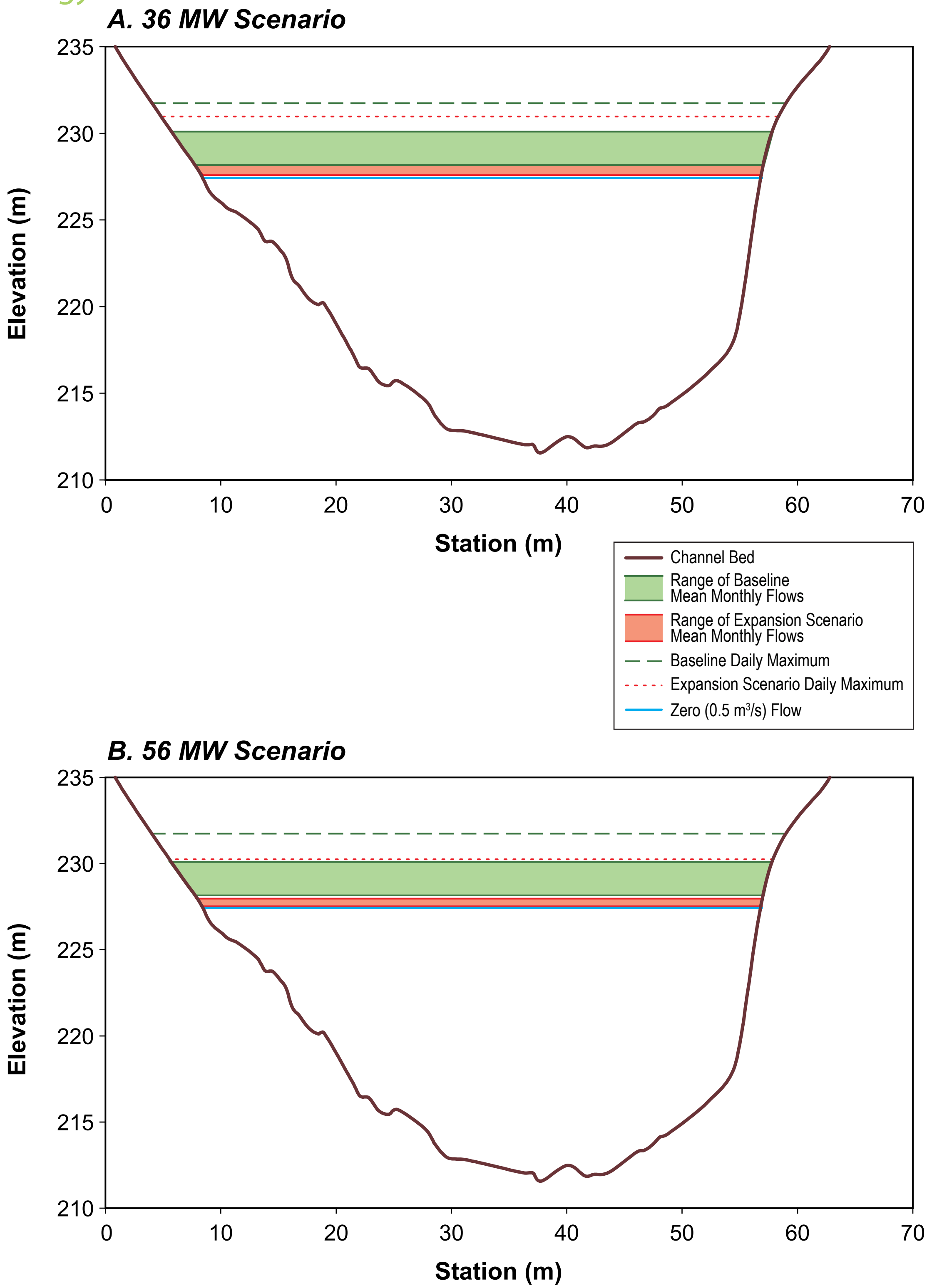
TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Predicted Water Levels at Cross Section TDL2** (503-005 / a21402m)	**Figure 14.3.10**



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TRUDEL 1 (503-005 / a21403m)	Figure 14.3.11

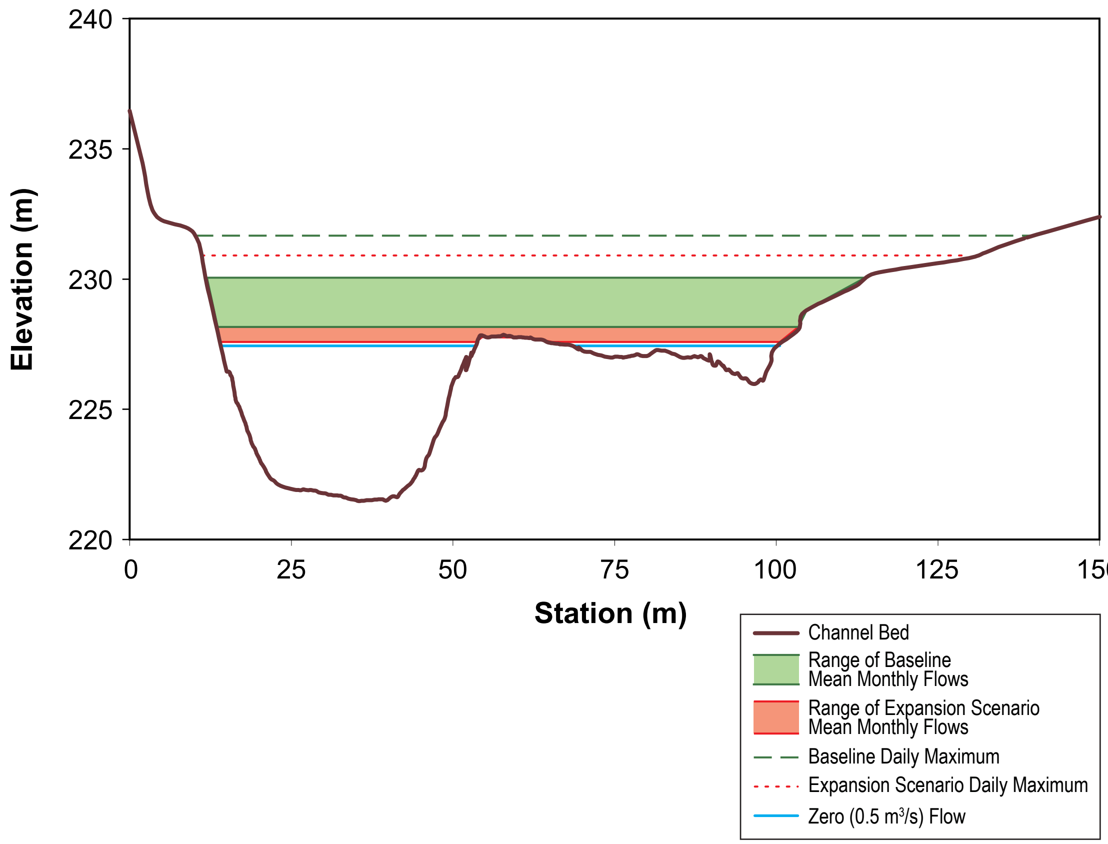


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Predicted Water Levels at Cross Section TDL3** (503-005 / a21404m)	**Figure 14.3.12**

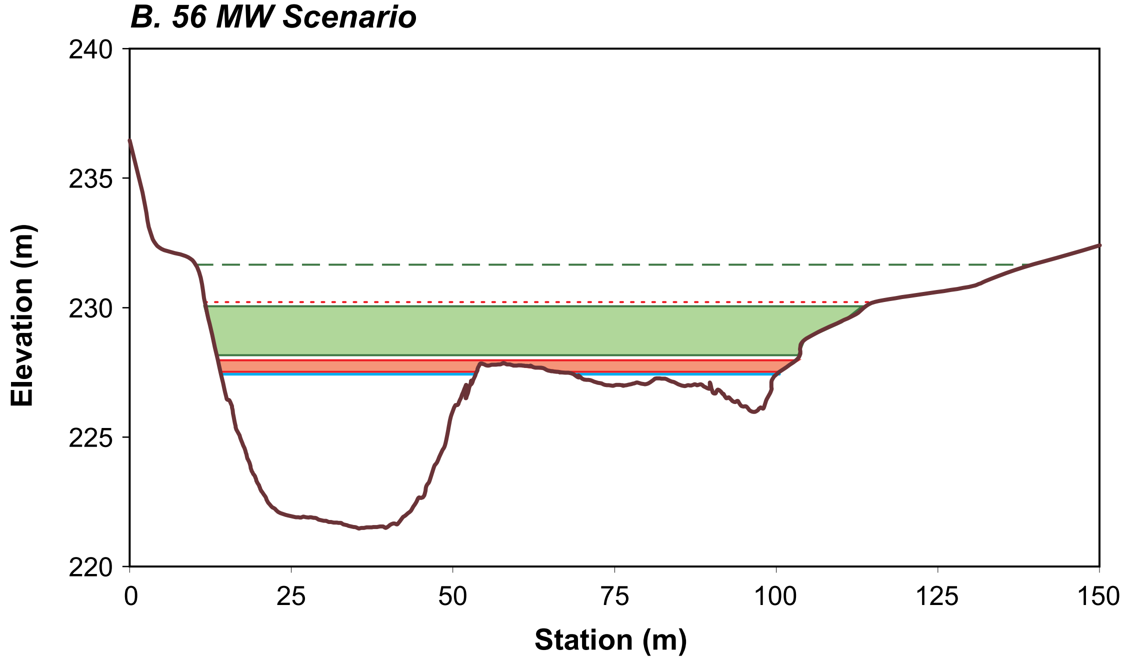


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL4 (503-005 / a21405m)	Figure 14.3.13

A. 36 MW Scenario

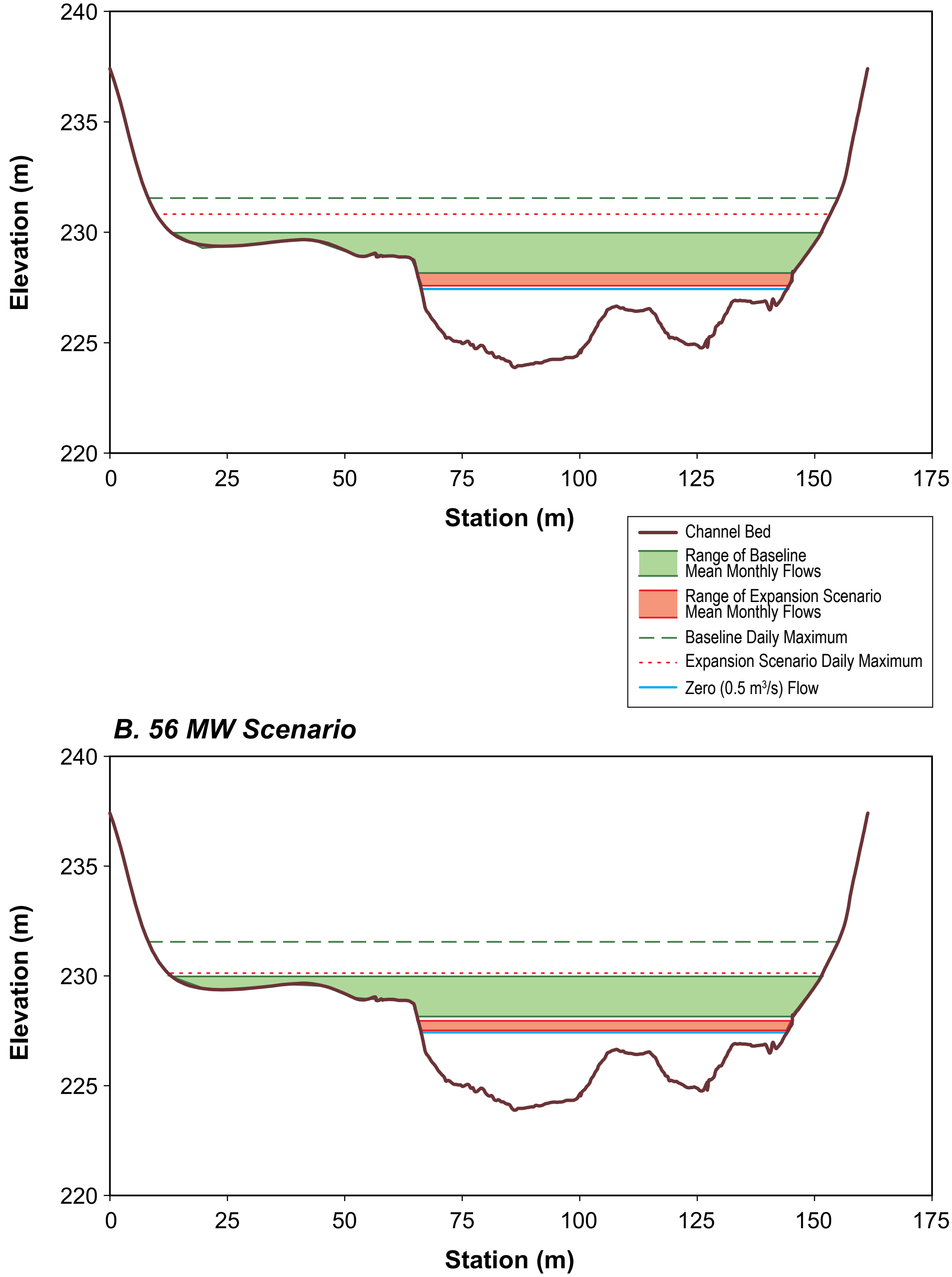


B. 56 MW Scenario

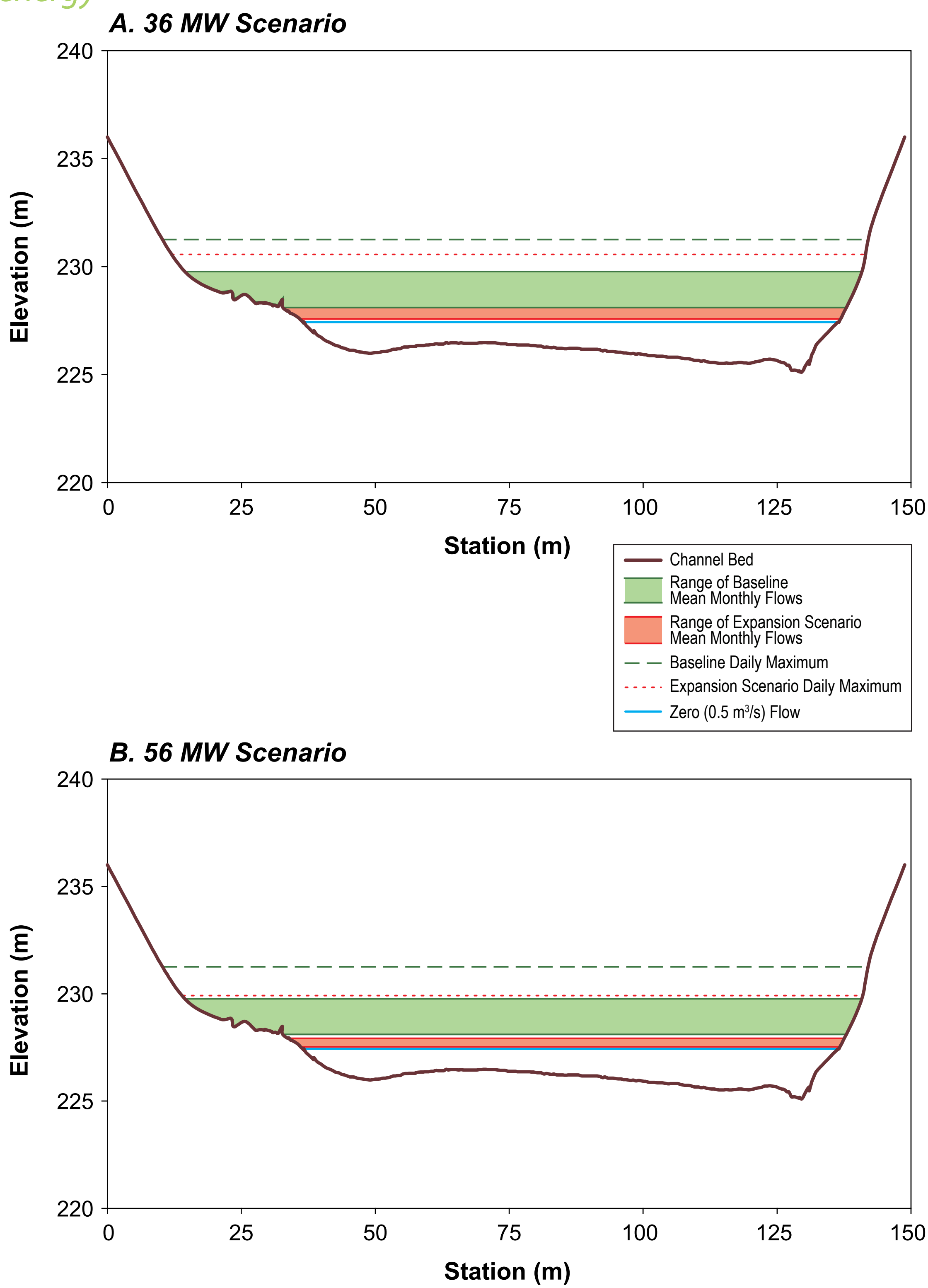


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL5 (503-005 / a21406m)	Figure 14.3.14

A. 36 MW Scenario

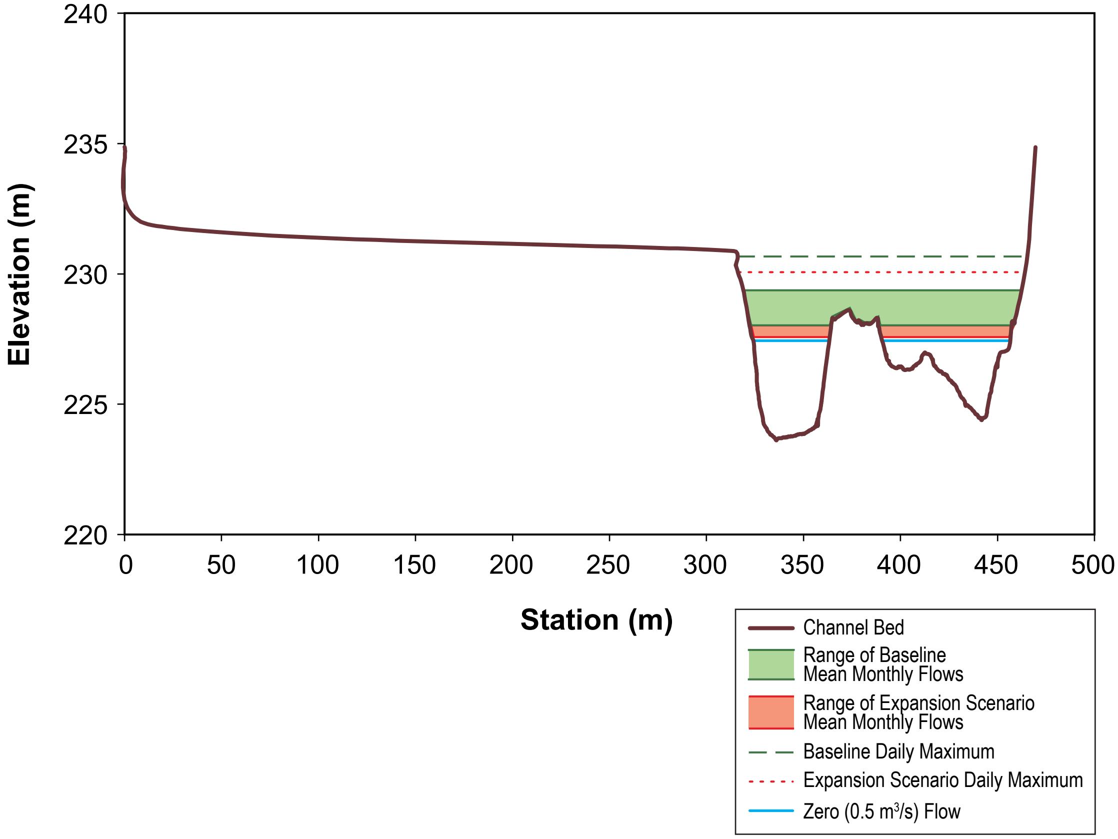


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL6 (503-005 / a21407m)	Figure 14.3.15

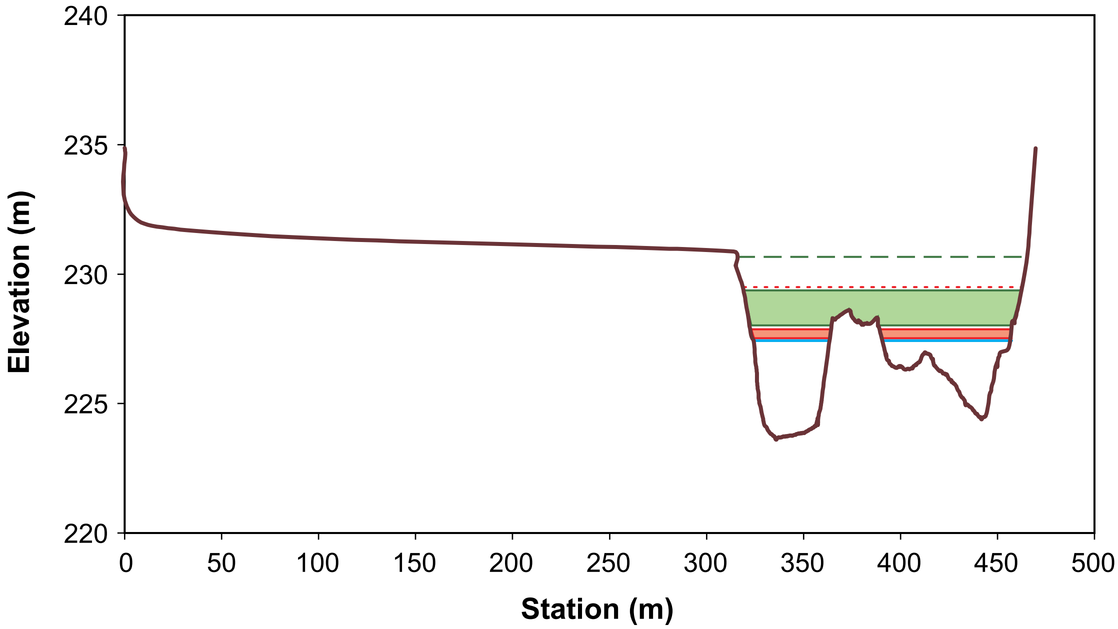


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL7 (503-005 / a21408m)	Figure 14.3.16

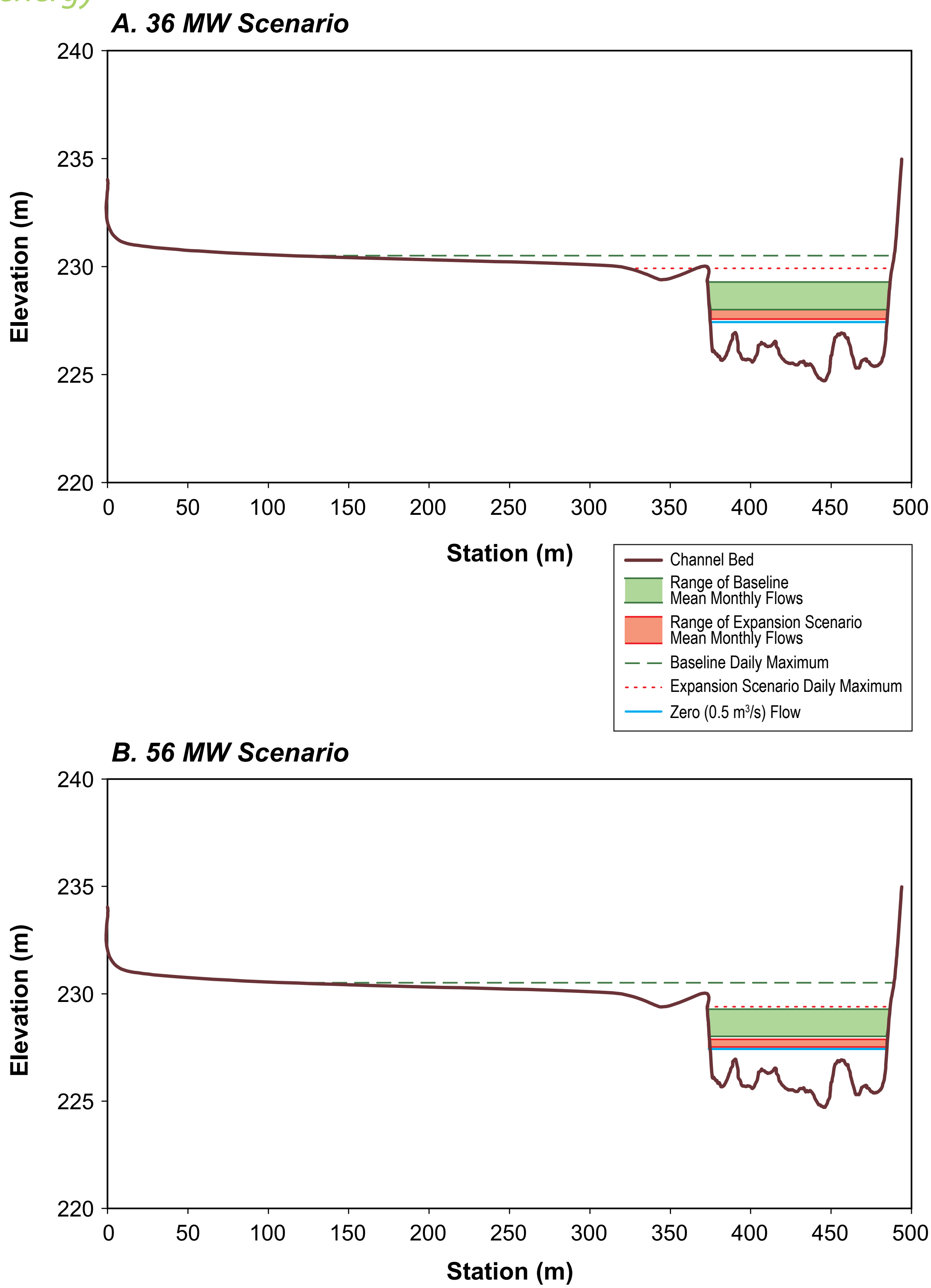
A. 36 MW Scenario



B. 56 MW Scenario



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Predicted Water Levels at Cross Section TDL8** (503-005 / a21409m)	**Figure 14.3.17**



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL9 (503-005 / a21410m)	Figure 14.3.18

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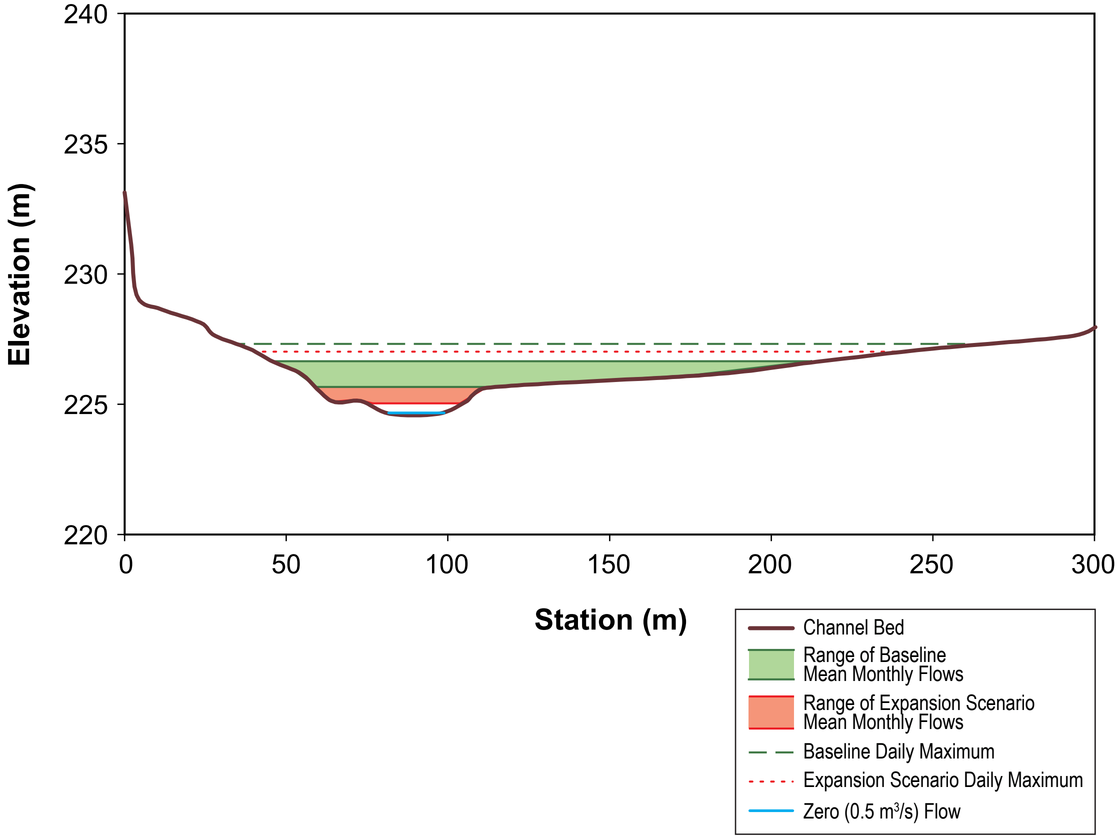
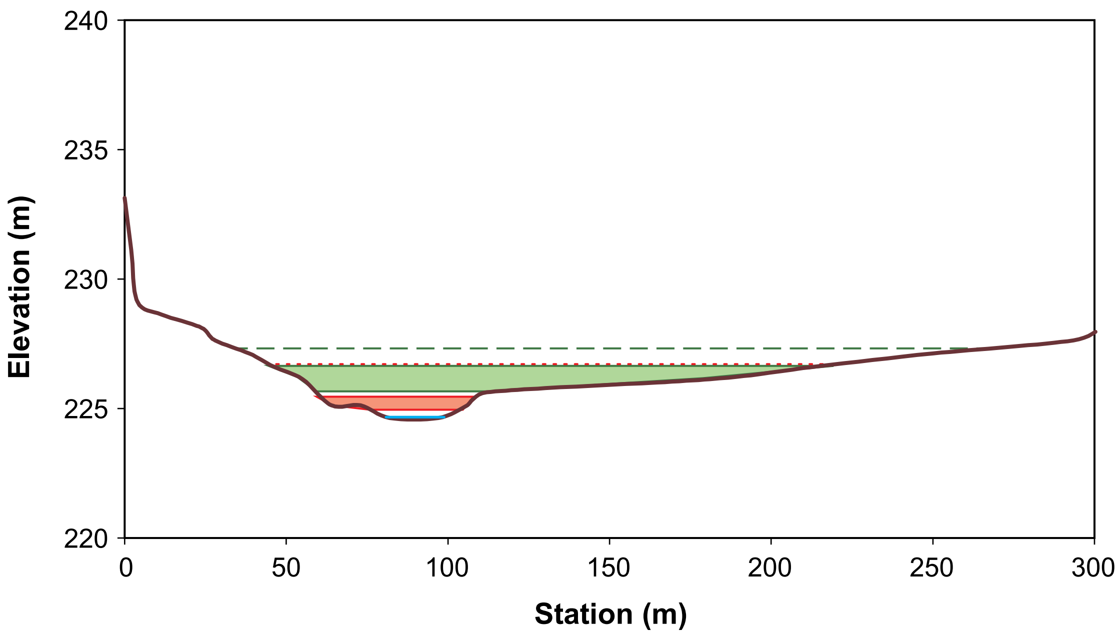
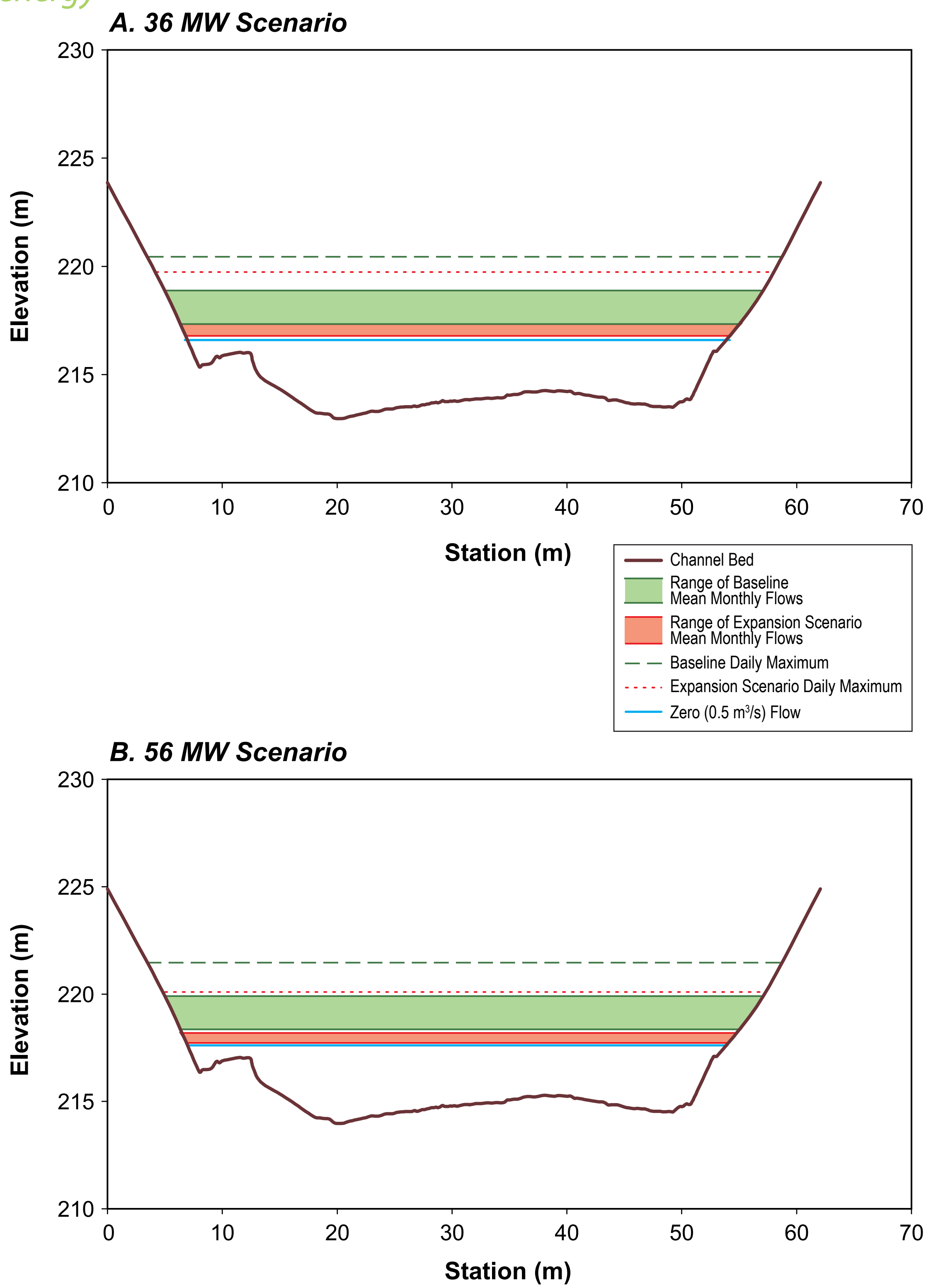
A. 36 MW Scenario



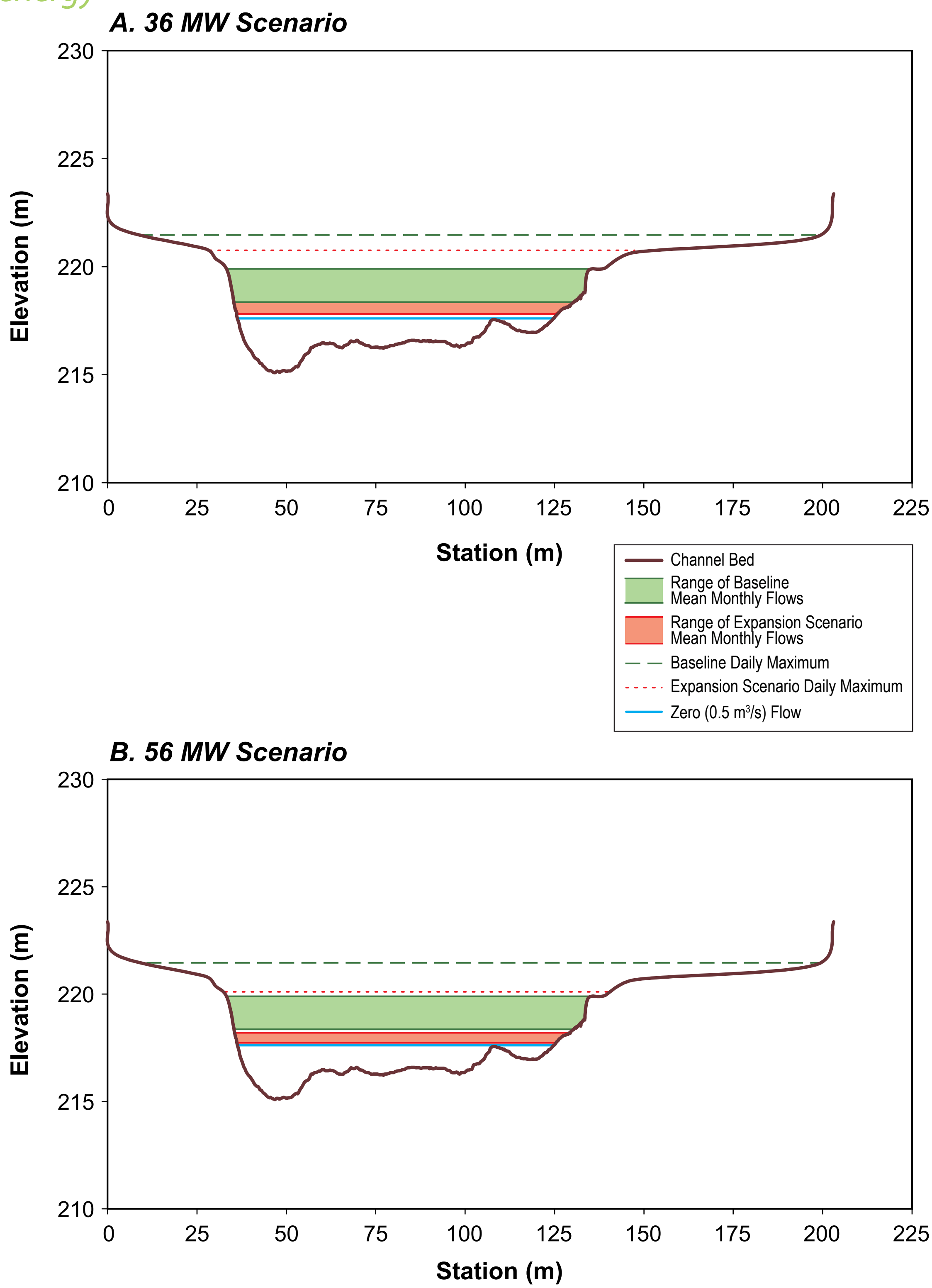
B. 56 MW Scenario



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section Rapids Downstream of TD04 (503-005 / a21411m)	Figure 14.3.19

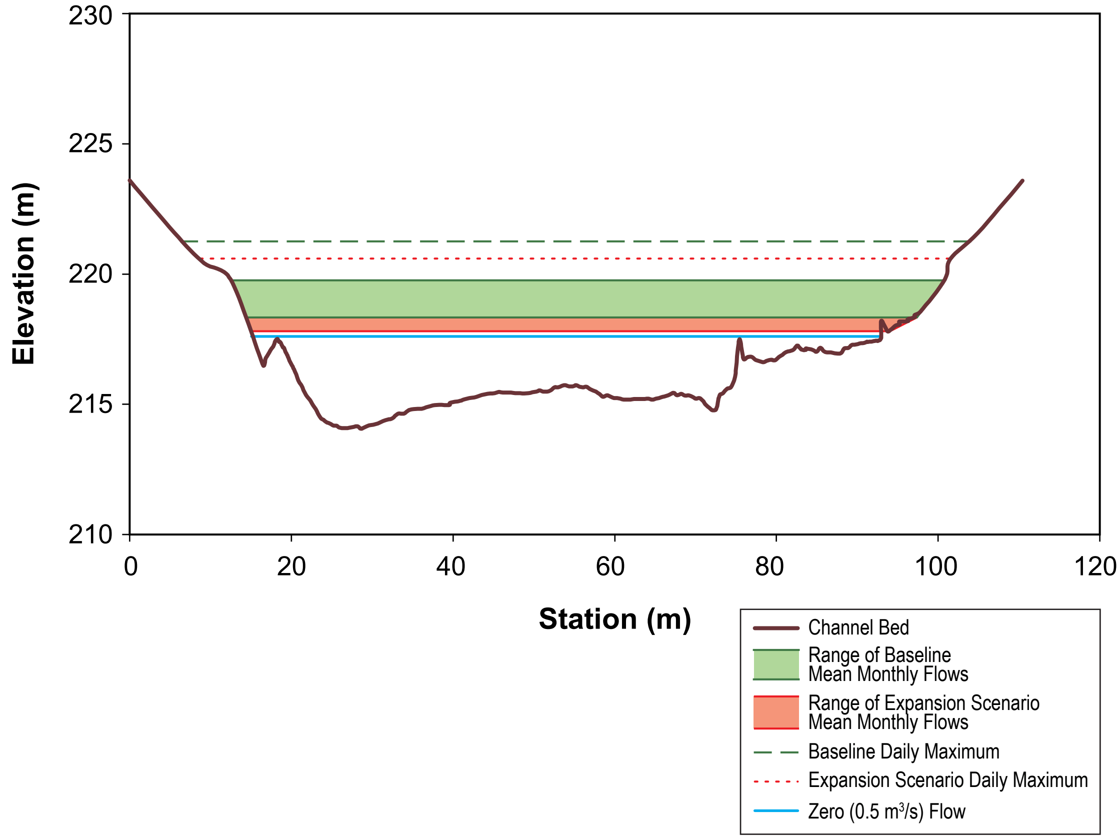


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Predicted Water Levels at Cross Section TDL11** (503-005 / a21412m)	**Figure 14.3.20**

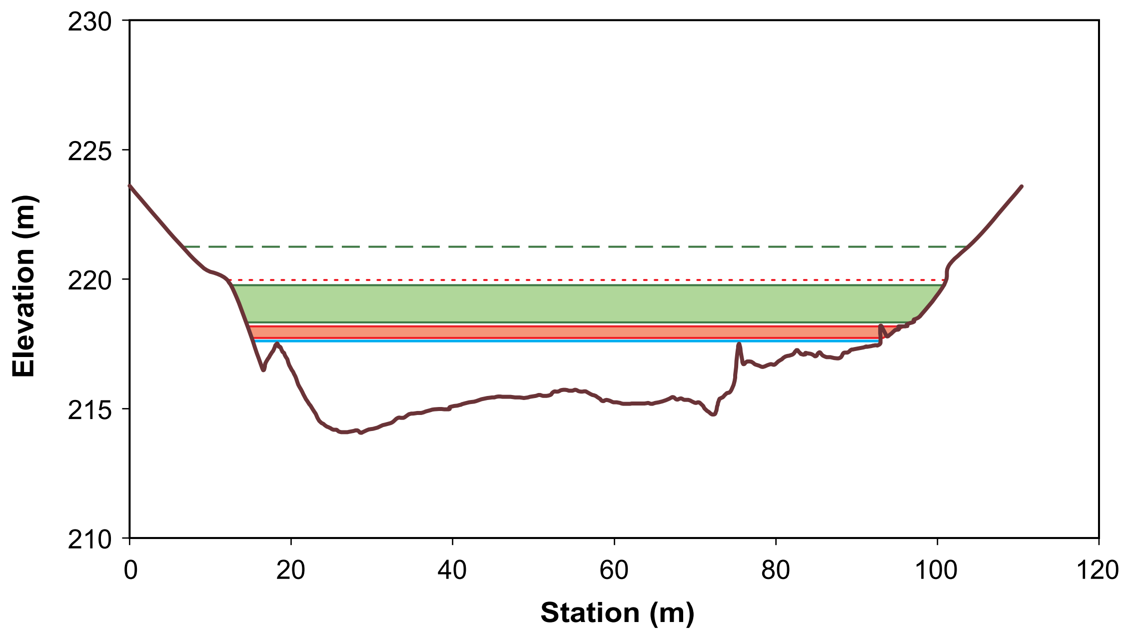


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report** **2009**	**Predicted Water Levels at Cross Section TDL13** (503-005 / a21413m)	**Figure** **14.3.21**

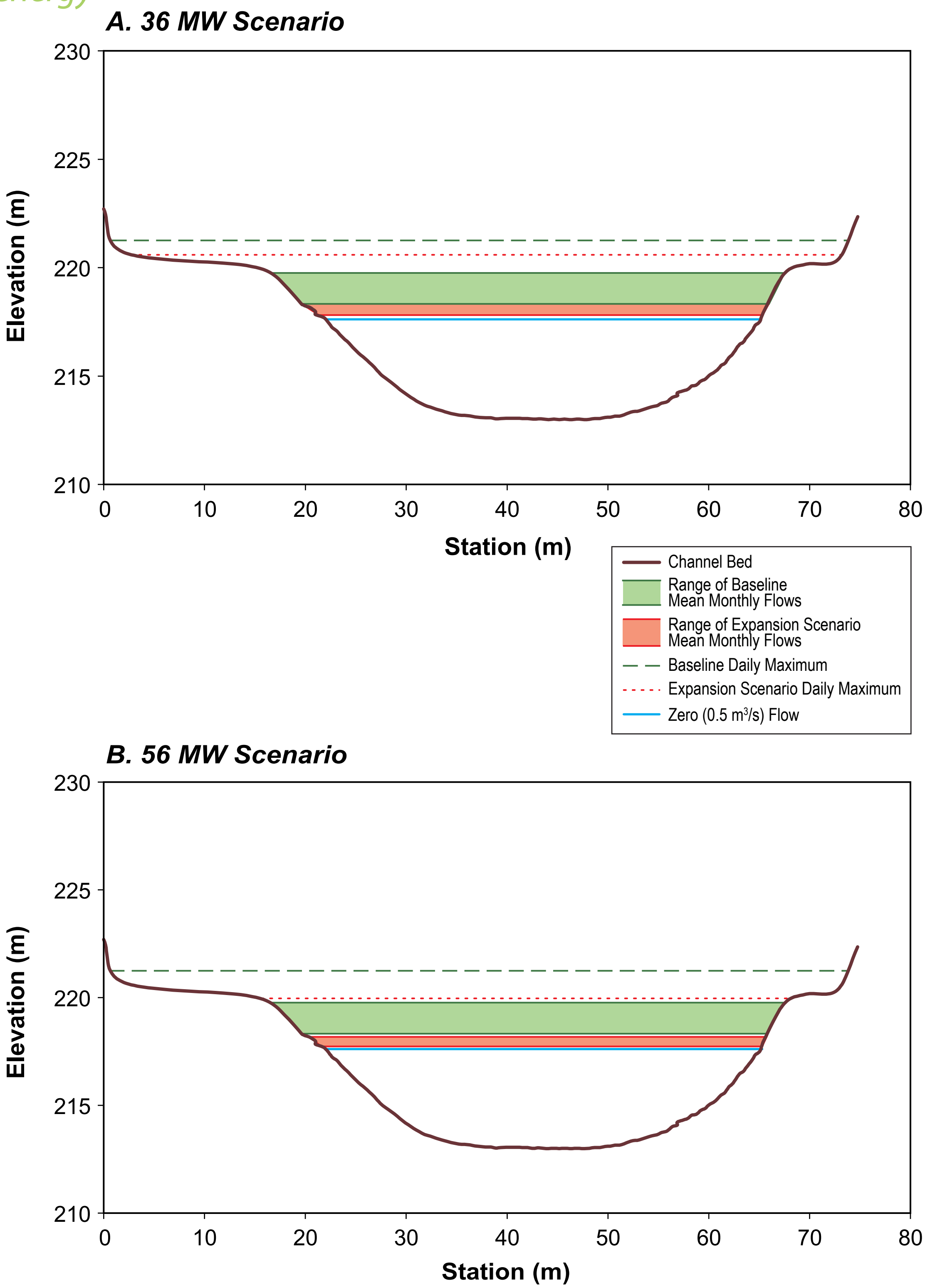
A. 36 MW Scenario



B. 56 MW Scenario

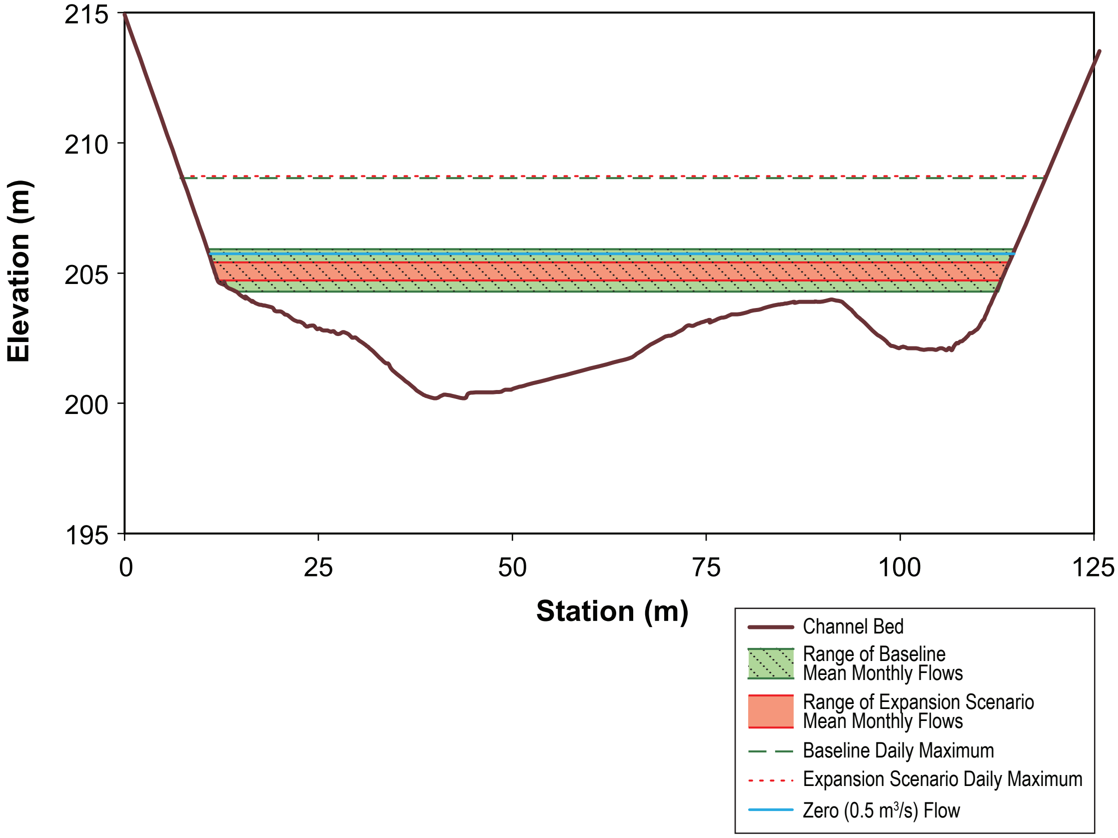


TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Predicted Water Levels at Cross Section TDL14** (503-005 / a21414m)	**Figure 14.3.22**

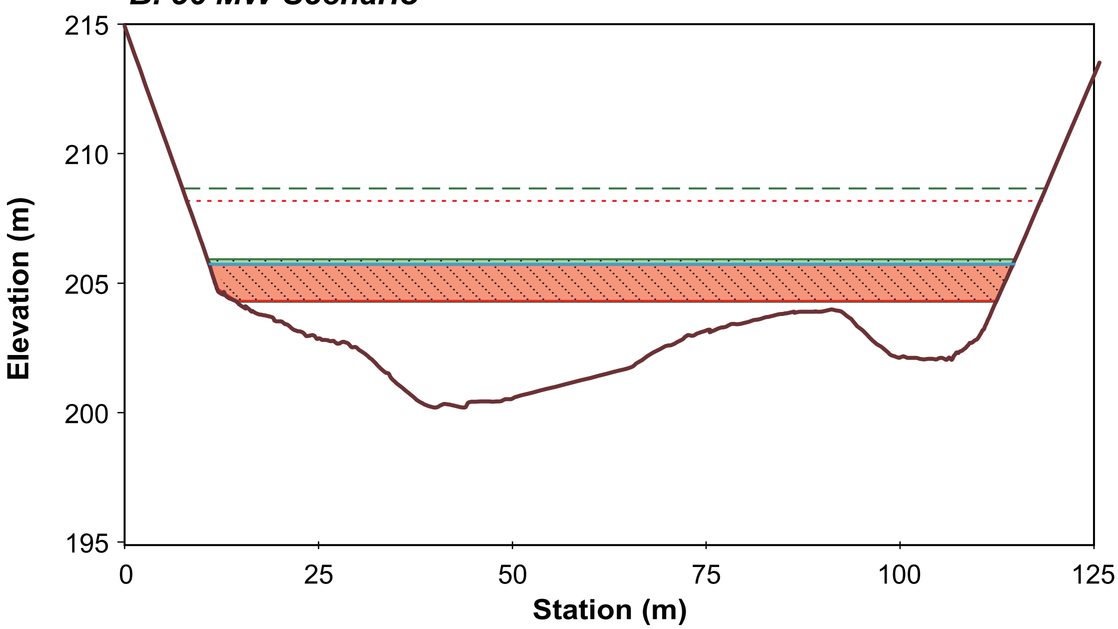


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL16 (503-005 / a21415m)	Figure 14.3.23

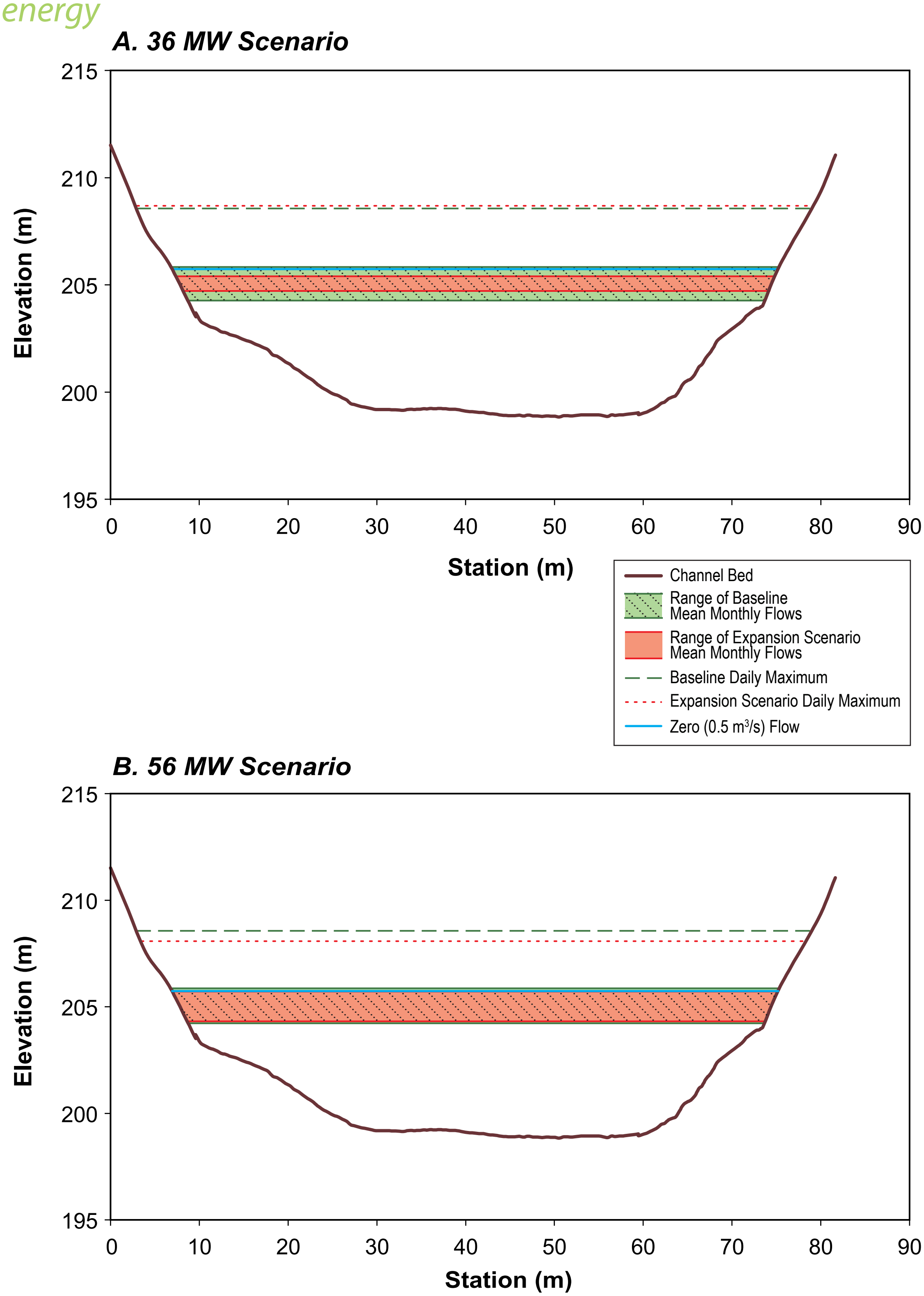
A. 36 MW Scenario



B. 56 MW Scenario



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL17 (503-005 / a21416m)	Figure 14.3.24



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Predicted Water Levels at Cross Section TDL18 (503-005 / a21417m)	Figure 14.3.25

Table 14.3.6 — Predicted Changes to Trudel Creek (36 MW Expansion)

River Station	CHANNEL DEPTH (m)			AVERAGE CHANNEL VELOCITY (m/s)			TOP CHANNEL WIDTH (m)			WETTED PERIMETER (m)		
	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)
TDL1	6.34	4.72	-25.1	0.51	0.16	-68.6	69.0	54.9	20.7	72.8	57.7	-20.9
TDL2	3.74	2.20	-40.1	0.78	0.39	-52.0	74.4	44.5	40.0	76.1	45.2	-40.5
TRUDEL1	4.24	2.84	-32.0	0.56	0.20	-64.9	82.0	65.6	19.9	83.7	66.7	-20.2
TDL3	7.86	6.51	-16.8	0.50	0.13	-74.9	50.1	47.7	4.8	55.4	51.8	-6.5
TDL4	17.6	16.3	-7.5	0.21	0.04	-80.0	50.9	49.1	3.5	68.1	64.8	-4.8
TDL5	7.72	6.41	-16.6	0.36	0.10	-72.5	96.1	85.6	-11.0	103	91.6	-11.1
TDL6	5.27	4.00	-23.5	0.41	0.12	-71.6	101	79.4	-18.9	105	82.8	-18.9
TDL7	3.91	2.75	-28.7	0.40	0.13	-68.9	118	103	-12.5	120	105	-12.9
TDL8	5.14	4.20	-17.9	0.34	0.09	-73.6	135	109	-18.9	140	113	-18.9
TDL9	3.98	3.09	-21.8	0.40	0.11	-73.4	112	111	-1.6	117	114	-2.1
Rapids downstream of TD4	1.63	0.76	-54.0	1.24	0.95	-23.6	131	47.0	-62.5	131	47.0	-62.4
TDL11	5.21	4.14	-20.0	0.65	0.17	-75.1	50.4	48.0	-4.8	54.7	51.4	-5.9
TDL13	4.09	3.03	-25.4	0.49	0.15	-69.4	99.5	92.7	-6.8	102	94.1	-7.5
TDL14	5.04	4.04	-19.3	0.46	0.12	-74.1	85.8	80.5	-6.1	91.5	85.5	-6.6
TDL16	6.11	5.11	-16.0	0.58	0.14	-76.9	48.8	45.1	-7.4	51.7	47.4	-8.1
TDL17	4.98	4.96	0.4	0.44	0.08	-82.0	102	102	0.3	104	105	0.3
TDL18	6.27	6.30	0.9	0.40	0.07	-82.1	66.9	67.0	0.1	69.9	70.0	0.2

Table 14.3.7 — Predicted Changes to Trudel Creek (56 MW Expansion)

River Station	CHANNEL DEPTH (m)			AVERAGE CHANNEL VELOCITY (m/s)			TOP CHANNEL WIDTH (m)			WETTED PERIMETER (m)		
	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)
TDL1	6.34	4.5	-28.6	0.51	0.11	-79.9	69.0	50.1	-27.7	72.8	52.7	-27.8
TDL2	3.74	2.0	-45.7	0.78	0.27	-67.0	74.4	40.3	-45.3	76.1	40.8	-45.8
TRUDEL1	4.24	2.7	-36.0	0.56	0.14	-77.1	82.0	62.9	-23.2	83.7	63.9	-23.6
TDL3	7.86	6.3	-18.8	0.50	0.08	-85.6	50.1	47.4	-5.4	55.4	51.3	-7.3
TDL4	17.6	16.2	-8.4	0.21	0.03	-87.9	50.9	48.9	-3.8	68.1	64.4	-5.4
TDL5	7.72	6.3	-18.7	0.36	0.07	-83.4	96.1	81.3	-15.5	103	87.2	-15.4
TDL6	5.27	3.8	-26.4	0.41	0.08	-82.7	101	79.0	-19.3	105	82.2	-19.4
TDL7	3.91	2.6	-32.4	0.40	0.09	-80.2	118	102	-13.4	120	103	-13.9
TDL8	5.14	4.1	-20.3	0.34	0.06	-83.5	135	108	-19.9	140	112	-19.9
TDL9	3.98	3.0	-24.8	0.40	0.07	-83.7	112	110	-1.8	117	114	-2.4
Rapids downstream of TD4	1.63	0.6	-65.3	1.24	0.82	-34.6	131	39.8	-68.9	131	39.9	-68.9
TDL11	5.21	4.0	-23.1	0.65	0.11	-85.1	50.4	47.6	-5.5	54.7	50.9	-6.8
TDL13	4.09	2.9	-29.4	0.49	0.10	-80.5	99.5	91.2	-8.4	102	92.5	-9.1
TDL14	5.04	3.9	-22.3	0.46	0.08	-83.7	85.8	79.3	-7.5	91.5	84.0	-8.2
TDL16	6.11	5.0	-18.4	0.58	0.09	-85.9	48.8	44.4	-8.9	51.7	46.6	-9.7
TDL17	4.98	5.0	-0.1	0.44	0.05	-89.6	102	102	0.0	104	104	0.0
TDL18	6.27	6.3	0.6	0.40	0.04	-89.5	66.9	67.0	0.1	69.9	70.0	0.2

Table 14.3.8 — Predicted Changes to Trudel Creek (Averaged over All Cross Sections) on a Monthly Basis (36 MW Expansion)

Month	CHANNEL DEPTH (m)			AVERAGE CHANNEL VELOCITY (m/s)			TOP CHANNEL WIDTH (m)			WETTED PERIMETER (m)		
	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)
January	5.56	4.76	-18.2	0.44	0.18	-66.2	84.5	72.3	-12.5	88.7	75.8	-12.9
February	5.32	4.66	-16.3	0.38	0.14	-69.4	81.7	70.9	-12.2	85.6	74.3	-12.6
March	5.11	4.60	-13.6	0.32	0.12	-68.6	78.7	70.4	-10.6	82.4	73.8	-10.8
April	4.92	4.46	-13.7	0.27	0.09	-76.8	75.1	68.7	-9.7	78.8	72.0	-9.9
May	5.31	4.53	-19.3	0.38	0.11	-77.9	81.6	69.8	-13.6	85.6	73.1	-14.0
June	6.37	5.04	-24.2	0.66	0.26	-63.9	92.1	75.3	-14.8	96.7	79.0	-15.4
July	6.59	4.99	-27.9	0.71	0.25	-68.1	95.0	74.7	-17.3	99.7	78.4	-17.9
August	6.56	5.06	-26.3	0.70	0.27	-65.7	94.3	75.6	-16.0	99.0	79.3	-16.6
September	6.37	4.87	-27.4	0.66	0.21	-71.4	92.1	73.3	-16.9	96.7	76.9	-17.6
October	6.10	4.80	-25.4	0.58	0.19	-72.1	89.7	72.8	-15.9	94.1	76.4	-16.5
November	5.98	4.86	-22.4	0.55	0.21	-66.7	88.7	73.3	-14.6	93.1	76.9	-15.2
December	5.82	4.79	-21.7	0.51	0.19	-68.7	87.4	72.6	-14.5	91.7	76.2	-15.0

Table 14.3.9 — Predicted Changes to Trudel Creek (Averaged over All Cross Sections) on a Monthly Basis (56 MW Expansion)

Month	CHANNEL DEPTH (m)			AVERAGE CHANNEL VELOCITY (m/s)			TOP CHANNEL WIDTH (m)			WETTED PERIMETER (m)		
	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)
January	5.56	4.6	-22.1	0.44	0.12	-79.3	84.5	70.1	-15.2	88.7	73.4	-15.7
February	5.32	4.4	-22.3	0.38	0.07	-87.2	81.7	68.3	-15.2	85.6	71.6	-15.7
March	5.11	4.4	-19.6	0.32	0.06	-86.7	78.7	68.0	-13.5	82.4	71.3	-13.9
April	4.92	4.4	-16.5	0.27	0.06	-84.3	75.1	67.9	-10.9	78.8	71.1	-11.1
May	5.31	4.4	-22.3	0.38	0.07	-87.2	81.6	68.3	-15.2	85.6	71.6	-15.7
June	6.37	4.9	-27.0	0.66	0.21	-71.8	92.1	73.4	-16.9	96.7	77.0	-17.6
July	6.59	4.9	-29.8	0.71	0.20	-74.8	95.0	73.2	-18.9	99.7	76.9	-19.6
August	6.56	4.9	-29.8	0.70	0.19	-76.0	94.3	73.1	-18.6	99.0	76.7	-19.3
September	6.37	4.8	-28.5	0.66	0.18	-76.1	92.1	72.6	-17.8	96.7	76.1	-18.5
October	6.10	4.7	-27.5	0.58	0.14	-80.2	89.7	71.0	-17.9	94.1	74.5	-18.6
November	5.98	4.7	-25.0	0.55	0.16	-75.9	88.7	71.7	-16.5	93.1	75.2	-17.1
December	5.82	4.6	-24.8	0.51	0.13	-80.1	87.4	70.5	-16.9	91.7	74.0	-17.5

Table 14.3.10 — Predicted Changes to Gertrude Lake on a Monthly Basis

Month	LAKE DEPTH (m)			SURFACE AREA (1000 m²)			LAKE DEPTH (m)			SURFACE AREA (1000 m²)		
	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)
January	10.85	10.08	-7.1	818	759.36	-7.2	10.85	9.93	-8.5	818	744.62	-9.0
February	10.65	9.99	-6.2	804	744.62	-7.3	10.65	9.75	-8.5	804	729.88	-9.2
March	10.48	9.95	-5.1	788	744.62	-5.5	10.48	9.73	-7.2	788	729.88	-7.3
April	10.33	9.81	-5.0	774	744.62	-3.8	10.33	9.73	-5.8	774	729.88	-5.7
May	10.65	9.9	-7.0	804	744.62	-7.3	10.65	9.75	-8.5	804	729.88	-9.2
June	11.56	10.32	-10.7	863	774.18	-10.2	11.56	10.18	-11.9	863	759.36	-12.0
July	11.76	10.29	-12.5	876	774.18	-11.6	11.76	10.16	-13.6	876	759.36	-13.3
August	11.73	10.34	-11.8	876	774.18	-11.6	11.73	10.13	-13.6	876	759.36	-13.3
September	11.56	10.18	-11.9	863	759.36	-12.0	11.56	10.09	-12.7	863	759.36	-12.0
October	11.32	10.11	-10.7	848	759.36	-10.4	11.32	9.99	-11.7	848	744.62	-12.2
November	11.21	10.17	-9.3	848	759.36	-10.4	11.21	10.03	-10.5	848	759.36	-10.4
December	11.07	10.1	-8.8	833	759.36	-8.9	11.07	9.96	-10.0	833	744.62	-10.6

Table 14.3.11 — Predicted Changes to Trudel Lake on a Monthly Basis

Month	LAKE DEPTH (m)			SURFACE AREA (1000 m^2)			LAKE DEPTH (m)			SURFACE AREA (1000 m^2)		
	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)
January	10.92	10.09	-7.6	1,050	947	-9.8	10.92	9.93	-9.1	1,050	921	-12.3
February	10.70	9.99	-6.6	1,024	921	-10.1	10.70	9.75	-8.9	1,024	895	-12.6
March	10.51	9.96	-5.2	997	921	-7.6	10.51	9.73	-7.4	997	895	-10.2
April	10.36	9.81	-5.3	973	921	-5.3	10.36	9.73	-6.1	973	895	-8.0
May	10.70	9.90	-7.5	1,024	921	-10.1	10.70	9.75	-8.9	1,024	895	-12.6
June	11.69	10.35	-11.5	1,152	973	-15.5	11.69	10.19	-12.8	1,152	947	-17.8
July	11.90	10.31	-13.4	1,180	973	-17.5	11.90	10.17	-14.5	1,180	947	-19.7
August	11.87	10.36	-12.7	1,180	973	-17.5	11.87	10.14	-14.6	1,180	947	-19.7
September	11.69	10.20	-12.7	1,152	947	-17.8	11.69	10.10	-13.6	1,152	947	-17.8
October	11.42	10.13	-11.3	1,128	947	-16.0	11.42	9.99	-12.5	1,128	921	-18.3
November	11.30	10.19	-9.8	1,102	947	-14.1	11.30	10.04	-11.2	1,102	947	-14.1
December	11.16	10.11	-9.4	1,076	947	-12.0	11.16	9.96	-10.8	1,076	921	-14.4

Table 14.3.12 — Predicted Changes to Unnamed Lake on a Monthly Basis

Month	LAKE DEPTH (m)			SURFACE AREA (1000 m^2)			LAKE DEPTH (m)			SURFACE AREA (1000 m^2)		
	Baseline	36 MW Expansion	Change (%)	Baseline	36 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)	Baseline	56 MW Expansion	Change (%)
January	8.36	7.75	-7.3	3,616	3,255	-10.0	8.36	7.63	-8.7	3,616	3,255	-10.0
February	8.20	7.68	-6.3	3,490	3,255	-6.8	8.20	7.53	-8.2	3,490	3,134	-10.2
March	8.06	7.65	-5.1	3,490	3,255	-6.8	8.06	7.52	-6.7	3,490	3,134	-10.2
April	7.94	7.57	-4.7	3,375	3,134	-7.1	7.94	7.52	-5.3	3,375	3,134	-7.1
May	8.20	7.61	-7.2	3,490	3,255	-6.8	8.20	7.53	-8.2	3,490	3,134	-10.2
June	8.93	7.94	-11.1	3,977	3,375	-15.1	8.93	7.82	-12.4	3,977	3,375	-15.1
July	9.09	7.91	-13.0	4,092	3,375	-17.5	9.09	7.81	-14.1	4,092	3,375	-17.5
August	9.06	7.95	-12.3	4,092	3,375	-17.5	9.06	7.79	-14.0	4,092	3,255	-20.5
September	8.93	7.83	-12.3	3,977	3,375	-15.1	8.93	7.76	-13.1	3,977	3,255	-18.2
October	8.73	7.78	-10.9	3,857	3,255	-15.6	8.73	7.68	-12.0	3,857	3,255	-15.6
November	8.64	7.82	-9.5	3,857	3,375	-12.5	8.64	7.71	-10.8	3,857	3,255	-15.6
December	8.53	7.77	-8.9	3,736	3,255	-12.9	8.53	7.65	-10.3	3,736	3,255	-12.9

Table 14.3.13 — Estimated Flows and Levels during a Scheduled Outage in Trudel Creek

Scheduled Outage Scenario	FLOW (m^3/s)		LEVEL (masl)	
	Estimated Value	Change from Pre-Outage	Estimated Value	Change from Pre-Outage
36 MW - Simulated to occur in April or May for 6 out of 13 years				
Pre-Outage	21.54		227.84	
Outage Maximum: Expansion Turbine	44.54	23.00	228.22	0.37
Outage Maximum: Existing Turbine	65.54	44.00	228.52	0.68
56 MW - Simulated to occur in April or May for 1 out of 13 years				
Pre-Outage	29.92		227.99	
Outage Maximum: Expansion Turbine	82.92	53.00	228.78	0.79
Outage Maximum: Existing Turbine	73.92	44.00	228.65	0.66

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF PLATES

APPENDICES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.4 ALTERATION OF WATER QUALITY

14.4.1 Introduction

Surface water is a critical component of the biological and physical environment. It is an indicator of environmental health because it is linked to key ecosystem components such as primary and secondary producers, fish, and wildlife. This section assesses how the proposed changes to the hydrological regime within the Project area may affect water quality in Zone 5.

This chapter provides the following:

- a summary of the current water quality in Zone 5, and
- a qualitative assessment of how changing water levels and flow rates in Zone 5 may result in changes to water quality.

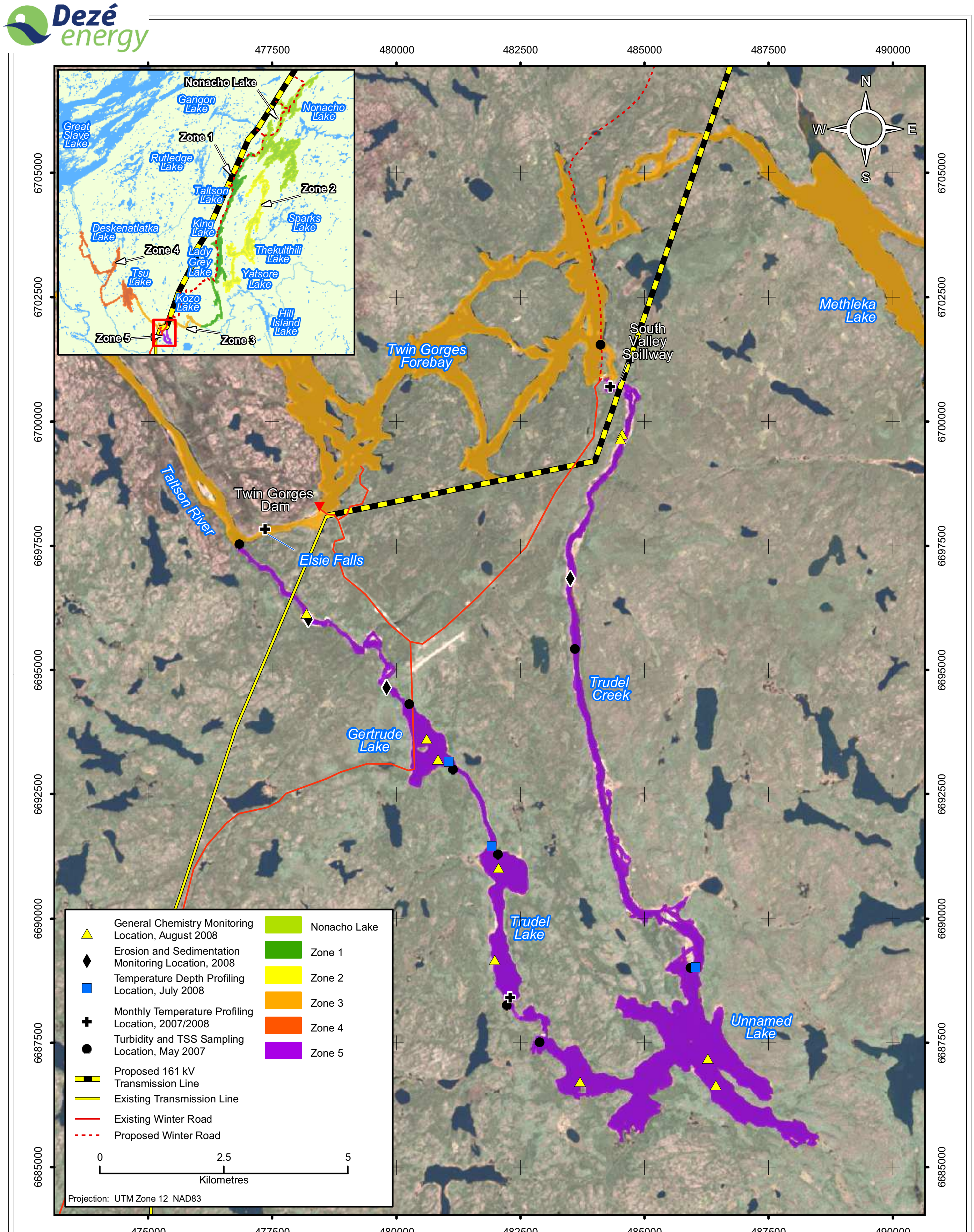
This assessment describes Zone 5 (Trudel Creek) of the Taltson Basin (Figure 14.3.1), which is between the South Valley Spillway (SVS) and the confluence of the Gertrude Lake outflow with the Taltson River. Water flowing over the SVS enters Zone 5, which includes Trudel Creek and a series of lakes (Unnamed, Trudel, and Gertrude), and meets with the outflow from the Twin Gorges hydropower facility into the Taltson River in Zone 3.

The proposed Expansion Project includes upgrade scenarios that would generate from 36 MW to 56 MW of additional hydroelectric power. These proposed upgrades require larger storage volumes in the winter at Nonacho Lake and a greater water demand at the Twin Gorges hydropower facility throughout the entire year. The increases in water demand would lower water levels in the Twin Gorges Forebay throughout the year and would divert water away from the SVS. This diversion would reduce water flow into Trudel Creek and its downstream lakes. The potential effects to water quality from changes in water levels and flow rates are assessed for general water chemistry, mercury and methylmercury, temperature, dissolved oxygen, eutrophication, erosion, and sedimentation.

The Project's construction phase is not expected to affect the water quality in Zone 5. There is no construction activity planned for Trudel Creek. Alterations to water quality from closure activities would be addressed upon development and finalization of the closure and restoration plan. Details of the closure and restoration plan were presented in Section 6.8. Changes to water quality from potential accidents (i.e., minor spills) and malfunctions are assessed in Chapter 17.

14.4.2 Existing Environment

This section describes the water quality of the water bodies in Zone 5, in particular: general water chemistry, total metals, temperature, dissolved oxygen, turbidity, and total suspended solids (TSS). Figure 14.4.1 presents the locations of the baseline monitoring that was conducted in this zone. Results of water parameters were compared to the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life (CCME, 2007). The Northwest Territories (NWT) does not have its own provincial guidelines and has adopted the CCME guidelines for the protection of aquatic life.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Water Quality Monitoring Locations in Zone 5	Figure 14.4.1

gis no. TAL-10-002DAR

14.4.2.1 General Chemistry

In 2007, water samples for turbidity and TSS were collected at eight locations within Zone 5 and one reference location in the Twin Gorges Forebay upstream of the SVS (Figure 14.4.1; Table 14.4.1). Overall, the water was relatively clear with a turbidity ranging from <3.0 to 12.5 nephelometric turbidity units (NTU) and TSS ranging from 2.73 mg/L to 4.66 mg/L. Water turbidity was slightly higher upstream of lake inlets compared to downstream of lake outflows.

Visual observations of turbidity and TSS were made along Trudel Creek during the high peak freshet flow of 2003. No water samples were collected, but observers noted a substantial difference in turbidity at the confluence of Trudel Creek and the Twin Gorges tailrace. These observations, together with the assessment of active erosion along Trudel Creek (see Section 14.4.2.4), suggest that at times of peak flow, baseline turbidity may greatly exceed the values reported herein.

Water samples for physical and organic parameters, dissolved anions, nutrients, and total metals were collected in August 2007 and 2008 at 10 sites in Zone 5 (Figure 14.4.1). In 2007, one sample was collected at each of three sites: Trudel Creek, Trudel Lake, and a reference site upstream of the SVS in the Twin Gorges Forebay. In 2008, samples were collected at Trudel Creek, Trudel Lake, Gertrude Lake, and Unnamed Lake. Four samples (from two locations at two depths) were taken from each location, and one sample was collected in the reference site.

Table 14.4.2 presents a summary of the water quality for each water body. The water bodies had similar physical and chemical properties (soft, relatively clear, slightly alkaline water with low buffering capacity and similar dissolved anion and nutrient content).

Trace metal concentrations were generally below CCME guidelines. The detection limit for some metals in 2007 was higher than in 2008 (e.g., cadmium, chromium, lead, silver, and thallium). Laboratory analyses showed that these metals were undetectable in the water samples. However, the default value of half the method detection limit (MDL), which was assigned to metals below their detection limit, was above the CCME guideline. The high detection limit also influenced the average concentrations for these metals (Table 14.4.2). Trudel Lake had chromium and copper concentrations slightly above CCME guidelines. These characteristics are considered typical of pristine northern Canadian water bodies.

Table 14.4.1 — Summary of Zone 5 Turbidity and Suspended Solids Monitoring: 2007

Sample ID	Sample Location	Turbidity (NTU)	Total Suspended Solids
Upstream SVS	Immediately upstream of the SVS	<3.0	2.74
Downstream SVS	Approximately mid-range point of long reach between Unnamed Lake and SVS	12.5	3.49
Upstream Unnamed	Immediately upstream of Unnamed Lake	7.9	2.73
Downstream Unnamed	Immediately downstream of Unnamed Lake	3.9	2.76
Upstream Trudel	Immediately upstream of Trudel Lake	5.2	2.89
Downstream Trudel	Immediately downstream of Trudel Lake	5.2	3.16
Upstream Gertrude	Immediately upstream of Gertrude Lake	9.2	4.66
Downstream Gertrude	Immediately downstream of Gertrude Lake	3.2	2.86
Upstream Taltson and Trudel	Immediately upstream of Trudel/Taltson confluence	8.5	3.9

Table 14.4.2 — Summary of Zone 5 Water Quality Monitoring: 2007 to 2008

Parameter	Detection Limit	CCME Guidelines[1]	Upstream SVS (N = 2)	Trudel Creek (N = 5)		Unnamed Lake (N = 4)		Trudel Lake (N = 5)		Gertrude Lake (N = 4)	
			Avg	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Physical Variables											
Colour, True (CU)	5	NG		7.025	7.7	6.975	7.3	7.175	7.4	7.475	7.7
Conductivity (µS/cm)	2	NG	41.1	41.32	43.5	41.125	41.4	40.375	42.1	40.725	41
Total Dissolved Solids	1	NG	16	23.34	25.3	25.7	26	23.32	25.9	25.525	25.7
Hardness ($CaCO_3$)	0.5	NG	10	15.6	17.4	17.6	17.7	15.74	17.4	17.375	17.6
pH (pH Units)	0.01	6.5 to 9.0	7.5	7.472	7.5	7.45	7.46	7.47	7.5	7.4275	7.47
Total Suspended Solids	3	25 above ambient		1.875	3	1.5	1.5	2.575	4.3	2.25	3
Turbidity (NTU)	0.1	NG		1.5775	2.48	1.545	1.64	3.0075	3.57	2.59	2.99
Dissolved Anions											
Acidity (to pH 8.3) ($CaCO_3$)	1	NG	17	1.475	1.5	1.5	1.5	1.475	1.5	1.5	1.6
Alkalinity, Bicarbonate ($CaCO_3$)	1	NG	21	17.1	21	16.5	16.7	17.1	19	16.4	16.5
Alkalinity, Carbonate ($CaCO_3$)	1 to 5	NG	2.5	0.9	2.5	0.5	0.5	0.5	2.5	0.5	0.5
Alkalinity, Hydroxide ($CaCO_3$)	1 - 5	NG	2.5	0.9	2.5	0.5	0.5	0.5	2.5	0.5	0.5
Alkalinity, Total ($CaCO_3$)	1	NG	17	16.3	17	16.5	16.7	16.5	17	16.4	16.5
Bromide- Br	0.05	NG		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025
Chloride-Cl	0.5 to 1.0	NG	0.5	0.97	1.11	1.1	1.11	0.986	1.13	1.1125	1.17
Fluoride-F	0.02	NG		0.0823	0.083	0.0825	0.083	0.08275	0.083	0.08275	0.083
Sulfate (SO_4)	0.5	NG	0.6	0.91	1.04	1	1	0.856	1.01	1.01	1.01

Parameter	Detection Limit	CCME Guidelines[1]	Upstream SVS (N = 2)	Trudel Creek (N = 5)		Unnamed Lake (N = 4)		Trudel Lake (N = 5)		Gertrude Lake (N = 4)	
			Avg	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Anion Sum (mEq/L)	---	NG		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Cation Sum (mEq/L)	---	NG		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Cation - Anion Balance (%)	---			4.475	5.9	5.375	6.1	3.8	4.8	4.975	5.9
Nutrients											
Total Ammonia	0.02	2.432		0.01	0.01	0.0125	0.02	0.01	0.01	0.01	0.01
Total Kjeldahl Nitrogen	0.05 to 0.2	NG	0.1	0.2126	0.222	0.21225	0.244	0.1986	0.244	0.19575	0.202
Nitrate	0.005 to 0.5	2.93	0.15	0.012	0.0025	0.0025	0.0025	0.012	0.05	0.0025	0.0025
Nitrite	0.001 to 0.05	0.06	0.025	0.0054	0.0005	0.0005	0.0005	0.0054	0.025	0.0005	0.0005
Nitrate + Nitrite	0.1	NG	0.05	0.05	0.05			0.05	0.05		
Total Nitrogen	0.06	NG		0.2158	0.222	0.21225	0.244	0.22325	0.244	0.19575	0.202
Total Phosphate	0.002 to 0.02	NG	0.01	0.0073	0.008	0.00705	0.0076	0.007775	0.0079	0.00875	0.0095
Total Phosphorous	0.02	NG	0.01	0.01	0.01			0.01	0.01		
Total Metals											
Aluminum	0.001 to 0.01	0.1	0.005	0.0488	0.13	0.0287	0.032	0.05172	0.07	0.052475	0.0585
Antimony	0.0001	NG		5E-05	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Arsenic	0.00003	0.005		0.0001	0.0001	0.000117	0.000121	0.000124	0.000131	0.000126	0.00013
Barium	0.00005	NG	0.005	0.005	0.006	0.004865	0.0049	0.005248	0.00532	0.00533	0.0054
Beryllium	0.0002 to 0.002	NG	0.001	0.0003	0.001	0.0001	0.0001	0.0003	0.001	0.0001	0.0001

Parameter	Detection Limit	CCME Guidelines[1]	Upstream SVS (N = 2)	Trudel Creek (N = 5)		Unnamed Lake (N = 4)		Trudel Lake (N = 5)		Gertrude Lake (N = 4)	
			Avg	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Bismuth	0.0005	NG		0.0003	0.0003	0.00025	0.00025	0.00025	0.00025	0.00025	0.00025
Boron	0.001 to 0.05	NG	0.025	0.0071	0.025	0.003025	0.0031	0.00746	0.025	0.003025	0.0031
Cadmium	0.000017 to 0.001	2E-05	0.0005	0.0001	0.00053	8.5E-06	8.5E-06	0.000109	0.00053	8.5E-06	8.5E-06
Calcium	0.02	NG	4.7	4.8	4.83	5.005	5.03	4.884	4.95	4.9325	4.97
Chromium	0.0005 to 0.005	0.001 Cr IV 0.0089 Cr III	0.0025	0.001	0.00253	0.000403	0.00086	0.001106	0.00157	0.000325	0.00055
Cobalt	0.0001 to 0.002	NG	0.001	0.0004	0.001	0.00005	0.00005	0.000262	0.001	0.00005	0.00005
Copper	0.0001 to 0.001	0.002	0.0005	0.0003	0.0005	0.00052	0.00079	0.001138	0.0026	0.00078	0.00132
Iron	0.01	0.3	0.007	0.0586	0.11	0.0455	0.051	0.0702	0.088	0.078	0.086
Lead	0.00005 to 0.005	0.001	0.0025	0.0008	0.00253	0.000103	0.000156	0.000579	0.00253	0.000266	0.000582
Lithium	0.005	NG		0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
Magnesium	0.005	NG	1.2	1.098	1.2	1.14	1.15	1.14	1.2	1.1175	1.13
Manganese	0.00005	NG	0.003	0.005	0.0064	0.006238	0.00661	0.00603	0.00659	0.006453	0.00661
Mercury	0.00001	3E-05		5E-06	5E-06	6.75E-06	0.000012	0.000005	0.000005	6.25E-06	0.00001
Molybdenum	0.00005 to 0.005	0.073	0.0025	0.0007	0.0025	0.000234	0.000247	0.000698	0.0025	0.000236	0.000249
Nickel	0.0001 to 0.002	0.025	0.001	0.0004	0.001	0.00076	0.00203	0.001778	0.00381	0.000863	0.00167
Phosphorus	0.3	NG		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Potassium	0.05	NG	0.8	0.742	0.8	0.75975	0.764	0.7462	0.764	0.7645	0.773

Parameter	Detection Limit	CCME Guidelines[1]	Upstream SVS (N = 2)	Trudel Creek (N = 5)		Unnamed Lake (N = 4)		Trudel Lake (N = 5)		Gertrude Lake (N = 4)	
			Avg	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Selenium	0.0001	0.001		5E-05	5E-05	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Silicon	0.05	NG		1.305	1.46	1.2325	1.24	1.405	1.43	1.435	1.47
Silver	0.00001 to 0.005	0.0001	0.0025	0.0005	0.00253	0.000005	0.000005	0.000504	0.00253	0.000005	0.000005
Sodium	0.01	NG	1	1.164	1.24	1.27	1.28	1.198	1.26	1.2525	1.26
Strontium	0.0001	NG	0.025	0.0258	0.0255	0.025875	0.0263	0.02555	0.029	0.0258	0.026
Thallium	0.0001 to 0.05	0.0008	0.025	0.005	0.0253	0.00005	0.00005	0.00504	0.0253	0.00005	0.00005
Tin	0.0001 to 0.05	NG	0.025	0.005	0.025	0.000323	0.00114	0.00005	0.025	0.00005	0.00005
Titanium	0.001 to 0.01	NG	0.0005	0.0052	0.006	0.005	0.005	0.0136	0.048	0.005	0.005
Uranium	0.00001	NG		6E-05	7E-05	0.000066	0.000067	7.13E-05	0.000075	7.13E-05	0.000072
Vanadium	0.00005 to 0.001	NG	0.0005	0.0002	0.0005	9.83E-05	0.000101	0.000216	0.0005	0.000175	0.000184
Zinc	0.001	0.03	0.0005	0.001	0.003	0.0005	0.0005	0.00152	0.00152	0.0014	0.0022
Organic Parameters											
Dissolved Organic Carbon	0.5	NG		4.8175	4.88	4.8625	4.94	4.7975	4.82	4.8675	5.02
Total Organic Carbon	0.5	NG		5.1875	5.39	5.22	5.28	5.2775	5.35	5.1775	5.19

[1] CCME Guidelines for the Protection of Aquatic Life, 2007. CCME Guideline for ammonia depends on pH and temperature. NG = No applicable CCME guideline.

NG = No applicable CCME guideline.

Units in mg/L unless noted.

14.4.2.2 TEMPERATURE

Temperature profiles were monitored at three locations (Figure 14.4.1) between July 2007 and June 2008 (Cambria Gordon 2008a, 2008b). The temperature was recorded every two hours. Peak water temperatures occurred between June and August and ranged from 18 ºC to 20 ºC. Temperatures dropped steadily between September and November, and remained at zero or sub-zero temperatures until May (Figure 14.4.2).

Temperature depth profiles were also collected once in July 2008 from representative shallow and deep riverine sections of Trudel Creek at the inflows of Unnamed and Gertrude lakes (Figure 14.4.3). Temperatures were measured every 0.5 m until the bottom was reached. A profile was also collected in the lower section of Trudel Lake near the outflow, representing shallow and deep lake strata. Figure 14.4.3 shows that Trudel Creek and lake waters were warm (17 ºC to 18 ºC) during the summer. There was no observed temperature stratification with depth.

14.4.2.3 DISSOLVED OXYGEN

Dissolved oxygen (DO) in Zone 5 was measured in the summer and modelled for winter months when the lakes are completely covered with ice.

DO depth profiles were collected in Trudel Creek and Trudel Lake once in July 2008 simultaneously with the temperature depth profiles described previously (Figure 14.4.3). DO concentrations were measured every 0.5 m until the bottom was reached. Figure 14.4.3 shows that during the summer, the waters were well oxygenated (9.6 O_2/L to 13.8 mg O_2/L) and 100% saturated for the corresponding water temperature and salinity (Tchobanoglous, Burton, & Stensel, 2002).

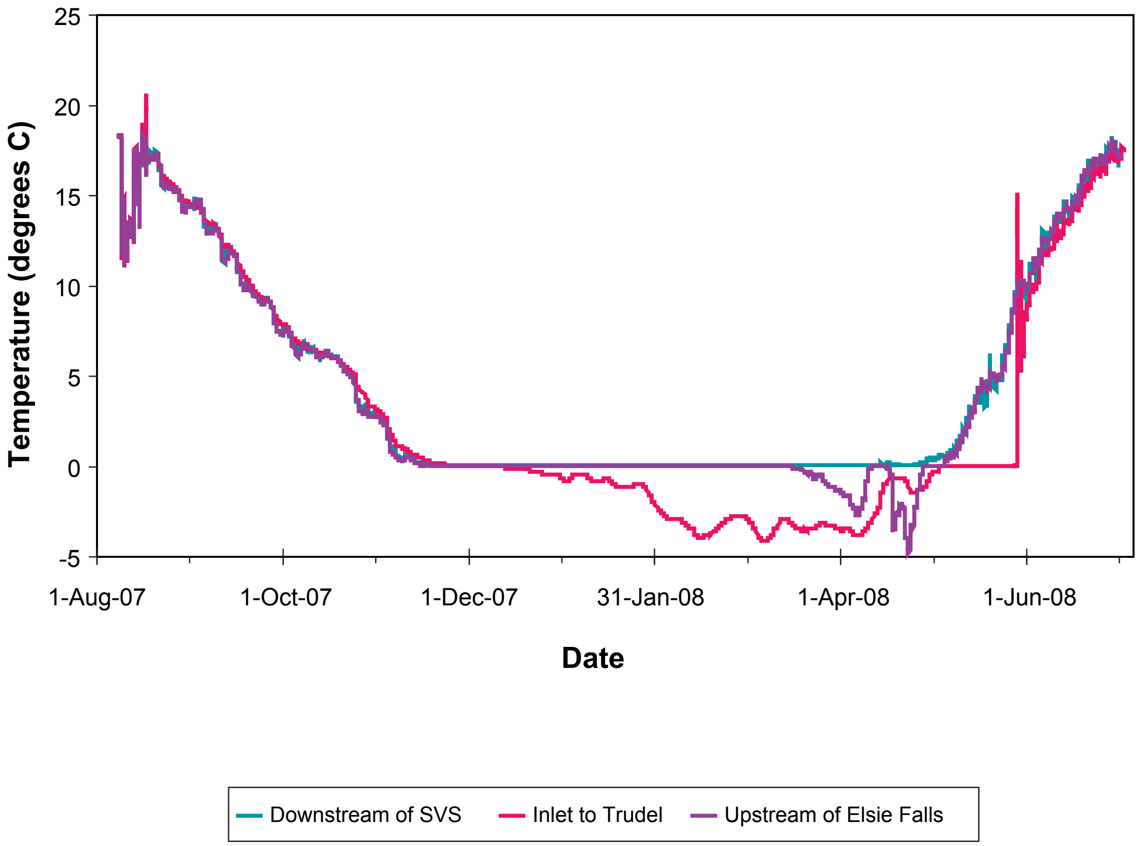
The DO guideline for warm water ecosystems was used for comparison because the Project area is in a Subarctic/temperate zone, with a wide range of temperatures throughout the year. The CCME DO guideline for warm water ecosystems is based on sensitive life stages of some fish species such as salmonids, where eggs may experience decreases in survival at DO concentrations below 5 mg O_2/L (CCME, 2007). In the summer, DO concentrations differed between Trudel Creek and Trudel Lake; stream waters were saturated while lake waters were supersaturated for their respective water temperatures. No stratification was noted within each site.

For each lake in Zone 5, baseline DO concentrations were modelled during the winter because ice formation over the entire lake surface prevents water aeration. Aquatic organisms in the water column and microbial degradation in the sediments could deplete DO concentrations during periods of prolonged winter ice cover. Consequently, lakes with prolonged ice cover may experience hypoxic conditions that may affect aquatic life.

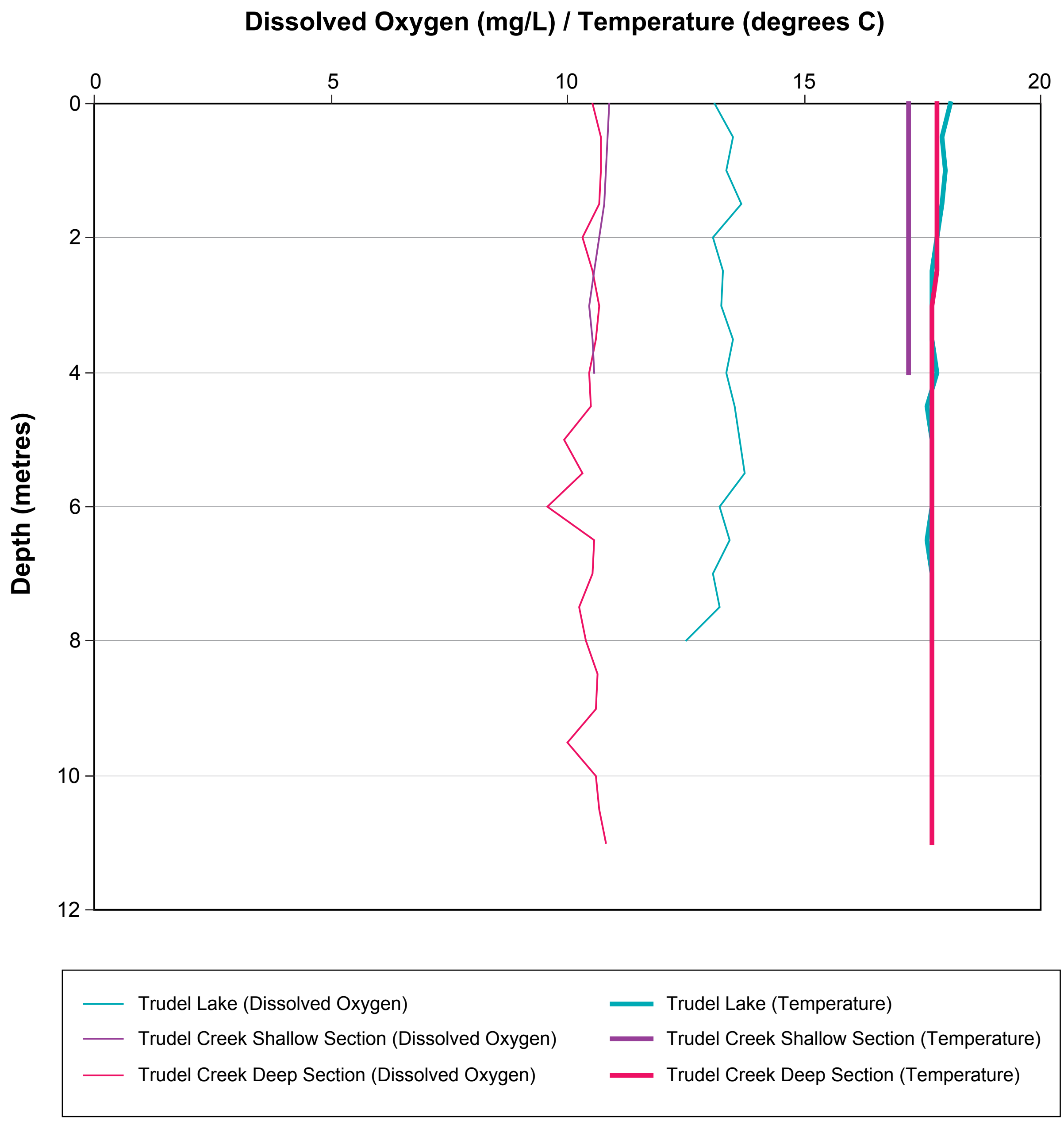
DO concentrations were modelled for months with winter ice cover (November to April) using a DO model described by Mathias and Barica (1980). A similar model described by White et al. (2008) makes several key assumptions about Arctic lakes, which were adapted for the DO model. The environmental characteristic assumptions used in the model were as follows:

- Arctic lakes seldom warm above 10°C and rarely stratify in the summer,
- the ice cover lasts for eight to nine months,
- oxygen is usually saturated at the start of the freeze-up but is depleted over time,
- total primary productivity is low and lakes are oligotrophic,
- fish are very slow growing, and
- decomposition rates are slow and large amounts of energy and nutrients are stored in dead organic matter.

Although these environmental characteristic assumptions were based on Arctic conditions and Zone 5 is Subarctic, they are considered appropriate and conservative.



25
20
15
10
5
0
-5
Temperature (degrees C)
1-Aug-07
1-Oct-07
1-Dec-07
31-Jan-08
1-Apr-08
1-Jun-08
Date
Downstream of SVS
Inlet to Trudel
Upstream of Elsie Falls



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Depth Profile of Temperature and Dissolved Oxygen in Zone 5 (503-005 / a21580m)	Figure 14.4.3

The lakes in Zone 5 exceed 10 °C in the summer, but this would have no effect on the DO model because it is applied during the winter, when lake waters are 0 °C prior to complete ice cover. The duration of ice cover is less than eight to nine months. Ice cover in Zone 5 lakes was estimated to be six months based on the duration of water temperature profiles that were zero or sub-zero from November to April (i.e., 181 days). At a temperature of 0 °C, the maximum oxygen saturation concentration in freshwater is 14.3 mg O_2/L. Zone 5 lakes were assumed to be saturated immediately prior to complete winter ice coverage based on complete saturation at Trudel Lake at all depths under baseline conditions in July 2008.

Oxygen levels and depletion rates in water are dependent on a number of factors. For the DO model, the two main factors considered were aquatic respiration in the water column and microbial degradation of organic carbon in the sediment. The presence of saturated water in July indicates that general chemistry water quality parameters that may affect the saturation of DO are low (i.e., salinity), which is typical of oligotrophic waters. The decrease in DO due to aquatic organisms in the water column is 10 mg/m^3/day, and is generally the same among all surface waters (Mathias and Barica, 1980). Factors such as low organic carbon in the water column or low nutrient content have negligible effects on oxygen consumption in the water column for these lakes as demonstrated by Welch (1974). The decrease in DO attributable to microbial decomposition of organic carbon in lake sediments is 80 mg/m^2/day (Mathias and Barica, 1980). The oxygen depletion rate from the water and sediment processes are also dependent on the lake water volume and benthic surface area.

Baseline DO concentrations were modelled based on the following formula:

$$DO_n = DO_0 - \frac{[(k_1 \times SA) + (k_2 \times VOL)] \times n}{VOL}$$

Where:

- DO_n = Dissolved oxygen concentration after *n* days of ice cover (mg O_2/L)
- DO_0 = Initial dissolved oxygen concentration at 100% saturation (14.3 mg O_2/L)
- k_1 = Oxygen depletion rate from carbon decomposition in sediments (80 mg/m^2/day)
- SA = Average lake surface area from November to April (m^2)
- k_2 = Oxygen depletion rate from organism respiration in water (10 mg/m^3/day)
- VOL = Average lake volume from November to April (L)
- n = Number of days that ice covers the lake completely (181 days)

The coefficients (k_1 and k_2) were the water and sediment DO depletion rates described by Mathias and Barica (1980). The average winter lake volume (VOL) and surface area (SA) were calculated using HEC-RAS modelling software. The maximum number of ice cover days from November to April is 181 days.

The modelled baseline DO concentrations in Gertrude, Trudel, and Unnamed lakes show a decrease from 14.3 mg O_2/L (representing saturation prior to ice cover) to 9.81 mg, 8.72 mg, and 7.34 mg O_2/L, respectively. The relationship between DO concentrations and number of ice cover days is described by the following formulas:

Gertrude Lake: $DO_n = -0.0248n + 14.3$

Trudel Lake: $DO_n = -0.0308n + 14.3$

Unnamed Lake: $DO_n = -0.0384n + 14.3$

The DO model overestimates the actual decrease in DO because it assumes that each lake is a closed system where no inflows occur. Inflows of surface water from upstream sections of Trudel Creek provide an influx of oxygen-rich water because the water is constantly flowing and is shallower than in lakes. Trudel Creek has a higher surface-area-to-volume ratio; therefore, its waters would be higher in DO than the lake that it flows into, offsetting the rate of oxygen depletion. In addition, Zone 5 lakes are small and the volume of inflowing water can quickly turn over the entire lake volume. Although this inflow could not be incorporated into the model, oxygen renewal from inflowing surface water is addressed below.

To determine the turnover time for each lake, the total lake volume was divided by the average winter flow over the SVS. Gertrude, Trudel, and Unnamed lakes were calculated to have a complete turnover of lake water volume every 0.6, 0.5, and 1.3 days, respectively, under baseline conditions (Figure 14.4.3). Therefore, even though the DO concentration was modelled for 181 days with no inflow, the turnover of all three lakes occurs at least once every two days. The extent of oxygen replenishment from surface water inflows is unknown because inflows may not be fully saturated with oxygen. Thus, the modelled oxygen depletion represents an overestimate of what the actual oxygen depletion levels would be during the 181 days of ice cover.

14.4.2.4 Erosion and Sedimentation

A study assessing the risk of bank erosion and sedimentation in Trudel Creek is presented in Appendix 14.4A. This study monitored three sites in Trudel Creek identified to be representative erosion sites (Figure 14.4.1). The erosion assessment was conducted in July 2008, corresponding to the peak flow month through Trudel Creek. The flow rate through Trudel Creek during the assessment was 175 m^3/s. A basic principal of erosion and sedimentation assessments is that higher water levels and flow rates increase the potential for erosion while lower water levels and flow rates result in sedimentation.

The first monitoring site was downstream of the SVS in Trudel Creek and is a wide floodplain. The floodplain soil consists of 68% sand and 32% fines, providing stream bank cohesion. The bank is low-lying and susceptible to erosion, which is shown by tension cracks (Plate 14.4.1). Over time, the tension cracks erode further, causing pieces to fall into the creek. However, the growth of low-lying vegetation and grasses suggests that the bank has not been flooded recently. The wide, shallow floodplain is a depositional area during low-flow periods, and a potential site of erosion during high flows or high water levels. The monitoring site at the outflow of Gertrude Lake consisted of a deposit bar and sandbank. Soil samples consisted of 93% sand, 6% gravel, and 1% fines, and the deposit bar consisted of 77% sand and 20% fines, which provide some bank cohesion. Overall, this site has a medium potential to erode.

The second monitoring site was at the outflow from Gertrude Lake. This site is composed of a sediment deposit bar and sandbank. The bank is composed of sand and cobblestone, which provide natural armouring against erosion (Plate 14.4.2). The highest water level in this monitoring site is 2 m higher than the levels during the assessment. The bank is composed of 93% sand, 6% gravel, and 1% fines. During rare years with high water flows, the maximum water level and flows would erode the sands downstream. As this occurs, the banks would naturally self-armour, exposing the gravel and cobblestone. Overall, this site has a low potential to erode.

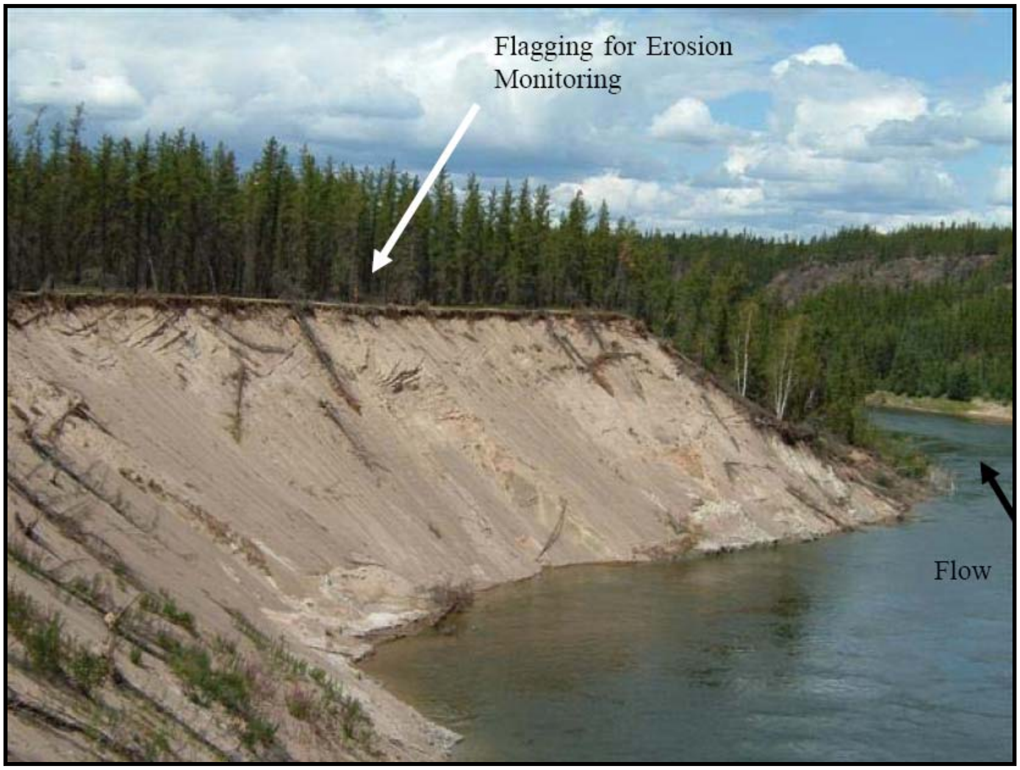
The third monitoring site is along the Trudel Creek, midway from the Gertrude Lake outflow and the confluence with Elsie Falls. This area contains self-armouring regions composed of cobblestones, which reduce water velocity causing backflows and sedimentation zones (Plate 14.4.3). The potential for erosion from high water flows in cobblestone areas is low. However, mudslide regions were noted on the banks of Trudel Creek (Plate 14.4.4). Mudslides in areas of reduced bank stability could deliver trees and sediments into the creek during years with very heavy rainfall. The slopes of these banks are very erodible at high water levels and consist of 42% sand and 56% fines. Overall, this site has a high potential to erode.

Plate 14.4.1 — Tension Cracks at Site 1

Plate 14.4.2 — Sand and Cobblestone Banks at Site 2

Plate 14.4.3 — Cobblestone Armouring Bank at Site 3

Plate 14.4.4 — Erodible Mudslide Region at Site 3



14.4.3 Predicted Alterations to Water Quality

14.4.3.1 INTRODUCTION

The proposed upgrades to the Taltson hydroelectric facilities would increase the degree of water-release management at the Nonacho Lake reservoir to maintain a steady water supply throughout the year to the Twin Gorges hydropower facility. The increased water demand would significantly reduce the water flow over the SVS at all times of the year relative to the baseline conditions. This would be the case under both the 36 MW and 56 MW expansion scenarios. Water flow into Zone 5 would decrease as the proposed power generation increases. The alteration of water levels and flow rates may be associated with changes in general water chemistry, mercury concentrations, temperature, dissolved oxygen, eutrophication, erosion, and sedimentation.

The following section presents the predicted changes in water quality in Zone 5 following the proposed Project expansion options. Water levels and flow rates were modelled using HEC-ResSim and HEC-RAS software to predict changes to Zone 5 under the 36 MW and 56 MW options as described in Section 14.3.

Table 14.4.3 presents the assessment criteria used to assess potential changes in water quality in Zone 5. The assessment criteria consider the potential probability, magnitude, and duration of the changes to water quality.

Table 14.4.3 — Assessment Criteria

Major	Major shift away from the baseline conditions, such that water quality parameters are continuously outside of the baseline range. Changes in water quality would be large and long-term in nature. Water quality would often exceed the CCME guidelines.
Medium	A moderate shift away from the baseline conditions such that water quality parameters are periodically outside of the baseline range. Changes in water quality would be moderate and medium-term in nature. Water quality would periodically exceed the CCME guidelines.
Low	Minor shift away from average baseline conditions but still within the baseline range. Changes in water quality would likely be relatively small and of a temporary nature. Water quality would remain well within the CCME guidelines.
Negligible	A non-detectable change or very slight change from the baseline conditions.

14.4.3.2 MODELLED FLOW AND WATER LEVELS

Under baseline conditions, water flow over the SVS is dependent on the time of year and annual variation in precipitation (Section 14.3). Simulated baseline flows in Zone 5 range from 0.3 m^3/s to 495.2 m^3/s during the 13 modelled years. During this time, the peak flow of 495.2 m^3/s was only experienced once. Annual peak flows exceeded 400 m^3/s twice during the modelled period. The average monthly flows range from 40.6 m^3/s to 222.2 m^3/s. January to May are low-flow months, with monthly average flows ranging from 40.6 m^3/s to 94.7 m^3/s. June to December are high-flow months, ranging from 121.8 m^3/s to 222.2 m^3/s.

The range of water levels in Trudel Creek (at Trudel) was 227.4 m to 232.0 m above sea level (masl). The average monthly water levels range from 228.1 masl to 230.0 masl. The lowest average monthly water levels occur from January to May, and range from 228.1 masl to 228.9 masl. From June to September, monthly average water levels range from 229.8 masl to 230.1 masl. The annual variation in mean monthly water levels in Trudel Creek is 1.98 m.

Table 14.4.4 presents a summary of the modelled changes in water flows and water levels from baseline conditions and to the 36 MW and 56 MW options over a 13-year simulation period.

14.4.3.3 36 MW OPTION

14.4.3.3.1 Modelled 36 MW Option

Under the 36 MW option, the higher water demand at the Twin Gorges hydropower facility would reduce the water flow over the SVS. The maximum water flow would decrease by 140.9 m^3/s (28%) to 354.3 m^3/s. This maximum would only occur once in a 13-year period, compared with flows that exceeded 400 m^3/s twice in 13 years under the baseline scenario.

The minimum water flow would increase by 3.7 m^3/s to 4.0 m^3/s under the 36 MW option, and water flow over the SVS would not drop below 4.0 m^3/s. This is a Project design mitigation measure that is intended to ensure that there would always be flow over the SVS into Zone 5. During years with very low precipitation, the minimum water flow could be experienced for the entire year because the Twin Gorges Forebay would not reach its water volume capacity.

Table 14.4.4 — Summary of Predicted Changes to Water Levels and Flows in Zone 5

Predicted Change		ZONE 5		
		Baseline	Change from Baseline	
			36 MW	56 MW
Daily Water Flow (m^3/s)	Max	495.2	-140.9	-251.1
	Min	0.3	+3.7	+3.7
Average Monthly Water Flow (m^3/s)	Max	222.2	-180.7	-194.2
	Min	40.6	-34.2	-36.6
Daily Water Level in Trudel 1 (masl)	Max	232.0	-0.8	-1.6
	Min	227.4	+0.1	+0.1
Average Monthly Water Level in Trudel 1 (masl)	Max	230.1	-2.1	-2.2
	Min	228.1	-0.6	-0.6
[1]Annual Variation in Mean Monthly Water Level in Trudel 1 (m)		1.98	0.49	0.36

[1] Excluding ramping events

Under the 36 MW option, the average monthly flow rates would decrease: the maximum average monthly flow rate by 180.7 m^3/s (81%) and the minimum average monthly flow by 34.2 m^3/s (84%). This would considerably reduce the total water volume entering Trudel Creek annually. In this option, the maximum average monthly water flow would be lower than the minimum average monthly water flow under baseline conditions.

The maximum water level in Zone 5 would decrease by 0.8 m, and the minimum water level would increase by 0.1 m, compared to baseline. The average monthly water levels would also decrease. Maximum average monthly water levels in Trudel Creek would decrease by 2.1 m, and the minimum average monthly water level would decrease by 0.6 m. Under these conditions, the maximum average monthly water level would be below the minimum average monthly water level modelled for baseline conditions. Overall lower water levels would be expected throughout the year. The annual variation in mean monthly water level would decrease to 0.49 m from 1.98 m at baseline, indicating a more consistent water level throughout the year.

14.4.3.3.2 General Chemistry Changes

Changes in water flows and levels would have varying effects on water quality in Trudel Creek. For example, lower flow rates would decrease water levels and allow suspended matter in the water column to settle. Parameters such as turbidity, TSS, and total metals could decrease as a result of the settling. However, given the clarity and low levels of metals that have been measured under baseline conditions, these potential improvements to water quality would be low for most of the year and possibly non-detectable. In the case of periodic high flows, the peak flow would be 28% lower than the baseline peak. A 28% reduction in peak flow would decrease erosion, and thus TSS and turbidity.

Changes in general water chemistry (concentrations) would be low. Lower flows would limit erosion and result in sedimentation of low-level metals and organic matter, improving water quality and lowering turbidity throughout the year. Given the clarity and low levels of metals measured under baseline conditions, these potential improvements to water quality would be low and possibly non-detectable outside of the freshet period.

Periods of high flow and high water level during freshets would still occur every year with the exception of very dry years, resulting in short-term peaks lasting days to weeks. During these periods, increased flow rates may disturb fine sediments and increase concentrations of general water quality parameters such as turbidity and total metal concentrations. However, given the peak flow reduction under the 36 MW option, conditions would likely remain within the baseline range.

These increases would be temporary and the overall effects considered low because the highest modelled average monthly water flow in Trudel Creek (41.5 m^3/s in June) would be almost the same as the lowest average monthly water flow at baseline conditions (40.6 m^3/s in April). Thus, the flows observed during high-flow months under the 36 MW option would be at or below the lowest flows under baseline conditions.

Overall, Zone 5's general chemistry is expected to improve, with lower measurable parameters. Concentrations of measured parameters may fluctuate periodically between different years with high and low flows. During high-flow years, sediments that had settled during low-flow years may be re-suspended. However, increases in measured parameters such as TSS, turbidity, and total metals would be within existing baseline conditions because the peak monthly flow and peak daily flow are also within the baseline range.

14.4.3.3.3 Mercury

The modelled changes in water flows and levels would have negligible effects on mercury and methylmercury concentrations in Trudel Creek. Decreased water flows and levels would not cause any changes that would increase mercury. Concentrations of mercury in the Zone 5 water bodies are expected to remain below the laboratory detection limit. The conditions in Trudel Creek would not be affected by methylmercury, which typically occurs in new hydroelectric reservoirs because of the flooding of large areas of terrestrial soils.

14.4.3.3.4 Eutrophication

The potential for nutrient influx leading to eutrophication would be negligible. The water levels in Trudel Creek would not rise above the baseline levels and no new soils would be affected. There would also be negligible effects from water flowing from the Forebay over the SVS.

14.4.3.3.5 Temperature

Lower water levels can affect summer water temperatures in lakes and rivers as well as the timing of ice formation and the duration of ice cover during the fall and winter periods. Water temperature affects the vertical structure and thermocline development of lakes. Temperature conditions are also influenced by a water body's thermal mass, surface area for radiant exchange, and retention time.

To determine the potential change in water temperature resulting from the lower water levels, temperature differences between shallow and deep lakes in the Wuskwatim hydroelectric reservoir in Manitoba were examined for comparison. In this project, shallow and deep lakes that were connected by streams or rivers differed by 3°C during the summer (Manitoba Hydro and Nisichawayasihk Cree Nation 2003). This difference between deep and shallow lakes in the Wuskwatim study was compared to Zone 5 lake water levels at baseline (deep levels) and under the 36 MW option (shallow levels). The depth difference between deep and shallow lakes in the Wuskwatim hydroelectric project was several metres. In comparison, all three Zone 5 lakes would experience a water level decrease of up to 0.8 m under the 36 MW option. Therefore, a predicted 2°C change in water temperature is assumed to be a conservative estimate.

Trudel Creek and downstream lakes would experience little change in water temperature throughout the year. The lakes in Zone 5 are small and the retention time in water in these lakes is only several days under the 36 MW scenario. The degree of temperature change would be seasonally dependent. In spring and summer months, lower water levels may result in slight increases in water temperatures from an average of 17°C to 18°C to an average of 19°C to 20°C. In winter months, water temperatures cannot decrease below the freezing point; however, the thickness and duration of winter ice cover may increase because of lower water levels. Overall, the effect on water temperature would be low.

14.4.3.3.6 Dissolved Oxygen

Changes in DO concentrations in Zone 5 lakes would be negligible during open water months. Baseline monitoring shows that Zone 5 lakes were fully saturated with DO and were not stratified in the summer when the waters were warmest. Lower water levels under the 36 MW option would cause an increase in water temperature by as much as 2 °C, which would have some effect on the total oxygen concentration in the water; however, the water column would still be fully-saturated at this increased temperature. For example, the oxygen saturation concentrations of oligotrophic freshwater at 18 °C and 20 °C are approximately 9.3 mg O_2/L and 9.1 mg O_2/L, respectively (Tchobanoglous et al. 2002).

During the ice-covered winter months, DO concentrations would experience low to negligible changes compared to baseline conditions. DO concentrations were modelled under the 36 MW option for lakes during the winter. Lower water levels in Zone 5 lakes would change ice formation rates and patterns. Ice cover would form more quickly and may be several centimetres thicker than existing conditions (Section 14.5). Thicker lake ice would increase the duration of ice cover in the lakes. Consequently, the modelled number of ice cover days was extended by one month (November to May) as a conservative estimate (i.e., 211 days).

Under the modelled ice cover days, DO concentrations in Gertrude, Trudel, and Unnamed lakes would decrease from 14.3 mg O_2/L to 8.85 mg, 7.24 mg, and 5.41 mg O_2/L, respectively. In comparison, baseline DO concentrations would be 9.81, 8.72, and 7.34 mg O_2/L after 181 days of ice cover (Figure 14.4.4). DO concentrations following extended periods of lake ice cover can be determined from the following formulas:

Gertrude Lake: $DO_n = -0.0258n + 14.3$
Trudel Lake: $DO_n = -0.0335n + 14.3$
Unnamed Lake: $DO_n = -0.0421n + 14.3$

The rate of oxygen depletion would increase the most in Unnamed Lake because it is shallower and has a larger lake surface area than the other lakes. Hence, the surface-area-to-volume ratio is the greatest in this lake, and the effect of oxygen consumption by degradation of sediment carbon is more substantial. However, the total change after the modelled 211 days is small.

The CCME guideline for DO is 6.0 mg O_2/L for sensitive early life stages and 5.5 mg O_2/L for all other life stages. The model also suggests that the DO concentrations may decrease below the CCME guideline in Unnamed Lake under the 36 MW option. However, the DO model used does not consider oxygen renewal from inflowing surface waters. Lake turnover rates were calculated for each lake based on modelled winter flows and lake volumes in Zone 5. Table 14.4.5 presents the changes in lake turnover time and Figure 14.4.1 presents the turnover time and DO for each lake. In Gertrude Lake, reduced flow would increase the lake turnover time from 0.6 to 2.5 days. In Trudel Lake, the turnover rate would increase from 0.5 to 2.1 days. The turnover rate in Unnamed Lake, which is the largest of the three lakes, would increase from 1.3 to 5.3 days.

Although the turnover times would increase under the 36 MW option, there would still be oxygenated water flowing into the lakes during the winter period. The modelled decrease in DO is conservative because it does not account for the inflow of oxygenated water. Therefore, DO concentrations would likely remain within the applicable CCME guideline.

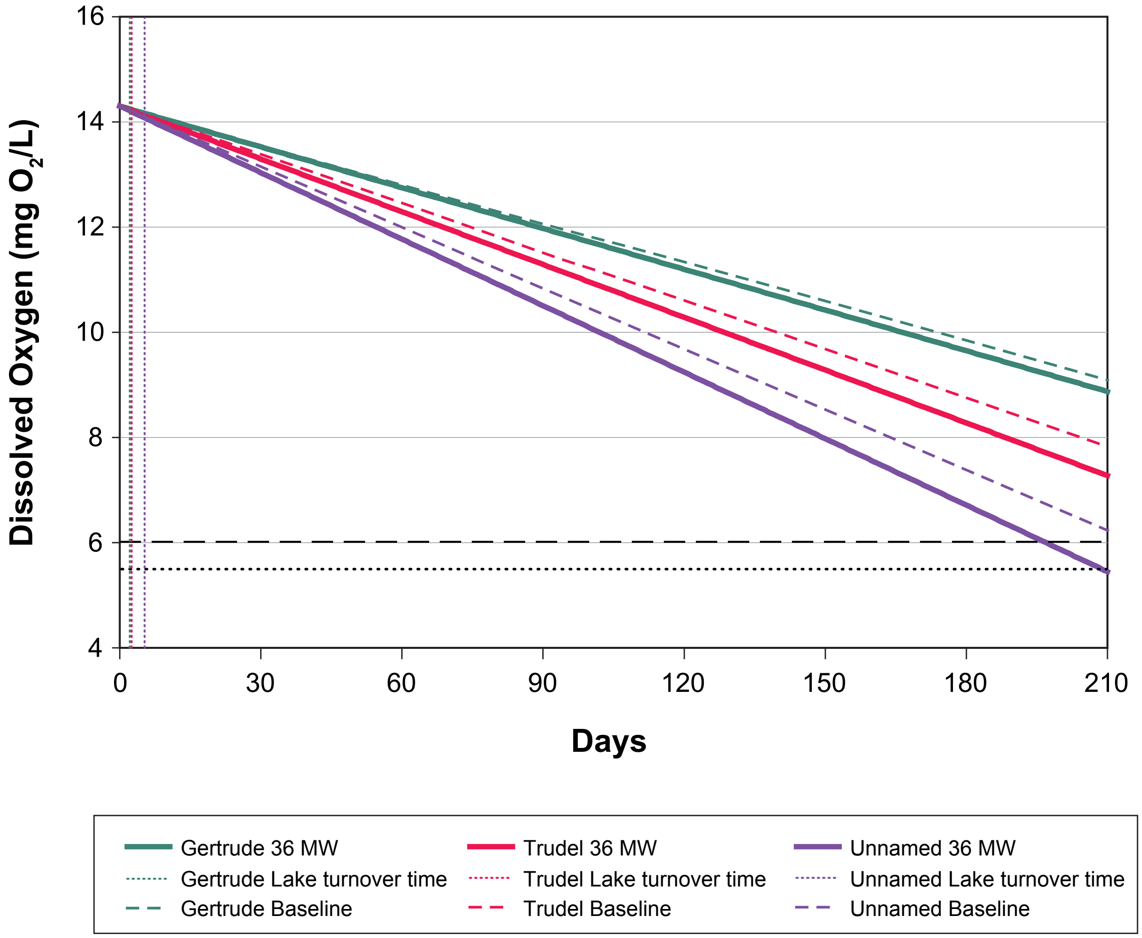
Table 14.4.5 — Lake Volume Turnover Times at 36 MW

	Baseline	36 MW
Average Monthly Winter Flow (m^3/s)	87.2	17.7
Average Winter Lake Volume (1,000 m^3)		
Gertrude	4,383.4	3,797.8
Trudel	3,981.3	3,185.2
Unnamed	10,114.4	8,099.0
Lake Volume Turnover Time (days)		
Gertrude	0.6	2.5
Trudel	0.5	2.1
Unnamed	1.3	5.3

14.4.3.3.7 Erosion and Sedimentation

Erosion is the process by which soil and weathered rock particles (sediment: gravel, sand, silt, and clay) are transported or moved from one place to another. The typical cause of bank erosion is a change in a hydrological or geological condition. Increasing water flow can erode soil and sediment through abrasion, dissolution, and scouring. Shoreline erosion can increase the sediment load and turbidity of the water and potentially act as a source of heavy metals. Soil that is eroded and transported by streams would eventually be deposited as sandbars in streams, as point-bars on the inner curve of a meandering stream, on floodplains and levees, or at the mouth of the river in a delta. Once erodible materials are transported away, self-armouring occurs from large rock particles or exposed bedrock. If there is no self-armouring material available, erosion would continue until the river becomes very wide, dispersing the energy in the river flows.

Under the 36 MW option, peak monthly flows and peak daily flows would be reduced by 81% and 28%, respectively; these flows would be well within the present river channel. The altered flow regime would result in a significantly reduced erosion rate compared to baseline conditions. Lower flows also lead to components in the water column settling into the sediments. Erosion rates would decrease and sedimentation rates would increase. New pocket zones of sedimentation would form as the environment adapts to the new hydrological regime (Appendix 14.4A). Because the water flows and levels under the proposed scenario are within the ranges that have been experienced under baseline conditions, sedimentation rates would not change beyond the range of what has already been experienced. The average rates of sedimentation would be higher than baseline because the lower flows would be experienced for longer periods of time. However, there would be a significant reduction in the rate of erosion and thus less overall material in the water column that would settle in depositional zones. Overall, there would be a reduction in erosion rates, with a negligible effect on water quality. The reduction in erosion rates would have a low reduction in sedimentation rates.



Note: Dashed line represents CCME guideline - warm water biota - early life stages.
Dotted line represents CCME guideline - warm water biota - other life stages.

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Modelled Decrease in Dissolved Oxygen During Winter Ice Cover at 36 MW** (503-005 / a21834m)	**Figure 14.4.4**

14.4.3.3.8 Summary

Table 14.4.6 presents a summary of the predicted effects to water quality under the 36 MW scenario.

Table 14.4.6 — 36 MW: Summary of Potential Water Quality Changes to Zone 5

Water Quality Parameter	36 MW
General Chemistry	Low
Total Mercury	Negligible
Eutrophication	Negligible
Temperature	Low
Dissolved Oxygen	Low to Negligible
Erosion	Negligible
Sedimentation	Low

14.4.3.4 56 MW Option

14.4.3.4.1 Modelled 56 MW Option

Under the 56 MW option, the maximum water flow would decrease by 251.1 m^3/s (50%) compared to the baseline maximum, and the minimum water flow would increase by 3.7 m^3/s (Table 14.4.4). The maximum average monthly water flow would decrease by 194.2 m^3/s (88%) compared to the baseline. During low-flow months from February to May, the average minimum monthly water flow would be 4.0 m^3/s, which would be a decrease of 90% from baseline flows.

Water levels in Trudel Creek would also decrease as a result of the reduced flows. The maximum water level in Trudel Creek would decrease by 1.6 m compared to baseline levels. The minimum water level would increase by 0.1 m to 227.5 masl under this scenario. Water levels cannot decrease beyond 227.5 masl because a minimum water flow of 4.0 m^3/s would be achieved at all times. The maximum average monthly water level would decrease by 2.2 m, and the minimum would decrease by 0.6 m. The annual variation in mean monthly water level would decrease to 0.36 m from 1.98 m. Water levels and flows in this option would remain at the minimum at most times of the year. When flows over the SVS are above the minimum rates, they would be well below the baseline flows.

14.4.3.4.2 General Chemistry Changes

The general water chemistry changes under the 56 MW option would be similar to those outlined under the 36 MW option. General chemistry parameters such as total metals, TSS, and turbidity would improve in the water because the lower flows would result in reduced erosion and allow substances suspended in the water column to settle out. These changes would improve the general chemistry compared to baseline conditions.

The reduced flow under the 56 MW option would have a positive effect on lake water quality. The large reduction in peak flow would improve the quality of water entering the Trudel system's three lakes, although the waters in Zone 5 are already pristine.

Water levels in these lakes would drop on average but not below baseline conditions. The guaranteed minimum release would also ensure a continued source of oxygenated water with lower TSS relative to baseline conditions.

14.4.3.4.3 Mercury

The modelled changes in water flows and levels would have negligible effects on mercury and methylmercury concentrations in Trudel Creek. Baseline water quality shows that existing concentrations are below the detection limit. Decreased water flows and levels would not cause any changes that would increase mercury. Water quality conditions in Trudel Creek would not be affected by methylmercury, which typically occurs in hydroelectric reservoirs because of the flooding of large areas of terrestrial soils.

14.4.3.4.4 Eutrophication

Under the 56 MW option, the potential for nutrient influx leading to eutrophication would be negligible. The lower water levels in Trudel Creek would not exceed the baseline levels and no new soils would be affected. There would also be negligible effects from water flowing from the Forebay over the SVS.

14.4.3.4.5 Temperature

Lower water levels can affect summer water temperatures in lakes and rivers as well as the timing of ice formation and the duration of ice cover during the fall and winter periods. Water temperature affects the vertical structure and thermocline development of lakes. Temperature conditions are also influenced by a water body's thermal mass, surface area for radiant exchange, and retention time.

To determine the potential change in water temperature resulting from the lower water levels, temperature differences between shallow and deep lakes in the Wuskwatim hydroelectric reservoir in Manitoba were examined for comparison. In this project, shallow and deep lakes that were connected by streams or rivers differed by 3 °C during the summer (Manitoba Hydro and Nisichawayasihk Cree Nation, 2003). This difference between deep and shallow lakes in the Wuskwatim study was compared to Zone 5 lake water levels at baseline (deep levels) and the 36 MW option (shallow levels). The depth difference between deep and shallow lakes in the Wuskwatim hydroelectric project was several metres. In comparison, all three lakes would experience a water level decrease of up to 1.6 m under the 56 MW option. Therefore, a predicted 2 °C change in water temperature is assumed to be a conservative estimate.

Trudel Creek and downstream lakes would experience little change in water temperature throughout the year. The lakes in Zone 5 are small and the retention time in water in these lakes is low, ranging up to several days. The degree of temperature change would be seasonally dependent. In spring and summer months, lower water levels may result in slight increases in water temperatures from an average of 17 °C to 18 °C to an average of 19 °C to 20 °C. In winter months, water temperatures cannot decrease below the freezing point; however, the thickness and duration of winter ice cover may increase because of lower water levels. Overall, the effect on water temperature would be low.

14.4.3.4.6 Dissolved Oxygen

The DO content would experience negligible effects during open water months. Saturation rates would be at 100% during the open water period because the lower water levels in Zone 5 would allow the shallower waters to saturate more quickly. The maximum saturation concentration would decrease based on the increase in water temperature during the summer. An increase in water temperature could facilitate higher microbial respiratory rates, but any decrease in water oxygen content should be offset by concomitant increases in benthic/littoral photosynthetic rates.

During the winter, Zone 5 lakes would experience low to negligible effects to DO concentrations. Ice thickness, rates of ice formation, and duration of ice coverage would increase because of the lower water level. DO concentrations were modelled for lake conditions under the 56 MW option for 211 days. The model predicts oxygen concentrations in Gertrude, Trudel, and Unnamed lakes would decrease from 14.3 mg O_2/L to 9.58 mg, 8.13 mg, and 6.51 mg O_2/L, respectively. In comparison, baseline concentrations for these lakes would be 9.81, 8.72, and 7.34 mg O_2/L.

The CCME guideline for DO for the protection of aquatic life at early life stages is 6.0 O_2/L. For all other life stages that are less sensitive, the DO guideline is 5.5 O_2/L. Under the 56 MW option, DO concentrations would not decrease below the guideline during ice cover months. This estimate is conservative because it does not consider oxygen replenishment from inflowing water into the lakes.

Extended periods of lake ice coverage can be determined from the following formula:

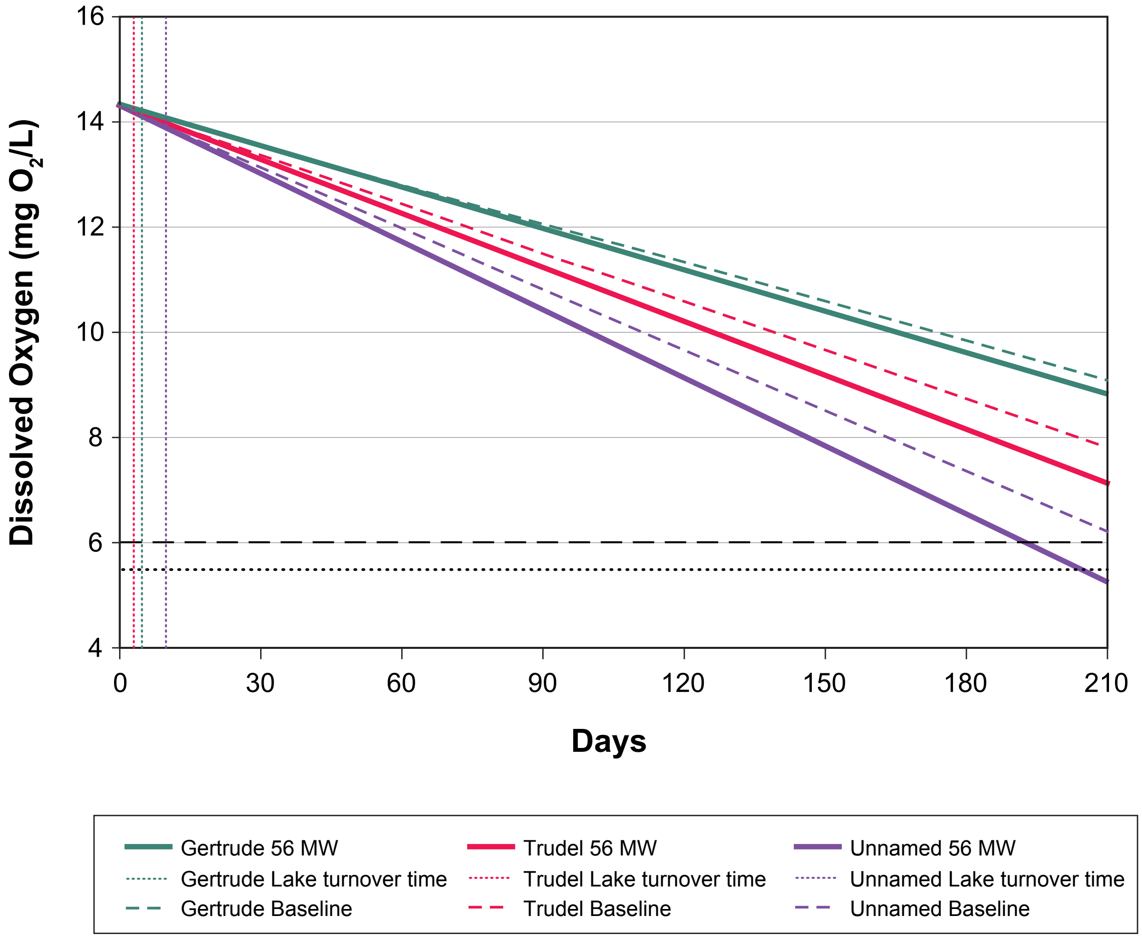
Gertrude Lake: $DO_n = -0.0261n + 14.3$

Trudel Lake: $DO_n = -0.0341n + 14.3$

Unnamed Lake : $DO_n = -0.043n + 14.3$

The relationship between ice cover days and DO concentration in the three lakes is presented in Figure 14.4.5 for a hypothetical scenario where ice cover is extended by one month from November to May (i.e., 211 days).

Turnover rates in Zone 5 lakes were calculated based on the reduction of average winter flows from 87.2 m^3/s at baseline to 9.1 m^3/s under the 56 MW option. Table 14.4.7 presents the changes in lake turnover time. In Gertrude, Trudel, and Unnamed lakes, reduced flow would increase the lake turnover time from 0.6, 0.5, and 1.3 days to 4.7, 3.0, and 9.8 days, respectively. The lake volume turnover rates and DO are presented in Figure 14.4.5. DO concentrations would experience low effects in all three lakes in Zone 5. Unnamed Lake would experience the most substantial effects, with modelled DO concentrations decreasing from 7.34 mg O_2/L to 6.51 mg O_2/L, assuming no water inflows and complete ice cover for 211 days. The estimate is conservative because DO concentrations would be replenished by low inflow rates. Small increases in ice thickness during the winter would also be unlikely to prolong ice cover in lakes by an additional month (211 days total). In comparison with the modelled daily decrease in DO presented in Figure 14.4.5, DO would experience low effects during winter months. The flows into Zone 5 would replenish DO in lakes during winter ice cover, preventing any substantial decreases in DO concentrations.



Note: Dashed line represents CCME guideline - warm water biota - early life stages.
Dotted line represents CCME guideline - warm water biota - other life stages.

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Modelled Decrease in Dissolved Oxygen During Winter Ice Cover at 56 MW** (503-005 / a21835m)	**Figure 14.4.5**

Table 14.4.7 — Lake Volume Turnover Times for 56 MW Option

	Baseline	56 MW
Average Monthly Winter Flow (m^3/s)	87.2	9.1
Average Winter Lake Volume (1,000 m^3)		
Gertrude	4,383.4	3,675.2
Trudel	3,981.3	3,028.7
Unnamed	10,114.4	7,733.1
Lake Volume Turnover Time (days)		
Gertrude	0.6	4.7
Trudel	0.5	3.0
Unnamed	1.3	9.8

14.4.3.4.7 Erosion and Sedimentation

Erosion is the process by which soil and weathered rock particles (sediment: gravel, sand, silt, and clay) are transported or moved from one place to another. The typical cause of bank erosion is a change in a hydrological or geological condition. Increasing water flow can erode soil and sediment through abrasion, dissolution, and scouring. Shoreline erosion can increase the sediment load and turbidity of the water and potentially act as a source of heavy metals. Soil that is eroded and transported by streams would eventually be deposited as sandbars in streams, as point-bars on the inner curve of a meandering stream, on floodplains and levees, or at the mouth of the river in a delta. Once erodible materials are transported away, self-armouring occurs from large rock particles or exposed bedrock. If there is no self-armouring material available, erosion would continue until the river becomes very wide, dispersing the energy in the river flows.

Erosion rates under the 56 MW option would be reduced, with negligible effects on water quality. The maximum water levels in this scenario would be 1.6 m lower than baseline conditions. At baseline conditions, Trudel Creek bank erosion was noted in sections with fine sediments and sand with low armouring. Water levels would decrease below these sections and they would no longer be affected by water-generated erosion. The decreased annual variation in mean monthly water levels from 1.98 m at baseline to 0.36 m indicates the lower water levels are maintained throughout the year, even in peak-flow months. The reduced erosion rates would also reduce the sedimentation rate of materials in Zone 5 lakes. The reduction in sedimentation would have a low effect on water quality.

14.4.3.4.8 Summary

Table 14.4.8 presents a summary of the predicted effects to water quality under the 56 MW option.

Table 14.4.8 — 56 MW: Summary of Potential Water Quality Changes to Zone 5

Water Quality Parameter	56 MW
General Chemistry	Low
Total Mercury	Negligible
Eutrophication	Negligible
Temperature	Low
Dissolved Oxygen	Low to Negligible
Erosion	Negligible
Sedimentation	Low

14.4.3.5 RAMPING

Flow ramping events would be part of normal operating conditions for both the 36 and 56 MW options. Section 14.3.3 provides details of the changes in flows and water levels along Trudel Creek during a ramping event from a scheduled power outage. Scheduled outages for turbine maintenance are currently planned annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion: 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the exiting 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 and 56 MW expansions would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events.

14.4.3.5.1 Ramping — Water Quality Effects

The six to ten hours required for ramping conditions to increase by 53 m^3/s may cause substantial water turbulence and remobilize sediments. Sediment mobilization would increase concentrations of general chemistry parameters in the water column such as total metals, organic solids, and suspended solids. However, the total flow would be well below the baseline rates and also below normal operating conditions under the 56 MW option.

The potential for ramping effects on general chemistry conditions would be low. The temporary ramping would cause parameters such as total metals and TSS to increase because these would have settled into sediments during winter low flow months. The flow rates during ramping would be well below the maximum flows during normal operating periods. Thus, changes may be detectable in the water but would not be substantial since the water is naturally oligotrophic and low in dissolved and suspended materials.

Total mercury and eutrophication potential in the water would experience negligible effects. Mercury levels in the water column would not change because of the low water solubility of mercury and because there would be no increase in mercury inputs into this system. Water levels under ramping conditions are also below the levels under normal operating conditions and no additional nutrients would enter the water system.

The potential for temperature effects in Trudel Creek and Zone 5 lakes would be low. Although scheduled shutdowns can occur at any time of year, ramping between April to May, when water flow over the SVS is lowest, would have the least effect on water temperature. During these months, Zone 5 would experience ice cover in lakes and sections of Trudel Creek. Increases in flow associated with ramping may result in water flowing over the ice, or increase the buoyancy of the ice layer, causing ice break-up. Ramping during the winter would cause warmer waters to flow into Zone 5. Although the temperature would be near freezing, water temperatures would increase and surface ice may melt more rapidly for the duration of the ramping event. In the summer, increased ramping flows would reduce temperatures in Zone 5 as cooler water from the Twin Gorges Forebay enters the shallower, warmer waters in Trudel Creek and Zone 5 lakes.

DO concentrations would experience negligible effects. Increased flows would cause more turbulence and potentially break surface ice cover in the winter, when DO concentrations are lowest. This turbulence would replenish DO in the water column throughout Zone 5.

Erosion and sedimentation would experience negligible effects. Although the rate of change of flows and water levels would be high, effects would be negligible because of the short duration of the change (6 hours) and because the total flow rate and water level is well below normal operating conditions.

Table 14.4.9 presents a summary of the predicted water quality changes during a scheduled partial outage.

Table 14.4.9 — Ramping: Summary of Potential Water Quality Changes to Zone 5

Water Quality Parameter	Ramping Effects
General Chemistry	Low
Total Mercury	Negligible
Eutrophication	Negligible
Temperature	Low
Dissolved Oxygen	Negligible
Erosion	Negligible
Sedimentation	Negligible

14.4.4 Uncertainty

A number of assumptions were made in predicting how changes in water levels and flows would affect water quality. Uncertainties associated with these assumptions are presented in the following section.

14.4.4.1 Water Levels and Water Flows

The predicted changes in water quality were based on modelled water levels and flows. The uncertainties associated with the hydrology model were described in Section 14.3. The overall trends in water flow and levels resulting from the proposed upgrades are assumed to be accurate.

14.4.4.2 Assessment Criteria

The predicted changes to water quality were based on water levels and flows from the HEC-RAS hydrological model. Qualitative water quality predictions were made based on the hydrological changes predicted for each scenario. However, modelled changes to flows and water levels cannot predict quantitative changes to water quality. For example, lower water levels in Zone 5 result in decreased water volume in Trudel Creek and downstream lakes. While this may increase water temperatures in the summer and prolong winter ice cover, quantitative predictions on temperature change would be highly variable and dependent on seasonal variations.

14.4.4.3 Dissolved Oxygen Model

The DO model described by Mathias and Barica (1980) describes aquatic respiration and carbon decomposition as the two major contributors to oxygen depletion in oligotrophic Arctic lakes during ice-covered months. However, the model assesses a lake as a closed system, and does not consider oxygen renewal from water inflow from Trudel Creek. Although water flowing in Zone 5 is substantially reduced under the 36 MW and 56 MW scenarios, a minimum flow of 4 m^3/s would be maintained throughout the year, providing some influx of oxygen. The lakes in Zone 5 are also small and turn over every 0.5 days to 1.3 days under baseline conditions. This lake renewal would replenish DO concentrations, although the overall influence of oxygen renewal cannot be determined since there are no monitoring data on the oxygen concentrations in the inflows and outflows. The lake turnover was addressed independently from the DO depletion. Hence, the modelled DO depletion rates are very conservative because it assumes no input of oxygen during the entire time the lake is under ice cover.

It is uncertain whether the surface water inflows would have a substantial effect on reducing the rate of DO depletion during winter months.

14.4.5 Summary

Table 14.4.10 presents a summary of the potential for water quality changes in Zone 5. Based on the changes in water level and flows in Zone 5, low to negligible changes to general water chemistry, mercury concentrations, temperature, dissolved oxygen, and erosion and sedimentation patterns would occur under both 36 MW and 56 MW scenarios. The water flow and level would not exceed baseline levels at any point in time, and the average water volume flowing into Zone 5 would be significantly reduced. Therefore, the flow rates and water levels that would be experienced in Zone 5 under both expansion scenarios would be lower than baseline levels.

Table 14.4.10 — Summary of Potential Water Quality Changes to Zone 5

Water Quality Parameter	36 MW	56 MW	Ramping
General Chemistry	Low	Low	Low
Total Mercury	Negligible	Negligible	Negligible
Eutrophication	Negligible	Negligible	Negligible
Temperature	Low	Low	Low
Dissolved Oxygen	Low to Negligible	Low to Negligible	Negligible
Erosion	Negligible	Negligible	Negligible
Sedimentation	Low	Low	Negligible

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.5 ALTERATION OF ICE STRUCTURE

14.5.1 Trudel Creek (Zone 5)

Water in excess of that required for power generation in the Twin Gorges Forebay discharges over the SVS into Trudel Creek. Upper Trudel Creek is a fairly uniform, low-gradient channel. Lower Trudel Creek features several lakes connected by a series of rapids. Lakes along this river reach include Unnamed, Trudel, and Gertrude lakes. Below Gertrude Lake, Trudel Creek has a series of relatively steeper sections before it reaches the confluence with Taltson River. Trudel Creek joins the Taltson River downstream of the Twin Gorges Dam.

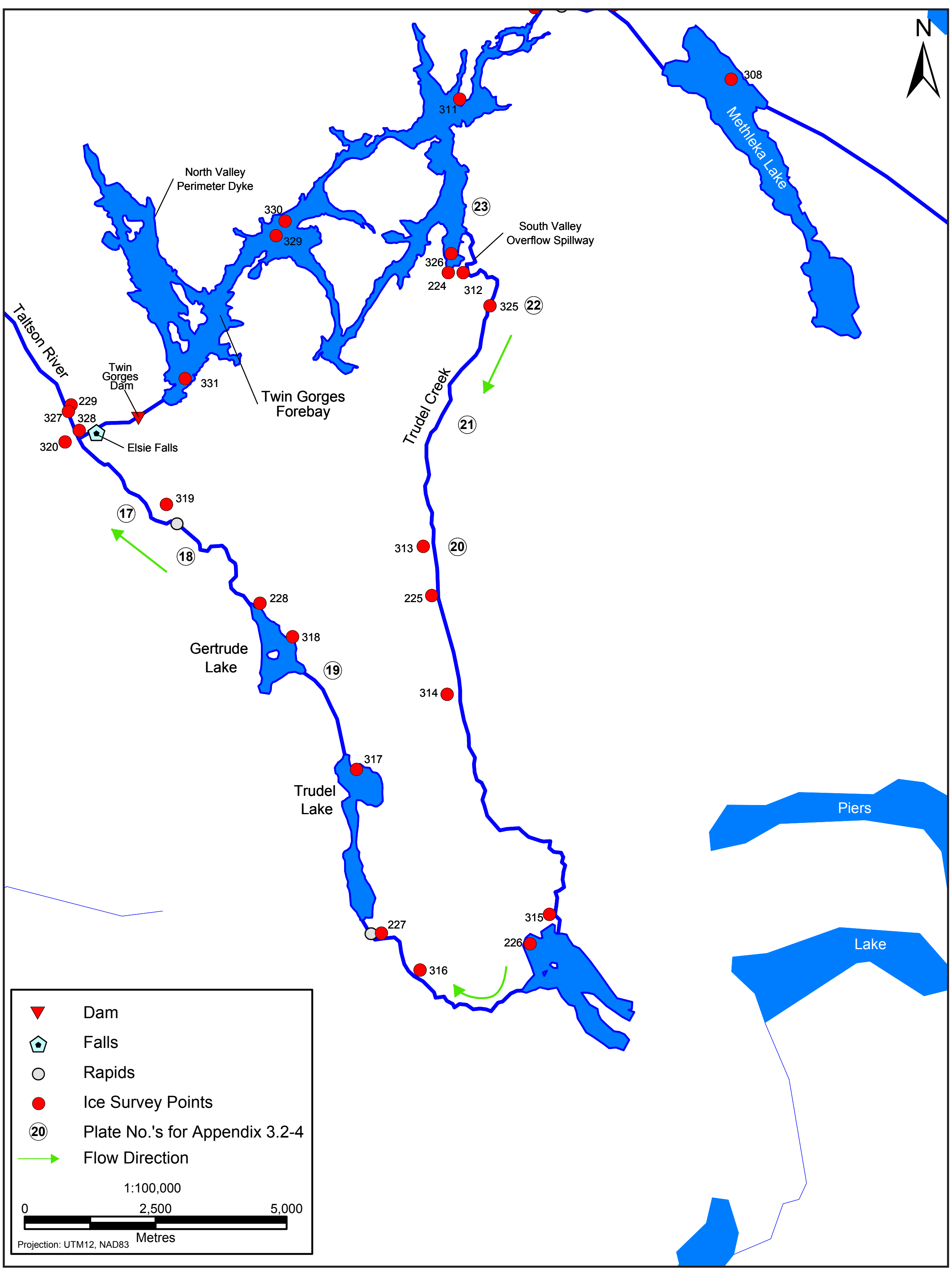
14.5.2 Existing Ice Conditions

14.5.2.1 ICE OBSERVATION REPORTS

Winter icing conditions on Trudel Creek are variable throughout the system, and change with various flow conditions and temperatures throughout the winter season. An ice-monitoring program was conducted for the Taltson River that included the collection of observations and ice thicknesses on Trudel Creek (Figure 14.5.1). The first set of observations was taken in November 2003, followed by observations in December 2006 and April 2007.

Early winter freeze-up processes were observed in November 2003. Observations generally showed that the water velocity in the river sections prohibited the development of thermal ice cover this early in the winter; however, frazil ice with some anchor ice was observed developing in the open water sections. Thermal ice covered all three lakes apart from the open water leads. Ice covers were observed to be actively advancing upstream of each of the lakes in the reach.

Measurements of ice thickness were taken in December 2006 and April 2007 (Whitlock, 2006; 2007) at Gertrude Lake. Monthly air temperatures at Fort Smith over the 2006-07 winter were reflective of the 29-year average air temperatures for the same period. In December the ice was 0.33 m thick and had been exposed to approximately 450 to 500 freezing-degree days. In April 2007, the ice was 0.63 m thick and had been exposed to approximately 2,500 to 3,000 freezing-degree days. Considering the number of freezing-degree days the cover had been exposed to, and the depth of snow on the lake, these thicknesses imply that the thermal ice growth is consistent with that of a slow-moving river section. When these measurements were taken, Gertrude, Trudel, and most of Unnamed Lake were completely frozen over as was most of the reach from Unnamed Lake to just downstream of the SVS. A short section with a higher gradient and higher-velocity flow immediately downstream of the SVS prohibited an ice cover from forming. This is consistent with the ice development observed in November 2003, which observed an actively-advancing ice cover in the reach between the SVS and Unnamed Lake, and evidence of anchor ice forming in this higher-velocity section.



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Taltson River Ice Survey Locations** **Zone 5: Trudel Creek**	**Figure 14.5.1**

Observations in December 2006 and April 2007 remained consistent with observations made in 2004 that slow-moving water in the three lakes and upstream from Unnamed Lake developed a competent ice cover, whereas faster-flowing water and rapid sections remained open with a considerable amount of ice build-up along the shorelines.

14.5.3 Current Typical Ice Conditions

Before construction of the original Twin Gorges dam in 1965, Trudel Creek was a small creek with relatively low flows. It is likely that it only connected to the Taltson River at the upstream end of the creek under extreme high-flow conditions. Trudel Creek now receives large flow volumes over the SVS all year.

The current ice regime for a typical winter on Trudel Creek is described below.

Each year, a thermal ice cover forms quickly on the Twin Gorges Forebay to a point just upstream of the SVS. Below the spillway, ice is initially generated in the 15 km reach between the spillway and the first downstream lake, Unnamed Lake. This ice begins accumulating and advancing against the thermal ice growth in Unnamed Lake, and eventually advances to a point that is approximately 1.5 km to 2 km downstream of the SVS.

Downstream of Unnamed Lake, the creek again narrows, but a thermal ice cover develops up to a point approximately 1 km upstream of Trudel Lake. At this point the river gradient steepens, and the river remains open up to its entrance into Trudel Lake. Ice generated in this reach of river accumulates against the thermal cover at the lake inlet.

The 2 km reach between Trudel and Gertrude lakes initially remains open, but ice generated in this reach begins to accumulate and advance against the thermal ice cover on Gertrude Lake. In tandem with this, border ice begins to extend from each bank, reducing the open water area of the river. This reach usually closes completely by winter's end.

This reach of Trudel Creek below Gertrude Lake is steeper and more swiftly flowing than the upper reaches of the creek. This reach typically remains open throughout the winter, and ice generated in this reach is deposited in the Taltson River downstream of its confluence with the Twin Gorges tailrace.

14.5.4 Predicted Ice Conditions

The proposed upgrades to the facility would result in a substantial decrease in the flow over the SVS into Trudel Creek. For both development scenarios, during the freeze-up months (October to December) the average monthly flow in Trudel Creek is expected to be approximately 20% of the average monthly flow that occurs during baseline conditions (see Section 14.3). Such a decrease in flow would cause ice freeze-up to progress much more rapidly in the river reaches of the creek. The reduction in flow velocity in some river sections has the potential to change the ice formation process from juxtaposition to simple lake ice generation (thermal ice cover). Freezing is not expected to extend all the way to the creek bed because there would be flow. However, some of the near shore shallow benches may freeze to the creek bed. Within lakes, the process of ice formation would remain the same;

however, lake levels are expected to be lower. There may be a slight increase in the thickness of thermal portions of the ice cover since river velocities are expected to be lower under the expansion scenarios.

On an annual basis, the turbines at Twin Gorges are scheduled to be shut down for routine maintenance and inspection. The timing of the outage would be set to coincide with the start of the spring freshet. As each turbine is turned off, water levels in the forebay would rise. Once levels reach the elevation of the SVS, flows into Trudel Creek would increase from approximately 4 m^3/s to a maximum of 57 m^3/s. This would likely increase the rate of spring break-up of the ice cover along Trudel Creek. Any mobilized ice fragments would then likely re-jam either at one of the downstream lakes, or, should the lake cover also be compromised, in the Taltson River.

14.5.5 Summary

Ice conditions on Trudel Creek have been reviewed and assessed qualitatively on the basis of three available ice surveys. Predictions have also been made on how the development of either a 36 MW or 56 MW expansion would would affect the existing ice regime in this reach.

At Trudel Creek, the changes in operations and the upgrades to the Twin Gorges facility are expected to substantially decrease flow within the creek. The decreased flow has the potential to affect ice formation. Ice freeze-up would occur more quickly with the lower river velocities. The ice has the potential to be thicker throughout the creek than under baseline conditions, and with the decrease in water levels, there is the potential for the creek to freeze to the bed within the near-shore shallow benches. Rising water levels in Trudel Creek caused by scheduled annual outages of the turbines at Twin Gorges may lead to an increased rate of ice cover break-up along Trudel Creek.

This assessment is based on a qualitative overview of the potential changes to ice structure in the study area. The effect of changes in flow conditions on ice structure at critical locations would depend on the local river hydraulics and stream morphology at the individual sites. Site-specific field work and possibly modelling would be required to give a quantitative assessment of change.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF PLATES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.6 WETLANDS

14.6.1 Existing Environment

Wetlands are transition ecosystems that connect aquatic and terrestrial environments (Mitsch and Gosselink, 2000). Environment Canada defines wetlands as "land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment" (NWWG, 1988). As a result of their environmental characteristics, wetlands perform functions that are critical to the maintenance of biodiversity and "healthy ecosystems." For instance, wetlands provide habitat for fish and wildlife and also regulate hydrology, water quality, and climate of a given area. The Canadian Environmental Assessment Agency (CEAA) defines wetlands as valued ecosystem/environmental components when they may be affected by a project. The baseline environmental conditions of wetlands in Zone 5 (Figure 14.3.1) were surveyed to determine the potential impacts to wetland extent and function by the Taltson Hydroelectric Expansion Project (the Project).

14.6.1.1 SURVEY SUMMARY

There were three components to the wetland baseline study: (1) mapping wetlands; (2) identifying wetland properties and wetland classification; and (3) modelling ecological assembly. Wetlands were mapped along Trudel Creek (Zone 5; Figure 14.3.1) using non-ortho corrected photos collected in 2007 and digital wetlands data (NTDB Wetlands) from GeoGratis (Natural Resources Canada, 2008). Complete photo capture and mapping methods are presented in Appendix 13.7A.

Wetlands along Trudel Creek were surveyed in August 2008. At each site, vegetation, soil, and hydrodynamic characteristics were recorded and used to classify sites into wetland classes following the Canadian System of Wetland Classification (Warner and Rubec, 1997). Elevations of the shrub/sedge wetland boundary were recorded using a differential GPS. These data were used to generate a predictive model of ecosystem assembly. The following sections summarize the baseline condition (size, distribution, functions and values) of wetlands found in Trudel Creek.

A total of 18 wetland ecosystems were surveyed in the Trudel Creek zone. The dominant ecosystem class was riparian marsh, which comprised five distinct communities. Two mapping sources were used to map wetlands and calculate their extent in Trudel Creek (Table 14.6.1). The aerial photos from 2007 were not ortho corrected. Thus, wetland areas should be considered approximate values.

The most common wetland community along Trudel Creek was the Sedge-Horsetail riparian marsh; it was observed at seven sites (39%) (Figure 14.6.1). The Sedge-Horsetail community (Plate 14.6.1) typically had less than 40 cm of fibric organic soil. The mineral soils were poorly to well drained sands, silts, or loams, with coarse fragment content usually below 20%; although, it exceeded 70% at sandier sites. Vegetation was typically dominated by *Carex utriculata* and/or *Carex aquatilis* and *Equisetum hyemale*.

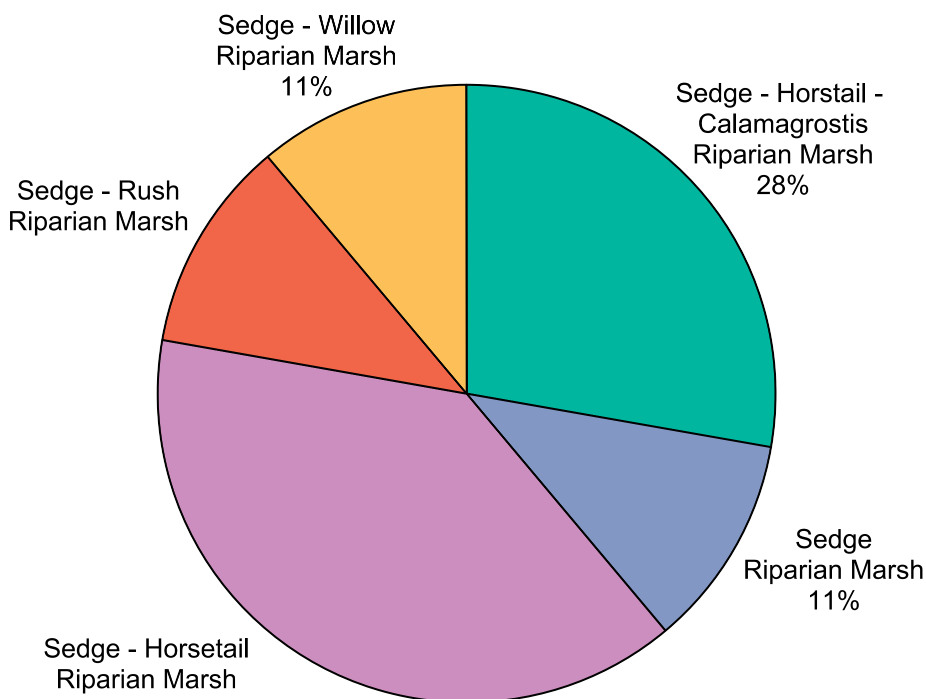
Table 14.6.1 — Wetland Area along Trudel Creek (Zone 5)

Data Source	Approximate Area (ha)
Non-Corrected Air Photos (2007)	104
NTDB – Wetlands file	472[1]

[1] The difference in area covered by the data sources reflects the difference in scale between the two sources: the NTDB wetlands were digitized from 1:50,000 raster maps, which is a smaller scale than the aerial photos and covers a larger area (Appendix 13.7A).

Plate 14.6.1 — Sedge-Horsetail Riparian Marsh at (TW7)

The next most abundant community in Trudel Creek was the Sedge-Horsetail-Calamagrostis riparian marsh (Plate 14.6.2). This community, represented 28% of the wetlands surveyed in Trudel Creek and was only observed in this zone of the Taltson Basin. The Sedge-Horsetail-Calamagrostis communities had little, if any, organic soil. The organic soil that was present was <10 cm of the soil surface and was typically fibric grassy-peat. The mineral soils were characterized as: very moist, poorly drained, loamy sand with up to 70% coarse fragments. Vegetation in this community was dominated by *Carex utriculata*, *Equisetum hyemale* and *Calamagrostis canadensis*. The Sedge-Horsetail-Calamagrostis community is similar to the Sedge-Horsetail community, with the exception of the significant cover by *Calamagrostis Canadensis*, which was not observed in the Sedge-Horsetail community.



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Wetland Vegetation Community Associations Observed in the Trudel Creek Study Area** (503-005 / a20714f)	**Figure 14.6.1**

Plate 14.6.2 — Sedge-Horsetail-Calamagrostis Riparian Marsh at (TW15)

Three remaining communities accounted for approximately 10% each (Figure 14.6.1) The three communities were: (1) Sedge riparian marsh; (2) Sedge-Rush riparian marsh; and (3) Sedge-Willow riparian marsh. These three communities were also observed in other zones of the Taltson Basin. The Sedge riparian marsh (Plate 14.6.3) had shallow organic soil (<40 cm) over a poorly-drained silty mineral soil. Vegetation was dominated by *Carex utriculata*. The Sedge-Rush community (Plate 14.6.4) was observed on the river bank and lake shores in the Trudel Creek Zone. These sites had shallow organic soil. The mineral soils were sands or silt loams and were poorly to imperfectly drained. Vegetation composition varied, but some semblance of sedge and rush/bulrush species dominated the community. Observed vegetation included *Carex lasiocarpa*, *Carex utriculata*, *Carex aquatilis*, *Scripus acutus*, *Juncus arcticus*, and possibly *Scripus microcarpus* (or similar species). The final marsh community observed was the Sedge-Willow riparian marsh. This marsh community was observed in all zones of the Taltson Basin. It was common for most riparian wetlands to have a willow component; however, the willow community typically existed as a band separating the sedge community from the upland. The Sedge-Willow marshes had this band but they also typically had a number of small willow communities scattered throughout the sedge-dominated portions of the wetland (Plate 14.6.5). These communities had shallow organic soil with varying ranges of decomposition. The mineral soils were poorly to imperfectly drained loams. Vegetation consisted of *Carex utriculata*, *Carex aquatilis*, and a variety of *Salix* spp.

Plate 14.6.3 — Sedge Riparian Marsh at (TW9), Zone 5

Plate 14.6.4 — Sedge-Rush Riparian Marsh at (TW4), Zone 5

Plate 14.6.5 — Sedge-Willow Riparian Marsh at (TW1), Zone 5

14.6.1.2 ECOLOGICAL ASSEMBLY

Ecological assembly is defined as the structure and composition of an ecosystem. Ecological assembly is an integral component of classification and mapping of wetlands. Structure relates to the vertical and horizontal ground cover by all species within a community whereas composition is the abundance and distribution of individual species within a community. Ecological assembly is used to separate ecosystem classes such as fens from bogs. It is also helpful in determining the function of wetland habitat and ecology. For example, songbirds that require shrub communities would not live in an area where the structure and composition of an ecosystem does not contain shrubs.

The relative proportion of woody shrubs versus sedges and other herbaceous plants in riparian wetlands is controlled by the flood regime. The flood regime is defined as the frequency and duration that water inundates various levels of wetlands throughout the year. The number of days that water inundates a wetland can be modelled from the water level of the river and the height of the flood-controlled community boundary (such as the willow-sedge boundary) within riparian wetland ecosystems. The effect of water inundation on a wetland is controlled primarily by flooding during the growing season. The growing season is established by the mean daily temperatures. Each of these factors (water levels, community boundary, and growing season as a function of temperature) can be modelled or measured in the field. Water levels were modelled throughout the baseline study area and data was available for specific hydrology model locations (Rescan, 2008b). Temperature was recorded by Environment Canada and compiled from data available for Fort Smith, NWT. The elevation of the community boundary was measured in the field using a differential GPS.

The principle behind the model is that flood levels control the presence and absence of shrub-dominated wetlands, particularly along riparian corridors. These ecosystems are shrub wetlands with drier areas described as shrub-carr. Shrub-carr communities do not fit the classic definition of a wetland but are often associated with wetland ecosystems. The sedge wetlands connected to the shrub wetlands are described as emergent wetland communities; emergent communities can also include species such as *Equisetum* sp. The submergent community is defined as the area currently under water in Trudel Creek supporting submergent vegetation.

For this assessment, the fraction of the growing season that was flooded was calculated at the ecosystem boundary elevation. Ecosystem boundary elevations were defined by the flood level. Water elevations above the ecosystem boundary were considered flood events, and growing season was established from temperature data. The ecosystem boundary was defined as the area of the wetland where there was >70% cover by *Salix* spp. These data were combined to build a flood regime data set which was used to predict community structure and composition based on the frequency and duration of flood events during the growing season.

Elevation above sea level was collected at three to five sites along the sedge-shrub ecosystem boundaries (Plate 14.6.6). This elevation was established as the flood zero (Fl0) position. Two other flood levels were established by adding or subtracting 0.5 m from the Fl0 position to create Fl+5 and Fl-5 positions respectively. Elevations were corrected by subtracting the difference between the hydrology station benchmark elevations and GPS elevations collected at these benchmarks on the same day of the survey.

Plate 14.6.6 — Ecological Assembly Survey Locations

Note: Arrows indicate the location of ecological assembly GPS survey positions.

Water level data from four hydrology reference locations was used to build the flood regime database for the Trudel Creek Zone. The distance between most of the ecology assembly survey locations and hydrology reference locations was <6 km; however, to remain consistent with modelling conducted for other zones within the Taltson Basin, ecological assembly was modelled at the site closest to the hydrology reference location.

The relative percent difference of the modelled elevation height and the average corrected GPS positions was calculated to identify significant errors between the measured elevation data and the data used in the model. The relative percent difference of the model height from the average GPS corrected height was less than 1% in all cases (Appendix 13.7A).

Another necessary component of the ecological assembly model was the establishment of the growing season. Growing season for the Project was calculated as the number of days between when the temperature exceeded 11 ºC for five of seven days and when temperature was below 11 ºC for five of seven days. Based on the temperature records, the growing season in Trudel Creek is 98 days (from May 28 to September 2). This growing season length is consistent with field observations and literature (Territorial Farmers Association, 2000).

For the growing season, the percent it was flooded at the Fl-5, Fl0 and Fl+5 elevations was calculated by counting the number of days in each growing season where water levels exceeded one of the flood levels, and dividing the total by the number of days in the growing season (98). The last day of the first flood (ld) and the time of the second flood (tsec) were also recorded; these variables were identified by Toner and Keddy (1997) as significantly correlated to ecological assembly. However, flooding often started before the growing season and at some locations continued past it; therefore, the ld and tsec data are not presented in this assessment. The Fl+5 flood statistics are also not presented because this elevation was never flooded during the growing season (Appendix 13.7A).

The Taltson basin hydrology model (Rescan, 2008a) predicts that in Trudel Creek water levels under both expansion scenarios would be lower than baseline conditions. The Taltson basin model is based on 13 years of hydrology data. During the growing season, water levels are expected to be on average 1.48 m below baseline for the 36 MW option and 1.61 m below baseline for the 56 MW option. Summer water flows over the South Valley Spillway are projected to be on average between 30 m^3/s and 40 m^3/s for the 36 MW option and between 20 and 30 m^3/s for the 56 MW option, although substantial variation would be expected. During the 13-year modelled period of record under the 36 MW and 56 MW scenarios, flows up to 355 m^3/s and 244 m^3/s, respectively, are possible along Trudel Creek, although, there is no real upper limit (Section 14.3). The ecosystem assembly model accounts for the large potential fluctuation in flows by using daily water level data, which is then averaged over the model period. Table 14.6.2 presents model variables for the baseline conditions at the Fl-5 and Fl0 flood positions.

14.6.2 Valued Components

Two Valued Components (VCs) relating to wetlands were identified for the effects assessment: (1) wetland extent and (2) wetland function.

Table 14.6.2 — Percentage of Growing Season Flooded in Trudel Creek at Fl-5 and Fl0 Positions for the Baseline Period

Hydrology Reference	Survey Plots	Flood Level	Growing Season Flooded % (Baseline)
TDL15	1	Fl-5	94.9
TDL12	3, 4, 5, 7, 8, 10	Fl-5	93.9
TDL9	11, 12, 13, 15	Fl-5	94.9
TDL7	16, 17, 18	Fl-5	93.9
TDL15	1	Fl0	38.8
TDL12	3, 4, 5, 7, 8, 10	Fl0	27.6
TDL9	11, 12, 13, 15	Fl0	33.7
TDL7	16, 17, 18	Fl0	26.5

14.6.2.1 Wetland Extent

Wetland extent is defined as the size of individual wetlands and total wetland area within the baseline study area. Wetland extent was chosen as a VC because loss of wetland area is one of the largest threats to wetlands in the Northwest Territories, Canada, and worldwide. Wetland extent is measured through a footprint analysis. Wetland extent in the Trudel Creek zone was mapped using non-ortho corrected photos collected in 2007 and was supported by wetland data (NTDB Wetlands) from GeoGratis (Natural Resources Canada, 2008). Wetland extent for the Trudel Creek zone accounts for approximately 104 ha (2007 aerial photos) and 472 ha (NTDB wetlands) of the total baseline study area.

14.6.2.2 Wetland Function

Wetland function was selected as a VC because it is a standard measure of wetland quality. Wetland function is defined as a process or series of processes that wetlands carry out, such as a wetland's ability to regulate the hydrology of a given area. Environment Canada (2003) identifies four primary functions in its Wetland Environmental Assessment Guideline document; however, only three functions were considered in this assessment. The three functions included in this assessment and their definitions are:

- hydrological function – contribution of the wetland to the quantity of surface and groundwater,
- habitat function – terrestrial and aquatic habitat provided, and
- ecological function – role of the wetland in the surrounding ecosystem.

The biochemical function of wetlands, such as their ability to sequester metals and break down environmental pollutants, is not included in this assessment. Although it is a key wetland function, biochemical data was not collected to support an assessment of project effects on wetland biochemical function. Effects of the Project on the biochemistry in the aquatic environment are addressed in Sections 14.4 and 14.8.

14.6.2.2.1 Hydrological Function

The wetlands in the baseline study area are closely connected with the surface water flow of Trudel Creek. Riparian wetlands are not net contributors of water; rather, they temporarily store water and release it over a long period. Riparian marshes are well known for their flood control and sediment trap functions. It is estimated that 0.4 ha of wetlands can store 6,000 m^3 of flood water (RAMSAR, 2008). Because wetlands are closely linked to the surface water system, alterations in wetland hydrology is a primary pathway for environmental impacts to wetland function. Marsh wetlands are particularly susceptible to hydrological changes (MacKenzie and Moran, 2004).

14.6.2.2.2 Habitat Function

The habitat function is the terrestrial and aquatic habitat provided by wetlands. It was identified through wildlife observations during the ecosystem survey. A number of amphibians and mammals was observed in the baseline study area. Moose frequent the many riparian marshes and shallow open water wetlands in the summer to cool off and escape from insect pests (Flook, 1959; Renecker and Hudson, 1986). A number of moose beds was observed in riparian marsh communities throughout the baseline study area. In the winter, willows found along the Sedge-Willow community boundary in riparian wetlands provide valuable forage for moose.

14.6.2.2.3 Ecological Function

Riparian wetlands in the baseline study area are strongly connected with the upland environment and often form complexes of multiple wetland associations. Riparian marsh associations abruptly transition into tall shrub swamps and shrub-carr associations before eventually drying out and becoming upland forest. The structural variety of wetland communities provides habitat for a number of wildlife species benefiting the function and biological integrity of surrounding ecosystems (Galatowitsch and Van Der Valk 1998).

14.6.3 Assessment Endpoints

The assessment endpoints represent the key features of the VC that should be protected and are used to illustrate how the pathways affect each VC. Assessment endpoints for each VC are presented in Table 14.6.3.

Table 14.6.3 — Wetland Valued Components and Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Ecological changes in Trudel Creek	Wetland extent	Preservation of wetland extent along Trudel Creek
Ecological changes in Trudel Creek	Wetland function	Maintenance of wetland function along Trudel Creek

14.6.4 Assessment Boundaries

The assessment boundary can be separated into two categories, spatial and temporal. The following section describes the spatial and temporal boundaries as they relate to wetlands.

14.6.4.1 Spatial Boundary

The spatial boundary for the assessment is wetlands of Trudel Creek. Trudel Creek spans 33 km of river and includes three lakes. Within the assessment boundary of Trudel Creek are small- and medium-scale assessment boundaries; single reach of Trudel Creek or single lakes of Trudel Creek; and multiple reaches or lakes of Trudel Creek (Figure 14.1.1 to Figure 14.1.5).

14.6.4.2 Temporal Boundary

This assessment addresses effects related to the operation stage of the Project only. The Project is anticipated to have a minimum lifetime of 40 years; the first 20 years would be used to supply power to existing and proposed diamond mines. Upon closure of the mines, there is the potential to connect to the NWT power grid, which would extend the life of the Project. However, for the purpose of the effects assessment, operations-related effects were assessed using a temporal boundary of 40 years.

Construction is not expected to have any significant impacts to wetlands in the Trudel Creek system because no construction activities are proposed for Trudel Creek or the South Valley Spillway. Construction activities would see the water levels in Nonacho Lake lowered over the fall and winter prior to the commencement of construction in the early spring. Although this would increase water levels in Trudel Creek some three weeks after drawdown begins, there are a number of lake systems between Trudel Creek and Nonacho Lake, which would store some of the excess water released from Nonacho Lake. Within Trudel Creek, water levels would likely be similar to those experienced during a baseline “wet” fall (Rescan 2008a).

The details on decommissioning are not comprehensive enough to complete an effects assessment at this time; however, it is the plan of the Dezé Energy Corporation to complete the necessary studies 7 to 10 years prior to closure. Closure and restoration details are provided in section 6.8 (Project Closure).

14.6.5 Project Components

Given that this assessment relates to the effects of the Project on wetlands because of potential changes to the ecology in Trudel Creek, it is likely that specific project components would not have any significant effect with respect to this KLOI. Therefore, the assessment would focus on project phases, principally operation. The operation of the Project refers to activities carried out after construction and in the normal operation of the Project under either the 36 MW or the 56 MW expansion scenarios and scheduled ramping of water levels due to the maintenance of turbines and power-generating facility at Twin Gorges. The potential effects anticipated within the Trudel Creek system are associated with the alteration of the existing hydrograph. Of the identified Project components, the operation of the Power Generating Facilities, including the flow release at the Nonacho control structure and/or flow through the generating facilities, is the only component that would result in flow alterations within Trudel Creek.

14.6.6 Pathway Identification

Pathways were identified that link potential effects to wetland extent and wetland function and ultimately the assessment endpoints (Table 14.6.4).

Table 14.6.4 — Wetland Assessment Pathways

Valued Component	Assessment Endpoint	Pathway
Wetland extent	Preservation of wetland extent along Trudel Creek	Water level changes leading to a change in flood regime which alters wetland extent. Rapid water level changes leading to a change in flood regime which alters wetland extent due to scheduled ramping.
Wetland function	Maintenance of wetland function along Trudel Creek	Changing water levels would change the flood regime which would alter wetland function (hydrological, habitat and ecological). Rapid water level changes would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to scheduled ramping.

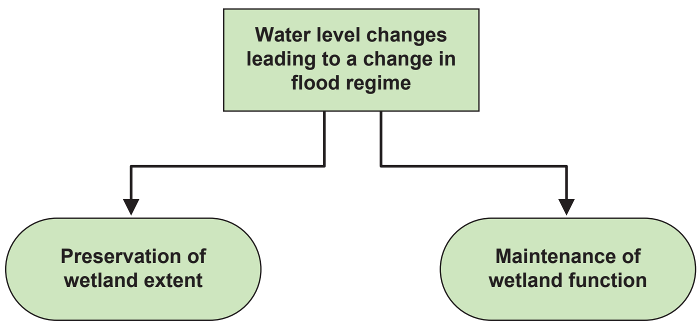
Four pathways exist that could affect the wetland assessment endpoints. Changing water levels would affect the current flood regime, which is the primary force in maintaining riparian wetland communities (Odland and Moral 2002; Toner and Keddy 1997; and Nilsson and Svedmark 2002) (Figure 14.6.2). The direction of change (increase or decrease in flows) is not as important as the magnitude and duration. Water levels substantially above or below current ecosystem community boundaries would result in species composition shift following natural succession. Water level changes in Trudel Creek are expected from normal operations and scheduled ramping.

14.6.7 Mitigation

Canadian federal policy regarding wetland conservation identifies three hierarchical mitigation alternatives (Lynch-Stewart et al., 1996) when considering potentially-affected wetland habitats:

- **avoid:** relocate Project activities to prevent loss of wetland habitat;
- **minimize:** plan Project activities to have few direct or indirect impacts to wetland ecosystems; and
- **compensate:** create wetland habitat with similar values to replace wetland habitat irrevocably altered during Project activities.

The Expansion Project would use mitigation measures to minimize potential effects to wetlands. A by-pass spillway would be constructed beside the power facilities to minimize the quantity of water spilled into Trudel Creek during a scheduled and unscheduled power outage. Upon start-up following a power outage, Dezé's operations plan would be to bring the turbines back online one at a time so that flow and water level changes are minimized.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wetlands - Pathways and Assessment Endpoints for Potential Effects in the Trudel Creek (503-005 / a22353f-C14)	Figure 14.6.2

14.6.8 Pathway Validation

Pathways were considered valid when there was an effect on a VC because of a Project component after mitigation measures (practice or design) were applied. Pathways where mitigation was not expected to avoid or reduce a negative effect were identified as valid, and were carried through to the effect classification and residual effect analysis.

Marsh wetland communities would undergo structural change if their hydrological regime is not maintained; this includes both water level increases and reductions. Specific, directional water level changes, as well as magnitude and duration, were addressed through using the ecological assembly model. Pathways were considered valid if the flood regime responsible for maintaining a specific community was altered. Table 14.6.5 presents the ecological assembly flood statistics comparing baseline conditions to the 36 MW and 56 MW expansion scenario flood statistics at the Fl-5 and Fl0 elevations.

Table 14.6.5 — Percentage of Growing Season Flooded in Trudel Creek at Fl-5 and Fl0 Positions for the Baseline and 36 MW and 56 MW Expansion Scenarios

Hydrology Reference	Survey Plots	Flood Level	Growing Season Flooded % (Baseline)	Growing Season Flooded % (36 MW)	Growing Season Flooded % (56 MW)
TDL15	1	Fl-5	94.9	0	0
TDL12	3, 4, 5, 7, 8, 10	Fl-5	93.9	0	0
TDL9	11, 12, 13, 15	Fl-5	94.9	0	0
TDL7	16, 17, 18	Fl-5	93.9	0	0
TDL15	1	Fl0	38.8	0	0
TDL12	3, 4, 5, 7, 8, 10	Fl0	27.6	0	0
TDL9	11, 12, 13, 15	Fl0	33.7	0	0
TDL7	16, 17, 18	Fl0	26.5	0	0

Pathways where mitigation reduced a negative effect were considered minor or invalid depending on the significance of the pathway and the degree to which mitigation reduced the negative effect. Only valid pathways were carried through to the effect analysis. Pathway validation for the 36 MW and 56 MW options are presented in Table 14.6.6.

Table 14.6.6 — Pathway Validation for the 36 MW and 56 MW Options

Valued Component	Pathway	Pathway Validation
Wetland extent	Water level changes leading to a change in flood regime which alters wetland extent.	Valid
Wetland extent	Rapid water level changes leading to a change in flood regime which alters wetland extent due to scheduled ramping.	Valid
Wetland function	Changing water levels would change the flood regime which would alter wetland function (hydrological, habitat and ecological).	Valid
Wetland function	Rapid water level changes would change the flood regime which would alter wetland function. (hydrological, habitat and ecological) due to scheduled ramping.	Valid

14.6.9 Effect Classification

Effects to wetland extent and function were defined for available information. The extent of Project effects on wetlands was quantified where possible and qualified based on the extent of the effect within Trudel Creek: single reach or lake, multiple reach or lake, and all of Trudel Creek.

Effects assessment descriptors are defined in Chapter 10 - Assessment Methods and Presentation for effect classification descriptor definitions except magnitude. Magnitude relates to a change in the ecological assembly in the form of a community shift, as measured as the difference from the baseline ecological assembly statistics. Magnitude divisions are presented in Table 14.6.7. Change in ecological assembly is a measurement endpoint that was used to quantify and qualify the magnitude of effect on the assessment endpoint (preservation of wetland extent along Trudel Creek).

Table 14.6.7 — Ecological Assembly Statistics and Assessment Magnitude

Difference from Baseline at Fl0 [1]	Assessment Magnitude	Difference from Baseline at Fl-5 [1]
0 to 5	Normal	0-5
6 to 10	Negligible	6-15
11 to 15	Low	16-25
16 to 20	Moderate	26-35
>20	High	>35

[1] Represent discrete value changes from the percent of growing season flooded ecological assembly model statistics.

14.6.9.1 Effects on Wetland Extent

The wetland baseline study identified between 104 ha and 472 ha of wetlands susceptible to alteration in the Trudel Creek Zone. Generally, the effects on riparian wetlands in this zone are the same for both the 36 MW and 56 MW expansion scenarios. The ecological assembly model predicted that at the Fl0 and Fl-5 flood positions under both expansion scenarios, substantial changes in ecological assembly are likely. The current Sedge-Willow community boundary (Fl0) would no longer be flooded at any time of the growing season (Table 14.6.5). This would result in a drying out of the current Fl0 position and a change from the current willow wetland to a willow shrub-carr ecosystem. Willow would likely colonize new areas below the Fl0 elevation; some of these newly colonized areas would be willow-dominated riparian wetlands.

The current submergent community and sedge wetland would also experience growing-season dewatering (Table 14.6.5), likely resulting in a colonization of these areas by willow and other upland species. Given that the Fl-5 elevation would no longer be flooded during the growing season, it is likely that willows and upland species would occupy this area, which would result in the complete replacement of current riparian sedge wetland communities. Although a total change of wetland community is predicted, the time-scale for succession is largely unknown. Sedge communities can survive a major drawdown for more than 14 years; however, significant alterations in wetland vegetation would be evident after 10 years (Odland, 2002), and potentially longer for *Salix* spp. (Odland and Moral, 2002).

The extent and rate of colonization by emergent species is difficult to predict, because information relating the slope, sediment composition, and seed bank is lacking. It is reasonable to assume that, under favourable conditions, *Carex* and *Calamagrostis* spp. would become re-established at new bands farther down-slope on the bank or previously submerged terraces/benches within Trudel Creek. This colonization would occur over approximately three years, but would not include colonization by *Equisetum* or *Salix* spp. because they represent extreme (relatively wet and dry, respectively) communities which would take longer to regenerate (Odland and Moral, 2002). New wetland communities would begin colonization of non-vegetated areas within 3 years but may not be diverse functioning communities for up to 10 to 20 years.

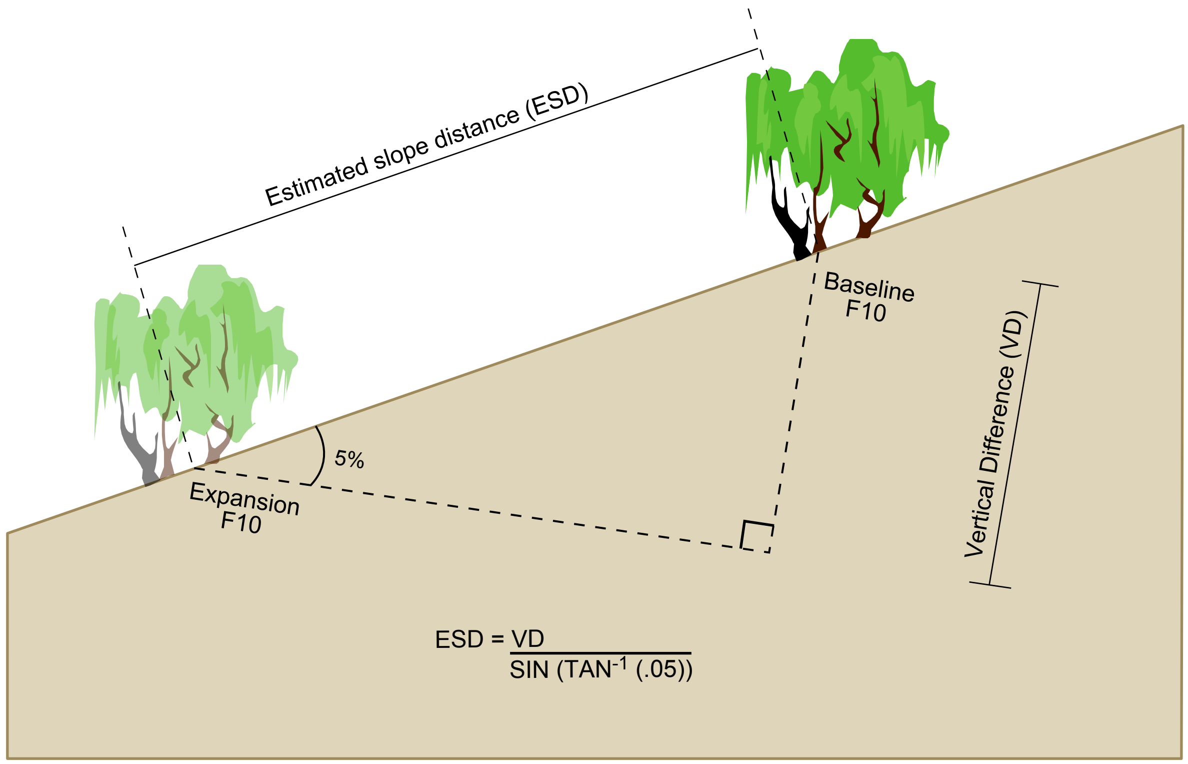
A series of 18 cross-sections (TDL 1-18) (Section 14.3) for Zone 5 show that under the 36 MW and 56 MW options, suitable combinations of topography and water depth would be present at TDL 3, 5, 6, 7, 8, 9, 11, 13, 14, and 17, which would allow for the colonization or maintenance of submergent communities. As well, suitable combinations of topography and water depth at TDL 1, 2, 5, 6, 8, 13, and 14 would allow for the colonization by emergent wetland species because a series of currently-submerged terraces/benches would no longer be flooded for the entire growing season. These cross-sections indicate that suitable physical conditions for vegetation regeneration exist in Trudel Creek.

To illustrate wetland loss and potential area available for wetland creation, the vertical distance between the baseline Fl0 elevation and post-expansion Fl0 level was calculated. The slope distance for the change between Fl0 baseline, Fl0 36 MW expansion, and Fl0 56 MW expansion was calculated for each ecological assembly model area by assuming a slope of 5% (Figure 14.6.3; Table 14.6.8). Assuming that vegetation communities are able to re-establish and the slope of the wetlands is 5%, the current Fl0 elevation would move approximately 31 m (36 MW scenario) and 33 m (56 MW scenario) toward Trudel Creek.

The extent of colonization by submergent species into new areas is also unknown, for similar reasons to that of the emergent vegetation. Information relating sediment composition, benthic substrate, and seed bank is lacking. However, under optimal conditions it is reasonable to assume that submergent species would colonize all areas with <2 m of water. This depth represents the approximate photic depth (the depth that light can penetrate water) allowing submergent plants the light requirements for photosynthesis.

A confounding factor contributing to the effect of the Project on wetland vegetation and its ability to colonize any areas, which, under baseline, were in the submergent zone, is the large potential fluctuations in flows in Trudel Creek. Water levels are projected to drop by an average of 1.48 m and 1.61 m under the 36 MW and 56 MW scenarios. However, maximum flows under the expansion scenarios are projected to reach 355 m^3/s for the 36 MW option and 244 m^3/s for the 56 MW option. The implication is that previously submerged areas, which would be exposed unvegetated areas post-expansion, would be susceptible to flooding. This may reduce the ability of colonizing species to quickly establish in the riparian areas of Trudel Creek. These large fluctuations in flows would ultimately transport sediment, seeds, and nutrients into and out of the system. Sediment transport may provide substrate suitable for colonization as the waters recede. However, these sediments may be transported downstream to areas not suitable for wetland development. They may also be deposited in existing wetlands, further impacting communities downstream.

The direct effects to the emergent wetland communities by the Project are adverse because the ecological assembly of Trudel Creek wetlands would change. The geographic extent of the Project effects extend throughout Trudel Creek. The magnitude of the effect to Trudel Creek wetlands is high, given that all wetlands maintained by current flood levels would undergo a change in flood regime and extent. The effect on wetland extent is medium-term because it would take up to 10 years for new ecological assembly to establish. All effects are reversible, provided that water levels and water level fluctuations post-expansion allow new riparian wetland communities, similar to pre-expansion communities, to develop and flourish. The overall residual effect is moderate. Table 14.6.9 presents the effect classification for wetland extent in Zone 5.



$$ESD = \frac{VD}{SIN(TAN^{-1}(.05))}$$

TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Estimated Slope Distance Calculation for F10 Position Change between Baseline and Expansion** (503-005 / a22115f)	**Figure 14.6.3**

Table 14.6.8 — Projected Vertical and Horizontal Differences between Baseline and Expansion at the Fl0 Elevations in each Ecological Assembly Model Area

Hydrology Reference	Survey Plots	Flood Level	Vertical Difference (36 MW) (m)	Vertical Difference (56 MW) (m)	Estimated Slope Distance Change – Fl0 (36 MW) (m)	Estimated Slope Distance Change – Fl0 (56 MW) (m)
TDL15	1	Fl0	1.5	1.7	30	33
TDL12	3, 4, 5, 7, 8, 10	Fl0	1.7	1.8	33	35
TDL9	11, 12, 13, 15	Fl0	1.3	1.4	26	28
TDL7	16, 17, 18	Fl0	1.7	1.9	34	37

14.6.9.2 Effects on Wetland Function

The effects on wetland function along Trudel Creek are presented in Table 14.6.9. The effects of the Project on wetland function are directly related to wetland extent. Wetlands would only carry out their functions if they are present in an area. Wetlands currently function by buffering downstream environments from flooding during high water and maintaining water flow during low water periods. This function is preformed by both sedge and willow communities. The contributions of each community to the overall hydrological function were not directly studied but it is likely that changes in wetland extent would affect a given wetland's ability to function hydrologically. One of the primary contributors to wetland hydrological function is wetland soil, which forms, in part, because of the vegetation present. The surface soil layer of the riparian marsh communities surveyed was organic. Organic soil functions as a sponge, soaking up water as water level rises and releasing it slowly as water levels subside. As flooding during the growing season is changed and submergent areas become exposed, it would take time for organic soil to be physically transported or to develop over top of any mineral sediments and bedrock. The rate of soil development is a slow process that can take hundreds to thousands of years (CSSC, 1987). Although wetlands perform this hydrological function, they are not the dominant feature controlling river hydrology. This is particularly the case for Trudel Creek, where water levels are controlled throughout the system by only a few key hydraulic controls at or near the outlet of Trudel lakes. These hydraulic controls maintain relatively high water levels even under very low flow conditions (see Section 14.3 - Alterations of Water Quantity).

The change predicted in community structure and wetland extent would alter the habitats and ecological functions; however, the alteration is not expected to cause a significant effect on wetland-dependant species as there would be little overall net change in extent of wetlands over time. That is, as willows move down-slope into sedge-dominated areas, sedge are predicted to move down-slope into submergent-dominated areas. Thus, habitat and ecological functions should undergo a slow transition until they eventually destabilize.

Table 14.6.9 — Wetlands Effects Classification under the 36 MW and 56 MW Option for Trudel Creek

Pathway	Project Phase	Direction	Magnitude	Geographic Extent	Duration	Reversi-bility	Frequency	Likeli-hood	Overall Residual Effect
Water level changes leading to a change in flood regime which alters wetland extent (36 MW)	Operation	Adverse	High	Trudel Creek	Medium - term	Reversible	Continuous	Highly likely	Moderate
Water level changes leading to a change in flood regime which alters wetland extent (56 MW)	Operation	Adverse	High	Trudel Creek	Medium - term	Reversible	Continuous	Highly likely	Moderate
Changing water levels would change the flood regime, which would alter wetland function (hydrological, habitat and ecological) (36 MW)	Operation	Adverse	High	Trudel Creek	Medium-term	Reversible	Continuous	Highly likely	Moderate
Changing water levels would change the flood regime, which would alter wetland function (hydrological, habitat and ecological) (56 MW)	Operation	Adverse	High	Trudel Creek	Medium-term	Reversible	Continuous	Highly likely	Moderate
Rapid water level changes leading to a change in flood regime which alters wetland extent due to scheduled ramping	Operation	Adverse	Low	Trudel Creek	Short-term	Reversible	Periodic	Likely	Low
Rapid water level changes would change the flood regime, which would alter wetland function (hydrological, habitat and ecological) due to scheduled ramping	Operation	Adverse	Low	Trudel Creek	Short-term	Reversible	Periodic	Likely	Low

14.6.9.3 EFFECTS OF RAMPING

Flow ramping events would be part of normal operating conditions for both the 36 MW and 56 MW options. Section 14.3.3 provides details of the changes in flows and water levels along Trudel Creek during a ramping event from a scheduled power outage. Scheduled outages for turbine maintenance are currently planned annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion: 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the existing 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 MW and 56 MW expansions would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modelled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events. The direct effects to the emergent wetland communities by scheduled ramping would be adverse because wetlands currently present would be stressed, given higher-than-usual water levels. The magnitude of effects to wetland function and extent is low, given that ramping would not cause changes in extent and function. The extent of the effect would be observed throughout Trudel Creek. Effects are considered to be short-term, as any effects would not last beyond the ramping event. All scheduled ramping effects are considered reversible, because effects on wetland extent and function would not be measureable beyond the duration of the ramping event. Thus, the overall residual effect would be low. Table 14.6.9 presents the effect classification for wetland function and extent in Zone 5.

14.6.9.4 CUMULATIVE EFFECTS

No mining or forestry projects situated within the Taltson Watershed have overlap with the Trudel Creek study area. Additional hydroelectric projects have not been registered in the area. As there are no reasonably foreseeable projects identified in the study area, no other projects would provide cumulative effects to the Expansion Project since there is no spatial overlap. Should any projects move towards development in the regional assessment area, there may be cumulative effects to the proposed Expansion Project.

Existing developments include a hydroelectric facility in the Tazin River system. The regulated flows of the Tazin River into Taltson River have been considered in the current Taltson hydrologic model used for all assessments in this document. There are no additional potential cumulative effects from the Tazin River facility.

Initial development of the Twin Gorges Project facility resulted in greatly increased flows within Trudel Creek. This is assumed to have had a major effect on wetland communities within Trudel Creek. This assumption is based on known hydrologic changes and is supported by aerial photographs of habitat. There are no data on wetland communities from this period. However, such a major change from the low-flow era to higher water levels (post-original development) would have inundated emergent vegetation and farther covered submergent vegetation, changing ecosystem structure, distribution and function. Pre-development photographs indicate meandering stream channels winding through wetland areas in sections of Reach 3 of Trudel Creek. Existing wetland communities are most likely stabilized from this initial anthropogenic stress which occurred 43 years ago. Riparian wetland communities have developed within Trudel Creek based on the new hydrologic regime, but could be quite different from pre-development wetland habitat as watercourse structure and volume has changed significantly.

The proposed expansion options present incremental adverse effects including reduced wetland extent and altered wetland function, at least until mature wetland communities would be assumed to develop (3 to 10 years following expansion). The adverse incremental effects arise from changing water levels and their affect on wetland extent and function. Residual cumulative effects from initial hydroelectric Project development include changes in wetland structure, loss of wetland habitat, and alterations to wetland function. There exists a high degree of uncertainty as to how the wetland communities have changed in terms of extent, structure, and function, from pristine times to post-initial-development (e.g. 1969) to baseline periods, and exactly how future periods would compare. In any case, the proposed development presents further change to the Trudel Creek wetlands, which have likely stabilized since the initial development and would be expected to restabilize in 10 to 20 years following proposed expansion of Twin Gorges (based on rates of vegetative succession in emergent communities).

14.6.10 Uncertainty

There are a number of types of uncertainty in this assessment: (1) mapping data sources at the baseline scale, (2) inputs and interpretations of the ecological assembly model, (3) factors contributing to wetland vegetation succession, and (4) information on the "pristine conditions" of wetlands.

14.6.10.1.1 Mapping Data

Non-ortho corrected aerial photographs collected in 2007 were used to map wetland extent in Zone 5. NTDB digital wetland data was also used to augment the mapping; however, it was prepared from the original topographic maps produced by NRC. The NRC data is more accurate because it was built using a projected database which uses a specific geographic model to account for the curvature of the earth. The photos from 2007 are essentially flat, resulting in a distortion of area when the photos were georeferenced to their real-world locations. The result is a data set of wetland extent that is not comparable between data sources. Confounding this issue is the fact that the photos collected in 2007 covered 35% of Zone 5, and were collected from a helicopter without recording exact heights above ground for each photo and yaw angle of the helicopter (Appendix 13.7A).

Regional wetland data was compiled from the 1:250000 map sheet for the area including Trudel Creek. This data is essentially created from the 1:250000 raster images. This scale is too small to effectively identify wetland communities, and often includes areas of forest and open water in wetland areas, resulting in an over-estimate of wetland area. These maps are also in the range of 30 to 50 years old. In the past 20 years, climatic changes in the Northwest Territories have resulted in changes to water available and wetland extent.

14.6.10.1.2 Ecological Assembly Model

The model of ecological assembly is a powerful tool to track the potential changes to ecosystem structure from dynamic water levels. However, the accuracy of the model is dependant on the accuracy of the data used to build the model. Water levels used for the ecological assembly model were themselves modelled for the baseline, 36 MW, and 56 MW expansion scenarios. These modelled water levels have their own levels of uncertainty because of the methods used to calculate them (Rescan, 2008a). The flood levels that were established for the ecological assembly model were collected using a GPS with a vertical accuracy of <1 m. Although sub-metre accuracy is acceptable, it is not as precise as necessary to narrow the vertical difference between the flood positions (Fl-5 and Fl+5). Toner and Keddy (1997) used flood positions of ± 0.05 m, which improves the accuracy of the model. The relatively large (1 m) vertical difference between the flood positions in this study removes some of the resolution of the model. This is reflected in that of the three variables calculated, only one was applicable at all model locations. The last day of the first flood and the time to the second flood were not always available because of the large vertical difference in flood positions.

Another factor leading to uncertainty was the difference between ecological assembly survey locations and the hydrology reference locations. The reference locations used by Toner and Keddy (1997) were generally less than 5 km from the wetlands surveyed. Although the average distance between hydrology reference locations and wetland survey locations in this study was within the 5 km distance employed by

Toner and Keddy (1997), to remain consistent with ecological model for the remainder of the baseline study area (Section 9.6), wetlands closest to hydrology reference locations were modelled. The model results were used to infer changes to community structure over the portion of the baseline study area upstream of the hydrology reference location, until the next hydrology reference location. Although this is not ideal, it does provide useful information relating the potential for community change with respect to different water levels and is consistent between all areas modelled for ecological assembly.

14.6.10.1.3 Succession

The rate of succession and colonization is difficult to determine because they are dependant on the magnitude, duration, and timing of flood regime changes, as well as the species involved. Succession and colonization rates would likely be different for different wetland areas given varying site conditions and species. There currently exists little information on the area available for colonization, seed availability, and slope and composition of the substrate. Even if information was collected to improve these data gaps, the rates of succession and colonization would still be difficult to determine given the potentially large water level and flow fluctuations expected in the system each year (Section 14.3 and Section 14.6.1.2).

14.6.10.1.4 Pristine Conditions

Pristine condition relates to status of the area prior to the original Taltson Hydroelectric Project. Information describing the pristine conditions of wetlands was needed to complete the cumulative effects assessment. However, there exists very little pristine condition and specifically the condition of wetlands. Cumulative effects were described to wetlands assuming that areas adjacent to the small meandering stream, as observed in historical photos, were wetlands and not associated flood ecosystems.

14.6.11 Monitoring

Any monitoring should be done ensuring consistent and transferable data so that comparisons can be made to wetlands before, during, and after the Expansion Project. A monitoring program should be tied into monitoring of wildlife within Trudel Creek.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF PLATES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.7 AQUATIC RESOURCES

Aquatic resources are closely linked to water quality and together form an important indicator of environmental health. In Trudel Creek, aquatic resources include all the primary and secondary producers within the creek and associated lakes and wetlands. Fish were assessed separately (Section 14.8 Fisheries Resources). Primary producers are defined as photosynthetic energy suppliers in ecosystems and include periphytic algae (attached to submerged substrates or the bottom of a water body or wetland), phytoplankton (free-floating algae), and aquatic plants (emergent and submergent). Secondary producers are organisms feeding on autotrophs, detritus, and each other. They are represented by zooplankton, which are free-swimming invertebrates in the water column, and benthic invertebrates (benthos) living within sediment habitat. Together, these primary and secondary producers compose the bulk of aquatic ecosystem biomass and diversity, and provide the energy base for aquatic food webs, including fish and wildlife, which are highly-valued resources to federal and provincial governments, Aboriginal groups, and the public.

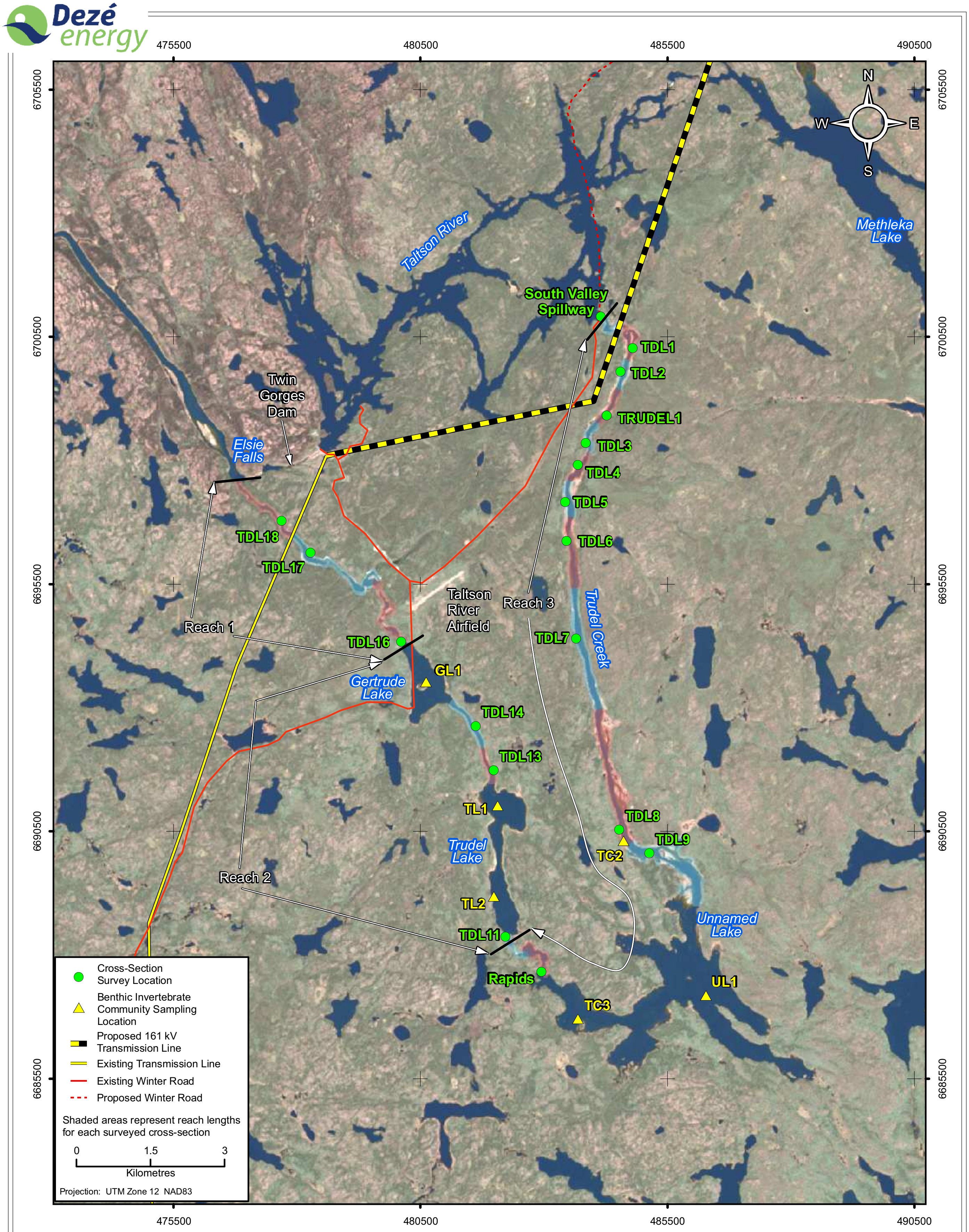
Primary and secondary producer communities are widely used in aquatic monitoring programs to detect changes related to development. Because of their relatively limited mobility, aquatic resources provide excellent tools to assess physical or chemical changes in both water and sediment. For example, algae are reliable indicators of changes in nutrient levels. To detect changes in water quality, zooplankton communities are often assessed because they are the main consumers of phytoplankton. Benthos are also key indicators of environmental health, particularly water and sediment quality. Benthic invertebrate communities form an important link in the food web, often acting as a primary food source for both small and large fish. This is especially true in shallow areas with heavy macrophyte growth. The benthic invertebrate life cycle is relatively short compared to fish, and therefore benthos often show the effects of changing water or sediment quality faster than fish. As a result, aquatic resources are identified as a Valued Component (VC).

14.7.1 Existing Environment

Baseline aquatics studies in Trudel Creek and its associated lakes included surveys of fish community and habitat, water quality (see Section 15.6; Rescan 2006), and benthic invertebrate communities (Figure 14.7.1; Rescan 2008). To date, there have been no studies assessing primary producers or lake zooplankton in the Trudel basin.

Fish habitat assessments were conducted at 21 sites on Trudel Creek. These assessments indicated low gradients and banks dominated by either wetland vegetation or bedrock. Most of the instream cover consisted of aquatic vegetation (Plate 14.7.1). Unnamed, Trudel and Gertrude lakes were generally shallow and well-mixed due to wind generation of waves.

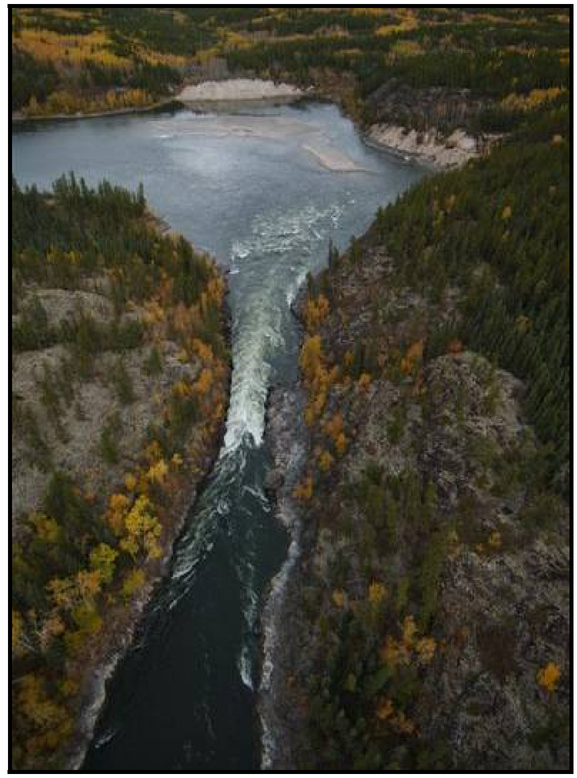
Water samples collected in 2006, 2007, and 2008 within Trudel Creek indicated the water was relatively clear (only turbidity and total suspended solids were analyzed in 2006). In general, concentrations of the parameters measured were characteristic of northern lakes (physical parameters and metals were analyzed in 2008). Lakes and the creek were characterized as oligotrophic with organic carbon mostly present in the dissolved form (or bound to extremely fine particulates in the water column). Total and dissolved metals tended to be highest in the lake sites and lowest in the creek sites, though there was little variation between the sites sampled. A detailed evaluation of water quality in this system was presented in Section 14.4 - Alteration of Water Quality.



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Benthic Invertebrate Community Sampling and Cross-Section Survey Locations in Trudel Creek and Associated Lakes, August 2008**	**Figure 14.7.1**

gis no. TAL-01-004DAR

Plate 14.7.1 — Trudel Creek Mainstem Banks Dominated by Wetland and Bedrock



Baseline data on aquatic resources in Trudel Creek are limited to one benthos survey completed in 2008. The benthic invertebrate community was sampled qualitatively in littoral areas of Trudel Creek and Trudel Lake, and quantitatively in profundal areas in Unnamed Lake, Trudel Lake, Gertrude Lake, and Trudel Creek (Figure 14.7.1).

Average densities of benthos collected from the deep water habitat varied from 825 organisms/m^2 in Gertrude Lake to 5,165 organisms/m^2 in Unnamed Lake. Density was similar in Gertrude and Trudel lakes and was highest in Unnamed Lake. Genus richness was lowest in Gertrude Lake, moderate in Trudel Lake, and highest in Trudel Creek and Unnamed Lake. A similar pattern was observed with the Simpson's Diversity Index.

The invertebrate community composition was similar amongst all deep water habitats sampled. Dipterans were the dominant taxa in all three lakes and Trudel Creek (47% to 71%). Nematodes, oligochaetes and mollusks also comprised significant proportions of the taxa in these water bodies (3% to 32%). Mayflies and caddisflies were present in small proportions in all lakes (except Gertrude Lake, which had no mayflies).

Table 14.7.1 — Baseline Benthic Invertebrate Community Data for Trudel Creek and Associated Lakes: August 2008

Station ID	Density (organisms/m^2)	Genus Richness (# of taxa)	Simpson's Diversity Index
Deep Water			
Trudel Creek	1,793 to 2,370	16 to 18	0.60 to 0.87
Unnamed Lake	2,711 to 9,259	17 to 20	0.82 to 0.87
Trudel Lake	385 to 1,956	5 to 10	0.55 to 0.80
Gertrude Lake	741 to 948	4 to 5	0.59 to 0.70
Littoral area			
Trudel Creek	n/a	15 to 24	0.77 to 0.92
Trudel Lake	n/a	12 to 13	0.51 to 0.73

n/a = data not available

The littoral area invertebrate community composition was different in Trudel Lake (mostly oligochaete worms with some dipterans, hemipterans, and ostractods) when compared to Trudel Creek habitat (mostly mayflies and amphipods). This is typical of lakes and rivers because of their different habitat features.

14.7.2 Valued Components

Aquatic resources were identified together as one VC related to the effects assessment in this chapter of the Taltson Developer's Assessment Report (DAR). Aquatic resources were also identified in the Terms of Reference (TOR) for the Project. The inclusion of aquatic resources is supported by their importance in a variety of ecological functions in aquatic systems. These functions include aquatic biodiversity, aiding in nutrient and organic material cycling, photosynthetic energy production, and transfer through the food web. In addition, they are easily and commonly measured (practical measurement endpoints), and are effectively used in biomonitoring programs for a variety of anthropogenic stressors (i.e. temperature, flows, habitat quality, contaminants). They form the bulk of biomass in aquatic systems, and are the food base for a number of aquatic (i.e. amphibians, reptiles, birds, fish) and terrestrial (i.e. birds, mammals, reptiles) organisms. As such, their importance is underlined by cultural and aesthetic values placed on a variety of fish, duck, raptor, and bear species that rely on this abundant food source.

14.7.2.1.1 Assessment Endpoint

The assessment endpoint represents key features of the VC that should be protected and are used to illustrate how the assessment pathways affect each VC. The evaluation of aquatic resources considered a single comprehensive assessment endpoint: preservation of sustainable aquatic resources within Trudel Creek (Table 17.4.2). Within the umbrella of this assessment endpoint lie several overlapping attributes including: (1) levels of biological productivity within lakes and rivers of aquatic resources, (2) biodiversity of primary and secondary producer communities, and (3) community structure and taxonomic dominance of primary and secondary producers.

Table 14.7.2 — Aquatic Resources Assessment Endpoints and Pathways

Key Line of Inquiry	Valued Component	Assessment Endpoints
Ecological changes in Trudel Creek	Aquatic Resources	Preservation of sustainable aquatic resources within Trudel Creek

Productivity of the plant and animal life that is sustained within the Trudel Creek system is one component of the assessment endpoint. There are a number of measurement endpoints that can be used to predict effects on the productivity of aquatic resources, including change in habitat extent (both permanent and temporary) and change in hydrologic parameters that influence habitat complexity and change in water chemistry.

Biodiversity in ecosystems is considered a valuable trait of healthy systems, and can aid in resisting perturbation through redundancies in ecological niches and capacities for adaptation to new conditions or environments (Rosenfeld 2002). Various measurement endpoints were calculated to assist in the classification of residual effects on biodiversity in aquatic resources.

Community structure and the presence of dominant taxonomic groups is useful in monitoring changes to ecosystems and can be used to detect change prior to more serious effects as more sensitive taxa are the first to show signs of stress. Species-level quantification of community-level effects was not possible. Rather, the community as a whole was considered in terms of potential stress from proposed expansion scenarios. Potential effects were described based on measurement endpoints computed using hydrologic modelling (see Section 14.3 - Alterations of Water Quantity).

14.7.2.1.2 Measurement Endpoints

A measurement endpoint is a quantifiable attribute of a biological system that relates directly to an assessment endpoint. For aquatic resources, the assessment endpoint was sustainability of aquatic resources. The sustainability of aquatic resources can be evaluated through an assessment of aquatic resource productivity, biodiversity and community structure. These three components of aquatic resources are directly affected by changes in aquatic habitat (i.e. measurement endpoint of aquatic resources).

Habitat was broken down into littoral, profundal and pelagic habitat for both Trudel Creek and associated lakes. Pelagic habitat is aquatic habitat within the water column that is dominated by phytoplankton and zooplankton. Littoral and profundal habitat are benthic habitat (both shallow and deep water, respectively). Generally, littoral habitat is the most productive and diverse habitat within rivers and lakes. Littoral habitat is the “shallow” zones of rivers and lakes. The habitat is home to emergent and submergent vegetation which adds a degree of complexity to the benthic habitat and thus benthic diversity and productivity. A field assessment of littoral habitat of the Trudel Creek system was completed by CGL (2008a) where they defined littoral habitat to extent approximately 1 m and 2 m below summer water levels in Trudel Creek and Trudel lakes, respectively. These depths of littoral and profundal habitat should be considered an approximation of conditions within 33 km of river habitat and three lakes. CGL (2008a) relied on the visual presence of aquatic plants to define the lower extent of the littoral zone. Habitat deeper than 1 m (river) and 2 m (lakes) was defined as profundal habitat. Profundal habitat was considered less productive and less biologically diverse.

Project-induced hydrological changes that cause changes in river and lake water levels have the potential to affect aquatic habitat, both littoral and profundal. An increase in water level would increase wetted area. The newly-inundated wetted area may or may not meet the requirements of littoral habitat in terms of sediment characteristics and submergent/emergent plants. Thus the newly-inundated habitat would require time to become "suitable littoral habitat." For this assessment, ***suitable littoral habitat*** is shallow water habitat (less than 2 m for Trudel lakes and less than 1 m for Trudel Creek) that has the appropriate habitat characteristics to support, and is currently supporting, a productive community of macrophytes, algae and invertebrates. Conversely, if water levels decrease, suitable littoral habitat would be dewatered and thus there would be a net loss of habitat. The newly-formed littoral zone would take time to become "suitable" (i.e. presence of submergent/emergent vegetation). However, over time littoral habitat should obtain pre-disturbance productivity, biodiversity and community structure and thus little net loss of littoral habitat would occur. There would be, however, a net loss of profundal habitat.

Considering strictly increases and decreases in water levels, profundal habitat does not have a "suitability" requirement as per littoral habitat. If water levels increase, sections now below the photic zone would be considered profundal. If water levels decrease, there would be a permanent loss of profundal habitat as the habitat shifts down to deeper elevations.

Changes in suitable littoral habitat and profundal habitat are used throughout this assessment to quantify and subsequently qualify effects on the sustainability of aquatic resources within Trudel Creek.

14.7.3 Assessment Boundaries

The assessment boundaries can be separated into two categories, spatial and temporal. The following section describes the spatial and temporal boundaries as they relate to aquatic resources.

14.7.3.1 Spatial Boundary

Trudel Creek was classified as hydrologic study Zone 5 during baseline studies. This is the maximum extent of the assessment boundary. It is recognized that aquatic communities of Trudel Creek do not exist in isolation of other aquatic communities both upstream and downstream of Trudel Creek and neighboring communities via terrestrial interactions. Trudel Creek is a branch of the Taltson River. Currently, Trudel Creek is the main branch with Twin Gorges power facilities being the other branch. The spatial boundary for the assessment included Trudel Creek from the South Valley Spillway downstream, approximately 33 km, to where the creek re-joins the Taltson River downstream of Twin Gorges plant. This includes the three lakes associated with Trudel Creek. Within the assessment boundary of Trudel Creek, local assessment areas were identified as individual reaches (Reach 1, 2 and 3) and individual lake (Unnamed Lake, Trudel Lake, and Gertrude Lake) (Figure 14.1.1 and Figure 14.1.5).

14.7.3.2 TEMPORAL BOUNDARY

It is anticipated that construction would have little to no effect on water levels in the Trudel Creek. Therefore, this assessment only examined the operations phase of the Project for both the 36 MW and 56 MW expansion options. The Project is anticipated to have a minimum lifetime of 40 years; the first 20 years would be used to supply power to existing and proposed diamond mines. Upon closure of the mines, there is the potential to connect to the NWT power grid or other future mining projects, which would extend the life of the Project. However, for the purpose of the effects assessment, operation-related effects were assessed using a temporal boundary of 40 years.

The details on decommissioning and post-closure are not comprehensive enough to complete an effects assessment at this time; however, it is the plan of the Dezé Energy Corporation to complete the necessary studies 7 to 10 years prior to closure. Closure and restoration details are provided in Section 6.8.

14.7.4 Project Components

The TOR for the Project requires that the effects assessment for Zone 5 (Trudel Creek and its associated lakes) be conducted separately from the rest of the basin, and has been identified as its own key line of inquiry (KLOI). Project components linked to hydrologic changes affecting aquatic resources in Trudel Creek include the power generating facilities (flow release at the Nonacho control structure and/or flow through the generating facilities).

The potential effects to aquatic resources within this zone were assessed separately for lake and river habitat.

14.7.5 Pathway Analysis

14.7.5.1 IDENTIFICATION OF PATHWAYS

Pathways were identified that link potential effects to the aquatic resources VC (Table 14.7.3). The pathways presented in this section are considered typical for hydroelectric projects and do not consider the specifics of the Expansion Project. This section took a wide and all-encompassing view of potential pathways to effects on aquatic resources based on general knowledge of the Expansion Project and typical hydro projects. The pathway validation section that follows considers the specifics of the Project and assesses whether the generic pathways presented in Table 14.7.5 are valid after considering the details of the Development Description (chapter 6) and the resulting hydrological changes to Trudel Creek (Section 14.3 - Alterations of Water Quantity).

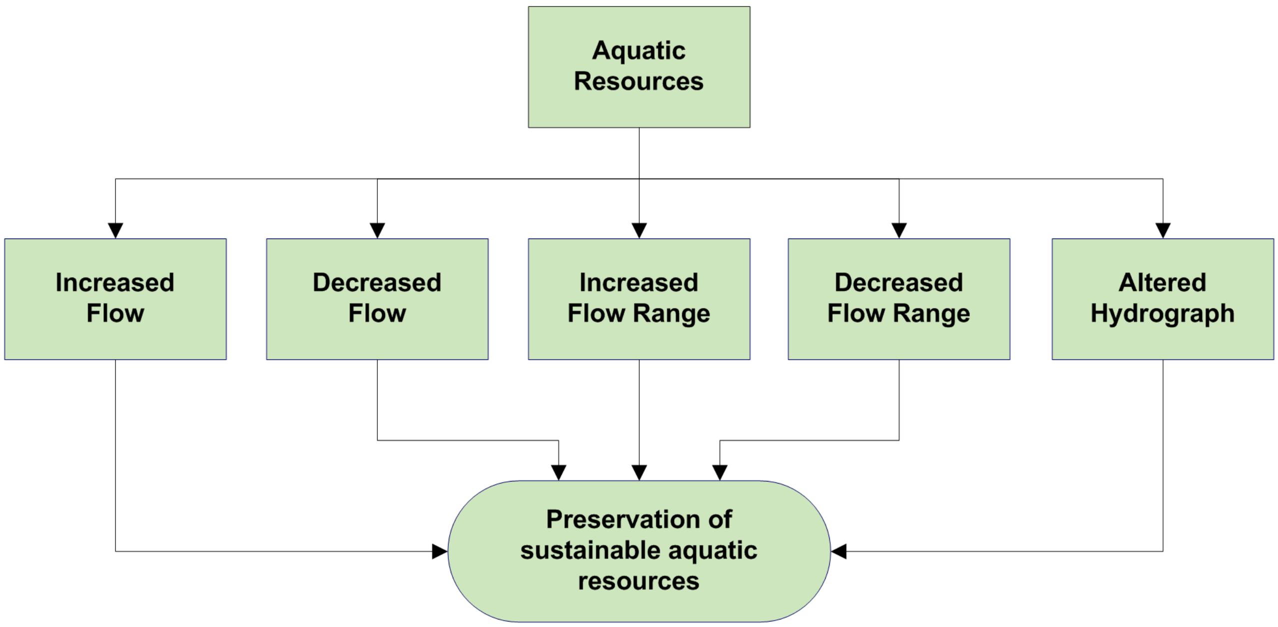
Lake and river areas of the Trudel Creek system were grouped together at this early stage of pathway identification because they share common basic pathways. In addition, both expansion scenarios were included together in the identification of pathways. Although the specific characteristics and extent of potential effects from each pathway could differ between the two expansion options and among riverine and lentic aquatic habitat, the basic nature of the pathways is the same.

There are five potential pathways that could lead to effects to the assessment endpoints for aquatic resources in Trudel Creek and associated lakes (Figure 14.7.2); these include:

- Increased flows.
- Decreased flows.
- Increased flow range.
- Decreased flow range.
- Altered hydrograph parameters (timing and duration of freshet and minimum flows, rate of change in flow).

Table 14.7.3 — Potential Pathways to the Valued Component Aquatic Resources

Valued Component	Assessment Endpoint	Pathway and Associated Effect
Aquatic Resources	Preservation of sustainable aquatic resources within Trudel Creek	*Increased flows* — loss of suitable littoral habitat and reduced productivity; decreased habitat quality (from increased methylmercury increases, increased nutrient loading, increased TSS); increased productivity (from altered ice processes); altered physical habitat (due to increased velocity); potentially increased profundal habitat and pelagic habitat for plankton.
		Decreased flows — loss of suitable littoral habitat and reduced productivity; loss of profundal habitat; loss of pelagic habitat for plankton; decreased habitat quality and productivity (from altered ice processes); altered physical habitat (due to slower water velocities).
		Increased flow range — increased winter drying of habitat; increased disturbance of wetted areas; decreased habitat quality (from release of methylmercury, increased TSS and nutrients loadings from riparian habitat); unstable littoral habitat.
		Decreased flow range — decreased habitat quality (from decreased inputs of nutrients from riparian habitat); decreased habitat complexity; potentially more stable littoral habitat.
		Altered hydrograph parameters — altered habitat quality and complexity (through altered timing and duration of freshet period, extended periods of minimum flows, rapid decreases and increases in flow, i.e. ramping).



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Aquatic Resources - Pathways and Assessment Endpoints for Potential Effects in Trudel Creek	Figure 14.7.2

14.7.5.1.1 Increased Flows

Increasing flows above baseline levels within Trudel Creek would lead to secondary pathways on aquatic resources: increased water levels, wetted perimeter and area, surface area, cross-sectional area, volume and river velocities. These secondary pathways can be quantified to characterize effects on the assessment endpoints of aquatic resources.

Water velocity plays a strong role in determining the aquatic community that colonizes and occupies an aquatic environment, in terms of affecting hunting/feeding behaviour, availability of substrates for building shelters, and movement. Certain biotic groups are more accustomed to fast-flowing river conditions, while others require slow-moving or static conditions of a lake. A major increase in the velocity of a system could drive lentic benthic invertebrates to drift downstream to more suitable habitat. It could also affect availability of fine organics to benthos, increase erosion rates (increased TSS loadings) and affect the aquatic plant and algal communities that would then be forced to endure stronger currents. In the fall, it could delay the onset of ice formation and ice thickness, and cause earlier ice break-up. Some areas near pinch points could be affected more strongly (less ice) than other sections such as lake areas. This would translate into a lengthened open-water season, potentially positively affecting life cycles and increasing productivity.

Increased water levels could result in a variety of physical and chemical changes to the aquatic environment. First, it would transform existing littoral zones into deeper aquatic (profundal) habitat, thus there would be an increase in profundal habitat. However, the new littoral zone my not contain the habitat requirements of littoral communities and thus cause a loss of suitable littoral habitat in the short-term until the new littoral habitat becomes suitable. The creation of suitable littoral habitat can take months to years, and is dependent on availability of seed banks from various species, organic materials available, and substrate composition (Wallace, 1990). For this assessment, ***suitable littoral habitat*** is shallow water habitat (less than 2 m for Trudel lakes and less than 1 m for Trudel Creek) that has the appropriate habitat characteristics to support, and is currently supporting, a productive community of macrophytes, algae and invertebrates. The extent of the effect on suitable habitat and gain in profundal habitat would largely depend on the slope of shoreline ground (shallower slope would mean that more terrestrial area is inundated; cliff zones would preclude inundation of terrestrial zones). The current hydrologic model does consider shoreline slopes for rivers at discrete points along Trudel Creek and shoreline slopes from bathymetric data from the three Trudel Creek lakes (see Section 14.3 - Alterations of Water Quantity).

Increased water levels could also result in increased nutrients and organics. Nutrients (nitrogen- and phosphorus-based) and organics from riparian areas from leaf litter and decomposing plant and animal matter could be washed into nearby river or lake habitat during periods of raised water levels. This would affect productivity levels, dissolved oxygen and physical parameters. Algal blooms could result in changes in water clarity and quality, which could in turn reduce productivity.

Increased water levels could result in flooding of shoreline terrestrial areas and could result in increased terrestrial mercury recruitment and methylmercury production in an aquatic system (Rodgers et al., 1995). The degree of terrestrial mercury recruitment would depend on whether the terrestrial areas had been flooded previously and the frequency in which it was flooded. If an area had been previously flooded, it would not be likely to produce more methylmercury, since the available mercury in the soil would have previously been leached out. This compound is highly toxic to aquatic life, and if it did increase in concentration, could result in mortality and habitat degradation for aquatic resources. Other metals potentially toxic to aquatic organisms (e.g. cadmium, copper and zinc) could be mobilized into the water column as a result of increased water levels (Finlayson et al., 2000); this was assessed in Section 14.4 (Water Quality).

Wetted areas would also increase with increased flows, related to increased water levels discussed above. As flows and levels increase, the extent of a river or lake would expand over terrestrial habitat. Depending on the nature of the hydrograph, this could create new aquatic habitat, or simply provide ephemeral side channels which may be prone to drying over the year (leading to potential loss of trapped biota in those areas).

Volume of a river or lake would increase with increased flows, related to increases in water levels discussed above. Pelagic organisms (phytoplankton, zooplankton) would then have a greater extent of habitat under these conditions. The productivity within the lake could increase, depending on availability of nutrients (nitrogen and phosphorous) and water temperatures.

14.7.5.1.2 Decreased Flows

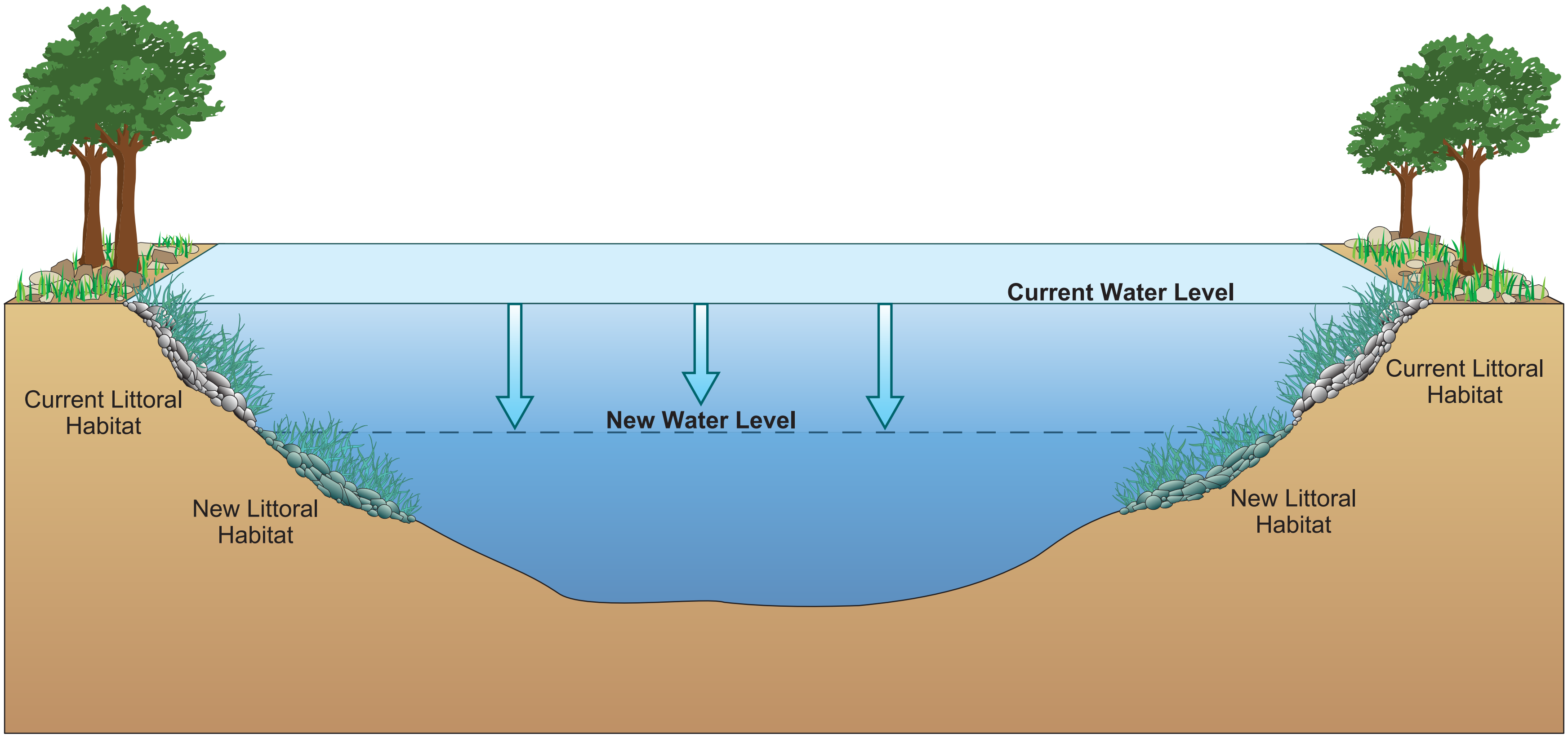
Decreasing flows below baseline levels within Trudel Creek would lead to secondary pathways on aquatic resources: decreased water levels, wetted perimeter and area, surface area, cross-sectional area, volume and river velocities. These secondary pathways can be quantified to characterize effects.

Decreased flows could result in reduced water velocity in rivers and at the inlet/outlet of lakes. These reduced velocities would represent a change to the physical environment of aquatic resources. Species accustomed to faster-flowing waters would likely leave these areas, to be gradually replaced by slow-water species. This could affect not only algae and aquatic plants but also benthic invertebrates. Water quality could also change, with reduced erosion (lower TSS loadings), and increased settling of fines in bottom substrate (more organics). These water quality changes could be beneficial to remaining biota in terms of clarifying water quality and increasing organics for food and shelter. However, under greatly reduced velocities, anoxia can become an issue leading to unsuitability of habitat and reduced productivity. This is more of a potential concern in winter during ice cover than during the open-water season. In the fall, reduced water velocity could also cause earlier onset of ice formation, greater ice thickness (a threat to shallow areas which could experience higher risk of freezing to bottom) and in the spring cause later ice break-up. This would translate into a shortened open-water season and potentially greater risk of mortality from ice damage, adversely affecting life cycles and productivity. Potential changes in ice conditions and formation were presented in Section 14.5 - Alteration of Ice Structure.

Decreased water levels could dry out existing aquatic habitat, resulting in mortality of macrophytes, algae and invertebrates. Depending on the drop in water levels, littoral or both littoral and profundal habitat could be dewatered. This would result in loss of productivity where aquatic biota would be lost through exposure to air and dried habitat. A shift in community structure and loss of some diversity would also be possible, depending on the areas exposed (Aroviita and Hämäläinen, 2008). Littoral areas are generally the more productive and taxonomically diverse areas of lakes and rivers (Rennie and Jackson 2005), and to a lesser degree in rivers. It is also likely that some profundal (deep water) areas may become suitable littoral habitat (Figure 14.7.3). For this assessment, suitable littoral habitat is shallow water habitat (less than 2 m for Trudel lakes and less than 1 m for Trudel Creek) that has the appropriate habitat characteristics to support, and is currently supporting, a productive community of macrophytes, algae and invertebrates. Profundal habitat shifting to suitable littoral habitat would depend on available seed banks, substrates and organic content of previously deep zones that could potentially be colonized by new aquatic flora and fauna. It was assumed that, for any affected littoral habitat that was lost due to lowered water levels, that new littoral habitat would develop of equivalent extent and quality. However, there would then be a net loss of some profundal habitat and short-term loss of suitable littoral habitat. Emergent and submergent vegetation communities are reported to take approximately three years and one to two years for basic colonization, respectively (Odland and Moral, 2002; Cott et al., 2008).

Wetted area would also decrease as flows decreased. As flows and levels decrease, the extent of a river or lake would recede away from the existing water line, drying out littoral habitat, leading to mortality of organisms (plants, algae, some benthos) unable to move to deeper water areas and reducing productivity. In the case where littoral zones are completely removed, this would temporarily reduce taxonomic richness and alter community structure.

The volume of a river or lake would also decrease with decreased flows. Pelagic organisms (phytoplankton, zooplankton) would then have a reduced extent of habitat under these conditions, depending on the proportionate volume lost. This could then result in a reduction in productivity within the lake, depending on availability of nutrients and water temperatures which can also limit productivity levels in the sub-Arctic.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Decreasing Water Levels in River Causing a Shift in Littoral Zone Habitat (503-005 / a21036f-B)	Figure 14.7.3

14.7.5.1.3 Increased Flow Range

Increased flow ranges would result in lower annual minima and higher annual maxima for water levels, surface areas, and volumes of creek and lake habitat. This represents a general increase in the level of disturbance of aquatic habitat. Potential adverse effects include drying of littoral habitat dewatered as the new peak flow recedes, increased erosion and TSS loading to waterways from repeated drying and wetting of habitat (particularly in the case where aquatics plants die off, since they act to stabilize creekbed substrates), and increased methylmercury or nutrient loadings from riparian sources. For mercury and nutrients, this pathway relates to frequency of fluctuation in flows or levels, and represents a repeated source effect related to increased disturbance of sediment layers that could release these chemicals, unlike continuously-increased water levels which could affect nutrient loadings in a different manner. Methylmercury risk is discussed above under Increased Flows.

Effects from wetting and drying of littoral habitat, which would cause stress or mortality to organisms, depends on the frequency, timing and degree that water levels fluctuated (Leira and Cantonati, 2008). For example, monthly fluctuations up to 1 m were optimal for maintaining diverse littoral zone communities; however, narrow ranges (i.e. <1 m) allow few competitively dominant species and greater fluctuations (i.e. >1 m) allow only tolerant species to survive (NIWA 2003). Submergent vegetation could become exposed, and any algae or invertebrates living on this vegetation would also be affected. This could affect diversity and productivity. Habitat loss in the littoral zone can be replaced by habitat with a comparable degree of complexity in the profundal zone. However, given greater and more long-term fluctuations, only tolerant species are likely to survive. Littoral zone habitat suitability would be the most affected by water level fluctuations. Thus, benthic invertebrate richness and taxonomic abundance can be reduced in littoral zone habitats as a result of habitat loss (e.g. Baumgärtner et al. 2008; Brauns et al. 2008; White et al. 2008).

14.7.5.1.4 Decreased Flow Range

Reservoirs provide hydroelectric operators the ability to actively manage water to maximize power generation. The general change in the hydrograph of an actively-managed watershed for power generation can be described as an overall flattening. Thus, the range from the peak to the minimum flow is reduced. Water is released slowly over the entire year to ensure sufficient water remains to maximize power generation during times when water is not typically available, for example, during the winter in the sub-Arctic.

Decreased flow ranges would result in more constant water levels, surface areas and volumes of creeks and lakes throughout the year. Water levels would not drop as low or rise as high throughout the year. This represents a change to the normal hydrologic regime. Potential adverse effects include a reduction in nutrient and organics loadings from riparian zones, and a reduction in habitat complexity related to littoral zones that undergo wetting/drying cycles. This latter effect could reduce biodiversity in the local area. Potential positive effects could include a more stable aquatic environment since shoreline vegetation and biota would not experience as much drying/wetting cycles, and erosion rates would also be expected to decrease, which would reduce TSS loadings.

14.7.5.1.5 Altered Hydrograph Parameters

The hydrograph of a river that is actively managed to maximize power generation can look very different from baseline. The Taltson Expansion Project is somewhat unique in that its spillway is the headwaters of Trudel Creek, which has a flow length of around 33 km. If maximum flow requirements for power generation are not being met, freshet flows would be routed through the power generating facilities. Thus the flows over the spillway and along Trudel Creek would not increase until flows to the generating facility are maximized.

If freshet flows do increase to the point where spilling is required, the duration of the managed freshet can be considerably shorter than baseline. The timing can also be delayed, as flows prior to freshet may be substantially below the maximum needed for full power production. Thus, initial freshet flows would be directed through the power facilities. Conversely, minimum flows which naturally may last a few weeks at a time could extend for months on end. Changes to the existing hydrograph within rivers and lakes could have adverse effects on resident biota.

Changes to the timing of freshet could affect productivity if it occurred a significant amount of time before or after normal freshet timing, since life cycles of aquatic organisms (life stage development, reproduction) are adapted to their physical environment and timed based on seasonality and climate of a particular region. It is likely that biological communities would require a number of years to adjust and synchronize to the new freshet period, and it is possible that some species would be more flexible in their life history than others. This could then result in a change in productivity (until communities adjust) and community structure (more permanent). Moderate changes in the duration of freshet would not affect aquatic resources so long as nutrient and organic loadings remained fairly similar (see decreased flows and flow ranges). Large-scale changes in the duration of freshet could reduce productivity, depending on flows and flow changes that relate to nutrient and organics supply to aquatic biota as energy and shelter substrates.

Extended periods of minimum flow could adversely affect aquatic resources depending on the timing of these low flows relative to the normal hydrograph. If minimum flows extended throughout the critical summer period for feeding, growth and reproduction, adverse effects to aquatic resources would be expected. Late summer and early fall are especially important for seeding (aquatic plants) and egg-laying (benthos), although many aquatic species carry out multiple generations each summer.

Another attribute of an actively managed hydrograph is the rate at which flows increase and decrease. This effect can been seen during flow ramping events when a turbine or turbines are taken offline for maintenance or involuntarily taken offline via an accident or malfunction (see Chapter 17 — Accidents and Malfunctions for discussion of turbine outages and flow ramping from accidents and malfunctions). Sudden decreases and increases in flow rates (ramping) during a scheduled shutdown of the turbines could affect aquatic resources. Ramping would present a new hydrologic event that does not occur normally in nature. A sudden drop in flow over a period of hours could leave aquatic life stranded in side channels and pools, since they may not be able to move to deeper water areas fast enough. In this case, it would then lead to mortality and loss of productivity. Some species of plants and benthos are more suited to short-term periods of drying compared to other species, and therefore biodiversity could be affected. A sudden increase in flow could also cause adverse effects related to increased erosion, scouring and TSS loading, and physical effects of washing away biota downstream should they not find shelter in time. This could also reduce productivity and biodiversity of aquatic communities.

14.7.6 Mitigation

To preserve aquatic resources and fish resources in Trudel Creek, several mitigation design features are proposed. There would be a minimum flow released from the Forebay to Trudel Creek of 4 m^3/s (Cambria Gordon Ltd. 2008). Plant maintenance would be scheduled to ensure that only one turbine is taken off-line at a time to minimize the unnatural and rapid increase in flow rates to Trudel Creek, and a by-pass spillway would be constructed to further reduce the volume of water spilled into Trudel Creek during a scheduled shutdown. Additionally, multiple power-generating facilities at Twin Gorges would reduce the effect of sudden flow fluctuations as a result of scheduled shutdowns.

14.7.7 Pathway Validation

Pathways were considered valid when they could lead to an effect on the VC because of a Project component after all mitigation practices and designs are considered. Pathways where mitigation is not expected to avoid or reduce a negative effect were identified as valid, and were carried through to the effects analysis. Pathways where mitigation reduces a negative effect were considered minor or valid depending on the significance of the pathway and the degree to which mitigation would likely lessen the negative effect. Only valid pathways were carried through to the effects analysis. Pathway validation was carried out for river habitat (i.e. Trudel Creek; Section 14.7.7.1), followed by the pathway validation for effects within lake habitat (Unnamed, Gertrude, Trudel) in Section 14.7.7.2. Given that the nature and direction of effects from the identified pathways were similar for both the 36 MW and 56 MW options, validations were completed together.

To assess potential effects to aquatic resources, information regarding changes to the hydrologic regime was used. The hydrologic modelling divided Trudel Creek into 16 sections (Figure 14.7.1). Changes to water levels were determined by examining data presented in Section 13.3 - Water Quantity. This included time series and monthly summary figures for each of the study zones in the Taltson River study area. The mean monthly values were compared for each expansion option to the baseline mean. To assess change in fluctuation of levels with each expansion option, the minimum and maximum monthly values (the bars stemming from the monthly summary figures) were examined, as well as the 13-year time series (min and max values). Ramped water flows during scheduled outages were also calculated in the model, as was potential flooding in relation to shoreline elevation under baseline conditions. Ice formation and timing was assessed in Section 14.5 — Alteration of Ice Structure. All of these model outputs were used to validate or invalidate the above five potential pathways.

14.7.7.1 TRUDEL CREEK (36 MW AND 56 MW OPTIONS)

14.7.7.1.1 Increased Flow

Increasing the flows along Trudel Creek would result in increased water levels, wetted area, surface area, water volume and velocities. These changes could cause numerous effects to Trudel Creek aquatic resources; see Section 14.7.5.1 for discussion of effects of increased flows.

The hydrologic model developed for the Taltson Basin during operations of the 36 MW and 56 MW options (see Section 13.3 Alteration of Water Quantity) presents monthly average flows for Trudel Creek. The average monthly flow and the range of average monthly flows are predicted to decrease for both expansion options. Thus increased flows is not a valid pathway to effects on aquatic resources (Table 14.7.4).

Table 14.7.4 —Pathway Validation for Aquatic Resources in Trudel Creek: 36 & 56 MW Options

Pathway	Effects	Validation
1. Increased flows	Loss of suitable littoral habitat	Invalid: flows would not increase
	Decreased habitat quality (from increased mercury, nutrients, TSS)	Invalid: flows would not increase
	Increased productivity (from altered ice processes)	Invalid: flows would not increase
	Altered physical habitat (due to increased velocity)	Invalid: flows would not increase
	Increase in profundal and pelagic habitat	Invalid: flows would not increase
2. Decreased flows	Loss of suitable littoral habitat	Valid: flows would decrease
	Loss of profundal habitat	Valid: flows would decrease
	Loss of pelagic habitat	Minor: flows would decrease but the contribution of the pelagic zone to overall productivity is minor; biodiversity and community structure not expected to change
	Decrease habitat quality (from altered ice processes)	Valid: flows would decrease
	Altered physical habitat (due to reduced velocities)	Minor: flows would decrease but velocities are not expected to change enough to alter productivity, biodiversity and community structure
3. Increased flow range	Increased habitat quality (from release of mercury/nutrients/ TSS, drying and flooding of habitat)	Invalid: flow range would not increase

Pathway	Effects	Validation
4. Decreased flow range	Decreased habitat quality and complexity (from decreased inputs of nutrients and decreased range in water levels)	Valid: flow range would decrease markedly from baseline
5. Altered hydrograph parameters	Decreased habitat quality and Complexity (through altered duration of freshet and minimum flow period and flow ramping events)	Valid: hydrograph characteristics would change during extreme events

14.7.7.1.2 Decreased Flow

Decreasing the flows along Trudel Creek would result in decreased water levels, wetted area, surface area, water volume and velocities. These changes could cause numerous effects to Trudel Creek aquatic resources.

14.7.7.1.2.1 Loss of Suitable Littoral Habitat

Decreasing water levels in Trudel Creek would dry out some aquatic habitat in Trudel Creek and associated lakes. The extent of change would depend on the degree of flow reduction, geometry of the creek, and the quality of the aquatic habitat subject to change. Drying out aquatic habitat can cause algae, aquatic plant and invertebrate mortalities. This would influence shallow littoral areas (Plate 14.7.2), which tend to be the more productive and taxonomically diverse areas in lakes (Rennie and Jackson 2005).

Plate 14.7.2 — Trudel Creek Littoral Habitat Expected to be Influenced by Reduction in Water Levels

A reduction in water levels, and thus wetted area, would cause a reduction in the living space of biota and cause mortality to sessile organisms and life stages (e.g. algae, eggs). Reduced extent of habitat could then play a role in altering the heterogeneity of habitat, if, for example, the littoral areas were dried up and only profundal habitat remained. Lack of habitat heterogeneity in turn could signal a reduction in biodiversity and a change in community composition, as certain species would have lost their preferred habitat.

Some profundal (deep water) areas would become shallower as water levels dropped, and thus littoral by definition (Figure 14.7.3). However, the suitability of the newly formed littoral habitat would likely depend on available seed banks, substrates, and organic content of previously deep areas that could potentially be colonized by new aquatic flora and fauna. Initially, there could be a reduction in the productivity, diversity and community structure as the newly-formed littoral habitat is formed and littoral communities develop. Emergent and submergent vegetation communities are reported to take approximately three years and one to two years for basic colonization, respectively (Odland and Moral, 2002; Cott et al, 2008). The quality and extent of new suitable littoral habitat is unknown but it is assumed that it would replace lost suitable littoral habitat.

Effects to littoral habitat are best quantified by determining the change in water level and calculating the loss in littoral area associated with the change in water level. The depth of littoral habitat in Trudel Creek varies. CGL (2008a) completed a comprehensive assessment of littoral habitat within the three reaches of Trudel Creek and within Trudel lakes (Gertrude, Trudel and Unnamed Lake). Based on the findings of CGL's investigation, the average depth of the littoral zone in Reach 3 is approximately 1 m below summer water levels (see Figure 14.1.1 and 14.1.2). The geometry of Reach 1 and 2 is such that the extent (or area) of the littoral zone is relatively small. The banks are steep and so too is the creek bed (Plate 14.7.3). Thus, depths increase rapidly from the left and right banks. The focus of the potential effects is therefore placed on Reach 3 as effects of the various Project pathways would be most severe in Reach 3. The depth below summer water levels that was used to define the maximum depth of littoral habitat was 1 m.

Plate 14.7.3 — Trudel Creek Cliff-Type Habitat Expected to have Negligible Effects as a Result of Reduction in Water Levels

The hydrology models (Sections 13.3 and 14.3 Alterations of Water Quantity) predict that under the proposed 36 MW and 56 MW options, over the year the average monthly flow in Trudel Creek would drop 81% (ranging from 76% to 86%) and 87% (ranging from 65% to 95%), respectively. The average of the monthly average drop in water levels among the 16 sites modeled in Trudel Creek would be 119 cm (24%) and 135 cm (28%) below baseline for the 36 MW and 56 MW options, respectively (Table 14.7.5, Table 14.7.6). Summer water levels were predicted to drop an average of 162 cm (29%) and 181 cm (33%) for 36 MW and 56 MW options, respectively. These decreases in water level would cause the temporary loss of a large portion of suitable littoral habitat during the summer, based on littoral habitat extending to 1 m below average summer water levels. However, the absolute maximum decrease in water level for the 36 MW and 56 MW options would be 222 cm and 251 cm, respectively. This decrease is considered to be beyond the littoral zone. Thus, if the first year of operations occurred during an extreme low flow year (1:10 to 1:25 low flow year), there would be a complete loss of suitable littoral habitat. Therefore, decreases in flow under both the 36 MW and 56 MW options is a valid pathway to loss of suitable littoral habitat (Table 14.7.4).

Table 14.7.5 — Water Level Changes Along Trudel Creek for Entire Year and Summer Periods: 36 MW Option

Water Depth	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min (cm)	Max (cm)	Average		Min (cm)	Max (cm)
	cm	%			cm	%		
TDL1	-162	-25	-84	-227	-211	-29	-194	-227
TDL2	-154	-40	-76	-220	-205	-45	-187	-220
TRUDEL1	-141	-32	-61	-210	-196	-39	-179	-210
TDL 3	-135	-17	-59	-202	-189	-22	-173	-202
TDL 4	-133	-7	-58	-199	-186	-10	-170	-199
TDL 5	-131	-17	-58	-196	-183	-22	-168	-196
TDL 6	-127	-23	-57	-190	-177	-29	-162	-190
TDL 7	-116	-29	-52	-173	-161	-35	-146	-173
TDL 8	-94	-18	-45	-140	-130	-23	-118	-140
TDL 9	-89	-22	-44	-132	-122	-27	-111	-132
Rapids downstream of TD4	-87	-54	-62	-109	-98	-49	-91	-106
TDL 11	-107	-20	-55	-159	-148	-25	-134	-159
TDL 13	-107	-25	-55	-159	-148	-31	-134	-159
TDL 14	-99	-19	-52	-147	-137	-24	-124	-147
TDL 16	-99	-16	-52	-147	-137	-20	-124	-147
MINIMUM	**-87**	**-7**	**-44**	**-109**	**-98**	**-10**	**-91**	**-106**
MAXIMUM	**-162**	**-54**	**-84**	**-227**	**-211**	**-49**	**-194**	**-227**
AVERAGE	-119	-24	-58	-174	-162	-29	-148	-174

Table 14.7.6 — Water Level Changes Along Trudel Creek for Entire Year and Summer Periods: 56 MW Option

Water Depth	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min (cm)	Max (cm)	Average		Min (cm)	Max (cm)
	cm	%			cm	%		
TDL1	-185	-29	-91	-251	-241	-33	-221	-251
TDL2	-175	-46	-83	-241	-231	-50	-212	-241
TRUDEL1	-157	-36	-67	-227	-218	-43	-199	-227
TDL 3	-151	-19	-65	-218	-209	-24	-192	-218
TDL 4	-149	-8	-64	-215	-206	-11	-189	-215
TDL 5	-147	-19	-64	-212	-203	-24	-186	-212
TDL 6	-143	-26	-63	-205	-196	-33	-180	-205
TDL 7	-130	-32	-58	-187	-179	-39	-163	-187
TDL 8	-107	-20	-50	-151	-145	-25	-132	-151
TDL 9	-101	-25	-49	-143	-136	-30	-124	-143
Rapids downstream of TD4	-105	-65	-71	-122	-117	-59	-109	-122
TDL 11	-123	-23	-63	-173	-165	-28	-150	-173
TDL 13	-123	-29	-63	-173	-165	-35	-150	-173
TDL 14	-115	-22	-60	-160	-153	-27	-138	-160
TDL 16	-115	-18	-60	-160	-153	-23	-138	-160
MINIMUM	**-101**	**-8**	**-49**	**-122**	**-117**	**-11**	**-109**	**-122**
MAXIMUM	**-185**	**-65**	**-91**	**-251**	**-241**	**-59**	**-221**	**-251**
AVERAGE	-135	-28	-65	-189	-181	-32	-166	-189

14.7.7.1.2.2 Loss of Profundal Habitat

The hydrologic model generated for Trudel Creek presents a drop in waters level along Trudel Creek during operations (40 years). This drop equates to a decrease in wetted area. As discussed above, the littoral community would be displaced and shift into deeper areas of the creek bed. Table 14.7.7 and Table 14.7.8 present the absolute area of profundal habitat lost and the percent of the overall area lost. Based on average monthly water levels, the wetted area in Trudel Creek would on average decrease by 20.2 ha (16%) and 22.3 ha (19%). The range in the average monthly wetted area lost for the 36 MW and 56 MW options is 2% to 62% and 2% to 69%, respectively. Therefore, decreased flow under both the 36 MW and 56 MW options is a valid pathway to permanent loss of profundal habitat (Table 14.7.4).

Table 14.7.7 — Changes in Wetted Area along Trudel Creek for Entire Year and Summer Periods: 36 MW Option

Surface Area	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min	Max	Average		Min	Max
	m^2	%	m^2	m^2	m^2	%	m^2	m^2
TDL1	-12,496	-21	-8,928	-17,226	-12,235	-18	-10,544	-13,769
TDL2	-19,654	-40	-11,664	-24,601	-18,784	-35	-17,039	-21,917
TRUDEL1	-14,172	-20	-8,501	-17,874	-14,622	-20	-13,910	-15,364
TDL 3	-2,386	-6	-1,076	-3,559	-3,324	-9	-3,037	-3,559
TDL 4	-2,323	-5	-972	-3,538	-3,289	-7	-2,979	-3,538
TDL 5	-8,427	-11	-3,750	-11,013	-9,605	-12	-8,753	-10,205
TDL 6	-34,089	-19	-2,852	-86,386	-74,750	-37	-56,385	-86,386
TDL 7	-39,810	-13	-10,477	-56,684	-54,975	-17	-52,858	-56,684
TDL 8	-78,780	-19	-14,573	-98,893	-96,435	-22	-94,084	-98,893
TDL 9	-5,746	-2	-2,809	-8,498	-7,906	-3	-7,185	-8,498
Rapids downstream of TD4	-63,586	-62	-20,432	-88,769	-84,283	-67	-80,334	-88,769
TDL 11	-1,943	-6	-984	-2,887	-2,687	-8	-2,436	-2,887
TDL 13	-5,739	-8	-4,156	-8,335	-6,711	-9	-5,095	-8,335
TDL 14	-6,469	-7	-5,065	-8,050	-6,689	-7	-6,056	-7,346
TDL 16	-6,770	-8	-3,941	-9,700	-8,679	-10	-7,626	-9,700
TOTAL	**-302,390**				**-404,974**			
MINIMUM	**-1,943**	**-2**	**-972**	**-2,887**	**-2,687**	**-3**	**-2,436**	**-2,887**
MAXIMUM	**-78,780**	**-62**	**-20,432**	**-98,893**	**-96,435**	**-67**	**-94,084**	**-98,893**
AVERAGE	-20,159	-16	-6,679	-29,734	-26,998	-19	-24,555	-29,057

Table 14.7.8 — Changes in Wetted Area along Trudel Creek for Entire Year and Summer Periods: 56 MW Option

Surface Area	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min	Max	Average		Min	Max
	m^2	%	m^2	m^2	m^2	%	m^2	m^2
TDL1	-16,638	-28	-12,849	-18,734	-14,932	-22	-12,849	-16,223
TDL2	-22,399	-46	-12,148	-27,221	-26,030	-48	-24,671	-27,221
TRUDEL1	-16,521	-24	-9,215	-19,394	-18,771	-25	-17,940	-19,311
TDL 3	-2,689	-7	-1,202	-3,843	-3,682	-10	-3,368	-3,843
TDL 4	-2,589	-5	-1,063	-3,825	-3,643	-7	-3,307	-3,825
TDL 5	-11,704	-15	-9,464	-14,541	-10,420	-13	-9,464	-10,924
TDL 6	-34,900	-19	-3,242	-86,986	-75,505	-37	-57,075	-86,986

Surface Area	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min	Max	Average		Min	Max
	m^2	%	m^2	m^2	m^2	%	m^2	m^2
TDL 7	-42,688	-14	-11,327	-59,684	-58,542	-18	-56,258	-59,684
TDL 8	-82,889	-20	-16,613	-102,624	-101,322	-23	-98,922	-102,624
TDL 9	-6,536	-2	-3,155	-9,234	-8,828	-3	-8,037	-9,234
Rapids downstream of TD4	-68,977	-69	-22,879	-91,247	-88,782	-71	-84,491	-91,247
TDL 11	-2,232	-7	-1,138	-3,142	-2,997	-9	-2,715	-3,142
TDL 13	-6,928	-9	-4,596	-9,228	-7,821	-10	-6,078	-9,228
TDL 14	-8,019	-8	-6,067	-9,244	-8,889	-9	-8,210	-9,244
TDL 16	-8,069	-10	-4,978	-11,120	-10,323	-12	-9,110	-11,120
TOTAL	**-333,778**				**-440,487**			
MINIMUM	**-2,232**	**-2**	**-1,063**	**-3,142**	**-2,997**	**-3**	**-2,715**	**-3,142**
MAXIMUM	**-82,889**	**-69**	**-22,879**	**-102,624**	**-101,322**	**-71**	**-98,922**	**-102,624**
AVERAGE	-22,252	-19	-7,996	-31,338	-29,366	-21	-26,833	-30,924

14.7.7.1.2.3 Loss of Pelagic Habitat

Decreases in flow would cause a decrease in the volume of water in the water column, thus reducing the overall productivity of this habitat. Diversity and community structure is not expected to changes measurable. Productivity would be affected; however, the contribution of plankton to the overall productivity of a riverine system such as Trudel is not believed to contribute markedly to the overall productivity of the river. Moreover, plankton in sub-arctic and arctic lakes and rivers are often limited by nutrient levels as opposed to habitat. Therefore, decreased flow under both the 36 MW and 56 MW options is a minor pathway to long-term loss of plankton habitat/productivity (Table 14.7.4).

14.7.7.1.2.4 Decreased Habitat Quality (Altered Ice Processes)

Decreased flows can affect ice formation. Changes in timing, location, type, and magnitude of ice pack in rivers and lakes of the Project area may affect aquatic habitat. This would likely have a more severe effect on the littoral area aquatic community, including vegetation and macroinvertebrates. Potential changes in ice conditions and formation were presented in Section 14.5 - Alteration of Ice Structure.

The flow from October to December were predicted to decrease by approximately 80% under the two expansion scenarios, indicating that freeze-up could start earlier and progress more quickly than normal. There would be a potential increase in the frequency and extent of frozen areas. For instance, some stretches of Trudel Creek could freeze closer to the bottom, particularly within shallow bench zones (see Section 14.5 -Alteration of Ice Structure. This solid freezing in littoral habitat could cause mortality to biota which normally survive the winter under water in non-frozen conditions. Some decreases in habitat quality, productivity, and biodiversity could occur. Therefore, decreased flow and resulting changes in the ice process, under both the 36 MW and 56 MW options, is a valid pathway to decreased habitat quality of new littoral habitat (Table 14.7.4).

14.7.7.1.2.5 *Altered Physical Habitat (Decrease in Velocity)*

This effect of the Project on aquatic resources relates to the decrease in average velocity along Trudel Creek that would result from decreased flows. Currently, Trudel Creek is generally a system with slow to moderate water velocity. The degree of change in water velocity from baseline to operations would have negligible influence on the physical or chemical nature of the aquatic habitat, in terms of habitat suitability, water quality, sediment deposition and particle size distribution, or oxygen levels. Therefore, decreased flow under both the 36 MW and 56 MW options is a minor pathway to change in overall suitability of benthic habitat (Table 14.7.4).

14.7.7.1.3 Increased Flow Range

As flows are actively managed to maximize power generation, flows over the SVS would be reduced. Under normal operating conditions, there would always be more flow routed through the power plant than during baseline. Thus, the baseline peak Trudel Creek flow would not be reached during normal operating conditions. The minimum flow released into Trudel Creek is set at 4 m^3/s, which is slightly above the average monthly minimum of 3.66 m^3/s during baseline. Thus, the range in flow, based on average monthly min/max flows for the modelled period of record, is less under either expansion scenario. Therefore, increased flow range under both the 36 MW and 56 MW options is an invalid pathway to effects on aquatic resources (Table 14.7.4).

14.7.7.1.4 Decreased Flow Range

As flows are actively managed to maximize power generation, flows over the SVS would be reduced. Under normal operating conditions, there would always be more flow routed through the power plant than during baseline. Thus, the baseline peak Trudel Creek flow would not be reached during normal operating conditions. The minimum flow released into Trudel Creek is set at 4 m^3/s, which is slightly above the average monthly minimum of 3.7 m^3/s during baseline. Thus, the range in flow, based on average monthly min/max flows for the modeled period of record, is less under either expansion scenario. Based on the Taltson Basin hydrology model (Section 13.3 - Alteration of Water Quantity), the range in the average monthly flows, where average monthly flows were computed using the 13-year period of record for the model, would decrease from 182 m^3/s (baseline) to 35 m^3/s and 24 m^3/s for the 36 MW and 56 MW options, respectively. The absolute range in monthly average flows would decrease from 486 m^3/s (baseline) to 325 m^3/s and 194 m^3/s for the 36 MW and 56 MW options, respectively.

A reduction in the range of flow would limit the recruitment of nutrients from adjacent riparian habitat and could limit the complexity of aquatic habitat as large-channel changing peak flows are reduced. Based on model flows in Trudel Creek, flows would on average be multiples of the minimum flow of 4 m^3/s during the natural freshet period (Figure 13.3.31). Although the range in flows from baseline to expansion is reduced, freshet flows and ramped up flows during scheduled outages of turbines would serve to recruit nutrients and likely add complexity to the aquatic habitat. During low flow years, the range could decrease to zero for both expansion scenarios. However, there would be a three-week period of increased flows during scheduled maintenance of the turbines.

Therefore decreased flow range under both the 36 MW and 56 MW options is a valid pathway to decreased nutrient recruitment and habitat complexity (Table 14.7.4).

14.7.7.1.5 Altered Hydrograph Parameters

The hydrologic parameters discussed below that would be potentially altered under both the 36 MW and 56 MW options are the duration and timing of freshet and minimum flows, and the rate of change in flows. For the 36 MW and 56 MW expansion options, the flow capacity of the Twin Gorges power facility would increase from 74 m^3/s to approximately 180 m^3/s and 240 m^3/s, respectively. Thus, the freshet peak and the overall freshet volume that is available for Trudel Creek would be markedly reduced. In addition, as freshet flows recede below 180 m^3/s (36 MW option) and 240 m^3/s (56 MW option), water would no longer spill into Trudel Creek. This would reduce the duration of freshet.

Figure 13.3.31 (see Section 13.3) presents the average monthly flows over the SVS for the modelled period of record. On average, Trudel Creek would experience a reduced freshet peak and volume, but flows on average would naturally increase during the freshet period and remain elevated during the summer months for both expansion scenarios. (Potential effects of decreases in the peak flow and flow volume are discussed under ***Decreased Flow*** above). However, during low flow years and particularly during consecutive low flow years, flows may not increase above the minimum flow for the entire freshet period. Based on a comparison of the modelled flow data (Section 13.3 Alteration of Water Quantity) to the long-term period of record at Tsu Lake, low flows years that would eliminate freshet flows altogether would occur once every two years (36 MW option) and once every ten to 25 years (56 MW option).

The changes to the timing and duration of the minimum monthly average flow are also presented in Figure 13.3.31. On average, the timing and duration of the minimum flow for the 36 MW and 56 MW options would not differ from baseline. However, during low flow years and particularly during consecutive low flow years, the minimum flow of 4 m^3/s could be maintained throughout the year. These flow conditions are expected to occur once every 10 to 25 years (56 MW option).

Flow ramping events would be part of normal operating conditions for both the 36 MW and 56 MW options. Section 14.3.3 provides details of the changes in flows and water levels along Trudel Creek during a ramping event from a scheduled power outage. Scheduled outages for turbine maintenance are currently planned annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion; 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the exiting 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 MW and 56 MW expansions would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with a slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events.

The rate of flow increase during scheduled outages would be greater than typically experienced under baseline freshet conditions. Given the size of the upstream watershed of Trudel Creek, the system (Taltson Basin) responds relatively slowly to temperature changes at the onset of freshet and precipitation events. Thus large changes in the rate of flow during a scheduled maintenance event of the turbines would be different than baseline. Therefore, altered hydrograph parameters (decreased freshet duration, increased minimum flow duration and increased rate of change in flow under both the 36 MW and 56 MW options) are a valid pathway to decreased nutrient recruitment and habitat complexity (Table 14.7.4).

14.7.7.2 TRUDEL LAKES (36 MW AND 56 MW OPTIONS)

14.7.7.2.1 Increased Flow

The hydrologic models developed for the Taltson Basin and Trudel Creek during operations of the 36 MW and 56 MW options (Section 13.3 and 14.3) presents monthly average flows and water levels for Trudel Creek and associated lakes. The average monthly flow and the range of average monthly flows are predicted to decrease for both expansion options. Therefore, increased flows is not a valid pathway to effects on aquatic resources (Table 14.7.9).

Table 14.7.9 — Pathway Validation for Aquatic Resources in Trudel Lakes: 36 MW and 56 MW Options

Pathway	Effects	Validation
1. Increased flows	Loss of suitable littoral habitat	Invalid: flows would not increase
	Decreased habitat quality (from increased mercury, nutrients, TSS)	Invalid: flows would not increase
	Increased productivity (from altered ice processes)	Invalid: flows would not increase
	Altered Physical habitat (due to increased velocity)	Invalid: flows would not increase
	Increase in profundal and pelagic habitat	Invalid: flows would not increase
2. Decreased flows	Loss of suitable littoral habitat	Valid: flows would decrease
	Loss of profundal habitat	Valid: flows would decrease
	Loss of Pelagic habitat	Minor: flows would decrease but the contribution of the pelagic zone to overall productivity is minor; biodiversity and community structure not expected to change
	Decrease habitat quality (from altered ice processes)	Valid: flows would decrease
	Altered physical habitat (due to reduced velocities)	Minor: flows would decrease but velocities are not expected to change enough to alter productivity, biodiversity and community structure
3. Increased flow range	Increased habitat quality (from release of mercury/nutrients/ TSS, drying and flooding of habitat)	Invalid: flow range would not increase
4. Decreased rlow range	Decreased habitat quality and complexity (from decreased inputs of nutrients and decreased range in water levels)	Valid: flow range would decrease markedly from baseline
5. Altered hydrograph parameters	Decreased habitat quality and complexity (through altered duration of freshet minimum flow period and flow ramp up events)	Valid: hydrograph characteristics would change during extreme events

14.7.7.2.2 Decreased Flow

14.7.7.2.2.1 Loss of Suitable Littoral Habitat

The hydrology model for the 36 MW and 56 MW scenarios predicted that lake water levels, as a result of altered flows from the SVS, would decrease by 99 cm and 115 cm (Gertrude Lake), 107 cm and 123 cm (Trudel Lake) and 78 cm and 89 cm (Unnamed Lake) relative to baseline over the entire year, respectively (Table 14.7.10 and Table 14.7.11). These projected decreases would dewater a portion of the littoral areas (approximately 2 m deep) but would not dry profundal areas, which are considered to occur at lake depths greater than 2 m. For the summer period, water levels under the 36 MW and 56 MW options would decrease by 137 cm and 153 cm (Gertrude Lake), 148 cm and 165 cm (Trudel Lake) and 109 cm and 122 cm (Unnamed Lake) relative to baseline, respectively. Normal summer monthly variation is between 7 cm and 11 cm, indicating fairly constant lake levels from June to August. The projected decreases in lake levels from baseline are much larger than changes in levels over a typical summer, indicating that project related decreases are relevant.

Decreased summer levels relates to projected temporary loss of suitable littoral habitat around the lakes. Low water years would show more severe drops in average water levels relative to baseline. This could result in reduced productivity, a shift in community structure, and likely a loss of some diversity while the new littoral habitat becomes suitable. The degree of change in community structure and diversity would depend on the areas exposed (e.g. Aroviita and Hämäläinen 2008; Baumgärtner et al. 2008). The newly-formed littoral habitat is expected to develop into suitable habitat for littoral communities and thus maintain overall littoral productivity. Emergent and submergent vegetation communities are reported to take approximately three years and one to two years for basic colonization, respectively (Odland and Moral 2002; Cott et al. 2008).

Table 14.7.10 — Water Level Changes in Lakes of Trudel Creek for Entire Year and Summer Periods: 36 MW Option

Location	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min (cm)	Max (cm)	Average		Min (cm)	Max (cm)
	cm	%			cm	%		
Gertrude Lake	-99	-9	-52	-147	-137	-12	-124	-147
Trudel Lake	-107	-9	-55	-159	-148	-13	-134	-159
Unnamed Lake	-78	-9	-37	-118	-109	-12	-99	-118

Table 14.7.11 — Water Level Changes In Lakes of Trudel Creek for Entire Year and Summer Periods: 56 MW Option

Location	ENTIRE YEAR				SUMMER (JUNE TO AUGUST)			
	Average		Min (cm)	Max (cm)	Average		Min (cm)	Max (cm)
	cm	%			cm	%		
Gertrude Lake	-115	-10	-60	-160	-153	-13	-138	-160
Trudel Lake	-123	-11	-63	-173	-165	-14	-150	-173
Unnamed Lake	-89	-10	-42	-128	-122	-14	-111	-128

As discussed above, water levels would decrease and thus affect the littoral community. The extent of lost suitable littoral habitat can be quantified by determining the lost wetted area with less than 2 m water depth for average summer water levels (Table 14.7.12, Table 14.7.13, and Table 14.7.14). The predicted decreases in water levels are all less than 2 m, thus all lost wetted area is considered a direct loss of suitable littoral habitat. During an average flow year under both 36 MW and 56 MW options, Trudel lakes are predicted to lose 19.2% and 23.1% (Gertrude Lake), 39.5% and 48.0% (Trudel Lake) and 24.3% and 29% (Unnamed Lake) of the suitable littoral habitat, respectively.

Given the predicted decreases in water levels and surface areas of Trudel lakes, decreases in flow is a valid pathway to the loss of suitable littoral habitat (Table 14.7.9).

Table 14.7.12 — Water Level and Wetted Area Changes in Gertrude Lake: 36 MW and 56 MW Options

36 MW Option	ENTIRE YEAR			SUMMER PERIOD		
	Ave	Min	Max	Ave	Min	Max
Change in Water Level (m)	-0.99	-0.52	-1.47	-1.37	-1.24	-1.47
Change in Total Wetted Area (ha)	-1.0	-0.3	-2.8	-2.3	-1.8	-2.8
% Change in Total Wetted Area	-1.3	-0.4	-3.6	-3.0	-2.4	-3.6
% Change in Littoral Area	-19.2	-6.2	-52.9	-43.3	-34.6	-52.9
56 MW Option	**ENTIRE YEAR**			**SUMMER PERIOD**		
	Ave	**Min**	**Max**	**Ave**	**Min**	**Max**
Change in Water Level (m)	-1.15	-0.6	-1.6	-1.53	-1.38	-1.6
Change in Total Wetted Area (ha)	-1.20	-0.40	-3.30	-2.90	-2.30	-3.30
% Change in Total Wetted Area	-1.6	-0.5	-4.4	-3.8	-3.1	-4.4
% Change in Littoral Area	-23.1	-7.7	-63.5	-55.8	-44.2	-63.5

Table 14.7.13 — Water Level and Wetted Area Changes in Trudel Lake: 36 MW and 56 MW Options

36 MW Option	ENTIRE YEAR			SUMMER PERIOD		
	Ave	Min	Max	Ave	Min	Max
Change in Water Level (m)	-1.07	-0.55	-1.59	-1.48	-1.34	-1.59
Change in Total Wetted Area (ha)	-7.9	-3.2	-14.0	-12.7	-11.0	-14.0
% Change in Total Wetted Area	-6.2	-2.5	-11.0	-10.0	-8.7	-11.0
% Change in Littoral Area	-39.5	-16.0	-70.0	-63.5	-55.0	-70.0
56 MW Option	**ENTIRE YEAR**			**SUMMER PERIOD**		
	Ave	**Min**	**Max**	**Ave**	**Min**	**Max**
Change in Water Level (m)	-1.23	-0.63	1.73	-1.65	-1.5	-1.73
Change in Total Wetted Area (ha)	-9.6	-4.0	-15.6	-14.8	-12.9	-15.6
% Change in Total Wetted Area	-7.6	-3.1	-12.3	-11.7	-10.2	-12.3
% Change in Littoral Area	-48.0	-20.0	-78.0	-74.0	-64.5	-78.0

Table 14.7.14 — Water Level and Wetted Area Changes in Unnamed Lake: 36 MW and 56 MW Options

36 MW Option	ENTIRE YEAR			SUMMER PERIOD		
	Ave	Min	Max	Ave	Min	Max
Change in Water Level (m)	-0.78	-0.37	-1.18	-1.09	-0.99	-1.18
Change in Total Wetted Area (ha)	-18.1	-4.7	-32.5	-28.1	-25.5	-32.5
% Change in Total Wetted Area	-4.4	-1.2	-8.0	-6.9	-6.3	-8.0
% Change in Littoral Area	-24.3	-6.3	-43.6	-37.7	-34.2	-43.6
56 MW Option	**ENTIRE YEAR**			**SUMMER PERIOD**		
	Ave	**Min**	**Max**	**Ave**	**Min**	**Max**
Change in Water Level (m)	-0.89	-0.42	-1.28	-1.22	-1.11	-1.28
Change in Total Wetted Area (ha)	-21.6	-6.0	-36.1	-32.3	-28.8	-36.1
% Change in Total Wetted Area	-5.3	-1.5	-8.9	-7.9	-7.1	-8.9
% Change in Littoral Area	-29.0	-8.1	-48.5	-43.4	-38.7	-48.5

14.7.7.2.2.2 Loss of Profundal Habitat

Profundal habitat is habitat with water levels greater than 2 m during the summer period. As water levels drop under both expansion options and littoral habitat shifts down in elevation, there is a loss of profundal habitat. Given that water levels would remain lower than baseline for the life of the Project, this is a permanent loss of profundal habitat. The wetted areas lost under both expansion options are presented in Table 14.7.12, Table 14.7.13, and Table 14.7.14. The overall loss in wetted area based on the maximum average monthly water level is around 10%. Therefore, decreased flow under both the 36 MW and 56 MW options is a valid pathway to permanent loss of profundal habitat in Trudel lakes (Table 14.7.9).

14.7.7.2.2.3 Loss of Pelagic Habitat

Pelagic habitat is habitat within the water column. It can be quantified by calculating lake volume. As water levels drop, lake volume and thus pelagic habitat would be lost. Given that water levels would remain lower than baseline for the life of the Project, this is a long-term loss of pelagic habitat. The amount of pelagic habitat lost was indirectly quantified by using lake water levels and general bathymetric data: maximum lake depth. The maximum depths of Trudel lakes range from 8 m to 11 m. Table 14.7.12 and Table 14.7.13 present the decrease in lake water levels for the 36 MW and 56 MW options, respectively. Lake water levels would decrease for both expansion scenarios and thus so too would the extent of pelagic habitat. The maximum drop in water level is predicted to be 1.7 m; this compares to maximum depths of 8 m to 11 m, which represents a maximum drop of just over 20%. It is also noted that productivity of pelagic habitat in arctic and sub-arctic lakes is not limited by habitat, but by nutrient levels. Thus, the decrease in pelagic habitat is secondary to the overall pelagic productivity. Given that roughly 80% of the habitat would remain, diversity should not be negatively affected. Moreover, as the euphotic (photosynthetically active) depth likely reaches to the lake bottom, and the fraction of lake volume lost relative to total volume is fairly small, plankton communities should show negligible effects. Therefore, decreased flow under both the 36 MW and 56 MW options is a minor pathway to long-term loss of pelagic habitat in Trudel lakes (Table 14.7.9).

14.7.7.2.2.4 Decreased Habitat Quality (Altered Ice Processes)

Decreased flows can affect ice formation. Changes in timing, location, type, and magnitude of ice pack in rivers and lakes of the Project area may affect aquatic habitat. This would likely have a more severe effect on the littoral community, including vegetation and macroinvertebrates. Potential changes in ice conditions and formation were presented in Section 14.5 - Alteration of Ice Structure.

The flow from October to December was predicted to decrease by approximately 80% under the two expansion scenarios, indicating that freeze-up could start earlier and progress more quickly than normal. There would be a potential increase in the extent of frozen areas and the frequency of the extent. For instance, some lake littoral habitat under baseline would freeze to the lakebed. Under the expansion options the area of frozen lakebed would increase (see Section 14.5 - Alteration of Ice Structure). This solid freezing in littoral habitat could cause mortality to biota which normally survive the winter under water in non-frozen conditions. Some decreases in habitat quality, productivity, and biodiversity could therefore occur. Therefore, decreased flow and resulting changes in the ice process under both the 36 MW and 56 MW options is a valid pathway to decreased habitat quality of new littoral habitat (Table 14.7.9).

14.7.7.2.2.5 Altered Physical Habitat (Decrease in Velocity)

The effect of altered physical habitat is driven by the secondary pathway of reduced velocities. As discussed for Trudel Creek under both expansion scenarios, the change in velocities is expected to be negligible and thus there would not be alterations to physical habitat from changes in velocity. Therefore, decreased flows under both the

36 MW and 56 MW options are a minor pathway to altered physical habitat (Table 14.7.9).

14.7.7.2.3 Increased Flow Range

As flows are actively managed to maximum power generation, flows over the SVS would be reduced. Under normal operating conditions, there would always be more flow routed through the power plant than during baseline. Thus, the baseline peak Trudel Creek flow would not be reached during normal operating conditions. The minimum flow released into Trudel Creek is set at 4 m^3/s, which is slightly above the average monthly minimum of 3.7 m^3/s. Thus, the range in flow, based on average monthly min/max flows for the modeled period of record, is less under either expansion scenario. Based on the Taltson Basin hydrology model (Section 13.3 - Alteration of Water Quantity), the range in average monthly flows would decrease from 182 m^3/s (baseline) to 35 m^3/s and 24 m^3/s for the 36 MW and 56 MW options, respectively. The decreased flow range equates to a decrease in the lake water level range as well (Table 14.7.15). During low flow years where the minimum flow from the SVS is maintained year round, the range in water levels on Trudel lakes would be close to zero year-round. Therefore, increased flow range under both the 36 MW and 56 MW options is an invalid pathway to effects on aquatic resources (Table 14.7.9).

Table 14.7.15 — Minimum and Maximum Average Monthly Lake Depths and Range in Average Monthly Lake Depths (m) for Trudel Lakes: 36 & 56 MW Options

	GERTRUDE LAKE			TRUDEL LAKE			UNNAMED LAKE		
	Baseline	36 MW	56 MW	Baseline	36 MW	56 MW	Baseline	36 MW	56 MW
Min	10.33	9.81	9.73	10.36	9.81	9.73	7.94	7.57	7.52
Max	11.76	10.34	10.18	11.9	10.36	10.19	9.09	7.95	7.82
Range	1.43	0.53	0.45	1.54	0.55	0.46	1.15	0.38	0.3

14.7.7.2.4 Decreased Flow Range

As discussed above and presented in Table 14.7.15, the range in lake depths would decrease under both expansion options. A reduction in the range of lake depths would limit the recruitment of nutrient from adjacent riparian habitat and could limit the complexity of aquatic habitat as large channel changing peak flows are reduced.

Based on average monthly flows for the entire year, freshet flows along Trudel Creek would on average be multiples of the minimum flow (4 m^3/s) during the natural freshet period (Figure 13.3.31). Although the range in flows from baseline to expansion is reduced, freshet flows and ramped up flows during scheduled outages of turbines would serve to recruit nutrients and likely add complexity to the aquatic habitat. However, during low flow years the range in lake depths could approach zero. Therefore decreased flow range under both the 36 MW and 56 MW options is a valid pathway to decreased nutrient recruitment and habitat complexity (Table 14.7.9).

14.7.7.2.5 Altered Hydrograph Parameters

The hydrologic parameters discussed below that would be potentially altered under both the 36 MW and 56 MW options are the duration and timing of freshet and minimum flows, and the rate of change in flows. For the 36 MW and 56 MW expansion options, the flow capacity of the Twin Gorges power facility would increase from 74 m^3/s to approximately 180 and 240 m^3/s, respectively. Thus, the freshet peak and the overall freshet volume that is available for Trudel Creek would be markedly reduced. In addition, as freshet flows recede below 180 m^3/s (36 MW option) and 240 m^3/s (56 MW option), water would no longer spill into Trudel Creek. This would reduce the duration of freshet.

Table 14.7.12 to Table 14.7.14 present the average monthly water levels for Trudel lakes. Based on the long-term average monthly water levels, Trudel lakes would experience a reduced maximum water level, but water levels on average would naturally increase during the freshet period and remain elevated during the summer months for both expansion scenarios. However, during low flow years and particularly during consecutive low flow years, flows may not increase above the minimum flow for the entire freshet period. Based on a comparison of the modelled flow data (Section 13.3 Alteration of Water Quantity) to the long-term period of record at Tsu Lake, low flows years that would eliminate freshet flows altogether would occur once every two years (36 MW option) and once every ten to 25 years (56 MW option).

The changes to the timing and duration of the minimum monthly average flow are also presented in Figure 13.3.31. On average, the timing and duration of the minimum flow for the 36 MW and 56 MW options would not differ from baseline. However, during low flow years and particularly during consecutive low flow years, the minimum flow of 4 m^3/s could be maintained throughout the year. These flow conditions are expected to occur once every 10 to 25 years (56 MW option).

The changes to the timing and duration of the minimum average water levels are presented in Table 14.3.20 to Table 14.3.22 (see Section 14.3). On average, the timing and duration of the minimum flow for the 36 MW and 56 MW options would not differ from baseline. However, during dry years and particularly during consecutive dry years the minimum flow of 4 m^3/s could be maintained throughout the year. These flow and water level conditions are expected to occur once every 10 to 25 years.

Flow ramping events would be part of normal operating conditions for both the 36 MW and 56 MW options. Section 14.3.3 provides details of the changes in flows and water levels along Trudel Creek during a ramping event from a scheduled power outage. Scheduled outages for turbine maintenance are currently planned annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion; 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the exiting 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 MW and 56 MW expansions would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with a slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events

As discussed above for Trudel Creek, ramping events during scheduled outages for turbine maintenance is a valid pathway to rapid changes in flow rates (and thus water levels) for Trudel lakes. The lakes would experience similar water level changes during a scheduled ramping event as predicted for Trudel Creek.

The effect of reduced duration of freshet, increased duration of minimum flow, and rapid changes in flow rates is a valid pathway to effects on aquatic resources for both expansion scenarios (Table 14.7.9).

14.7.8 Residual Effect Analysis and Classification

Following consideration of mitigation, the analysis and classification of residual effects was conducted for each of the valid pathways for Trudel Creek and Trudel lakes separately. The classification of residual effects was further separately by expansion scenario (36 MW and 56 MW).

Table 10.5 presents the classification criteria that were used to classify effects to the assessment endpoint. However, the definitions used to define the geographical extent of an effect were changed for the Trudel Creek KLOI. Geographic extent includes three scales:

- single reach or lake within Trudel Creek (small scale),
- multiple reaches or lakes within Trudel Creek (medium scale), and
- all of Trudel Creek (large scale).

The assessment endpoint of sustainability of aquatic resources includes productivity, biodiversity and community structure. Quantitative analysis of various measurement endpoints was used to qualitatively classify effects to the assessment endpoint. An overall residual effect rating was determined for each effect based on the classification criteria. Overall residual effects were rated as low, moderate or high, based largely on magnitude, geographic extent and duration of the effect on the assessment endpoint. High overall residual effects would be considered serious issues affecting the design and acceptance of the Project. A high overall residual effect means the long-term sustainability of the aquatic resources within the Trudel Creek is in question.

The hydrologic model (Section 14.3 - Alteration of Water Quantity) and available bathymetry, aquatic biology, aquatic habitat (Rescan 2006; Cambria Gordon Ltd. 2008), and chemistry data formed the basis for quantifying changes to various measurement endpoints: change in habitat extent and change in hydrologic parameters affecting habitat complexity and quality. The effects to aquatics are linked to effects to water quality, sediment quality, fish, wildlife, and wetlands (Sections 14.4 Alteration of Water Quality, 14.6 Wetlands, 14.8 Fisheries Resources, and 14.9 Wildlife).

This assessment draws heavily on the hydrologic model for Trudel Creek to quantify changes to various measurement endpoints relevant to aquatic resources. Thus the assessment is bound by the same assumptions and limitations tied to the model. Water levels were modeled at 18 cross-sections along Trudel Creek, and within the three lakes, based on monthly mean flows projected for each month under both the 36 MW and 56 MW expansion options (Figure 14.7.1). The bottom two sections (TDL16 and TDL17) were not included since they experience backwater effects from the Taltson River. This represents the bottom 2 km of Trudel Creek, the bulk of Reach 1. Areas between the remaining 16 cross-sectional study areas were assumed to gradually transition to the next downstream cross-section. The first cross-section (Spillway) represents the upper constraint on the model and thus functions more to initial the model then to represent a cross-section of Trudel Creek. As such, Spillway was not used as part of the assessment of effects. In addition, substrate type was assumed to be similar to the nearest cross-sectional survey study area (see Figure 14.7.1 for cross-section locations and areas). Three reach areas are described throughout this assessment. These include: Reach 1 (lower Trudel Creek from confluence with Taltson River up to the outlet of Gertrude Lake); Reach 2 (Gertrude Lake upstream to Trudel Lake); and Reach 3 (Unnamed Lake upstream to SVS at Twin Gorges Forebay). Lake sites were considered representative of their respective lake habitats (Figure 14.7.1).

Note that effects assessment is focused on the operations phase of the project. No effects to aquatic resources in the Trudel Creek system are predicted during the construction phase of either of the proposed expansion scenarios.

14.7.8.1 EFFECTS TO RIVER HABITAT — 36 MW OPTION

14.7.8.1.1 Decreased Flows

14.7.8.1.1.1 Loss of Suitable Littoral Habitat

The maximum depth of littoral habitat was defined based on CGL (2008a) as 1 m below summer water levels. This is an approximation and is most applicable to Reach 3. The data presented in Table 14.7.5 and Table 14.7.6 show that water levels on average would decrease by 119 cm under the 36 MW option. In Reach 3, the average is approximately 140 cm, with a long-term maximum average monthly decrease of 227 cm. Thus, the entire littoral zone within Reach 3 would be lost during the first year of operations assuming average flow conditions. If the first year of operations coincided with a high flow year, water levels would drop by approximately 60 cm (roughly a 60% loss in suitable littoral habitat). In areas consisting of rock outcrops (e.g. much of Reach 1) and cliff-type habitat on shorelines, effects would be lower, since little aquatic vegetation grows and relatively fewer organisms inhabit these areas.

These results indicate that a large amount of river habitat along the banks of Trudel Creek would be lost during the growing season due to lowered water levels. Productivity, biodiversity and structure of littoral plant and invertebrate communities would all likely show high mortality until such a time (1 to 3 years) that littoral habitat could develop at the new water levels (Figure 14.7.3).

It was assumed that, for any affected littoral habitat that was lost through lowered water levels, new littoral habitat would develop after a certain time. Habitat loss would then be short-term for littoral habitat, but long-term (Project lifetime) for loss of profundal habitat. This development period was assumed to be approximately one to 3 years for submergent vegetation and up to 10 years for emergent vegetation, with corresponding benthic invertebrate communities developing within these time frames (Cott et al., 2008; Odlund and Moral; 2002; Wallace, 1990). Diversity of communities could lag behind initial colonization as richness could increase over time.

The quality and extent of new littoral habitat is difficult to quantify. Trudel Creek is a managed system that has undergone major hydrologic changes in the past, and new aquatic communities have developed. A shift in community structure and loss of diversity in aquatic organisms is likely, depending on the areas exposed (e.g. Aroviita and Hämäläinen 2008; Baumgärtner et al. 2008) in the short-term.

The magnitude of the effect of loss of suitable littoral habitat on the productivity, biodiversity and community structure is high as a large percentage of littoral habitat would shift to lower elevations (Table 14.7.16). The geographic extent is Trudel Creek as the entire assessment area would experience this effect. The duration of the effect is deemed short-term as suitable littoral habitat is expected to establish within a few years of the initial effect. The effect is reversible given that suitable littoral habitat would form. The frequency would be continuous and the likelihood is likely.

The overall residual effect of decreased water levels on productivity, biodiversity and community structure of aquatic resources in Trudel Creek would be moderate (Table 14.7.16). Although there would be a considerable effect on littoral habitat in the first few years, it is assumed that new littoral habitat would develop in this time. Therefore, habitat diversity would be maintained, allowing viable populations of aquatic biota to reside in Trudel Creek.

14.7.8.1.1.2 Loss of Profundal Habitat

Table 14.7.7 and Table 14.7.8 present the loss in wetted area of Trudel Creek. This loss directly relates to the long-term loss of profundal habitat. On average, there would be a loss of 19% of profundal habitat within Trudel Creek during the summer period. The range in per cent loss is large, however the maximum of 67% occurs at a rapids section which would not be considered quality profundal habitat given the water velocities in this area. Reach 3 on average would lose about 20% of the wetted area. The maximum lost wetted area within a single section of Reach 3 is 24%.

The magnitude of the loss in profundal habitat presented in the Trudel Creek hydrology model (Section 14.3 — Alteration of Water Quantity) on aquatic resources productivity, biodiversity and community structure is low. The effect of loss of profundal habitat extents throughout most of Trudel Creek and thus the geographic extent is Trudel Creek, though the greatest per cent loss is in Reach 3. The duration is long-term. The effect is continuous but reversible following operations, and the likelihood is likely. The overall residual effect is rated as low as the overall productivity would not be measurably affected (Table 14.7.16). Biodiversity is not expected to change markedly given that profundal habitat typically represents a small portion of the overall biodiversity of riverine systems. Community structure would also change as the per cent of profundal species that exist within Trudel Creek would decrease. However, a major shift in community structure is not expected.

14.7.8.1.1.3 Decrease Habitat Quality (Altered Ice Processes)

The major reductions in flows over the fall and winter period result in earlier freeze-up times predicted for Trudel Creek, resulting in slightly shorter growing season. Ice formation may shift in nature from juxtaposition to simple thermal ice cover. Some shallower sections of Trudel Creek may experience higher frequency and duration of solid freeze-up under the 36 MW option. This could affect aquatic resources by damaging seeds, roots, and invertebrates, and this could slightly reduce productivity, habitat quality, and biodiversity. The magnitude of effect is rated low due to the likely limited extent in which solid ice-up could occur along Trudel Creek, given that there would be a minimum flow maintained through the winter. The overall residual effect is assigned a rating of low (Table 14.7.16).

14.7.8.1.2 Decreased Flow Range

14.7.8.1.2.1 Decreased Habitat Quality and Complexity

The range in flow along Trudel Creek would decrease under 36 MW expansion. Over the course of a year, varying flows assist in providing habitat complexity and maintaining habitat quality through recruitment of nutrients. Loss in habitat complexity could lead to reduced productivity, biodiversity and community structure of aquatic resources. Figure 13.3.31 presents the flow range under the 36 MW expansion. The range would be reduced. However, on average there would still be periods of high and low flow. Thus, flows that maintain habitat complexity and nutrient recruitment would occur under the new hydrologic regime. During extreme flow years, the range would be further reduced and for some very low flow years (1:10 to 1:25 years), the range in flow would be eliminated. Given the low frequency of occurrence of these low flow years, habitat complexity would either be maintained or re-establish during the next average year. In addition, scheduled maintenance of the turbines would ensure Trudel Creek does experience a short-term range in flow if low-flow years occurred consecutively.

The magnitude of the effect of decreased flow range on aquatic resource productivity, biodiversity and community structure is low (Table 14.7.16). The overall residual effect is rated as low.

14.7.8.1.3 Altered Hydrograph Parameters

14.7.8.1.3.1 Decreased Habitat Quality and Complexity

This Project pathway focuses on potential changes in productivity, biodiversity and community structure from changes in the duration of freshet flows and minimum flows, and the rate of change in flow during a scheduled outage event (i.e. maintenance of turbines). The timing of freshet under the 36 MW option does not differ from baseline, based on average monthly flows generated from 13 years of consecutive flow data. The duration also does not differ from baseline. Based on average flow conditions under the 36 MW option, flows increase slightly in May as freshet begins. June flows are considerably higher than May flows, and July and August flows remain at or close to June levels. Flows begin to taper off in September and continue to decline through the winter.

During extreme low flow years, freshet flows would be non-existent (Figure 13.3.30). The data set used to generate the 36 MW option hydrograph included three years of consecutive low flow, which is a rare occurrence based on the long-term data set for the Taltson River watershed. Individually, these low flows are estimated to occur once every 10 to 25 years. Given the life expectancy of the Project, these low flow years would occur during operations, but it is unlikely that these events would occur consecutively. The effect of such low flow events is reduced recruitment of nutrients and reduced habitat complexity. This would affect productivity, biodiversity and potentially change community structure. However, the effects would only last until the next average or high flow year, thus the effect would be short-term.

Rapid increases in flow rates resulting from ramping events are expected to have a frequency of occur of roughly every other year (36 MW ramping event). Effects on erosion and deposition of sediment in the littoral zones are rated as low given that these flows have occurred during April/May under baseline conditions and are expected to occur through the normal operating period, see Section 14.4.3.5 for detailed assessment of effects on water quality. The magnitude of the effects on aquatic resources is also predicted to be low. There would be increases in drift and loss of some aquatic life but the event is scheduled to occur during a period of low productivity and would only last for a short duration. The aquatic community is expected to recover to baseline productivity and biodiversity during the following summer.

Considering the extreme events (both high and low) that would occur during the life of the Project the magnitude of altered hydrograph parameters on productivity, biodiversity and community structure is considered low (Table 14.7.16). The duration is short-term given that aquatic resources would either recover from any measurable effects the following year or the effects would be within natural variation. The geographic extent is Trudel Creek. The frequency is periodic and the likelihood is likely. The overall residual effect is rated as low.

Table 14.7.16 — Classification of Residual Effect on Aquatic Resources (Productivity, Biodiversity and Community Structure) in Trudel Creek: 36 MW Option

Pathway	Effect	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Overall Residual Effect
Decreased flows	Loss of suitable littoral habitat	Adverse	High	Trudel Creek	Short-term	Continuous	Reversible	Likely	Moderate
	Loss of profundal habitat	Adverse	Low	Trudel Creek	Long-term	Continuous	Reversible	Likely	Low
	Decrease habitat quality	Adverse	Low	Trudel Creek	Long-term	Continuous	Reversible	Likely	Low
Decrease flow range	Decrease habitat quality	Adverse	Low	Trudel Creek	Long-term	Continuous	Reversible	Likely	Low
Altered hydrograph parameters	Decrease habitat quality and complexity	Adverse	Low	Trudel Creek	Short-term	Periodic	Reversible	Likely	Low

14.7.8.2 EFFECTS TO RIVER HABITAT — 56 MW OPTION

14.7.8.2.1 Decreased Flows

14.7.8.2.1.1 Loss of Suitable Littoral Habitat

Water levels in Trudel Creek were predicted to decrease slightly more with the 56 MW option compared to the 36 MW option. For an average flow year (for both summer period and full year), the decrease would dry out most littoral habitat. Average loss of the top third of river height during summer is related to an average loss of 87% of flows over all sites in Trudel Creek (Section 13.3). Aquatic field surveys of Reach 3 in Trudel Creek indicated that emergent and submergent vegetation grows to approximately 1 m below summer water levels (CGL 2008a). As summer water levels would decrease by up to 251 cm, this would be expected to completely dewater all littoral habitats in Trudel Creek. As with the 36 MW option, Reach 3 shows the greatest predicted decreases.

Macrophytes, benthic algae, and invertebrates living in littoral habitat that dried out on the banks of Trudel Creek would be lost, depending on position of algal colonies and root bases for aquatic plants relative to water lines. Reaches 2 and 3 were described to have a varying density of emergent and especially submergent vegetation growing in margins and along shallow shelves (Cambria Gordon Ltd. 2008). Wetlands, beaches, and shallow shelves with macrophytes present could experience the highest magnitude of adverse effects. Rock outcrops and cliff-type habitat on shorelines (i.e. Reach 1 extending from Gertrude Lake downstream to confluence of Taltson River and Twin Gorges Dam outflow) would have less potential for effects, as less vegetation is found in these areas. The reductions in littoral benthic habitat may only last for a few years, as the littoral areas are replaced by areas currently in deeper waters (Hatfield et al. 2003).

These results indicate that a large amount of river habitat along the banks of Trudel Creek would be lost during the growing season due to lowered water levels. Productivity, biodiversity and structure of littoral plant and invertebrate communities would all likely show high mortality until such a time (1 to 3 years) that littoral habitat could develop at the new water levels (Figure 14.7.3). The quality and extent of new littoral habitat is difficult to quantify. Trudel Creek is a managed system that has undergone major hydrologic changes in the past, and new aquatic communities have developed.

The magnitude of the effect of loss of suitable littoral habitat on the productivity, biodiversity and community structure is high as a large percentage of littoral habitat would shift to lower elevations (Table 14.7.17). The geographic extent is Trudel Creek as the entire assessment area would experience this effect, though Reach 3 would incur the majority of effects. The duration of the effect is deemed short-term as suitable littoral habitat is expected to establish within a few years of the initial effect. The effect is reversible given that suitable littoral habitat would form. The frequency would be continuous and the likelihood is likely.

The overall residual effect of decreased water levels on productivity, biodiversity and community structure of aquatic resources in Trudel Creek would be moderate (Table 14.7.17). Although magnitude of suitable littoral habitat would be high in Reach 3, sustainability of primary and secondary producer communities is not threatened given development of suitable littoral zones. Therefore, habitat diversity would be maintained, allowing viable populations of aquatic biota to reside in Trudel Creek. It is assumed that submerged areas could become areas with emergent vegetation and that benthic invertebrates would colonize newly-developed littoral zones to the extent now occurring in the system.

14.7.8.2.1.2 Loss of Profundal Habitat

Table 14.7.7 and Table 14.7.8 present the loss in wetted area of Trudel Creek. This loss directly relates to the long-term loss of profundal habitat. Profundal habitat loss is marginally greater for the 56 MW option versus the 36 MW option, 2%. Profundal habitat that became littoral would represent a net loss over the entire duration of the Project. Profundal productivity would decrease proportionately, but diversity and community structure in deep-water communities would remain unchanged since the nature of their habitat would not change.

The magnitude of the loss in profundal habitat of the nature presented in the Trudel Creek hydrology model (Section 14.3 - Alteration of Water Quantity) on aquatic resources, productivity, biodiversity and community structure is low (Table 14.7.17). The effect of loss of profundal habitat extends throughout most of Trudel Creek and thus the geographic extent is Trudel Creek. The duration is long-term. The effect is continuous but reversible at the end of operations, and the likelihood is likely. The overall residual effect is rated as low, as the overall productivity would remain at levels necessary to sustain aquatic resources. Biodiversity is not expected to change markedly given that profundal habitat typically represents a small portion of the overall biodiversity of riverine systems. Community structure would also change as the per cent in which profundal species exist within Trudel Creek would decrease. However, a major shift in community structure is not expected.

14.7.8.2.1.3 Decrease in Habitat Quality

The major reductions in flows over the fall and winter period result in earlier freeze-up times predicted for Trudel Creek, resulting in a slightly shorter growing season. Ice formation may shift in nature from juxtaposition to simple thermal ice cover. Similar changes in ice processes are predicted for both expansion options. Thus, the magnitude of the effect is rated low due to the likely limited extent in which solid ice-up could occur along Trudel Creek, given that there would be a minimum flow maintained through the winter. The overall residual effect is assigned a rating of low (Table 14.7.17).

14.7.8.2.2 Decreased Flow Range

14.7.8.2.2.1 Decreased Habitat Quality and Complexity

The decrease in the flow range would be more pronounced under the 56 MW expansion than the 36 MW expansion, given the increase in power requirements. However, as per the 36 MW expansion, there would still be periods of high and low flow based on an average flow year (Figure 13.3.31). During high flow years, the pre-freshet flow would increase from around 20 m^3/s to over 100 m^3/s. Thus, flows that maintain habitat complexity and nutrient recruitment would occur under the new hydrologic regime. During extreme low flow years, there would likely be no water spilled from the SVS to Trudel Creek, thus no range in flow. These extreme events are rare (once in every 10 to 25 years) and thus are not expected to measurably decrease habitat quality and complexity. In addition, scheduled maintenance of the turbines would ensure Trudel Creek does experience a short-term range in flow if low-flow years occurred consecutively. The magnitude of the effect of decreased flow range on aquatic resource productivity, biodiversity and community structure is rated as low (Table 14.7.17). The overall residual effect is rated as low.

14.7.8.2.3 Altered Hydrograph Parameters

14.7.8.2.3.1 Decreased Habitat Quality and Complexity

This Project pathway focuses on potential changes in productivity, biodiversity and community structure from changes in the duration of freshet and minimum flows, and the rate of change in flow during a scheduled outage event (i.e. maintenance of turbines). As per the 36 MW expansion, the average 56 MW expansion hydrograph shows freshet timing and duration to be similar to baseline. The duration of the minimum flow, though difficult to define, appears to occur earlier in the winter, February versus March, but last until April as per the baseline hydrograph.

However, during extreme low flow years freshet flows would be non-existent (Figure 13.3.30). The data set used to generate the 56 MW option hydrograph included three years of consecutive low flow, which is a rare occurrence based on the long-term data set for the Taltson River watershed. Individually, these low flows are estimated to occur once every 10 to 25 years. Given the life expectancy of the Project, these low flow years would occur during operations, but it is unlikely that these events would occur consecutively. The effect of such low flow events is reduced recruitment of nutrients and reduced habitat complexity. This would affect productivity, biodiversity and potentially change community structure. However, the effects would only last until the next average or high flow year, thus the effect would be short-term. Rapid increases in flow rates resulting from ramping events are expected to have a frequency of occur of roughly every other year (36 MW ramping event). Effects on erosion and deposition of sediment in the littoral zones are rated as low given that these flows have occurred during April/May under baseline conditions and are expected to occur through the normal operating period, see Section 14.4.3.5 for detailed assessment of effects on water quality. The magnitude of the effects on aquatic resources is also predicted to be low. There would be increases in drift and loss of some aquatic life but the event is scheduled to occur during a period of low productivity and would only last for a short duration. The aquatic community is expected to recover to baseline productivity and biodiversity during the following summer.

Considering the extreme events (both high and low) that would occur during the life of the Project the magnitude of altered hydrograph parameters on productivity, biodiversity and community structure is considered low (Table 14.7.17). The duration is short-term given that aquatic resources would either recover from any measurable effects the following year or the effects would be within natural variation. The geographic extent is Trudel Creek. The frequency is periodic and the likelihood is likely. The overall residual effect is rated as low.

Table 14.7.17 — Classification of Residual Effect on Aquatic Resources (Productivity, Biodiversity and Community Structure) in Trudel Creek: 56 MW Option

Pathway	Effect	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Overall Residual Effect
Decreased flows	Loss of suitable Littoral habitat	Adverse	High	Trudel Creek	Short-term	Continuous	Reversible	Likely	Moderate
	Loss of profundal habitat	Adverse	Low	Trudel Creek	Long-term	Continuous	Reversible	Likely	Low
	Decrease habitat quality	Adverse	Low	Trudel Creek	Long-term	Continuous	Reversible	Likely	Low
Decrease flow range	Decrease habitat quality	Adverse	Low	Trudel Creek	Long-term	Continuous	Reversible	Likely	Low
Altered hydrograph parameters	Decrease habitat quality and complexity	Adverse	Low	Trudel Creek	Short-term	Periodic	Reversible	Likely	Low

14.7.8.3 EFFECTS TO LAKE HABITAT — 36 MW OPTION

14.7.8.3.1 Decreased Flows

14.7.8.3.1.1 Loss of Suitable Littoral Habitat

Large decreases in flow are expected along Trudel Creek during operations of the 36 MW expansion. The reduction in flow would result in decreases in water levels. These decreases in water levels would extend through most of the baseline littoral habitat. Littoral areas are extremely important because of their higher productivity. Their high productivity is due to the presence of macrophytes, based on higher light penetration, allowing high rates of photosynthesis by aquatic plants and algae. Dissolved oxygen levels tend to remain higher for more of the year within shallow areas, aiding local productivity levels. Diversity is also generally higher in littoral areas compared to profundal habitat. Therefore, loss of suitable littoral habitat is an important measure of potential effects to lake aquatic resources. Natural variation in lake water levels over summer months was used to gauge the relevance of projected changes in wetted area.

Aquatic field surveys of Trudel Lake indicated that emergent vegetation grew to a depth of 95 cm, and submergent vegetation (true macrophytes) was observed down to 210 cm (CGL 2008a). Table 14.7.10, and Table 14.7.12 to Table 14.7.14, present the expected changes in water levels for Trudel lakes. The absolute maximum decrease in water level, based on a long-term data set and predicted flows and water levels, is 173 cm on Trudel Lake. Based on the working definition of baseline littoral habitat (approximately 2 m below summer water levels), all decreases in water levels would be within the littoral habitat. Thus, some suitable littoral habitat would remain even during the first year of operations under an extreme low flow year.

NIWA (2003) showed that a water level drop of 20 cm to 50 cm in a New Zealand lake would have a minor effect on the reduction in littoral habitat. The small reduction in littoral habitat would likely affect benthic communities, but the effects would be restricted to a small portion of the littoral area, and therefore the overall effect to aquatic communities would be minimal. Aroviita & Hämäläinen (2008) found that for 11 lakes with drawdown ranges between 119 cm and 675 cm annually, macroinvertebrate richness decreased and taxonomic composition varied when compared to an unregulated lake (natural draw down of 55 cm annually). The authors also found a negative relationship of the intensity of regulation (drawdown) and species richness. Notwithstanding, there remains a high level of uncertainty associated with these categories, dependent on slope of lakeshore, types of vegetation present (horsetail vs. taller bulrush species), and physical substrates present (silt and sand vs. bedrock, relating to TSS issues from fluctuating water levels, for example).

Water level decreases were used to calculate the loss in wetted area and the per cent loss of littoral habitat. The loss of littoral habitat during the summer period for an average flow year would be 43% (Gertrude Lake), 64% (Trudel Lake) and 38% (Unnamed Lake). The absolute maximum loss during an extreme low flow year would be 53% (Gertrude), 70% (Trudel) and 44% (Unnamed Lake). These percentages represent high magnitude losses in suitable littoral habitat if operations were to commence during an extreme low flow year. The low flow events used to generate the model results represent 1 in 10 to 1 in 25 year low flow events.

Trudel Lake's shoreline is characterized as steep and rocky with sporadic vegetation distribution (Plate 14.7.4; Cambria Gordon Ltd., 2008b; Rescan 2006). Gertrude Lake is the deepest of the three lakes within Trudel Creek; however, there are areas of thick littoral vegetation in shallow margins of the lake. Unnamed Lake would have the largest absolute loss of area (33 ha, compared to 3 ha and 14 ha in Gertrude and Trudel lakes, respectively), and is considered shallower than the other lakes with a few deep locations (up to 9 m; Cambria Gordon Ltd., 2008b; Rescan 2006). Its shoreline is dominated by steep slopes, but there are some wetland areas. Unnamed Lake's shallow areas are dominated by submergent and emergent vegetation with large woody debris (Plate 14.7.5).

As discussed for river habitat, the loss of a portion of suitable littoral habitat is expected to be temporary, depending on when the new shallow zones developed littoral communities of aquatic plants and invertebrates. The loss of suitable littoral habitat would cause temporary declines in productivity, biodiversity and community structure. The magnitude of this effect on aquatic resources is high. The geographic extent is all Trudel lakes. The duration is short-term and the effect is reversible. The effect would be continuous and likely. The overall residual effect is moderate (Table 14.7.18).

Plate 14.7.4— Trudel Lake Littoral Habitat (Sampled in 2008 for Benthic Invertebrate Communities)

Plate 14.7.5 — Unnamed Lake Littoral Habitat

Table 14.7.18 — Classification of Residual Effect on Aquatic Resources (Productivity, Biodiversity and Community Structure) for Trudel Lakes: 36 MW Option

Pathway	Effect	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Overall Residual Effect
Decreased flows	Loss of suitable littoral habitat	Adverse	High	All Trudel Lakes	Short-term	Continuous	Reversible	Likely	Moderate
	Loss of profundal habitat	Adverse	Low	All Trudel Lakes	Long-term	Continuous	Reversible	Likely	Low
	Decrease habitat quality	Adverse	Low	All Trudel Lakes	Long-term	Continuous	Reversible	Likely	Low
Decrease flow range	Decrease habitat quality	Adverse	Low	All Trudel Lakes	Long-term	Continuous	Reversible	Likely	Low
Altered hydrograph parameters	Decrease habitat quality and complexity	Adverse	Low	All Trudel Lakes	Short-term	Periodic	Reversible	Likely	Low

14.7.8.3.1.2 *Loss of Profundal Habitat*

Table 14.7.12 to Table 14.7.14 present the loss in wetted area of Trudel lakes. This loss directly relates to the loss of profundal habitat. The maximum average monthly per cent loss in wetted area is predicted to be 4% (Gertrude Lake), 11% (Trudel Lake) and 8% (Unnamed Lake). The maximum monthly percent loss in wetted area is based on model results from a long-term consecutive year data set.

A magnitude of the loss in profundal habitat on aquatic resources productivity, biodiversity and community structure is low (Table 14.7.18). The effect extends into all Trudel lakes. The duration is long-term. The effect is continuous but reversible following operations, and the likelihood is likely. The overall residual effect is rated as low as the overall productivity of Trudel is not predicted to change measurably.

14.7.8.3.1.3 *Decrease Habitat Quality (Altered Ice Processes)*

The major reductions in flows over the fall and winter period result in earlier freeze-up times predicted for Trudel Creek and associated lakes resulting in slightly shorter growing season. Ice formation may shift in nature from juxtaposition to simple thermal ice cover. Shallower sections of Trudel lakes may experience higher frequency and duration of solid freeze-up under the 36 MW option. This could affect aquatic resources by damaging seeds, roots, and invertebrates, and this could slightly reduce productivity, habitat quality, and biodiversity. The magnitude of effect is rated low due to the likely limited extent in which solid ice-up could occur within the lakes, given that there would be a minimum flow maintained through the winter. The residual effect is assigned a rating of low (Table 14.7.18).

14.7.8.3.2 Decreased Flow Range

14.7.8.3.2.1 *Decreased Habitat Quality and Complexity*

The range in water levels on Trudel lakes would decrease under 36 MW expansion. Over the course of a year, varying flows assist in providing habitat complexity and maintaining habitat quality through recruitment of nutrients. Loss in habitat complexity could lead to reduced productivity, biodiversity and community structure of aquatic resources.

Table 14.7.15 presents the water level range under the 36 MW expansion. The range would be reduced for this option relative to baseline. However, on average there would still be periods of high and low water levels. Thus, flows that maintain habitat complexity and nutrient recruitment would occur under the new hydrologic regime. During extreme flow years, the range would be further reduced and for some very low flow years (1:10 to 1:25 years), there would be no range in flow. Given the frequency of occurrence of these low flow years, habitat complexity would either be maintained or re-establish during the next average year. In addition, scheduled maintenance of the turbines would ensure Trudel Creek does experience a short-term range in flow if low-flow years occurred consecutively.

The magnitude of the effect of decreased flow range on aquatic resource productivity, biodiversity and community structure is low (Table 14.7.18). The overall residual effect is rated as low.

14.7.8.3.3 Altered Hydrograph Parameters

14.7.8.3.3.1 *Decreased Habitat Quality and Complexity*

This Project pathway focuses on potential changes in productivity, biodiversity and community structure from changes in the duration of freshet flows and minimum flows, and the rate of change in flow during a scheduled outage event (i.e. maintenance of turbines). Changes in these flow parameters would result in changes in lake water levels.

The timing of freshet under the 36 MW option does not differ from baseline, based on average monthly flows generated from 13 years of consecutive flow data; the duration also does not differ from baseline. Based on average flow conditions under the 36 MW option, flows increase slightly in May as freshet begins. June flows are considerably higher than May flows, and July and August flows remain at or close to June levels. Flows begin to taper off in September and continue to decline through the winter. The same pattern is observed in water levels of Trudel lakes (Tables 14.3.9 to 14.3.11).

The changes to the timing and duration of the minimum water levels are presented in Tables 14.3.9 to 14.3.11. On average, the timing and duration of the minimum flow for the 36 MW option would not differ from baseline. However, during low flow years and particularly during consecutive low flow years, the minimum flow of 4 m^3/s could be maintained throughout the year (Figure 13.3.30). Thus, there would be no freshet flow.

The data set used to generate the 36 MW option hydrograph included three years of consecutive low flows. These flow and water level conditions are expected to occur once every 10 to 25 years. Although these individual low flow years are rare, the likelihood of these events occurring consecutively is rarer, though obviously not impossible. Given the life expectancy of the Project, these low flow years would occur during operations. The effect of such low flow events is reduced recruitment of nutrients and reduced habitat complexity. This would affect productivity, biodiversity and potentially change community structure. However, the effects would only last until the next average or high flow year, thus the effect would be short-term.

Ramping events under the 36 MW expansion are presented for the 56 MW expansion, as the 56 MW expansion represents the most severe possible effects from the Project activity.

Considering the extreme events (both high and low) that would occur during the life of the Project the magnitude of altered hydrograph parameters on productivity, biodiversity and community structure is considered low (Table 14.7.18). The duration is short-term given that aquatic resources would either recover from any measurable effects the following year or the effects would be within natural variation. The geographic extent is Trudel Creek. The frequency is periodic and the likelihood is likely. The overall residual effect is rated as low.

14.7.8.4 EFFECTS TO LAKE HABITAT — 56 MW OPTION

14.7.8.4.1 Decreased Flows

14.7.8.4.1.1 Loss of Suitable Littoral Habitat

The 56 MW expansion option would also result in decreased flows and water levels on all three lakes within the Trudel Creek system. Table 14.7.11 to Table 14.7.14 present the expected changes in water levels for Trudel lakes. The absolute maximum decrease in water level, based on a long-term data set and predicted flows and water levels, is 173 cm on Trudel Lake. Based on the working definition of baseline littoral habitat (approximately 2 m below summer water levels), all decreases in water levels would be within the littoral habitat. Thus, some suitable littoral habitat would remain even during the first year of operations under an extreme low flow year.

Water level decreases were used to calculate the loss in wetted area and the percent loss of littoral habitat. The per cent loss of littoral habitat during the summer period for an average flow year would be 56% (Gertrude Lake), 74% (Trudel Lake) and 43% (Unnamed Lake). These percentages represent high-magnitude losses in suitable littoral habitat if operations were to commence during an extreme low flow year. The low flow events used to generate the model results represent 1 in 10 and 1 in 25 year low flow events.

As discussed for river habitat, the loss of a portion of suitable littoral habitat is expected to be temporary, depending on when the new shallow zones developed littoral communities of aquatic plants and invertebrates. The loss of suitable littoral habitat would cause temporary declines in productivity, biodiversity and community structure. The magnitude of this effect on aquatic resources is high. The geographic extent is all Trudel lakes. The duration is short-term and the effect is reversible. The effect would be continuous and likely. The overall residual effect is moderate (Table 14.7.19).

14.7.8.4.1.2 Loss of Profundal Habitat

Table 14.7.12 to Table 14.7.14 present the loss in wetted area of Trudel lakes. This loss directly relates to the long-term loss of profundal habitat. The maximum average monthly per cent loss in wetted area is predicted to be 4% (Gertrude Lake), 12% (Trudel Lake) and 9% (Unnamed Lake). The maximum monthly per cent loss in wetted area is based on model results from a long-term consecutive year data set.

A magnitude of the loss in profundal habitat on aquatic resources productivity, biodiversity and community structure is low (Table 14.7.19). The effect extends into all Trudel lakes. The duration is long-term. The effect is continuous but reversible at the end of operations, and the likelihood is likely. The overall residual effect is rated as low as the overall productivity of Trudel Creek would not be measurably affected.

14.7.8.4.1.3 Decrease Habitat Quality (Altered Ice Processes)

As discussed for the 36 MW option, the major reductions in flows over the fall and winter period result in earlier freeze-up times predicted for Trudel Creek and associated lakes resulting in slightly shorter growing season. The magnitude of effects is rated low due to the likely limited extent in which solid ice-up could occur within the lakes, given that there would be a minimum flow maintained through the winter. The residual effect is assigned a rating of low (Table 14.7.19).

14.7.8.4.2 Decreased Flow Range

14.7.8.4.2.1 Decreased Habitat Quality and Complexity

The range in water levels on Trudel lakes would decrease under the 56 MW expansion option. Table 14.7.15 presents the water level range under the 56 MW expansion, which would be reduced for this option. However, on average there would still be periods of high and low water levels. Thus, flows that maintain habitat complexity and nutrient recruitment would occur under the new hydrologic regime. During extreme flow years, the range would be further reduced and for some very low flow years (1:10 to 1:25 years), there would be no range in flow. Given the frequency of occurrence of these low flow years, habitat complexity would either be maintained or re-establish during the next average year. In addition, scheduled maintenance of the turbines would ensure Trudel Creek does experience a short-term range in flow if low-flow years occurred consecutively.

The magnitude of the effect of decreased flow range on aquatic resource productivity, biodiversity and community structure is low (Table 14.7.19). The overall residual effect is rated as low.

14.7.8.4.3 Altered Hydrograph Parameters

14.7.8.4.3.1 Decreased Habitat Quality and Complexity

This Project pathway focuses on potential changes in productivity, biodiversity and community structure from changes in the duration of freshet flows and minimum flows, and the rate of change in flow during a scheduled outage event (i.e. maintenance of turbines). Changes in these flow parameters would result in changes in lake water levels.

As per changes outlined under the 36 MW option, the timing of freshet under the 56 MW option does not differ from baseline, based on average monthly water levels (Table 14.3.9 to 14.3.11). The changes to the timing and duration of the minimum water levels are presented in Tables 14.3.9 to 14.3.11. On average, the timing and duration of the minimum flow for the 56 MW option would not differ from baseline. However, during low flow years and particularly during consecutive low flow years the minimum flow of 4 m^3/s could be maintained throughout the year (Figure 13.3.30). Thus, there would be no freshet flow. The data set used to generate the 56 MW option hydrograph included three years of consecutive low flows. These flow and water level conditions are expected to occur once every 10 to 25 years. Although these individual low flow years are rare, the likelihood of these events occurring consecutively is rarer, though obviously not impossible. Given the life expectancy of the Project, these low flow years would occur during operations. The effect of such low flow events is reduced recruitment of nutrients and reduced habitat complexity. This would affect productivity, biodiversity and potentially change community structure. However, the effects would only last until the next average or high flow year, thus the effect would be short-term.

Considering the extreme events (both high and low) that would occur during the life of the Project the magnitude of altered hydrograph parameters on productivity, biodiversity and community structure is considered low (Table 14.7.17). The duration is short-term given that aquatic resources would either recover from any measurable effects the following year or the effects would be within natural variation. The geographic extent is Trudel Creek. The frequency is periodic and the likelihood is likely. The overall residual effect is rated as low.

Table 14.7.19 — Classification of Residual Effect on Aquatic Resources (Productivity, Biodiversity and Community Structure) for Trudel Lakes: 56 MW Option

Pathway	Effect	Direction	Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Likelihood	Overall Residual Effect
Decreased flows	Loss of suitable littoral habitat	Adverse	High	All Trudel Lakes	Short-term	Continuous	Reversible	Likely	Moderate
	Loss of profundal habitat	Adverse	Low	All Trudel Lakes	Long-term	Continuous	Reversible	Likely	Low
	Decrease habitat quality	Adverse	Low	All Trudel Lakes	Long-term	Continuous	Reversible	Likely	Low
Decrease flow range	Decrease habitat quality	Adverse	Low	All Trudel Lakes	Long-term	Continuous	Reversible	Likely	Low
Altered hydrograph parameters	Decrease habitat quality and complexity	Adverse	Low	All Trudel Lakes	Short-term	Periodic	Reversible	Likely	Low

14.7.9 Cumulative Effects

No mining or forestry projects situated within the Taltson Watershed have overlap with the Trudel Creek study area. Additional hydroelectric projects have not been registered in the area. As there are no reasonably foreseeable projects identified in the study area, no other projects would provide cumulative effects to the Expansion Project since there is no spatial overlap. Should any projects move towards development in the study area, these could potentially cause cumulative effects to the proposed Expansion Project.

Existing developments include a hydroelectric facility in the Tazin River system. The regulated flows of the Tazin River into Taltson River have been considered in the current Taltson hydrologic model used for all assessments in this document. There are no additional potential cumulative effects from the Tazin River facility.

Initial development of the Twin Gorges project facility resulted in greatly increased flows within Trudel Creek. This is assumed to have had major adverse effects on the aquatic biological communities within Trudel Creek, based on these hydrologic changes supported by aerial photographs of habitat. There are no data on primary and secondary producer communities from this period. However, such a major change from low flow creek habitat to higher water levels would have inundated emergent vegetation and farther covered submergent vegetation, reducing productivity and potentially altering community structure and biodiversity of plant communities and associated invertebrate life. Pre-development photographs indicate meandering stream channels winding through wetland areas in sections of Reach 3 of Trudel Creek. Lake littoral zones would also have been inundated in Unnamed, Gertrude and Trudel lakes. Existing biological communities are most likely stabilized from this initial anthropogenic stress, which occurred 43 years ago. It is estimated that recolonization and redevelopment of stable aquatic communities was related to development of both littoral and riparian wetland communities. Both of these types of communities are important to aquatic biota. Littoral habitat development depends on the availability of seed banks, colonizing invertebrates, suitable water quality and sediment conditions, and appropriate habitat (sufficiently shallow to allow photosynthesis by emergent and submergent vegetation). Riparian wetland communities likely have developed within Trudel Creek based on the new hydrologic regime, but could be different from pre-development wetland habitat as watercourse structure and volume has changed significantly.

On a local scale only, the proposed expansion options present incremental adverse residual effects including reduced productivity, altered habitat extent and quality, reduced biodiversity and altered community structure (at least until a mature littoral zone developed, which is assumed to be in approximately three years following expansion). These arise from several pathways including decreases in flow, decreases in flow range and altered hydrograph parameters. Residual cumulative effects from initial hydroelectric project development includes changes in habitat structure, loss of primary and secondary productivity during inundations from large rises of water levels, reduced biodiversity, and mortality of existing aquatic communities. There exists a high degree of uncertainty as to how the biological communities have changed in terms of density and diversity of primary and secondary producers, from pristine times to post-initial development (e.g. 1969) to baseline periods, and exactly how future periods would compare. In any case, the proposed development presents further change to the Trudel Creek aquatic resources which have likely stabilized since the initial development, and which would be expected to restabilize in 10 to 20 years following proposed expansion of Twin Gorges (based on rates of vegetative succession in emergent communities). However, the sustainability of aquatic resources is predicted to remain so following the Expansion Project.

14.7.10 Uncertainty

The assessment of Trudel Creek was conducted using modelled hydrologic data to provide a quantitative assessment of potential changes based on physical changes to the aquatic environment regarding water flows and depths. There is much less uncertainty for the Trudel Creek KLOI for aquatic resources than for Taltson River. This is a result of the more detailed baseline hydrology studies conducted in Trudel Creek, providing more accurate measures of the river cross-sections and flows at a much smaller scale than those conducted along the Taltson River.

However, there were still data gaps and assumptions required to complete this assessment. The following factors contributed to uncertainty in the effects assessment:

- Assumption that new littoral habitat of equivalent quantity and quality would develop in river and lake habitat after a few growing seasons. Field observations and aerial data provide indications this is a realistic assumption. Tied to the development of littoral areas is the assumption that secondary communities would also develop with similar structure and function compared to existing communities. This also is a reasonable assumption. It is fairly certain that at least a basic secondary community would develop, and also likely this community could be similar to existing ones, provided sufficient littoral habitat and conditions are provided.
- Limited knowledge of aquatic primary producer community diversity and productivity at the 18 hydrology stations and the three lakes; data from one year of surveys at a small number of creek and lake sites. It was assumed that all others would be intermediary of these sites.
- Assumption that bathymetry between 19 cross-sections of 35 km of Trudel Creek were representative of the entire section of river, which is unlikely but provided a rough approximation in order to try to quantify losses of benthic habitat.

14.7.11 Monitoring

Monitoring of aquatic resources in Trudel Creek is recommended prior to construction and at regular intervals during the life of the Project. Any monitoring should be done ensuring consistent and transferable data so that comparisons can be made to conditions before, during, and after the Expansion Project.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

APPENDICES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.8 FISHERIES RESOURCES

14.8.1 Existing Environment

Information used to establish the existing fish and fish habitat conditions in Trudel Creek were obtained from various sources, including field study programs, literature reviews and local knowledge of the area. A select list of the detailed study programs include:

- Taltson Expansion Project: Trudel Creek Fish and Fish Habitat Assessment. Rescan Environmental Services Ltd. (November 2006);
- Trudel Creek: Spring Low Flow Fisheries Assessment Data Report. Rescan Environmental Services Ltd. (May 2007);
- Trudel Creek August 2007 Fish and Fish Habitat Data Report – Draft. Cambria Gordon Ltd. (August 2007);
- Final Report on Northern Pike Spawning and Rearing Habitat in Trudel Creek. Rescan Environmental Services Ltd. (May 2008);
- Littoral Habitat Assessment of Nonacho Lake, Lady Gray Lake and Trudel Creek. Cambria Gordon Ltd. (July 2008);
- Trudel Creek Photomosaic and Photo Catalogue. Cambria Gordon Ltd. (May 2007); and
- Flow and River Sectional Measurements and Bathymetry. Rescan Environmental Services (2006 and 2007).

The Trudel Creek Fish and Fish Habitat Assessment (Rescan, 2006b) was designed to characterize fish community composition and relative abundance in Trudel Creek, characterize existing fish habitat quality, collect water quality and map the bathymetry of the Trudel Creek system (including Unnamed Lake, Gertrude Lake and Trudel Lake). Sampling efforts were not specific to certain species and/or life-stages and the results of the study were used to compile a fish inventory for the entire Trudel system with comparisons to the lower Taltson River.

The Trudel Creek Spring Low Flow Fisheries Assessment (Rescan, 2007b) focused specifically on the identification of spawning and rearing areas of northern pike and lake whitefish, determination of the usage of those areas for spawning and rearing activities, and collecting water quality data. Sampling efforts for this program targeted juvenile species in areas that potentially support their preferred habitat requirements.

The Trudel Creek August 2007 Fish and Fish Habitat Data Report (Cambria Gordon Ltd, 2007b) was a follow-up program to the May 2007 assessment. The main objective was to identify spawning and rearing habitats of northern pike and lake whitefish, quantify the usage of those habitats during the summer season, and collect water quality data.

The Final Report on Northern Pike Spawning and Rearing Habitat in Trudel Creek (Rescan 2008) involved a statistical analysis to determine if northern pike are currently using the identified spawning and rearing areas and to quantify early spring habitat in Trudel Creek.

The littoral habitat assessment (Cambria Gordon Ltd., 2008) was designed to establish fish use of stream margins and shoreline habitats, determine the growth zones of submergent/emergent vegetation communities, identify the in-stream aquatic vegetation species present, and to characterize the substrate conditions.

To assist in locating and evaluating northern pike and lake whitefish spawning and rearing habitats, 1:14,000 and 1:2,000 vertical aerial photographs were collected on May 25, 2007 (Cambria Gordon Ltd. 2007). In addition, aerial oblique photographs were taken along the main channel of Trudel Creek and the entire shoreline of each of the three lake systems. These aerial photos provide an excellent overview of the Trudel system and allow for habitat typing and identification, locating fish obstacles and barriers, qualifying habitat modeling results, marking active erosion sites, and for making comparisons.

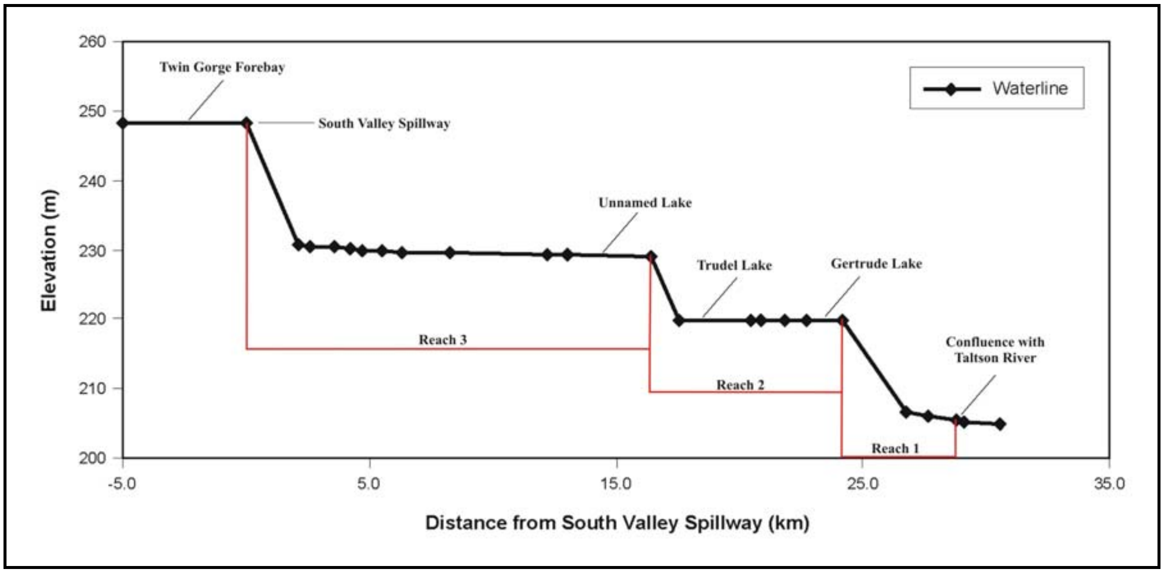
Flow and river section measurements and bathymetry were collected in October 2006 and July 2007 to verify the hydrological model results and to determine water level elevations at various flows (Rescan 2006a, 2007). The HEC-RAS flow model was run using a range of flows from near zero to flood flow conditions.

14.8.1.1 TRUDEL CREEK FISH HABITAT

For the purpose of evaluating fish habitat, the Trudel Creek system was broken into three distinct reaches. Reach breaks were established at three bedrock controls, which are velocity and/or elevation obstructions. These bedrock controls likely prevent upstream fish migration at all flows and for every species life-stage that is currently found in the Trudel system. Figure 14.8.1 illustrates the longitudinal profile of Trudel Creek. The three reach breaks are summarized below and are illustrated in Figure 14.8.2 through to Figure 14.8.8.

1. Reach 1 extends upstream from the confluence of Trudel Creek and the Taltson River to the downstream end of Gertrude Lake where a series of cascades, rapids and chutes likely prevents fish access from lower Trudel Creek into Gertrude Lake.
2. Reach 2 extends from the downstream end of Gertrude Lake to the upstream end of Trudel Lake where two high and narrow chutes likely prevent fish access from Trudel Lake upstream into Un-named Lake.
3. Reach 3 extends from the upstream end of Trudel Lake to the South Valley Spillway where numerous rapids immediately downstream of the SVS likely prevent fish access from Trudel Creek to the base of the SVS. The SVS is a barrier to upstream movement into Twin Gorges Forebay.

Figure 14.8.1 — Longitudinal Profile of Trudel Creek with Reach Breaks

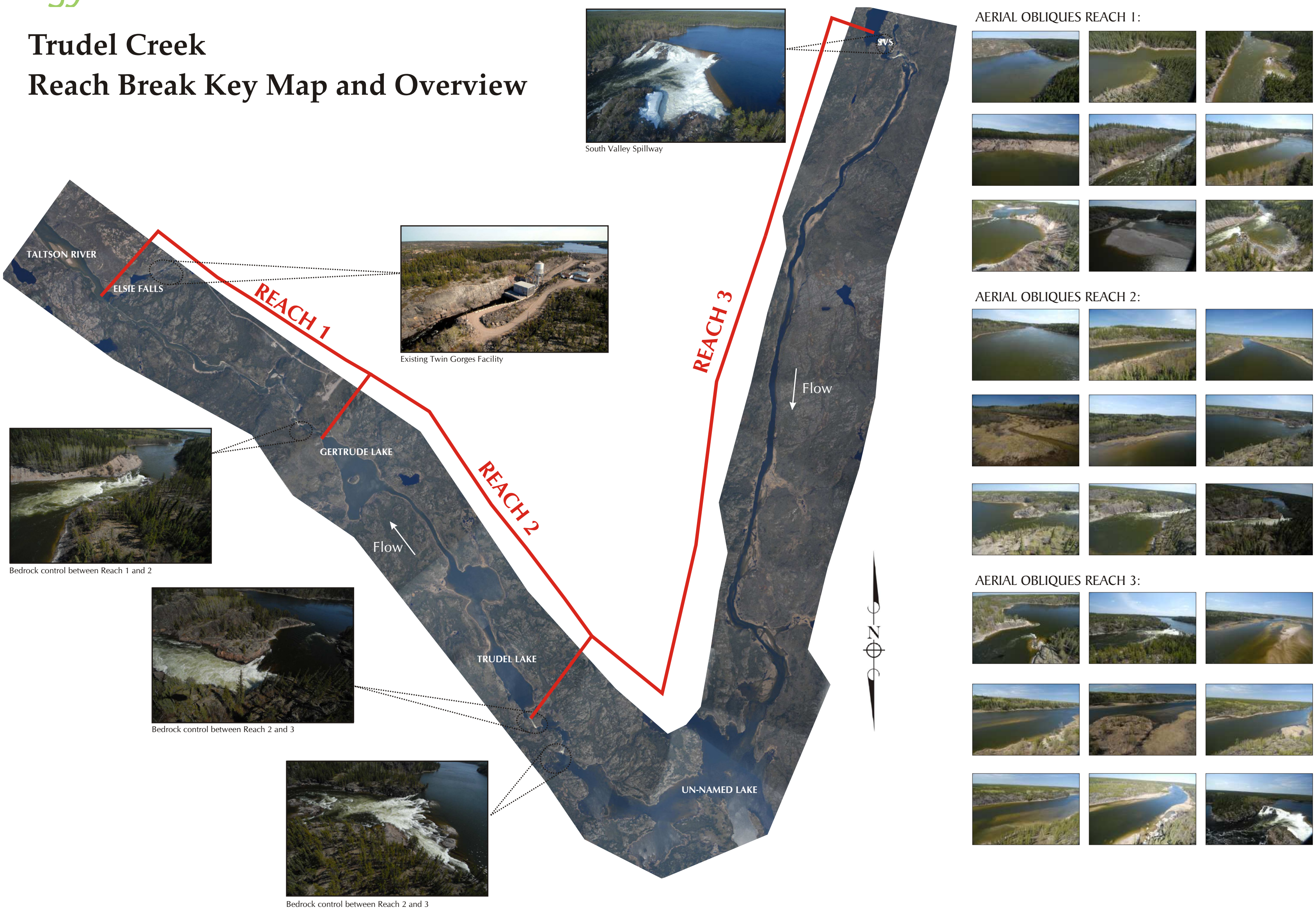


14.8.1.1.1 Reach 1 – Taltson River to Gertrude Lake

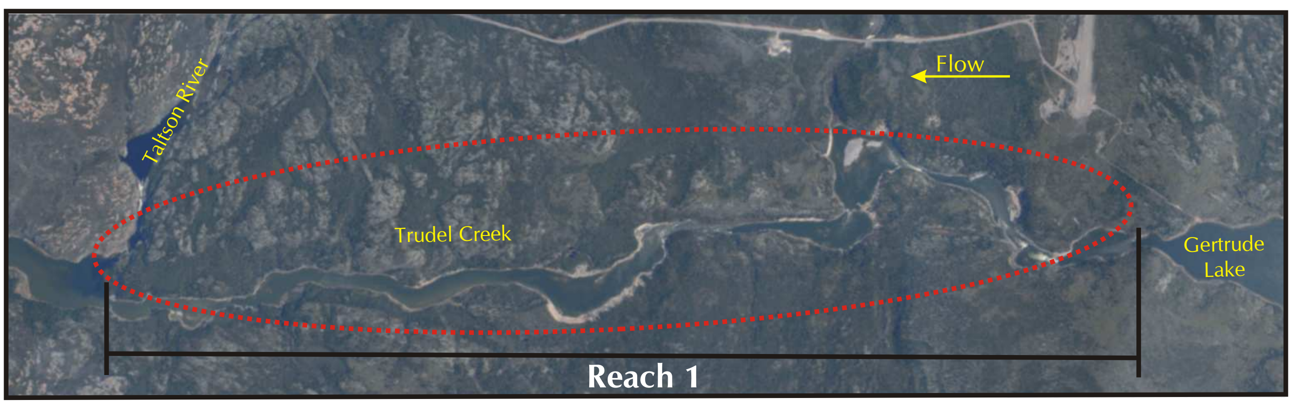
Reach 1 extends approximately 5,100 m upstream from the confluence of Trudel Creek and the Taltson River to the downstream end of Gertrude Lake (Figure 14.8.3). Bankfull widths in Reach 1 vary from 60 m to 180 m with an average water depth of approximately 3.5 m. The gradient in Reach 1 is steeper than either Reach 2 or Reach 3 with a 0.3% grade (Figure 14.8.3), and contains few sections of slower velocity habitats where submergent vegetation can successfully establish.

Reach 1 is dominated by high, eroding cut-banks and bedrock outcroppings. Substrate in this reach is dominated by sand and mud along with a few bars consisting of cobble and boulder substrate. Cover is provided intermittently by aquatic vegetation that grows adjacent to the shoreline in areas where the banks are lower, as well as boulders and large woody debris that has been carried into Trudel Creek by slope failures. Rapids and riffle habitat with cobble and boulder substrate is present in the upstream portion of this reach.

Trudel Creek
Reach Break Key Map and Overview



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report** **2009**	**Trudel Creek Reach Break Key Map** **and Overview**	**Figure** **14.8.2**



Reach 1 extends from the confluence of Trudel Creek and the Taltson River, upstream to the outlet of Gertrude Lake. High sandy and eroding cutbanks and bedrock outcroppings are the dominant habitat type in this area. The substrate is generally composed of sand, mud, cobbles and boulders.

TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Reach 1** **Trudel Creek**	**Figure 14.8.3**

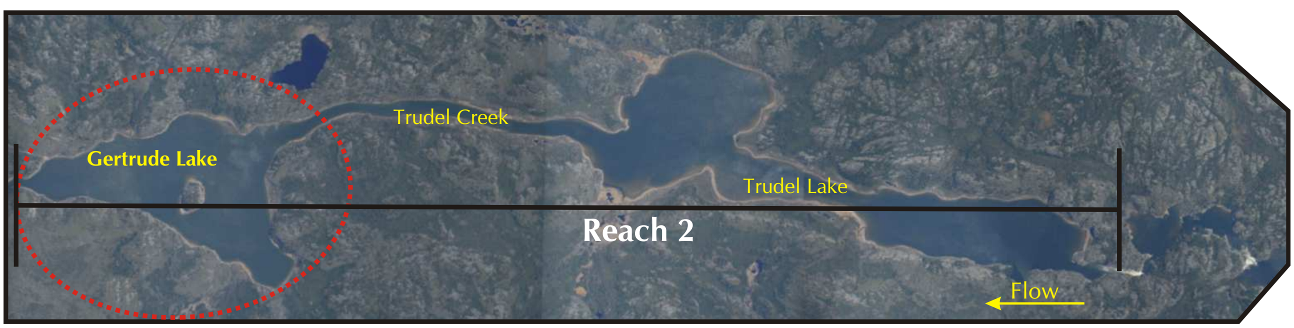
14.8.1.1.2 Reach 2 – Gertrude Lake to Trudel Lake

Reach 2 extends approximately 8,000 m from the outlet of Gertrude Lake (85 ha) to the upstream end of Trudel Lake (107 ha). Lake surface areas were based on maximum mean monthly flows. Reach 2 is predominately defined by lacustrine (lake) habitat with one small (approximately 2,000 m) riverine section connecting Gertrude Lake to Trudel Lake. The gradient associated with Reach 2 is flat at 0.0% (Figure 14.8.1) and due to the presence of the two lake systems, water velocities are slow-moving.

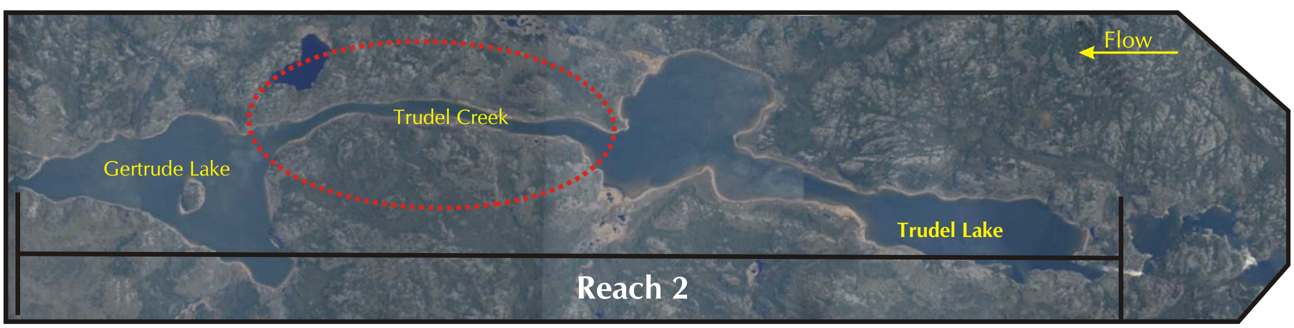
Gertrude Lake is located at the downstream end of Reach 2 (Figure 14.8.4). The shoreline is dominated by shallow benches and sheltered areas that support dense submergent vegetation. Substrate in these benched areas is generally sand and silts. Some rocky exposed shorelines also occur, but to a lesser extent. Near the outlet of the lake, the shoreline is characterized by course gravel and cobble substrate. The average depth of Gertrude Lake is 5.5 m; however, pockets within the lake reach depths of 11.5 m. The dissolved oxygen and temperature profiles collected for Gertrude Lake show no signs of stratification, due to the relatively shallow depths of the lake and the continuous flows from Trudel Creek.

Gertrude Lake is connected to Trudel Lake via a confined riverine section of Trudel Creek (Figure 14.8.5). The shoreline of this riverine section is characterized by a narrow strip of aquatic vegetation along both sides of the river. The shoreline adjacent to the narrow strip of aquatic vegetation drops off steeply, resulting in less in-stream vegetation than other riverine areas. The substrate along this riverine section of Reach 2 is predominantly clays and silts.

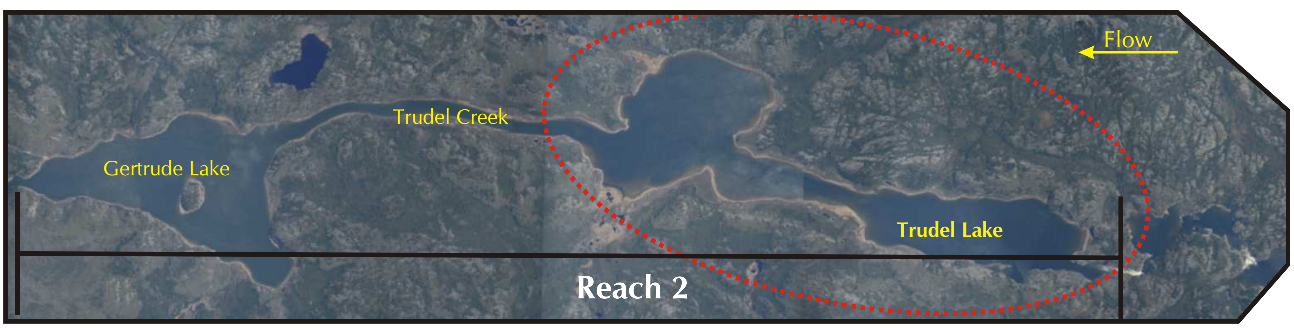
Trudel Lake is dominated by rocky exposed shorelines, usually with a steep slope and sporadically-distributed vegetation; the sections of the shoreline that are protected from winds, current, and wave actions contain dense submergent and emergent vegetation (Figure 14.8.6). The substrate in areas where vegetation has established generally consists of fine materials, such as sands and silts. The average depth of Trudel Lake is 3.8 m; however, small pockets within the lake reach depths of 11 m. As with Gertrude Lake, the dissolved oxygen and temperature profiles show no signs of stratification or mixing.



Gertrude Lake is within Reach 2, which extends from the downstream end of Gertrude Lake to the upstream end of Trudel Lake. The shoreline along Gertrude Lake is dominated by shallow benches and sheltered areas which support dense vegetation. The substrate is generally sand and mud.



Gertrude Lake is connected to Trudel Lake by a confined riverine section of Trudel Creek. The shoreline of this riverine section is characterized by a narrow strip of aquatic vegetation along both sides of the river. The substrate along this riverine section of Reach 2 is predominantly clays and silts.



Trudel Lake is within Reach 2, which extends from the downstream end of Gertrude Lake to the upstream end of Trudel Lake. The shoreline of Trudel Lake is made up of rocky exposed shorelines, usually with a steeper slope and sporadically distributed vegetation. There are also shallow sections of shoreline containing submergent and emergent vegetation.

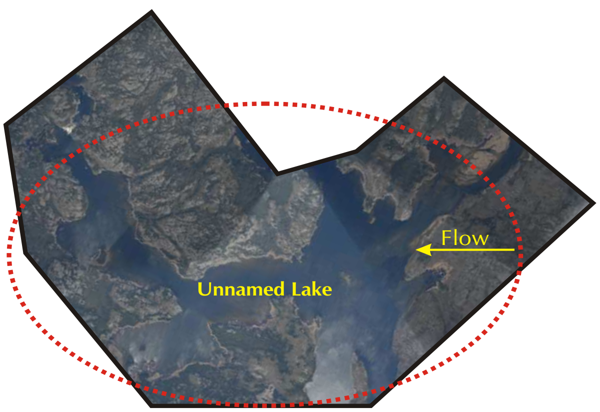
TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Reach 2 Trudel Lake**	**Figure 14.8.6**

14.8.1.1.3 Reach 3 - Trudel Creek to South Valley Spillway

Reach 3 extends approximately 18,000 m from the upstream end of Trudel Lake to the South Valley Spillway (SVS) located at the Twin Gorges Forebay. Reach 3 is defined by prominent sections of both riverine and lacustrine habitats consisting of shallow mud shelves with dense in-stream vegetation, relatively deep side channels and shallow sand bars and benches. The gradient of Reach 3 is relatively flat with a grade of 0.1% with a steeper grade section immediately downstream of the SVS (Figure 14.8.1).

Unnamed Lake (440 ha) contains some back channels and areas of stagnant water with submergent and emergent vegetation and large woody debris (Figure 14.8.7). The majority of the shoreline around Unnamed Lake is rocky and exposed, usually with a steep slope and sporadically-distributed boulders and vegetation. The average depth of Unnamed Lake is 3.0 m with small pockets reaching a depth of 9.0 m. The dissolved oxygen and temperature profiles collected for Unnamed Lake show no signs of stratification or mixing likely due to the shallow depths.

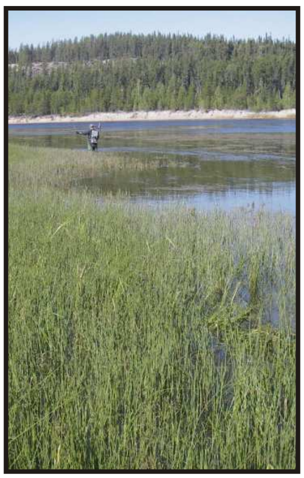
The riverine section of Reach 3 contains a variety of habitats, such as shallow sand bars created from sediment deposition, side bay habitats with dense submergent/emergent vegetation, and sections with steeply sloped stream margins associated with bedrock cliffs (Figure 14.8.8). The average bankfull width of the riverine section ranges from 130 m to 230 m with an average water depth of 4 m.



Reach 3 - Unnamed Lake

Unnamed Lake is within Reach 3 on Trudel Creek which extends from the downstream end of Unnamed Lake to the SVS. The shoreline around Unnamed Lake is variable and is composed of: rocky and exposed areas with a steeper slope, areas of emergent vegetation with a sandy substrate and large woody debri, as well as backchannels and stagnant water.

TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Reach 3 Unnamed Lake**	**Figure 14.8.7**



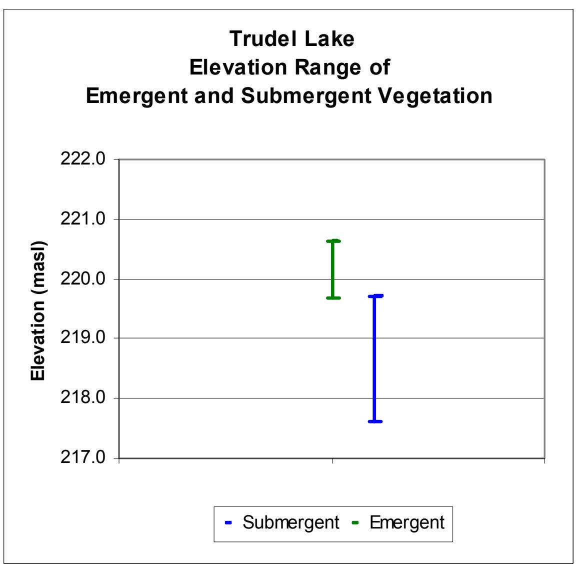
TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Reach 3 Trudel Creek**	**Figure 14.8.8**

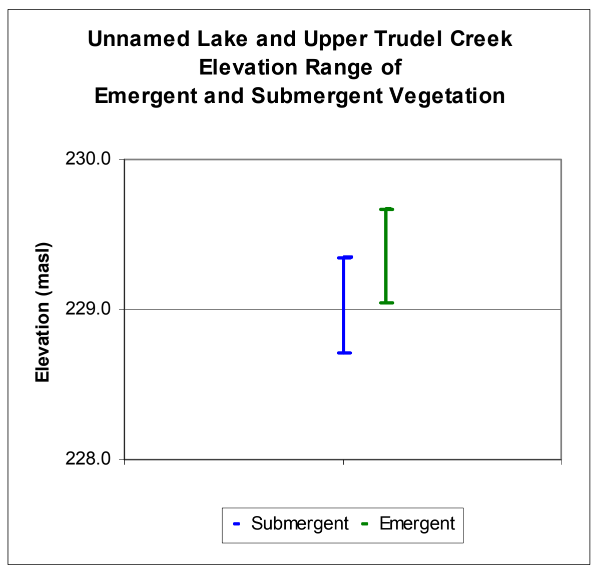
14.8.1.2 TRUDEL CREEK SUBMERGENT AND EMERGENT VEGETATION COMMUNITIES

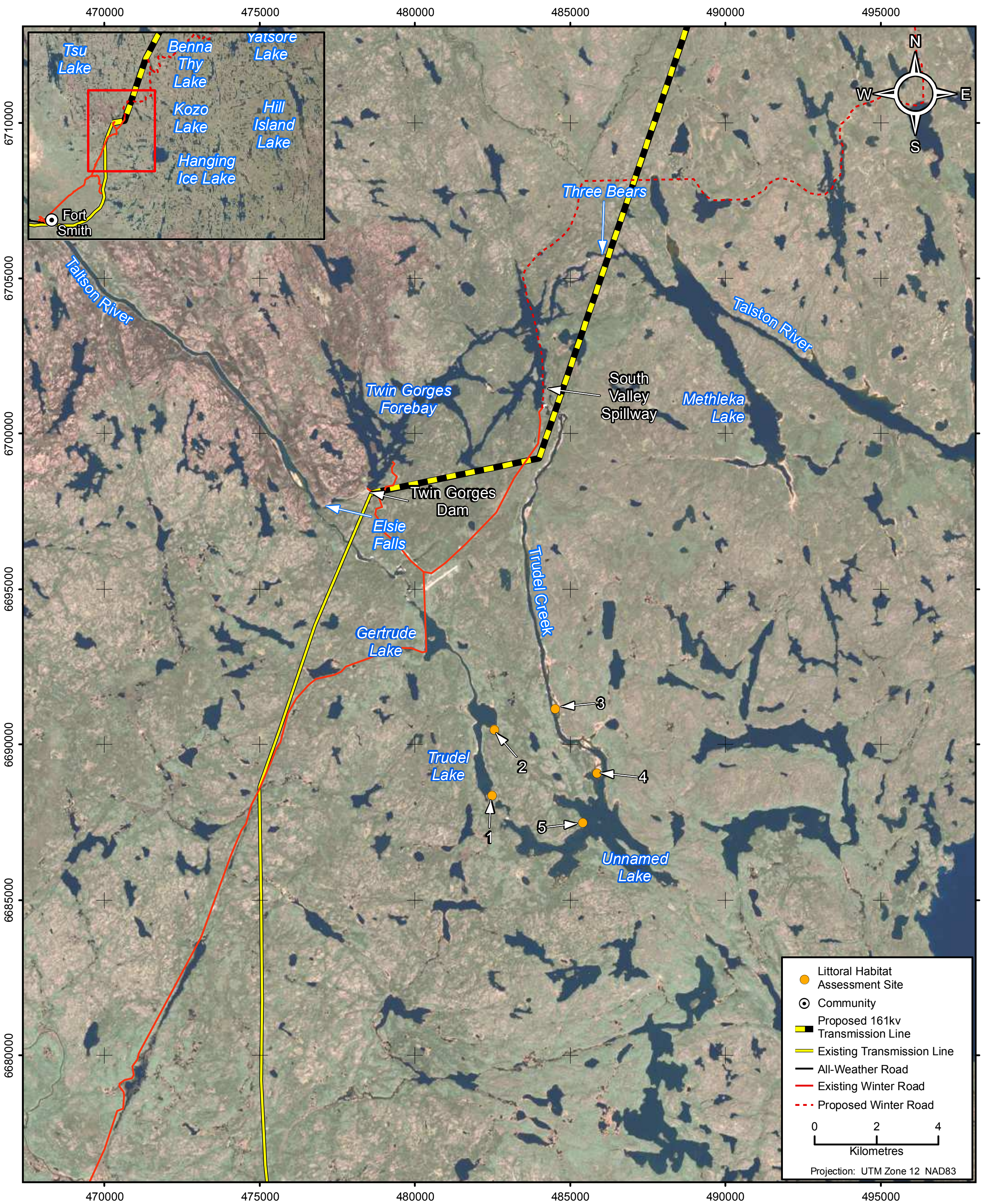
An elevation gradient exists along Trudel Creek; therefore, the elevation of the aquatic vegetation also varies between the upper and lower areas of Trudel Creek. Transect measurements indicate that the emergent plant community in the upper reach of Trudel Creek and Unnamed Lake was present within a total elevation range of 229.67 masl to 229.04 masl (Figure 14.8.9). The emergent plant community in Trudel Lake was present within a total elevation range of 220.63 masl to 219.68 masl (Figure 14.8.9). Transect locations are illustrated in Figure 14.8.10. The emergent vegetation communities appeared to be fairly consistent throughout the Trudel Creek system and mainly comprise of beaked sedge (*Carex utriculata*), common mare's tale (*Hippuris vulgaris*) and horsetails (*Equisetum* spp.).

Transect measurements indicate that the submergent plant community in the upper reach of Trudel Creek and Unnamed Lake was present within a total elevation range of 229.67 masl to 229.04 masl (Figure 14.8.9); however, the submergent plant community in Unnamed Lake continues to depths greater than those noted on these transects. It appears that vegetation grows continuously across the shallow bay areas of the lake at depths exceeding 2 m. The submergent plant community in Trudel Lake was present within a total elevation range of 219.71 masl to 217.61 masl (Figure 14.8.9). The submergent vegetation community is also fairly consistent throughout the Trudel Creek system is mainly comprised of Pondweed (*Potamogeton* spp.).

Figure 14.8.9 — Submergent and Emergent Vegetation Community Elevation Ranges in the Trudel Creek System





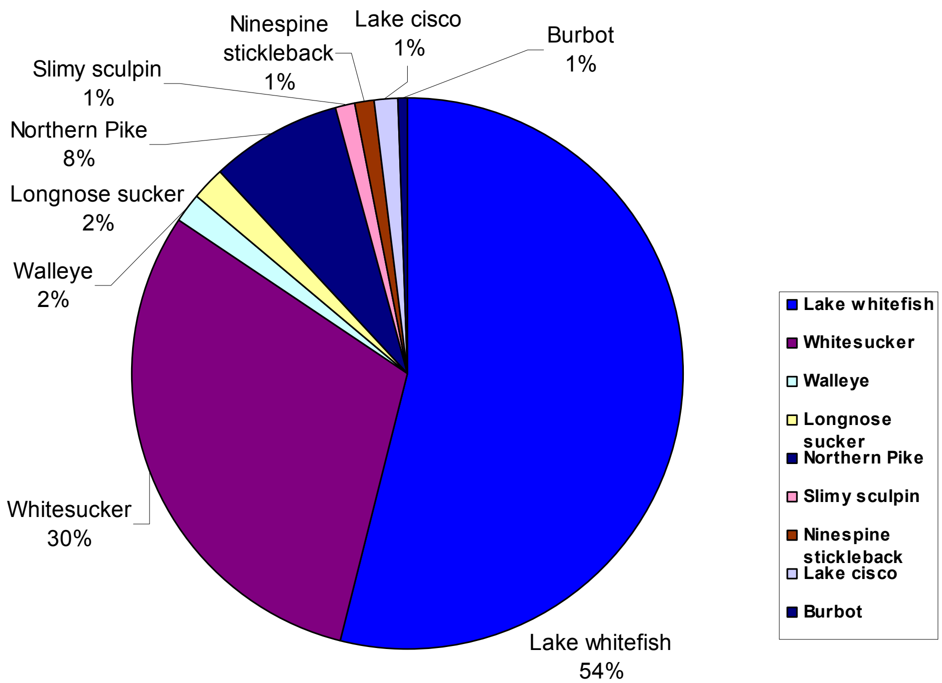


TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Trudel Creek** **Littoral Habitat Assessment Sites**	**Figure 14.8.10**

14.8.1.3 TRUDEL CREEK FISH COMMUNITIES

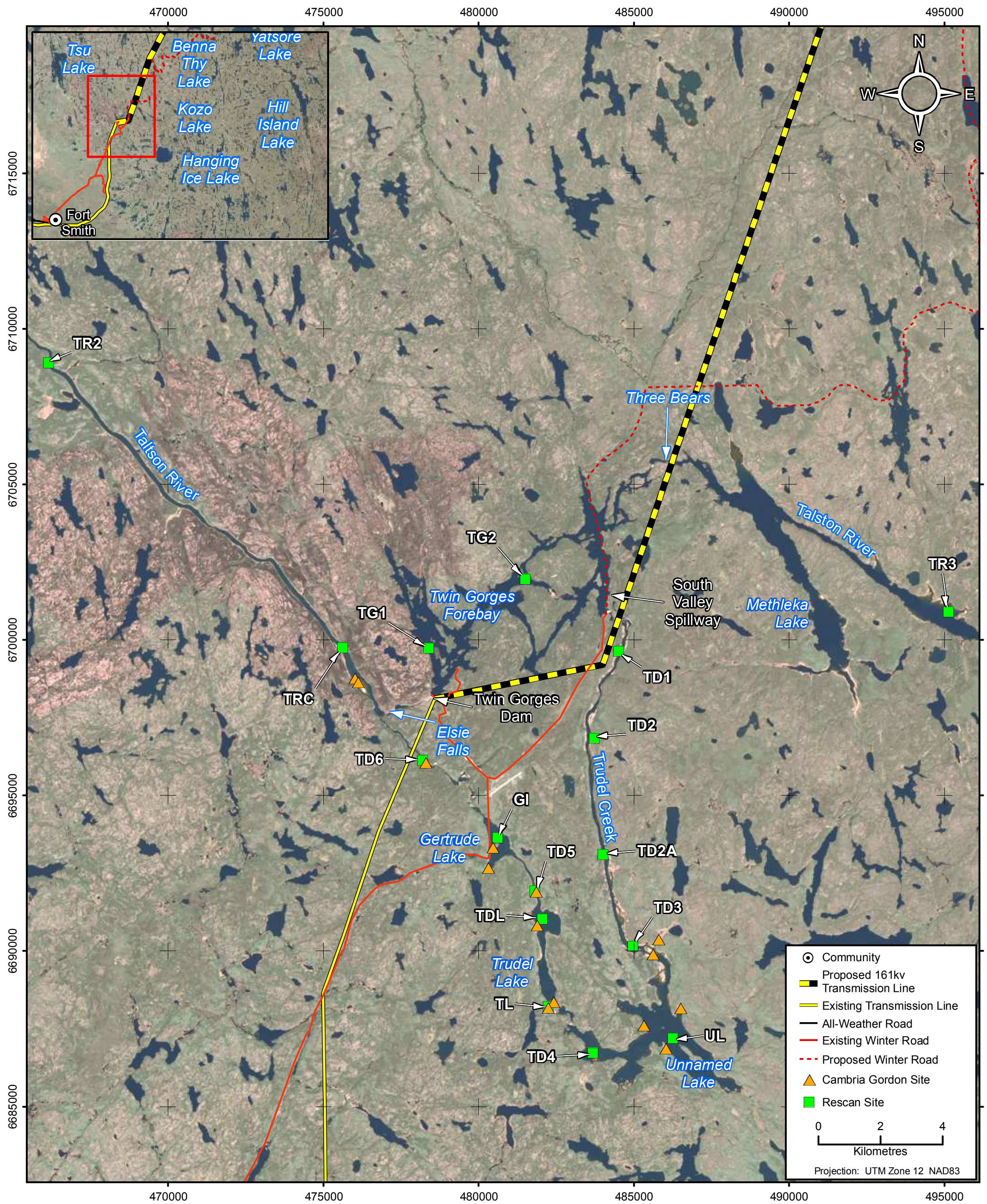
Fish sampling in Trudel Creek was completed by Rescan Environment Services Ltd. in 2006 and 2007 and by Cambria Gordon Ltd. in 2007. A total of nine fish species have been identified in Trudel Creek including: lake whitefish, white sucker, walleye, longnose sucker, northern pike, slimy sculpin, ninespine stickleback, lake cisco and burbot. There was a degree of uncertainty with regard to the identification of the lake cisco. The results of these sampling efforts have been compiled and are illustrated in Figure 14.8.11.

Figure 14.8.11 — Compiled Fish Sampling Results from Zone 5



Based on the sampling results, lake whitefish is the most abundant species followed by white sucker, northern pike, slimy sculpin, walleye, longnose sucker and ninespine stickleback. Fish sampling locations are shown in Figure 14.8.11 as follows.

A description of the life history characteristics of the 9 fish species identified in Trudel Creek is provided in Section 9.5 – Biological Environment.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Fish Sampling Locations in Trudel Creek	Figure 14.8.12

14.8.2 Valued Components

14.8.2.1 Valued Component Selection

Valued Components were selected based on the comments received by government and community agencies during the MVLWB and MVEIRB screening and scoping sessions, and known fish and fish habitat conditions within Trudel Creek and their sensitivity to changes in habitat. The identified Valued Components and the rationale for their selection are:

- northern pike
- lake whitefish
- walleye

Northern pike was selected as a Valued Component as it has specific habitat requirements along vegetated stream margins and/or shorelines that overlap with the other known species within Trudel. In addition, northern pike is a high-level predator and typically requires an ecologically productive habitat for foraging.

Lake whitefish has been included as a Valued Component due to its relative abundance in Trudel Creek and its importance to regional user groups. Also, lake whitefish is predominately a deep-water species, thereby complementing the preferred habitat conditions of northern pike (a shallow-water species).

Walleye was selected as a Valued Component due to its ranking of "Sensitive" by the Government of the Northwest Territories and its different habitat preferences than northern pike and lake whitefish for spawning.

The diversity of preferred habitat conditions and life history characteristics of northern pike, lake whitefish and walleye is considered to cover the interests of the fish and fish habitat conditions within the Trudel Creek system.

14.8.2.2 Assessment Endpoints and Pathways

The Department of Fisheries and Oceans Canada (DFO) has developed Risk Assessment Framework and created Pathways of Effects (POE) for common in-stream and land-based activities. These POEs describe "cause and effect relationships" that are known to exist, and the mechanisms by which stressors ultimately lead to effects in the aquatic environment. Each cause-and-effect relationship is represented as a line, known as a pathway, connecting the activity to a potential stressor, and a stressor to some ultimate effect on fish and fish habitat, known as an assessment endpoint. For each pathway, mitigation measures can be applied to reduce or eliminate a potential effect.

To date, DFO has identified 19 POE, of which 2 have direct interactions with the Valued Components and the proposed Project components relating to Trudel Creek. The identified POEs include Flow Management (Altered Frequency, Amplitude, Duration, Timing and Rate of Change of Flow) and Fish Passage Issues as summarized in Figure 14.8.13 and Figure 14.8.14 respectively. These pathways lead to 16 direct assessment endpoints.

Figure 14.8.13 — Flow Management Pathway of Effect Flow Diagram (Source: Clarke et. al. 2008)

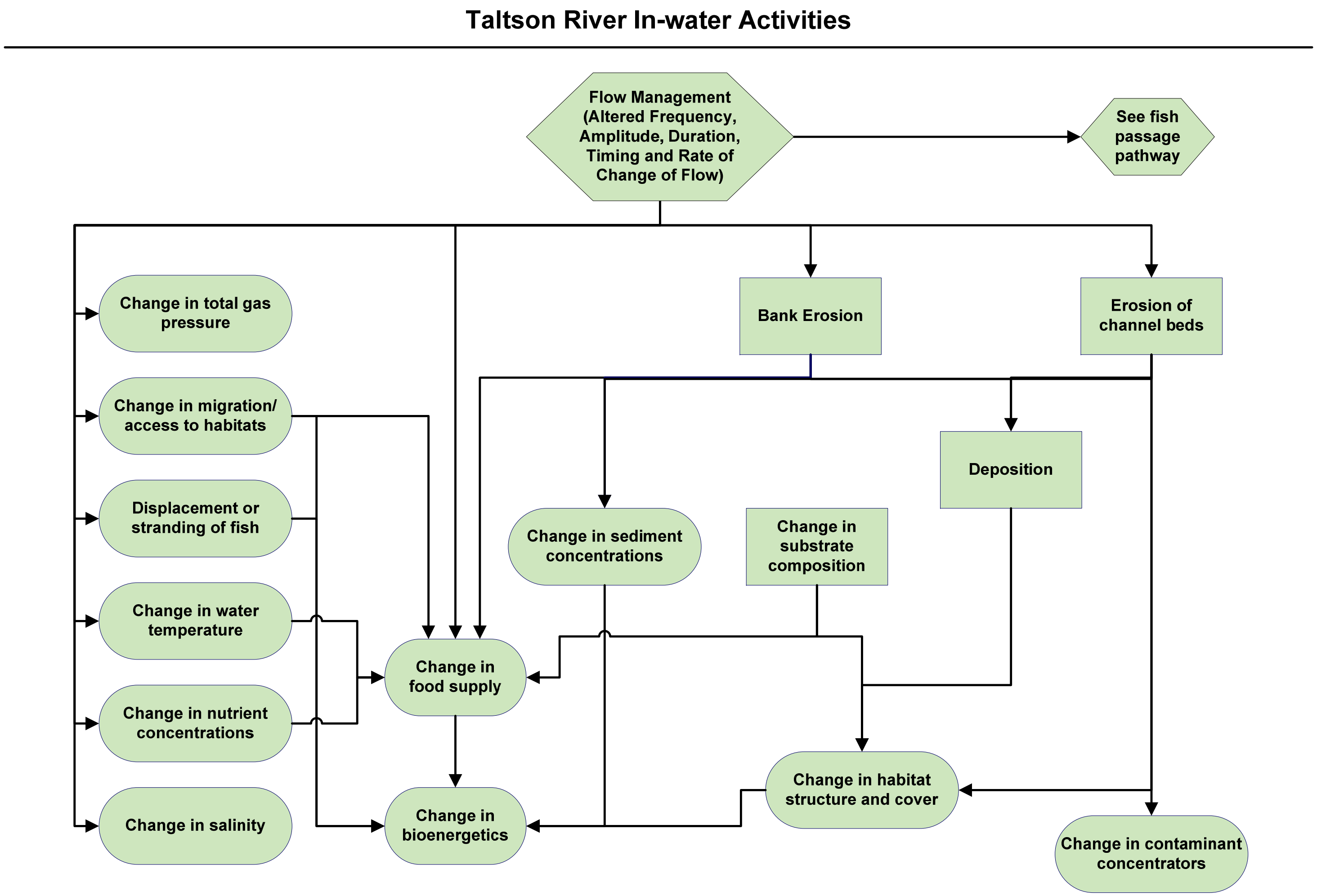
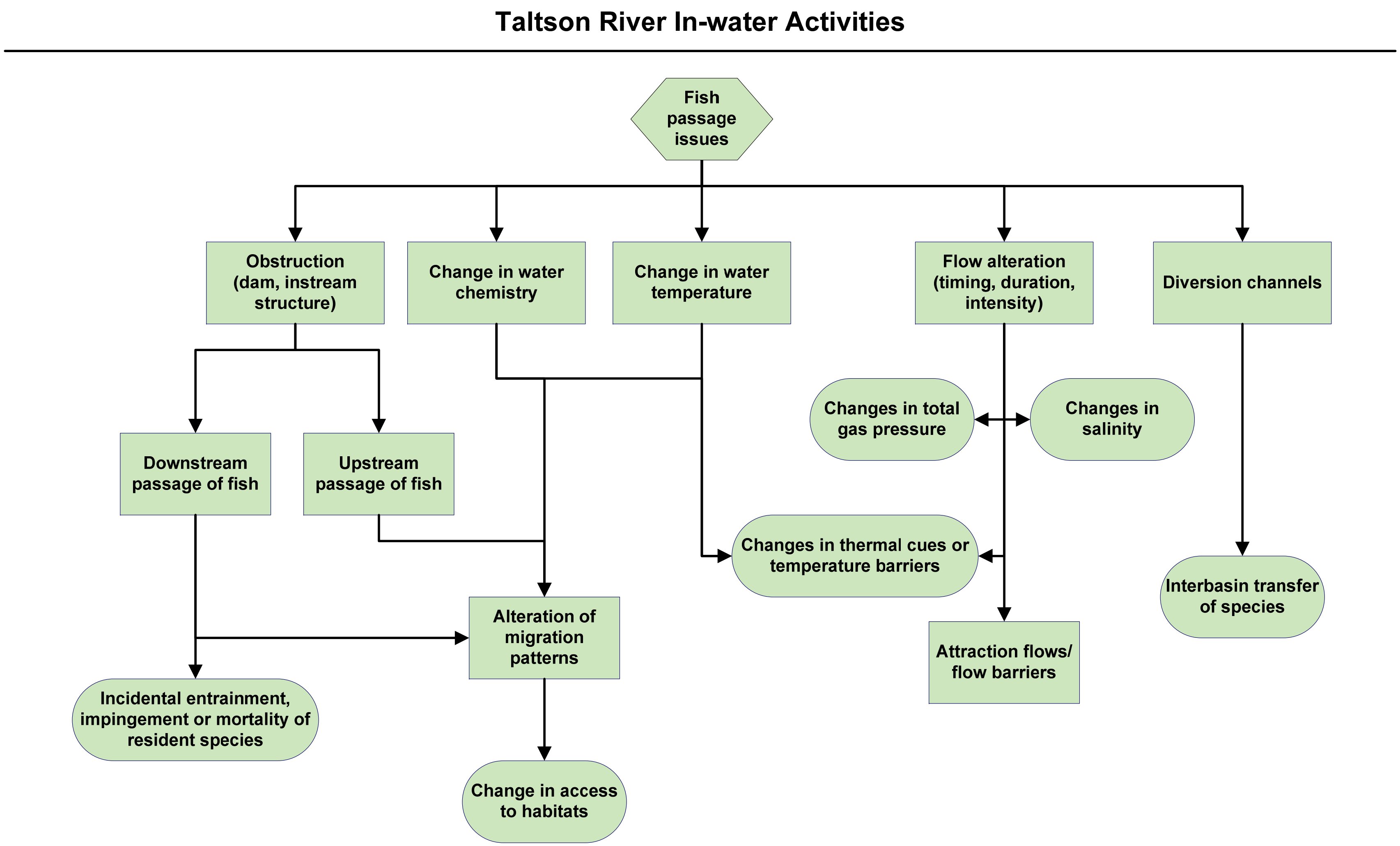


Figure 14.8.14 — Fish Passage Issues Pathway of Effect Flow Diagram (Source: DFO)



A complete review of the available DFO Risk Assessment Framework, pathways and assessment endpoints are available on the DFO web page: http://www.dfo-mpo.gc.ca/oceans-habitat/habitat/modernizing-moderniser/pathways-sequences/water-aquatique_e.asp. In addition to the available information on the DFO web page, Clarke et al. (2008), at the request of DFO, conducted an extensive review of the Flow Management pathway and assessment endpoints, which were used in this assessment. Table 14.8.1 summarizes the assessment endpoints, and the pathways leading to those endpoints, for the Valued Components of northern pike, lake whitefish and walleye.

Table 14.8.1 — Valued Components, Assessment Endpoints and Pathways Identified for Trudel Creek

Valued Component	Assessment Endpoint	Pathways
Northern pike Lake whitefish Walleye	Changes in water temperature	Flow management with respect to water temperature
	Changes in dissolved oxygen	Flow management: alteration of depth conditions with respect to dissolved oxygen Flow management: alteration of flow conditions with respect to dissolved oxygen
	Changes in food supply	Flow management: bank erosion / erosion of channel bed with respect to food supply
	Changes in nutrient concentration	Flow management: alteration of flow conditions with respect to nutrient concentration
	Changes in sediment concentration	Flow management: bank erosion / erosion of channel beds with respect to Sediment concentration
	Changes in contaminant concentration	Flow management: erosion of channel beds with respect to contaminant concentration Flow management: flooding with respect to contaminant concentration
	Changes in thermal cues or temperature barriers	Fish passage issues: change in water chemistry with respect to thermal cues
	Inter-basin transfer of fish species	Fish passage issues: diversion channels with respect to inter-basin fish migration
	Changes in habitat access / migration: overwintering	Fish passage issues: alteration of migration Patterns with respect to overwintering habitat access / migration
	Changes in habitat access / migration: spawning, rearing and food	Fish passage issues: alteration of migration Patterns with respect to Spawning and Rearing habitat and Food access / migration
	Changes in habitat Structure and Cover: spawning, rearing, overwintering	Flow management: bank erosion / erosion of channel beds with respect to fish habitat structure and cover Flow management: alteration in depth, cover, velocity and substrate conditions with respect to fish habitat structure and cover
	Changes in total gas pressure	Flow management with respect to total gas pressure

Valued Component	Assessment Endpoint	Pathways
	Change in salinity	Flow management with respect to change in salinity
	Changes in depositional zones and quantities	Flow management: bank erosion / erosion of channel beds with respect to deposition zones
	Displacement or stranding of fish	Flow management: increase flows with respect to ramping events

14.8.3 Spatial and Temporal Boundaries

The analysis of identified pathways between Project components and the aquatic components within the Trudel Creek system (Table 14.8.1) was conducted on a local, regional and beyond regional study area. The local area included the in-stream habitats from high water mark to high water mark, ranging from the SVS down Trudel Creek to the confluence with the Taltson River. The regional study area encompassed the in-stream habitats of Trudel Creek extending downstream to the confluence of the Taltson River with Tsu Lake. The beyond regional study area includes the Taltson River watershed from Nonacho Lake to Tsu Lake, including those habitats associated with Zone 2 and Trudel Creek.

As no in-stream construction activities are required within Trudel Creek, temporal boundaries are related directly to the operational phase of the Project. Currently, the Project is expected to be in operation for 20 years to service the existing and proposed diamond mines; however, the Project infrastructure would have a lifespan of 40 years, and it is the intent of Dezé to solicit new customers to extend the Project beyond 20 years. The alteration of flows within Trudel Creek would occur throughout the lifespan of the Project. Therefore, the temporal boundaries of the potential effects on Trudel Creek have been assumed to be 40 years.

The spatial and temporal boundaries as described above apply to all the identified pathways for the Valued Components of northern pike, lake whitefish and walleye in the Trudel Creek system.

14.8.4 Project Components

The potential effects anticipated within the Trudel Creek system are associated with the alteration of the existing hydrograph. Of the identified Project components, the operation of the power-generating facilities, including the flow release at the Nonacho control structure and/or flow through the generating facilities, is the only component that would result in flow alterations within Trudel Creek.

14.8.5 Pathway Analysis

14.8.5.1 Pathway Validation

The implications of the anticipated changes to the Trudel Creek hydrograph were considered for each pathway identified in Table 14.8.1. This consideration takes into account the mitigation measures as described in Section 14.1 – Trudel Creek Introduction. It is not anticipated that any of the proposed mitigation measures (mitigation practices or mitigation designs) would eliminate the potential effects associated with any of the identified pathways; however, the effects associated with many of the pathways would be reduced.

The validation process was conducted using similar rationale as described in the DFO POEs and on the revised POE for Flow Management as presented in Clarke et al. (2008). This process involves linking the effects of flow alterations to the specific life history traits (survival, growth and reproductive potential) of the Valued Components (northern pike, lake whitefish and walleye). Therefore, a pathway was considered Valid if the effect could result in a change to an assessment endpoint. Minor pathways recognize there may be a change to an assessment endpoint; however, the resulting effect is anticipated to be negligible. A pathway classified as Invalid is a pathway associated with typical Project components that have been identified by DFO; however is not applicable, or has no effect, for that specific Project component.

The results of the pathway validation assessment are summarized in Table 14.8.2. Rationale for the classification of pathways as Valid, Minor or Invalid is provided in Sections 14.8.5.1.1, 14.8.5.1.2 and 14.8.5.1.3, respectively.

Table 14.8.2 — Pathway Validation Table for Northern Pike, Lake Whitefish and Walleye

Valued Component	Pathway	Pathway Validation
Northern pike Lake whitefish Walleye	Flow management: bank erosion / erosion of channel beds with respect to fish habitat structure and cover	Minor
	Flow management: alteration in depth, cover, velocity and substrate conditions with respect to fish habitat structure and cover	Valid
	Flow management with respect to total gas pressure	Invalid
	Flow management with respect to water temperature	Minor
	Flow management: alteration of depth conditions with respect to dissolved oxygen	Invalid
	Flow management: alteration of Flow conditions with respect to dissolved oxygen	Minor
	Flow management: alteration of Flow conditions with respect to nutrient concentration	Minor
	Flow management with respect to change in salinity	Invalid
	Flow management: bank erosion / erosion of channel bed with respect to food supply	Minor
	Flow management: erosion of channel beds with respect to contaminant concentration	Minor
	Flow management: flooding with respect to contaminant concentration	Invalid
	Flow management: bank erosion / erosion of channel beds with respect to sediment concentration	Minor
	Flow management: bank erosion / erosion of channel beds with respect to deposition zones	Valid
	Flow management: Increase flows with respect to ramping events	Valid

Valued Component	Pathway	Pathway Validation
	Fish passage issues: alteration of migration patterns with respect to spawning and rearing habitat and food supply access / migration	Valid
	Fish passage issues: change in water chemistry with respect to thermal cues	Invalid
	Fish passage issues: alteration of migration patterns with respect to overwintering habitat access / migration	Invalid
	Fish passage issues: diversion channels with respect to inter-basin fish migration	Minor

In total, 18 pathways have been identified between the Project component "Operation of the Power Generating Facility" and the aquatic components of Trudel Creek. Of the 18 identified pathways, 4 were Valid pathways to an assessment endpoint, 8 were Minor pathways to an assessment endpoint, and 6 were Invalid pathways.

14.8.5.1.1 Valid Pathways

14.8.5.1.1.1 Flow Management: Alteration in Depth, Cover, Velocity and Substrate Conditions with Respect to Fish Habitat Structure and Cover

Fish habitat structure and cover is predominately a measure of four parameters: depth, velocity, cover and substrate. Hydrology modelling (refer to Section 14.3 – Alteration of Water Quantity) indicates that the proposed reduction of flow would result in a considerable decrease to the depth and velocity conditions currently experienced within Trudel Creek. In addition, the anticipated decrease in depth would result in a relocated stream margin and/or shoreline, which could alter the baseline substrate and cover conditions utilized by the Valued Components. Therefore, the reduction in flow could considerably change the depth, velocity, substrate and cover conditions within the Trudel Creek system, thereby altering the preferred habitat condition of northern pike, lake whitefish and walleye. As such, the pathway has been classified as Valid.

14.8.5.1.1.2 Fish Passage Issues: Alteration of Migration Patterns with Respect to Spawning and Rearing Habitat and Food Supply Access / Migration

An alteration in water depth, flow and/or substrate size can cause a disruption in access to fish habitats essential for the various life processes within a given fish population.

The off-channel habitats are primarily vegetated ponds that have potential to support northern pike spawning and rearing. As the off-channel habitats do not support the preferred spawning conditions for walleye, and juvenile walleye utilize habitats adjacent to their spawning grounds prior to moving to deeper waters in mid-summer, it has been assumed that juvenile rearing walleye would not utilize the off-channel habitats. Based on the lack of depth in these habitats, lake whitefish would not utilize the off-channel habitats to support any stage of their life history.

Aquatic invertebrate and other food sources are known to be productive in these habitat types (refer to Section 14.7 – Aquatic Resources). Therefore, an alteration to the flow conditions and subsequently depth could result in a considerable alteration to northern pike access to rearing habitats and food supplies. As such, the pathway has been classified as Valid for northern pike. Lake whitefish and walleye access to rearing habitats and food supplies would not be altered. As such, the pathway has been considered Invalid for lake whitefish and walleye.

14.8.5.1.1.3 *Flow Management: Bank Erosion / Erosion of Channel Beds with Respect to Deposition Zones*

The dislodgement, transport and deposition of sediment can collect in a water body and (through infilling) affect physical processes, structural attributes and ecological conditions such as the availability of spawning/rearing habitats. A study of baseline erosion characteristics within the Trudel Creek system by Klohn Crippen Berger (2008) indicated that the erosion rate would be considerably less during operation of the Expansion Project facility, thereby decreasing sediment and bed loads and baseline deposition rates. Therefore, the reduction in flows over the SVS could considerably alter the baseline dislodgement, transport and deposition of sediment within the Trudel Creek system. As such, the pathway has been classified as Valid.

14.8.5.1.1.4 *Flow Management: Increase in Flows with Respect to Scheduled Ramping Events*

Flow ramping events would be part of normal operating conditions for both the 36 and 56 MW options. Section 14.3.3 provides details of the changes in flows and water levels along Trudel Creek during a ramping event from a scheduled power outage. Scheduled outages for turbine maintenance are currently planned annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion; 20 m^3/s versus 50 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the exiting 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (50 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 and 56 MW expansion would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with a slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events.

Therefore, the increase in flows over the SVS could be considerable, which has the potential to effect fish and fish habitat within Trudel Creek. As such, the pathway has been classified as Valid.

14.8.5.1.2 Minor Pathways

14.8.5.1.2.1 *Flow Management: Bank Erosion / Erosion of Channel Beds with Respect to Fish Habitat Structure and Cover*

The addition of in-stream organics and the deposition of eroded soil can affect the capacity of a watercourse to maintain a diverse community of aquatic organisms by restricting habitat connectivity and the opportunities for organisms to use, colonize, and move between existing aquatic environments. Klohn Crippen Berger (2008) indicates that the flow regime for Trudel Creek during operations of the Expansion Project would result in a significantly reduced erosion rate compared to the baseline erosion rate, since peak monthly and peak daily flows would be reduced between 60 and 80% (refer to Section 14.3 – Alteration of Water Quantity).

Northern pike primarily utilize slow moving vegetated areas in protected side-channel or back-eddy habitats that undergo limited erosion under baseline conditions. Lake whitefish are known to utilize deep water habitats that undergo limited, if any, erosion under baseline conditions. Walleye utilize both slow moving vegetated areas in protected side-channel or back eddies and deep-water habitats, each of which undergo limited erosion under baseline conditions. Therefore, a decrease to the baseline erosion rate and subsequently deposition would result in no or negligible changes to the preferred habitat structure and cover conditions of northern pike, lake whitefish and walleye. As such, the pathway has been classified as Minor.

14.8.5.1.2.2 *Flow Management: Alteration of Flow Conditions with Respect to Dissolved Oxygen Levels*

Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms. Dissolved oxygen levels within a water body can be affected by a number of parameters, namely water temperature, biological activity and turbulence.

In 2007, a series of temperature data loggers were installed in Trudel Creek to collect water temperature readings every six hours. These data indicate that under baseline conditions water temperatures range from 0 °C in winter to approximately 21 °C in summer. The reduction in flows over the SVS and subsequent reduction in depth and velocity conditions may increase the water temperatures between 2 °C and 3 °C (refer to Section 14.4 – Alteration of Water Quality).

Biological activity within a water body typically increases when depth and velocity conditions decrease and water temperatures increase, potentially leading to eutrophication. The increase in biological activity in Trudel Creek would be partly mitigated through a proposed minimum flow of 4 m^3/s. In addition, freshet flows that exceed production needs would be spilled over the SVS and into Trudel Creek. The proposed minimum flow, and possible freshet flows, would reduce the potential for the majority of habitats within Trudel Creek to become stagnant and would allow for continual mixing within both riverine and lacustrine areas. Section 14.4 – Alteration of Water Quality indicates that the potential for eutrophication in Trudel Creek is low.

A model was prepared to determine the potential changes to dissolved oxygen concentrations throughout the winter months and under the ice conditions for each of the lake systems in Trudel Creek (refer to Section 14.4 – Alteration of Water Quality). Interpretation of the model results suggests that with the proposed minimum flow, dissolved oxygen levels within the Trudel Creek lake systems would remain above the CCME guidelines for the protection of aquatic life.

Therefore, the alteration of flow conditions would likely result in a decrease of dissolved oxygen concentrations; however, the anticipated changes would be negligible to the health of northern pike, lake whitefish and walleye in Trudel Creek. As such, the pathway has been classified as Minor.

14.8.5.1.2.3 *Flow Management: Alteration of Flow Conditions with Respect to Nutrient Concentration*

An increase in the nitrifying elements such as nitrogen and phosphorus can lead to eutrophication, thick growth of aquatic plants (primarily algae) that block light needed for vegetation growth. When the additional plant matter and algae dies, decomposition of the organic material can increase the biological oxygen demand in the water body and decrease the overall dissolved oxygen levels. Clarke et al. (2008) states that longitudinal, lateral and vertical pathways of nutrient transport can be affected in three ways:

- interruption of the upstream to downstream transport of nutrients,
- disconnection between the river channel and the river edge, and
- disconnection between the riparian zone and floodplains.

As the Project would not require additional damming or flow diversions, there would be no change to the longitudinal pathway of nutrient transport in Trudel Creek (transport of nutrients from the SVS to the confluence with the Taltson River). Lateral pathways refer to nutrient exchange between the near-shore zone of Trudel Creek and riparian zone of the floodplain. Due to the decreased flows and the flattening effect of the Project on the Trudel Creek hydrograph, lateral pathways of nutrient exchange would still occur, albeit to a lesser degree. In addition, there would be a temporal effect to the lateral pathways of nutrient exchange during the vegetation re-colonization period along the shifted stream margin. Vertical pathways of nutrient exchange refer to the interactions between groundwater aquifers and carbon cycling in running waters. As there would be no alteration to baseline groundwater conditions, there are no anticipated effects to the vertical pathways or the existing carbon cycle. Therefore, the alteration of flow conditions would result in no or negligible changes to the nutrient concentration in the Trudel Creek system. As such, the pathway has been classified as Minor.

14.8.5.1.2.4 *Flow Management: Bank Erosion / Erosion of Channel Beds with Respect to Food Supply*

The aquatic food supply must be plentiful and diverse to sustain the productivity of a water body. Clarke et al (2008) indicate that natural scouring events actually lengthen the functionally important food chains by promoting the natural succession of species and positively affecting predator-prey interactions. Furthermore, the absence of bed-scouring floods could result in shorter food chains and reduced food supplies for fish.

Klohn Crippen Berger (2008) indicates that the flow regime for Trudel Creek during operations of the Expansion Project would result in a significantly reduced erosion rate compared to the baseline erosion rate, since peak monthly and peak daily flows would be reduced between 60% and 80%. This would lead to a decrease in bank and channel-bed erosion.

Northern pike rearing and feeding typically occurs in shallow slow moving vegetated areas that are not currently undergoing erosion, whereas lake whitefish and walleye utilize deep-water habitats. These areas under baseline conditions are not actively eroding. Therefore, a decrease in the rate of bank/channel-bed erosion would result in no or negligible changes to the food supply of northern pike, lake whitefish and walleye. As such, the pathway has been classified as Minor.

14.8.5.1.2.5 Flow Management: Bank Erosion / Erosion of Channel Beds with Respect to Sediment Concentration

An increased erosion of banks and channel beds could result in an excess of fragmented organic and inorganic material within the water column, which could damage fish gills and affect water quality and light penetration. Klohn Crippen Berger (2008) indicates that the flow regime for Trudel Creek during operations of the Expansion Project would result in a significantly reduced erosion rate compared to the baseline erosion rate, since peak monthly and peak daily flows would be reduced between 60% and 80%.

Turbidity testing has been conducted over three field programs throughout the Trudel Creek system and under various flow scenarios. Results of this analysis indicate that turbidity (NTU) levels within Trudel are low (<10NTU) and well within the CCME guidelines for the Protection of Aquatic Life. Therefore, a decrease in bank/channel-bed erosion would result in no or negligible changes to sediment concentrations. As such, the pathway has been classified as Minor.

14.8.5.1.2.6 Flow Management with Respect to Water Temperature

Water temperature directly affects many physical, biological and chemical characteristics of a water body. Water temperatures within the Trudel Creek system were measured with a series of temperature data loggers. The data indicates that under baseline conditions water temperatures range from 0 °C in winter to approximately 21 °C in summer. The reduction in flows over the SVS and subsequent reduction in depth and velocity conditions may increase the water temperatures between 2 °C and 3 °C (refer to Section 14.4 – Alteration of Water Quality). This increase in water temperature would have negligible changes to the biological, physical and chemical characteristics of processes occurring in Trudel Creek. As such, the pathway has been classified as Minor.

14.8.5.1.2.7 Flow Management: Erosion of Channel Beds with Respect to Contaminant Concentration

An increase in the concentration of toxins and pollutants in sediments and waters can breach the range of chemical parameters that support healthy aquatic communities, thereby seriously affecting fish and fish habitat. Klohn Crippen Berger (2008) indicates that the flow regime for Trudel Creek during operations of the Expansion Project would result in a significantly reduced erosion rate compared to the baseline erosion rate, since peak monthly and peak daily flows would be reduced between 60% and 80%.

The decreased erosion rate of channel beds would reduce the potential for settled contaminants from becoming re-suspended into the water column. A suite of testing for trace and heavy metals was completed in 2007 and 2008. Trace and heavy metal concentrations were within the CCME guidelines for the Protection of Aquatic Life.

Therefore, decreasing channel bed erosion would result in no or negligible changes to contaminant concentrations. As such, the pathway has been classified as Minor.

14.8.5.1.2.8 Fish Passage Issues: Diversion Channels with Respect to Inter-Basin Fish Migration

The diversion of water from one water body to another can promote the insurgence of invasive species or other non-native organic species. Under baseline conditions, fish species are capable of migrating from the upper Taltson River (Twin Gorges Forebay) and into Trudel Creek over the SVS or through two side channels adjacent to the SVS. During low flow periods (4 m^3/s), fish migration over the SVS and through the side channels would be lost as these systems would become dewatered. Fish movement over the SVS and down the two side channels is anticipated to be low under baseline conditions and is likely accidental as opposed to purposeful migration to desired habitats. Therefore, the alteration of flows would result in an alteration of inter-basin fish migration during low flow events. As such, the pathway has been classified as Minor.

14.8.5.1.3 Invalid Pathways

14.8.5.1.3.1 Fish Passage Issues: Alteration of Migration Patterns with Respect to Habitat Access / Migration to Overwintering Habitat

An alteration to water depth, flow and/or substrate size can cause a disruption in access to fish habitats essential for various life processes within a given fish population.

Assuming an ice thickness of 1.5 m (as requested by DFO) in all areas where thermal ice is known to accumulate (refer to Section 14.5 — Alteration of Ice Structure), at no location is it anticipated that ice would freeze to the ground and result in an impediment to fish migration. In addition, northern pike, lake whitefish and walleye all overwinter at depths where they conserve energy by limiting movement and migratory activities. Therefore, an alteration of flows would not alter northern pike, lake whitefish or walleye migration and/or access to overwintering habitats.

14.8.5.1.3.2 Fish Passage Issues: Alteration of Migration Patterns with Respect to Habitat Access / Migration to Rearing Habitats

An alteration to water depth, flow and/or substrate size can cause a disruption in access to fish habitats essential for various life processes with a given fish population.

Juvenile lake whitefish typically utilize the habitats adjacent to their spawning grounds for rearing in early summer. As temperatures rise, lake whitefish would move away from the shallower shoreline areas (2 m to 9 m in depth) to the pelagic zones of the lake. Adult rearing habitat is associated with the deeper sections of the riverine and lacustrine habitats. Therefore, an alteration of flows would not alter lake whitefish migration and/or access to rearing habitats. As such, the pathway has been classified as Invalid.

14.8.5.1.3.3 Flow Management with Respect to Total Gas Pressure

Total gas pressure (TGP) occurs when air gets trapped in water and is submerged to sufficient depths to create a pressurized environment. Under baseline conditions, the potential for TGP generation does not exist as there are no locations within the Trudel Creek system that support a pressurized environment. Therefore, the alteration of flows would not lead to s change in total gas pressure within the Trudel Creek system. As such, the pathway has been classified as Invalid.

14.8.5.1.3.4 *Flow Management with Respect to Salinity*

Increased volumes of freshwater flows into estuaries at certain times can decrease salinity levels, which can affect the diversity, abundance and distribution of some vegetation and fish species. The Project would not interact with brackish waters, estuaries or any water bodies that are influenced by tides. Therefore, the alteration of flows would not alter the salinity concentrations within Trudel Creek. As such, the pathway has been classified as Invalid.

14.8.5.1.3.5 *Flow Management: Flooding with Respect to Contaminant Concentration*

An increase in the concentration of toxins and pollutants in sediments and waters can breach the range of chemical parameters that support healthy aquatic communities, thereby seriously affecting fish and fish habitat. The alteration of flows would not result in flooding conditions within the Trudel Creek system. Therefore, flow management would result in no changes to toxins/pollutants (i.e., mercury) as a result of flooding. As such, the pathway has been identified as Invalid.

14.8.5.1.3.6 *Fish Passage Issues: Change in Water Chemistry with Respect to Thermal Cues*

Water temperature can serve as a behavioural cue for fish to initiate various stages of their life history (i.e., spawning). In addition, thermal pollution can increase water temperatures and shift the timing of reproduction and changes in the community structure.

A series of temperature data loggers were installed in Trudel Creek to collect water temperature readings every six hours. These data indicate that under baseline conditions water temperatures range from 0 °C in winter to approximately 21 °C in summer. The reduction in flows over the SVS and subsequent reduction in depth and velocity conditions may increase the water temperatures between 2 °C and 3 °C (refer to Section 14.4 – Alteration of Water Quality). This increase in water temperature is not anticipated to alter or shift the timing of thermal cues of fish species within the Trudel Creek system. As such, the pathway has been classified as Invalid.

14.8.6 Effects Analysis

14.8.6.1 ASSESSMENT METHODOLOGY

The Province of British Columbia developed the BC Instream Flow Methodology Guidelines (Lewis et al 2004) for assessing the effects of Independent Power Project (IPP) to fish habitat structure and cover (BC Guidelines). These guidelines were developed in consultation with DFO and provide a means to assess effects qualitatively and quantitatively in a manner that is compatible with DFO's No Net Loss policy. These guidelines are built on the most current knowledge of effects from minimum release flows, current environmental protection policies and sound science.

For the purposes of assessing the potential Project effects on the Valued Components in Trudel Creek, the BC Guidelines were used in parallel with DFO's Risk Assessment Framework.

The BC Instream Flow Assessment Methodology can be reviewed in full text at http://wlapwww.gov.bc.ca/wld/documents/bmp/assessment_methods_instreamflow_in_bc.pdf and the DFO Risk Assessment Framework can be found at http://www.dfo-mpo.gc.ca/oceans-habitat/habitat/policies-politique/operating-operation/risk-risques/index_e.asp.

The identified pathways between Project components and the aquatic components in Trudel Creek have been discussed in the previous sections. Those pathways identified to be valid have been carried forward for effects assessment as identified in Table 14.8.3.

Table 14.8.3 — Valid Pathways for Aquatic Valued Components

Valued Component	Pathway
Northern pike Lake whitefish Walleye	Flow management: alteration in depth, cover, velocity and substrate conditions with respect to fish habitat structure and cover
Northern pike	Fish passage issues: alteration of migration patterns with respect to spawning and rearing habitat and food access / migration
Northern pike Lake whitefish Walleye	Flow management: bank erosion / erosion of channel beds with respect to deposition zones
Northern pike Lake whitefish Walleye	Flow management: increased flows with respect to ramping events

14.8.6.2 INCREMENTAL EFFECTS BASED ON A 36 MW POWER PLANT

14.8.6.2.1 Fish Habitat Structure and Cover Pathway [36 MW]

A principal effect of the Project would be flow reductions in Trudel Creek that affect the water depth and velocity, which could affect the quality and quantity of fish habitat. To assist with the effects assessment of the fish habitat structure and cover pathway, the approach as described in the BC Guidelines was used.

The BC Guidelines provide a scientifically-based approach to determine the habitat usability of the stream channel, as expressed in Weighted Usable Area (WUA) for the various life-stages of the indicator species. The WUA is the portion of river channel or lake where habitat conditions (i.e., depth, velocity, substrate and cover) are suitable for the particular species and life-stages being considered. As outlined in the BC Guidelines, measurements of habitat characteristics are collected at predetermined cross-section locations of the watercourse.

Based on the different use of the riverine and lacustrine habitats by each life-stage of the Valued Components, a separate analysis was conducted for riverine and lacustrine habitats.

For the study on Trudel Creek riverine habitats, data for the analysis were obtained from bathymetric surveys at cross-section profiles completed by Rescan Environmental Services Ltd. in the fall of 2006 and spring of 2007 (refer to Section 14.3 – Alteration of Water Quantity). During these surveys, depth and velocity measurements at each transect cross-section were collected with substrate information observed where possible.

For the analysis of lacustrine habitat, bathymetric surveys of the Trudel Creek lakes were completed by Rescan in the spring of 2007. The WUA analysis for the Trudel Creek lake systems only includes field data for depth and velocity conditions. Field observations were used to estimate the in-stream cover (submergent/emergent vegetation, large woody debris, etc.) and substrate information as measured quantities were not available.

The WUA model was used to determine the change in preferred habitat conditions within the Trudel Creek system for the Valued Components: northern pike, lake whitefish and walleye. The life-stages evaluated included:

- northern pike spawning,
- northern pike juvenile rearing,
- lake whitefish juvenile rearing,
- lake whitefish adult rearing,
- lake whitefish spawning, and
- walleye spawning.

These life-stages were selected in consultation with the DFO Yellowknife Office Habitat Officer in 2007 due to their importance to regional user groups and the overlap of preferred habitat conditions with other fish species present in Trudel Creek. Changes to overwintering habitat for northern pike, lake whitefish and walleye were not assessed through the WUA model based on the anticipated changes in waterline elevations in the lacustrine and riverine habitats. Waterline elevations within the lake systems and in the riverine sections would vary based on channel morphology as summarized in Section 14.3 – Alteration of Water Quantity. Based on these anticipated reductions and assuming an ice thickness of 1.5 m (as requested by DFO), a significant amount of overwinter habitat would remain during the Expansion Project hydrological regime and would not effect the overwintering fish populations.

Separate WUA curves were generated for both riverine and lacustrine habitats in each reach of the Trudel Creek system. The WUA model results are shown as line graphs representing fish habitat (WUA, in hectares) versus discharge within a range of 0.25 m^3/s to 200 m^3/s for riverine habitats and 0.5 m^3/s to 500 m^3/s for lacustrine habitats (minimal flow values within the limitations of the model were used for flow modeling). The WUA model does not account for discharges above 200 m^3/s in riverine habitats as velocity data was not available. The WUA values presented in the graphs are the mean of all the transects within the reach or lake. The WUA curves are summarized in Appendix 14.8A.

14.8.6.2.1.1 WUA Results

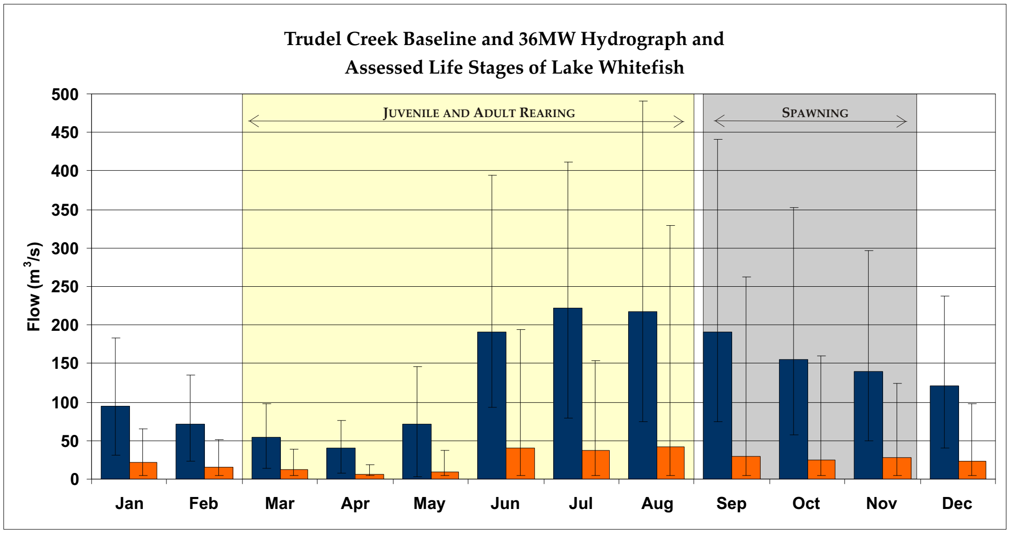
Northern pike, lake whitefish and walleye life-stages occur within different timing windows and under different flow regimes. To understand the flow conditions of Trudel Creek during each of the analyzed life-stages, the timing windows were compared to the mean monthly baseline hydrograph and for the Expansion Project hydrograph based on a 36 MW power generating facility. Figure 14.8.15 and Table

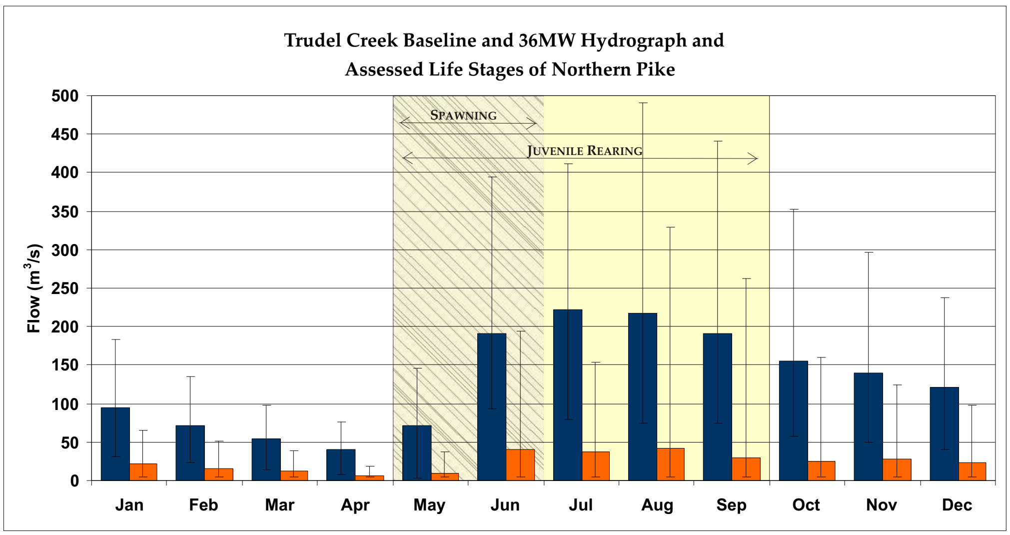
14.8.4 illustrate the flow conditions during each assessed life-stage of northern pike, lake whitefish and walleye for the baseline and Expansion Project.

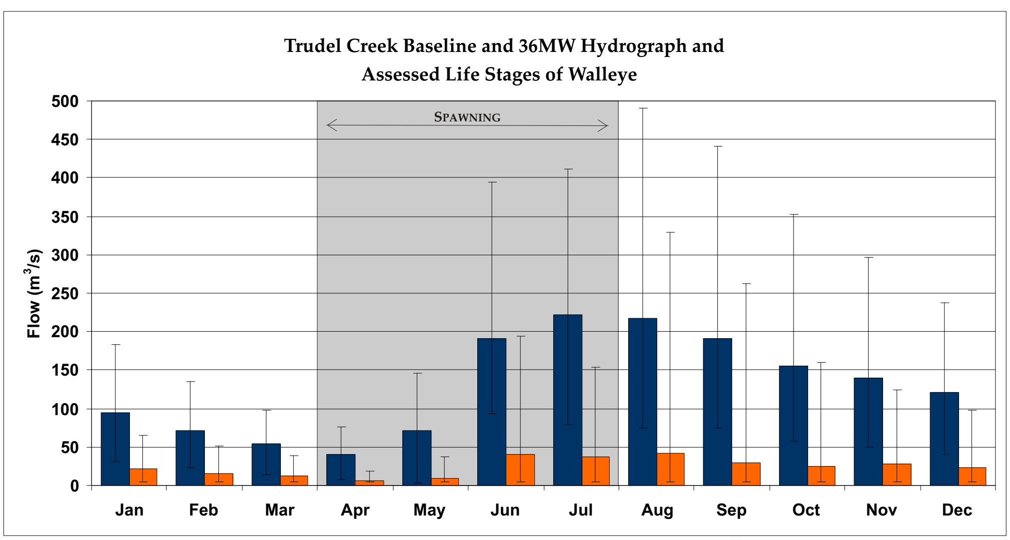
Table 14.8.4 — Flow conditions during each life-stage of the indicator species for the Baseline Hydrological Regime and Expansion Project

Flow Condition by Hydrological Regime	Northern Pike Juvenile Rearing (m^3/s)	Northern Pike Spawning (m^3/s)	Lake Whitefish Juvenile Rearing (m^3/s)	Lake Whitefish Adult Rearing (m^3/s)	Lake Whitefish Spawning (m^3/s)	Walleye Spawning (m^3/s)
Baseline	71.8 to 222.2	71.8 to 191.5	40.6 to 222.2	40.6 to 222.2	139.9 to 191.1	40.6 to 222.2
Expansion Project	9.6 to 41.5	9.6 to 40.2	6.4 to 41.5	6.4 to 41.5	24.6 to 28.8	6.4 to 40.2

The mean monthly flows were used in conjunction with the WUA curves to determine the habitat availability for northern pike, lake whitefish and walleye during the life-stage period. As many of the life-stage periods extend for more than one month and the mean monthly flows vary, minimum and maximum values of habitat availability were determined as summarized in Table 14.8.5, Table 14.8.6 and Table 14.8.7 respectively.







Baseline 36 MW Power Plant

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Flow Conditions for each Indicator Species: Baseline and 36 MW Project Conditions	Figure 14.8.15

Table 14.8.5 — Northern Pike WUA Values under Baseline Conditions and 36 MW Expansion Project Conditions

Northern Pike Life Stage	REACH 1		REACH 2						REACH 3				Trudel Creek (Totals for All Reaches)	
	Riverine Habitat		Gertrude Lake		Trudel Lake		Riverine Habitat		Unnamed Lake		Riverine Habitat			
	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)
Juvenile Rearing														
Baseline Conditions	0.2	0.6	4.4	4.9	10.3	12.7	0.0	0.7	34.2	50.2	12.6	15.6	**61.7**	**84.7**
Expansion Project	1.0	1.3	5.6	8.3	16.0	17.4	0.5	1.3	50.6	52.7	17.1	30.7	**90.8**	**111.7**
Change in WUA	**0.8**	**0.7**	**1.2**	**3.4**	**5.7**	**4.7**	**0.5**	**0.6**	**16.4**	**2.5**	**4.5**	**15.1**	**29.1 (47%)**	**17.6 (27%)**
Spawning														
Baseline Conditions	0.0	0.1	2.3	2.4	4.6	6.3	0.0	0.4	18.6	26.7	4.1	7.6	**29.6**	**43.5**
Expansion Project	0.0	0.5	3.0	3.3	7.9	9.0	0.0	0.3	26.1	28.7	6.8	13.8	**43.8**	**55.6**
Change in WUA	**0.0**	**0.4**	**0.7**	**0.9**	**3.3**	**2.7**	**0.0**	**-0.1**	**7.5**	**2.0**	**2.7**	**6.2**	**14.2 (48%)**	**12.1 (28%)**

Note: Minimum and maximum values are associated with the life-stage period

Table 14.8.6 — Lake Whitefish WUA Values under Baseline Conditions and 36 MW Expansion Project Conditions

Lake Whitefish Lifestage	REACH 1		REACH 2						REACH 3				Trudel Creek (totals for all reaches)	
	Riverine Habitat		Gertrude Lake		Trudel Lake		Riverine Habitat		Unnamed Lake		Riverine Habitat			
	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)
Juvenile Rearing														
Baseline Conditions	11.5	23.5	48.1	56.1	47.8	75.6	8.0	10.9	77.2	154.6	41.3	61.5	**233.9**	**382.2**
Expansion Project	20.6	22.6	45.5	48.1	41.2	47.8	3.5	8.0	60.3	79.9	29.8	41.3	**200.6**	**247.7**
Change in WUA	**9.1**	**-0.9**	**-2.6**	**-8.0**	**-6.6**	**-27.8**	**-4.5**	**-2.9**	**-16.9**	**-74.7**	**-11.5**	**-20.2**	**-33.3 (-14%)**	**-134.5 (-35%)**
Adult Rearing														
Baseline Conditions	17.4	20.8	45.5	54.1	27.3	57.6	0.7	7.9	33.2	84.5	15.9	36.3	**140.4**	**261.2**
Expansion Project	12.0	17.4	40.8	44.5	21.3	27.3	0.0	0.7	22.1	34.8	8.6	15.9	**104.8**	**140.6**
Change in WUA	**-5.4**	**-3.4**	**-4.7**	**-9.6**	**-6.0**	**-30.3**	**-0.7**	**-7.2**	**-11.1**	**-49.7**	**-7.3**	**-20.4**	**-35.6 (25%)**	**-120.6 (46%)**
Spawning														
Baseline Conditions	1.9	2.0	13.4	13.8	5.4	6.3	0.3	0.5	86.4	86.6	9.0	10.3	**116.4**	**119.6**
Expansion Project	1.9	1.9	8.7	8.8	8.3	8.8	1.2	1.3	79.1	80.0	6.2	6.4	**105.4**	**107.2**
Changes in WUA	**0.0**	**-0.1**	**-4.7**	**-5.0**	**2.9**	**2.5**	**0.9**	**0.8**	**-7.3**	**-6.6**	**-2.8**	**-3.9**	**-11.0 (9%)**	**-12.4 (-10%)**

Note: Minimum and maximum values are associated with the life-stage period

Table 14.8.7 — Walleye WUA Values under Baseline Conditions and 36 MW Expansion Project Conditions

Walleye Life Stage	REACH 1		REACH 2						REACH 3				Trudel Creek (totals for all reaches)	
	Riverine Habitat		Gertrude Lake		Trudel Lake		Riverine Habitat		Unnamed Lake		Riverine Habitat			
	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)
Juvenile Rearing														
Baseline Conditions	5.1	9.9	16.1	17.2	37.8	44.5	0.1	0.4	131.0	145.6	3.3	6.4	**193.4**	**224.0**
Expansion Project	1.1	7.8	16.6	17.2	41.9	43.8	0.1	0.4	137.3	145.1	0.8	5.1	**197.8**	**219.4**
Change in WUA	**-4.0**	**-2.1**	**0.5**	**0.0**	**4.1**	**-0.7**	**0.0**	**0.0**	**6.3**	**-0.5**	**-2.5**	**-1.3**	**4.4 (2%)**	**-4.6 (-2%)**

Note: Minimum and maximum values are associated with the life-stage period

Northern Pike

In general, the results of the WUA model indicate that under average flow conditions, the habitat structure and cover within Trudel Creek system would be more suitable to the northern pike preferred rearing and spawning conditions during the Expansion Project. Overall, the analysis indicates an increase of 29.1 ha to 17.6 ha (47% to 27%) of preferred habitat for juvenile rearing and 14.2 ha to 12.1 ha (48% to 28%) of preferred habitat for spawning.

The habitat values generated under the Expansion Project assumed that submergent and emergent vegetation would establish along the shifted stream margins and shorelines. Cambria Gordon Ltd. (2008) identified that under current conditions, riverine habitats support submergent and emergent vegetation communities at depths ranging from 0 m to 2 m in most areas of low velocity and the lacustrine habitats support submergent vegetation at depths up to and greater than 3 m. Under the Expansion Project flow regime, depths within the riverine and lacustrine habitats are anticipated to decrease (refer to Section 14.3 – Alterations of Water Quantity). Therefore, it is anticipated that under a reduced flow and a subsequently lower waterline elevation, portions of the stream margins and shoreline habitats would continue to support submergent and emergent vegetation communities. With time, as historically demonstrated within the Trudel Creek system, in-stream vegetation communities are anticipated to re-establish along the stream margins and shorelines to depths similar to baseline conditions; however, as vegetation re-establishes there would be a temporal effect to pike habitat and potentially to the pike population throughout the Trudel Creek system. Section 14.6 – Wetlands further discusses the re-colonization of wetland habitats.

Vegetation plays an important role in pike spawning success, as pike prefer habitats dominated by grasses and sedges and show low use of the cattail covered areas (Cooper et al. 2008). Other vegetation may be used; however, plant mats need to be thick enough to suspend egg masses above the substrate and keep them in the well-oxygenated areas (Casselman and Lewis 1996). A recent study by Pierce et al. (2007) involving the use of microtransmitters inserted into egg masses prior to spawning, indicated that although pike do prefer shallow near-shore habitats dominated by sedges, they also use deeper (3.7 m to 5.2 m) bars for egg deposition.

The predominant quantity of preferred habitat under the baseline and Expansion Project hydrological conditions is associated with the lacustrine and riverine habitats of Reach 3. Unnamed Lake provides, and would continue to provide, the preferred habitat conditions for northern pike spawning and rearing. The model indicates that the preferred habitat conditions in Unnamed Lake would be substantially more (5% to 48%) abundant under a reduced flow. The riverine habitats within Reach 3 would also continue to provide the preferred habitat conditions for northern pike spawning and rearing. The model indicates that the preferred conditions within the riverine habitats of Reach 3 would increase between 36% and 97%.

The shorelines of Gertrude Lake and Trudel Lake in Reach 2 consist of wetland habitats interspersed between bedrock cliffs. The changes to the preferred habitat conditions for northern pike spawning and rearing within these two lakes are low, as determined by the WUA analysis (Table 14.8.5). As such, no direct implications are anticipated on northern pike rearing and/or spawning conditions within the lacustrine habitats of Reach 2 as a result of the Expansion Project.

Riverine habitats associated with Reach 1 and 2 are characterized by steeply-sloped stream margins that provide limited shallow, low-velocity bench-type habitats. Field observations and review of the low-level aerial photographs indicate that emergent and submergent vegetation communities are not as abundant along the riverine habitats of Reaches 1 and 2 when compared to the lower Taltson River and the lacustrine habitats of Reach 2. In addition, northern pike usage of the riverine habitats within Reaches 1 and 2 was documented to be low. The WUA model indicates that the decrease in flows over the SVS would increase the abundance of the preferred habitat conditions within Reaches 1 and 2, however, to a small degree (Table 14.8.5) that would likely have little influence on the overall productivity of northern pike within these reaches.

Overall, the reduction in flows over the SVS would result in an increase in the abundance of preferred habitat conditions for northern pike in Trudel Creek; however, this increased abundance of preferred habitat conditions would not necessarily lead to an increase in northern pike populations. Field observations indicate that under baseline conditions, northern pike appear to be under-utilizing available habitat. A summer field sampling program conducted by Cambria Gordon Ltd. (August 2008) sampled northern pike preferred spawning and rearing habitats with a 9 m seine net, which resulted in a Catch per Unit Effort (CPUE) of 0.48 pike for every 100 m^2 sampled. The results of these study programs suggest that habitat is not the limiting factor affecting northern pike population growth. Therefore, increasing the abundance of the preferred habitat conditions would not necessarily meet the specific requirements needed for the pike population to increase.

Lake Whitefish

The results of the WUA model indicate that under average flow conditions the habitat structure and cover conditions within Trudel Creek would be less suitable to the lake whitefish preferred rearing and spawning during the Expansion Project. Overall, the analysis predicts a decrease of 33.3 ha to 134.5 ha (14% to 35%) of preferred juvenile rearing habitat, 35.6 ha to 120.6 ha (25% to 46%) of preferred adult rearing habitat and 11.0 ha to 12.4 ha (9% to 10%) of spawning habitat.

The predominant quantity of habitat for lake whitefish under the baseline hydrological conditions is associated with the lake systems, particularly Unnamed Lake in Reach 3. Preferred habitat conditions of juvenile and adult lake whitefish are primarily a factor of depth. As flow over the SVS decrease and depth conditions within the lakes drop, the preferred habitat conditions become less available. The WUA model indicates that the abundance of preferred habitat conditions within Unnamed Lake would decrease as follows:

- Juvenile rearing preferred habitat conditions would decrease between 16.9 ha and 74.7 ha, or 22% to 48% respectively.
- Adult rearing preferred habitat conditions would decrease between 11.1 ha and 49.7 ha, or 33% to 59% respectively.
- Spawning preferred habitat conditions would decrease between 7.3 ha and 6.6 ha, or 8%.

Reach 3 also provides the highest abundance of preferred habitat conditions in riverine habitats for lake whitefish under the baseline hydrological regime. As discharges over the SVS decrease and the water level elevation in the riverine habitats drop, the abundance of habitat meeting the preferred conditions would be reduced. The WUA model indicates that the abundance of preferred habitat conditions in the riverine habitats of Reach 3 would decrease as follows:

- Juvenile rearing preferred habitat conditions would decrease between 11.5 ha and 20.2 ha, or 28% to 33%.
- Adult rearing preferred habitat conditions would decrease between 7.3 ha and 20.4 ha, or 46% to 56%.
- Spawning preferred habitat conditions would decrease between 2.8 ha and 3.9 ha, or 31% to 38%.

The decrease in preferred habitat conditions within Gertrude Lake and Trudel Lake (Reach 2) are significantly lower than that experienced in Unnamed Lake (Table 14.8.6), with the exception of juvenile rearing. Rearing juvenile lake whitefish initially use the stream margins and shorelines adjacent to the spawning grounds. As water temperatures warm in the summer, juvenile lake whitefish would migrate to the deeper water habitats. The decrease in preferred habitat conditions as described by the WUA model for Gertrude and Trudel Lakes is primarily a condition of depth. Therefore, the decrease in juvenile rearing habitat would likely only apply during the first three months of the life-stage (March through to May) as juvenile lake whitefish would move to deeper water habitats in June.

Riverine habitats associated with Reaches 1 and 2 provide a relatively minimal area of preferred habitat conditions (Table 14.8.6) for lake whitefish under the baseline regime when compared to the riverine habitats of Reach 3. Lake whitefish use of the riverine habitats within Reaches 1 and 2 was documented to be low. The WUA model indicates that a reduction in flows over the SVS would decrease the abundance of preferred habitat conditions within the riverine habitats of Reaches 1 and 2. Based on the abundance of habitat in the riverine sections of Reach 1 and 2 under baseline flows and the abundance of fish using these habitats, it is likely that lake whitefish rely on the habitats in the Taltson River downstream of Reach 1 and in Gertrude Lake and Trudel Lake in Reach 2. Therefore, the decrease in preferred habitat conditions within the riverine sections of Reaches 1 and 2 would likely have little influence on the overall productivity of lake whitefish within these reaches.

Overall, the reduction in flows over the SVS would result in a decrease in the preferred habitat conditions for lake whitefish in the Trudel Creek system, primarily a result of the change in depths. This decrease in preferred habitat conditions does not necessarily indicate there would be a decrease in fish usage and/or a decline in existing fish populations. The field sampling programs conducted to date indicate that even though lake whitefish are one of the more predominant species in the Trudel Creek system, their overall productivity is low given the amount of available habitat. Therefore, habitat availability is not considered a limiting factor affecting lake whitefish population growth.

Walleye

The results of the WUA model indicate that under average flow conditions the depth, velocity, cover and substrate parameters within Trudel Creek would be more suitable for walleye spawning in lacustrine habitats and less suitable in riverine habitats during the Expansion Project regime. Overall, the analysis indicates a change of 10.9 ha to -1.2 ha (6% to 0.6%) of preferred habitat for walleye spawning in lacustrine habitats and a decrease of 6.5 ha to 3.4 ha (76% to 20%) of preferred habitat for walleye spawning in riverine habitats.

The predominant quantity of habitat for walleye spawning under the baseline hydrological regime is associated with the lake systems, particularly Unnamed Lake in Reach 3. The model indicates that during the Expansion Project flow regime the preferred habitat conditions for walleye spawning in the lake systems of Trudel Creek would increase as follows:

- Spawning preferred habitat conditions would increase between 0.5 ha and 0.0 ha, or 3% and 0% in Gertrude Lake.
- Spawning preferred habitat conditions would increase between 4.1 ha and -0.7 ha, or 11% and -2% in Trudel Lake.
- Spawning preferred habitat conditions would increase between 6.3 ha and -0.5 ha, or 5% and 0.3% in Unnamed Lake.

The preferred conditions for walleye spawning within the riverine habitats of Trudel Creek are predominately located in Reach 3 and Reach 1; the riverine sections in Reach 2 provide scarce (Table 14.8.7) preferred walleye spawning habitat. The model indicates that during the Expansion Project flow regime the preferred habitat conditions for walleye spawning in the riverine sections of Trudel Creek would decrease as follows:

- Spawning preferred habitat conditions would decrease between 4.0 ha and 2.1 ha, or 78% and 21% in Reach 1.
- Spawning preferred habitat conditions would decrease between 0.0 ha and 0.0 ha, or 0% in Reach 2
- Spawning preferred habitat conditions would decrease between 2.5 ha and 1.3 ha, or 76% and 20% in Reach 3.

Field sampling programs conducted by Cambria Gordon Ltd. (2008) and Rescan (2007), suggest walleye populations within the Trudel Creek system are small (Figure 14.8.11). Based on the results of these field programs and on the abundant preferred spawning habitat conditions within the lake systems, habitat is not the limiting factor affecting walleye population growth. During the Expansion Project flow regime, walleye would likely rely on spawning habitat conditions within Unnamed Lake in Reach 3, Gertrude and Trudel Lakes in Reach 2, and the lower Taltson River in Reach 1.

14.8.6.2.2 Fish Migration and Access to Habitats Pathways [36 MW]

Trudel Creek, in its current state, is a large river with fluctuating water levels. It is characterized by low-gradient, straight-channel morphology and confined banks. The generally homogenous, low-gradient system features three lakes held by a series of bedrock controls. Baseline channel widths are between 70 m and 230 m. The lake and rivers provide habitat for all the Valued Components and their life-stages. Small areas of off-channel habitat, identified as pool-type habitat outside of the lake and river margins with channel connectivity to the lake or river, exist primarily along the lakes and riverine sections of Reach 2 and 3.

These off-channel habitats are primarily vegetated ponds that have potential to support northern pike spawning and rearing. As the off-channel habitats do not support the preferred spawning conditions for walleye, and juvenile walleye use habitats adjacent to their spawning grounds prior to moving to deeper waters in mid-summer, it has been assumed that juvenile rearing walleye would not use the off-channel habitats. Based on the lack of depth in these habitats, lake whitefish would not use the off-channel habitats to support any stage of their life history.

Loss of northern pike migration and/or access to off-channel habitats in the Trudel Creek system would occur where low flows cause a section of river to become impassable due to water depths.

The review of off-channel habitats was conducted at a desktop level using low level aerial photography. It was assumed that 100% of the off channel area meet the preferred habitat conditions for northern pike juvenile rearing and spawning. Under baseline conditions, many of the off-channel sites are not connected during the winter months and/or low flow periods that sporadically occur during the year. During the Expansion Project hydrological regime, it is likely that the off-channel habitat would become disconnected with the mainstem channel throughout most if not all of the year, with occasionally connectivity occurring only in periods of high flow.

Results of the off channel habitat desktop review are summarized in Figure 14.8.16 through Figure 14.8.20 and in Table 14.8.8.

Table 14.8.8 — Summary of Off-Channel Habitat in the Trudel Creek System

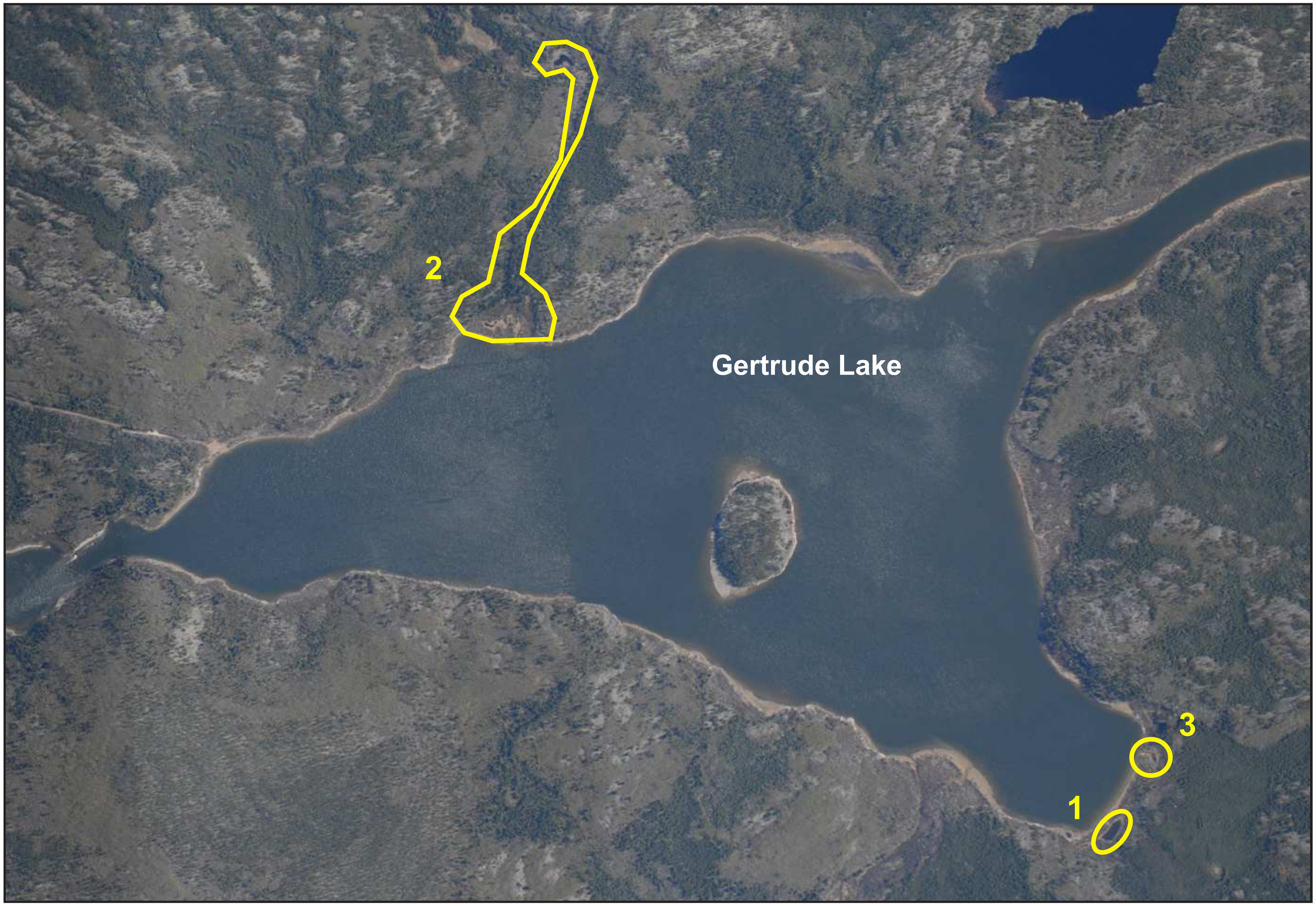
Location	Number of Off-Channel Sites	Total Area of Off-Channel Habitats (ha)
Gertrude Lake	3	0.05
Trudel Lake	2	0.07
Un-named Lake	7	1.04
Reach 2 Riverine Habitats	9	0.31
Reach 3 Riverine Habitats	25	2.85

Note: No off-channel sites exist along the riverine margins in Reach 1.

The WUA model results discussed in the fish habitat structure and cover section above indicate that northern pike spawning and juvenile rearing preferred habitat conditions would increase as a result of a 36 MW Expansion Project. Table 14.8.9 summarizes the quantities of habitat that would meet the preferred habitat conditions of northern pike during the Expansion Project (36 MW) hydrological regime (WUA results) and the amount of off channel habitat potentially lost by reach in the Trudel Creek system.

Table 14.8.9 — Summary of Preferred Habitat Availability and Off-Channel Habitats based on a 36 MW Power Plant

Location	Northern Pike Juvenile Rearing Habitat Availability (ha)	Northern Pike Spawning Habitat Availability (ha)	Loss of Off-Channel Habitat (ha)
Reach 1			
Riverine	1.0 to 1.3	0.0 to 0.5	0.0
Reach 2			
Gertrude Lake	5.6 to 8.3	3.0 to 3.3	0.1
Riverine	0.5 to 1.3	0.0 to 0.3	0.3
Trudel Lake	16.0 to 17.4	7.9 to 9.0	0.1
Reach 3			
Un-named Lake	50.6 to 52.7	26.1 to 28.7	1.0
Riverine	17.1 to 30.7	6.8 to 13.8	2.9

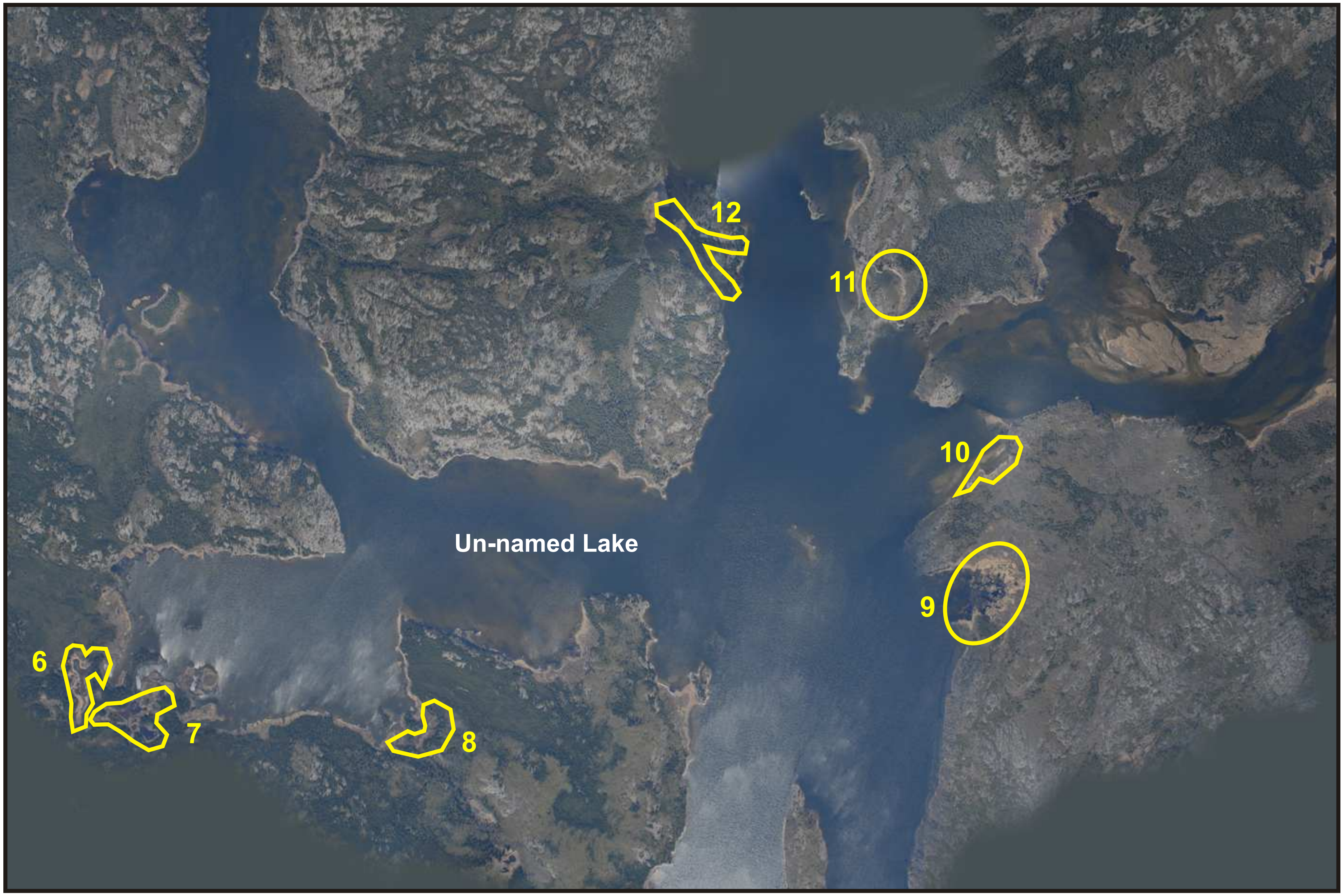


TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report** **2009**	**Gertrude Lake** **Off Channel Habitat**	**Figure** **14.8.16**

Photographed: May 25, 2007

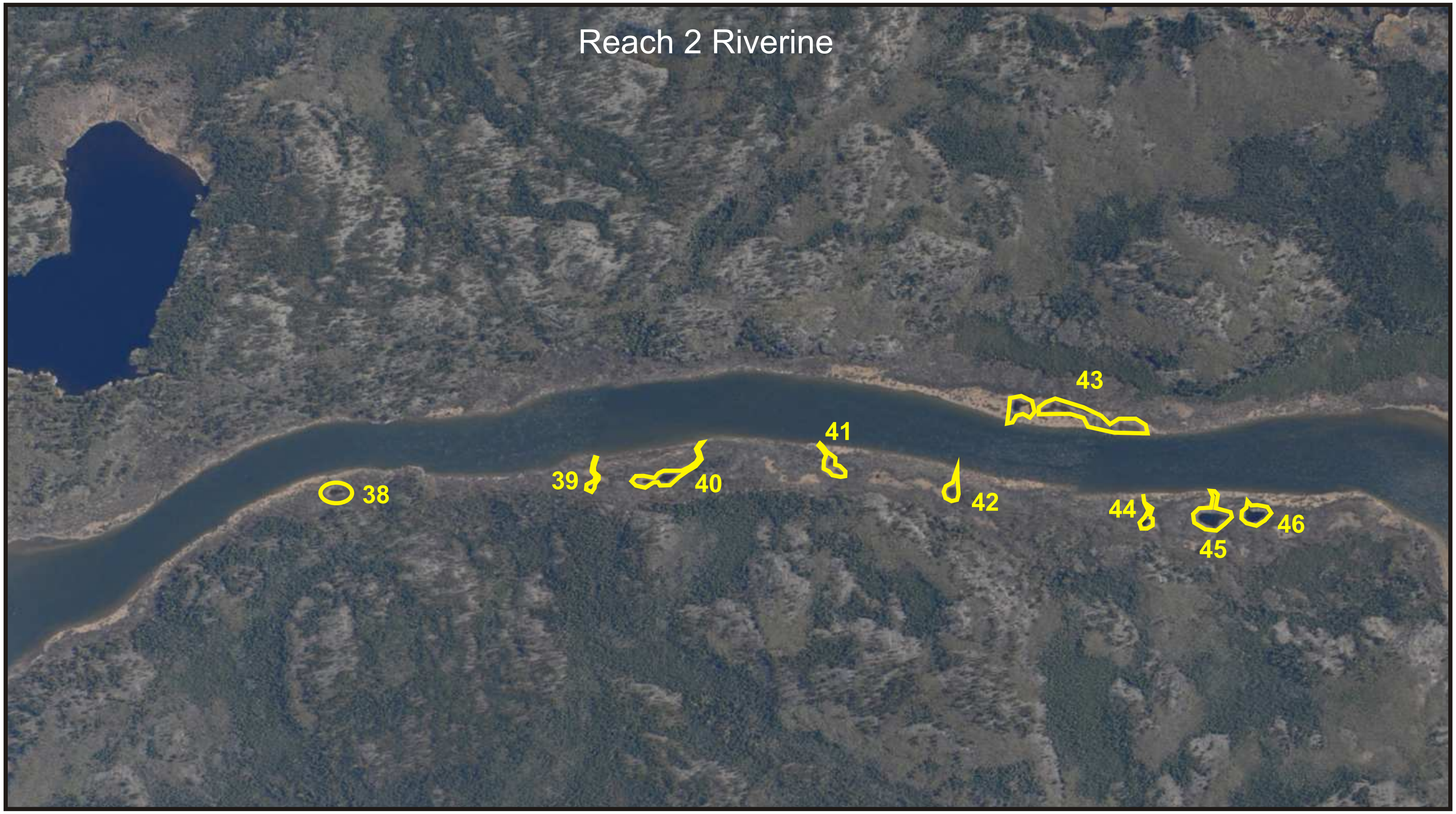
TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Trudel Lake Off Channel Habitat**	**Figure 14.8.17**

Dezé energy



Photographed: May 25, 2007

TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report** **2009**	**Un-Named Lake** **Off Channel Habitat**	**Figure** **14.8.18**



Gertrude Lake

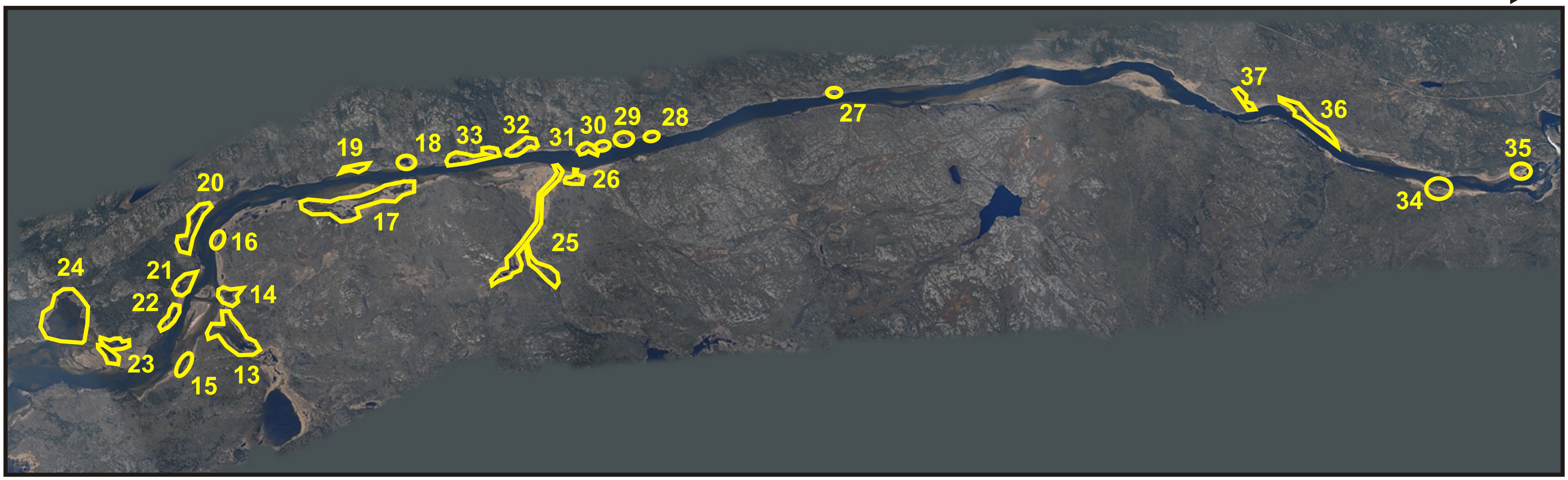
Trudel Lake

Photographed: May 25, 2007

TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Reach 2 Riverine Off Channel Habitat	Figure 14.8.19

Reach 3 Riverine

South Valley Spillway



Unnamed Lake

Photographed: May 25, 2007

TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Reach 3 Riverine Off Channel Habitat**	**Figure 14.8.20**

Assuming the off-channel habitat provides 100% preferred habitat conditions for both northern pike spawning and rearing, there would be a total loss of 4.31 ha to each life-stage. With this loss of off-channel habitat, a substantial amount (Table 14.8.9) of habitat remains in each riverine and lacustrine habitat for northern pike juvenile rearing and spawning.

In addition to the off-channel habitats identified above for northern pike juvenile rearing and spawning, access and/or migration to and from two side channels adjacent to the SVS (within Reach 3) would be lost as a result of the Expansion Project. A fish and fish habitat assessment conducted on the two side channels by Cambria Gordon (2008) indentified three habitat types within the side channel area: deep pool, riffle-pool and cascade pool (Figure 14.8.21).

The two side channels drain into a large deep pool before discharging into Trudel Creek through two outlets. The primary outlet is likely a fish barrier due to the channel morphology (confined canyon), channel gradient, and subsequent water velocities. The second outlet is similar to an overflow channel in that it only discharges water during high flow events. The secondary outlet is defined by a riffle-pool morphology with angular cobble and boulder sized substrates. When flows are discharging through the second outlet, it is likely that white suckers could migrate up the riffle-pool channel and access the deep pool habitat associated with the two side channels; however, the life history characteristics of northern pike, lake whitefish and walleye suggests that they likely would not attempt to access these habitats. Fish sampling efforts identified large numbers of white sucker young-of-year; however, no northern pike, lake whitefish or walleye were observed.

A quantification of the habitats available within the two side channels and associated pool is provided in Figure 14.8.21 and is summarized as follows:

- 2.12 ha of deep pool habitat,
- 0.16 ha of riffle-pool habitat, and
- 0.52 ha of cascade-pool habitat.

SVS Side Channel Habitat Area (hectares)

Pool   Riffle-pool   Cascade-pool

Photographed: June 04, 2008

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Off Channel Habitat Associated with the SVS	Figure 14.8.21

The Project would result in a loss of flow into the side channels from the Twin Gorges Forebay during the operation of the new power generating facility. Water within the side channels would completely drain into the deep pool immediately downstream. Water within the deep pool would also drain into Trudel Creek through the outlet channels; however, a considerable portion of the deep pool is anticipated to remain wetted as the depth within the pool habitat exceeds the invert elevation of both discharge locations. Therefore, access and migration downstream from the Twin Gorges Forebay and upstream from Trudel Creek into the habitats associated with the two side channels would be lost during most of the year as a result of the Project.

As the Valued Components do not rely on, or access the habitats associated with the two side channels, a loss of connectivity to the Twin Gorges Forebay or Trudel Creek would result in no or negligible changes to access and/or migration characteristics for the Valued Components. The fish and fish habitat assessment identified a considerable number of young-of-year white suckers, suggesting white suckers utilize the side-channel habitat for spawning and rearing, and potentially to support their full life history requirements. Therefore, the habitats associated with the two side channels have been considered in the effects classification.

14.8.6.2.3 <u>Deposition and Erosional Characteristics Pathways [36 MW]</u>

Erosion occurs when high flows increase river energy, specifically water velocities, which cause scour and mobilization of bank material. Velocities are further increased at the outside edge of river bends, especially in higher gradient sections.

The erosion sites observed in Trudel Creek reflect this typical erosion process. Reaches 2 and 3 are very low-gradient, relatively straight sections of river. Average velocity increases under different modelled flow scenarios increases from 0.1 m/s during baseline average low flows to 0.7 m/s during high flows. In Reach 1, where most of the erosion sites occur, the river is more confined, has slightly higher gradient sections, has more river bends, and the average velocities range from 0.4 m/s to 1.0 m/s throughout a typical year under baseline conditions.

To understand the erosion and deposition characteristics anticipated for the Expansion Project flows, Klohn Crippen Berger (2008) conducted an assessment of erosion on Trudel Creek. The following description is an excerpt from the geomorphologist's technical memo titled "Taltson Expansion Project: Trudel Creek Erosion Assessment."

> *The Expansion Project flow regime would result in a significantly reduced erosion rate compared to the present erosion rate, since peak monthly and peak daily flows would be reduced by greater than 50% respectively. The base flows are also significantly reduced so that the base flows would be contained well within the present wide river channel. Initially this may result in some erosion of fines from former depositional areas. Therefore, the Expansion Project flow regime should improve the water quality and turbidity. Since the Expansion Project flow regime would have lower flows than the existing flow regime, the energy and sediment transport power of the river would be reduced. As mentioned above, there may be some zones where erosion of previously deposited sediments could occur. These are expected to be isolated, contributing very little to the sediment load. In general, the transport of fine sediments would be much reduced under the Expansion Project flow regime.*

> *Under the expansion flow regime, the area of many of the existing sediment depositional zones would be significantly reduced and may be eliminated in some cases due to the reduction in flows. Some of the present depositional zones may not be covered by water. At some locations, the lower flows may result in remobilization of the deposited sediments. This would occur if a depositional zone was only partly covered and a back eddy no longer formed over the former depositional zone.*

A reduction in deposition typically allows submergent and emergent vegetation to establish. Coarse substrates would not be lost or buried and there would be a reduction in the potential for deposition to cover incubating eggs.

Under baseline conditions in Trudel Creek, submergent and emergent vegetation has established along most slow-moving shallow habitats. Substrate conditions are predominately fines with select areas adjacent to rapids where coarse gravel and cobble substrates are present. Incubating eggs are typically at depths within the lake systems or in dense in-stream vegetation, both locations where active deposition is minimal. Therefore, the reduction in deposition within Trudel Creek would have a net benefit to habitat structure and cover; however, it would not result in a considerable increase in habitat values.

14.8.6.2.4 Ramping Pathways [36 MW]

The pathway of higher water levels caused by ramping is valid for both expansion options. However, the magnitude of water level changes would be less during a 36 MW ramping event. Given that the magnitude of effects on VCs are highly correlated with the magnitude of water level changes, only the 56 MW expansion effects were classified as it was considered to represent a worst-case scenario for magnitudes of effects. However, in terms of frequency of occurrence, 36 MW ramping events would occur more often; 6 out of 13 years versus 1 out of 13 years for modelled flows (36 MW and 56 MW expansions, respectively). To ensure a conservative prediction of adverse effects, the frequency of occurrence of the 36 MW ramping event was rated together with the attributes of the 56 MW ramping event. Besides frequency of occurrence, the two ramping events were deemed to differ only in magnitude of effect, see Section 14.8.6.3.2.

14.8.6.3 INCREMENTAL EFFECTS BASED ON A 56 MW POWER PLANT

The similarities between the hydrographs for Trudel Creek associated with a 36 MW and 56 MW power generating facility resulted in nearly identical implications of the identified pathways to the Valued Components under each operational option. The magnitude of the effects varied slightly for the pathways identified under habitat structure and cover, and ramping; however, the magnitude to fish migration and access to habitat pathways and sedimentation and erosional characteristics pathways was identical to the 36 MW option. Therefore, the only pathways discussed as part of the incremental effects of a 56 MW power plant include habitat structure and cover pathways and ramping pathways.

14.8.6.3.1 Fish Habitat Structure and Cover [56 MW]

A principal effect of the Project would be flow reductions in Trudel Creek that affect the water depth and velocity, which could affect the quality and quantity of fish habitat. To assist with the effects assessment of the fish habitat structure and cover pathways, the approach as described in the BC Guidelines was used.

The BC Guidelines provide a scientifically-based approach to determine the habitat usability of the stream channel, as expressed in Weighted Usable Area (WUA) for the various life-stages of the indicator species. The WUA is the portion of river channel or lake where habitat conditions (i.e., depth, velocity, substrate and cover) are suitable for the particular species and life-stages being considered. As outlined in the BC Guidelines, measurements of habitat characteristics are collected at predetermined cross-section locations of the watercourse.

The WUA model was used to determine the change in preferred habitat conditions within the Trudel Creek system for the Valued Components: northern pike, lake whitefish and walleye. The life-stages evaluated included:

- northern pike spawning,
- northern pike juvenile rearing,
- lake whitefish juvenile rearing,
- lake whitefish adult rearing,
- lake whitefish spawning, and
- walleye spawning.

Separate WUA curves were generated for both riverine and lacustrine habitats in each reach of the Trudel Creek system. The WUA model results are shown as line graphs representing fish habitat (WUA, in hectares) versus discharge within a range of 0.25 m^3/s to 200 m^3/s for riverine habitats and 0.5 m^3/s to 500 m^3/s for lacustrine habitats (minimal flow values within the limitations of the model were used for flow modeling). The model does not account for discharges above 200 m^3/s in riverine habitats as velocity data was not available. The WUA values presented in the graphs are the mean of all the transects within the reach or lake. The WUA curves are summarized in Appendix 14.8A .

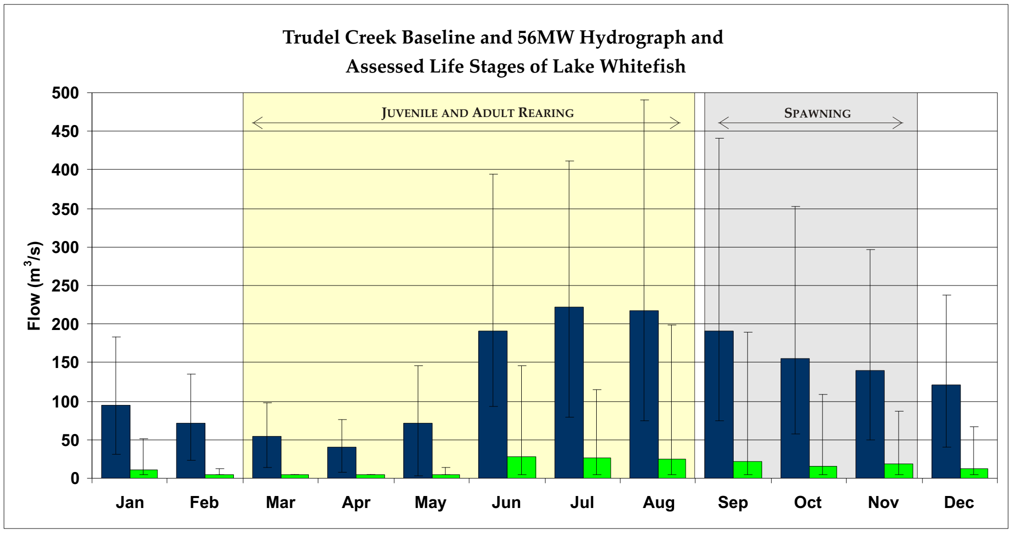
14.8.6.3.1.1 WUA Results

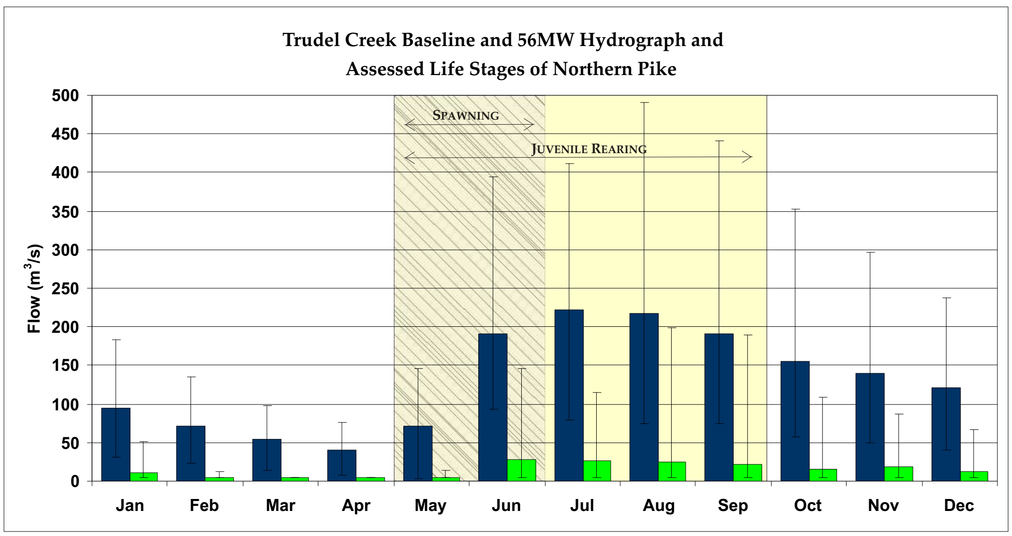
Northern pike, lake whitefish and walleye life-stages occur within different timing windows and under different flow regimes. To understand the flow conditions of Trudel Creek during each of the analyzed life-stages, the timing windows were compared to the mean monthly hydrograph for the baseline condition and for the Expansion Project based on 56 MW generation. Figure 14.8.22 and Table 14.8.10 illustrates the flow conditions during each life-stage of northern pike, lake whitefish and walleye for the baseline conditions and Expansion Project.

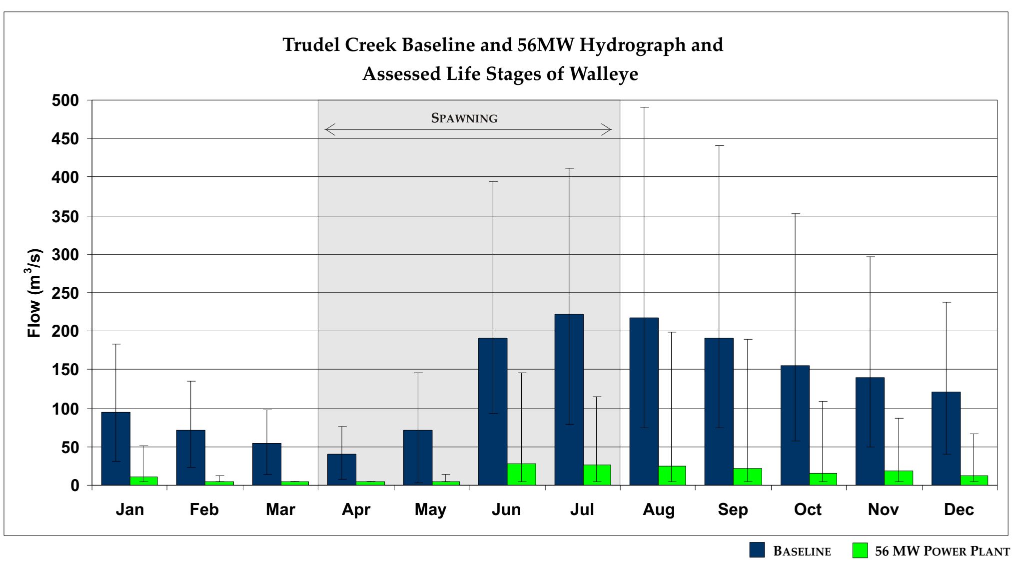
Table 14.8.10 — Flow Conditions During Each Life-Stage of the Indicator Species for the Baseline Hydrological Regime and Expansion Project

Flow Condition by Hydrological Regime	Northern Pike Juvenile Rearing (m^3/s)	Northern Pike Spawning (m^3/s)	Lake Whitefish Juvenile Rearing (m^3/s)	Lake Whitefish Adult Rearing (m^3/s)	Lake Whitefish Spawning (m^3/s)	Walleye Spawning (m^3/s)
Baseline	71.8 to 222.2	71.8 to 191.5	40.6 to 222.2	40.6 to 222.2	139.9 to 191.1	40.6 to 222.2
Expansion Project	4.9 to 28.0	4.9 to 28.0	4.0 to 28.0	4.0 to 28.0	15.3 to 21.9	4.0 to 28.0

The mean monthly flows were used in conjunction with the WUA curves to determine the minimum and maximum habitat availability for northern pike, lake whitefish and walleye during the life-stage period, as summarized in Table 14.8.11, Table 14.8.12, and Table 14.8.13, respectively.







TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Flow Conditions for each Indicator Species: Baseline and 56 MW Project Conditions	Figure 14.8.22

Table 14.8.11 — Northern Pike WUA Values under Baseline Conditions and 56 MW Expansion Project Conditions

Northern Pike Life Stage	REACH 1		REACH 2						REACH 3				Trudel Creek (totals for all reaches)	
	Riverine Habitat		Gertrude Lake		Trudel Lake		Riverine Habitat		Unnamed Lake		Riverine Habitat			
	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)
Juvenile Rearing														
Baseline Conditions	0.2	0.6	4.4	4.9	10.3	12.7	0.0	0.7	34.2	50.2	12.6	15.6	**61.7**	**84.7**
Expansion Project	0.8	1.2	6.6	8.5	16.6	17.4	0.6	1.8	50.2	52.3	17.1	26.8	**91.9**	**108.0**
Change in WUA	**0.6**	**0.6**	**2.2**	**3.6**	**6.3**	**4.7**	**0.6**	**1.1**	**16.0**	**2.1**	**4.5**	**11.2**	**30.2 (49%)**	**23.3 (28%)**
Spawning														
Baseline Conditions	0.0	0.1	2.3	2.4	4.6	6.3	0.0	0.4	18.6	26.7	4.1	7.6	**29.6**	**43.5**
Expansion Project	0.0	0.5	3.1	3.7	8.3	9.0	0.0	0.3	25.4	28.0	6.8	11.9	**43.6**	**53.4**
Change in WUA	**0.0**	**0.4**	**0.8**	**1.3**	**3.7**	**2.7**	**0.0**	**-0.1**	**6.8**	**1.3**	**2.7**	**4.3**	**14.0 (47%)**	**9.9 (23%)**

Note: Minimum and maximum values are associated with the life-stage period

Table 14.8.12 — Lake Whitefish WUA Values under Baseline Conditions and 56 MW Expansion Project Conditions

Lake Whitefish Life Stage	REACH 1		REACH 2						REACH 3				Trudel Creek (totals for all reaches)	
	Riverine Habitat		Gertrude Lake		Trudel Lake		Riverine Habitat		Unnamed Lake		Riverine Habitat			
	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)
Juvenile Rearing														
Baseline Conditions	11.5	23.5	48.1	56.1	47.8	75.6	8.0	10.9	77.2	154.6	41.3	61.5	**233.9**	**382.2**
Expansion Project	20.3	22.3	45.2	47.2	41.2	45.7	3.0	6.9	60.3	69.9	28.7	38.5	**198.7**	**230.5**
Change in WUA	**8.8**	**-0.2**	**-2.9**	**-8.9**	**-6.6**	**-29.9**	**-5.0**	**-4.0**	**-16.9**	**-84.7**	**-12.6**	**-23.0**	**-35.2 (-15%)**	**151.7 (-40%)**
Adult Rearing														
Baseline Conditions	17.4	20.8	45.5	54.1	27.3	57.6	0.7	7.9	33.2	84.5	15.9	36.3	**140.4**	**261.2**
Expansion Project	11.2	16.4	40.4	43.4	21.3	52.1	0.0	0.5	22.1	28.5	8.2	13.4	**103.2**	**154.3**
Change in WUA	**-6.2**	**-4.4**	**-5.1**	**-10.7**	**-6.0**	**-5.5**	**-0.7**	**-7.4**	**-11.1**	**-56.0**	**-7.7**	**-22.9**	**-37.2 (-26%)**	**106.9 (-41%)**
Spawning														
Baseline Conditions	1.9	2.0	13.4	13.8	5.4	6.3	0.3	0.5	86.4	86.6	9.0	10.3	**116.4**	**119.6**
Expansion Project	1.9	2.0	8.6	8.6	8.9	8.9	1.4	1.5	76.1	78.0	5.9	6.0	**102.8**	**105.0**
Change in WUA	**0.0**	**0.0**	**-4.8**	**-5.2**	**3.5**	**2.6**	**1.1**	**1.0**	**-10.3**	**-8.6**	**-3.1**	**-4.3**	**-13.6 (-12%)**	**-14.6 (-12%)**

Note: Minimum and maximum values are associated with the life-stage period

Table 14.8.13 — Walleye WUA Values under Baseline Conditions and 56 MW Expansion Project Conditions

Walleye Life Stage	REACH 1		REACH 2						REACH 3				Trudel Creek (totals for all reaches)	
	Riverine Habitat		Gertrude Lake		Trudel Lake		Riverine Habitat		Unnamed Lake		Riverine Habitat			
	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)	Min WUA (ha)	Max WUA (ha)
Juvenile Rearing														
Baseline Conditions	5.1	9.9	16.1	17.2	37.8	44.5	0.1	0.4	131.0	145.6	3.3	6.4	**193.4**	**224.0**
Expansion Project	0.4	6.0	16.6	17.1	41.9	43.6	0.0	0.4	137.3	143.5	0.3	3.9	**196.5**	**214.5**
Change in WUA	**-4.7**	**-3.9**	**0.5**	**-0.1**	**4.1**	**-0.9**	**-0.1**	**0.0**	**6.3**	**-2.1**	**-3.0**	**-2.5**	**6.2 (2%)**	**-7.1 (-4%)**

Note: Minimum and maximum values are associated with the life-stage period

Table 14.8.14 compares the availability of preferred habitat conditions of the Valued Components under a 36 MW and 56 MW power generating facility.

Table 14.8.14 — Availability of Preferred Habitat Conditions Associated with a 36 MW and 56 MW Power Generating Facility

Location	Northern Pike Juvenile Rearing		Northern Pike Spawning		Lake Whitefish Juvenile Rearing		Lake Whitefish Adult Rearing		Lake Whitefish Spawning		Walleye Spawning	
	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW	36 MW	56 MW
Trudel Creek	90.8 to 111.7	91.9 to 108.0	43.8 to 55.6	43.6 to 53.4	200.6 to 247.7	198.7 to 230.5	104.8 to 140.6	103.2 to 154.3	105.4 to 107.2	102.8 to 105.0	197.8 to 219.4	196.1 to 210.2

Based on the similarities in the availability of preferred habitat conditions under a 36 MW and a 56 MW operation scenario, the implications to habitat structure and cover for each of the Valued Component would be the same.

14.8.6.3.2 Ramping Pathways [56 MW]

A complete discussion of the baseline and post Expansion Project ramping conditions is provided in Section 14.3.3 and Section 6.6 Project Operations. The effects as described below are associated with scheduled or planned outages for maintenance purposes. Under a scheduled outage, turbines would be taken offline one at a time to limit ramping effects.

A scheduled or planned outage would result in the contiguous shutdown of the three turbines for maintenance purposes during April and/or May to coincide with the onset of freshet. Each new turbine associated with the proposed 56 MW expansion would generate 28 MW and require 80 m^3/s to run at full capacity. Upon shutdown of the 28 MW turbine, the spillway channel would be opened and 30 m^3/s would be directed to the existing tailrace location. Therefore, during a scheduled shutdown event, flows over the SVS would increase by 50 m^3/s during the maintenance of the new turbines. The existing 18 MW turbine requires a similar amount of water to operate at full capacity and thus would cause similar ramping conditions along Trudel Creek

Based on the HEC-RAS model, the increase in 50 m^3/s would result in roughly an 80 cm increase in water elevation based on typical water levels along Trudel Creek during April/May. Velocity changes from 0.25 m/s to 0.50 m/s are also predicted. Based on these anticipated depth and velocity changes, a scheduled ramping event has the potential to affect the Valued Components northern pike, lake whitefish and walleye in four ways:

- incubating egg displacement during increased flows,
- juvenile and adult displacement during plant start-ups,
- dewatering of incubating eggs during plant start-ups, and
- increased erosion and deposition, potentially smothering incubating eggs.

14.8.6.3.2.1 Displacement of Incubating Eggs

The proposed scheduled outages and/or maintenance period of the turbines has been planned to occur in April/May to coincide with the onset of freshet. This time period overlaps the timing window of spawning/egg incubation of walleye and northern pike; lake whitefish emergence typically occurs by March. Therefore, there could be a potential to displace northern pike and walleye incubating eggs.

Within the riverine habitats, northern pike would spawn in protected bay-type habitats along the stream margins, which are characterized by low gradients, dense in-stream vegetation and low velocity. These areas are typically off-channel habitats that would experience less of a velocity increase than that anticipated in the mainstem channel. As such, it is not anticipated that northern pike incubating eggs would become displaced during a scheduled ramping event.

Walleye within the Trudel Creek system can spawn in both riverine and lacustrine habitats. Within riverine habitats, walleye can spawn in shallow and deep water habitats in flows ranging from pools to rapids. Walleye prefer to spawn over larger substrates where their adhesive eggs can stick to the substrate. The anticipated increase in velocities during a scheduled ramping event would not exceed the preferred habitat conditions of walleye spawning. In addition, the increased velocities would not result in the movement of gravel or cobbles, of which incubating walleye eggs would likely be attached. As such, it is unlikely that a scheduled ramping event would result in dislodgement and or transport incubating walleye eggs in riverine habitats. Velocity conditions are not anticipated to change in lacustrine habitats. Therefore, scheduled ramping events would not result in the displacement of incubating walleye eggs in the lakes.

In the event that a scheduled shutdown occurred earlier in the year (i.e., March), ramping would occur during lake whitefish egg incubation period. Lake whitefish typically spawn within lakes at depths greater than 2 m over cobbles, gravels or sand. As lake whitefish are broadcast spawners, incubating eggs would be found within the interstitial spaces of the substrates associated with the spawning grounds. The anticipated velocity increases associated with a scheduled outage would not result in the movement of even sand-sized substrates. Therefore, it is unlikely that the ramping flows associated with a scheduled plant outage would result in the displacement and/or transport of incubating lake whitefish eggs.

14.8.6.3.2.2 Displacement of Juvenile and Adult Fish

Controlled shutdowns followed by a plant start-up could lead to displacement and potentially stranding of northern pike, lake whitefish and walleye.

Northern pike are likely to move into the newly-wetted habitats associated with an elevated waterline where water depths are lower and more suited to their preferred habitat conditions. During the plant start-up and subsequent decrease in waterline elevation, northern pike could become displaced. A slow or non-abrupt reduction in waterline elevation typically allows fish the opportunity to move out of pool habitats before they become disconnected from the mainstem. Operational guidelines would be in place to regulate the rate at which turbines are brought back online, thus regulating flows over the SVS. This regulated flow over the SVS, coupled with the natural attenuation of flows within the lake systems of Trudel Creek, would provide fish considerable time to move out of pool areas; however, a possibility still exists for fish that have moved into pool habitats to become displaced.

Plant start-ups are not likely to result in the stranding of lake whitefish or walleye as rearing and overwintering typically takes place at depth and these species are not likely to move into habitats associated with an elevated waterline.

14.8.6.3.2.3 De-watering Incubating Eggs

The proposed scheduled outages and/or maintenance period of the turbines have been planned to occur in April/May. This time period overlaps the timing window of spawning/egg incubation of walleye and northern pike; lake whitefish emergence typically occurs by March. Therefore, there could be a potential to dewater incubating eggs.

During a scheduled shutdown the waterline elevation within Trudel Creek would increase. As maintenance on the turbines would be conducted contiguously to minimize the increase of flows over the SVS and into Trudel Creek, the maintenance period is anticipated to extend over three weeks. If the shutdown event occurs during April/May, species such as northern pike and walleye could move into the newly wetted stream margins to spawn. Upon completion of the maintenance works and the start-up and operation of all three turbines, flows over the SVS would decrease and subsequently the waterline elevation would drop. Incubating eggs spawned in water 0.8 m or less could potentially become dewatered.

Northern pike spawning typically begins after ice breakup and in waters ranging from 4 °C to 16 °C (Evans et al., 2002). Based on the installed temperature loggers, water temperatures do not reach 4 °C until late May in Trudel Creek. In addition, ice breakup also occurs in May on Trudel Creek. Therefore, northern pike spawning is not anticipated to begin until late May/early June in Trudel Creek. If the scheduled shutdown event occurred in early April, there would be limited, if any, incubating eggs effected by the shutdown. Should the shutdown event extend into May, the potential for northern pike incubating eggs to become dewatered increases. Northern pike eggs typically incubate between 14 and 18 days prior to emergence. Therefore, the shutdown event has the potential to effect approximately two weeks of the spawning window; no eggs spawned 18 day previous to the plant start-up or post plant start-up are likely to be affected. In addition, the timing of the scheduled shutdown event is anticipated to occur simultaneously with freshet. Depending on the flow conditions prior to freshet, a portion of the freshet flows may be spilled into Trudel Creek during the scheduled shutdown. Therefore, if Trudel Creek experiences freshet flows, the waterline elevation would not drop to pre shutdown levels.

Walleye spawning occurs in the spring through April and June when water temperatures range between 4.5 °C to 14 °C (Evans et al. 2002). No juvenile walleye have been identified within Trudel Creek to confirm emergence timing; however, based on the installed temperature loggers, water temperatures do not reach 4.5 °C until the end of May/early June. Therefore, it can be assumed that walleye spawning would not begin until mid to late May. With a scheduled shutdown occurring for three weeks, it is anticipated that the majority of maintenance would be completed prior to walleye spawning. In addition, walleye spawn at depths from 0.2 m to depths greater than 2 m. Therefore, not all incubating walleye eggs would be affected.

14.8.6.3.2.4 Erosion and Deposition

The proposed increase in depth and velocity conditions has been planned to occur in April and/or May. This time period overlaps the timing window of spawning/egg incubation of walleye and northern pike; lake whitefish spawning and egg incubation periods are typically complete by March.

The potential for the increase in velocities to dislodge and transport sediment downstream to a deposition area are low. Historical erosion rates within Trudel Creek following the construction of the Twin Gorges facility resulted in an increase in channel widths and the channel banks began to self-armour (Klohn Crippen Berger 2008). The proposed increase in flow of 50 m^3/s and subsequent depth (0.8 m) and velocity (0.25 m/s) increases would result in a low increase in erosion potential within most sections of Trudel Creek based on the channel widths, historic self-armouring of channel banks, and low increase in channel velocities.

14.8.6.4 CUMULATIVE EFFECTS

The hydrological regimes within Trudel Creek have varied throughout the operational history of the Twin Gorges power plant. For the purpose of this description, the hydrology of Trudel Creek has been divided into four time periods, or hydrological eras. These periods include the Pre-Twin Gorges era (pre–1964), the Pine Point era (1964–1986), the Baseline era (1986–present), and the Expansion Project era.

Prior to development of the Twin Gorges Facility in 1964, Trudel Creek was a non-regulated system. There was no in-stream development or flow management in the Taltson River or Trudel Creek watersheds, according to the NWT license database review and local knowledge of activities that could affect Trudel Creek. The hydro development of the Tazin River occurred in 1929, pre-Twin Gorges; however, changes in connectivity from pristine to post-Tazin development is not known. Therefore, the pre-1964 condition of Trudel Creek was considered the “pristine” condition for this cumulative effects assessment. There are no foreseeable projects that would affect Trudel Creek in addition to the Expansion Project.

Limited data is available to determine pre-development conditions, as no descriptions, drawings, ground level photographs, or flow records of Trudel Creek or the site of the SVS prior to construction were attainable.

Therefore, the watershed assessment was conducted through historic aerial photograph review and traditional knowledge to assess the pre-development condition and Pine Point era condition, channel morphology, flows and connectivity with the Taltson River. The results of the watershed assessment are summarized in Section 14.1 – Trudel Creek Introduction.

14.8.6.5 CUMULATIVE EFFECTS ASSESSMENT

This section discusses the anticipated cumulative effects of those pathways that are anticipated to have a residual effect from the proposed Expansion Project. They would be discussed in the context of what we know of about the pristine (i.e., unaltered) environment associated with Trudel Creek and the residual effects of previous and existing developments.

Past and previous developments having residual effects on the Trudel Creek system include the components associated with the Twin Gorges construction (1965) and operation (1986–present). The construction of the Twin Gorges power generating facility included: damming the Taltson River; installing the penstock pipeline, powerhouse and tailrace facilities; and installing a concrete apron and a spillway channel at the SVS. In terms of Pathways of Effect, this development imposed many of the pathways associated with the *"Flow Management (Altered Frequency, Amplitude, Duration, Timing and Rate of Change of Flow)*" and "*Fish Passage Issues*" (see POE flow charts in Figure 14.8.13 and Figure 14.8.14 respectively).

The pathways associated with ongoing residual effects of the Twin Gorges operation (1986–present) in Trudel Creek are as follows:

- Flow Management: alteration in Depth, Cover, Velocity and Substrate Conditions with Respect to Fish Habitat Structure and Cover.
- Flow Management: increase in Flows (Ramping) with Respect to Displacement or Stranding of Fish.
- Fish Passage Issues: alteration of Access/Migration Patterns with Respect to Rearing and Spawning Habitat and Food Supplies.

Based on the incremental effects analysis, residual effects in Trudel Creek associated with the proposed Expansion Project (both 36 MW and 56 MW scenarios) include:

- Flow Management: alteration in Depth, Cover, Velocity and Substrate Conditions with Respect to Fish Habitat Structure and Cover.
- Flow Management: increase in Flows (Ramping) with Respect to Displacement or Stranding of Fish.
- Flow Management: bank Erosion/Erosion of Channel Bed with Respect to Deposition Zones.
- Fish Passage Issues: alteration of Access/Migration Patterns with Respect to Rearing and Spawning Habitat and Food Supplies.

Therefore, pathways resulting in potential cumulative effects in Trudel Creek include:

- Flow Management: alteration in Depth, Cover, Velocity and Substrate Conditions with Respect to Fish Habitat Structure and Cover.
- Fish Passage Issues: alteration of Access/Migration Patterns with Respect to Rearing and Spawning Habitat and Food Supplies.

Ramping was identified as an ongoing effect as well as an incremental effect, but was not considered for the cumulative effects assessment as the residual effects do not build on each other.

14.8.6.5.1 Fish Habitat Structure and Cover

To assist with the incremental effects assessment of the fish habitat structure and cover pathways, the approach as described in the BC Guidelines was used. This approach was not possible for the determination of cumulative effects as WUAs could not be accurately generated for the pre-Twin Gorges hydrological era. The erosional processes that occurred during the first 5 to 10 years of operation of the existing power-generating facility altered the pristine channel morphology. The cross-sectional data that the WUA curves are based on represent current morphology conditions and would therefore misrepresent the pristine conditions. Therefore, a qualitative review of the potential cumulative effects was conducted.

Aerial photo interpretation indicates that meandering channel morphology and a low-energy system was present prior to the Twin Gorges development. Minimal fast-moving water would likely have existed, although small falls or rapid sections may have been present in the locations of the baseline bedrock controls which hold the lakes. Trudel Creek likely provided dense in-stream submergent and emergent vegetation communities and a variety of riparian vegetation species.

Twin Gorges operation (1986–present) significantly increased the flows experienced in Trudel Creek and resulted in an elevated waterline. Clearly, the in-stream and riparian vegetation communities along the stream margins were altered and the depths throughout the entire Trudel Creek system were increased. Based on recent fish and fish habitat assessments, the in-stream submergent and emergent vegetation communities have established and stabilized along the elevated stream margins. The system remains a relatively slow-moving channel due to the low gradient nature; however, some rapid sections have resulted in Reach 1.

The proposed alteration in flow management into Trudel Creek would result in a decreased waterline elevation, thereby bringing Trudel Creek closer to the pre-development or “pristine” conditions.

A hydrological assessment of Trudel Creek (Rescan, 2007) suggests that even though the Project would result in a decreased waterline elevation, it would likely be higher, on average, than that experienced during pristine conditions. Therefore, it can be assumed that the water depths within Trudel Creek would be greater than those experienced during pristine conditions and as such, would likely provide more habitat availability to lake whitefish and walleye. An increased waterline elevation over pristine would likely provide a negligible increase to northern pike habitat availability as they depend on the shallow stream margins that would be present in similar quantities in both situations. Therefore, the cumulative effects associated with the Expansion Project would likely result in an increase in preferred habitat conditions for lake whitefish and walleye and a neutral change to northern pike habitat availability.

14.8.6.5.2 Access and Migration to Rearing and Spawning Habitat and Food Supplies

Under pristine conditions, the accessibility and quantity of off-channel areas providing rearing and spawning habitat for the Valued Components was not attainable. Review of the historical aerial photos indicates that the system was characterized by a slow-moving meandering channel; however, it was not possible to identify with confidence the number, quantity or accessibility of off-channel habitat sites. Therefore, a cumulative effects assessment on access and migration to off-channel habitats was not possible based on the limited information available.

14.8.7 Effect Classification

Table 14.8.15 summarizes the classification of the incremental effects on the Valued Components northern pike, lake whitefish and walleye. The risks to fish and fish habitat within Trudel Creek range from low adverse to moderate adverse.

Effects were classified together for both the 36 MW and 56 MW expansions. Where classifications differed, the more severe effect was rated and presented in the classification table. Specifically, the scheduled outage would cause a ramping event along Trudel Creek that would last for three weeks. The highest change in water levels would occur under the 56 MW expansion (80 cm for three weeks). This magnitude change in water level is greater than the predicted change under the 36 MW expansion (40 cm for two weeks and roughly 70 cm for one week). In terms of potential magnitude of effects to fish, and in particular northern pike, the two options would be similar but more marginally more severe under the 56 MW expansion. However, the frequency of occurrence of the 56 MW ramping event is considerably rarer compared to that of the 36 MW ramping event. By using the more severe magnitude of effect predicted under the 56 MW expansion together with the greater frequency of occurrence under the 36 MW expansion, the overall residual effect is considered conservative on the side of over estimating the adverse effect.

Table 14.8.15 — Incremental Effects Assessment Classification

Valued Component	Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Overall Risk / Assessment Effect
Northern pike Walleye	Flow management: alteration in depth, cover, velocity and substrate conditions with respect to fish habitat structure and cover	Beneficial	Moderate	Trudel Creek	Medium-term	Reversible	Continuous	Highly likely	Moderate / Beneficial
Lake whitefish	Flow management: alteration in depth, cover, velocity and substrate conditions with respect to fish habitat structure and cover	Adverse	Moderate	Trudel Creek	Medium-term	Reversible	Continuous	Highly likely	Moderate / Adverse
Northern pike Lake whitefish Walleye	Flow management: bank erosion / erosion of channel beds with respect to deposition zones	Beneficial	Low	Trudel Creek	Medium-term	Reversible	Continuous	Highly likely	Low / Beneficial
Northern pike, Lake whitefish Walleye	Flow management: increase flows with respect to ramping events	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Periodic	likely	Low / Adverse
Northern pike	Fish passage issues: alteration of migration patterns with respect to rearing habitat and food access/migration	Adverse	Low	Trudel Creek	Long-term	Reversible	Continuous	Highly likely	Low / Adverse

14.8.8 Significance Determination

Table 14.8.16 summarizes the determination of significance for the incremental effects on the Valued Components northern pike, lake whitefish and walleye.

Table 14.8.16 — Determination of Significance to the Valued Components

Valued Component	Valued Component Assessment Endpoint	Overall Residual Effect	Overall Significance	Uncertainty
Northern pike	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events Changes to rearing and spawning habitat and food access / migration	Moderate/Beneficial Low/Beneficial Low/Adverse Low/Adverse	Not significant	Intermediate
Lake whitefish	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events	Moderate/Adverse Low/Beneficial Low/Adverse	Not significant	Low
Walleye	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events	Moderate/Beneficial Low/Beneficial Low/Adverse	Not significant	Low to Intermediate

14.8.9 Uncertainty

14.8.9.1 Northern Pike

The primary assumption made during the analysis of northern pike was that vegetation would re-establish along the shifted stream margins and shorelines of the riverine and lacustrine habitats respectively. If this does not occur, the WUA model would have overestimated the preferred cover conditions for northern pike rearing and spawning during the Expansion Project hydrological conditions. As previously mentioned, the assumption was based on the following parameters:

- Trudel Creek has historically re-established a diverse community of emergent and submergent vegetation after experiencing a significant alteration to the hydrological conditions.
- The rooted depth zone in the lake systems and some sections of the riverine habitat is below the anticipated change in water level elevation.
- Submergent and emergent vegetation appears to establish in all areas that are defined by shallow slow-moving waters and fine substrates.

The above assumption was based on information gathered during the field study programs, and from model data, supporting literature, and professional judgment.

14.8.9.2 Lake Whitefish

The primary assumption made during the analysis of lake whitefish was in respect to the change in depth conditions within each of the lake systems. Depth changes within the lake systems were based on lake transect data generated from bathymetry. The maximum water level change from baseline to Expansion Project over a calendar year, based on maximum and minimum monthly averages, was calculated at approximately 2 m in each lake. The model indicates that depths associated with the lakes may be considerably lower (refer to Section 14.3 – Alterations of Water Quantity). For this reason, the WUA analysis may have overestimated the change in preferred habitat conditions within Gertrude and Unnamed Lake as water depths would not decrease as much as originally calculated.

The above assumption was based on information gathered during the field study programs, and from model data, supporting literature, and professional judgment.

14.8.9.3 WALLEYE

The primary assumption made during the analysis of walleye was that walleye would use lacustrine habitats to spawn as readily as riverine habitats. The WUA model suggests that walleye spawning in riverine habitats of Trudel Creek would be reduced 3.5 ha to 6.5 ha; however, walleye spawning in lacustrine habitats could be increased by up to 10.9 ha. If walleye would not use the lacustrine habitats to spawn, the effects associated with the reduction of flows over the SVS would be under-estimated.

The above assumption was based on information gathered during the field study programs, and from supporting literature and professional judgment. As such, there is an intermediate level of certainty in the walleye assessment.

14.8.10 Monitoring

Monitoring programs were developed to record the effects over time, to compare the predictions made in this effects assessment, and to determine the effectiveness of the implemented environmental design features for Trudel Creek. The monitoring program for Trudel Creek focuses on two key biological aspects, including fish and habitat use, and vegetation re-establishment. Tools used to undertake monitoring of these as well as other aspects of the ecological components of Trudel Creek include vertical aerial photography and field sampling programs.

14.8.10.1 VERTICAL AERIAL PHOTOGRAPHY

Low and high level aerial photographs would be collected every two years over an eight-year period. Aerial photographs would be used to monitor:

- active erosion and deposition sites,
- vegetation community and wetland re-establishment rates, and
- access to off-channel habitats.

Aerial photographs would be collected in late summer where in-stream submergent and emergent vegetation communities and wetland vegetation communities would be in full bloom.

14.8.10.2 FISH AND HABITAT USE

Fish and Fish Habitat would be monitored once during the first two years of the Expansion Project and again two years later. Monitoring would include:

- re-evaluating previously-identified spawning and rearing habitats of northern pike, lake whitefish and walleye;
- conducting a fish sampling program focussing on abundance and diversity of fish populations in comparison to baseline conditions; and

- identifying any migration barriers or obstacles within the Trudel Creek system through an aerial reconnaissance, and ground-truthing where necessary.

Fish sampling and photo point-monitoring sites would be established at various locations within Trudel Creek to evaluate the change of habitat quality over the four-year period.

14.8.10.3 VEGETATION

Vegetation monitoring of in-stream submergent and emergent vegetation communities would be conducted over three times over an eight-year period. Vegetation assessment and photo point-monitoring sites would be established at various locations along the Trudel Creek system to evaluate the change of vegetation communities over the eight-year period. At each monitoring site, the following information would be collected:

- submergent and emergent vegetation species presence;
- elevation range of submergent and emergent vegetation growth in relation to waterline elevation; and
- channel morphology and depth characteristics at each site.

Information collected would be used in conjunction with the aerial photographs to evaluate the growth rates associated with all riverine and lacustrine habitats in Trudel Creek.

14.8.10.4 TEMPERATURE LOGGERS

Temperature data loggers would be installed in Trudel Creek to measure annual water temperatures every six hours. Data collected pre-Expansion Project would be compared to post-Expansion Project water temperatures to determine if the reduction in flows over the SVS may have affected water temperatures in Trudel Creek.

TABLE OF CONTENTS

PAGE

TABLE OF FIGURES

TABLE OF TABLES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.9 WILDLIFE

Wildlife surveys were conducted in the Project area as part of baseline studies and the Northwest Territories Power Corporation's (NTPC) Water Effects Monitoring Program (WEMP). Aerial surveys were conducted for beaver and muskrat in 2000 and 2001, respectively, as part of the WEMP (Rescan 2000, 2001). In 2003, a follow-up aerial beaver survey was also conducted for the WEMP (Rescan 2004a). Aerial surveys were flown in 2003 and 2004 to document raptors, waterfowl, ungulates, and carnivores as part of baseline studies; however, the flight lines did not overlap with Trudel Creek (Rescan 2004b). In 2008, baseline studies were conducted to document the presence of yellow rail, waterfowl, and northern leopard frogs within Trudel Creek (Appendix 13.10A).

Many of the wildlife effects assessed in this section rely heavily on results of models developed for the Project. This includes the hydrological model that has been developed for Trudel Creek (Section 14.3) and the wetlands model (Section 14.6).

14.9.1 Existing Environment

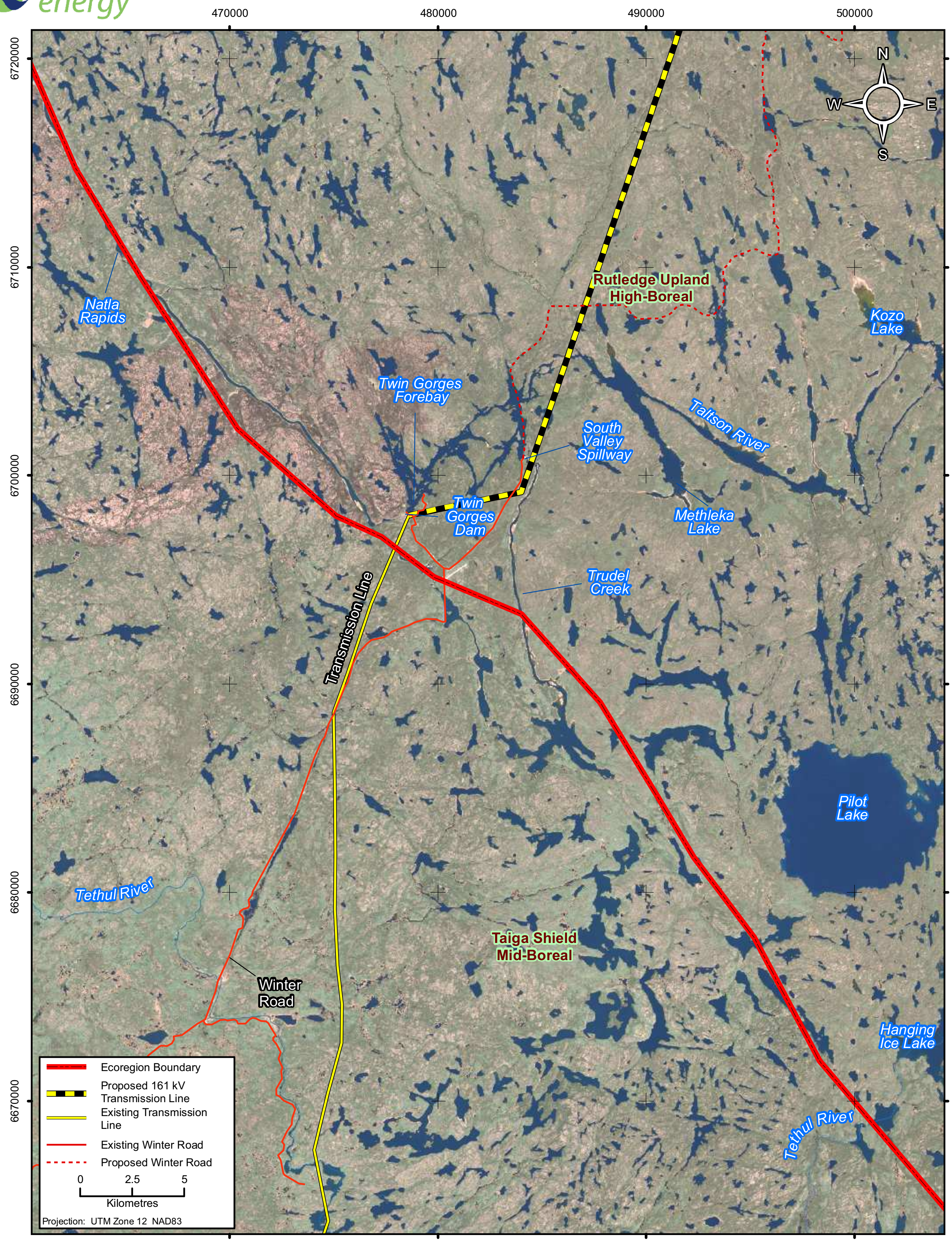
The Taltson Hydroelectric Expansion Project ("Project" or "Expansion Project") falls within the Taiga Shield ecozone (Figure 14.9.1 - Environment Canada 2005; Ecosystem Classification Group 2007). Ecozones are large, generalized units at the top of the ecological hierarchy that are defined by the Canada Committee on Ecological Land Classification (Ecological Stratification Working Group 1995). Ecozones are further subdivided into ecoprovinces and ecoregions (see Table 9.1.1). An ecoregion is part of an ecozone characterized by distinctive regional ecological factors, including climate, physiography, vegetation, soil, water, fauna, and land use. The ecoregions that overlap Trudel Creek (Zone 5) are the Slave Plain Mid-Boreal (MB) and the Rutledge Upland High-Boreal (HB).

14.9.1.1 SLAVE PLAIN MID-BOREAL ECOREGION

The Taiga Shield MB ecoprovince lies within the Taiga Shield ecozone. It is bounded on the east by the Rutledge Upland High-Boreal ecoregion and the Taiga Plain ecozone on the west (Ecosystem Classification Group, 2007). This ecoprovince contains the most south-western Project area. It has a mid-boreal climate with the mildest conditions in the NWT. The mean annual temperature ranges from –3.0 °C to –4.0 °C. The mean temperature is –22 °C in January, the coldest month, and 16 °C in July, the warmest month. Mean annual precipitation is between 330 mm and 360 mm, with the wettest period occurring between May and October and the driest period between November and April. About 60% of the precipitation falls as rain and 40% as snow. Permafrost is uncommon.

Peatlands cover nearly a third of the Taiga Shield MB ecoprovince. Fens are the characteristic wetland; they cover large areas and are interspersed with sedge and grass meadows and upland forests. Productive mixed-wood, deciduous, and coniferous stands occur on imperfectly- to well-drained lacustrine and fluvial deposits, which are most extensive in the southern half of the ecoregion. The dominant tree species are trembling aspen, Jack pine, and white and black spruce. The understorey consists of typical boreal species such as low-bush cranberry, prickly rose, and reed-bentgrass. The species found within moist meadows are awned sedge, reed-bentgrass, and other grasses, sedges, and forbs. The grass and sedge meadows found in this ecoregion provide habitat for bison and moose.

Wildlife species in the Slave Plain ecozone include moose, woodland caribou, wood bison, wolf, black bear, marten, lynx, muskox, and Arctic ground squirrel (Environment Canada 2005). Mink and otters are also common near water bodies and other wetlands with suitable habitat. The Taiga Shield MB ecoprovince contains the highest diversity of vegetation and avian habitats in the Taiga Shield. Reported bird observations are highest along the shores of Great Slave Lake at the northern boundary of the ecoregion and near the community of Fort Smith, close to the south-western corner. Common raptors include: bald eagles, ospreys, northern goshawks, sharp-shinned hawks, red-tailed hawks, American kestrels, merlins, and northern harriers. Rough-legged hawks (a variety of owl species) and shorebirds are among the many avian migrants using the area as they travel farther north. The many lowland wetlands within the Taiga Shield MB ecoprovince provide prime habitat for a large variety and abundance of dabbling ducks. Diving ducks and other fish-eating birds frequently nest on the shorelines of Great Slave Lake and along the Taltson River, where fish are readily available. The Mackenzie Valley also forms one of the most travelled migratory routes for waterfowl in North America.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Ecoregions that fall within Trudel Creek (Zone 5)	Figure 14.9.1

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14.9.1.2 Rutledge High-Boreal Ecoregion

The Rutledge HB ecoregion is characterized by a sub-humid, high-boreal ecoclimate. The mean annual temperature ranges between –3 °C and –6 °C (Environment Canada 2005). The mean annual precipitation ranges from 280 mm to 360 mm, with most of the precipitation falling as rain during the summer months. Permafrost is extensive but discontinuous throughout most of this area. This ecoregion contains hummocky, gently-sloping bedrock ridges and plains. Organic landforms are not common because terrain is hummocky to rolling bedrock or bouldery till. Common peatland types are peat plateaus, peat palsas, floating fens, and shore fens.

Continuous till blankets and extensive fires have produced a landscape dominated by jack pine regeneration; young jack pine stands are common on recently burned outwash and bedrock. Elsewhere, closed black spruce stands with lichen and shrub understories are dominant; paper birch or dwarf birch regeneration are common on recent burns. Moss forests with a moderately dense black spruce, white spruce, or jack pine canopy occur in areas with deeper, moister soils such as the thicker till deposits in the southeast and lacustrine pockets along the western boundary. These forests usually have a shrubby or feather moss understorey. These ecoregions contain numerous small lakes linked by fast-flowing streams that eventually drain into Great Slave Lake. Strongly glaciated rock outcrops are common.

Within the Taiga Shield ecozone, the abundance of water attracts hundreds of thousands of waterfowl that either rest and feed on their way to Arctic breeding grounds or nest in the ecozone. Bird species include the Arctic and red-throated loon and the northern phalarope (Environment Canada, 2005). Wildlife found in these ecoregions includes moose, black bear, woodland caribou, wolf, beaver, muskrat, snowshoe hare, and spruce grouse. Mink are common near water bodies and other wetlands that provide suitable habitat. Otters are only found near fish-bearing streams.

14.9.1.3 Furbearers

Several stream-resident mammals occur in the study area, including beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), river otter (*Lontra canadensis*), and American mink (*Neovison vison*). Beaver and muskrat are important food and economic resources and concerns regarding their continued abundance in the Project area have been expressed (see Section 9.6).

14.9.1.3.1 Beaver (Castor canadensis)

For background biological information including baseline surveys on the beaver, refer to Section 9.5.5.9. Beaver abundance in Trudel Creek and a reference site is shown in Table 14.9.1. Locations of beaver observations in Trudel Creek are shown in Figure 14.9.2

Beaver lodges have been observed in both riverine and lake sections of Trudel Creek.

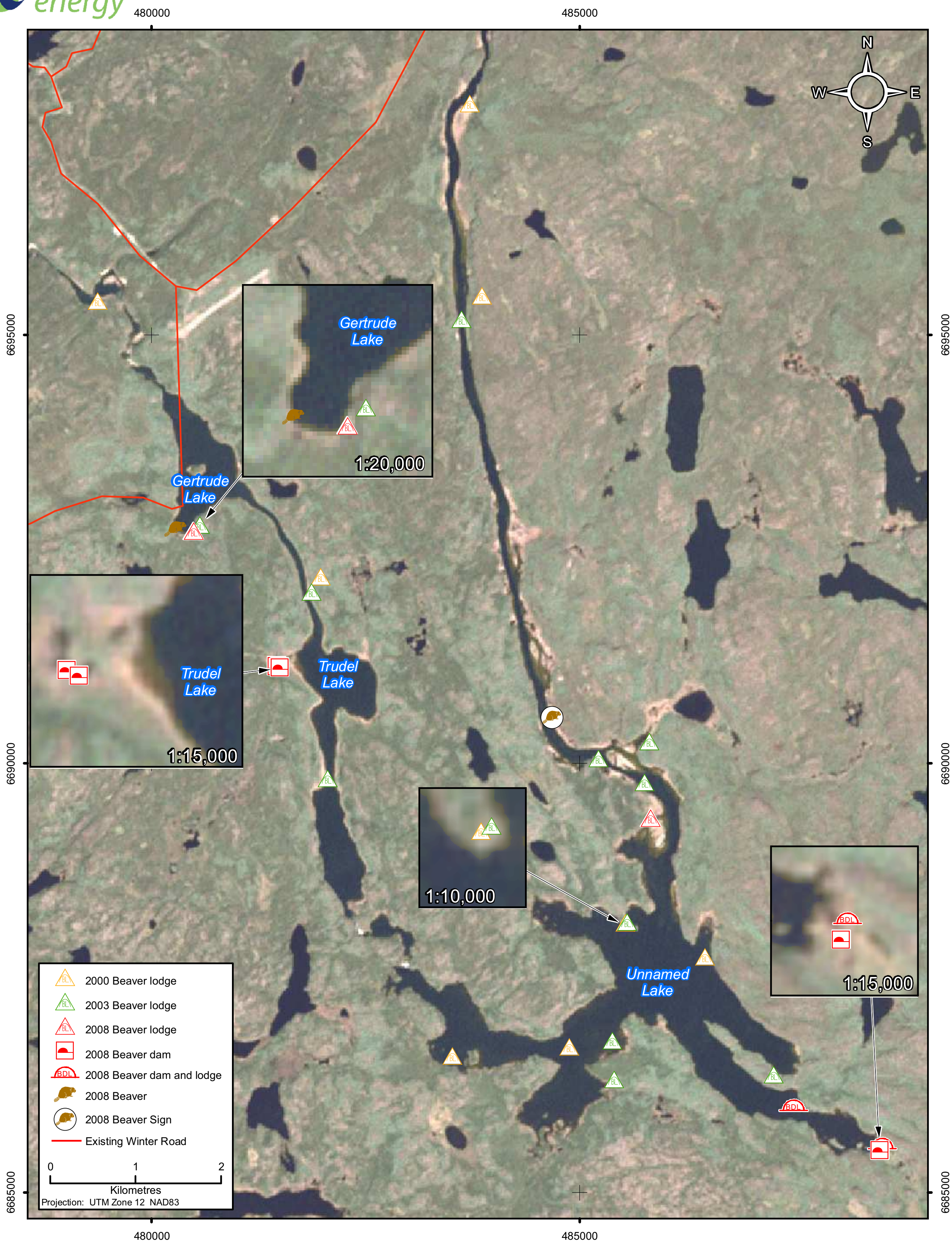
Table 14.9.1 — Results of 2000 and 2003 Aerial Beaver Surveys in Trudel Creek

Water body	# Active Lodges (2000)	# Active Lodges (2003)	# Active Lodges/ Linear km of Flown Shoreline (2000)	# Active Lodges/ Survey Hour (2003)
Trudel Creek	8	11	0.19	11.19
Hanging Ice Lake and Tethul River[1]	24	19	0.662	17.5

[1] Selected as reference/control sites.

14.9.1.3.2 Muskrat (*Ondatra zibethicus*)

For background biological information on the muskrat including baseline surveys, refer to Section 9.5.5.10. Muskrat abundance in the Trudel Creek and at a reference site is shown in Table 14.9.2. Locations of muskrat observations in Trudel Creek are shown in Figure 14.9.3.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Beaver Observations within Trudel Creek (Zone 5)	Figure 14.9.2

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Muskrat occur in marshes, ponds, lakes, and slow-moving rivers. The Project area falls at the edge of their range, which follows the treeline (Erb & Perry Jr., 2003). Muskrats in southern populations can have multiple litters a year; litter number decreases with increasing latitude and populations at the northern edge of the range may only have a single litter per year (Erb & Perry Jr., 2003; Simpson & Boutin, 1993). Muskrats build a variety of structures depending on available habitat. Along rivers, where bank substrate is appropriate for digging, they dig extensive burrows with underwater entrances as a defence against predators. The entrances to these burrows are usually 15 cm below the water surface (Rezendes, 1999). In marshes, muskrat build lodges out of vegetation and mud. Lodges vary in height from 40 cm to 180 cm (Kiviat, 1978; Rezendes, 1999). Lodge construction occurs in areas with water depths that average 30 to 40 cm and may be as low as 10 cm to 15 cm (Erb & Perry Jr. 2003). They also build feeding platforms and "push-ups" (i.e., shelters made of vegetation that cover a hole in the ice used for feeding and breathing holes). Push-ups are typically more numerous and smaller than muskrat lodges (Rezendes, 1999). Push-ups vary from 30 cm to 46 cm in height above the ice (Erb & Perry Jr. 2003).

Table 14.9.2 — Results of 2001 Aerial Muskrat Survey in Trudel Creek

Water body	# Muskrat Push-ups	# Muskrat Push-ups/Linear km of Flown Shoreline
Trudel Creek	2	0.185
Hanging Ice Lake and Tethul River [1]	23	0.634

[1] Selected as reference/control sites.

14.9.1.3.3 River Otter (Lontra canadensis)

For background biological information on the river otter including results from an aerial carnivore track survey, refer to Section 9.5.5.8 – Key Mammals: River Otter.

River otters exploit a variety of wetlands including lakes and ponds, as well as riverine habitat; they are capable of travelling long distances over land to access aquatic environments. Riparian habitat, particularly areas with fallen trees and woody debris, is important for otters (Melquist 1997). Structural complexity in stream or shoreline areas often promotes prey species diversity by providing shelter for fish and aquatic invertebrates. These areas are then used as foraging grounds by otters. Fish form the largest part of their diet; when fish are limited, they may eat crayfish, amphibians, reptiles, birds, or terrestrial vertebrates (Melquist 1997). Otters do not build houses or burrows (Ontario Fur Managers Federation, 2008), but use abandoned beaver dams or established burrows and cavities along the shore for security and overwinter denning (Melquist 1997; Ontario Fur Managers Federation, 2008). In Melquist & Hornocker, (1983; as cited in Melquist 1997) and Martin (2001), beaver presence was shown as important for otters because beaver dams create foraging and secure habitat for otters.

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Muskrat Observations within Trudel Creek (Zone 5)	Figure 14.9.3

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14.9.1.3.4 American Mink (Neovison vision)

For background biological information on the American mink including results from an aerial carnivore track survey, refer to Section 9.5.5.9 – Key Mammals: American Mink.

Mink are active hunters in both upland and aquatic habitats; their diet includes aquatic invertebrates, fish, insects, and a variety of small mammals and amphibians. Mink build shallow burrows along rivers and under logs and will often usurp burrows dug by other species, particularly muskrats (Melquist 1997). Riparian areas provide the necessary food and security elements required by mink, making them a determining factor in mink habitat quality (Martin 2001; Melquist 1997). In particular, mink often use streamside areas with fallen trees and logjams, i.e., banks with high proportions of woody debris, as foraging sites for aquatic invertebrates and temporary security habitat from predators (Melquist 1997; Ontario Fur Managers Federation 2008). The woody debris provides excellent security and cover while hunting. Along the shoreline, these areas also provide suitable burrowing habitat.

14.9.1.4 MOOSE (*ALCES ALCES*)

For background biological information on moose, refer to Section 9.5.5.7.

No targeted surveys were conducted for moose in Trudel Creek. However, incidental observations of moose and moose sign (e.g., tracks, pellets) were recorded during fisheries, wildlife, and wetland surveys in 2008 (Figure 14.9.4; Appendix 13.10A; Jason Côté, [B.Sc.] personal communication, September 19, 2008).

Dezé energy

TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Moose Observations within Trudel Creek (Zone 5)	Figure 14.9.4

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14.9.1.5 BIRDS

14.9.1.5.1 Waterfowl

For background biological information on waterfowl including baseline studies conducted in the Project area, refer to Section 9.5.3.3.

Waterfowl that build their nests on the ground close to water, feed primarily on fish, and/or feed on submerged aquatic plants within the littoral zone (i.e., dabbling ducks) may be particularly affected by hydrological changes. Table 14.9.3 presents all bird species detected in the Project area that fall within the categories listed above. There were 37 species observed in the Project area that fit one or more of the criteria described above. Ground-nesters may be affected by changes to the riparian habitat. Piscivorous species may be affected by bioaccumulation of methylmercury.

Table 14.9.3 — Bird Species Observed within the Taltson River Watershed that are Ground-Nesting or have a Piscivorous or Aquatic Vegetation Diet

Avian Group	Common Name	Scientific Name	Ground-Nesting	Piscivorous Diet	Aquatic Plant Diet	Observed along Trudel Creek
Loons	Common loon	*Gavia immer*	X	X		X
	Pacific loon	*Gavia pacifica*	X	X		
	Red-throated loon	*Gavia stellata*	X	X		
Grebes	Horned grebe	*Podiceps auritus*	X	X		X
	Red-necked grebe	*Podiceps grisegena*	X	X		X
Pelicans	American white pelican	*Pelecanus erythrorhynchos*	X	X		
Bitterns	American bittern	*Botaurus lentiginosus*	X		X	
Swans	Tundra swan	*Cygnus columbianus*	X		X	X
Geese	Canada goose	*Branta canadensis*	X		X	X
	Greater white-fronted goose	*Anser albifrons*	X		X	
	Snow goose	*Chen caerulescens*	X		X	
Waterfowl	American wigeon	*Anas americana*	X		X	X
	Blue-winged teal	*Anas discors*	X		X	X
	Bufflehead	*Bucephala albeola*		X[1]		X
	Common goldeneye	*Bucephala clangula*		X		X
	Common merganser	*Mergus merganser*	X	X		X

Avian Group	Common Name	Scientific Name	Ground-Nesting	Piscivorous Diet	Aquatic Plant Diet	Observed along Trudel Creek
	Eurasian wigeon	*Anus Penelope*	X		X	
	Greater scaup	*Aythya marila*	X	X[1]	X	
	Green-winged teal	*Anas crecca*	X		X	X
	Hooded merganser	*Lophodytes cucullatus*		X		
	Lesser scaup	*Aythya affinis*	X	X[1]	X	
	Long-tailed duck	*Clangula hyemalis*	X	X	X	
	Mallard	*Anas platyrhynchos*	X		X	X
	Northern pintail	*Anas acuta*	X		X	
	Northern shoveler	*Anas clypeata*	X		X	X
	Red-breasted merganser	*Mergus serrator*	X	X		
	Ring-necked duck	*Aythya collaris*	X		X	X
	Surf scoter	*Melanitta perspicillata*	X	X[1]		
	White-winged scoter	*Melanitta fusca*	X	X[1]		
Gruids	Sandhill crane	*Grus canadensis*	X			
	Sora	*Porzana carolina*	X			X
	Whooping crane	*Grus americana*	X			X
Shorebirds	Greater yellowlegs	*Tringa melanoleuca*	X	X		X
	Lesser yellowlegs	*Tringa flavipes*	X	X		
	Solitary sandpiper	*Tringa solitaria*	X	X		(unknown sandpiper seen)
	Spotted sandpiper	*Actitis macularia*	X			
	Wilson's snipe	*Gallinago delicata*	X	X[1]		X

[1] molluscs/clams more than fish

14.9.1.5.2 Whooping Crane (*Grus americana*)

For background biological information on whooping crane, refer to Section 9.5.7.3.10.

14.9.1.5.3 Passerines

For background biological information on passerines (songbirds), refer to Section 9.5.3.3.

14.9.1.5.4 Rusty Blackbird (*Euphagus carolinus*)

For background biological information on rusty blackbird, refer to Section 9.5.7.3.13.

14.9.1.5.5 Raptors

For background information on raptors refer to Section 9.5.3.2.

Hydrological changes and methylmercury bioaccumulation may affect raptors that consume fish. Two species observed in the Project regional assessment boundary (RAB) having a piscivorous diet are the bald eagle and osprey. Bald eagles have been observed at Nonacho Lake and in Zone 1; osprey were detected within the RAB (Rescan 2004b).

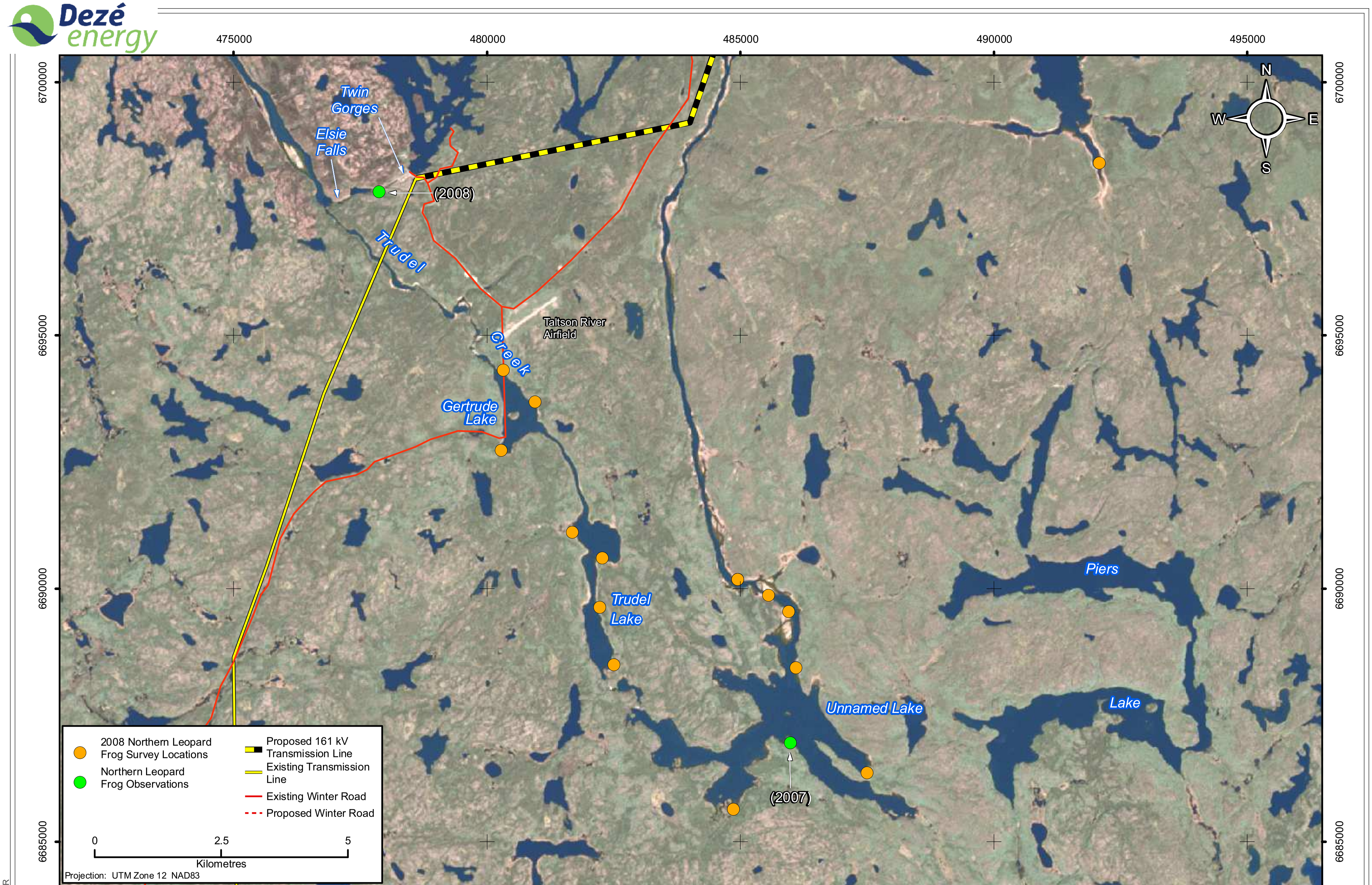
14.9.1.6 AMPHIBIANS

Two amphibian species were observed within the Project area, the wood frog (*Lithobates sylvaticus*) and the northern leopard frog (*L. pipiens*). The wood frog has the largest range of any amphibian within Canada and is considered widespread and abundant (CARCNET, 2008). The northern leopard frog is a federal species of Special Concern (COSEWIC 2000) and is discussed further below.

14.9.1.6.1 Northern Leopard Frog (*Lithobates pipiens*)

For background biological information on the northern leopard frog, refer to Section 9.5.7.3.6.

Visual encounter surveys were used to document the presence of the northern leopard frog in the Taltson River basin during July 2008. Fourteen sites were searched for northern leopard frogs in Trudel Creek as well as one nearby site upstream of Elsie Falls within Zone 3 (Figure 14.9.5). Observations had previously been made at two of these sites in August 2007 and in early July 2008 (Jason Côté, B.Sc., personal communication, July 9, 2008). Northern leopard frogs were not detected again at these sites in late July 2008. The two sites where northern leopard frog had been observed previously were classified as northern leopard frog summer habitat. Individual northern leopard frogs were probably transient and in low densities. Wood frogs were observed at 13 of the sites including tadpoles at one site classified as wood frog breeding habitat.



TALTSON
Hydroelectric Expansion Project

Developer's Assessment Report
2009

Northern Leopard Frog Observations in Trudel Creek (Zone 5)

Figure
14.9.5

14.9.2 Valued Components

14.9.2.1 Valued Component Selection

Species or wildlife communities were chosen as VCs based on a number of different criteria, including:

- identification in the Terms of Reference (TOR);
- identification as important species through community consultation (i.e., identified as socially, culturally, or economically important); or
- identification as species at risk by COSEWIC, the Species at Risk Act (SARA), or as At Risk by the GNWT General Status Ranking (GNWT, 2008; Section 9.5.7.3).

Semi-aquatic furbearers that use riparian habitat were identified within the TOR as a wildlife community to consider. Furbearer species that were chosen as VCs were beaver and muskrat. Beaver and muskrat were both identified as valued ecosystem components during the community consultation with local stakeholders performed for the 1999 WEMP (Clark 1999). Both are harvested as a food item and for commercial purposes (see Chapter 9.6). Beaver and muskrat shelters (dens, dams, lodges, and push-ups) are protected under the NWT Wildlife Act (1988). This states "no person shall without a permit entitling him or her to do so – break into, destroy or damage any den, beaver dam or lodge or muskrat push-up outside any municipality or prescribed area, unless authorized to do so by the regulations or any other law," (NWT Wildlife Act 1988). Beavers and muskrat rely on riparian and aquatic habitat for all their life history stages and requirements including foraging, shelter, and reproduction. Otters and mink were also included as VCs because they are piscivorous mammals and concerns regarding changes to mercury levels were voiced during community consultations.

Moose were selected as a VC because they are an important dietary component for the residents of Fort Resolution, Fort Smith, and Łutsel K'e (see Section 9.6). Moose are also associated with wetland and riparian habitat and are an important prey species for wolves in the Taiga Shield High-Boreal Ecoregion (Ecosystem Classification Group 2008). Moose use riparian habitat for foraging and seasonal cover.

Waterfowl that use riparian habitat were also identified within the TOR as a wildlife community to assess, and ground-nesting shorebirds were also included because of overlapping habitat requirements. Migratory birds including waterfowl, cranes, and shorebirds are protected under both the NWT Wildlife Act (1988) and the Migratory Birds Convention Act (1994). The Migratory Birds Convention Act (1994) states "no person shall disturb, destroy or take a nest, egg…of a migratory bird." Waterfowl, such as the common loon, and raptors that primarily rely on fish for their diet were also assessed.

The federally listed species at risk that were chosen as VCs were the northern leopard frog, whooping crane, and rusty blackbird, because these species use riparian and wetland habitat. These species are all afforded protection under SARA (2002). The northern leopard frog in the Project area is thought to primarily use riparian habitat for summer foraging and possibly overwintering. Whooping cranes use riparian habitat for foraging and roosting. Rusty blackbirds use riparian habitat for foraging, reproduction, and roosting.

14.9.2.1.1 Rationale for Exclusion of Species from Effects Assessment

The federally listed species that were not included as VCs were short-eared owl, common nighthawk, olive-sided flycatcher, and peregrine falcon. None of these species rely solely on aquatic or riparian habitat, and therefore were not included for assessing effects of hydrological changes. The yellow rail was not chosen as a VC because documentation of this species within the Project RAB has not been confirmed.

14.9.2.2 Assessment Endpoints

The assessment endpoint for furbearers, moose, and waterfowl is preservation of harvesting opportunities within the Taltson River watershed. This implies preservation of habitat and populations as abundance levels need to be maintained for harvesting opportunities to continue. The assessment endpoints for shorebirds, raptors that primarily consume fish, whooping crane, rusty blackbird, and northern leopard frog are preservation of habitat and/or populations within the Taltson River watershed (Table 14.9.4). Populations of the wildlife VCs occur throughout the Taltson River watershed and are not restricted to only the Project zones. Therefore, preservation of harvesting opportunities, habitat, and populations are considered within the broader regional context although Project effects were assessed at a local scale and then related to the larger area.

Table 14.9.4 — Wildlife Valued Components and Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Ecological changes in Trudel Creek	Furbearers	Preservation of furbearer harvesting opportunities along Trudel Creek
	Moose	Preservation of moose harvesting opportunities along Trudel Creek
	Waterfowl and Shorebirds	Preservation of waterfowl harvesting opportunities along Trudel Creek
		Preservation of habitat and populations along Trudel Creek
	Raptors that primarily consume fish	Preservation of populations along Trudel Creek
	Whooping crane	Preservation of habitat and populations along Trudel Creek
	Rusty blackbird	Preservation of habitat and populations along Trudel Creek
	Northern leopard frog	Preservation of habitat and populations along Trudel Creek

14.9.3 Spatial and Temporal Boundaries

The assessment boundary for preservation of wildlife harvesting activities and wildlife populations along Trudel Creek is all of Trudel Creek including a 500 m buffer (Figure 14.9.6). However, it is recognized that these populations do not exist in isolation of neighboring wildlife and that this assessment boundary is not necessarily representative of true wildlife population boundaries. Thus the assessment boundary and the overall assessment findings focus on wildlife populations along Trudel Creek and not necessary wildlife populations as they exist at a regional scale (Figure 14.9.7).

Within the assessment boundary of Trudel Creek, local assessment areas were identified as individual or multiple reaches (Reach 1, 2 and 3) and individual or multiple lakes (Unnamed Lake, Trudel Lake, and Gertrude Lake) where effects were isolated to certain sections of Trudel Creek (Figure 14.1.2).

This assessment evaluates effects related to the Project operations phase only. There are no activities during the Project construction phase that would measurably affect Trudel Creek hydrology. Currently, the Project is expected to operate for 20 years to service the existing and proposed diamond mines. However, the infrastructure would have a lifespan of at least 40 years, and it is the intent of Dezé Energy Corporation to solicit new customers to extend the Project beyond 20 years. Subsequently, the expected length of time that Project-related stressors would influence VCs during the operation phase is assumed to be 40 years. Although Dezé intends to operate the Project longer than 40 years if customers can be found, increasing the duration of the operation phase of the Project would increase the uncertainty in the effects predictions. For example, it is currently not known how much of the transmission line would be in operation after 40 years. Therefore, 40 years was defined as the longest reasonable duration of the operation phase for predicting and assessing effects from the Project.

14.9.4 Project Components

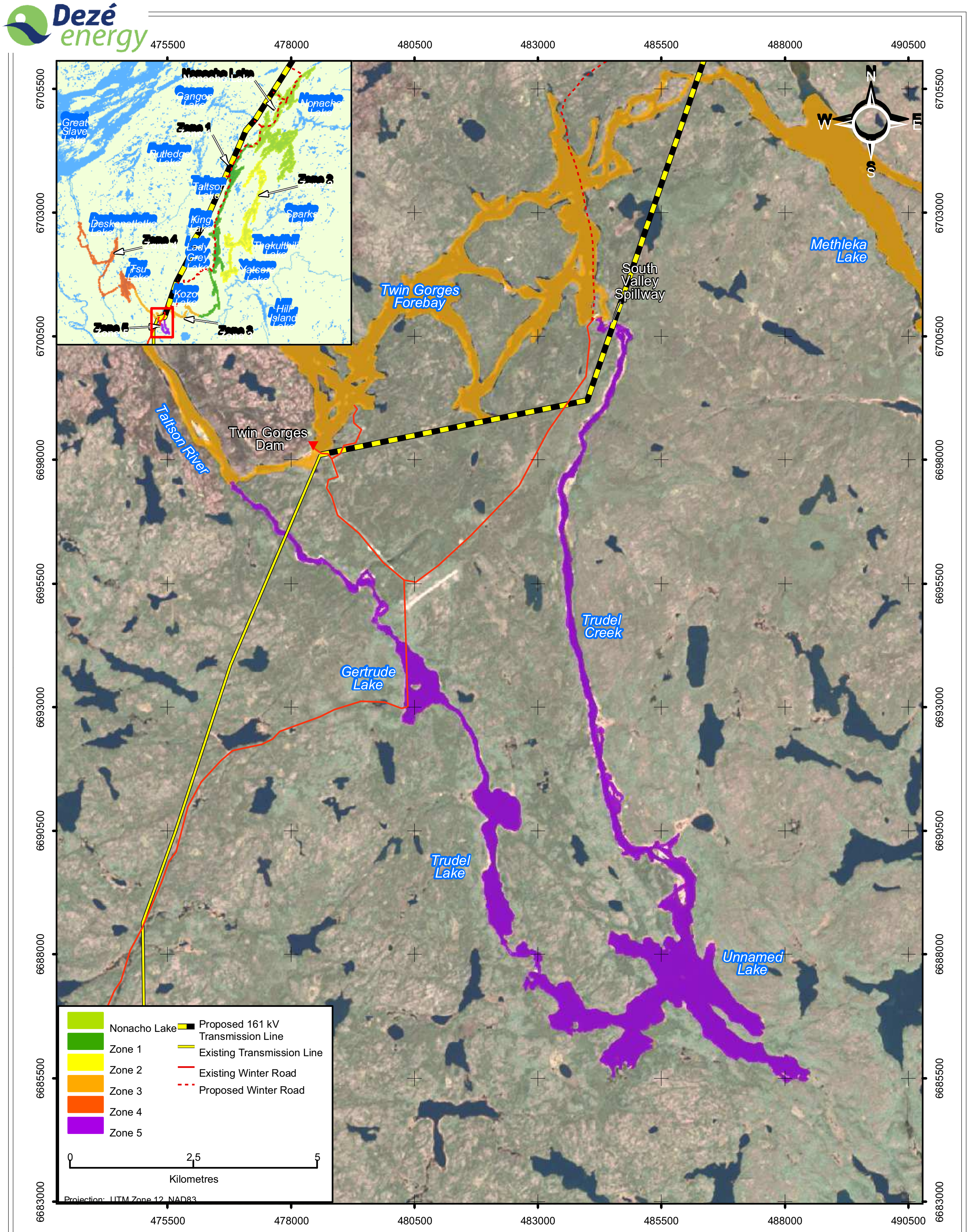
The Project operations phase refers to activities carried out under either the 36 or the 56 MW expansion options. The potential effects anticipated within the Trudel Creek system are associated with the alteration of the existing hydrograph. Of the identified Project components, the operation of the power generating facilities, including the flow release at the Nonacho control structure and/or flow through the generating facilities, are the only components that would result in flow and water level alterations within Trudel Creek. The effects of unscheduled total generation-facility shutdowns are not assessed in this section, but can be found in the Accidents and Malfunctions chapter (Chapter 17). Other Project components that may affect wildlife that are not related to changes in the hydrological regime were assessed in other KLOIs and SONs.

14.9.5 Pathway Analysis

14.9.5.1 IDENTIFICATION OF PATHWAYS

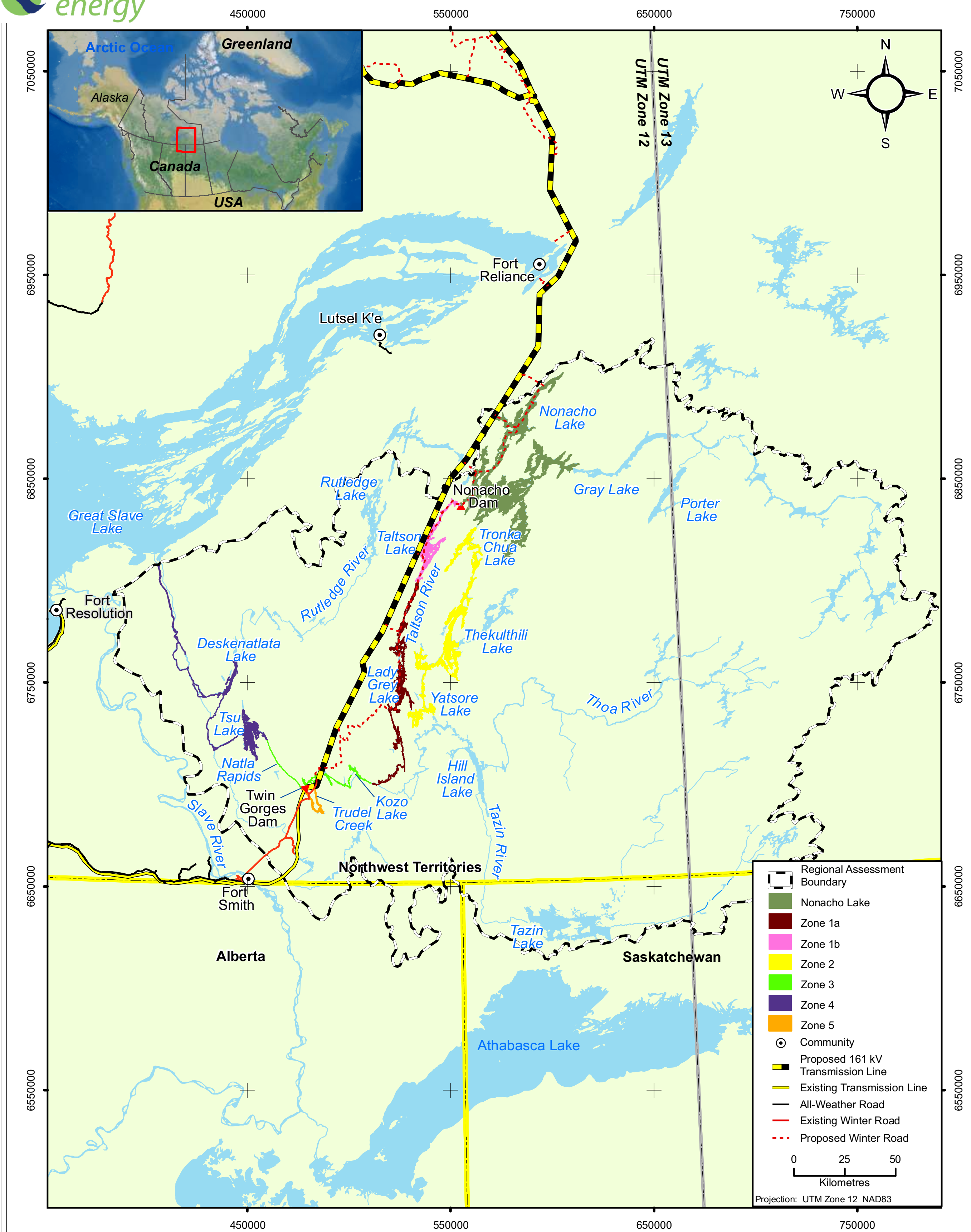
The general pathways that could affect the wildlife assessment endpoints are direct mortality, reduced reproductive success, sublethal effects through changes to diet (i.e., type or quality of diet), and riparian habitat loss or modification, all of which could lead to changes in population abundance.

Direct mortality occurs when Project activities result in the death of individual VCs. This could occur through altered water levels that create inhospitable conditions within sites used for nesting, denning, or shelter or through increased exposure of these sites to predators.



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Wildlife Assessment Boundary for Trudel Creek**	**Figure 14.9.6**

gis no. TAL-23-024bDAR



TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report 2009**	**Regional Wildlife Assessment Boundary**	**Figure 14.9.7**

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Sublethal effects, such as diet changes or habitat alteration and disturbance to feeding and breeding habitats, may not cause direct mortality but may worsen physical condition and decrease reproductive success. Reproductive success is measured as the number of young that each female produces that reach reproductive age. Reduced reproductive success can lead to declines in abundance. Females in good condition will often have more, fatter, healthier offspring who have an increased chance of surviving to adulthood. Females in poor condition will produce fewer or less healthy young. When adult females are displaced into lower-quality habitat, the young may be subjected to lower feeding rates and thus lower body mass, decreasing their likelihood of successfully surviving the winter. Poor-quality habitats with little refuge from predators may also increase juvenile mortality, as juveniles are often preferred prey. Thus, alterations to the hydrological regime in Trudel Creek may not be lethal for adults but may have an effect on reproductive success and thus population sizes. Reduced reproductive success occurs when Project activities result in the destruction of nests or denning sites, disruption of mating/breeding, and increased mortality of young.

Habitat loss occurs when Project infrastructure or activities directly displace or destroy existing habitat for wildlife species. Habitat loss can be classed as temporary or permanent or as habitat alteration/modification. Temporary loss occurs when vegetation and/or abiotic cover components are removed but subsequently recover or are reclaimed to near-original condition. Permanent loss can occur when cleared natural areas are used to support development facilities that cannot be reclaimed. Habitat alteration occurs by design, by accident, or by natural vegetation responses to temporary or permanent habitat losses nearby (e.g., edge effects, invasive species), which may change wildlife use patterns, moisture regime, competition, and/or nutrient cycling. Of these three types of habitat loss, the most serious effects are typically from permanent loss of habitat, which can involve the removal of high-quality habitat, easily disturbed habitat, large areas of habitat, or critical habitat.

In the riverine and lake sections of the Trudel system, lower water levels would result in a temporary loss of riparian habitat. For example, lower water levels would cause a loss of habitat for the emergent and submergent aquatic vegetation community (see Section 14.6). The riparian habitat loss associated with this Project is thought to be temporary and reversible as riparian communities adjust to the new hydrological regime (see Section 14.6 – Wetlands). Plant species can begin colonizing areas exposed by water drawdowns within years but may still not have stabilized after a decade or more (Odland & Moral, 2002; Shaforth, Friedman, Auble, Scott, & Braatne, 2002).

The VCs, assessment endpoints, and pathways are presented in Table 14.9.5. The rest of this section describes the general pathways per VC associated with altered water levels, and are further elaborated with reference to the Project effects in Section 14.9.5.3.

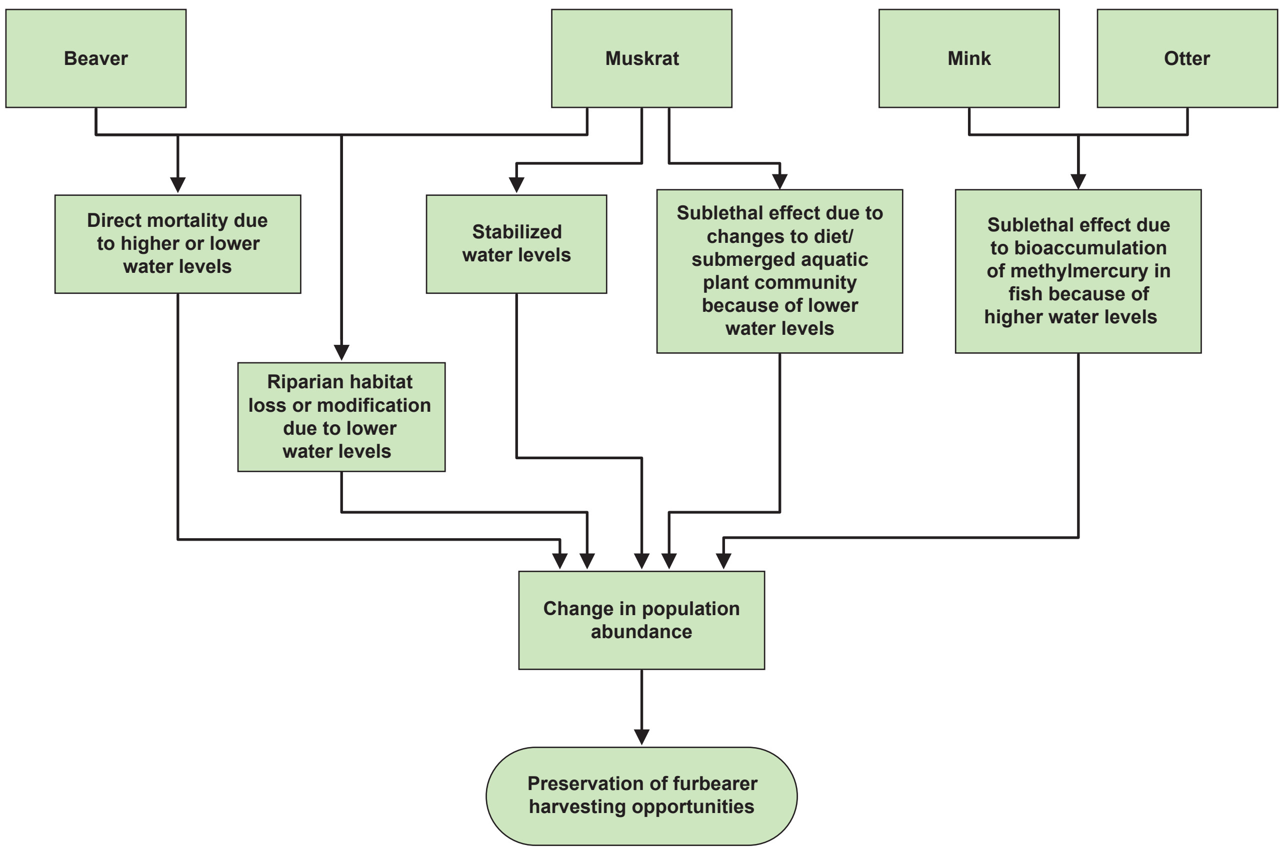
Table 14.9.5 — Wildlife Assessment Pathways

Valued Component	Assessment Endpoint	Pathway
Furbearers (beaver and muskrat)	Preservation of furbearer harvesting opportunities along Trudel Creek	Direct mortality leading to reduced population abundance
Furbearers (beaver and muskrat)	Preservation of furbearer harvesting opportunities along Trudel Creek	Riparian habitat loss/modification leading to change in population abundance
Furbearers (muskrat)	Preservation of furbearer harvesting opportunities along Trudel Creek	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Furbearers (muskrat)	Preservation of furbearer harvesting opportunities along Trudel Creek	Stabilized water levels leading to increased abundance
Furbearers (mink and otters)	Preservation of furbearer harvesting opportunities along Trudel Creek	Sublethal effect due to bioaccumulation of methylmercury in fish
Moose	Preservation of moose harvesting opportunities along Trudel Creek	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Moose	Preservation of moose harvesting opportunities along Trudel Creek	Riparian habitat loss/modification leading to change in population abundance
Waterfowl (Canada goose, mallard, loons) and Shorebirds	Preservation of waterfowl harvesting opportunities, habitat, and populations along Trudel Creek	Reduced reproductive success leading to reduced population abundance
Waterfowl (Canada goose, mallard, loons) and Shorebirds	Preservation of waterfowl harvesting opportunities, habitat, and populations along Trudel Creek	Riparian habitat loss/modification leading to change in population abundance: loss of nesting habitat
Waterfowl (dabbling ducks and aquatic vegetation feeders)	Preservation of waterfowl harvesting opportunities, habitat, and populations along Trudel Creek	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Waterfowl (fish-eating species)	Preservation of waterfowl harvesting opportunities, habitat, and populations along Trudel Creek	Changes to diet/bioaccumulation of mercury in fish (sublethal effect) leading to reduced population abundance
Raptors that primarily consume fish (bald eagle, osprey)	Preservation of raptor populations along Trudel Creek	Reduced reproductive success
Raptors that primarily consume fish (bald eagle, osprey)	Preservation of raptor populations along Trudel Creek	Sublethal effect due to bioaccumulation of methylmercury in fish
Rusty Blackbird	Preservation of rusty blackbird habitat and populations along Trudel Creek	Riparian habitat loss/modification leading to change in population abundance

Valued Component	Assessment Endpoint	Pathway
Rusty Blackbird	Preservation of rusty blackbird habitat and populations along Trudel Creek	Reduced reproductive success
Whooping Crane	Preservation of whooping crane habitat and populations along Trudel Creek	Riparian habitat loss/modification leading to change in population abundance: loss of nesting habitat
Whooping Crane	Preservation of whooping crane habitat and populations along Trudel Creek	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance
Whooping Crane	Preservation of whooping crane habitat and populations along Trudel Creek	Reduced reproductive success
Northern Leopard Frog	Preservation of northern leopard frog habitat and populations along Trudel Creek	Riparian habitat loss/modification leading to change in population abundance
Northern Leopard Frog	Preservation of northern leopard frog habitat and populations along Trudel Creek	Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas

14.9.5.1.1 Furbearers

Beaver and muskrat rely on riparian and aquatic habitat for all their life history stages and requirements including foraging, shelter, and reproduction. The two pathways for Project operations that pertain to both these species are direct mortality and riparian habitat loss/modification leading to reduced population abundance (Figure 14.9.8, Table 14.9.5). Direct mortality to furbearers could potentially occur because of lower or higher water levels in relation to lodges, food caches, and shelter entranceways. Lower water levels relative to baseline conditions have been modelled for Trudel Creek under operating conditions. Higher water levels could occur because of scheduled power outages and ramping of excess water through Trudel Creek because of turbines shutting down for regular maintenance (see Section 14.3.3). Riparian wetlands have been modelled to change both at the emergent/submergent vegetation boundary and at the emergent/willow boundary (Section 14.6 - Wetlands). Riparian habitat loss/modification could lead to a change in the availability of resources for foraging and shelter.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Furbearers	Figure 14.9.8

Two additional pathways were identified specifically for muskrat. There may be sublethal effects caused by changes to the submerged plant community, and therefore the muskrat's diet. A stabilized water level leading to increased abundance was identified as a beneficial effect for muskrat (Messier, Vergl, & Marinelli, 1990). The new hydrographs under the 36 MW and 56 MW options would be flattened for Trudel Creek in comparison to baseline conditions (see Figures 14.3.5 and 14.3.6 in Section 14.3).

A separate pathway was identified for mink and otter as their dietary requirements are different from beaver and muskrat. The pathway is a sublethal effect from decreased diet quality because of bioaccumulation of methylmercury in fish. Otters and mink have been identified as sensitive bioindicators of mercury levels (Kucera, 1983). Methylmercury bioaccumulation in the food web is associated with hydroelectric development, specifically the creation of reservoirs through the flooding of terrestrial areas (Rosenberg et al., 1997). Habitat requirements for otter and mink overlap with beaver and muskrat so their other life cycle requirements would be captured by the pathways identified for beaver and muskrat. Therefore, the only pathway assessed for them was specific to mercury.

Altered water levels in rivers and lakes can have negative effects on resident mammals depending on the flow characteristics and the time of year. If flow or water levels are decreased below baseline conditions during the winter, freeze-out can occur where there is insufficient water under the ice for beaver and muskrat survival (Ontario Fur Managers Federation, 2008). Muskrats require 30 cm to 60 cm of water to avoid freeze-out, thus shallow water levels are associated with lowered overwintering success (Messier et al., 1990). Winter conditions where snow cover is limited can also cause water to freeze deeper and cut off access to food resources that become frozen in the water and mud (Erb & Perry Jr. 2003). Muskrat populations have been shown to decline following dam creation because of the loss of overwintering habitat in shallow marshes (Rosenberg, Bodaly & Usher 1995; Rosenberg et al. 1997). During a six-month survey of muskrat lodges and bank burrows in the spring and summer, the number of active dwellings decreased from 105 to 55 when water levels were artificially lowered by 40 cm (Messier et al., 1990). Mink predation was believed to cause this decrease in muskrat abundance; mink predation has been found to increase with lowered water levels (Proulx, McDonnell, & Gilbert 1987). Entranceways to muskrat bank burrows would be particularly susceptible to lowered water levels because they are known to be within 15 cm of the water's surface. Lowered water levels can also expose entranceways to beaver lodges, making them more susceptible to wolf predation (Cott, Sibley, Somers, Lilly, & Gordon, 2008; Nolet & Rosell 1998). Lowered winter water levels led to increased foraging activity away from lodges for beavers, decreased juvenile condition, and spring lodge abandonment (Smith & Peterson 1991). Smith and Peterson (1991) recommended that overwinter water level drawdowns be maintained from 50 to 70 cm at the most.

Increased flows or water levels during the fall and winter can flood muskrat and beaver out of their lodges. Increased water levels have been found to limit muskrat populations, as water can fill burrows and drown young (Erb & Perry Jr., 2003). Higher water levels can destroy muskrat dwellings, leading to increased movements and subsequent increased predation and reduced survival. Higher water levels during the winter can raise ice, and any muskrat lodges embedded in the ice layer would be torn apart (Shaun Freeman, B.Sc., R.P.Bio, personal communication, October 23, 2008). If flows are very high during the fall and winter, beaver dams and food piles can be removed, resulting in reduced over-winter survival. In areas where beaver and muskrat populations are expected to decline, the populations of their predators may also be negatively affected, such as American mink, river otter, and fisher (*Martes pennanti*).

14.9.5.1.2 Moose

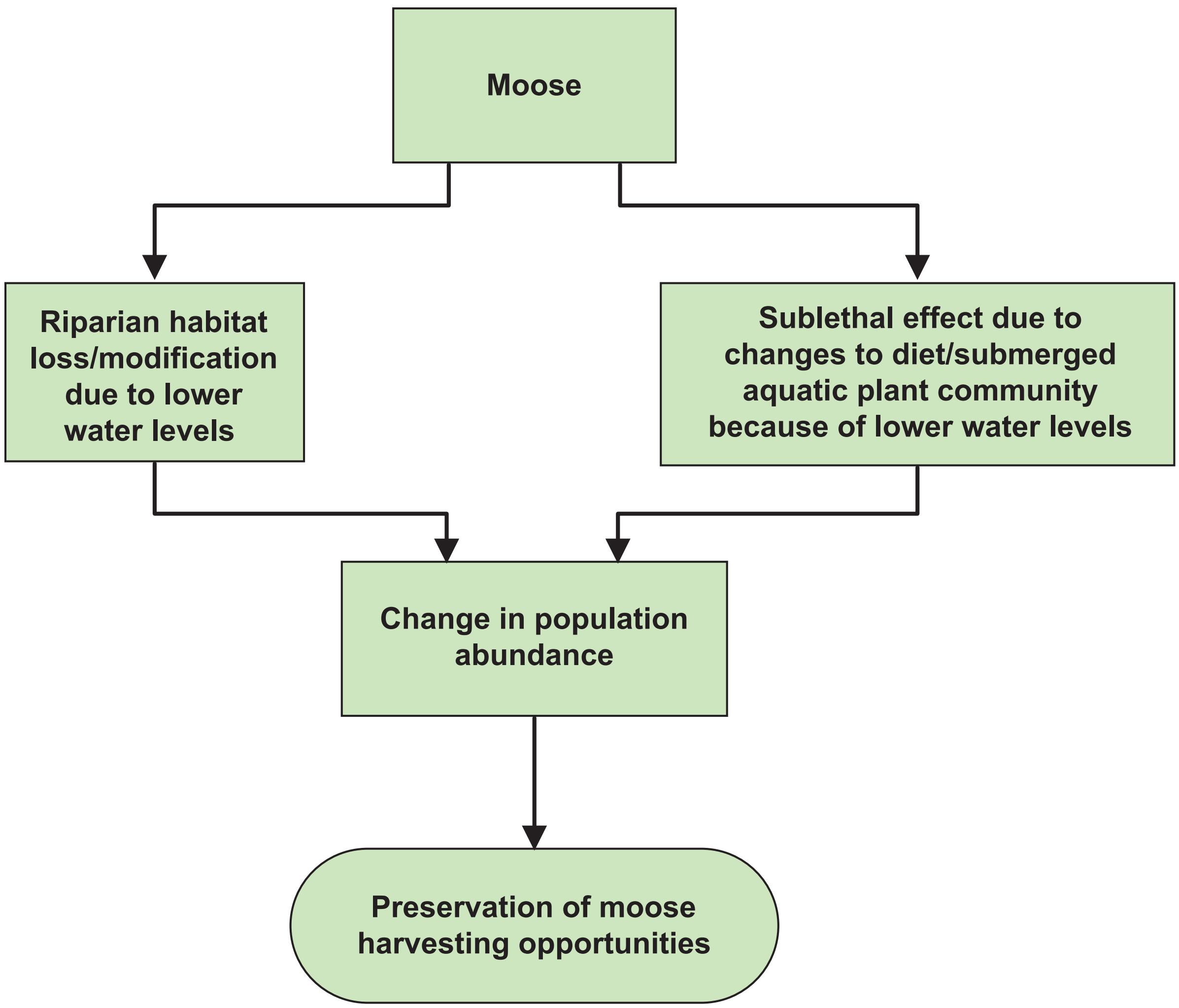
Two pathways associated with Project operations were identified for moose: changes to their diet caused by alterations in the submerged aquatic vegetation community, and riparian habitat loss/modification. Both of these pathways could lead to changes in population abundance (Figure 14.9.9; Table 14.9.5). Riparian wetland habitat has been modelled to change at the emergent/submergent vegetation boundary and at the sedge/willow boundary under operating conditions caused by lowered water levels. Riparian areas are important to moose for forage during the spring and summer as well as for calving and seasonal cover.

14.9.5.1.3 Birds

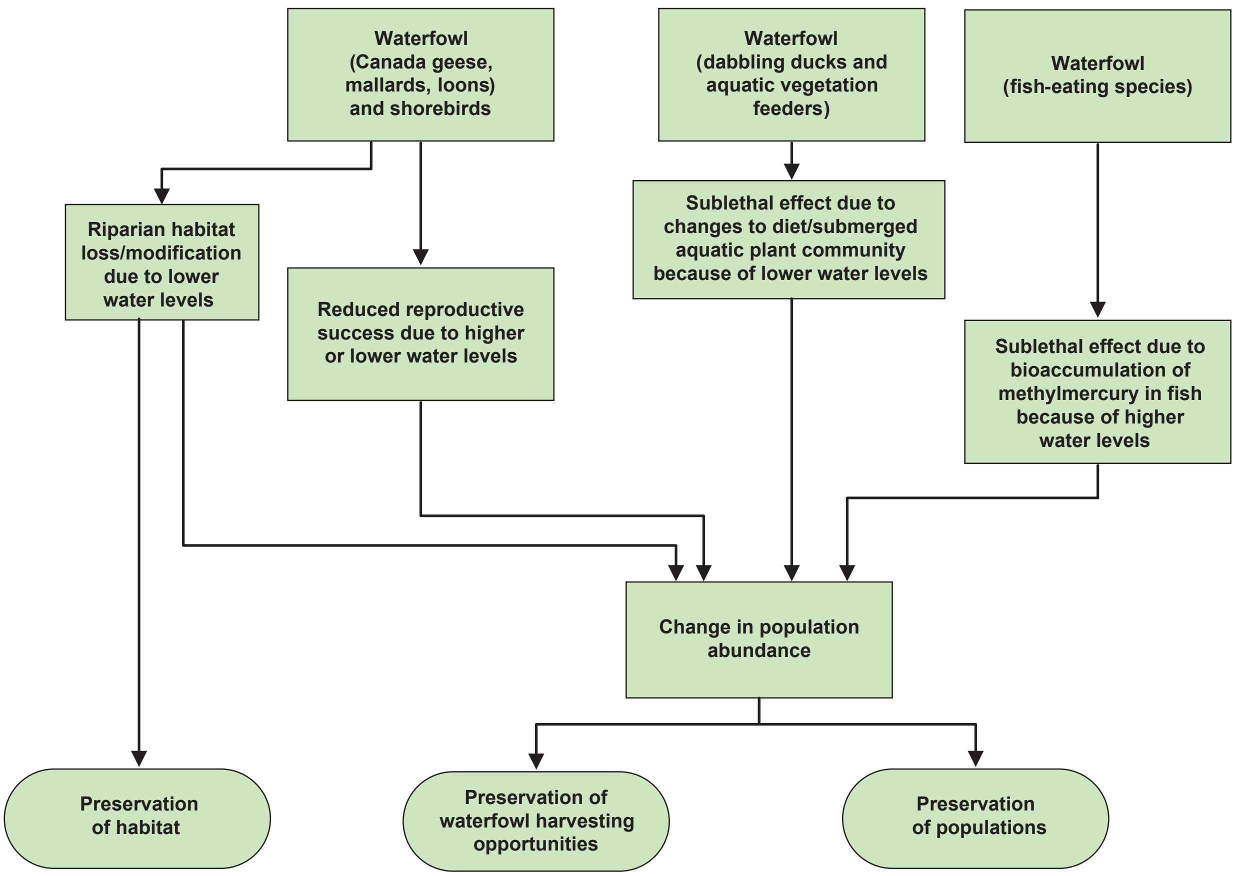
The pathways identified that could affect waterfowl, shorebirds, raptors, rusty blackbird, and whopping crane are presented in Figures 14.9.10 through 14.9.13 respectively, and in Table 14.9.5.

The pathways under operations include: reduced reproductive success either through lower or higher water levels, sublethal changes to diet, and riparian habitat loss/modification.

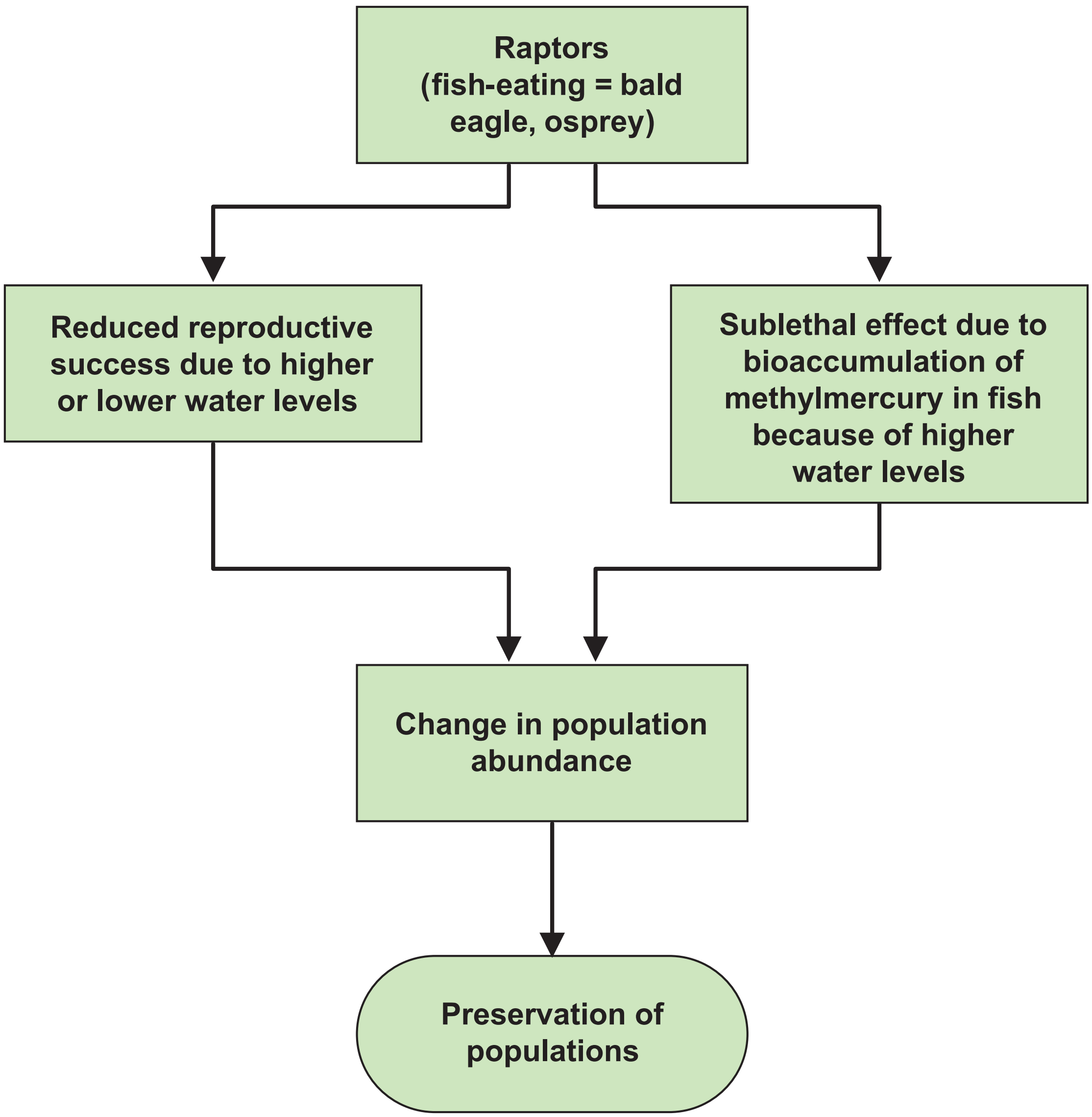
For ground-nesting waterfowl, stable water levels are important for reproductive success (Cott et al., 2008). Drawdowns or flooding may cause nest failures for species such as common loons that nest on reservoirs where the water level is not maintained at a steady level. Rapidly increasing water levels can flood nests, and falling water levels can leave nests stranded. Loon nests are most successful when water levels do not increase more than 15 cm or decrease more than 30 cm during the peak nesting season (Evers, 2004). Nests stranded by drawdowns are also more susceptible to nest predation. Riparian habitat loss/modification could result in the loss of nesting habitat.



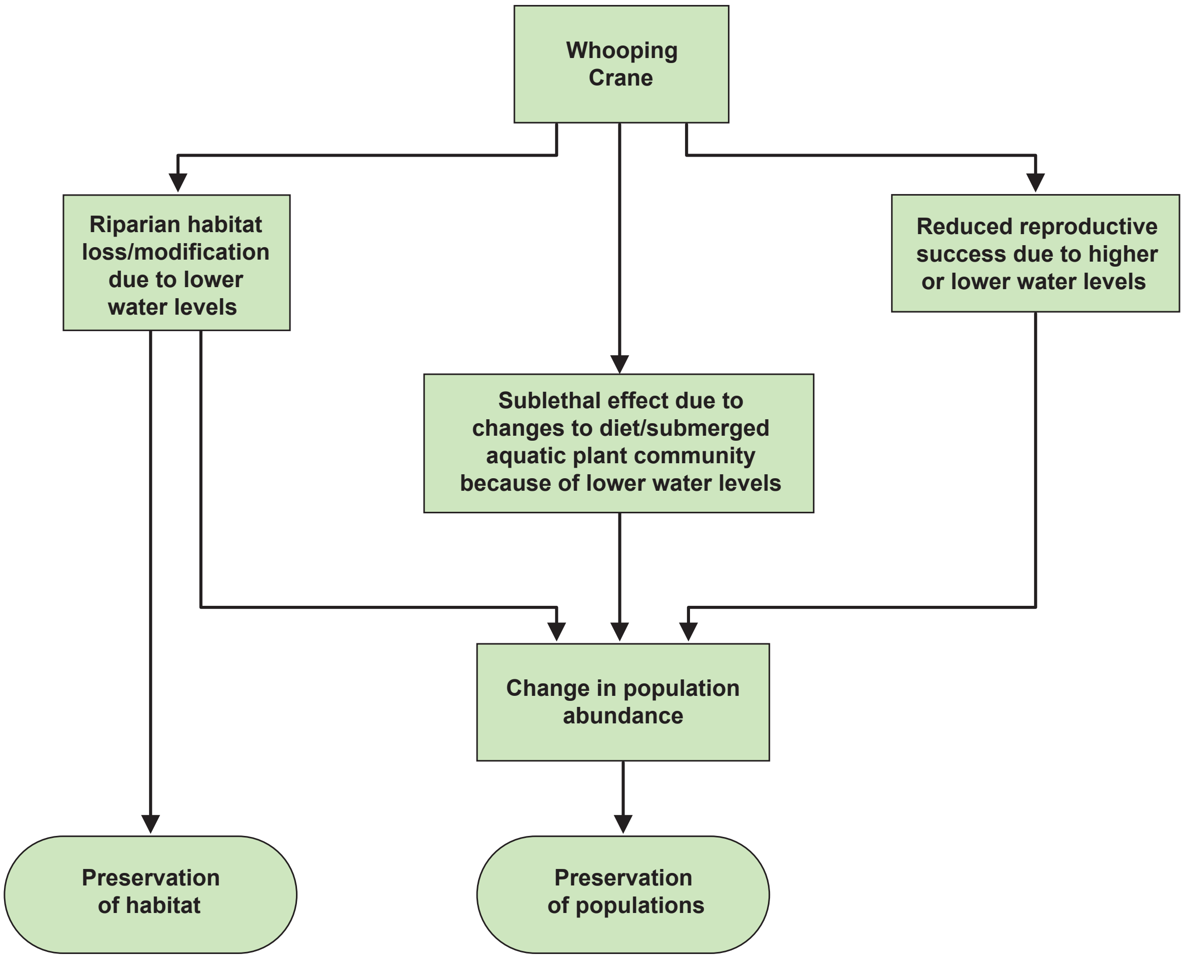
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Moose	Figure 14.9.9



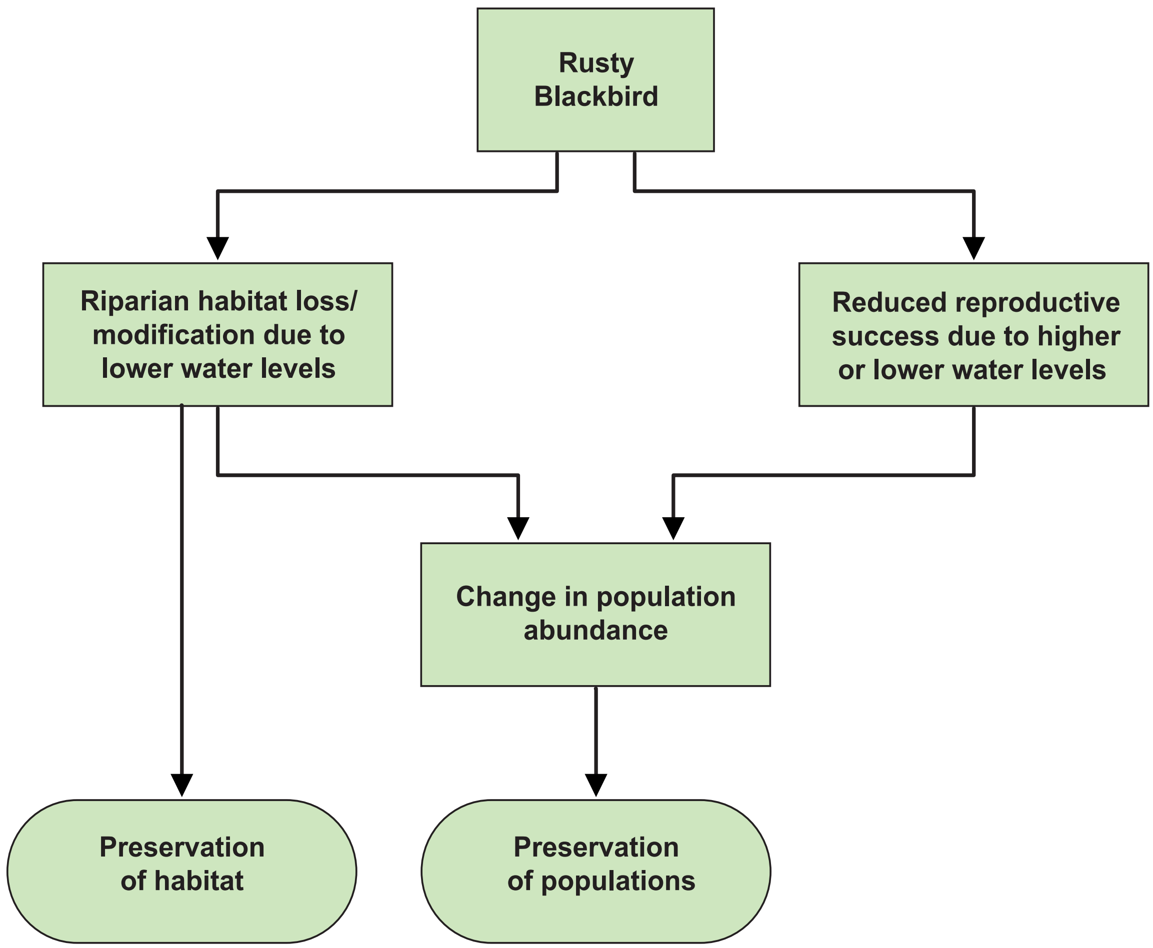
TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Waterfowl and Shorebirds	Figure 14.9.10



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Raptors	Figure 14.9.11



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Whooping Crane	Figure 14.9.12

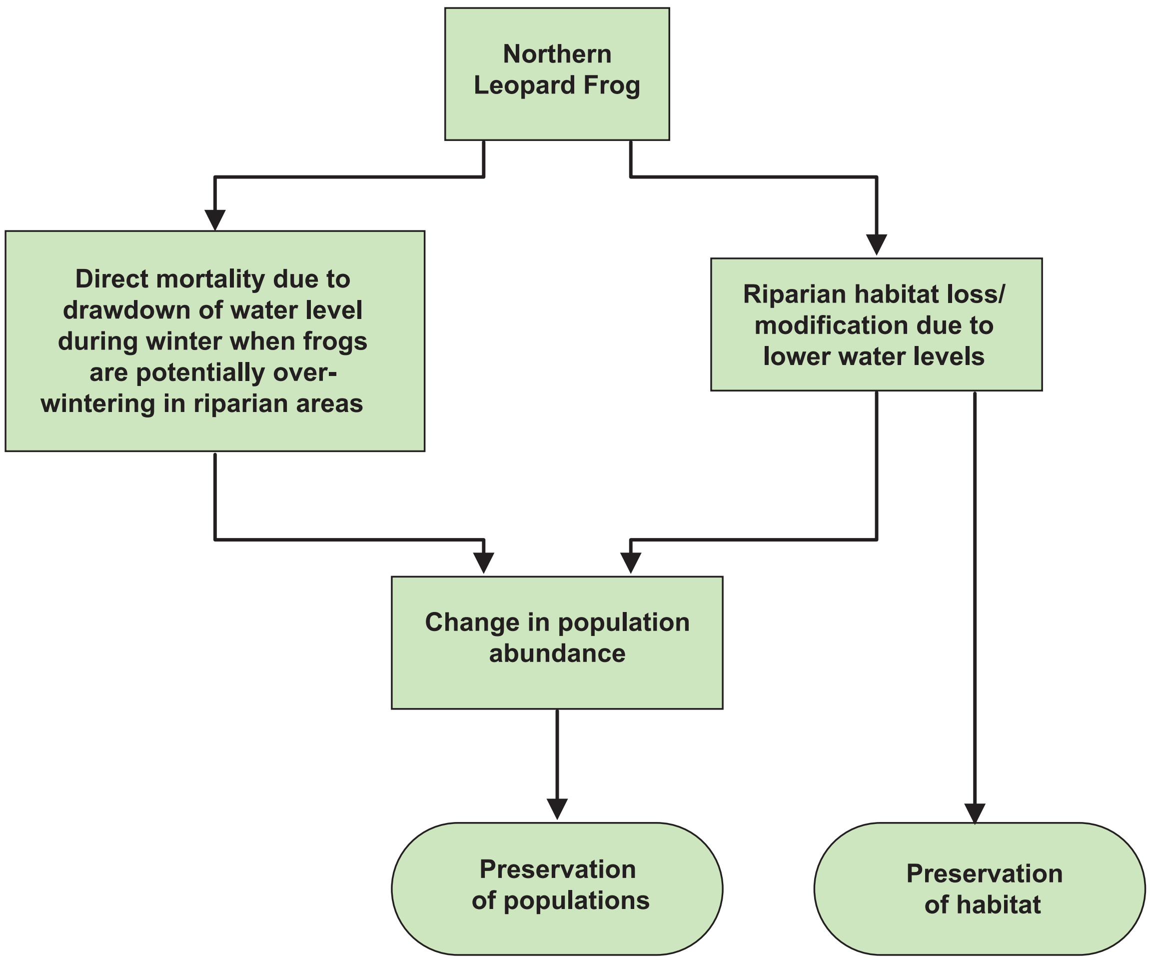


TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Rusty Blackbird	Figure 14.9.13

Changes to the diet of dabbling ducks that may have adverse effects could occur through changes to the submerged aquatic plant communities that these species forage on within the littoral zone (Cott et al., 2008). Changes to the diet of piscivorous waterfowl and raptors could occur through the bioaccumulation of methylmercury in fish. Mercury can occur naturally in aquatic systems, but levels in water bodies have increased in the past century because of atmospheric deposition of mercury from sources such as coal combustion, incinerators, and industries. Elevated mercury levels in fish can bioaccumulate and have deleterious effects to piscivorous waterfowl such as common loons. Mercury toxicity has been associated with loon mortality and even at non-lethal levels, loon and raptor reproductive success and behaviour can be negatively affected by increased concentrations of mercury in the blood.

14.9.5.1.4 Northern Leopard Frog

Two pathways were identified for northern leopard frogs: direct mortality caused by lowered water levels during the winter, and riparian habitat loss/modification (Figure 14.9.14, Table 14.9.5). Northern leopard frog mortality during the winter caused by insufficient oxygen levels, freezing, disease, and toxic exposures has been reported (Seburn & Seburn, 1998). The northern leopard frog is the only frog in the NWT that overwinters underwater. Individuals are more vulnerable to mortalities during winter from drought conditions, as shallower wetlands are more prone to freeze completely to the bottom. Riparian habitat loss/modification could reduce population abundance as these areas are used for foraging and seasonal cover during the spring and summer.



TALTSON Hydroelectric Expansion Project	Developer's Assessment Report 2009	Wildlife Assessment Pathways - Effects of Altered Water Levels on Northern Leopard Frogs	Figure 14.9.14

14.9.5.2 MITIGATION PRACTICES AND DESIGN FEATURES

The minimum flow over the South Valley Spillway (SVS) is a mitigation design feature that would aid in the establishment of a new riparian habitat along the margins of Trudel Creek over time. A bypass spillway is also planned to direct water away from the upper reach of Trudel Creek during outage events at the power facilities. The bypass spillway would have a 30 m^3/s design capacity and would operate during any scheduled or unexpected turbine outage, thereby reducing any ramping of flows into Trudel Creek.

Artificial nest platforms can be used for waterfowl management to increase reproductive success and are an appropriate mitigation strategy to avoid contravention of the Migratory Birds Convention Act (1994). Nest platforms have been successfully employed for species present in the Project area, including the common loon, mallard, and Canada goose (Ball 1988; Evers 2004; Zenner, Lagrange, & Hancock, 2008). Under both the 36 MW and 56 MW options, reproductive success of ground-nesting waterfowl would be negatively affected as water levels could rise by approximately 80 cm during the nesting period and then fall back down after three weeks of maintenance work if water flows through Trudel Creek are low. If birds were to nest during the three-week ramping event for scheduled maintenance, their nests would become stranded when the water levels were lowered. Common loon reproductive success is known to be negatively affected when water levels drop by more than 30 cm during the nesting period (Evers, 2004).

Construction, deployment, monitoring, and maintenance of artificial nesting platforms could mitigate water level alteration in Trudel Creek. Trudel Creek should first be surveyed during the waterfowl and shorebird breeding season to determine which species are breeding in the area and at what abundance. The baseline waterfowl data collected in 2008 consisted of two aerial transects to determine waterfowl species present, but the study was not designed to determine waterfowl breeding. Boat and ground-based surveys to count breeding pairs, nests, or broods would provide a more accurate estimate of waterfowl breeding in Zone 5 (RIC, 1999). Establishing which species may require platforms would also be important as design features may differ according to target species. For instance, common loons benefit from constructing floating platforms, but mallards may not need the same type of design (Evers 2004; Zenner et al. 2008). This survey would also identify areas where placing artificial nesting platforms would be appropriate. If the population size of breeding waterfowl and shorebirds warrants mitigation, then artificial nesting platforms could be deployed the first spring of operations with the new turbines.

14.9.5.3 Pathway Validation

Pathways were validated together for the 36 MW and 56 MW options. Water levels were modelled at 18 cross-sections along Trudel Creek, and within the three lakes, based on monthly average flows projected for each month under both the 36 MW and 56 MW expansion options. The bottom two sections (TDL17 and TDL18) were not included since they experience backwater effects from the Taltson River. The hydrograph for these sections would be flattened and fall within the range of baseline monthly mean water levels. This represents the bottom 2 km of Trudel Creek. The two sections between Trudel and Gertrude Lakes were also omitted since they represent an area with rapids which would not be suitable furbearer habitat. Areas between the remaining 12 cross-sectional study areas were assumed to gradually transition to the next downstream cross section (see Figure 14.3.8 for cross-section locations and areas). River and lake sections of Trudel Creek were assessed together as they would experience similar changes in water levels under the 36 MW and 56 MW options.

14.9.5.3.1 Furbearers

Direct furbearer mortality through higher water levels is an invalid pathway during operations as the hydrology model indicates that water levels would be lower in Trudel Creek as compared to baseline conditions for both the 36 MW and 56 MW options (Table 14.9.6; see Figures 14.3.9 to 14.3.23). Sublethal effects to mink and otter from decreased diet quality is also an invalid pathway. Potential sublethal effects could occur because of mercury bioaccumulation in fish; however, negligible change in mercury levels as compared to baseline conditions is expected (Section 14.4).

Table 14.9.6 — Pathway Validation for Wildlife VCs for the 36 MW and 56 MW Options

Valued Component	Pathway	Pathway Validation
Furbearers (beaver and muskrat)	Direct mortality leading to reduced population abundance through higher water levels and loss of shelter followed by subsequent drowning, starvation, predation, freezing.	Invalid: normal operations Valid: ramping
Furbearers (beaver and muskrat)	Direct mortality leading to reduced population abundance through lower water levels causing freeze out, loss of shelter, or drawdown of water below entranceway to lodge/burrow and subsequent starvation, predation, freezing.	Valid
Furbearers (beaver and muskrat)	Riparian habitat loss/modification leading to change in population abundance.	Valid
Furbearers (muskrat)	Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Valid
Furbearers (muskrat)	Stabilized water levels leading to increased abundance.	Valid
Furbearers (mink and otters)	Sublethal effect due to bioaccumulation of methylmercury in fish.	Invalid: see Section 14.4 - Alterations of Water Quality No change in mercury levels from baseline conditions.

Valued Component	Pathway	Pathway Validation
Moose	Riparian habitat loss/modification leading to change in population abundance.	Valid
Moose	Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Valid
Waterfowl (Canada goose, mallard, loons) and Shorebirds	Reduced reproductive success due to lower water levels leading to reduced population abundance.	Invalid Valid: ramping but see Mitigation section.
Waterfowl (Canada goose, mallard, loons) and Shorebirds	Reduced reproductive success due to higher water levels/flooding leading to reduced population abundance.	Invalid: normal operations Valid: ramping but see Mitigation section.
Waterfowl (Canada goose, mallard, loons) and Shorebirds	Riparian habitat loss/modification leading to change in population abundance: loss of nesting habitat.	Invalid
Waterfowl (fish eating species)	Changes to diet/bioaccumulation of mercury in fish (sublethal effect) leading to reduced population abundance.	Invalid: see Section 14.4 - Alterations of Water Quality, no change in mercury levels from baseline conditions.
Waterfowl (dabbling ducks and aquatic vegetation feeders)	Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Valid
Raptors that primarily consume fish (bald eagle, osprey)	Sublethal effect due to bioaccumulation of methylmercury in fish.	Invalid: see Section 14.4 - Alterations of Water Quality No change in mercury levels from baseline conditions.
Whooping Crane	Riparian habitat loss/modification leading to change in population abundance: loss of nesting habitat.	Invalid: whooping cranes do not breed in Zone 5
Whooping Crane	Reduced reproductive success.	Invalid: whooping cranes do not breed in Zone 5
Whooping Crane	Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Invalid: see Section 14.4 - Alterations of Water Quality No change in mercury levels from baseline conditions and diet does not consist of primarily aquatic plants.
Rusty Blackbird	Riparian habitat loss/modification leading to change in population abundance.	Invalid: shrub/tree communities would not be flooded.
Rusty Blackbird	Reduced reproductive success under normal operating conditions.	Invalid: nests close to water but in trees
Northern Leopard Frog	Direct mortality leading to reduced population abundance: lower water levels during winter when frogs are potentially overwintering in riparian areas.	Invalid
Northern Leopard Frog	Riparian habitat loss/modification leading to change in population abundance.	Valid

Furbearer direct mortality caused by higher water levels from ramping water through Trudel Creek during regularly-scheduled turbine maintenance is a valid pathway.

Flow ramping events would be part of normal operating conditions for both the 36 MW and 56 MW options. Section 14.3.3 provides details of the changes in flows and water levels along Trudel Creek during a ramping event from a scheduled power outage. Scheduled outages for turbine maintenance are currently planned to occur annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion; 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the existing 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 MW and 56 MW expansions would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events.

Under the 56 MW option, water levels were modelled to rise roughly 80 cm from pre-outage levels during a scheduled outage scenario (Table 14.3.13). Water level increases of 75 cm have been predicted to affect 100% of muskrat shelters in a model developed for the St. Lawrence River in Ontario and Quebec (Ouellet et al. 2004). Rising water levels could wash away muskrat push-ups that are on the ice either through increased flows or a faster ice break-up. Lodges could either be flooded or damaged due to the more rapid ice break-up. Channel width was modelled to increase 1 m to 25 m along Trudel Creek river stations (Table 14.9.7). For furbearer lodges established at the new water line during the fall, the increase in channel width is indicative of shelters potentially becoming inundated. Rising water levels could flood both beaver and muskrat lodges and cause drowning. Flooding could also lead to shelter loss, with subsequent increased predation. Sudden increases in stream water levels prior to spring break-up can destroy lodges and occupants or drown beavers under the ice (Hakala 1952 as cited in Baker & Hill 2003).

Direct furbearer mortality through lower water levels causing freeze-out, loss of shelter, or drawdown of water below shelter entranceways, and subsequent starvation, predation, and freezing is a valid pathway. Based on average conditions, the hydrology model indicates that water levels would be 78 cm to 162 cm below baseline levels for the 36 MW option and 89 cm to 185 cm for the 56 MW option (Table 14.9.8). Channel widths would decrease 2 to 30 m under the 36 MW option and 2 to 34 m under the 56 MW option (Table 14.9.9). Under the current construction plan, new turbine operation would begin in the fall. Furbearers may not have enough time to reconstruct shelters at the new water level before winter's onset. Muskrat bank burrows have entrances that are typically 15 cm below the surface of the water, and water levels lowered by 40 cm during a six-month period during spring and summer have been found to lead to decreased muskrat abundance (Messier et al., 1990; Rezendes, 1999).

Riparian habitat loss/modification is also a valid pathway as water levels were modelled to be over 150 cm lower than baseline conditions during the growing season. This would lead to changes in the riparian wetlands. Similarly, a change to muskrat diet caused by changes to the submerged aquatic plant community is a valid pathway. Stabilized water levels leading to increased muskrat abundance is a valid pathway as the new 36 MW and 56 MW hydrographs are predicted to have less of a difference between their maximum and minimum average monthly levels than baseline conditions. Hydrology modeling predicted that fluctuations in water levels of Trudel Creek would decrease by over 50% at river station TRUDEL1 from an average of 162 cm to 77 cm for the 36 MW option and from an average of 162 cm to 57 cm for the 56 MW option. The lakes farther downstream in this zone would therefore also experience proportionately less variation in water levels.

Table 14.9.7 — Modelled Channel Width Increases Associated with Scheduled Ramping under Low Flow Conditions

River Station	Change in Channel Width (m)
TDL1	19.3
TDL2	24.7
TRUDEL1	15.1
TDL3	1.7
TDL4	1.0
TDL5	16.3
TDL6	2.6
TDL7	6.9
TDL8	15.2

River Station	Change in Channel Width (m)
TDL9	1.2
TDL13	7.3
TDL14	5.3
TDL16	3.1
Unnamed Lake	Not modelled
Trudel Lake	Not modelled
Gertrude Lake	Not modelled

Table 14.9.8 — Modelled Water Level Decreases Associated with Operations under the 36 MW and 56 MW Options

River Station	36 MW OPTION			56 MW OPTION		
	Average (cm)	Min (cm)	Max (cm)	Average (cm)	Min (cm)	Max (cm)
TDL1	-162	-84	-227	-185	-91	-251
TDL2	-154	-76	-220	-175	-83	-241
TRUDEL1	-141	-61	-210	-157	-67	-227
TDL3	-135	-59	-202	-151	-65	-218
TDL4	-133	-58	-199	-149	-64	-215
TDL5	-131	-58	-196	-147	-64	-212
TDL6	-127	-57	-190	-143	-63	-205
TDL7	-116	-52	-173	-130	-58	-187
TDL8	-94	-45	-140	-107	-50	-151
TDL9	-89	-44	-132	-101	-49	-143
TDL13	-107	-55	-159	-123	-63	-173
TDL14	-99	-52	-147	-115	-60	-160
TDL16	-99	-52	-147	-115	-60	-160
Unnamed Lake	-99.4	-52.0	-147	-114.5	-60.0	-159.9
Trudel Lake	-109	-54.9	-159	-122	-63.0	-173.0
Gertrude Lake	-78.4	-37.0	-118.0	-89.3	-41.9	-128

Table 14.9.9 — Modelled Channel Width Decreases Associated with Operations under the 36 MW and 56 MW Options

River Station	36 MW OPTION			56 MW OPTION		
	Average (m)	Min (m)	Max (m)	Average (m)	Min (m)	Max (m)
TDL1	-14.1	-9.8	-19.8	-18.9	-14.3	-21.3
TDL2	-29.9	-17.9	-37.2	-34.0	-18.5	-41.2
TRUDEL1	-16.4	-9.9	-20.5	-19.1	-10.7	-22.4
TDL3	-2.4	-1.1	-3.5	-2.7	-1.2	-3.8
TDL4	-1.8	-0.7	-2.8	-1.9	-0.7	-3.0
TDL5	-10.5	-4.4	-14.1	-14.8	-11.6	-18.4
TDL6	-22	-1.4	-56.8	-22.4	-1.6	-57.0
TDL7	-15.1	-4	-21.4	-16.1	-4.3	-22.6
TDL8	-26.1	-4.6	-32.8	-27.4	-5.2	-34.0
TDL9	-1.8	-0.9	-2.5	-1.9	-0.9	-2.8
TDL13	-26.1	-5.3	-9.8	-8.3	-5.8	-11
TDL14	-5.25	-4	-6.6	-6.4	-4.6	-7.5
TDL16	-3.6	-2.0	-5.2	-4.3	-2.6	-6.0

14.9.5.3.2 Moose

Both pathways identified for moose are valid: riparian habitat loss/modification, and sublethal effects caused by diet changes. Riparian habitat was modelled to change as water levels would be over 150 cm lower during the growing season as compared to baseline conditions. This would also lead to changes in the submerged aquatic vegetation communities that moose exploit as forage.

14.9.5.3.3 Birds

Reduced reproductive success caused by lower water levels is an invalid pathway. Although water levels under both the 36 MW and 56 MW options are lower than baseline conditions, the water levels over the course of the breeding and nesting period (May to August) increase between May and June and then are fairly stable according to the hydrology model (see Figure 14.3.5 and Figure 14.3.6). This pathway would only be valid if water levels were modelled to drop more than 30 cm within the nesting period as this reduction has been found to be detrimental for ground-nesting waterfowl such as loons (Evers, 2004).

Reduced reproductive success caused by higher water levels is also an invalid pathway under normal operations as the hydrology modelling indicates that water levels would be lower than baseline conditions and fairly stable over the course of the year. Loss of nesting habitat through loss or modification of riparian habitat is an invalid pathway for waterfowl, including whooping cranes, as additional shoreline riparian habitat should become available with the lowering of water levels under the 36 MW and 56 MW options.

A change to the diet of piscivorous waterfowl is an invalid pathway as mercury levels are not expected to change from baseline conditions. This pathway is also invalid for piscivorous raptors.

Reduced reproductive success for whooping cranes is an invalid pathway as this species does not breed in the Project area. Sublethal effects through changes to their diet is an invalid pathway for whooping cranes as they have an omnivorous diet comprising invertebrates, fish, amphibians, and plant tubers. Reduced reproductive success for rusty blackbird is also an invalid pathway because, although they nest near the water, they nest in trees rather than on the ground. Therefore, they would not be affected by changes to the hydrological regime.

Reduced reproductive success caused by altered water levels is a valid pathway as ramping caused by scheduled power outages for turbine maintenance could lead to nests and young being flooded and drowned or stranded if water levels fall back down to low levels after scheduled maintenance. However, it is possible to mitigate for this effect and so the pathway is not carried forward. A change to the diet of dabbling ducks, which feed primarily on submerged aquatic vegetation, is a valid pathway as water levels during the growing season were modelled to be more than 150 cm lower than baseline conditions. This was modelled to change riparian wetlands.

Riparian habitat loss/modification is an invalid pathway for rusty blackbirds as the species nests in trees. There would not be a loss of wetland shrub communities associated with this Project, as no new flooding would occur.

14.9.5.3.4 Northern Leopard Frog

Direct mortality to northern leopard frogs caused by lower water levels during the winter is an invalid pathway. Although modelled water levels under both the 36 MW and 56 MW options would be lower than baseline conditions, they would be fairly stable over the course of the year. Direct mortality would only be a concern if there was a drop in water levels between the fall when frogs would be moving into overwintering sites and the winter when they would be below the ice of streams or rivers.

Riparian habitat loss/modification is a valid pathway for northern leopard frogs as they are known to forage in the riparian zone during the summer and this area has been modelled to change because of lower water levels during the growing season.

14.9.6 Effect Classification

For the purpose of this effect classification, definitions for geographical extent and duration have been changed from those presented in the Assessment Methods and Presentation chapter (Chapter 10). The definitions used to qualify the geographical extent of an effect were changed for the Trudel Creek KLOI. Geographic extent includes three scales:

1. Single reach or lake within Trudel Creek (small scale).
2. Multiple reaches or lakes within Trudel Creek (medium scale).
3. All of Trudel Creek (large scale).

Because effects are only considered for the Project operations phase, the definitions for Duration were changed to the following:

- Short-term: effects that last as long as the generation time of a VC or less.
- Medium-term: effects that last as long as a few generation times of a VC.
- Long-term: effects that last beyond the duration of the Project (>40 years)
- Indefinite.

14.9.6.1 OPERATIONS UNDER THE 36 MW OPTION

14.9.6.1.1 Furbearers

Hydrological model results indicate that under the 36 MW option, water levels at river station TRUDEL1 (Reach 3) would drop up to 130 cm lower than baseline conditions in the winter (November) and would drop 210 cm below baseline conditions during the summer (July; see Figure 14.3.6). Similarly, water levels during the fall, when the turbines are expected to be initiated, were modelled to drop 95 cm or more at the other river stations and lakes (see Section 14.3). In association with the water level decrease would also be a narrowing of channel width. The amount of channel bed exposed would depend on the slope of the channel. In steeper sections such as at river station TDL3, less shoreline would be exposed as compared to river stations with gradually sloping shores like TDL6 (Figure 14.3.9 to Figure 14.3.23). However, at all river stations the channel width was modelled to decrease in the order of metres (Table 14.9.9). This would likely leave the majority of furbearer shelters no longer connected to the new water line. The effects of direct mortality from lower water levels causing freeze-out, loss of shelter, or water levels dropping below the entranceways to shelters for beavers and muskrats and subsequent starvation, freezing, or predation was classified as high (Table 14.9.10). The effect would be observed along all of Trudel Creek. The effect would be medium-term as the effects would take a few generations to reverse. The magnitude of this effect might be less if the turbines were initiated earlier in the summer, giving furbearers more time to reconstruct shelters before winter's onset. The overall residual effect for beaver and muskrats from lowered water levels was assessed as moderate.

The effect of higher water levels caused by ramping was only assessed under the 56 MW option (Section 14.9.6.2), as the 56 MW option represents a worst-case magnitude change in water levels from ramping. However, the higher frequency of occurrence of 36 MW ramping events was applied to the 56 MW ramping event for a conservative assessment of overall effects to furbearers (see Section 13.3.4 for hydrological ramping details).

Sublethal effects to muskrat caused by diet changes as a consequence of changes to the submerged vegetation community were classified as moderate and would be observed throughout Trudel Creek. This effect would be continuous but reversible as vegetation communities would re-establish themselves under the new hydrological regime. It was considered a moderate effect since the physical health of muskrats may be compromised while vegetation communities are stabilizing and the duration of this effect is predicted to be medium-term (i.e., the effect would last until riparian vegetation stabilizes). The overall residual effect was assessed as low.

The effect of riparian habitat loss or modification was classified as moderate in magnitude for all of Trudel Creek based on the wetland model results, which suggested that lowered water levels would change the riparian habitat both at the sedge/willow and emergent/submergent vegetation boundaries within Trudel Creek. The frequency of this effect was classified as continuous but reversible as it was assumed that riparian vegetation would be altered in the medium-term but would adapt to the new hydrological regime and lowered water level. The overall residual effect to furbearers (i.e., beavers and muskrat) because of habitat loss/modification was low.

The water level difference between average monthly maximum and average monthly minimums would decrease by 150 cm under the 36 MW option as compared to baseline conditions at river station TRUDEL1 and would follow a similar trend at the other modelled locations. This was classified as a beneficial effect for muskrat and was assessed as likely with high magnitude. Winter mortality because of freeze-outs and predation caused by exposed entranceways to shelters would be reduced because of the new flattened hydrological regime. This may lead to an increase in muskrat abundance in Trudel Creek. The overall residual positive effect was classified as moderate.

14.9.6.1.2 Moose

The magnitude of sublethal effects caused by diet changes was assessed as low because of the abundance of wetland habitat within the area and the ability of moose to access other food sources. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

14.9.6.1.3 Waterfowl and Shorebirds

The magnitude of the sublethal effect of diet changes for dabbling ducks and other waterfowl that feed on submerged aquatic vegetation was classified as low because birds can access other wetland and riparian habitat in the area and feed in those areas. However, birds that are nesting in the area may forage locally. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

14.9.6.1.4 Northern Leopard Frog

The effect of riparian habitat loss or modification was classified as low for northern leopard frogs since they are primarily using this habitat at low densities for foraging during the summer and it does not appear to offer breeding habitat. The effect would occur throughout Trudel Creek, having a medium-term duration, and was considered a low overall residual effect.

Table 14.9.10 — Wildlife Effects Classification under the 36 MW Option for Trudel Creek

Pathways	Direction	Likelihood	Magnitude	Geographic Extent	Duration[1]	Reversibility	Frequency	Overall Residual Effect
Effects on Furbearers								
Direct mortality leading to reduced population abundance through lower water levels causing freeze out, loss of shelter, or drawdown of water below entranceway to lodge/burrow and subsequent starvation, predation, freezing (muskrat and beaver)	Adverse	Highly likely	High	Trudel Creek[2]	Medium-term	Reversible	Continuous	Moderate
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance (muskrat)	Adverse	Highly likely	Moderate	Trudel Creek	Medium-term	Reversible	Continuous	Low
Riparian habitat loss/modification leading to change in population abundance (muskrat and beaver)	Adverse	Highly likely	Moderate	Trudel Creek	Medium-term	Reversible	Continuous	Low
Stabilized water levels leading to increased abundance (muskrat)	Beneficial	Likely	High	Trudel Creek	Long-term	Reversible	Continuous	Moderate
Effects on Moose								
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low
Riparian habitat loss/modification leading to change in population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low

Pathways	Direction	Likelihood	Magnitude	Geographic Extent	Duration[1]	Reversibility	Frequency	Overall Residual Effect
Effects on Waterfowl and Shorebirds								
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low
Effects on Northern Leopard Frog								
Riparian habitat loss/modification leading to change in population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low

[1] Duration: Short-term one generation or less; medium-term a few generations; long-term >40 years
[2] As indicated in the text, Trudel Creek, includes all riverine and lake areas with the exclusion of the last 2 km that experience backwater effects from the Taltson River.

14.9.6.2 OPERATIONS UNDER THE 56 MW OPTION

14.9.6.2.1 Furbearers

Hydrological model results indicate that under the 56 MW option water levels at river station TRUDEL1 would drop 150 cm lower than baseline conditions in the winter (January) and 230 cm below baseline conditions during the summer (July; see Figure 14.3.6). Similarly, water levels during the fall, when the turbines are expected to be initiated, were modelled to drop 105 cm or more at the other river stations and lakes (see Section 14.3). In association with the water level decrease would also be a narrowing of channel width. At all river stations the channel width was modelled to decrease in the order of meters (Table 14.9.9). This would leave the majority of furbearer shelters no longer connected to the new water level. The effect of direct mortality caused by freeze-out and water levels dropping below the entranceways to shelters for beavers and muskrats and subsequent increased predation rates was classified as high for all of Trudel Creek (Table 14.9.11). The effect would be medium-term as it would take a few generations before the effect reverses. Under the current construction schedule, the Expansion Project turbines would be initiated in the fall. The effect would be medium-term as the effects would take a few generations to reverse. The overall residual effect for beaver and muskrats from lowered water levels was assessed as moderate.

Under the 56 MW expansion the flow during April and into May could be at the minimum release flow of 4 m^3/s when scheduled outages are planned. However, because water levels would be low at this time, power production likely would be below maximum output. Therefore, ramping events would not always occur during a scheduled outage as water from the off-line turbine would be taken up by the other operating units. Thus, the frequency of a ramping event from a scheduled outage would depend on flow conditions at the time of the outage. Based on an analysis of the modelled data set, scheduled outages would result in ramping events 6 out of 13 years and 1 out of 13 years under the 36 MW and 56 MW expansions, respectively.

A 56 MW ramping event would result in water levels increasing roughly 80 cm and channel width increasing roughly 20 m for a duration of three weeks. Water level and channel width increases would occur over a 6- to 10-hour period. The magnitude of the effect on furbearers from higher water levels was assessed as high for muskrats and moderate for beaver throughout Trudel Creek. For animals that are inside their dens when water levels increase, mortality could occur to animals that are not able to escape the flooded shelter. For animals that can escape the rising water levels there still may be a loss of shelter which would increase their exposure to inclement weather conditions and possible predation. Beaver depredation in spring by wolves has been inferred through wolf scat analysis (Smith & Peterson, 1991). Rapidly rising water levels may also cause ice break up to occur more quickly. Moving ice fragments could also potentially destroy furbearer shelters. Food resources are also reduced at this time of year so ramping would represent an additional physiological stressor for animals that escaped direct mortality. The effect would be continuous, but short-term and reversible as subsequent generations replace lost individuals. If the duration of effect is longer than predicted it is possible that furbearer habitat within Trudel Creek may become "sink" habitat: annual mortality associated with ramping would cause negative local population growth (Battin, 2004). Baseline surveys for muskrat indicated that muskrat abundance was low possibly because of the fluctuations in water levels under baseline conditions. Under the 56 MW option, in order to maintain local populations of beaver and muskrat, immigration from other nearby populations that have positive population growth may be necessary. However, immigration from neighbouring furbearers was not considered in the assessment classification. The overall residual effect for beaver and muskrats from higher water levels was assessed as moderate.

Sublethal effects to muskrat (caused by diet changes) as a consequence of changes to the submerged vegetation community were classified as moderate for all of Trudel Creek. This effect would be continuous but reversible as vegetation communities would re-establish themselves under the new hydrological regime. It was considered a moderate effect since the physical health of muskrats may be compromised while vegetation communities are stabilizing. The overall residual effect was assessed as low.

The effect of riparian habitat loss or modification was classified as moderate in magnitude for all of Trudel Creek based on the wetland model results, which suggested that lowered water levels would change the riparian habitat both at the sedge/willow and emergent/submergent vegetation boundaries within Trudel Creek. It was assumed that the furbearers would adapt to the new riparian vegetation from lowered water levels. Subsequently, this effect was also considered reversible as riparian vegetation re-establishes in the medium-term. The overall residual effect to furbearers (i.e., beavers and muskrat) because of habitat loss/modification was assessed as low.

The water level difference between average monthly maximum and average monthly minimums would decrease by 160 cm under the 56 MW option as compared to baseline conditions at river station TRUDEL1 and would follow a similar trend at the other modelled locations. This was classified as a beneficial effect for muskrat and was assessed as likely with high magnitude. Winter mortality caused by freeze-outs and predation through exposed entranceways to shelters would be reduced by the new flattened hydrological regime. This may lead to an increase in muskrat abundance in Trudel Creek. The overall residual positive effect was classified as moderate.

Table 14.9.11 — Wildlife Effects Classification under the 56 MW Option for Trudel Creek

Pathways	Direction	Likelihood	Magnitude	Geographic Extent	Duration[1]	Reversibility	Frequency	Overall Residual Effect
Effects on Furbearers								
Direct mortality leading to reduced population abundance through lower water levels causing freeze out, loss of shelter, or drawdown of water below entranceway to lodge/burrow and subsequent starvation, predation, freezing (muskrat and beaver)	Adverse	Highly likely	High	Trudel Creek	Medium-term	Reversible	Continuous	Moderate
Direct mortality leading to reduced population abundance through higher water levels due to scheduled outages and ramping at Twin Gorges (muskrat and beaver)	Adverse	Highly likely	High (muskrat) Moderate (beaver)	Trudel Creek	Short-term	Reversible	Continuous	Moderate
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance (muskrat)	Adverse	Highly likely	Moderate	Trudel Creek	Medium-term	Reversible	Continuous	Low
Riparian habitat loss/modification leading to change in population abundance (muskrat and beaver)	Adverse	Highly likely	Moderate	Trudel Creek	Medium-term	Reversible	Continuous	Low
Stabilized water levels leading to increased abundance (muskrat)	Beneficial	Likely	High	Trudel Creek	Long-term	Reversible	Continuous	Moderate
Effects on Moose								
Riparian habitat loss/modification leading to change in population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low

Pathways	Direction	Likelihood	Magnitude	Geographic Extent	Duration[1]	Reversibility	Frequency	Overall Residual Effect
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low
Effects on Waterfowl and Shorebirds								
Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low
Effects on Northern Leopard Frog								
Riparian habitat loss/modification leading to change in population abundance	Adverse	Highly likely	Low	Trudel Creek	Medium-term	Reversible	Continuous	Low

[1]Duration: Short-term one generation or less; medium-term a few generations; long-term >40 years

14.9.6.2.2 Moose

The magnitude of sublethal effects of diet changes was assessed as low because of the abundance of wetland habitat in the area and the ability of moose to access these food sources. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

The magnitude of the effect of riparian habitat loss or modification for moose was classified as low because of the abundance of wetlands and the ability of moose to access these other habitats. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

14.9.6.2.3 Waterfowl and Shorebirds

The magnitude of the sublethal effect of changes in diet for dabbling ducks and other waterfowl that feed on submerged aquatic vegetation was classified as low because birds can access other wetland and riparian habitat in the area and feed in those areas. However, birds that are nesting in the area may forage locally. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

14.9.6.2.4 Northern Leopard Frog

The effect of riparian habitat loss or modification was classified as low for northern leopard frogs since they are primarily using this habitat at low densities for foraging during the summer and it does not appear to offer breeding habitat. The effect would occur throughout Trudel Creek, have a medium-term duration and was considered a low residual effect.

14.9.6.3 Cumulative Effects

The other historic or existing disturbances within the watershed, namely mineral exploration and forestry operations, have little or no interaction with the hydrological regime of Trudel Creek.

Existing developments include a hydroelectric facility in the Tazin River system. The regulated flows of the Tazin River into Taltson River have been considered in the current Taltson hydrologic model used for all assessments in this document. There are no additional potential cumulative effects from the Tazin River facility. Additional hydroelectric projects have not been registered in the area. As there are no reasonably foreseeable projects identified in the study area, no other projects would provide cumulative effects to the Expansion Project since there is no spatial overlap. Should any projects move towards development in the regional assessment area there may be cumulative effects to the proposed Expansion Project.

Initial development of the Twin Gorges Project facility resulted in greatly increased flows within Trudel Creek. Traditional knowledge suggests that the original dam may have had adverse effects on furbearer populations, and survey data at a reference site for beavers and muskrat supports this (Rescan, 2000, 2001). Beaver abundance at the Nonacho Lake latitude may have always been low as data from Porter Lake that was used as a reference site for Nonacho Lake had only one active beaver lodge (Table 13.10.1). However, Hanging Ice Lake and a portion of the Tethul River were chosen as reference survey areas because they are outside the zone of influence of the Nonacho Lake control structure and the Twin Gorges dam. The abundance of beaver lodges in the reference area was greater in absolute numbers, number of lodges detected per flown kilometre, and number of lodges per survey hour than any of the other surveyed areas, including Trudel Creek. This suggests that the areas within the Taltson River system, including Trudel Creek, that were surveyed had lower beaver abundance (as determined through number of lodges), possibly caused by effects from the original Twin Gorges dam and accompanying hydrological changes. A higher abundance of muskrat push-ups per linear kilometre of shoreline flown was also found at Hanging Ice Lake and Tethul River compared to Trudel Creek (Table 14.9.2).

During community scoping sessions, personal testimonials were recorded that reflect the changes to furbearer populations observed following construction of the original Twin Gorges dam in the 1960s. Most of the statements were generalized to the Taltson River without specific reference to Trudel Creek. During community consultation in Fort Resolution in 2006, changes to waterfowl populations and significant decline in muskrat as a result of the original dam were also mentioned (Boucher, 2006). Some of the possible causes include wetland habitat loss caused by channelization of Trudel Creek, higher water levels and flows, an altered hydrological regime, increased erosion, and decreased water quality.

The reported effect on furbearers from the construction of the original dam is thus considered a residual effect within the Project area. This residual effect must be considered cumulatively with the incremental residual effects identified for furbearers in this assessment. There may also be a residual effect to waterfowl populations from the original Project, which must be considered cumulatively with the incremental residual effects identified for waterfowl in this assessment.

14.9.6.3.1 Cumulative Effects Assessment

Compared to pristine conditions, the construction of the original dam likely had adverse effects on furbearers and waterfowl along Trudel Creek. The 36 MW and 56 MW options also represent a disturbance and change from the current conditions with the identified incremental adverse effects. Therefore, the possible proximate causes for furbearer and waterfowl declines caused by the original dam construction and operation, combined with the incremental effects of the proposed expansion, represent an overall adverse effect to the assessment endpoint of preservation of furbearer harvesting opportunities. Specifically, the adverse cumulative effects include:

- wetland habitat loss from channelization of Trudel Creek for the original dam construction and operation,
- declines of furbearers and waterfowl following the original dam construction and operation,
- riparian habitat loss/modification under the 36 MW and 56 MW options,
- changes to muskrat diet from changes to submerged plant communities under the 36 MW and 56 MW options,
- direct mortality from ramping under the 36 MW and 56 MW options, and

- direct mortality from lower water levels causing freeze-out or leading to increased predation under the 36 MW and 56 MW options.

14.9.7 Significance Determination

Significant effects to assessment endpoints were considered when overall residual effects from the incremental effects classification were categorized as high or when multiple pathways were combined for an overall significant effect. Significant effects are ones that threaten the preservation of harvesting, habitat, and populations of the wildlife VCs at the scale of Trudel Creek. Significance was considered the same for both the 36 MW and 56 MW options, and therefore is presented in a single table (Table 14.9.12).

Uncertainty of the effects classification is presented in Table 14.9.12 and represents the level of confidence in the effect predictions that were classified at a local level. With additional data on local wildlife populations, the significance of the effects would probably not change but the likelihood and magnitude of the effects classification would be more accurate.

14.9.7.1 Furbearers

The assessment endpoint of preservation of furbearer harvesting opportunities within Trudel Creek was considered to be not significantly adversely affected by the Project. The pathways of direct mortality due to decreased water levels when the turbines are initialized and direct mortality due to increased water levels during ramping events were both classified as having a moderate residual effect. Considered together, these pathways could significantly adversely affect furbearer populations if the frequency of the ramping events would be greater than predicted or if furbearers were not able to recover from the effects of a ramping event prior to the next ramping event. Furbearer populations would be adversely effected by the decreases in water level and concurrent decrease in channel width upon start-up. Currently, the initial decrease in water levels would occur in the fall as the Project begins operations. This leaves furbearers with little time to adjust before much colder weather sets in. Although decreased water levels and channel widths led to only limited instances of direct mortality for beaver in Minnesota through starvation and wolf depredation when water levels were lowered during the winter (Smith & Peterson 1991), temperatures are not as severe as in the Project area. During extreme cold, beavers remain under the ice or inside their lodges, where temperatures are closer to 0 °C. Energy is conserved by remaining within their lodges as activity above the ice at temperatures below –10 °C requires substantial energy inputs (Baker & Hill, 2003).

Once the new water level is established, in the absence of ramping, the new hydrological regime would probably be beneficial to furbearers since variation in water level decreases. Under this scenario, furbearer populations are predicted to be maintained near or potentially above current conditions. However, scheduled ramping would increase water levels and channel widths at a potentially unprecedented rate for the system. Ramping could lead to direct mortality through drowning, predation, and loss of food supplies. However, these ramping events would not occur every year and in fact would be rare under the 56 MW expansion and roughly every other year under the 36 MW expansion. The 36 MW expansion would have slightly less magnitude of effect given that water level increases would not be as great. For either expansion option, is it predicted that the effects of ramping events would not pose a threat to the long-term sustainability of furbearer populations along Trudel Creek.

It should also be noted that this assessment of significance does not include the positive effect on the population from migrant individuals adjacent to Trudel Creek. As determined in the KLOI for the Taltson River watershed, Project effects on furbearers are not significant as the assessment of effects in the Taltson River watershed included the positive effect of migrant individuals.

14.9.7.2 MOOSE

The assessment endpoint of preservation of moose harvesting opportunities was not considered to be significantly adversely affected by the Project. The predicted changes to riparian habitat and diet would not limit moose habitat nor would it markedly reduce moose food supply.

14.9.7.3 WATERFOWL AND SHOREBIRDS

The assessment endpoint for preserving waterfowl harvesting opportunities, specifically within Trudel Creek, was determined to be not significantly adversely affected by the Project when considering incremental effects. However, the pathway of reduced reproductive success caused by altered water levels as a result of ramping events from scheduled maintenance would have a moderate residual effect, but given the frequency of occurrence it is unlikely that populations would be at risk. With mitigation through the use of artificial nesting platforms for waterfowl, this overall residual effect would be further reduced and thus increase the certainty of the determination of not significant. The residual effect of changes to the diet of waterfowl that forage on submerged aquatic vegetation was low as this effect is medium-term and reversible.

Table 14.9.12 — Significance of Wildlife Effects

Valued Component	Assessment Endpoint	Pathways	Residual Effect (From Table 14.9.10 And Table 14.9.11)	Significance	Uncertainty
Furbearers (beaver and muskrat)	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance through lower water levels causing freeze out, loss of shelter, or drawdown of water below entranceway to lodge/burrow and subsequent starvation, predation, freezing (muskrat and beaver)	Moderate/Adverse	Not significant	High
		Direct mortality leading to reduced population abundance through higher water levels due to scheduled outages and ramping at Twin Gorges (muskrat and beaver)	Moderate/Adverse		
		Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance (muskrat)	Low/Adverse		
		Riparian habitat loss/modification leading to change in population abundance (muskrat and beaver)	Low/Adverse		
		Stabilized water levels leading to increased abundance (muskrat)	Moderate/Beneficial		
Moose	Preservation of moose harvesting opportunities	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance	Low/Adverse	Not significant	Low
		Riparian habitat loss/modification leading to change in population abundance	Low/Adverse		
Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities. Preservation of habitat and populations	Sublethal effect (changes to diet) leading to reduced population abundance	Low/Adverse	Not significant	Medium
Northern leopard frog	Preservation of habitat and populations	Habitat loss/modification leading to change in population abundance	Low/Adverse	Not significant	Low

14.9.7.4 NORTHERN LEOPARD FROG

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by the Project. Neither residual effect for the two pathways for this VC was considered high.

14.9.8 Uncertainty

The main factors affecting the uncertainty levels for wildlife in Trudel Creek are limited baseline data, errors in modelled hydrology data and wetlands, and difficulty in predicting the magnitude and duration of effects to furbearers due to ramping events from scheduled outages.

14.9.8.1.1 Furbearers

The uncertainty level for furbearers is high. Beaver and muskrat abundance has not been assessed within Trudel Creek since 2003 and 2001, respectively. During the 2001 muskrat survey, parts of Trudel Creek were already ice-free so an accurate abundance estimate was not possible. Also, the abundance of bank-dwelling furbearers has not been assessed. Predicting the effects of ramping events from scheduled outages is also difficult as comparable increases in flows were modelled to occur under baseline conditions, but over the course of days or weeks and not hours. It is difficult to determine how rapidly rising water levels and increasing channel widths may affect furbearers during the spring. The effects of ramping would probably be decreased if increased water levels occurred during the summer when conditions are less stressful. If ramping effects were shown to be minimal to furbearers, then the magnitude of the effect could be reduced.

14.9.8.1.2 Moose

The uncertainty level for the determination of significance for effects to the assessment endpoint for moose is low as there is abundant suitable habitat within the Project area that is easily accessible to this VC as it is a large and mobile animal.

14.9.8.1.3 Birds

The uncertainty level for waterfowl is medium as breeding/productivity surveys have not been conducted for waterfowl in Zone 5. If breeding surveys were conducted that indicated the majority of the breeding species in the Project area were not heavily reliant on submerged vegetation as their primary food source, then the magnitude of the effect might be decreased. If the abundance of waterfowl breeding in the Project area was shown to be minimal, then the magnitude of the local effect might be decreased. However, even with additional baseline data the significance to the assessment endpoints for waterfowl and shorebirds would not change.

14.9.8.1.4 Northern Leopard Frog

Uncertainty for northern leopard frog is low as baseline surveys have been conducted in this area. The magnitude of effects to this species may have been higher if baseline surveys had not indicated that the riparian areas of Trudel Creek are not being used as breeding habitat but rather are primarily summer foraging habitat.

14.9.9 Monitoring

Monitoring of wildlife within the Taltson River watershed is recommended prior to construction and at regular intervals during the life of the Project. Any monitoring should be done ensuring consistent and transferable data so that comparisons can be made to conditions before, during, and after the Expansion Project.

TABLE OF CONTENTS

PAGE

TABLE OF TABLES

14. ECOLOGICAL CHANGES IN TRUDEL CREEK

14.10 SUMMARY AND CONCLUSIONS

The Taltson Hydroelectric Expansion Project would cause a change in the hydrologic regime of Trudel Creek. Measurable changes in the hydrograph would cause changes in water quality, the ice regime, wetlands associated with Trudel Creek, aquatic resources, fish and wildlife. The effects to these valued components are summarized below, followed by a discussion of the overall effects on Trudel Creek from the Expansion Project.

Effects are presented together for both the 36 MW and 56 MW expansion options where appropriate. The effects assessment summarized below relate specifically to Trudel Creek and the sustainability of these valued components with this geographical context. The findings of the assessment of effects on Trudel Creek were incorporated into the effects assessment for the Taltson River Watershed KLOI (see Chapter 13). The Taltson KLOI used a holistic or populations approach to assessing effects, whereas the Trudel KLOI assessed effects in isolation of the surrounding environment.

A discussion and general assessment of effects resulting from cumulative effects was presented for each VC within Trudel Creek. These assessments were reviewed and incorporated into the cumulative effects assessment presented in the Taltson River Watershed KLOI (see Chapter 13). Assessment of cumulative effects considered the geographic boundary of the Taltson River watershed as a whole, and thus effects identified from pristine to baseline, and baseline to Expansion Project effects within Trudel Creek were grouped together with all past project effects and proposed effects within the Taltson River watershed (Section 13.11 and Chapter 19).

14.10.1 Alterations of Water Quantity

The predicted flow regime of the 36 MW and 56 MW expansion options is based on results from the Flow Model generated from 13 years of continuous flow data within the Taltson Watershed. Based on the flows generated by the Flow Model, a number of hydraulic parameters including water levels and velocities throughout Trudel Creek were simulated within a separate HEC-RAS model. The 13 years of continuous data used as input to the Flow Model is a subset of a larger flow data set from the Taltson River Watershed. The 13 years of data used to run the Flow Model and thus predict flows, water levels and velocities along Trudel Creek during operations include extreme low and high flows. Thus, the data set presents average and extreme low and high flow conditions that can be expected during operations.

On average, flows are predicted to decrease by 81% and 87% for the 36 MW and 56 MW options, respectively. However, for most years, the overall shape of the hydrograph would not change markedly from baseline relative to average operating conditions. Freshet is still predicted to begin in May/June, flows would remain high through July and August and then recede through the fall and winter, and the minimum flow would occur in March and April. The obvious difference in the baseline and operating hydrographs under the Expansion Project is the absolute flow values and the range in average flow.

During extreme low flow years, the minimum flow of 4 m^3/s could be maintained throughout the entire year. Although this occurs several times based on the 13-year model period, based on the longer record period of observed data, this occurrence would be rare (1:10 to 1:25 year event) but would likely occur during the life of the Project.

Flow ramping events would be part of normal operating conditions for both the 36 MW and 56 MW options. Scheduled outages for turbine maintenance are currently planned to occur annually in April/May to coincide with the onset of freshet. Both expansion scenarios would cause flows and water levels along Trudel Creek to rise. However, the specific magnitude of change differs from the 36 to the 56 MW ramping event. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion: 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the existing 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 MW and 56 MW expansion would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with a slightly less magnitude of change in water levels.

During extreme high flow years, flows could increase from the minimum of 4 m^3/s to over 350 m^3/s (56 MW option) based on the modelled flow record; the increase would occur over a natural freshet time period. Flow of this magnitude and higher occurred during baseline. Thus geometry of Trudel Creek has been formed by these flows in the past. The occurrence of such high flows would be rare (1:20 to 1:50 year events), but they would likely occur during the life of the Project.

The flow distance of Trudel Creek from the SVS to the confluence with the Taltson River (near Elsie Falls) is approximately 33 km (Figure 14.1.2). The total vertical drop from the Forebay to the Taltson River is less than 50 m. This equates to an average slope of 0.15%. Thus, on average Trudel Creek is a very low gradient stream. Upon further examination of the longitudinal profile of Trudel Creek, it is clear that most of the elevation drop along its 33 km occurs at three locations: Forebay to base of SVS, outflow of Unnamed Lake to inflow of Trudel Lake, and outflow of Gertrude Lake. The slope along the upper reach of Trudel Creek is very low and the slope between Trudel Lake and Gertrude Lake is also very low. Water levels in these river sections are controlled by outflow control of Gertrude Lake and Unnamed Lake, respectively.

A flow of 0.5 m^3/s (i.e., the lowest flow in which the flow model could function) was simulated in Trudel Creek using a HEC-RAS model to estimate water levels in the creek under a near-zero flow condition. Water levels in Reach 3 and 2 were quite high, indicating that the water level controls at the downstream lakes play a key role in determining stream water levels and average river velocity, as opposed to the rate of flow itself. Essentially the stream sections upstream of Gertrude Lake (Reach 3) and Unnamed Lake (Reach 2) are functioning more as extensions of their downstream lakes. Thus, velocities are relatively low for both low and high flows. This is an important finding of the modelling exercise because Trudel Creek would experience large flows during extreme high flow years but the velocities would be relatively low and thus should not alter channel geometry or increase erosion to excessive levels not experienced under baseline conditions.

Specifically, for the 36 MW and 56 MW options, the expected range in velocities prior to and during the freshet period along Reach 3 would increase from approximately 0.2 and 0.1 m/s to roughly 0.8 m/s and 0.65 m/s for a 1:20 to 1:50 year event, respectively. This corresponds to a flow increase from 40 m^3/s to 355 m^3/s for the 36 MW option, and 25 m^3/s to 244 m^3/s for the 56 MW option. Thus, a ten-fold increase in flow equates to roughly a four- to six-fold increase in velocity. Velocities of this nature are not expected to impact channel geometry or greatly increase erosion given that these velocities were part of the 20-year baseline flow regime following the closure of the Pine Point Mine.

14.10.2 Alterations of Water Quality

The effects of the Expansion Project on water quality would be limited to hydrologic changes. There is no planned effluent release or active discharge from the proposed facilities. However, changes in the hydrograph can affect water quality. For Trudel Creek, the main change in the hydrograph for an average flow year would be decreases in average flow, peak flow, and flow range. During extreme low flow years, natural freshet flow could be eliminated and the duration of the minimum flow increased. During high flow years, peak flows would increase above average but would not approach baseline levels given a large proportion of flows would be routed through the proposed new power facilities and thus away from Trudel Creek.

These changes would have subtle effects on water quality. Total metal and TSS levels would decline with reduced erosion. There would be slightly less recruitment of nutrients as the range in flow would be reduced. There would be negligible Project-induced methylmercury formation as flows would not exceed previous highs and the range of flow would decrease. The reduced flows are conservatively predicted to increase water temperature, although only slightly over baseline temperatures. Dissolved oxygen levels were also predicted to drop slightly as lower flows cause thicker ice and longer duration of ice cover.

Overall, the effects of the Project on water quality under both the 36 MW and 56 MW expansion options are predicted to be low to negligible. These findings were reviewed and incorporated into the assessment effects on aquatic resources, fisheries resources, wetlands and wildlife.

14.10.3 Alterations of Ice Structure in Trudel Creek

Ice conditions on Trudel Creek have been reviewed and assessed qualitatively on the basis of three available ice surveys. Predictions have also been made on how the development of either a 36 MW or 56 MW Expansion Project would affect the existing ice regime in this reach.

At Trudel Creek, the changes in operations and the upgrades to the Twin Gorges facility are expected to substantially decrease flow within the creek. The decreased flow has the potential to affect ice formation. Ice freeze-up would occur more quickly with the lower river velocities. The ice has the potential to be thicker throughout the creek than under baseline conditions, and with the decrease in water levels, there is the potential for the creek to freeze to the bed within the near shore shallow benches. Rising water levels in Trudel Creek caused by scheduled annual outages of the turbines at Twin Gorges may lead to an increased rate of ice-cover break-up along Trudel Creek.

For both expansion options, during the freeze-up months (October to December) the average monthly flow in Trudel Creek is expected to be approximately 10% to 20% of the average monthly flow that occurs during baseline conditions. Such a decrease in flow would cause ice freeze-up to progress much more rapidly in the river reaches of the creek. The reduction in flow velocity in some river sections has the potential to change the ice formation process from juxtaposition to simple lake ice generation (thermal ice cover). Freezing is not expected to extend all the way to the creek bed because there would be flow. However, some of the near-shore shallow benches may freeze to the creek bed. Within lakes, the process of ice formation would remain the same. However, lake levels are expected to be lower and thus there may be a slight increase in the thickness of thermal portions of the ice cover since river velocities are expected to be lower under the expansion options.

On an annual basis, the turbines at Twin Gorges are scheduled to be shut down for routine maintenance and inspection. The timing of the outage would be set to coincide with the start of the spring freshet. This would likely increase the rate of spring break-up of the ice cover along Trudel Creek. Any mobilized ice fragments would then likely re-jam either at one of the downstream lakes, or, should the lake cover also be compromised, in the Taltson River.

Based on the baseline information available and the nature of ice processes, qualitative predictions of effects on Trudel Creek ice have been made. The ice is expected to form slightly earlier and remain for longer. Ice is not expected to form to the bottom of the creek or lake beds but would likely be slightly thicker.

Overall, the effects of the Project on Trudel Creek ice are predicted to be low to minor. These findings were reviewed and incorporated into the assessment of effects on water quality (winter dissolved oxygen levels), aquatic resources, fisheries resources and wildlife.

14.10.4 Wetlands

Wetlands were selected as a valued component (VC) of Trudel Creek, specifically, as they influence the hydrologic regime and provide habitat to various wildlife including furbearers, moose, waterfowl, shorebirds, and northern leopard frogs along Trudel Creek. The assessment endpoints for the wetland VC were the preservation of wetland extent and the maintenance of wetland function. Wetland extent is the size of individual wetlands and total wetland area potentially affected by the Project. Wetland function is a process or series of processes that wetlands carry out, such as a wetland's ability to regulate the hydrology of a given area, provide habitat to wildlife, and support the ecology of its surroundings.

Two pathways, each affecting both wetland extent and function, were identified as valid: water level changes leading to a change in the flood regime, and rapid water level changes from flow ramping events.

The extent and function of wetlands along Trudel Creek are maintained by the flood regime. To determine effects to wetlands from the Project an ecological assembly model was developed for the existing wetlands. Ecological assembly is defined as the structure and composition of an ecosystem. Structure relates to the vertical and horizontal ground cover by all species within a community, whereas composition is the abundance and distribution of individual species within a community. Vegetation structure and composition, and therefore ecological assembly, are influenced by the hydrologic regime and ultimately water level fluctuations.

Within Trudel Creek wetlands, there exist clear transitions in vegetation from sedge to willow. This boundary corresponds to the elevation that is inundated for a given portion (< 40%) of the growing season. Given the hydrologic changes proposed under both expansion scenarios, this ecosystem boundary and thus wetland extent and function would be affected. The results of the Trudel flow model were input into the ecological assembly model to determine the effects on wetlands.

The effects on wetland extent are generally the same for both the 36 MW and 56 MW expansion. The ecological assembly model predicted marked changes in the new flood levels and thus changes in the ecological assembly.

The current Sedge-Willow community boundary would no longer be flooded at any time of the growing season. This would result in a drying out of the area, and initiate a change from the current willow wetland to a willow shrub-carr ecosystem. Willow would likely colonize new drier areas formerly in the baseline sedge wetland community; some of these newly-colonized areas would be willow-dominated riparian wetlands.

The current submergent community and sedge wetland would also experience growing-season dewatering, likely resulting in a colonization of these areas by willow and other upland species. Although a change of wetland community is predicted, the time scale for succession is largely unknown. Sedge communities can survive a major drawdown for more than 14 years; however, significant alterations in wetland vegetation would be evident after 10 years (Odland 2002), potentially longer for *Salix* spp. (Odland and Moral 2002).

With water level decreases greater than 1 m, there would be banks exposed with little to no submergent vegetation. Assuming a 5% slope on average along the banks of Trudel Creek, the Sedge-Willow ecosystem boundary would shift roughly 30 m slope distance from its current position. This would leave submergent and some profundal areas dewatered. The rate of recolonization of submergent vegetation was assumed to be two to three years. However, it would take more time (>3 years) before sedge move down toward the "new" water's edge and emergent vegetation populate newly formed littoral habitat.

The effects assessment for wetlands along Trudel Creek identified changes in the ecological assembly and thus wetland extent. The reduced water levels would initiate a shift in willow vegetation toward the river. Willow communities at higher elevations would eventually be replaced by upland vegetation. It is difficult to predict if this shift in willow location would result in a no net loss of willow extent. However, it is predicted that willow communities within Trudel Creek would not substantially be altered following development of the Expansion Project.

Sedge vegetation at and near the Sedge-Willow ecosystem boundary would, over time, be replaced with willow vegetation as succession occurs in response to the new flood regime. This would cause a loss of overall area occupied. However, it is anticipated that exposed bank that previously supported submergent vegetation would facilitate the succession of sedge vegetation over time.

The timing of ramping events, the frequency of occurrence, and the relatively short duration is not anticipated to cause a change in the community ecosystem boundary and thus would not affect wetland extent.

The effects of the Project on wetland function are directly related to wetland extent. Wetlands currently function by buffering downstream environments from flooding during high water and maintaining water flow during low water periods. This function is performed by both sedge and willow communities. Water levels in Trudel Creek are predominantly controlled by downstream lake levels, which in turn are controlled by the geometry of the lake outflows. Thus, although Trudel Creek wetland hydrologic function is expected to change, the role that wetlands play in regulating Trudel Creek water levels would not change.

The function of Trudel Creek wetlands as habitat for wildlife would also change as the ecological assembly changes. The implications of the change in habitat function are presented in the wildlife effects assessment (Section 14.9).

14.10.5 Aquatic Resources

The hydrologic changes under both the 36 MW and 56 MW expansion options that were deemed to be valid pathways to effects on aquatic resources were decreased flow, decreased flow range, and altered hydrograph parameters. The effects on aquatic resources were assessed separately for Trudel Creek and Trudel lakes (Gertrude, Trudel and Unnamed lakes). The two expansion options were also assessed separately for both Trudel Creek and Trudel lakes. However, the nature of effects was similar for both options.

Decreased flow had three effects on aquatic resources in both stream and lake habitat: loss of suitable littoral habitat, loss of profundal habitat, and decreased habitat quality from the resulting changes in the ice regime. The decrease in the flow results in a decrease in water level beyond or close to the current average depth of the littoral community. The littoral community was roughly defined as the wetted area above 1 m (river sections) and 2 m (lakes) in depth at summer water levels. This was the approximate depth of aquatic plants and thus the approximate depth of the most diverse habitat for benthic invertebrates. With the decrease in water levels along Trudel Creek and in Trudel lakes, the baseline littoral zone would shift down to the baseline profundal zone. Depending on the flow year during which Project operations begin, there could be a partial to total shift in littoral habitat. The new littoral zone would require time to develop into "suitable" littoral habitat, in that the area must support the right sediment structure for aquatic vegetation and a diverse benthic community. It was assumed that the process of developing suitable littoral habitat would require one to three years, and thus be short-term. For Trudel Creek, productivity, biodiversity and community structure are predicted to resemble baseline levels once the new littoral zones become "suitable." For Trudel lakes, there would be a long-term (<40 years; operations) reduction in the overall extent of littoral habitat, given the perimeter of the lake would be reduced. The maximum long-term loss of lake habitat (profundal and littoral combined) would be 12%.

Profundal habitat in both Trudel Creek and Trudel lakes would be reduced over the long term. The model predicted a 21% loss in profundal habitat along Trudel Creek under the 56 MW option (based on average summer flows). For Trudel lakes, the maximum loss of profundal habitat was estimated to be up to 12%, again based on average summer flows. These numbers would vary from year to year depending on summer flow conditions.

The assessment of effects on the ice regime of Trudel Creek predicted slightly earlier ice formation, delayed break-up, and thicker ice. These changes could lead to reduced productivity, biodiversity, and community structure. However, the changes are only expected to be minor and thus are not expected to significantly affect the aquatic resources.

Two different pathways were predicted to affect the overall habitat quality and complexity of Trudel Creek and Trudel lakes: decreased flow range and altered hydrograph parameters. As discussed above, the hydrograph under both expansion scenarios would maintain its overall shape and thus maintain periods of high and low flows. These changes would affect aquatic productivity, biodiversity and community structure. However, both river and lake habitat would see varying flows on average and would only be subjected to extended periods of minimum flow during extreme low flow periods. Thus, the effects are not predicted to significantly affect long-term productivity, biodiversity, and community structure within the aquatic environment.

Ramping events from scheduled maintenance of the turbines would cause a rapid change in water levels at a time when water levels typically increase gradually as freshet begins. The rapid increase in water levels was not predicted to increase erosion or cause excessive deposition in littoral zones. However, there would be increased drift and loss of some aquatic life as velocities wash eggs and less-resistant benthic species downstream. The effects are not predicted to reduce productivity, biodiversity or change community structure given that the onset of freshet is not a highly productive period for aquatic communities. Moreover, the summer growing season following a ramping event is not predicted to be affected by effects during a ramping event.

The findings of the aquatic resources effects assessment were reviewed and incorporated into the fisheries resources effects assessment (see Section 14.8).

14.10.6 Fisheries Resources

Within the valued component of fisheries resources, three species were selected to represent the range in habitat requirements, key ecological roles, community structure, importance to end users, and special designations by territorial and federal agencies:

- northern pike
- lake whitefish
- walleye

The diversity of preferred habitat conditions and life history characteristics of northern pike, lake whitefish and walleye is considered to cover the interests of the fish and fish habitat conditions within the Trudel Creek system.

The Department of Fisheries and Oceans Canada (DFO) has developed Risk Assessment Framework and created Pathways of Effects (POE) for common in-stream and land based activities. To date, DFO has identified 19 POEs, of which 2 have direct interactions with the Valued Components and the proposed Project components relating to Trudel Creek. The identified POEs include Flow Management (Altered Frequency, Amplitude, Duration, Timing and Rate of Change of Flow) and Fish Passage Issues. Four of the pathways were considered valid and were carried forward to a full effects assessment analysis, including:

- Flow management: alteration in depth, cover, velocity and substrate conditions with respect to fish habitat structure and cover.
- Fish passage issues: alteration of migration patterns with respect to spawning and rearing habitat and food access/migration.
- Flow management: bank erosion/erosion of channel beds with respect to deposition zones.
- Flow management: increase flows with respect to ramping events.

14.10.6.1 FISH HABITAT STRUCTURE AND COVER

To determine the magnitude of the potential changes to fish habitat structure and cover, an assessment was conducted on the degree of change in preferred habitat conditions, the quality of habitat being altered, and the usage of such habitat by the indicator species. The potential effects associated with icing, nutrient exchanges, dissolved oxygen, food supplies, water temperature, contaminant concentrations, salinity and total gas pressure on the baseline fish habitat structure and cover conditions were considered negligable.

It should also be noted that although the assessment focused on Trudel Creek, the habitats associated with Trudel Creek do not fulfill any critical components or requirements for northern pike, lake whitefish or walleye that are not met in other local drainages such as the Taltson River. Northern pike and lake whitefish are found throughout the Taltson River in abundances that are equal to or exceed those found in Trudel Creek; walleye have not been identified upstream of Trudel Creek and have only been identified in Reaches 1 and 2 in Trudel.

14.10.6.1.1 Northern Pike

The assessment of the potential effects of the Project to northern pike indicates that habitat quality and usage would remain similar to the current conditions and the availability of preferred habitat conditions would increase between 27% and 48% depending on the life-stage.

Northern pike are resilient to changes in habitat availability and habitat condition with the exception of cover. The success of the critical life-stages of northern pike (spawning and rearing) is linked to emergent and submergent vegetation. Studies indicate that the survival rates of juveniles in areas with little or no vegetation are considerably lower than in areas where pike are reared with sufficient vegetative cover. Based on the observations during the field study programs, emergent and submergent vegetation communities would remain along the shifted stream margins in most sections of the lakes and would re-establish in other areas within 5 to 10 years.

In consideration of these parameters, the magnitude of the effects was considered to be moderate in a beneficial direction. The effect would be long-term and continuous.

14.10.6.1.2 Lake Whitefish

The assessment of potential effects of the Project to lake whitefish indicates that the availability of preferred habitat conditions (specifically depth conditions) within the riverine and lacustrine habitats would decrease between 9% and 45% , depending on the life-stage.

Lake whitefish are relatively resilent to alterations in habitat, as their preferred habitat conditions are contained in a broad range and they can utilize a variety of habitat types. The one limiting factor to the success of lake whitefish is depth. Therefore, as long as sufficient depths (2 m or greater) remain, lake whitefish ability to respond to change is considered good. In addition and based on the observations during the field programs, the overall productivity of lake whitefish was considered low given the amount of available habitat.

In consideration of these parameters, the magnitude of the effects to lake whitefish habitat structure and cover was considered to be moderate in an adverse direction. The effect would be long-term and continuous.

14.10.6.1.3 Walleye

The assessment of potential effects of the Project to walleye indicates that the availability of preferred spawning habitat conditions within Trudel Creek would increase between 0.6% and 6% in lacustrine habitats and decrease by 20% and 76% in riverine habitats.

Field programs suggest walleye populations within the Trudel Creek system are small and limited to Reaches 1 and 2. Based on the results of these field programs and on the abundant preferred spawning habitat conditions within the lake systems, habitat availability is likely not the limiting factor affecting walleye population growth. During the Expansion Project flow regime, walleye could rely on spawning habitat conditions within Unnamed Lake in Reach 3, Gertrude and Trudel lakes in Reach 2, and the lower Taltson River in Reach 1.

In consideration of these parameters, the magnitude of the effects to walleye habitat structure and cover was considered moderate. The effects would be long-term and continuous.

14.10.6.2 Migration Patterns

Migration patterns within the mainstem channel of Trudel Creek would not be affected for any of the valued components; however, there is a potential loss of connectivity to off-channel habitats. These habitats are typically used by northern pike for spawning and rearing and are defined by slow-moving waters, fine sediments, and dense communities of emergent and submergent vegetation.

Assuming the off-channel habitat provides 100% preferred habitat conditions for both northern pike spawning and rearing, there would be a total loss of approximately 4 ha to each life-stage. With this loss of off-channel habitat, a substantial amount of habitat remains in each riverine and lacustrine habitat for northern pike juvenile rearing and spawning. Therefore, the magnitude of the effect was considered low.

14.10.6.3 Bank Erosion

To understand the erosion and deposition characteristics anticipated for the Expansion Project flows, Klohn Crippen Berger (2008) conducted an assessment of erosion on Trudel Creek. Conclusions of this study indicate that the Expansion Project would result in a significantly reduced erosion rate, since peak monthly and daily flows would be reduced by greater than 50%. This reduction in erosion would result in an increase in water quality and a reduction in deposition. Under baseline conditions, the effects of deposition on the emergent/submergent vegetation communities and incubating eggs are minimal. Therefore, the reduction in deposition within Trudel Creek would have a net benefit to habitat structure and cover; however, it would not result in a considerable increase in habitat values.

14.10.6.4 RAMPING (PLANNED SHUTDOWNS)

Scheduled ramping events have the potential to affect the valued components northern pike, lake whitefish and walleye in four ways:

- incubating egg displacement during increased flows;
- de-watering of incubating eggs during plant start-ups;
- increased erosion and deposition, potentially smothering incubating eggs; and
- juvenile and adult displacement/stranding during plant start-ups.

Of the identified potential affects, the dewatering of incubating eggs during plant start-ups was found to be the only effect likely to result in a residual effect.

The proposed scheduled outages and/or maintenance period of the turbines has been planned to occur in April and/or May. This time period overlaps the timing window of spawning/egg incubation of walleye and northern pike; lake whitefish emergence typically occurs by March. Therefore, there could be a potential to dewater incubating walleye and northern pike eggs.

During a ramping event from a scheduled shutdown, the waterline elevation within Trudel Creek would increase. As maintenance on the turbines would be conducted contiguously to minimize the increase of flows over the SVS and into Trudel Creek, the maintenance period is anticipated to extend over a three week period. If the shutdown event occurs in May, northern pike and walleye would likely move into the newly-wetted stream margins to spawn. Upon completion of the maintenance works and the start-up and operation of all three turbines, flows over the SVS would decrease and subsequently the waterline elevation would drop. Incubating eggs spawned in approximately 0.8 m of water or less could potentially become dewatered.

Spawning period for walleye and northern pike typically begin in mid- to late May. With the scheduled shutdowns occurring over a three-week period, it is anticipated that the majority of required maintenance would be completed prior to both northern pike and walleye spawning, and subsequently there would be little, if any, potential to dewater incubating eggs; however, should the scheduled shutdown not begin until mid-May, the potential risk to incubating eggs would increase. In addition, the egg incubation periods associated with both walleye and pike are short at around two weeks. Therefore, only the eggs spawned 14 to 18 days previous to the plant start-up and in water 0.8 m deep or less, would be at risk of dewatering. Eggs spawned more than 18 days prior to the plant start-up would likely be emerged young-of-year and could relocate as the waterline shifted down.

The frequency in which full ramping events would be experienced in Trudel Creek during a scheduled shutdown is anticipated to occur every other year. In years where full ramping events are not experienced, the change in water depths would be less than 0.8 m. The magnitude of depth change would vary depending on the flow conditions during the maintenance period; however, the less the change, the less potential there is for incubating eggs to become dewatered.

The maintenance period would be further refined during the detailed design phase to accommodate the fisheries and wildlife resources as well as the social components associated with Trudel Creek.

14.10.7 Wildlife

Within the wildlife VC, there are many species or wildlife communities that have different ecological requirements and thus respond to development differently. Table 14.10.1 lists the wildlife VCs that were identified based upon review of the requirements of the TOR, community concerns raised during consultation, and federal and territorial lists of species particularly susceptible to current and future development. The assessment endpoints are also listed in Table 14.10.1, and relate to preservation of the population and preservation of harvesting opportunities. Listed together with the assessment endpoint of preservation of the population is the measurement endpoint of habitat. Habitat is listed with population as they are closely related and thus directly overlap.

Table 14.10.1 — Wildlife Valued Components and Assessment Endpoints

Key Line of Inquiry	Valued Component	Assessment Endpoint
Ecological changes in Trudel Creek	Furbearers	Preservation of furbearer harvesting opportunities along Trudel Creek
	Moose	Preservation of moose harvesting opportunities along Trudel Creek
	Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities along Trudel Creek
		Preservation of habitat and populations along Trudel Creek
	Raptors that primarily consume fish	Preservation of populations along Trudel Creek
	Whooping crane	Preservation of habitat and populations along Trudel Creek
	Rusty blackbird	Preservation of habitat and populations along Trudel Creek
	Northern leopard frog	Preservation of habitat and populations along Trudel Creek

Twenty-one pathways were identified that could lead to effects on wildlife VCs, ten of which were validated and carried forward for effects analysis and classification. A complete residual effects classification was completed for valid pathways that lead to potential effects on furbearers, moose, waterfowl and shorebirds and northern leopard frog. However, invalid or minor pathways were found for raptors that primarily consume fish, rusty blackbird and whooping crane. Minor and invalid pathways were not carried through to the effects analysis and classification.

Below is a summary of the residual effect analysis and classifications for the four VCs that had valid pathways. Both the 36 MW and 56 MW expansion options are discussed together.

14.10.7.1.1 Furbearers

Hydrological model results indicate that under the 56 MW option, water levels at river station TRUDEL1 would drop 150 cm lower than baseline conditions in the winter (January) and 230 cm below baseline conditions during the summer. Similarly, water levels during the fall, when the turbines are expected to be initiated, were modelled to drop 105 cm or more at the other river stations and lakes. In association with the water level decrease would also be a narrowing of channel width. At all river stations, the channel width was modelled to decrease in the order of metres. This would leave the majority of furbearer shelters no longer connected to the new water level. The effect of direct mortality caused by freeze-out and water levels dropping below the entranceways to shelters for beavers and muskrats and subsequent increased predation rates was classified as high for all of Trudel Creek. The effect would be medium-term as it would take a few generations before the effect reverses. Under the current construction schedule, the Expansion Project turbines would be initiated in the fall. The effect would be medium-term as the effects would take a few generations to reverse. The overall residual effect for beaver and muskrats from lowered water levels was assessed as moderate.

Under the 56 MW expansion, the flow during April and into May could be at the minimum release flow of 4 m^3/s when scheduled outages are planned. However, because water levels would be low at this time, power production would likely be below maximum output. Therefore, ramping events would not always occur during a scheduled outage as water from the off-line turbine would be taken up by the other operating units. Thus, the frequency of a ramping event from a scheduled outage would depend on flow conditions at the time of the outage. Based on an analysis of the modelled data set, scheduled outages would result in ramping events 6 out of 13 years and 1 out of 13 years under the 36 MW and 56 MW expansions, respectively.

A 56 MW ramping event would result in water levels increasing roughly 80 cm and channel width increasing roughly 20 m for a duration of three weeks. Water level and channel width increases would occur over a 6- to 10-hour period. The magnitude of the effect on furbearers from higher water levels was assessed as high for muskrats and moderate for beaver throughout Trudel Creek. For animals that are inside their dens when water levels increase, mortality could occur to animals that are not able to escape the flooded shelter. For animals that can escape the rising water levels there still may be a loss of shelter, which would increase their exposure to inclement weather conditions and possible predation. Beaver depredation in spring by wolves has been inferred through wolf scat analysis (Smith & Peterson, 1991). Rapidly rising water levels may also cause ice break up to occur more quickly. Moving ice fragments could also potentially destroy furbearer shelters. Food resources are also reduced at this time of year so ramping would represent an additional physiological stressor for animals that escaped direct mortality. The effect would be continuous, but short-term and reversible as subsequent generations replace lost individuals. If the duration of effect is longer than predicted it is possible that furbearer habitat within Trudel Creek may become "sink" habitat: annual mortality associated with ramping would cause negative local population growth (Battin, 2004). Baseline surveys for muskrat indicated that muskrat abundance was low possibly because of the fluctuations in water levels under baseline conditions. Under the 56 MW option, in order to maintain local populations of beaver and muskrat, immigration from other nearby populations that have positive population growth may be necessary. However, immigration from neighbouring furbearers was not considered in the assessment classification. The overall residual effect for beaver and muskrats from higher water levels was assessed as moderate.

Sublethal effects to muskrat (caused by diet changes) as a consequence of changes to the submerged vegetation community were classified as moderate for all of Trudel Creek. This effect would be continuous but reversible as vegetation communities would re-establish themselves under the new hydrological regime. It was considered a moderate effect since the physical health of muskrats may be compromised while vegetation communities are stabilizing. The overall residual effect was assessed as low.

The effect of riparian habitat loss or modification was classified as moderate in magnitude for all of Trudel Creek based on the wetland model results, which suggested that lowered water levels would change the riparian habitat both at the sedge/willow and emergent/submergent vegetation boundaries within Trudel Creek. It was assumed that the furbearers would adapt to the new riparian vegetation from lowered water levels. Subsequently, this effect was also considered reversible as riparian vegetation re-establishes in the medium-term. The overall residual effect to furbearers (i.e., beavers and muskrat) because of habitat loss/modification was assessed as low.

The water level difference between average monthly maximum and average monthly minimums would decrease by 160 cm under the 56 MW option as compared to baseline conditions at river station TRUDEL1 and would follow a similar trend at the other modelled locations. This was classified as a beneficial effect for muskrat and was assessed as likely with high magnitude. Winter mortality caused by freeze-outs and predation through exposed entranceways to shelters would be reduced by the new flattened hydrological regime. This may lead to an increase in muskrat abundance in Trudel Creek. The overall residual positive effect was classified as moderate.

14.10.7.1.2 Moose

The magnitude of sublethal effects of diet changes was assessed as low because of the abundance of wetland habitat in the area and the ability of moose to access these food sources. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

The magnitude of the effect of riparian habitat loss or modification for moose was classified as low because of the abundance of wetlands and the ability of moose to access these other habitats. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

14.10.7.1.3 Waterfowl and Shorebirds

The magnitude of the sublethal effect of changes in diet for dabbling ducks and other waterfowl that feed on submerged aquatic vegetation was classified as low because birds can access other wetland and riparian habitat in the area and feed in those areas. However, birds that are nesting in the area may forage locally. This effect would be continuous, medium-term, and reversible as vegetation communities would re-establish themselves under the new hydrological regime. The overall residual effect was considered low.

14.10.7.1.4 Northern Leopard Frog

The effect of riparian habitat loss or modification was classified as low for northern leopard frogs since they are primarily using this habitat at low densities for foraging during the summer and it does not appear to offer breeding habitat. The effect would occur throughout Trudel Creek, have a medium-term duration, and was considered a low residual effect.

14.10.8 Significance of Trudel Creek Effects

Significance determination of Project effects on Trudel Creek are presented for fisheries resources and wildlife. The effects on these two VCs represent the summation of physical and biological effects from the Project on Trudel Creek as fish and wildlife are affected by changes in hydrology, water quality, ice, aquatics and wetlands. They also incorporate effects on human use of these resources in terms of harvesting opportunities.

The Trudel Creek effects assessment considered both a 36 MW and 56 MW expansion. The nature and direction of hydrological and biological effects were similar for both expansion options. Thus, these two expansion options were assessed together where appropriate.

However, for ramping events from scheduled outages, the two expansion options differed in the magnitude of effects and the frequency of occurrence. Less flow would be routed through Trudel Creek during the maintenance of the new turbines proposed for the 36 MW expansion relative to the 56 MW expansion: 23 m^3/s versus 53 m^3/s, respectively. However, both ramping scenarios would route similar flows during maintenance of the existing turbine. The routed flow during maintenance of the existing 18 MW turbine (44 m^3/s) is similar to the routed flow during maintenance of new 28 MW turbines (53 m^3/s) proposed for the 56 MW expansion. This is due to increased efficiency of the new turbines and additional elevation drop from the new tailrace configuration. Thus, the two ramping scenarios under the 36 MW and 56 MW expansion would differ in magnitude of flow and water level changes during the first two weeks of maintenance, but would have similar magnitude changes during the third week of maintenance.

The two ramping scenarios also differ in the frequency of occurrence. The 36 MW and 56 MW ramping events are predicted to occur 6 out of 13 years and 1 out of 13 years based on modeled flow data, respectively. Thus, the 36 MW ramping event would occur more often but with a slightly less magnitude of change in water levels. To minimize redundancy as much as possible, the 56 MW ramping event was the only event carried forward to the full effects analysis and classification. However, the frequency of occurrence of the 36 MW ramping event was applied to the 56 MW ramping event. This approach ensures a conservative assessment of the overall residual effect of ramping events and significance determinations for VCs affected by ramping events.

Trudel Creek was clearly identified in the Terms of Reference for the Taltson Developer's Assessment Report (DAR) (Mackenzie Valley Environmental Review Board, 2008) as an area of concern if the Expansion Project is to proceed. This chapter specifically addresses Project effects on Trudel Creek. However, and as discussed in Section 14.1, Trudel Creek is not an isolated entity; it is one of two channels of the Taltson River between the Forebay and Elsie Falls. As such, during the development of the DAR, it was noted that both Project effects and the assessment endpoints of various VCs include areas outside the geographic boundary of Trudel Creek. For example, the geographic extent of a population of furbearers includes habitat adjacent to Trudel Creek. Thus, assessing the overall Project effect on the assessment endpoint of furbearers ("preservation of harvesting activities") should include the population as a whole. For instance, if a Project activity caused a one-time direct mortality effect, individuals would be lost. However, if following this one time activity the habitat was still suitable for occupation, furbearers adjacent to Trudel Creek could move into the area. Thus, the sustainability of the population could be maintained.

To accommodate the need to present the effects of the Project on Trudel Creek in isolation, assessment endpoints and assessment boundaries were limited to areas within Trudel Creek for this chapter. The determination of significance was therefore completed for fish and wildlife while considering, at times, only portions of populations within Trudel Creek only. Thus, severity of the overall residual effects and subsequent determination of significance would be reduced if true population boundaries were considered. Natural population boundaries and extent of Project related effects were used to define the assessment boundaries and geographical extent definitions for water level fluctuations within the entire Taltson River watershed; see Chapter 13 (Water Level Fluctuations in the Taltson River Watershed). The findings of the effects assessment for Trudel Creek were incorporated into the overall determination of significance for the Taltson River watershed.

14.10.8.1 SIGNIFICANCE DETERMINATION – FISHERIES RESOURCES

Table 14.10.2 presents the determination of significance for the fisheries resources VCs of Trudel Creek. Both beneficial and adverse effects were identified. For northern pike and walleye, the highest rated overall residual effect (Moderate) from a single assessment endpoint was beneficial. Only lake whitefish had an adverse effect rated higher than low: moderate overall residual effect on changes to habitat structure and cover.

As per the methods outlined in Section 14.2, effects to the fisheries resources VCs were assessed in isolation of fish within fish-accessible zones of the Taltson River. Water level fluctuations along Trudel Creek were not predicted to have overall significant adverse or positive effects on fisheries resources in Trudel Creek.

Table 14.10.2 — Determination of Significance to the Valued Components

Valued Component	Valued Component Assessment Endpoint	Overall Residual Effect	Overall Significance	Uncertainty
Northern pike	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events Changes to rearing and spawning habitat and food access / migration	Moderate/Positive Low/Positive Low/Negative Low/Negative	Not significant	Intermediate
Lake whitefish	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events	Moderate/Negative Low/Positive Low/Negative	Not significant	Low
Walleye	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events	Moderate/Positive Low/Positive Low/Negative	Not significant	Low - Intermediate

14.10.8.2 SIGNIFICANCE DETERMINATION – WILDLIFE

The determination of significance of the Project effects on furbearers, moose, waterfowl and shorebirds, and northern leopard frog are presented in Table 14.10.3.

Uncertainty of the effects classification represents the level of confidence in the effect predictions that were classified at a local level. With additional data on local wildlife populations, the significance of the effects would probably not change but the likelihood and magnitude of the effects classification would be more accurate.

Table 14.10.3 — Significance of Wildlife Effects

Valued Component	Assessment Endpoint	Pathways	Residual Effect (From Tables 14.9.10 and 14.9.11)	Significance	Uncertainty
Furbearers (beaver and muskrat)	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance through lower water levels causing freeze out, loss of shelter, or drawdown of water below entranceway to lodge/burrow and subsequent starvation, predation, freezing (muskrat and beaver).	Moderate/Adverse	Not significant	High
		Direct mortality leading to reduced population abundance through higher water levels due to scheduled outages and ramping at Twin Gorges (muskrat and beaver).	Moderate/Adverse		
		Sublethal effects (changes to diet/submerged aquatic plant community) leading to reduced population abundance (muskrat).	Low/Adverse		
		Riparian habitat loss/modification leading to change in population abundance (muskrat and beaver).	Low/Adverse		
		Stabilized water levels leading to increased abundance (muskrat).	Moderate/Beneficial		
Moose	Preservation of moose harvesting opportunities	Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Low/Adverse	Not significant	Low
		Riparian habitat loss/modification leading to change in population abundance.	Low/Adverse		
Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities Preservation of habitat and populations	Sublethal effect (changes to diet) leading to reduced population abundance.	Low/Adverse	Not significant	Medium
Northern leopard frog	Preservation of habitat and populations	Habitat loss/modification leading to change in population abundance.	Low/Adverse	Not significant	Low

14.10.8.2.1 Furbearers

The assessment endpoint of preservation of furbearer harvesting opportunities within Trudel Creek was considered to be not significantly adversely affected by the Project. The pathways of direct mortality due to decreased water levels when the turbines are initialized and direct mortality due to increased water levels during ramping events were both classified as having a moderate residual effect. Considered together, these pathways could significantly adversely affect furbearer populations if the frequency of the ramping events would be greater than predicted or if furbearers were not able to recover from the effects of a ramping event prior to the next ramping event. Furbearer populations would be adversely effected by the decreases in water level and concurrent decrease in channel width upon start-up. Currently, the initial decrease in water levels would occur in the fall as the Project begins operations. This leaves furbearers with little time to adjust before much colder weather sets in. Although decreased water levels and channel widths led to only limited instances of direct mortality for beaver through starvation and wolf depredation when water levels were lowered during the winter, the study occurred in Minnesota where January temperatures are not as severe as in the Project area (Smith & Peterson, 1991). During extreme cold, beavers remain under the ice or inside their lodges, where temperatures are closer to 0 °C. Energy is conserved by remaining within their lodges as activity above the ice at temperatures below –10 °C requires substantial energy inputs (Baker & Hill, 2003).

Once the new water level is established, in the absence of ramping, the new hydrological regime would probably be beneficial to furbearers since variation in water level decreases. Under this scenario, furbearer populations are predicted to be maintained near or potentially above current conditions. However, scheduled ramping would increase water levels and channel widths at a potentially unprecedented rate for the system. Ramping could lead to direct mortality through drowning, predation, and loss of food supplies. However, these ramping events would not occur every year and in fact would be rare under the 56 MW expansion and roughly every other year under the 36 MW expansion. The 36 MW expansion would have a slightly less magnitude of effect given that water level increases would not be as great. For either expansion option, is it predicted that the effects of ramping events would not pose a threat to the long-term sustainability of furbearer populations along Trudel Creek.

It should also be noted that this assessment of significance does not include the positive effect on the population from migrant individuals adjacent to Trudel Creek. As determined in the KLOI for the Taltson River watershed, Project effects on furbearers are not significant as the assessment of effects in the Taltson River watershed included the positive effect of migrant individuals.

14.10.8.2.2 Moose

The assessment endpoint of preservation of moose harvesting opportunities was not considered to be significantly adversely affected by the Project. The predicted changes to riparian habitat and diet would not limit moose habitat nor would it markedly reduce moose food supply.

14.10.8.2.3 Waterfowl and Shorebirds

The assessment endpoint for preserving waterfowl harvesting opportunities, specifically within Trudel Creek was determined to be not significantly adversely affected by the Project when considering incremental effects. However, the pathway of reduced reproductive success caused by altered water levels as a result of ramping events from scheduled maintenance would have a moderate residual effect, but given the frequency of occurrence it is unlikely that populations would be at risk. With mitigation through the use of artificial nesting platforms for waterfowl, this overall residual effect would be further reduced and thus increase the certainty of the determination of not significant. The residual effect of changes to the diet of waterfowl that forage on submerged aquatic vegetation was low as this effect is medium-term and reversible.

14.10.8.2.4 Northern Leopard Frog

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by the Project. Neither residual effect for the two pathways for this VC was considered high.