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17. ACCIDENTS AND MALFUNCTIONS

17.1 INTRODUCTION

The likelihood and consequence of accidents and malfunctions during construction and operation of the Taltson Hydroelectric Expansion Project are presented below. The assessment of accidents and malfunctions used a risk assessment methodology to evaluate the likelihood and the resulting environmental, worker health and safety, and public safety consequences. All potential accidents and malfunctions were screened through a collaborative effort by Project engineers, biologists and socio-scientists. A full risk assessment was then completed using the risk assessment methodology presented below.

The objective of the risk assessment methodology was first to identify potential issues through review of Project components and then screen the associated activities that are expected to occur. The accidents and malfunctions identified through screening were brought forward to the full risk assessment where relevant. That is, accidents and malfunctions that have low consequence and are readily addressed through implementation of various management plans were not carried forward to the full risk assessment.

The assessment of accidents and malfunctions included all Project components and resulting relevant modes of accidents and malfunctions. This included winter roads, staging areas and barge landing locations, Nonacho Lake facilities, Tazin facilities, Twin Gorges facilities, and the transmission line.

17.2 ASSESSMENT METHODOLOGY

The risk assessment methodology used failure mode scenarios for all Project components, including infrastructure and activities, to determine potential accidents and malfunctions. The accidents and malfunctions were assessed to determine risk. Risk was defined as a function of the likelihood of the accident and malfunction and the resulting consequence.

The first step in the assessment was to identify all the Project components and the associated infrastructure and activities that could result in an accident or malfunction with environmental, worker health and safety, or public safety consequences. A screening table was generated to list all potential accidents and malfunctions (see Table 17.4).

Relevant accidents and malfunctions listed in the screening table were brought forward through the full risk assessment if the consequence of the accident and/or malfunction was deemed greater than "Low"; see definitions below. The full risk assessment identified the failure mode that would cause the accident and/or malfunction. The consequence and effect were then described in detail and mitigation applied to avoid, eliminate, or minimize the resulting severity of effect and/or likelihood of occurrence where necessary.

The likelihood of occurrence and the severity of effect (consequence) were ranked by various descriptors presented below. The level of confidence in the ranking of likelihood and severity of effect was then determined. Overall ranking of risk for each accident and malfunction was then presented in tabular form. For risks that were deemed "high risk", a full environmental effects assessment was completed for the accident/malfunction as per the effects methodology presented in Chapter 10.

17.2.1 Project Components

The Taltson Hydroelectric Expansion Project includes the following Project components: winter roads, staging areas and barge landing locations, Nonacho Lake facilities (dam, control structure and gates), Tazin facilities (dam), Twin Gorges facilities (South Valley Spillway, main dam, intake gates, penstocks, turbines, and control systems), and transmission line (transformers, towers, and lines).

17.2.2 Screening

The entire Expansion Project was screened to identify potential accidents and malfunctions. The screening process was an initial assessment to identify accidents and malfunctions that are readily addressed through widely-accepted and used management plans. For example, through both construction and operations there is a high likelihood for human/wildlife interactions. During the winter these interactions would likely be in the form of wildlife searching the camps for food or possibly shelter. Wildlife management plans used at projects in the Northwest Territories have shown the consequences of these interactions to be relatively benign following worker training regarding feeding wildlife, waste disposal, and worker response to wildlife encounters. The consequences of accidents and/or malfunctions resulting from human/wildlife interactions were ranked as "Low" during the screening process and thus were not carried forward to the full risk assessment.

17.2.3 Failure Mode

The failure mode was presented in the risk assessment tables. Modes of failure include operational and engineering-related failures.

17.2.4 Event Trigger

An event trigger is a systematic event that results in the failure of any facility or part thereof. Triggers can be related to environmental effects but are limited here to normal expected operating conditions. Unexpected, or extreme, environmental conditions (e.g. major flood) and any resulting accident or malfunction are covered under "Project Responses to the Environment" (Chapter 16).

17.2.5 Effect

The effect of the accident and malfunction was summarized in the risk assessment table. The effect was presented in terms of an environmental, worker health and safety, and public safety effect, or all three if applicable.

17.2.6 Mitigation

Mitigation in the form of Project design features and mitigation practices can avoid, eliminate, or minimize a potential accident and malfunction. Mitigation was presented and the residual risk of a given accident and malfunction was assessed.

17.2.7 Likelihood of Occurrence

A five-class system was used to define likelihood of occurrence. Each class descriptor was assigned a probability in terms of percent chance of occurrence (Table 17.1). The likelihood of occurrence that was assigned to each accident and malfunction related to its temporal boundary (3 years for construction; 40 years for operations).

Table 17.1 — Likelihood of Occurrence Scale

Likelihood Class	Likelihood Occurrence
Not Likely (NL)	<0.1%
Low (L)	0.1 to 1%
Moderate (M)	1 to 10%
High (H)	10 to 50%
Expected (E)	>50%

17.2.8 Consequence

Consequences of an accident and/or malfunction relate to the severity of the potential effect on the environment, worker health and safety, and public safety. Consequences were ranked using five different categories (Table 17.2).

Table 17.2 — Consequence Assessment Scale

Rating	Environmental Effect	Worker Health & Safety	Public Safety
Negligible (N)	No measureable effect	No concern	No concern
Low (L)	Minor effect on habitat/ecosystem or population	First aid required or small risk of serious injury	Minor effect to public safety/health
Moderate (M)	Moderately significant; reversible effect on habitat/ecosystem or population	Lost time or injury likely or some potential for serious injuries; small risk of fatality	Short-term effect with moderate to high magnitude
High (H)	Highly significant; reversible effect on habitat/ecosystem or population (large but reversible)	Severe injury or disability likely; some potential for fatality	Significant effect on public safety/health
Extreme (E)	Catastrophic effect on habitat/ecosystem or population (irreversible and large)	Fatality or multiple fatalities expected	Catastrophic effect on public safety/health

17.2.9 Risk Ranking

Risk was ranked via a consequence and likelihood matrix (Table 17.3). Rankings were defined as "acceptable risk" and "high risk". Rankings were based by arbitrarily defining the risk as a combination of consequence and likelihood. Risk rankings of "high risk" require further assessment and evaluation of the overall residual effect and if appropriate, a determination of significance. An effects assessment was completed for "high risk" accidents and malfunctions as per the methodology outlined in Chapter 10.

Table 17.3 — Risk Ranking Matrix by Likelihood and Consequence

Consequence	LIKELIHOOD				
	Not Likely	Low	Moderate	High	Expected
Negligible					
Low					
Moderate					
High					
Extreme					
Acceptable Risk					
High Risk					

17.2.10 Level of Confidence

The accident and malfunction risk assessment was completed by engineers and biologists experienced in construction and operations of hydro facilities and environmental effect assessments. However, there is a level of uncertainty inherent in predictions of possible events yet to occur. Assigning a level of confidence to the risk assessment predictions is required to better understand the limitations of the predictions. Uncertainty in the predictions can arise from limited understandings of actual operating conditions and lack of understanding of future environmental and human health and safety conditions.

The level of confidence assigned the accidents and malfunctions was low (<25%), medium (25% to 75%) and high (>75%).

17.3 RESULTS

The results of the risk assessment are presented separately for screening and full assessment of potential accidents and malfunctions. The screening process was comprehensive and conservative. The intent of the screening process was to eliminate accidents and malfunctions from the full risk assessment if it was clear that the consequence to the environment, worker health and safety and public safety were "Low."

17.3.1 Screening

The purpose of the screening process was to identify all potential accidents and malfunctions and then apply a conservative ranking of the consequence only, as opposed to consequence and likelihood, following mitigation. This process is meant to eliminate potential accidents and malfunctions that would be readily addressed through best management practices and proven construction and operation management plans. The following accidents and malfunctions were identified under most construction activities and some activities associated with Project components during operations (Table 17.4):

- vehicle accidents,
- human/wildlife interactions,
- spills,
- potential for worker injury, and
- explosives use.

Table 17.4 — Accidents and Malfunction Screening

Project Compo-nent	Sub-Components	Associated Activities	Accidents & Malfunctions	Phase	Mitigation / Comments	Conseq-uence
Nonacho Lake facilities	Intake canal	Mob and site prep (clearing etc.)	Vehicle accidents Human/wildlife interactions	Constr-uction	Driver training; construction management, including safety policies	Low
	Control structure & hydro generation plant	Blasting Trucking Waste/waste rock management Aggregate processing Concrete work In-stream blasting	Human/wildlife interactions Spills Explosives Injuries Vehicle accidents	Constr-uction	Spill response plan Explosives management Safety polices Worker training Wildlife management Water management	Low
	Dam modification	In-stream rock placement	Human/wildlife interactions Spills Explosives Injuries Vehicle accidents	Constr-uction	Spill response plan Explosives management; Safety polices Worker training Wildlife management Water management	Low
	Spillway raise	In-stream rock and concrete work	Human/wildlife interactions Spills Explosives Injuries Vehicle accidents	Constr-uction	Spill response plan Explosives management Safety polices Worker training Wildlife management Water management	Low

Project Compo-nent	Sub-Components	Associated Activities	Accidents & Malfunctions	Phase	Mitigation / Comments	Conseq-uence
	Mechanical & electrical	Installation of equipment	Human/wildlife interactions Spills Explosives Injuries Vehicle accidents	Constr-uction	Spill response plan Explosives management Safety polices Worker training Wildlife management Water management	Low
	Construction camp & work zone	Mob Setup Waste (sewage, refuse, metals, incineration, etc.)	Human/wildlife interactions Spills Explosives Injuries Vehicle accidents	Constr-uction	Spill response plan Explosives management Safety polices worker training Wildlife management Water management	Low
	Facility maintenance	Helicopter or plane access	Helicopter malfunctions	Opera-tions	Helicopter operating standards Worker training First Aid facilities	Low
	Structures (dam, control, gates)	General operations	Failure of Nonacho Lake dam, control structure, gates	Opera-tions	Spillway to pass flows Proper design and redundancy Inspections of equipment	High to Moderate
Twin Gorges facilities	Min flow release structure at SVS	Minor blasting and in-stream work	Human injury SVS failure	Constr-uction	Explosives management worker training Safety polices	High
	Min flow release structure at SVS	General operations	Min. Release structure failure (zero flow)	Operat-ions	SVS inspection and maintenance Min. flow backup equipment	High

Project Compo-nent	Sub-Components	Associated Activities	Accidents & Malfunctions	Phase	Mitigation / Comments	Conseq-uence
	Water conveyance canal construction (SON)	Mob and site prep (vegetation clearing) Blasting, Trucking Waste management Aggregate processing	Vehicle accidents Human/wildlife interactions Spills (fuel, concrete, explosives) Human injury	Constr-uction	Driver training and safety Policies Wildlife management Spill response Helicopter safety	Low
	Intake structure	In-stream blasting, concrete use	Spills Human injury Explosives	Constr-uction	Spill response Explosives management Materials management	Low
	Powerhouse, excavation & penstocks	Mob and site prep (vegetation clearing) Blasting Trucking Waste management Aggregate processing	Vehicle accidents Human/wildlife interactions Spills (fuel, concrete, explosives) Human injury	Constr-uction	Spill response Explosives management Materials management	Low
	Rock tailrace canal	In-stream blasting	Spills Human injury Explosives	Constr-uction	Safety policies waste management Spill response Explosives management	Low
	Waste rock stockpile	Earthmoving equipment	Human injury Mechanical fluid and fuel leaks/spills	Constr-uction	Driver training and safety policies Spill response Waste management	Low
	Mechanical & electrical	Installation of equipment	Vehicle accidents Human/wildlife interactions Spills (fuel, concrete, explosives) Human injury	Constr-uction	Driver training and safety policies Spill response Waste management	Low
	Transportation	Plane access	Plane malfunction	Constr-uction	Fixed-wing Safety protocols Safety polices First Aid facilities	Low

Project Component	Sub-Components	Associated Activities	Accidents & Malfunctions	Phase	Mitigation / Comments	Consequence
	Construction camp & work zone	Mob Setup Waste (sewage, refuse, incineration, etc)	Vehicle accidents Human/wildlife interactions Spills (fuel, concrete, explosives) Human injury	Construction	Driver training and safety policies Wildlife management Spill response helicopter safety	Low
	Camp		Vehicle accidents Human/wildlife interactions Spills (fuel, concrete, explosives) Human injury	Construction	Driver training and safety policies Wildlife management Spill response Helicopter Safety	Low
	Powerhouse & switchyard	Maintenance	Power generation failure	Operations	Water management	High
	Intake gate	General operations	Failure of intake structure	Operations	Inspection maintenance Stoplogs for isolation of structure for maintenance	Moderate
	Main dam	Failure during operations	Surge of water in Taltson River	Operations	Inspection Maintenance	High
	Penstocks & canal	General operations	Uncontrolled release of water Loss of generation until repaired	Operations	Redundancy in design Inspection Maintenance	High
	Turbine	General operations	Loss of generation	Operations	Redundancy in design Inspection Maintenance	Moderate
	Plant control system	General operations	Plant flow reduction Spill of water through Trudel	Operations	Redundancy in design Inspection Maintenance	Moderate
Staging areas & barge landings	Southern section staging areas and camps (operational all summer)	Vegetation clearing and site levelling	Vehicle accidents Human/wildlife interactions Spills Explosives Human injuries	Operations	Safety policies Wildlife management Spill response Explosives management Waste management	Low

Project Compo-nent	Sub-Components	Associated Activities	Accidents & Malfunctions	Phase	Mitigation / Comments	Conseq-uence
	Northern section staging areas and camps (winter prep, summer occupation)	Clearing and levelling	Vehicle accidents Human/wildlife interactions Spills Explosives Human injuries	Opera-tions	Safety policies Wildlife management Spill response Explosives management Waste management	Low
	2 Barge landing sites and staging areas	Vegetation clearing and levelling Camp facilities on barge Waste (sewage, refuse, materials, etc.)	Vehicle accidents Human/wildlife interactions Spills Explosives Human injuries	Opera-tions	Safety policies Wildlife management Spill response Explosives management Waste management	Low
	2 Barge camps	Waste (sewage, refuse, metals etc.)	Vehicle accidents Human/wildlife interactions Spills Explosives Human injuries	Constr-uction	Safety policies Wildlife management Spill response Explosives management Waste management	Low
Winter roads	Ft. Smith to Twin Gorges winter road	Brushing out existing overland sections Truck traffic	Vehicle accidents Vehicle through ice Human/wildlife interactions	Constr-uction	Safety policies Winter road Design standards Wildlife management	Low
	Twin Gorges to Nonacho winter road	Clearing portages Rock work (blasting) General use	Vehicle accidents Vehicle through ice Human/wildlife interactions Explosives use	Constr-uction	Safety policies Winter road Design standards Wildlife management Explosives management	Low
Trans-mission line	Transmission line from Twin Gorges to treeline	Helicopter supported work (slinging) Rock work (drill and blast rock foundations) Earthworks Vegetation clearing	Helicopter accidents Human/wildlife interactions Human injuries	Constr-uction	Helicopter safety protocol Wildlife management	Low

Project Component	Sub-Components	Associated Activities	Accidents & Malfunctions	Phase	Mitigation / Comments	Consequence
	Transmission line from treeline to Snap Lake, Gahcho Kué, Ekati, and Diavik mine sites.	Helicopter supported work (slinging) Rock work (drill and blast rock foundations) Earthworks	Helicopter accidents Human/wildlife interactions Human injuries	Construction	Helicopter Safety protocol Wildlife management	Low
	Transmission line operations	Hand clearing during operations Maintenance Major line outage Transformer failure Helicopter supported access	Equipment fatigue Helicopter accidents Note: T-line damage from environmental factors (e.g. Lightning) is addressed elsewhere	Operations	Inspection and maintenance Helicopter safety protocol	Moderate
Tazin facilities	Tazin dam	General operation of facilities Closure of generation facilities and redirection of flow to Taltson	Structural failure or overtopping leading to loss of dam End of serviceable life of facilities	Operations	Inspection Maintenance Reconstruction	Moderate

With the implementation of best management practices the consequences of the above accidents and malfunctions were rated as "Low". Accidents and malfunctions associated with failure of major structures and potentially severe environmental and human safety issues were assigned consequences of moderate or higher. These potential accidents and malfunctions were brought forward to the full risk assessment.

17.3.2 Risk Assessment

A full risk assessment was completed for all potential accidents and malfunctions that upon screening revealed a consequence of greater than "Low" (Table 17.5). The overall risk of the accident and malfunction, as defined as a combination of likelihood and consequence, was also assigned to each accident/malfunction during the assessment.

Table 17.5 — Accidents and Malfunctions Risk Assessment

Project Component	Sub-Component	Project Phase	Failure Mode	Likely Trigger	Effect	Mitigation	Likeli-hood	Consequence (Worst Case for all receptors)	Level of Confid-ence
Nonacho Lake facilities	Nonacho dam	Construction Operations	structural or overtopping leading to loss of dam	failure of control structure to operate	Uncontrolled release of Nonacho Lake to sill elevation (~3,000M m^3) Short-term sedimentation event; potential to strand fish; loss of habitat; erosion Potential human injury	spillway to pass high flow; proper design and redundancy; inspections to Dam Safety Guidelines	Not likely	High	High
	Control structure	Operations	structural failure leading to loss of gate control	design error or malfunction	Uncontrolled release of Nonacho Lake to sill elevation (~3,000M m^3) Short-term sedimentation event; potential to strand fish; loss of habitat; erosion Potential human injury	- proper factors of safety in design; inspections to Dam Safety Guidelines	Low	Moderate	High

Project Component	Sub-Component	Project Phase	Failure Mode	Likely Trigger	Effect	Mitigation	Likeli-hood	Consequence (Worst Case for all receptors)	Level of Confid-ence
	Underflow gates	Operations	failure of hoisting mechanism to raise or lower gate	operator error; icing; electrical fault, mechanical fault	Uncontrolled release of up to 50 m^3; gate closed: loss of operational flexibility Minor increase in downstream flow not likely to effect fish	- multiple gates; backup power; proper design; stoplogs available for quick repairs; inspections	Moderate	Moderate	High
Tazin facilities	Tazin Lake dam	Construction Operations	Structural or overtopping leading to loss of dam	Structural failure during normal operating conditions	Uncontrolled discharge from Tazin to Taltson Short-term sediment event Additional water over SVS and into Trudel Creek	Inspection and maintenance (Dam Safety Guidelines)	Low	Moderate	High
	Tazin operations	Construction Operations	Change in scheduled operations or closure of Tazin Facilities	Major change in utility operations plan or transmission link destroyed	Resumption of natural Tazin River flows into Taltson system	No mitigation required Advantage-ous to Project	Low	Moderate	High

Project Component	Sub-Component	Project Phase	Failure Mode	Likely Trigger	Effect	Mitigation	Likeli-hood	Consequence (Worst Case for all receptors)	Level of Confid-ence
Twin Gorges facilities	South valley spillway	Construction Operations	Structural failure of concrete sections	Structural failure during normal operating conditions or during construction work for minimum flow release structure	Uncontrolled release of Forebay into Trudel Creek headwaters until Forebay drained to sill level Surge of water along Trudel Creek and along Taltson River Short-term sedimentation and erosion event Flooding of shoreline habitat Work and public injury	Inspection and maintenance (Dam Safety Guidelines)	Not likely	High	High
Twin Gorges facilities	Minimum flow release structure at SVS	Operations	General equipment failure	No specific trigger	Zero flow through the minimum flow release structure; if this occurred during a low flow period then there would be zero flow through Trudel Creek	Fully functional backup equipment	Not likely	High	

Project Component	Sub-Component	Project Phase	Failure Mode	Likely Trigger	Effect	Mitigation	Likeli-hood	Consequence (Worst Case for all receptors)	Level of Confid-ence
	Main dam	Construction Operations	Overtopping or geotechnical failure	Major inflows coupled with plant outage Structural failure	Uncontrolled surge of water into the Taltson River Short-term sedimentation and erosion event; short-term flooding of shoreline habitat	Inspection and maintenance (Dam Safety Guidelines)	Not likely	High	High
	Intake gate	Construction Operations	Electrical or mechanical fault Debris causing jam Icing	No specific trigger Unpredictable	Partial power outage and increased flows into Trudel Creek. Duration could be weeks up to a month	Stoplogs for inspection and maintenance inspection and maintenance	Moderate	Moderate	High
	Powerhouse and switchyard	Operations	Equipment malfunction Failed equipment	No specific trigger Unpredictable	Full power outage and thus full ramping of Forebay water levels and Trudel Creek and Taltson River flows Duration could be weeks up to a month	Inspection and maintenance	Moderate	High	

Project Component	Sub-Component	Project Phase	Failure Mode	Likely Trigger	Effect	Mitigation	Likeli-hood	Consequence (Worst Case for all receptors)	Level of Confid-ence
Twin Gorges facilities	Penstocks and canal	Operations	Structural failure	Structural failure during normal operating conditions	Uncontrolled release of flows (volume depends on extent of failure) Erosion of flow path Surge of water in Taltson River Medium-term flooding of shoreline habitat	Inspection and maintenance	Low	High	High
	Turbine	Operations	Catastrophic failure of a single turbine	Fatigue failure No specific trigger	Loss of generation from one turbine Partial rerouting of flows over SVS for an extended period of time	Inspection and maintenance	Low	Moderate	High
	Plant control system	Operations	Operator error	No specific trigger Such events have occurred at other hydro projects	Plant flows curtailed or plant shutdown Additional flow over SVS (short-term)	Automatic shutdown sequence on DC power and hardwired logic	Moderate	Moderate	High
Transmission line	Transformer failure	Operations	Internal fault	Overheating No specific trigger	Plant shutdown; flows diverted over SVS Additional flow over SVS (up to a month)	Inspection and maintenance Spare parts available for repairs	Low	High	High

The structures and facilities associated with hydroelectric developments present risk to the environment, worker health and safety, and the safety of the public if in the area of the Project. These structures include dams, intake facilities, canal and penstocks, and spillways. All of these structures were rated as "High" consequence upon failure. This rating reflects the overall quantity of water that would be released if such an accident or malfunction would occur. These accidents/malfunctions were not rated as extreme environmentally because the quantity of water would not destroy the downstream environment. That is, the effects to habitat quality would be reversible in the medium-term and the effects would not eliminate entire populations in the short-term. General human health and safety (worker and public) was also not rated as extreme given the remoteness of the area and the likelihood that workers would be in harm's way during such a situation.

Many of the accidents/malfunctions were rated as low likelihood because such occurrences are readily avoidable when proper inspection, auditing, and maintenance plans are developed and followed. The operation plan would be part of a successful and safe project. Together with a commitment to worker training, auditing, inspections, and guidelines (Dam Safety Guidelines; Canadian Dam Association 2007), all screening accidents and malfunctions are readily avoidable.

One accident/malfunction was identified as having "high risk" based on the risk assessment matrix applied. A major equipment failure at the powerhouse or switchyard would cause a full power outage that could last up to a month. The consequences relate to environmental effects only. If such a malfunction was to occur water would no longer flow through the power facilities, however inflows to the Forebay would continue. Within a short period of time water levels would rise above the sill elevation of the SVS and flow into Trudel Creek. This ramping event would last the duration of the accident/malfunction. The effects to the environment would be the same if an environmental factor (e.g. major lightning strike) took the power facilities offline for an extended period of time. It is estimated that it would take days up to a month potentially to restore power production from either the accident/malfunction or a major effect of the environment. The risk ranking of "high risk" for the malfunction and a major effect of the environment warrant a full environmental assessment of the effects. Section 17.4 and Section 17.5 present the effects assessment from a full and lengthy (up to a month) power outage at Twin Gorges for Trudel Creek and the Taltson River, respectively.

17.4 RAMPING TRUDEL CREEK (ZONE 5)

Ramping in Trudel Creek would occur during a scheduled power outage for turbine maintenance and during an unscheduled power outage resulting from an accident, malfunction or from an effect of the environment (e.g. lightning strike). A scheduled partial power outage for turbine maintenance is part of the normal operating procedures of the Expansion Project; the effects assessment for normal operating procedures was completed in the Trudel Creek KLOI (Chapter 14). An unscheduled full power outage could occur from either an accident/malfunction (Section 17.3) or an effect of the environment (Chapter 16), with similar hydrologic and thus physical and biological effects. The effects assessment of an unscheduled full power outage originating from either an accident/malfunction or an effect of the environment is presented herein.

17.4.1 Overview

The overriding objective of the Expansion Project operations strategy would be to keep the river and Forebay system in a stable or slowly changing state, and avoid transient operations that lead to large fluctuations in flows over short periods of time. However, normal start-up and both scheduled and unscheduled outages of the Twin Gorges power facility may lead to temporary, but reasonably large-scale water level and flow changes in Trudel Creek and in the Taltson River downstream of the Twin Gorges power facility to Tsu Lake (lower Taltson River). Over the outage period, which can range from several hours to up to a month, the flows in these reaches would reach a new equilibrium. These more rapid changes from equilibrium conditions are termed flow ramping.

Partial outages at the Twin Gorges power facility would be scheduled on an annual basis to conduct routine maintenance. Additional outages would occur as a result of unscheduled and unplanned power plant malfunctions, line disruptions, or other factors. Potential environmental effects resulting from annual scheduled outages were assessed in Chapters 13 and 14. The focus of the following sections is on potential effects stemming from unscheduled full outages that shut down water flows through all turbines at the Twin Gorges power facility.

It is anticipated that unscheduled outages would occur on an annual basis. However, the majority of outages would be short in duration, likely persisting for less than one hour. Outages that result from major equipment failure or major line disruptions would likely be longer in duration; days up to a month. Outages due to lightning or forest fires would typically occur in the summer months. Outages caused by ice and wind loading may occur along the existing transmission line but would be very rare for the proposed line, as no major water body crossings are required, and appropriate design and construction methodology would virtually eliminate this possibility in normal terrain. Maintenance of the right-of-way clearing limits in treed areas would be of paramount importance in reducing line outages.

Outages that have durations from a few minutes to a few hours would result in only minor ramping of flows prior to the restart of the turbines. To assess effects of an extreme ramping scenario, the following sections assume a full outage with duration of up to one month. Such an event is estimated to have a one in five year average recurrence frequency.

Potential effects from ramping as a result of a full power outage in Zone 5 are presented in Section 17.4. Based on the hydrological predictions during an unscheduled full power outage, an effects assessment was conducted, as per the methodology outlined in Chapter 10, for the worst-case scenario for: water quality, wetlands, aquatic resources, fisheries resources, and wildlife.

The worst-case scenario for water quality was based on a full power outage under the 56 MW operating condition during a period with high flows (Q_{10} flows) through the Taltson Basin. Under this condition, water levels and flows would be higher than any other scenario, resulting in the highest water velocity, turbulence and mixing, which are physical factors affecting water quality parameters.

For wetlands, aquatic resources, fisheries resources and wildlife effects, the worst-case scenario was based on a full power outage under the 56 MW operating condition during a period with low flows through the Taltson Basin. Under this condition, the percent change of flows and water levels between pre-outage and outage conditions would be the greatest. The biological assessments are based on the percent change from pre-outage to outage conditions.

17.4.2 Hydrological Model Predictions

This section describes the predicted hydrological changes in the event of an unscheduled full power outage under the 56 MW scenario in Trudel Creek (Zone 5). The hydrological changes along Trudel Creek and in the lower Taltson River under the 56 MW scenario would be greater in magnitude than the 36 MW given the increased flow capacity of the larger plant. Therefore, during a full outage, a larger water volume would be re-directed from the Twin Gorges power facility to Zone 5 resulting in the greatest change in hydrological conditions between pre-outage and outage conditions. Therefore, a full outage under the 56 MW scenario would be the worse-case scenario. Hydrological changes as a result of a full outage under the 36 MW scenario were not presented because the effects would be less than the 56 MW scenario.

A single cross section of Trudel Creek (Trudel 1) was used to illustrate potential changes in water levels as a result of ramping in Zone 5. The location of the cross section is presented in Figure 17.1. Figures 17.2 and 17.3 present the changes in flow and water levels conditions at Trudel 1 during a full power outage and subsequent restart when pre-outage conditions are at the minimum water level and flow. Trudel 1 was selected as it is located within a key section of Trudel Creek for both fish and wildlife use. Moreover, with the exception of Reach 1 which experiences backwatering effects from the Taltson River, increases in water levels are fairly uniform through Trudel Creek and lakes.

In the event of an unscheduled full power outage, flows through all turbines at the Twin Gorges power facility would stop, causing the water level to rise in the Forebay. In the Taltson River downstream of the Twin Gorges power facility to Tsu Lake in Zone 3 (referred to as the lower Taltson River), flow would immediately reduce to the pre-outage flow from Trudel Creek plus a maximum of 30 m^3/s from the South Gorge Spillway. The South Gorge Spillway is a mitigation design measure to ensure some flow in the tailrace of the Twin Gorges power facility during a power outage. Due to the immediate closure of the plants, water levels below Twin Gorges would reach a minimum level immediately following an outage. Ramping effects would be attenuated beyond the inflow to Tsu Lake and would have almost no effect to flows and water levels in Zone 4.

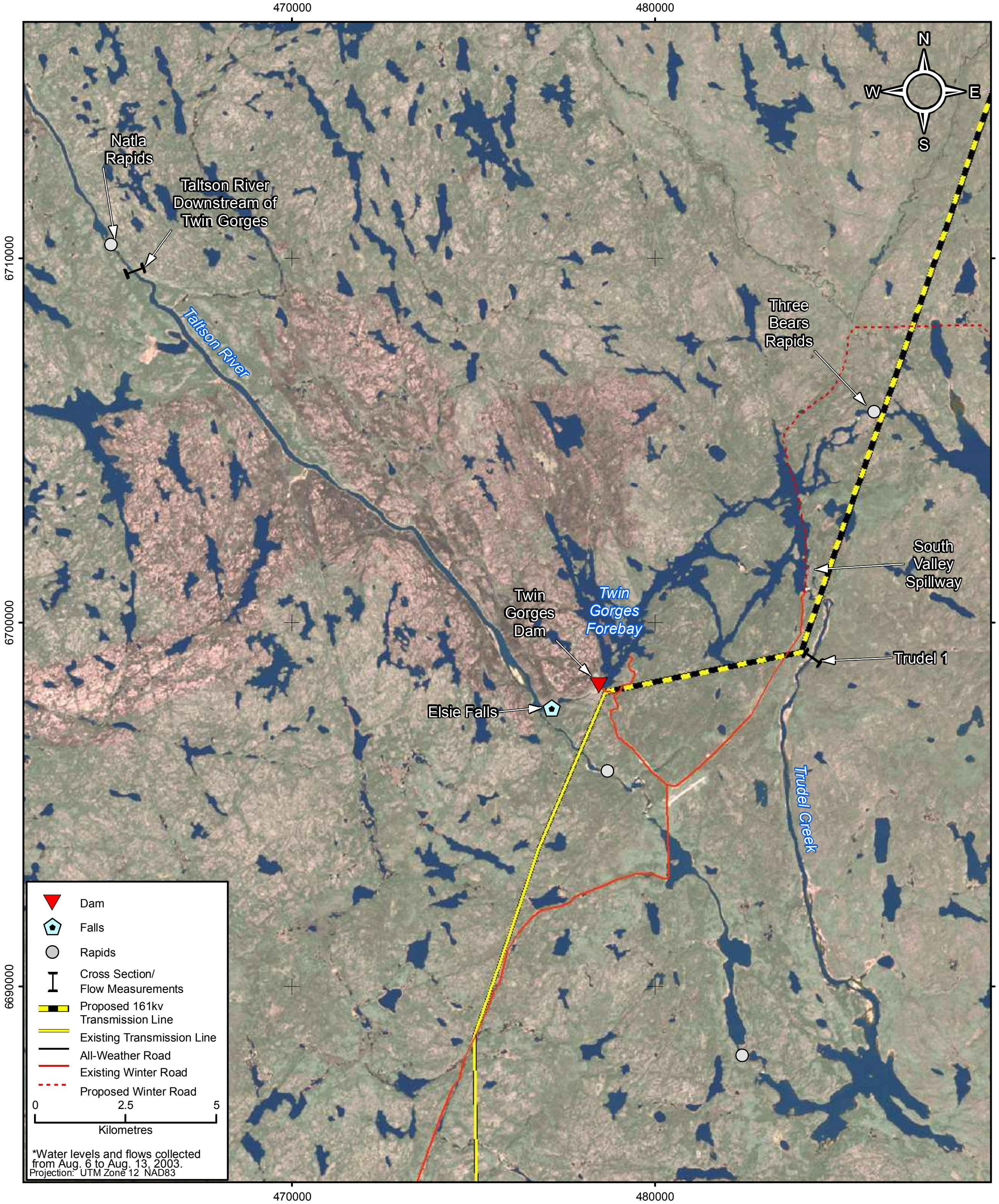
Following shut-down of the turbines, water levels in the Forebay would rise and result in increased flow over the SVS to Trudel Creek (Zone 5). Due to the Forebay storage capability, it would take approximately 8 hours for the full generation flow to be re-routed to Trudel Creek. Spills over the SVS would flow through Zone 5 in approximately 10 hours and return to the Taltson River in Zone 3, below Twin Gorges. Therefore, flows and water levels in the lower Taltson River would decrease immediately after a full power outage, and gradually return to pre-outage conditions approximately 18 hours later (Figure 17.3) (i.e. 8 hours for peak flows over the SVS, and 10 hours for the peak flow to travel through Zone 5 and re-enter Zone 3).

Although the three turbine units would be capable of being re-started simultaneously, a sequential start-up and loading process would be implemented to stage the flow ramping decreases in Trudel Creek and the flow ramping increases in the lower Taltson River. Three increments of flow would be introduced to the Taltson River as each turbine is restarted. This would result in rates of decline in flows over the SVS until the flows returned to pre-outage conditions. Typically, one turbine would be loaded every 4 to 6 hours, which would allow flows through Trudel Creek to decrease gradually. The first unit start is synchronized with the closure of the South Gorge spillway flows (30 m^3/s), and hence has a reduced peak from the start-up of the following two units.

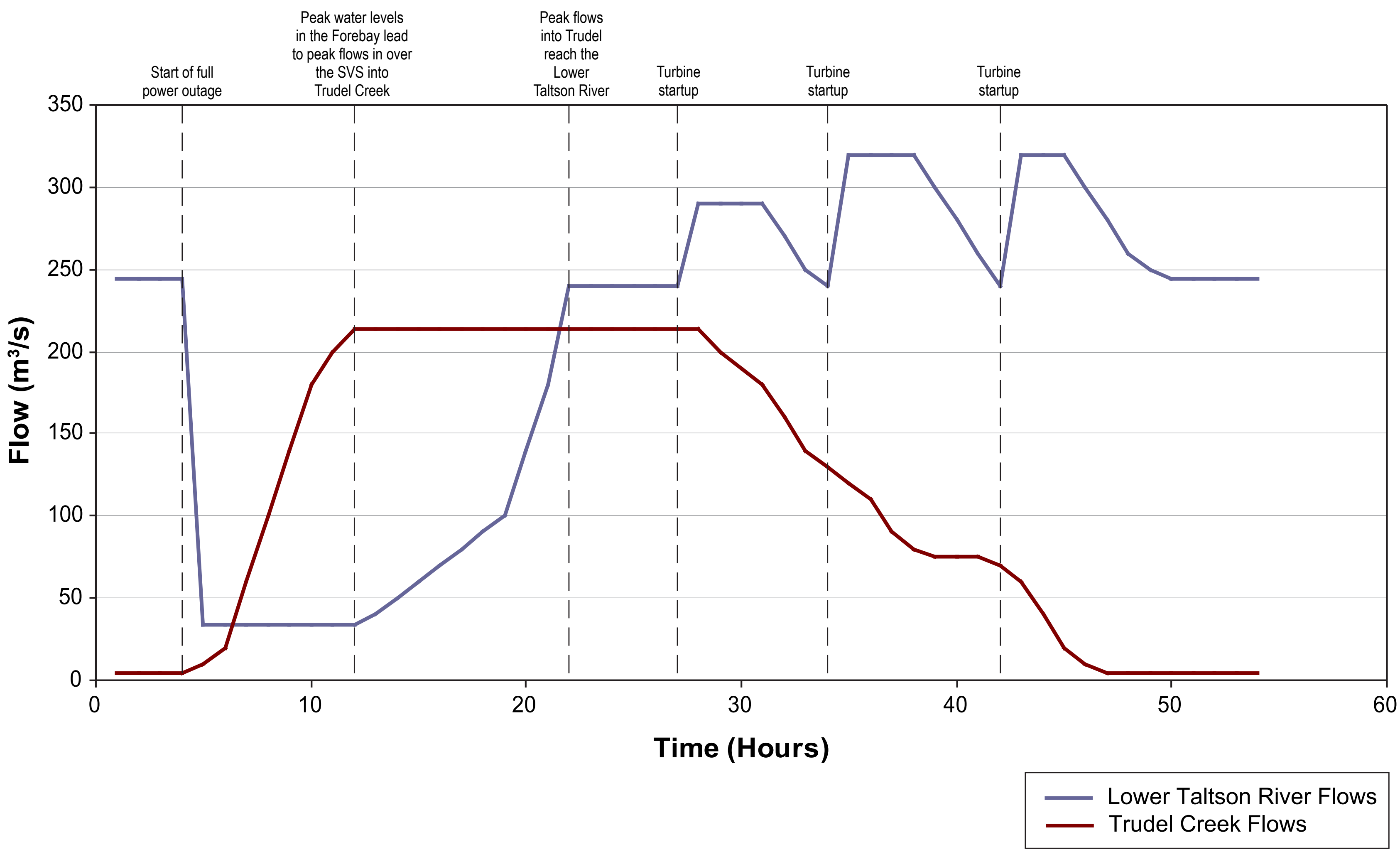
Based on the outage and restart hydrograph for Trudel Creek, water levels were estimated for other relevant ramping scenarios where background flows would be much higher than the minimum. Figure 17.4 presents the predicted water levels during an unscheduled full outage event that would occur under the following scenarios:

- background flows are at a minimum in Trudel Creek (low flow),
- background flows similar to a 2 year return period peak flow event (Q_2 = 45 m^3/s), and
- background flows similar to a 10 year return period flow (Q_{10} = 161 m^3/s).

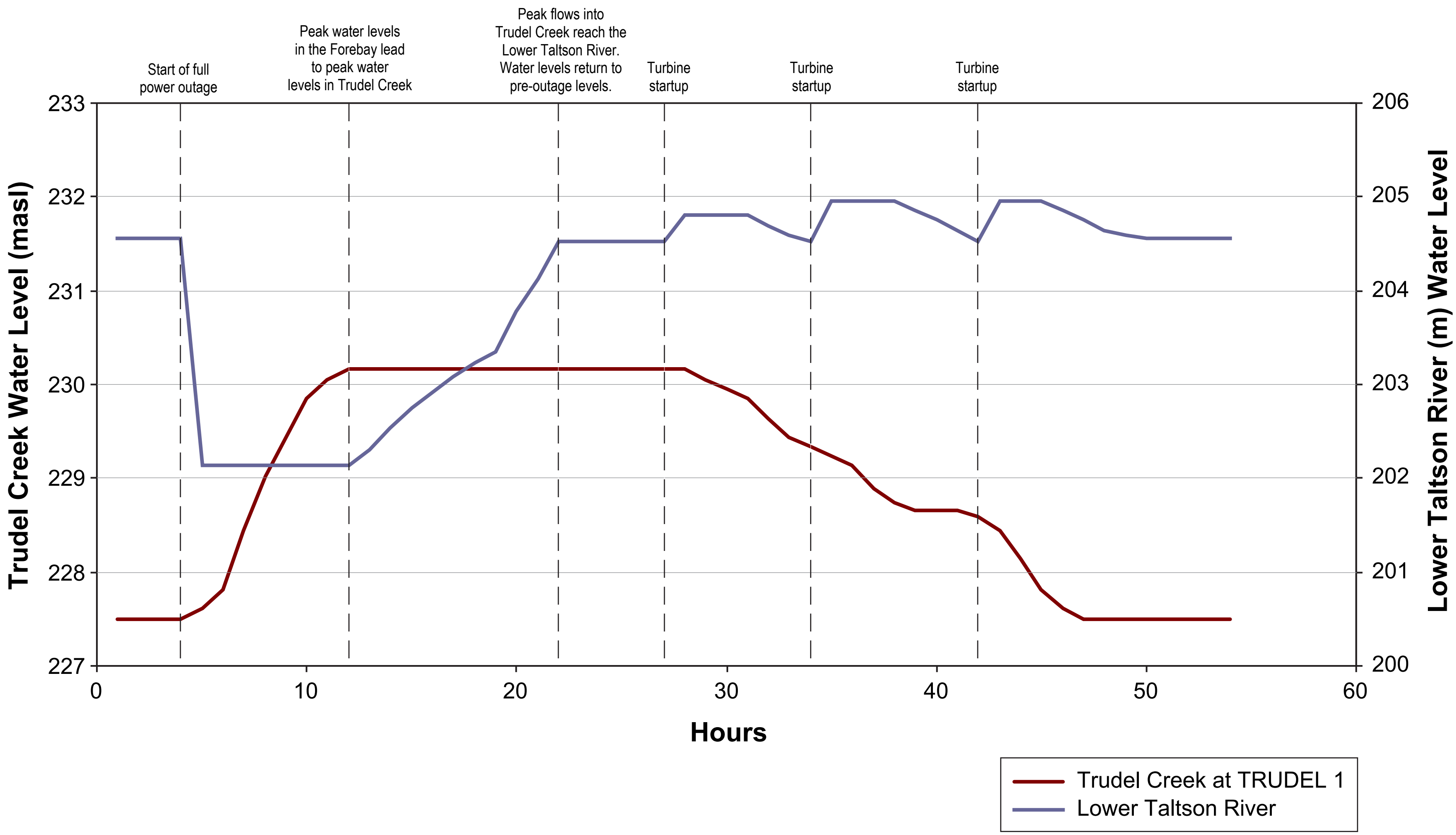
Table 17.6 presents the estimated absolute maximum flows over the SVS and water levels in Trudel Creek (Trudel 1) as well as the flows and water levels that would be experienced during low flow, Q_2 and Q_{10} events under the 56 MW scenario.



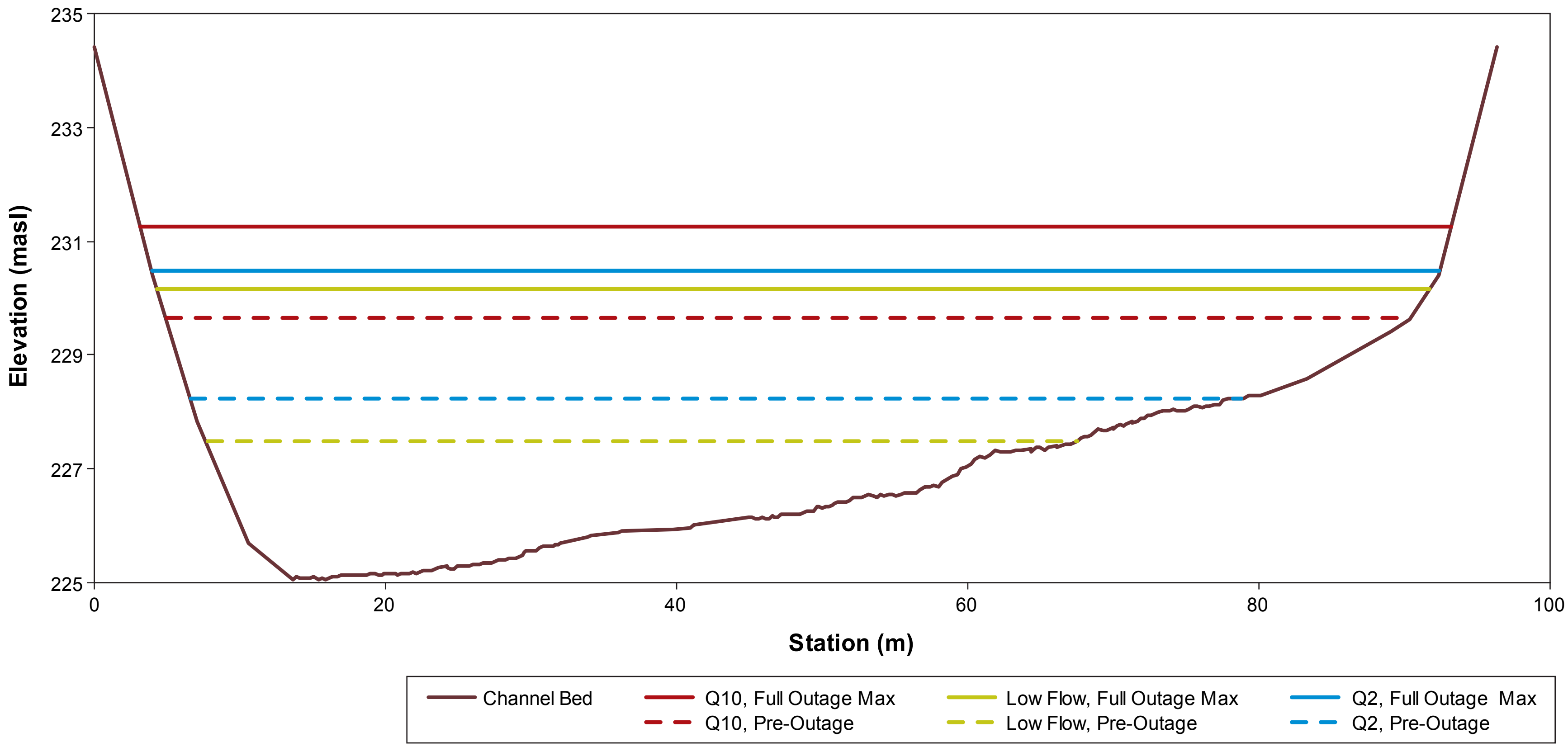
TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report 2009**	**Cross Sections Used to Illustrate Water Levels in Trudel Creek and the Taltson River below Twin Gorges under a Full Outage Scenario**	**Figure 17.1**



TALTSON HYDROELECTRIC EXPANSION PROJECT	**Developer's Assessment Report** **2009**	**Ramping Flows for Full Outage and Restart**	**Figure** **17.2**



TALTSON **Hydroelectric Expansion Project**	**Developer's Assessment Report** **2009**	**Water Levels for Full Outage and Restart** (503-005 / a22619w)	**Figure 17.3**



TALTSON Hydroelectric Expansion Project	**Developer's Assessment Report 2009**	**Water Levels in Trudel Creek at TRUDEL1 for Full Outage and Various Base Flows** (503-005 / a22621w)	**Figure 17.4**

Table 17.6 — Water Levels and Flows in Trudel Creek During a Full Outage

	56 MW Scenario	56 MW Outage During Low Flow	56 MW Outage During Q_2 Flow	56 MW Outage During Q_{10} Flow
Water Flows over the SVS (m^3/s)				
Absolute Maximum Flow	244			
Pre-outage Flow		4	45	161
Outage Peak Flow		214	255	371
Water Levels in Trudel Creek (masl)				
Absolute Maximum Water Level	230.4			
Pre-outage Water Level		227.5	228.2	229.7
Outage Peak Water Level		230.2	230.5	231.3

The maximum water level reached under the ramping scenarios would be greatest when background flows are the highest (i.e. Q_{10} = 231.3 masl). However, the change in water levels during a ramping event would be greatest when background flows are the lowest (i.e. low flow = +2.7 m).

The maximum flow in Trudel Creek during a full power outage (i.e. 371 m^3/s) would be higher than the absolute maximum flow during normal 56 MW operating conditions (i.e. 244 m^3/s) if it occurred during a Q_{10} flow event in Trudel Creek. The rate of increase in flows and water levels would be substantially greater during a full outage compared to normal 56 MW operations.

17.4.3 Mitigation

Effects of the Project can be minimized through two primary mitigation measures (1) mitigation design and (2) mitigation practise. Mitigation design refers to a Project component incorporated into the Project to reduce or avoid a negative effect. Mitigation practise includes activities and strategies that would reduce or avoid a negative effect.

Mitigation designs to minimize a full ramping effect include the South Gorge Spillway that would be constructed around the left abutment of the Twin Gorges power facility. The spillway would be opened in the event of a full outage that could not be corrected quickly (i.e. before water spills over the SVS into Zone 5) to release up to 30 m^3/s of water into the tailrace of the Twin Gorges power facility, instead of re-directing this flow over the SVS.

Mitigation practises to minimize a full ramping effect would occur when restarting operations at the Twin Gorges power facility. Each turbine would be restarted sequentially rather than simultaneously, allowing water levels to gradually return to pre-outage conditions over a longer period of time. This would reduce the rate of water level decreases in Zone 5 when the Twin Gorges power facility is restarted, and limit the effect of erosion and sedimentation by attenuating the change in flow and water levels over a longer time period.

17.4.4 Water Quality

17.4.4.1 INTRODUCTION

The following section describes the potential effects to water quality in Trudel Creek (Zone 5) from an unscheduled full power outage during 56 MW normal operating conditions. Key water quality parameters identified in the Key Line Of Inquiry (KLOI) for the Taltson Basin and Trudel Creek included: general chemistry, total mercury, eutrophication (i.e. nutrients), temperature, dissolved oxygen, erosion and sedimentation.

Section 17.4.2 described the hydrological conditions in the event of a full outage during a low, Q_2 and Q_{10} flow years under the 56 MW scenario. For water quality changes, the worst-case scenario is based on the maximum flow and water level that would be achieved at the peak of the ramping conditions. Therefore, for water quality parameters, a worst-case scenario would be an unscheduled full power outage occurring in a year with Q_{10} flows as shown in the comparison of flow conditions in Table 17.7.

The effects of ramping would affect: changes in flow rate, maximum flows and water levels. The ramping would affect water velocity, mixing/turbulence and changes in the ratio of base flow to total stream flow. These factors could in turn alter water quality.

17.4.4.2 Q10 FLOW OUTAGE IN ZONE 5 – TRUDEL CREEK

Table 17.7 presents the pre-outage and outage flow rates over the SVS and water levels in the first cross section of Trudel Lake (Trudel 1) during a year with Q_{10} flows. This scenario would be applicable only to the months of August and September, when the pre-outage flow (161 m^3/s) and water level (229.7 masl) could be reached. From October to July, the pre-outage flows and water levels cannot reach the Q_{10} pre-outage conditions, and a full outage occurring between these months would result in a less substantial change in water quality.

Table 17.7 — Water Levels and Flows in Zone 5 During a Q_{10} Flow Outage

	56 MW Scenario	56 MW Outage During Q_{10} Flow
Water Flows over the SVS (m^3/s)		
Absolute Maximum Flow	244	
Pre-outage Flow		161
Outage Peak Flow		371
Water Levels in Trudel Creek (masl)		
Absolute Maximum Water Level	230.4	
Pre-outage Water Level		229.7
Outage Peak Water Level		231.3

The pre-outage flow over the SVS would be 161 m^3/s with a water level of 229.7 masl. At peak ramping conditions, flows and water levels would increase to 371 m^3/s and 231.3 masl. These flows and water levels would be higher than the absolute maximums under the 56 MW scenario (244 m^3/s and 230.4 masl).

17.4.4.2.1 General Chemistry

During a period with Q_{10} flows, the general chemistry of the water would experience low changes during a full outage compared to normal 56 MW conditions and high baseline flows. The months where Q_{10} flows would occur are restricted to August and September; when flows, water velocity and turbulence are at the annual peak. During these months, the pre-outage turbidity, total suspended solids and total metals would be at its highest level for the year because suspended materials which settled into benthic sediments during winter months would be mobilized and redistributed back into the water column. Total dissolved solids and dissolved metals would be at their lowest levels because the ratio of base flow to total stream flow would be low. Additional flows would further dilute dissolved materials in the water.

The waters in Zone 5 are oligotrophic and baseline water quality conditions show low levels of turbidity, total suspended solids and total metals. These parameters generally reflect the conditions of the surrounding environment such as soils. The peak water level during a Q_{10} full outage would not rise beyond baseline levels. However, the ramping water levels would be higher than the absolute maximum water level under normal 56 MW operating conditions. Therefore, some additional inputs of substances could occur relative to normal operating conditions but the surrounding existing environment indicates the surrounding areas to be low in soluble materials.

17.4.4.2.2 Mercury

Mercury concentrations in the water would experience negligible changes from an outage during Q_{10} flow periods. Total mercury concentrations in the water column during August and September would be at its highest for the year because flows and water temperatures would be at or near the annual peak. Warmer temperatures may increase mercury solubility in the water column, but mercury concentrations in the water under the 56M scenario would be near or below the laboratory detection limit during the summer.

Ramping water levels would be within the baseline defined channel of Trudel Creek and would not overflow or flood terrestrial soils. Mercury inputs from the surrounding soil would be limited.

17.4.4.2.3 Eutrophication

Eutrophication or the potential for nutrient influx would be negligible for a full outage during Q_{10} flow periods. The water in Zone 5 is naturally oligotrophic, and nitrogen and phosphate levels under the 56M scenario would be near the laboratory detection limit. These concentrations would be reflective of low nutrient content in the sediments and soils surrounding the area.

Water levels during a Q_{10} flow outage would be higher than the normal 56 MW operating conditions, but within the baseline defined channel of Trudel Creek. There would be limited additional source of nutrient loading in the water from the surrounding terrestrial soil because water levels would not reach these soils.

17.4.4.2.4 Temperature

Water temperature would experience a negligible change during a Q_{10} flow outage. Under normal operating conditions, flows originating from the Forebay over the SVS would pass through Zone 5 in approximately 10 hours. The existing environment show that water temperature in the Taltson Basin is similar throughout all zones during the summer. Ramping would increase flows over the SVS, but there would be no conditions that would change the water temperature between the SVS and the outflow into Zone 3 within the 10 hour period.

17.4.4.2.5 Dissolved Oxygen

Dissolved oxygen concentrations would experience a negligible change for a full outage during a Q_{10} flow year. Under the 56 MW operating scenario, environmental dissolved oxygen concentrations during the summer would be supersaturated or near supersaturation (Section 14.4.3.4). Oxygen supersaturation may be facilitated by oligotrophic water conditions from low concentrations of dissolved substances (i.e. dissolved metals, nutrients, salinity). These parameters would not experience a substantial change compared to pre-outage conditions.

Increases in flow during a full outage would increase water turbulence and mixing, particularly during the ramping increases. The mixing would facilitate the increase in dissolved oxygen concentrations, however, this is not considered to be detrimental.

17.4.4.2.6 Erosion

Erosion rates would experience a low to medium increase for a Q_{10} flow outage compared to normal operations under the 56 MW scenario. The main factor for erosion during a full outage would be the rapid increase in flows during the initial eight hour period when flows increase from pre-outage to outage peak. The rate of increase is higher than what is experienced under normal 56 MW operating conditions. Turbulence and eddy formation along the banks of Trudel Creek would increase the rate of erosion in areas that were identified as potential erosion sites (Section 14.4.2.4).

17.4.4.2.7 Sedimentation

Sedimentation rates would experience a low to medium change during a Q_{10} flow outage in Zone 5 lakes. The potential for sedimentation is related to erosion. The ramping increase in flow from a full outage would lead to a low to medium increase in erosion rates. Suspended materials transported from the banks and benthos of Trudel Creek would flow to the next downstream lake and settle out of the water column.

17.4.4.2.8 Summary

Table 17.8 presents the summary of water quality effects to Zone 5 resulting from an unscheduled full power outage during Q_{10} flow periods under the 56 MW scenario. This would be the worst-case scenario for water quality effects because the total flow and water level would be the highest.

Other potential scenarios, such as an outage during a low flow and Q_2 flow event under the 56 MW operating conditions would experience less substantial water quality effects. All power outage scenarios under the 36 MW operating conditions would also experience less substantial water quality effects.

Table 17.8 — Water Quality Effects in Zone 5 During a Q_{10} Flow Outage

Parameter	Q_{10} Flow
General Chemistry	Low
Total Mercury	Negligible
Eutrophication	Negligible
Temperature	Negligible
Dissolved Oxygen	Negligible
Erosion	Low to Medium
Sedimentation	Low to Medium

17.4.5 Wetlands

17.4.5.1 INTRODUCTION

The following section describes the effect to wetlands due to an unscheduled full power outage at the Twin Gorges power facility. The methods for this effects assessment follows those presented in Chapter 10. Wetland Valued Components (VCs) (i.e. wetland extent and function), assessment endpoints, spatial boundaries, and relevant Project components were presented in Section 14.6.

The wetland assessment considers the worst-case scenario, which is based on the magnitude of water level change that would affect wetland areas during an unscheduled full power outage. Therefore, the worst-case scenario would be an outage occurring in a low flow year when the pre-outage water levels are at the annual minimum. Table 17.6 presents the pre-outage and outage water levels during a low flow full power outage, which would result in an increased water level of 2.7 m.

The ramping conditions under the 36 MW scenario would be less substantial and effects to wetlands would be comparatively minor to the 56 MW scenario. Therefore, a full outage under the 36 MW scenario was not assessed.

17.4.5.2 PATHWAY ANALYSIS

Pathways were identified that link potential effects to wetland extent and wetland function and ultimately the assessment endpoints (Table 17.9).

Changing water levels can affect the flood regime of water bodies, which is the primary force in maintaining riparian wetland communities (Odland and Moral 2002; Toner and Keddy 1997; and Nilsson and Svedmark 2002). The direction of change (increase or decrease in water levels) is not as important as the magnitude and duration of change. Water levels substantially above or below existing ecosystem community boundaries, results in species composition shifts, following natural succession. The rate of flow increase is not as important as the magnitude of change or the duration when considering the long-term stability of a wetland and in particular the ecosystem community boundary. However, floods with short-term duration that occur very rapidly present the potential for effects to wetlands in terms of erosion and deposition (i.e. changes to habitat quality). The majority of the ramping events would be very short-term (less than a few hours), however there would be some more pronounced events that could last days, weeks, even a long as a month. If a month long ramping event occurred during the growing season it could potentially alter wetland extent and function if the ecosystem community boundary changed in response to the ramping event.

Table 17.9 — Wetland Assessment Pathways in Zone 5

Valued Component	Assessment Endpoint	Pathway
Wetland extent	Preservation of Wetland Extent	Rapid water level changes leading to a change in flood regime and habitat quality which alters wetland extent due to a ramping event from a full power outage
Wetland function	Maintenance of Wetland Function	Rapid water level changes would change the flood regime and habitat quality which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full outage ramping event

17.4.5.3 MITIGATION

The effects of full outage ramping can be minimised through Project design mitigation and mitigation practise. These mitigation measures were presented in Section 17.4.3.

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 little direct or indirect effects 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 minimise 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.

17.4.5.4 PATHWAY VALIDATION

Table 17.10 presents the pathway validation for each VC identified in the pathway analysis. Although the mitigation design and practises for a full outage would reduce the ramping effects to wetland extent and function, both pathways would remain Valid. The mitigation would only redirect a small fraction of the water (i.e. 30 m^3/s of 240 m^3/s total flow through the South Gorges Spillway) in the Forebay from spilling over the SVS.

17.4.5.5 EFFECT CLASSIFICATION

The magnitude of effects to wetland extent and function were largely defined by the magnitude of water level change between pre-outage and outage levels. The magnitude of the effect was similar throughout Trudel Creek, thus the geographic extent was all of Trudel Creek.

During an extreme low flow year the pre-outage water level would be at 227.5 masl for the entire year. Thus, a full outage at any time of the year would increase water levels by 2.7 m to 230.2 masl. Under normal 56 MW operating conditions, the absolute maximum water level in Trudel Creek would reach 230.4 masl. Thus the maximum ramped water level would not exceed the normal operating water level, nor would it exceed the maximum baseline level given that a portion of the flow would be routed through the by-pass spillway.

A full outage could occur at anytime of the year. Thus, effects were evaluated for ramping in the spring, summer, fall and winter. The duration of an unexpected outage could last from hours up to a month. A full outage lasting up to tens of minutes would have no effect to wetlands because the water level in the Forebay would not reach the crest of the SVS and no additional water would flow into Zone 5. Therefore, full outages lasting tens of minutes were not considered for this assessment.

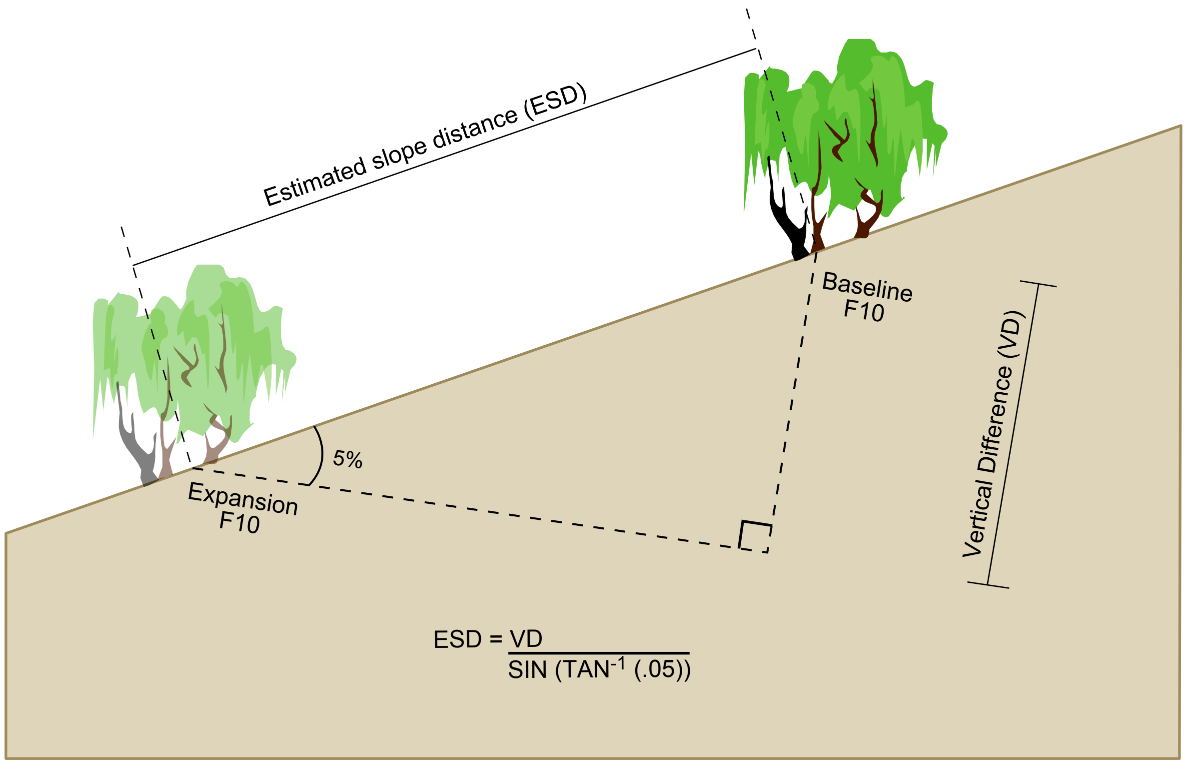
Table 17.10 — Pathway Validation for Wetland Effects in Zone 5

Valued Component	Pathway	Pathway Validation
Wetland extent	Rapid water level changes leading to a change in flood and habitat quality regime which alters wetland extent due to a ramping event from a full power outage	Valid
Wetland function	Rapid water level changes would change the flood regime and habitat quality which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full outage ramping event	Valid

17.4.5.5.1 <u>Effects on Wetland Extent and Function</u>

Table 17.11 presents the effects classification for wetland extent and function in Zone 5. The effects of ramping water levels to riparian wetlands extent and function in Zone 5 is dependent on the magnitude of ramping (and the resulting surface area that would be submerged), the duration of the full outage event, and the rate at which flows would change. To illustrate potential effects to wetlands due to ramping water levels, the estimated slope distance (ESD) along Trudel Creek was calculated (Figure 17.5). In order to calculate the ESD it was assumed that there would be 5% wetland slope roughly perpendicular to Trudel Creek. This assumption was based on the assessment of baseline wetland areas in Zone 5 (Section 14.6). The total water level increase (i.e. 2.7 m) during a full outage scenario was also used to calculate the ESD. Using the slope and water level increase, an ESD of 54.3 m was calculated. Thus, a zone of 54.3 m along the shores of Trudel Creek would be submerged for the duration of the full outage.

A full outage ramping of water levels during the growing season (late May to early September) could have the potential to wash away seeds and seedlings with poor root structure. When normal operations are re-established and the water levels return to pre-outage conditions, suspended soils may settle, potentially burying low lying vegetation and seedlings. Thus, the potential negative effect to wetland function would be greatest if a full outage occurred during the growing season (June to August). In September, October and May, the potential effects would be lower because riparian wetland vegetation would be in a transition state, between the dormant and growing stages. From November to April, wetland vegetation is in a dormant stage and a full outage would have the least effect to wetland extent and function.



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

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 17.5

Table 17.11 — Wetland Effects Classification in Zone 5 During a Full Outage

Pathway	Direction	MAGNITUDE			Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
		Growing Period (June - Aug)	Transition Period (May, Sept, Oct)	Dormant Period (Nov - Apr)						
Rapid water level changes leading to a change in flood regime which alters wetland extent due to a ramping event from a full power outage	Adverse	Moderate	Low	Negligible	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low
Rapid water level changes would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full outage ramping event	Adverse	Moderate	Low	Negligible	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low

The duration of the full outage would also influence the degree of effect. During the growing season, a full outage of any duration that causes water levels to reach the ramping peak (i.e. 230.2 masl) would potentially slow the growth and development of wetland for that year. A ramping event of short or medium-term duration (i.e. hours to days), which submerges established existing riparian wetland communities, would experience minor to negligible vegetative mortality. A long-term ramping (i.e. weeks to a month), where existing riparian wetland communities experience prolonged submergence, could lead to mortality of wetland vegetation (effects on extent). This could also result in a change in wetland community structure (effects on function).

The wetland vegetation boundary is re-established annually based on annual water levels. The worst case duration of a full outage ramping event is estimated to be one month. Flooding of wetlands above the ecosystem community boundary for one month of the growing season, once every five years, is not expected to change the community boundary. The effects of increased deposition of sediments and loss of seeds and some direct mortality are considered reversible, as wetland extent and function would recover in the short-term (1 to 3 years) even following a long-term ramping event. Moreover, the reversibility of the effect in the short-term assumes that ramped flows would not erode wetland habitat. This assumption was made given that ramped flows would be within baseline levels. Water quality was not assessed for a full outage during a low flow event because it was not the worst-case scenario for water quality effects. Therefore, erosion during a low flow outage would be less than the assessed scenario in Section 17.4.4, which was rated as low to medium under a Q_{10} full outage.

The overall residual effect from a long-term duration ramping event (one month) during the growing season was rated as low given the short-term nature and thus reversibility of the effect.

17.4.5.6 UNCERTAINTY

There are two types of uncertainties in this assessment: (1) factors contributing to wetland vegetation succession, and (2) information on the pre-outage condition of wetlands.

The assessment of residual effects assumed that wetland species could survive a period of up to one month of flooding, little erosion of wetland soil, and that pre-outage conditions were similar to baseline conditions in terms of wetland extent and function. Pre-outage condition relates to status of the area prior to a full outage under the proposed 56 MW operating scenario. Information on the pre-outage condition of wetlands was based on the assessed ecological changes to Trudel Creek wetlands (Section 14.6). The wetlands assessment was based on a ground-verified assessment of the existing wetlands and modelled hydrological data for the proposed 56 MW operating scenario. However, there was uncertainty associated with the predicted changes to wetlands in Trudel Creek. Therefore, there would be a high degree of uncertainty in predicting the effects of a full outage to Zone 5 wetlands because the pre-outage wetland conditions are uncertain and could only be verified after the proposed 56 MW expansion scenario is established and operational.

17.4.6 Aquatic Resources

17.4.6.1 Introduction

The following section presents an assessment of the potential for effects to aquatic resources due to a full power outage. The methods used for this effects assessment followed those presented in Chapter 10.

Section 14.7 presents a complete description of the aquatic resource assessment endpoints (i.e. preservation of sustainable aquatic biological communities), assessment boundaries and Project components used for the prediction of effects to aquatic resources within Trudel Creek under normal operating conditions.

The aquatic resources assessment considered the worst-case scenario, defined as a full power outage occurring in a low flow year under the 56 MW operating scenario. Under the 56 MW scenario, the pre-outage water levels in Zone 5 would be at the minimum and would experience the largest magnitude of increase at the peak of the outage. The ramping conditions under the 36 MW scenario would be less substantial and effects to aquatic resources would be comparatively minor to the 56 MW scenario. Therefore, a full outage under the 36 MW scenario was not assessed.

In the event of a full power outage at the Twin Gorges power facility, water would stop flowing through the turbines. Water levels in the Forebay would rise rapidly and spill over the SVS into Zone 5 when water levels exceed the SVS crest. The ramping water flow would increase water levels substantially in Trudel Creek and Trudel lakes, and peak approximately eight hours after the full outage.

Increasing water levels would further submerge littoral habitat for the duration of the outage, potentially affecting emergent, submergent and benthic zones. The degree of effect would be dependent on the duration of the outage. The duration of an unexpected outage could last from minutes up to a month. A full outage lasting up to tens of minutes would have no effect to aquatic resources because the water level in the Forebay would not reach the crest of the SVS and no additional water would flow into Zone 5. Therefore, a full outage lasting tens of minutes was not considered for this assessment.

17.4.6.2 Pathway Analysis

The potential ramping of flows and water levels during a full outage at the Twin Gorges power facility could cause adverse effects to aquatic resources. The pathway for these potential effects would be related specifically to the rapid and high magnitude change in water level and flow rate compared to the pre-outage values and the duration of the outage.

Flow changes and increased water levels are known to cause shifts in taxonomic abundance ranging from more large-body sessile species to small-body disturbance-resistant taxa (Mannes et al. 2008; Robinson and Uehlinger 2008). Robinson and Uehlinger (2008) found that even with floods that were temporary (eight hours) and relatively infrequent (approximately twice a year over a six-year period), there was a significant change in density, biomass, taxon richness, and individual biomass of benthic invertebrates.

A full outage could cause inundation and damage to emergent vegetation, which could lead to mortality and loss of suitable littoral habitat, where suitable littoral habitat is shallow water zones with aquatic plants and a diverse benthic community. Submerged vegetation would be under deeper water layers which, over time could cause reduced productivity and eventual mortality as less light could reach them. Associated invertebrate life at shallow and moderate depths would also be reduced due to rapid changes in flows causing disturbance leading to drift and loss of deposited eggs or early instar larvae, particularly in littoral zones. There could also be a loss of biodiversity as species more sensitive to changes in water levels and velocities are outcompeted or experience high mortality relative to more hardy species.

Changes in primary and secondary community structure could also occur. Profundal benthos would not be expected to show as substantial adverse effects from the elevated water levels since their habitat would remain fairly similar following ramping.

Table 17.12 presents the pathways that were identified, which links the conditions that would be experienced in Trudel Creek and Trudel lakes during a full outage at the Twin Gorges power facility, and the assessment endpoints for the VC that was identified.

Table 17.12 — Aquatic Resources Assessment Pathways in Zone 5

Valued Component	Assessment Endpoint	Pathway
Aquatic resources	Preservation of sustainable aquatic communities	Rapid increases in flow rates and water levels, changing aquatic habitat in Trudel Creek and associated lakes
		Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in Trudel Creek and associated lakes
		Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced productivity in Trudel Creek and associated lakes

17.4.6.3 MITIGATION

Effects of full outage ramping can be minimised through Project design mitigation and mitigation practise. These mitigation measures were presented in detail in section 17.4.3.

The Expansion Project would use mitigation measures to minimize potential effects to aquatic resources. A by-pass spillway would be constructed beside the power facilities to minimise 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 occur slower than otherwise.

17.4.6.4 PATHWAY VALIDATION

Although the mitigation design and practise for a full outage would reduce the effects to aquatic resources extent and function, all three pathways are considered Valid (Table 17.13).

Table 17.13 — Pathway Validation for Aquatic Resource Effects in Zone 5

Valued Component	Pathway	Pathway Validation
Aquatic resources	Rapid increases in flow rates and water levels, changing aquatic habitat in Trudel Creek and associated lakes	Valid
	Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in Trudel Creek and associated lakes	Valid
	Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced productivity in Trudel Creek and associated lakes	Valid

During a low flow year, under the 56 MW option, a full unscheduled outage would result in flow rates in Trudel Creek increasing from 4 m^3/s to 214 m^3/s over an 8 hour period. In low flow years and unscheduled full outage would result in increases of up to 2.7 m from pre-outage levels. These changes in flows and associated increases in water levels could affect aquatic resources in both Trudel Creek and associated lakes. Such effects could include: altering habitat and stressing or killing organisms which could cause reduced productivity, biodiversity and potentially change community structure.

17.4.6.5 EFFECT CLASSIFICATION

17.4.6.5.1 Classification Categories

In order to assess the effects of altered water levels on aquatic resources, several points were considered. First, the relative change in level compared to pre-outage conditions was calculated. The calculated change in water levels were used to classify the magnitude of the effect and were categorized as follows:

- 0 cm to 19 cm = Negligible,
- 20 cm to 49 cm = Low,
- 50 cm to 99 cm = Moderate, and
- 100 cm or more = High.

These categories were selected using professional judgment and were based on typical depths of littoral zones and associated vegetation. Altered water levels also relate to effects to macrophytes and benthic organisms in shallow zones which could become dewatered. For this assessment the cross-section (Trudel 1) was used to represent the entire section of Trudel Creek. Any highly productive areas (e.g. wetlands) or low productive areas (rocky outcrops, cliff habitat) were not incorporated in this assessment. Altered water levels are relevant to aquatic resources living within the water column.

17.4.6.5.1.1 *Effects Classification for Rivers*

Trudel Creek could experience minor increases in bank erosion relative to normal 56 MW operating conditions for the duration of the outage. Water quality was assessed for a full outage during a Q_{10} flow event because it was the worst-case scenario for water quality effects. Erosion during a low flow outage would be less than the assessed effect in Section 17.4.4, which was rated as low to medium under a Q_{10} full outage. Suitable littoral habitat could be temporarily lost due to a full outage ramping event. Invertebrates would undergo alteration of their physical habitat and as a result experience stress leading to increased downstream drift, loss of eggs and substrates for food and shelter, depending on existing flows at the time of ramping. Photosynthetic capacity could be altered as existing plants would be under deeper water; therefore, they would receive less or no light. This could reduce productivity in the Trudel system.

If ramping occurred in winter, water levels would potentially shift ice cover and cause blockages in narrows or lake zones, although this potential exists under current conditions as well. Ramping events in late summer would likely have the most deleterious effects since it is during this period that biological activity is highest, including reproductive effort in plants and animals. Ramped increases in water levels during this period could compromise aquatic community stability, leading to changes in community structure and productivity. Species residing in shallow areas would be expected to show highest effects. This would mostly relate to longer term outages.

The effects classification for aquatic resources in Trudel Creek from full outage is presented in Table 17.14. In the case of a full outage of all turbines at the Twin Gorges power facility under the 56 MW option, ramping of water flow rates into Trudel Creek would result in high magnitude increases in water levels (i.e. 100 cm or more), however the magnitude of the effect on the assessment endpoint is moderate as marked changes from baseline are not expected during or immediately after the ramping event. The geographic extent of both the ramping effect and the effect on aquatic resources is all of Trudel Creek. The duration of ramping is difficult to predict but it could last from hours to possibly one month. The duration of resulting effects to aquatic resources is considered short-term because the moderate magnitude effects on aquatic resources (altered habitat, mortality and loss of biodiversity) could endure for at least a full year. However, all effects would be reversible and would not permanently affect aquatic resources in Trudel Creek. The frequency of a full power outage is isolated and difficult to predict but assumed to occur once every five years, and the likelihood would be likely over the course of the operating period. Overall residual effects from ramping are rated low for river habitat under the 56 MW option (Table 17.14) given that aquatic resources would likely recover in the short-term and the frequency of the full outage ramping events lasting up to one month would be rare occurrence.

Table 17.14 — River Habitat Effect Classification in Zone 5 During a Full Outage

Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
Rapid increase in flow rates and water levels, changing aquatic habitat in Trudel Creek and associated lakes	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low
Rapid increase in flow rates and water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in Trudel	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low
Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced productivity in Trudel Creek	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low

17.4.6.5.1.2 Effects Classification in Lakes

The rapid changes in water levels in Trudel Creek during a full outage would have similar effects in Trudel lakes as predicted for Trudel Creek habitat. These lakes do not have large storage areas; therefore, their levels would also quickly rise by a high magnitude (i.e. >1 m) once Trudel Creek levels increased. Inundation of littoral habitat in the lakes could cause mortality aquatic resources, which would reduce the quality of habitat and productivity levels. The magnitude of effect would be moderate for all lakes although the peak water level would be within the highest water mark under normal 56 MW operating conditions. The effect of the ramping event would be observed in all three lakes thus the geographic extent is Trudel Creek. The duration of resulting effects to aquatic resources is considered short-term because the moderate magnitude effects on aquatic resources (altered habitat, mortality and loss of biodiversity) could endure for at least a full year. However, all effects would be reversible and would not permanently affect aquatic resources in Trudel Creek. The frequency of a full power outage is isolated and difficult to predict but assumed to occur once every five years, and the likelihood would be likely over the course of the operating period. Overall residual effects from ramping are rated low for river habitat under the 56 MW option (Table 17.15) given that aquatic resources would likely recover in the short-term and the frequency of the full outage ramping events lasting up to one month would be rare occurrence.

Table 17.15 — Lake Habitat Effect Classification in Zone 5 During a Full Outage

Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
Rapid increases in flow rates and water levels, changing aquatic habitat in Trudel Creek and associated lakes	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low
Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in Trudel Creek and associated lakes	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low
Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced productivity in Trudel Creek and associated lakes	Adverse	Moderate	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low

17.4.6.6 UNCERTAINTY

The assessment of Trudel Creek was conducted using modeled hydrologic data to provide an assessment of potential changes based on physical changes to the aquatic environment regarding water flows and depths. The level of uncertainty was moderate for local residual effects. Changes to the extent of physical aquatic habitat and related productivity within the Trudel Creek zone are difficult to precisely quantify, leading to uncertainty on the local scale. However, none of the ramping changes in Trudel Creek would result in effects to regional effects. Uncertainties associated with this assessment are the same as those presented in Section 14.7.

17.4.7 Fisheries Resources

17.4.7.1 INTRODUCTION

The following section describes the effect to fisheries resources due to an unscheduled full power outage at the Twin Gorges power facility. The methods for this effects assessment follows those presented in Chapter 10 - Methodology. Fisheries resource Valued Components and rationale for their selection are presented in Section 14.8.

In the event of a full power outage, water would stop flowing through the turbines, would rise in the Forebay and spill over the SVS and into Trudel Creek. Water levels within Trudel Creek are anticipated to rise a maximum of 2.7 m (based on a low flow worst case scenario) and would peak approximately 8 hours after the full outage.

17.4.7.2 PATHWAY ANALYSIS

The potential ramping of flows and water levels during a full outage could cause adverse effects to fish habitat structure and cover conditions in Trudel Creek. The pathway for these potential effects would be related specifically to the change in water levels and flow rate compared to pre-outage values and the duration and timing of the outage.

Increasing water levels associated with turbine shutdowns can displace adult and juvenile fish and adversely effect habitat quality. The duration of an unexpected outage could last between minutes to months. Following the plant start-up, flows within Trudel Creek would decrease and subsequently water levels would lower, likely to pre-outage conditions. During a lowering of water levels, adult/juvenile fish could become stranded/displaced and incubating eggs spawned during the high water duration could become dewatered.

Table 17.16 summarizes the assessment endpoints, and the pathways leading to those endpoints, for the Valued Components of northern pike, lake whitefish and walleye.

Table 17.16 — Fisheries Resource Assessment Pathways in Zone 5

Valued Component	Assessment Endpoint	Pathways
Northern Pike Lake Whitefish Walleye	Changes in incubating egg mortality	Ramping of flow rates and water levels leading to the displacement of incubating eggs
		Ramping of flow rates and water levels leading to the dewatering of incubating eggs
		Ramping of flow rates and water levels leading to increased erosion/deposition and the smothering of incubating eggs
	Changes in displacement of juvenile/adult fish	Ramping of flow rates and water levels leading to the displacement/stranding of juvenile and adult rearing fish

17.4.7.3 MITIGATION

Effects to full outage ramping can be minimized through Project design mitigation and mitigation practise. These mitigation measures are presented in Section 17.4.3.

17.4.7.4 PATHWAY VALIDATION

The results of the pathway validation assessment are summarized in Table 17.17. Rationale for the classification of pathways as Valid, Minor or Invalid is provided below

Table 17.17 — Pathway Validation for Fisheries Resource Effects in Zone 5

Valued Component	Pathway	Pathway Validation
Northern pike Lake whitefish Walleye	Ramping of flow rates and water levels leading to the displacement of incubating eggs	Minor
	Ramping of flow rates and water levels leading to the dewatering of incubating eggs	Valid
	Ramping of flow rates and water levels leading to increased erosion/deposition and the smothering of incubating eggs	Minor
	Ramping of flow rates and water levels leading to the displacement/stranding of juvenile and adult rearing fish	Valid

17.4.7.4.1 <u>Valid Pathways</u>

Ramping of flow rates and water levels leading to the displacement of juvenile and adult rearing fish

Uncontrolled shutdowns followed by a plant start-up could lead to the displacement or potentially stranding of adult and juvenile fish.

Of the identified Valued Components, northern pike are the only species anticipated to move into the newly-wetted habitats associated with an elevated waterline. 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.

During the plant start-up and subsequent decrease in waterline elevation, northern pike that had moved into the newly wetted habitat could become stranded. 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 the Forebay and 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 stranded.

Due to the mitigation practices during re-start of the turbines, the magnitude of the effect is considered to be low; however, the effect would occur during each uncontrolled ramping and water levels would drop by over 2 m in roughly 20 hours. As such, the pathway has been classified as Valid.

Ramping of flow rates and water levels leading to the dewatering of incubating eggs

Uncontrolled or unscheduled shutdowns can occur at anytime throughout the year; however, are anticipated to predominantly occur during the summer months. The worst case scenario would be a full outage occurring in May or June that persists for 2 to 6 weeks; the maximum full outage is expected to be one month. This period from May to June overlaps with northern pike and walleye spawning/egg incubation life-stages. As lake whitefish typically spawn at depth, the likelihood of incubating eggs becoming dewatered is low.

In order for incubating eggs to become dewatered, fish would have to move into the newly wetted stream margins to spawn during the shutdown event. The likelihood of fish moving into the newly wetted stream margins during a short (i.e. a few hours to one week) period is low; however, the longer the outage continues the greater the likelihood is for fish to utilize the new habitats for spawning purposes.

The potential to dewater incubating eggs occurs when the turbines are turned-on, and subsequently the flows and water levels in Trudel Creek decrease. Incubating eggs within the ramp up zone (2.7 m of water or less) would become dewatered.

Northern pike and walleye eggs typically incubate between 14 and 18 days prior to emergence. Thus, eggs spawned 18 days previous to the plant start-up would likely be emerged and could relocate with the lowered water levels. Therefore, under a worst case scenario, 18 days of the spawning/egg incubation window would be affected and an entire age class likely would not be lost.

The likelihood of a prolonged uncontrolled shutdown occurring during the peak northern pike/walleye spawning and egg incubation periods is low; however, the magnitude of the effect if it does occur is high. As such, the pathway has been classified as Valid.

17.4.7.4.2 Minor Pathways

Ramping of flow rates and water levels leading to the displacement of incubating eggs

Uncontrolled or unscheduled shutdowns can occur at anytime throughout the year; however, are anticipated to predominately occur during the summer month. A full outage occurring in May or June would overlap with the timing window of walleye and northern pike spawning/egg incubation. Therefore, there could be a potential to displace northern pike and walleye incubating eggs if a full outage occurs in May and/or June.

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 littoral area habitats that would experience low velocity increase. Therefore northern pike incubating eggs are not likely to become displaced during an unscheduled 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 flows would not result in the movement of the preferred spawning substrates. As such, it is unlikely that a scheduled ramping event would result in dislodgement and or transport incubating walleye eggs in riverine habitats. Therefore, scheduled ramping events would not result in the displacement of incubating walleye eggs in the lakes.

In the event that an uncontrolled shutdown occurred early 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 within the lakes. 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.

Overall, the potential for incubating eggs to become displaced during a full outage is low. As such, the pathway of displacement of incubating eggs has been classified as Minor.

Ramping of flow rates and water levels leading to increased erosion/deposition and the smothering of incubating eggs

Uncontrolled or unscheduled shutdowns can occur at anytime throughout the year; however, are anticipated to predominantly occur during the summer months. The worst case scenario would be a full outage occurring in May or June as this time period overlaps with northern pike and walleye spawning/egg incubation life-stages. In addition, the effects to Valued Components would be greater if baseline flows in

Trudel Creek were high at the time of the outage, as greater flows would be experienced (i.e. <210 m^3/s).

The potential for the increase in flows to dislodge and transport sediment downstream to a deposition area are low-moderate. 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 210 m^3/s and subsequent depth (2.7 m) increases would result in a low-moderate increase in erosion potential within most sections of Trudel Creek; see Section 17.4.4. The large channel widths, historic self-armouring of channel banks, and natural attenuation of flows within the three lake systems would assist in dissipating the hydrologic energy of the increased flows.

The low-moderate increase in sediment laden water and erosion potential would not result in the smothering of incubating eggs. The likelihood of an uncontrolled shutdown event resulting in a considerable increase in erosion/deposition potential during the peak northern pike/walleye spawning and egg incubation periods is low. As such, the pathway has been classified as Minor.

17.4.7.4.3 Invalid Pathways

No Invalid pathways were identified.

17.4.7.5 Effects Classification

Table 17.18 presents the effects classification for the identified Valid pathways.

Table 17.18 — Fisheries Resource Effects Classification in Zone 5 During a Full Outage

Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
Ramping of flow rates and water levels leading to the displacement of juvenile and adult rearing fish	Adverse	Low	Trudel Creek	Short-term	Reversible	Isolated	Likely	Low
Ramping of flow rates and water levels leading to the dewatering of incubating eggs	Adverse	High	Trudel Creek	Short-term	Reversible	Isolated	Possible	Low

17.4.7.6 SIGNIFICANCE DETERMINATION

Table 17.19 summarizes the determination of significance for all residual effects identified to fisheries resources within Trudel Creek. This includes residual effects during normal operations and the residual effects identified herein from unscheduled full outage ramping events.

Table 17.19 — Determination of Significance to the Fisheries Resources Valued Components within Trudel Creek

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 Changes in incubating egg mortality (unscheduled ramping) Changes in displacement of juvenile/adult fish (unscheduled ramping)	Moderate/Beneficial Low/Beneficial Low/Adverse Low/Adverse Low/Adverse Low/Adverse	Not significant	Intermediate
Lake whitefish	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events Changes in incubating egg mortality (unscheduled ramping) Changes in displacement of juvenile/adult fish (unscheduled ramping)	Moderate/Adverse Low/Beneficial Low/Adverse Low/Adverse Low/Adverse	Not significant	Low
Walleye	Changes to habitat structure and cover Changes to depositional zones Changes to ramping events Changes in incubating egg mortality (unscheduled ramping) Changes in displacement of juvenile/adult fish (unscheduled ramping)	Moderate/Beneficial Low/Beneficial Low/Adverse Low/Adverse Low/Adverse	Not significant	Low - Intermediate

The residual effects identified for the effects assessment of normal operating conditions (Chapter 14) were considered when determining the overall significance of effects on the Valued Components northern pike, lake whitefish and walleye. The key residual effects that were considered were changes to habitat structure and cover associated with a decreased water level and changes to incubating egg mortality during scheduled and unscheduled ramping events.

As discussed in Chapter 14, fish habitat structure and cover conditions would be altered as a result of the lowered waterline elevation. This effect would be a one time occurrence, where water conditions in Trudel Creek would become stabilized along the lowered littoral areas. In addition, effects to wetland extent and function and effects to aquatic productivity are anticipated to re-stabilize in 3 to 10 years, thereby providing stable cover and food conditions to fish. Thus, no significant adverse effects to the habitat structure and cover conditions of northern pike, lake whitefish and walleye within Trudel Creek were predicted.

In the event incubating eggs become dewatered, the magnitude of the effect would be high; however, would not affect the entire year class. The frequency in which scheduled/unscheduled ramping events would affect incubating eggs within Trudel Creek is low and is not anticipated to occur on an annual basis. Therefore, the effect to fish populations would be reversible in the short term. As such, no significant adverse effects to northern pike, lake whitefish or walleye as a resulted of dewatered incubating eggs were predicted.

Given the low magnitude, duration and frequency of the other associated assessment endpoints, no significant adverse effects were predicted.

17.4.7.7 UNCERTAINTY

The assessment of Trudel Creek was conducted using the modeled hydrologic data to provide an assessment of potential changes on the aquatic environment regarding water flows and depths. The potential to dewater incubating eggs and displace/strand fish is primarily dependant on the change in water levels. The model indicates that the magnitude of water level changes would vary depending on the location within Trudel Creek; however, the worst case scenario of a 2.7 m change was applied to the whole system. As the assessment considered only the worst case scenario, the degree of uncertainty is considered low. Additional uncertainties associated with fish habitat structure and cover are discussed in Chapter 14.8.

17.4.8 Wildlife

17.4.8.1 INTRODUCTION

The following section describes the potential effect of ramping flows and water levels to wildlife in the event of a full power outage during 56 MW operating conditions. The methods used for this effects assessment followed those presented in Chapter 10. The wildlife VCs selected for the full outage scenario were: furbearers (muskrats and beavers), moose, waterfowl, shorebirds, whooping crane, rusty blackbird, and northern leopard frog. The rationale for selecting species or wildlife communities as VCs was presented in Section 14.9. Section 14.9 also presents a complete description of the wildlife assessment endpoints (i.e. preservation of wildlife populations, habitat and harvesting opportunities), assessment boundaries and Project components used for the prediction of effects to wildlife VCs.

A full outage could occur at anytime of the year. The duration of an unscheduled outage could last from minutes up to a month. A full outage lasting up to tens of minutes would have no effect to wildlife because the water level in the Forebay would not reach the crest of the SVS and no additional water would flow into Trudel Creek. Therefore, full outages lasting tens of minutes were not considered for this assessment.

The assessment considers the worst-case scenario, defined as a full outage occurring in a low flow year. The worst-case full outage scenario would experience the largest magnitude of increase in water levels and flows in Zone 5. Under these conditions, flow rates in Trudel Creek would increase over eight hours from the minimum flow of 4 m^3/s to 214 m^3/s, this would result in increases in water levels of up to 2.7 m. These changes were compared to levels during normal 56 MW operating conditions.

17.4.8.2 PATHWAY ANALYSIS

The general pathways that could affect the wildlife assessment endpoints due to a full power outage are direct mortality and reduced reproductive success. Direct mortality occurs when Project activities result in the death of an individual VC. 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. Reproductive success is the number of young that each female produces that reach reproductive age. Reduced reproductive success can lead to declines in abundance. Alterations to the hydrological regime due to ramping 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.

The VCs, assessment endpoints and pathways are presented in Table 17.20. The following section describes the pathways for each VC.

17.4.8.2.1 Furbearers

Beaver and muskrat rely on riparian and aquatic habitat for all their life history stages and requirements including foraging, shelter, and reproduction. The pathway for ramping that pertains to both these species is direct mortality leading to reduced population abundance (Table 17.20). Direct mortality to furbearers could occur due to elevated water levels in relation to lodges, food caches, and shelter entranceways.

Altered water levels in rivers and lakes can have negative effects on resident mammals depending on the flow characteristics and the time of year. 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 due to water filling burrows and drowning young (Erb and 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 cause ice to be raised and any muskrat lodges embedded in the ice layer would be torn apart. If flows are very high during the fall and winter, beaver dams and food piles could be removed, and result 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 mink, river otter, and fisher.

Table 17.20 — Wildlife Assessment Pathways in Zone 5

Valued Component	Assessment Endpoint	Pathway
Furbearers	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance
Moose	Preservation of moose harvesting opportunities	Direct mortality leading to reduced population abundance
Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities	Direct mortality leading to reduced population abundance Reduced reproductive success leading to reduced population abundance
Rusty blackbird	Preservation of habitat and populations	Direct mortality leading to reduced population abundance Reduced reproductive success leading to reduced population abundance
Whooping crane	Preservation of habitat and populations	Direct mortality leading to reduced population abundance Reduced reproductive success leading to reduced population abundance
Northern leopard frog	Preservation of habitat and populations	Direct mortality leading to reduced population abundance

17.4.8.2.2 Moose

The pathway associated with complete power outages for moose is potential direct mortality due to increased water levels. Rapidly rising water levels could lead to mortality of calves, if moose are within the riparian zone when increased water levels occur associated with a full power outage. Riparian areas are important to moose for foraging during the spring and summer as well as calving and seasonal cover.

17.4.8.2.3 Birds

Identified pathways that could affect waterfowl, shorebirds, rusty blackbird and whooping crane are presented in Table 17.20.

Direct mortality and reduced reproductive success due to elevated water levels were potential pathways. Water levels that rise over a short time period could flood nests and wash away young. For ground nesting waterfowl, stable water levels are important for reproductive success (Cott et al. 2008). 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. 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).

17.4.8.2.4 Northern Leopard Frog

The pathway identified for northern leopard frogs was direct mortality due to elevated water levels (Table 17.20). Direct morality could occur in association with rapidly rising water levels if frogs are foraging within the riparian habitat and are washed away with the increased flow.

17.4.8.3 MITIGATION

Effects of full outage ramping can be minimised through Project design mitigation and mitigation practise. Project design mitigation measures were presented in Section 17.4.3.

Mitigation practises may include artificial nest platforms for waterfowl management in order 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; Zenner et al. 1992; Evers 2004). Under a full power outage reproductive success of ground-nesting waterfowl would be negatively affected by ramping as water levels could rise up to 2.7 m in Trudel Creek. These water level changes could flood nests and wash away young in Trudel Creek. Common loons nest most successfully when water levels do not increase more than 15 cm or decrease more than 30 cm during the nesting season (Evers, 2004). Without mitigation, the change in water levels due to ramping would have adverse effects on all ground-nesting waterfowl.

Construction, deployment, monitoring, and maintenance of artificial nesting platforms could mitigate for this alteration of water levels. 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 along Trudel Creek consisted of two aerial transects to determine species of waterfowl present but was not designed to determine waterfowl breeding. Boat and ground-based surveys to count either breeding pairs, nests or broods would provide a more accurate estimate of waterfowl breeding in Zone 5 (RIC 1999). Establishing which species would be candidates for using 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 necessitate the same design requirement (Zenner et al. 1992; Evers 2004). This survey would also identify areas where placement of 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.

17.4.8.4 PATHWAY VALIDATION

Table 17.21 summarizes the pathway validation for wildlife effects in Zone 5.

Table 17.21 — Pathway Validation for Wildlife Effects in Zone 5

Valued Component	Pathway	Trudel Creek (Zone 5)
Furbearers	Direct mortality leading to reduced population abundance due to rapid increase in water levels	Valid
Moose	Direct mortality leading to reduced population abundance due to rapid increase in water levels	Invalid
Waterfowl and shorebirds	Direct mortality leading to reduced population abundance due to rapid increase in water levels	Valid (Minor with mitigation)
Waterfowl and shorebirds	Reduced reproductive success leading to reduced population abundance due to rapid increase in water levels	Valid (Minor with mitigation)
Rusty blackbird	Direct mortality leading to reduced population abundance due to rapid increase in water levels	Invalid
Whooping crane	Direct mortality leading to reduced population abundance due to rapid increase in water levels	Invalid
Northern leopard frog	Direct mortality leading to reduced population abundance through higher water levels	Valid

17.4.8.4.1 Furbearers

Direct mortality of muskrat and beaver through higher water levels is a Valid pathway in Trudel Creek as water levels could rise in the order of meters over the course of hours, depending on flow levels in the basin at the time of full outage. Rapidly rising water levels could flood muskrat lodges and cause drowning, particularly of any young that are inside lodge dens and are not as mobile as adults. Flooding could also lead to loss of shelter which would be particularly detrimental during the winter with subsequent freezing or predation. Rapidly rising water levels could also wash away food caches.

17.4.8.4.2 Moose

Changes to water levels from a full power outage are considered a Minor pathway for moose. Since moose are not a riparian or aquatic dependent species they can avoid changing water levels by moving into a different area.

17.4.8.4.3 Birds

Direct mortality and reduced reproductive success due to higher water levels are Valid pathways for Trudel Creek as elevated flows and water levels due to ramping could lead to nests and young being flooded and drowned. However, it is possible to mitigate for this effect and so the pathway is considered Minor and is not carried forward. The pathway is Invalid during ramping conditions for rusty blackbirds as they do not nest on the ground within the riparian zone. It is Invalid for whooping cranes as they are not known to breed in the Project area.

17.4.8.4.4 Northern Leopard Frog

Direct mortality due to ramping is a Valid pathway in Trudel Creek as frogs may be not be able to move out of the riparian zone when water levels increase in the order of metres over the course of hours.

17.4.8.5 EFFECT CLASSIFICATION

The effects classification is based on a worst-case scenario in the event of a full power outage. The definition of the worse-case scenario for wildlife effects would be a full outage during periods when pre-outage water levels are at the minimum under the 56 MW operating scenario. The rate of increase in flows and water levels in Trudel Creek would be the greatest under this scenario.

The geographical extent of all wildlife effects and the ramping event itself is all of Trudel Creek. The duration, reversibility and overall residual effects are described separately for each VC. A full outage would typically be an isolated incident resulting from an accident, malfunction or environmental disturbance (e.g. ice storm, forest fire). Thus, the frequency of a full outage is difficult to predict but would be isolated and relatively rare (1 in 5 year event). The likelihood of such an event would be likely over the life of the Project.

A summary table of the effects classification is presented in Table 17.22.

Table 17.22 – Wildlife Effects Classification in Zone 5 During a Full Outage

Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
Direct mortality on furbearers through higher water levels leading to reduced population abundance	Adverse	High	Trudel Creek	Medium-term	Reversible	Isolated	Possible	Moderate
Direct mortality to Northern leopard frog through higher water levels leading to reduced population abundance	Adverse	Low	Trudel Creek	Medium-term	Reversible	Isolated	Possible	Low

17.4.8.5.1 Furbearers

Direct mortality due to higher water levels in Trudel Creek was classified as an isolated event, with a high magnitude. The worst-case full outage scenario would experience the largest magnitude of increase in water levels and flows along Trudel Creek. Under these conditions, flow rates in Trudel Creek would increase over eight hours from the minimum flow of 4 m^3/s to 214 m^3/s, this would result in increases in water levels of up to 2.7 m. Such a large change in water levels over a short period of time would have adverse effects to furbearers. For animals that are inside their dens, particularly young and nursing females, when the water levels increase, mortality could occur to animals that are not able to escape the shelter. This could affect reproductive success on an isolated basis and lead to population declines. Rapidly rising water levels could also adversely affect muskrat push ups and lodges that are less permanent shelters as compared to beaver lodges. The duration of these effects is medium-term because the effect to furbearers would last a few generations. The effects (i.e. mortality and reduced reproductive success) would be reversible given the isolated nature of the ramping events. The overall residual effect from ramping was classified as moderate.

17.4.8.5.2 Northern Leopard Frog

Water levels that rise 2.7 m over the course of 8 hours in Trudel Creek could cause mortality of northern leopard frogs using the riparian habitat. The effects (i.e. mortality) to the northern leopard from would be medium-term and reversible. Given the low densities of frogs within this habitat area the effect was classified as low. The effect was classified as isolated and the overall residual classification was low.

17.4.8.6 SIGNIFICANCE DETERMINATION

Significance of the effects of ramping on furbearers and northern leopard frogs was determined by considering all Valid pathways to effects on these VCs within Trudel Creek. That is, effects resulting from Valid pathways identified during normal operating conditions and during full outage ramping events were evaluated as a summation of effects on the VC assessment endpoints. Table 17.23 presents a summary table of the significance determination of wildlife effects in Trudel Creek

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Table 17.23 — Significance of Wildlife Effects

Valued Component	Assessment Endpoint	Pathways	Overall Residual Effect	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		
		Stablized water levels leading to increased abundance (muskrat)	Moderate/Beneficial		
		Direct mortality leading to reduced population abundance through higher water levels due to unscheduled full outages and ramping at Twin Gorges (muskrat and beaver)	Moderate/Adverse		
Northern leopard frog	Preservation of habitat and populations	Habitat loss/modification leading to change in population abundance	Low/Adverse	Not significant	Low
		Direct mortality leading to reduced population abundance through higher water levels due to unscheduled full outages and ramping at Twin Gorges	Low/Adverse		

17.4.8.6.1 Furbearers

The residual effects identified for the effects assessment of normal operating conditions (chapter 14) were considered when determining the overall significance of effects on furbearer harvesting opportunities. The key residual effects that were considered were direct mortality from decrease water levels during initial start-up of operations, the effect of stabilized water levels (beneficial effect) and the effect of direct mortality from scheduled ramping events. As discussed in Chapter 14, the initial effect of direct mortality at start-up would require a few generations to reverse. If the ramping events under the 56 MW option, both scheduled and unscheduled, occurred with greater frequency there would be a concern that furbearer populations and thus harvesting opportunities would not be sustainable. However, the ramping events would occur at a low enough frequency to allow effects on furbearers within Trudel Creek to reverse.

Thus, no significant adverse effects to the preservation of furbearer harvesting opportunities within Trudel Creek were predicted; however, for muskrat and beaver the residual effect due to ramping effects in Trudel Creek was classified as moderate. In Trudel Creek, elevated water levels could flood furbearer shelters, destroy muskrat shelters and wash away food caches. Young inside of lodges might also be drowned due to higher water levels.

The key assumptions made to complete the effects assessment for furbearers in Trudel Creek were: medium-term recovery from the initial water level decrease at start up, long-term beneficial effect from stabilized water levels, medium-term recovery from effects of scheduled and unscheduled ramping events, and medium-term change in riparian vegetation with little loss of food or habitat while the riparian community changes in response to changes in the hydrologic regime.

Given the length of time required by furbearers to recover from effects, it is possible that compounding effects may occur via initial start-up effects and ramping or overlapping ramping effects. If these effects are compounded it is predicted that the recovery time would be lengthened, however, long-term harvesting opportunities are predicted to not be significantly affected.

17.4.8.6.2 Northern Leopard Frog

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by scheduled and unscheduled ramping events and the temporary loss of habitat incurred during the initial start-up of operations.

17.4.8.7 UNCERTAINTY

17.4.8.7.1 Furbearers

The uncertainty level is medium because baseline furbearer data is not current but has been conducted in the past. Aerial surveys in 2000 over a 42 km shoreline section of Trudel Creek showed a beaver lodge density of 0.12 lodges per linear kilometre of shoreline. In 2003, beaver lodge density along the same length of shoreline was calculated as # Active Lodges/Survey Hour, equalling 11.19/survey hour. It was assumed that the current population of furbearers is the same as the previously collected data. If current baseline studies indicated higher furbearer abundance than previously then the magnitude of the effect might be increased although the non-significance determination would not change.

17.4.8.7.2 Northern Leopard Frog

The uncertainty levels are low for Trudel Creek as baseline data has been collected for this zone in 2008, which indicated that the riparian habitat is primarily being used for summer foraging and cover and not for breeding. If breeding were occurring in the riparian area, then elevated water levels would potentially wash tadpoles away and would affect reproductive success. However, baseline studies indicated that the riparian habitat does not offer breeding habitat.

17.5 RAMPING TALTSON BASIN (ZONE 3)

17.5.1 Overview

Potential effects from ramping as a result of a full power outage in Zone 3 are presented herein. Zone 3 is addressed as two separate sub-sections; the Twin Gorges Forebay, which is upstream of the Twin Gorges power facility, and the lower Taltson River downstream of the power facility to Tsu Lake. Ramping effects beyond Tsu lake would be attenuated and have negligible effect to flows and water levels in Zone 4. Based on the hydrological predictions during an unscheduled full power outage, an effect assessment was conducted for the worst-case scenario for: water quality, wetlands, aquatic resources, fisheries resources and wildlife.

The worst-case scenario for water quality was based on a full power outage under the 56 MW operating conditions in a year with high flows (Q_{10} flows) through the Taltson Basin. Under this condition, water levels in the Forebay would be higher than any other scenario, potentially inundating soils along the banks of the Forebay. In the lower Taltson River, flows and water levels would be substantially reduced following a full power outage, and the flows would be redirected over the SVS into Zone 5(Trudel Creek). Any changes in water quality experienced in Zone 5 would also be experienced in the lower Taltson River, when the redirected flows re-enter Zone 3 shortly downstream of the Twin Gorges power facility.

For wetlands, aquatic resources, fisheries resources and wildlife, the worst-case scenario was based on a full power outage under the 56 MW operating conditions in a year with low flows through the Taltson Basin. Under this condition, the percent change of flows and water levels between pre-outage and outage conditions would be the greatest.

17.5.2 Hydrological Model Predictions

This section describes the predicted hydrological changes in the event of a full power outage under the 56 MW scenario in the Twin Gorges Forebay and the Taltson River downstream of Elsie Falls (lower Taltson River).

The hydrological changes under the 56 MW scenario would be greater in magnitude than the 36 MW scenario because more water would have been released from the Nonacho dam control structure prior to the outage. Therefore, during a full outage, a larger water volume would be re-directed from the Twin Gorges power facility to

Zone 5 resulting in the greatest change in hydrological conditions between pre-outage and outage conditions, particularly in the Taltson River downstream of the Twin Gorges power facility to the Tsu Lake inflow. Therefore, a full outage under the 56 MW scenario would be the worse-case scenario. Hydrological changes under the 36 MW scenario were not presented because the effects would be less substantial than the 56 MW scenario. Moreover, there is no difference in frequency of occurrence of the full outage ramping event between the two expansion options.

In the event of a full power outage, flows through all turbines would stop, which would cause the water level to rise in the Forebay and decrease in the Taltson River, downstream of the Twin Gorges power facility (Figures 17.3 and 17.4). Flows through the Twin Gorges power facility would rapidly decrease in the first hour of the outage with a subsequent decrease in water levels in the lower Taltson River. As the Forebay water level rises, flow over the SVS into Trudel Creek (Zone 5) would increase. It would take approximately 8 hours for the generation flow to be fully re-routed to Trudel Creek. It would take approximately 10 hours for the spilled water to reach the lower Taltson River in Zone 3, downstream from Elsie Falls. When flows reach the lower Taltson River, the water level, which rapidly decreased following the power outage, would gradually return to pre-outage conditions over a period of 18 hours from the beginning of the outage. A single cross section of the lower Taltson River was used to illustrate potential changes in water levels as a result of ramping in Zone 3. The location of the cross section is presented in Figure 17.1.

To minimize the disruption in flows during an outage, the South Gorge Spillway would automatically open after a fixed time period to allow up to 30 m^3/s of flow into the tailrace. A minimum flow would be experienced in the lower Taltson River for several hours before water levels begin to return to pre-outage conditions as water that was re-routed to Trudel Creek returns to the Taltson River.

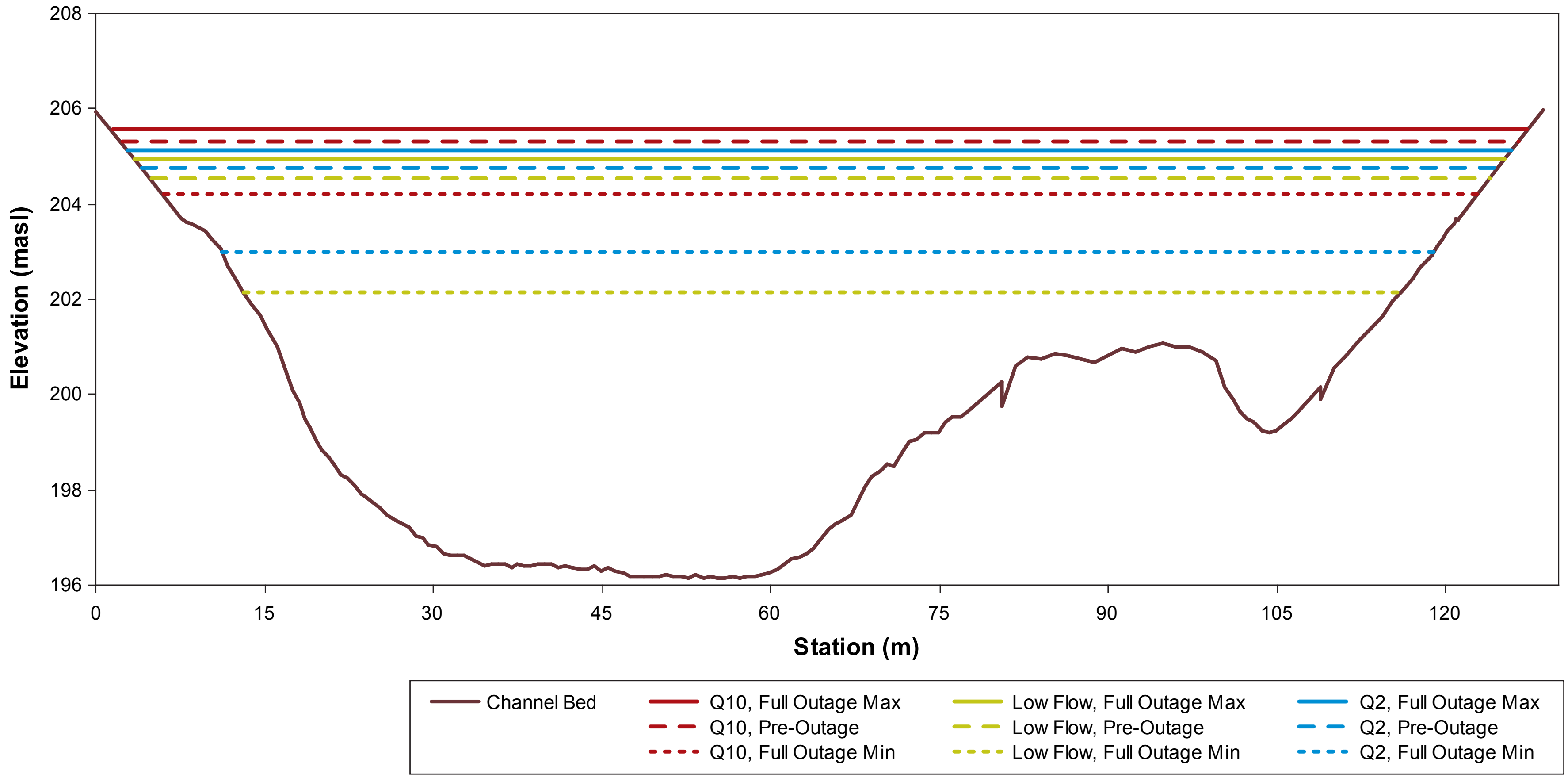
Upon restarting the turbines, the South Gorges Spillway would first be closed. Although all three turbine units would be capable of being restarted simultaneously, a sequential start-up and loading process would be implemented to minimize the flow ramping in the lower Taltson River. Three increments of flow would be introduced to the Taltson River. Typically, one unit would be loaded every 4 to 6 hours. Upon re-start under the 56 MW scenario, flows would increase by 50 m3/s as the first turbine is re-started and the South Gorge Spillway is closed. The increase in flow and levels below Twin Gorges would last a few hours and then return to pre-outage conditions once flow from Trudel Creek decreased in response to the reduction of spill from Twin Gorges at the SVS, assuming constant background flows into the Forebay. Following the re-start of the second turbine, flow would increase again in the Taltson River by up to 80 m^3/s above pre-outage conditions and 30 m^3/s above the first re-start ramping event. Again this would last for a few hours until flows from Trudel decreased. Following the re-start of the third turbine, flow would increase and return to pre-outage conditions in the Taltson River below Twin Gorges to a similar magnitude and over a similar duration to the re-start of the second turbine. The ramping of flow in the Taltson River below Twin Gorges would be similar to ramping that would result following re-start flow from a scheduled outage for maintenance of the turbines. However, the ramping events due to the re-start of each turbine would follow one after the other in the case of re-start from a total outage, while the re-start of the three turbines under a schedule outage scenario for turbine maintenance would be separated by approximately one week. The effects of the ramp up flow during re-start are addressed in Chapter 13.

Based on the outage and restart hydrograph for Zone 3 under the 56 MW scenario, water levels were estimated for other relevant ramping scenarios where background flows would be much higher than the minimum. Figure 17.6 presents the predicted water levels during a full outage event that would occur under the following scenarios:

- Background flows are at a minimum in Trudel Creek (Low flow outage),
- Background flows similar to a 2 year return period peak flow event in Trudel Creek (Q_2 = 45 m^3/s), and
- Background flow at a 10 year return period flow in Trudel Creek (Q_{10} = 161 m^3/s).

Table 17.24 presents the pre-outage and outage peak water levels under each flow scenario in the Twin Gorges Forebay and lower Taltson River. The estimated absolute maximum water levels under the 56 MW scenario are also presented for comparison.

In the Twin Gorges Forebay, water levels would increase between 0.3 to 0.6 m from pre-outage levels during a full outage. The largest increase (+0.6 m) would occur during a low flow outage, and would be at the same water level as the estimated absolute maximum under 56 MW operating conditions. The peak water level (248.5 masl) would occur if a full outage occurred during a Q_{10} flow event in Trudel Creek, and would be 0.2 m higher than the estimated absolute maximum level under the 56 MW operating conditions.



TALTSON HYDROELECTRIC EXPANSION PROJECT	Developer's Assessment Report 2009	Water Levels in Taltson River for Full Outage and Various Base Flows	Figure 17.6

Table 17.24 — Water Levels (masl) in Zone 3 During a Full Outage

	56 MW Scenario	56 MW Outage During Low Flow	56 MW Outage During Q_2 Flow	56 MW Outage During Q_{10} Flow
Twin Gorges Forebay				
Absolute Maximum Water Level	248.3			
Pre-outage Water Level		247.7	247.9	248.2
Outage Peak Water Level		248.3	248.4	248.5
Taltson River Downstream of Twin Gorges Power Facility				
Absolute Maximum Water Level	205.6			
Pre-outage Water Level		204.6	204.8	205.3
Outage Minimum Water Level		202.1	203.1	204.2

In the lower Taltson River, water levels would decrease between 1.1 to 2.5 m in the first hour of a full outage and flows would decrease to the minimum of 34 m^3/s (30 m^3/s from the South Gorge Spillway and at least 4 m^3/s from Trudel Creek). Flows re-directed into Zone 5 would require approximately 10 hours to re-enter Zone 3 at the lower Taltson River near Elsie Falls. When these flows re-enter the lower Taltson River, water levels would increase and return to pre-outage conditions for the remaining duration of the full outage. The largest decline in water levels (2.5 m) would occur during a low flow outage, while a full outage during a Q_{10} event in Trudel Creek would experience the smallest decline (1.1 m).

The ramp up during re-start of the turbines would equate to roughly a 0.3 m increase in water level for a duration of roughly 16 hours. The effects of the ramp up event during re-start of the power facilities is addressed in Chapter 13 under scheduled outage ramping events as both scheduled and unscheduled ramping events would have the same ramp up effects on flows and water levels.

17.5.2.1 MITIGATION

Effects of the Project can be minimized through two primary mitigation measures (1) mitigation design and (2) mitigation practise. The proposed mitigations were described in Section 17.4.3.

17.5.3 Water Quality

17.5.3.1 INTRODUCTION

The following section describes the potential effects to water quality from increasing water levels in the Twin Gorges Forebay of Zone 3 and the decreasing water levels in the lower Taltson River during a full power outage. Key water quality parameters identified in the Key Line of Inquiry (KLOI) for the Taltson Basin included: general chemistry, total mercury, eutrophication (i.e. nutrients), temperature, dissolved oxygen, erosion and sedimentation.

Section 17.4.2 described the hydrological conditions in the event of a full outage during a low, Q_2 and Q_{10} flow event under the 56 MW scenario. A full outage during a year with Q_{10} flows would be a worst-case scenario because during a Q_{10} outage, the pre-outage and outage water levels in the Forebay would be the highest. The Forebay water level during a Q_{10} outage would also rise above the normal 56 MW operating conditions and would submerge a small area of soils along the lake bank.

In the lower Taltson River, the magnitude of water level change is the smallest under the Q_{10} scenario. However, the worst-case assessment for this area is also affected by the resulting inflows from Zone 5. When a full outage occurs, the majority of the flow is directed into Zone 5, substantially ramping up the flow rates and water levels. The subsequent effects to Zone 5 water quality under a Q_{10} full outage was described in Section 17.4.4. When these flows enter Zone 3 in the lower Taltson River near Elsie Falls, materials such as total metals and suspended solids would also rise. It should be noted that in the lower Taltson River, the duration of the ramping flow change is short-term, lasting hours. When water flow is redirected into Zone 5 and re-enters Zone 3 in the lower Taltson River, flows and water levels would return to conditions similar to normal operating conditions within the day; even in the event of a long-term outage lasting weeks or up to a month.

A full outage under the 36 MW scenario was not considered because a lower volume of water would be released from the Nonacho dam control structure. In the event of a full power outage, less water volume would be redirected from the Twin Gorges power facility, and the ramping flows would be of a lesser magnitude than the 56 MW scenario. Consequently, potential effects to key water quality parameters would also be of a lesser magnitude than the 56 MW scenario.

17.5.3.2 Q10 Flow Outage in Zone 3 – Twin Gorges Forebay

Table 17.25 presents the pre-outage and outage water levels in the Forebay during a period with Q_{10} flows.

Table 17.25 — Water Levels in the Twin Gorges Forebay during a Full Outage

	56 MW Scenario	56 MW Outage During Q_{10} Flow
Absolute Maximum Water Level (masl)	248.3	
Pre-outage Water Level (masl)		248.2
Outage Peak Water Level (masl)		248.5

The pre-outage water levels during a Q_{10} flow period would be 248.2 masl. The peak water levels during a full outage would be 248.5 masl. In comparison, under the 56 MW operating conditions, the highest water level experienced would be 248.3 masl. A full outage during a year with Q_{10} flows, would increase water levels in the Forebay by 0.2 m above what would be experienced under the 56 MW scenario.

The increase in water level would occur over eight hours during a full outage. However, the levels in the Forebay would not be substantially higher than the 56 MW operating conditions.

17.5.3.2.1 General Chemistry

General chemistry parameters (e.g. turbidity, TSS, TDS, total metals) in the Forebay would experience negligible changes in the event of a full outage during a Q_{10} flow event.

During a full outage, inflows into the Forebay would not cause any substantial water turbulence in benthic zone, and settled particulates would not remobilize in the water column. The Q_{10} peak water level during an outage would be slightly higher than the absolute maximum level under the 56 MW operating conditions. The low water turbulence associated with Forebay level rises and the relatively small increase in inundated Forebay shores to the total Forebay benthic surface area would not introduce any substantial quantity of materials into the water column.

17.5.3.2.2 Mercury

Mercury concentrations in the water would experience negligible changes for a full outage during a Q_{10} flow period. Increases in mercury concentration are typically caused by long-term (i.e. years) or permanent inundation of terrestrial soils, which causes soil-bound mercury to be released into the water. The outage peak water levels in the Forebay would be slightly higher than absolute maximum water levels 56 MW operating conditions, and the duration of these levels would only occur for the duration of the outage. A prolonged outage lasting several months would have a negligible effect on mercury release from the inundated soils and concentrations in the water column would be unaffected.

17.5.3.2.3 Eutrophication

Eutrophication or increases in nutrient concentration would experience negligible changes for a full outage during a Q_{10} flow period. There would be no nutrient sources during the ramping conditions, and the Forebay under the 56 MW operating scenario would be oligotrophic with low nutrient content.

17.5.3.2.4 Temperature

Temperature changes would experience negligible changes for a full outage during a Q_{10} flow period. Temperature changes would typically occur if water levels decreased substantially and lowered the Forebay surface area to water volume ratio, or if ramping conditions changed the temperature of inflowing water into the Forebay. A ramping increase in water level that is 0.2 m higher than the absolute maximum water level under the 56 MW scenario would not cause any substantial temperature change for an outage of any duration because the increase is small relative to the total Forebay depth.

17.5.3.2.5 Dissolved Oxygen

Dissolved oxygen concentrations would experience negligible changes for a full outage during a Q_{10} flow period. Dissolved oxygen concentrations during open water months, under the 56 MW operating conditions, would be supersaturated with oxygen due to the low temperature of the region and the oligotrophic nature of the water. There would be no environmental factors occurring in the Forebay during a full outage that would change the rate of oxygen depletion in the water.

17.5.3.2.6 Erosion

Erosion rates would be negligible for a full outage during Q_{10} flow periods. During a full outage, water levels would increase to its peak and remain until the Twin Gorges power facility operations are restored.

17.5.3.2.7 Sedimentation

Sedimentation rates would be negligible for a full outage during a Q_{10} flow period. Sedimentary materials are transported from sections of the Taltson River upstream of the Forebay. The ramping scenario has no effect on areas upstream of the Forebay, and there would be no potential for sedimentation rates to change.

17.5.3.2.8 Summary

Table 17.26 presents the summary of water quality effects to the Forebay resulting from a full outage during a Q_{10} flow period.

Table 17.26 — Water Quality Effects in the Twin Gorges Forebay During a Full Outage

Parameter	Q_{10} Flow
General Chemistry	Negligible
Total Mercury	Negligible
Eutrophication	Negligible
Temperature	Negligible
Dissolved Oxygen	Negligible
Erosion	Negligible
Sedimentation	Negligible

17.5.3.3 Q10 Flow Outage in Zone 3 –Lower Taltson River (Downstream of the Twin Gorges Power Facility)

Table 17.27 presents the pre-outage and outage water levels in the lower Taltson River during a Q_{10} flow event. The pre-outage water levels during a Q_{10} event would be 205.3 masl. During a full outage, the water level would decrease in the first hour by 1.1 m to 204.2 masl. Levels would return to pre-outage conditions 18 hours after the start of the outage when the redirected flow over the SVS enters the lower Taltson River near Elsie Falls.

Upon restarting the Twin Gorges power facility, inflows to the lower Taltson River from Zone 5 would be at its peak. When the turbines at the Twin Gorges power facility are restarted sequentially, the flow through the turbines would be in addition to the peak flows from Zone 5 entering the lower Taltson River. This effect leads to three small increases in water level lasting up to four hours per event. Water levels in the lower Taltson River would return to pre-outage conditions several hours after the last turbine is restarted. However, the increase would be within the levels experienced during normal operations under the 56 MW scenario and would be contained within the river channel.

Table 17.27 — Water Levels in the Lower Taltson River (Zone 3) During a Full Outage

	56 MW Scenario	56 MW Outage During Q_{10} Flow
Absolute Maximum Water Level (masl)	205.6	
Pre-outage Water Level (masl)		205.3
Outage Minimum Water Level (masl)		204.2

17.5.3.3.1 General Chemistry

General chemistry parameters (e.g. turbidity, TSS, TDS, total metals) in the lower Taltson River would experience low changes in a full outage during a Q_{10} flow event. Water levels would experience a rapid decrease of 1.1 m within an hour. The rapid decline in water level would not affect general parameters such as turbidity, total metals and TSS because there would be a reduction in water turbulence and velocity. Water levels would begin to return to pre-outage conditions when redirected water in Zone 5 enters the lower Taltson River near Elsie Falls.

The redirected flow from the Forebay to Zone 5 would cause a substantial rise in flow rates and water levels, which were discussed in Section 17.4.4. These flows could have disturbed settled materials in Zone 5 prior to entering Zone 3 at the lower Taltson River near Elsie Falls. The effect to general chemistry in Zone 5 from a full ramping was assessed to be low, which reflects the low rating assessed for general chemistry in Zone 3.

Potential effects to water quality would last up to several days after normal operations at the Twin Gorges power facility are restored, and the redirected water over from the Forebay into Zone 5 drains into Zone 3.

17.5.3.3.2 Mercury

Mercury concentrations in the water would experience negligible changes for a full outage during a Q_{10} flow period. Increases in mercury concentration would be caused by long-term or permanent flooding or inundation of terrestrial soils, which causes soil-bound mercury to be released into the water. Such changes are not predicted in this scenario.

In the lower Taltson River, a substantial decrease in water levels would be experienced during the full outage. The conditions would have negligible effects to mercury concentrations. There would also be no potential of mercury influx from the redirected water entering the lower Taltson River from Zone 5.

17.5.3.3.3 Eutrophication

Eutrophication would experience negligible changes for a full outage during a Q_{10} flow period. There would be no additional nutrient sources from the ramping conditions. The lower Taltson River would experience a substantial decrease in water levels during a full outage. The conditions would have no potential effect to nutrient concentrations. There would also be no potential of nutrient influx from the redirected water entering the Taltson River from Zone 5.

17.5.3.3.4 Temperature

Temperature changes would experience negligible changes for a full outage during a Q_{10} flow period. The lower Taltson River water levels would decrease initially during a full outage, but would return to pre-outage conditions within 18 hours. There would be negligible temperature changes to inflows from Zone 5 because there are no factors that could change water temperature.

17.5.3.3.5 Dissolved Oxygen

Dissolved oxygen concentrations would experience negligible changes for a full outage during a Q_{10} flow period. During pre-outage conditions, water flowing through the Twin Gorges power facility would cause substantial mixing. Pre-outage dissolved oxygen concentrations would be at or near saturation concentrations.

The decrease in water levels and flows in the lower Taltson River would last approximately 18 hours before returning to pre-outage levels. There would be no potential for dissolved oxygen concentrations to change substantially since no other water parameters (i.e. salinity, temperature, biological oxygen demand, sediment oxygen demand) affecting dissolved oxygen would be altered.

17.5.3.3.6 Erosion

Erosion rates would be negligible to low for a full outage during Q_{10} flow periods. Water levels and flows in the lower Taltson River would be substantially reduced initially during a full outage. These conditions would not increase erosion of the river banks.

The ramped Trudel Creek flows would quickly increase water levels in the Taltson River back to pre-outage levels. dThis would cause water turbulence and eddy formations which would lead to some short-term erosion along the banks of the Taltson River lasting several hours.

17.5.3.3.7 Sedimentation

Sedimentation rates would be negligible to low for a full outage during a Q_{10} flow period. Reduced flows in the lower Taltson River would not increase sedimentation rates because the lower flows would be short-term, lasting several hours.

Approximately 18 hours after the outage, water levels would return to pre-outage conditions. The redirected flow from the Forebay to Zone 5 would cause a substantial rise in flow rates and water levels, which were discussed in section 17.4.4. These flows could have caused low levels of erosion along the banks of Trudel Creek prior to entering Zone 3. Upon entering the lower Taltson River near Elsie Falls, any suspended material could potentially settle along the Taltson River causing low levels of sedimentation.

17.5.3.3.8 Summary

Table 17.28 presents the summary of water quality effects to the lower Taltson River downstream of the Twin Gorges power facility resulting from a full outage during a Q_{10} flow period.

Table 17.28 — Water Quality Effects in the Lower Taltson River During a Full Outage

Parameter	Q_{10} Flow
General Chemistry	Low
Total Mercury	Negligible
Eutrophication	Negligible
Temperature	Negligible
Dissolved Oxygen	Negligible
Erosion	Negligible to Low
Sedimentation	Negligible to Low

17.5.4 Wetlands

17.5.4.1 INTRODUCTION

The following section describes the effect to wetlands in Zone 3 due to a full power outage at the Twin Gorges power facility. This zone is separated into two subzones: (1) the Twin Gorges Forebay, and (2) downstream of the Twin Gorges power facility (i.e. lower Taltson River). The methods for this effects assessment follow those presented in Chapter 10. Wetland VCs (i.e. wetland extent and function), assessment endpoints, spatial boundaries, and relevant Project components were presented in Section 13.7.2.

The wetland assessment considers the magnitude of water level change that could affect wetland areas. The assessment considers the worst-case scenario, defined as a full power outage occurring in a low flow year under the 56 MW operating conditions. Under the 56 MW scenario, the pre-outage water levels in Zone 5 would be at the minimum and would experience the largest magnitude of change during a full outage. The ramping conditions under the 36 MW scenario would be less substantial and effects to wetlands would be comparatively minor to the 56 MW scenario. Therefore, a full outage under the 36 MW scenario was not assessed.

A full outage could occur at anytime of the year. Potential wetland effects were considered based on the time of year that a full outage would occur. The duration of an unscheduled outage could last from minutes to up to a month; however, hydrological changes would be experienced for approximately the first 18 hours, in the lower Taltson River, after the outage as described by the hydrological model predictions in Section 17.5.2. In the Forebay, the increased water levels would remain for as long as the total power outage lasted. A full outage lasting up to tens of minutes would have no effect to wetlands along the Forebay because the water level in the Forebay would not increase measurably. These short-term outages would also not have an effect on wetlands along the Taltson River downstream of the power facilities as water levels would not reach the crest of the SVS and no additional water would flow into Zone 5 and thus the Taltson River. Therefore, full outages lasting tens of minutes were not considered for this assessment.

17.5.4.2 Pathway Analysis

Pathways were identified that link potential effects to wetland extent and wetland function and ultimately the assessment endpoints (Table 17.29).

Two pathways exist that could affect the wetland assessment endpoints during a full outage. 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). The direction of change (increase or decrease in water levels) is not as important as the magnitude and duration of change. Water levels substantially above or below current ecosystem community boundaries would result is species composition shifts, following natural succession.

Table 17.29 — Wetland Assessment Pathways in Zone 3

Valued Component	Assessment Endpoint	Pathway
Wetland extent	Preservation of wetland extent	Rapid water level increase in the Twin Gorges Forebay leading to a change in flood regime which alters wetland extent due to a ramping event from a full power outage
		Rapid water level decrease in the lower Taltson River leading to a change in flood regime which alters wetland extent due to a ramping event from a full power outage
Wetland function	Maintenance of wetland function	Rapid water level increase in the Twin Gorges Forebay would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full power outage
		Rapid water level decrease in the lower Taltson river would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full power outage

17.5.4.3 Mitigation

Effects of full outage ramping can be minimised through Project design mitigation and mitigation practise. These mitigation measures were presented in Section 17.5.3.

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 little direct or indirect effects 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 minimise the quantity of water spilled into Trudel Creek and thus into Zone 3 of the Taltson River 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.

17.5.4.4 PATHWAY VALIDATION

Table 17.30 presents the pathway validation for each VC identified in the pathway analysis. The mitigation design and practises for a full outage would have minor effects in reducing the magnitude of ramping flow and water level changes in the Forebay and lower Taltson River.

Table 17.30 — Pathway Validation for Wetland Effects in Zone 3

Valued Component	Pathway	Pathway Validation
Wetland extent	Rapid water level increase in the Twin Gorges Forebay leading to a change in flood regime which alters wetland extent due to a ramping event from a full power outage	Minor
	Rapid water level decrease in the lower Taltson River leading to a change in flood regime which alters wetland extent due to a ramping event from a full power outage	Minor
Wetland function	Rapid water level increase in the Twin Gorges Forebay would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full power outage	Minor
	Rapid water level decrease in the lower Taltson river would change the flood regime which would alter wetland function (hydrological, habitat and ecological) due to a ramping event from a full power outage	Minor

In the Forebay, a water level rise of 0.6 m would be experienced during a low flow full outage. The pathway for wetland effects is Invalid for both wetland extent and function in the Forebay. The increase in water level would be within natural variation during both operating and baseline levels. The water level rise of 0.6 m would not submerge developing wetlands below the photic zone required for photosynthesis. Moreover, the increase would only occur for a relatively short duration and the frequency of this event would be in the order of once every five years. This is predicted to be similar to the frequency of occurrence for increases in water levels during normal operating conditions

In the lower Taltson River, water levels would rapidly decrease by 2.5 m immediately after a full power outage. The reduction in flows would be very temporary, and would begin to return to pre-outage water levels after 8 hours when flows over the SVS into Zone 5 return to Zone 3. After 18 hours, water levels would have returned to pre-outage conditions. The short duration of ramping water levels in the lower Taltson River would not affect wetland extent and function. Therefore, both pathways are Invalid in the lower Taltson River.

None of the potential pathways were carried forward to the effects classification.

17.5.5 Aquatic Resources

17.5.5.1 INTRODUCTION

The following section presents an assessment of the potential for effects to aquatic resources in Zone 3 due to a full power outage. The methods used for this effects assessment followed those presented in Chapter 10.

Aquatic resources are closely linked to water quality and together form an important indicator of environmental health. Thus, aquatic resources were identified as a VC. A detailed rationale for the selection of aquatic resources as a VC was presented in Section 13.8. Section 13.8 also presents a complete description of the aquatic resource assessment endpoints (i.e. preservation of sustainable aquatic biological communities), assessment boundaries and Project components used for the prediction of effects to aquatic resources.

The aquatic resources assessment considers the worst-case scenario, defined as a full power outage occurring in a low flow year under the 56 MW operating conditions. Under the 56 MW scenario, the pre-outage water levels in Zone 5 would be at the minimum and would experience the largest magnitude in change during an outage. The ramping conditions under the 36 MW scenario would be less substantial and the effects to aquatic resources would be comparatively minor to the 56 MW scenario. Therefore, a full outage under the 36 MW scenario was not assessed.

In the event of a full power outage at the Twin Gorges power facility, water would stop flowing through the turbines and store in the Forebay causing water levels to gradually rise until it reaches the crest of the SVS and spill over into Zone 5. The peak water levels in the Forebay would be reached approximately eight hours into the full outage.

In the lower Taltson River, water flowing through the turbines would be completely stopped resulting in a 2.5 m decline in water levels. The South Gorge Spillway would be opened to ensure a release of up to 30 m^3/s into the tailrace. The decline in water levels would be experienced for approximately 10 hours following the full outage, after which, water levels would begin to increase and return to pre-outage levels after 18 hours as the redirected water from the Forebay over the SVS would flow through Zone 5 and reach the lower Taltson River near Elsie Falls.

This section describes the potential effects to aquatic resources in the Twin Gorges Forebay and the lower Taltson River in the event of an unscheduled full power outage of the Twin Gorges power facility during a low flow year. This scenario was determined to be the worst-case scenario for a full outage.

17.5.5.2 PATHWAY ANALYSIS

The potential ramping of water levels during a full outage at the Twin Gorges power facility could cause adverse effects to aquatic resources in the Forebay and lower Taltson River. The pathways for these potential effects would be related specifically to the rate of change in water level and flow rate compared to those under normal 56 MW expansion operating conditions. These could cause drying and subsequent inundation of emergent vegetation and benthic invertebrates, leading to loss of productivity, biodiversity and change in community structure. Table 17.31 presents the pathways that were identified.

Table 17.31 — Aquatic Resources Assessment Pathways in Zone 3

Valued Component	Assessment Endpoint	Pathway
Aquatic Resources	Preservation of sustainable aquatic communities	Rapid increase in water levels, changing aquatic habitat in the Twin Gorges Forebay
		Rapid increase in water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in the Twin Gorges Forebay
		Rapid increase in water levels, selecting against species that are sensitive to flooding; reduced productivity in the Twin Gorges Forebay
		Rapid decrease in water levels, changing aquatic habitat in the lower Taltson River
		Rapid decrease in water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in the lower Taltson River
		Rapid decrease in water levels, selecting against species that are sensitive to flooding; reduced productivity in the lower Taltson River

Bechman et al. (1985) compared benthos populations in zones subjected to dewatering with those in non-dewatered zones of Lake Roosevelt and found that mean density of benthos was lowest in the dewatering zones in all season samples. Survival would depend on the ability of each species to quickly move to deeper sections of the river (potentially amphipods), or to burrow deeper into sediment during the drying period. Sediment affinity for water retention would also affect benthic species survival, as sand and gravel based areas would drain more quickly than organic or clay zones. Species attached to substrates (e.g. some chironomids and caddisflies) would likely show greatest declines compared to more mobile or burrowing species.

The rapid rate of change in water levels could also cause disturbance leading to drift and loss of deposited eggs or early instar larvae, particularly in littoral zones. There could also be a loss of biodiversity as species more sensitive to changes in water levels and velocities are outcompeted or experience high mortality relative to more hardy species.

Flow changes are known to cause shifts in taxonomic abundance ranging from more large-body sessile species to small-body disturbance-resistant taxa (Mannes et al., 2008; Robinson and Uehlinger 2008). Robinson and Uehlinger (2008) found that even with floods that were temporary (eight hours) and relatively infrequent (approximately twice a year over a six-year period), there was a significant change in density, biomass, taxon richness, and individual biomass of benthic invertebrates. Changes in primary and secondary community structure could also occur. Profundal benthos would not be expected to show as serious adverse effects from the elevated water levels since their habitat would likely remain less altered than shallow or moderate depth areas. However, water quality could also be degraded to various degrees based on increased erosion of banks along river and lake habitat, and altered sediment deposition which could alter habitat. This could disturb aquatic biota at all depths, see section 17.5.4 for water quality assessment.

17.5.5.3 MITIGATION

Effects of full outage ramping can be minimised through Project design mitigation and mitigation practise. These mitigation measures were presented in Section 17.4.3.

17.5.5.4 PATHWAY VALIDATION

Rapid changes in water levels could affect aquatic resources by altering habitat, stressing or killing organisms, and reducing productivity.

The rate of water level change in the Twin Gorges Forebay would be relatively small based on the hydrological model predictions described in Section 17.5.2. The primary concern during a full outage would be a rapid change in water level, which would select against invertebrate species that are sensitive to flooding. The water level rise in the Forebay during a full outage would not rise beyond the normal 56 MW operating level. Water levels in the Forebay would normally experience variations throughout the year. Therefore, the pathways for effects to aquatic resources in the Twin Gorges Forebay were Invalid and not carried forward to the effect classification.

In the lower Taltson River, the rapid change in water levels during a full power outage would occur over a short time scale (less than one hour). The worse-case scenario would involve the 56 MW option under lowest flow conditions, with all three turbines shutdown at once. Under these conditions, water levels in the lower Taltson River would first decrease from 204.6 masl to 202.1 masl in less than one hour as shown in Figure 17.3. As diverted flows pass through Trudel Creek to the lower Taltson River, the latter would then experience ramp-up of water levels back to pre-outage conditions (204.6 masl) approximately 18 hours following the initial outage event, and remain at that level until the turbines at the Twin Gorges power facility are restarted. Restarting the turbines would cause incremental water level increases of 0.2 m to 0.4 m for a short period of time. The effects of re-starting the turbines are presented in Section 13.8 (Taltson Aquatics).

The shutdown and restart during ramping is a Valid pathway for effects in Zone 3 for the lower Taltson River under the 56 MW option because the changes in water level are very rapid. The rapid decline in water levels, which would occur almost immediately following a full outage, would provide insufficient time for many aquatic invertebrates to adjust to (i.e. move to lower water levels to prevent exposure). Table 17.32 presents the pathway validation for effects to aquatic resources in the lower Taltson River.

Table 17.32 — Pathway Validation for Aquatic Resource Effects in Zone 3

Valued Component	Pathway	Pathway Validation
Aquatic Resources	Rapid increase in water levels, changing aquatic habitat in the Twin Gorges Forebay	Invalid
	Rapid increase in water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in the Twin Gorges Forebay	Invalid
	Rapid increase in water levels, selecting against species that are sensitive to flooding; reduced productivity in the Twin Gorges Forebay	Invalid
	Rapid decrease in water levels, changing aquatic habitat in the lower Taltson River	Valid
	Rapid decrease in water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in the lower Taltson River	Valid
	Rapid decrease in water levels, selecting against species that are sensitive to flooding; reduced productivity in the lower Taltson River	Valid

17.5.5.5 EFFECT CLASSIFICATION

17.5.5.5.1 Classification Categories

In order to assess the effect of altered water level on aquatic resources, several points were considered. First, the relative change in water level compared to pre-outage levels were calculated and rated as magnitude of water level change, which relates to the magnitude of the effect on aquatic resources but was not used in isolation to determine the magnitude of the effect on aquatic resources. Changes in water levels were categorized as follows:

- 0 cm to 19 cm = Negligible,
- 20 cm to 49 cm = Low,
- 50 cm to 99 cm = Moderate, and
- 100 cm or more = High.

These categories were selected using professional judgment. These categories were based on typical depths of littoral zones and associated vegetation. However, there remains a high level of uncertainty associated with these categories as they relate to changes in littoral zones. The uncertainty is dependent on slope of lake or river bed, types of vegetation present (horsetail vs. taller bulrush species), and physical substrates present (i.e. silt and sand vs. bedrock, relating to TSS issues from fluctuating water levels). Literature reviews suggest that this categorization is relevant for an effects assessment. For example, NIWA (2003) suggest 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.

17.5.5.5.2 Effects in Taltson River

During a full outage scenario, ramping of water flow rates would result in high magnitude decreases in water levels passing down the tailrace and into lower Taltson River. Following restart, associated water level increases would be low in magnitude (see Section 13.8) discussion on ramp up during turbine restart after scheduled outages). Therefore effects assessment is mainly concerned with the decrease during shutdown rather than the slight increases during restart. The frequency of a full outage event is rare (estimated to be a 1 in 5 year event) and would be an isolated event. The duration of the ramping event is difficult to predict but could last for hours up to a month depending on the cause of the power outage. However, the duration of resulting effects to aquatic resources was considered short-term because altered habitat, mortality and loss of biodiversity could endure up to a few years (less than 3 years) following such an event. Due to their importance in food web dynamics for fish and wildlife, decreased productivity and diversity of plant, algae and benthic invertebrate communities are considered ecologically relevant and may relate to effects to these other VCs, see full outage ramping assessment below for fish and wildlife.

Portions of suitable littoral habitat in lower Zone 3 would be temporarily lost due to dewatering. Lowered water levels could result in increased disturbance and transport of sediment, which would now be at the water surface. This could result in degraded water quality, decreasing productivity. Water quality changes from ramping were rated low, and were not considered significant. Ramping events in late summer could likely have the most deleterious effects since it is during this period that biological activity is highest, including reproductive effort in plants and animals. This could alter aquatic community stability, leading to changes in community structure and productivity. Species residing in shallow areas would be expected to show highest effects, while profundal areas would largely be unaffected by the temporary drops in water levels. Overall residual effects from ramping are rated low given that such ramping events would be rare and infrequent which would give the aquatic community time to reverse the effects (Table 17.33).

Table 17.33 — River Habitat Effect Classification in Zone 3 During a Full Outage

Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
Rapid increases in flow rates and water levels, changing aquatic habitat in Trudel Creek and associated lakes	Adverse	Moderate	Local	Short-term	Reversible	Isolated	Possible	Low
Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced diversity and altered structure in Trudel Creek and associated lakes	Adverse	Moderate	Local	Short-term	Reversible	Isolated	Possible	Low
Rapid increases in flow rates and water levels, selecting against species that are sensitive to flooding; reduced productivity in Trudel Creek and associated lakes	Adverse	Moderate	Local	Short-term	Reversible	Isolated	Possible	Low

17.5.5.6 UNCERTAINTY

The following factors contributed to the levels of uncertainty in this assessment:

- Lack of knowledge of aquatic primary producer community diversity and productivity in the lower Taltson River. Information was collected in the Forebay. It was assumed that the lower Taltson River was similar to these conditions.
- Limited knowledge of habitat quality along shores, in littoral zones (relating to potential for nutrient inputs, erosion and sedimentation).
- Uncertainty associated with the hydrological modelling data and the predicted changes in hydrological conditions.
- Uncertainty associated with the assessed magnitude of effects based on water level changes.

17.5.6 Fisheries Resources

17.5.6.1 INTRODUCTION

This section describes the effect on fisheries resources in the Taltson Basin which would result from a full power outage at the Twin Gorges power facility. This effects assessment follows the methods presented in Chapter 10. The rationale for the fisheries resource VCs, assessment endpoints, etc are discussed in detail in Section 13.9.

A full power outage could occur from an accident/malfunction or from an effect of the environment on the Project (Chapter 16). In the event of a full power outage, the entire plant is taken off-line virtually instantaneously, and the turbines completely shut down within seconds. The generating flow would then collect in the Forebay, raising the Forebay level until the flow is “detoured” through Trudel Creek via the South Valley Spillway. The immediate effect downstream of Twin Gorges is a reduction in total flow.

In a worst-case scenario, the generating inflow would be approximately 180 m^3/s for the 36 MW development scenario, and 240 m^3/s for the 56 MW scenario and the flow over the South Valley Spillway would likely be at or close to the minimum release.

The flow in the Taltson River would remain reduced until inflows to the Forebay are routed through Trudel Creek to the lower Taltson River. It has been calculated that the flows would remain minimal for 8 hours and then return to pre-event levels after 18 hours following the initial decrease. To minimize the disruption in flows during an outage, the South Gorge Spillway would automatically open after a fixed time period to allow up to 30 m^3/s of flow into the tailrace. Upon restarting the turbines, the South Gorges Spillway would first be closed. Although all three turbine units would be capable of being restarted simultaneously, a sequential start-up and loading process would be implemented to minimize the flow ramping in the lower Taltson River. Three increments of flow would be introduced to the Taltson River. Typically, one unit would be loaded every 4 to 6 hours.

The following discussion is based on short-term full outages (less than 4 hours) happening at least once a calendar year and a full outage (that lasts several days up to a month) once every five years. These could happen at any time of year, although the primary cause is anticipated to be lightning strikes in July/August (T. Vernon, pers. com., 2009).

The primary difference between the two events is that there would be no water "detoured" through Trudel Creek in a 4 hour event, so there would be no increase above pre-event flows when generation is restarted.

17.5.6.2 Pathway Analysis

The pathways of effect to consider are those that relate to sudden and dramatic fluctuations in water flow. And these are limited to two: *Flow management as it relates to displacement or stranding of fish (ramping)* and *Flow management: Bank erosion / deposition as it relates to habitat structure and cover.*

In terms of potential geographic extent, the effects of total power outages are restricted to the Forebay, Trudel Creek and the lower Taltson River. There is potential for some backwatering upstream of the Forebay, though the magnitude of change in water levels are believed to be low. The implications of a total shutdown event in Trudel Creek fisheries resources have been discussed previously.

17.5.6.3 Mitigation

Effects of full ramping would be reduced but not eliminated. The South Gorge Spillway would ensure a minimum release in the lower Taltson River. It would also reduce the full ramping effect along Trudel Creek. Upon start-up, the turbines would be brought back on-line one at a time every four to six hours to minimize the ramp up effect in the lower Taltson River.

17.5.6.4 Pathway Validation

The pathways of effect to consider from such events are: Flow management as it relates to displacement or stranding of fish (ramping) and Flow management: Bank erosion / deposition as it relates to habitat structure and cover. These are discussed below.

17.5.6.4.1 Flow Management as it Relates to Displacement or Stranding of Fish (ramping)

There are two potential effects on fish and fisheries resources from the full outage ramping events. Firstly, fish could be left stranded in isolated pools when flows quickly drop by at least a meter. Secondly, fish could be carried into inappropriate places during times of increased flow and left there when the flows decrease to pre-event levels. The effect of isolating fish upon re-start of the turbines is addressed in Section 13.9.

Clearly the initial shutdown creates the greatest potential for effects. The nearly instantaneous loss of 85% of the flow could clearly lead to stranding of fish in shallow water. The water level implications of these flow changes on the lower Taltson River have been modelled for low, medium (Q2) and high (Q10) flows in the Taltson River and are presented in Table 17.34. These results are based on channel cross-sections downstream of the tailrace for the new powerhouse, which is, downstream of the confluence of Trudel Creek.

Table 17.34 — Predicted Water Level During Full Outages at Differing Background Flows on the Taltson River Below Elsie Falls

	pre-outage level (masl)	minimum level (masl)	initial decrease (m)	Maximum level (masl)	decrease on return to pre-outage levels (m)
Low flow	204.55	202.13	2.42	204.8	0.25
Mid-range flow	204.78	203.1	1.68	205.14	0.36
High flow	205.3	204.2	1.1	205.58	0.28

These events are of particular concern to northern pike, which use near-shore habitats for spawning and rearing. They often spawn on riparian vegetative substrates in water less than 0.3 m deep and remain near those habitats during their natal year (Evans et. al., 2002). Pike spawn shortly after break-up (usually in May) and the eggs incubate for six to ten days. The newly-hatched larvae remain attached to the spawning substrate for another eight to ten days while they absorb nutrients from the yolk sac. Therefore it is two to three weeks before the new generation is free-swimming. Therefore, the young pike are immobile, in one form or another, from May until June – and they are in water about 0.3 m deep. The data in Table 17.34 (above) show that a total shutdown would result in water levels being lowered by over 1 metre regardless of the initial flow level, meaning that the young northern pike would almost certainly be de-watered during a shutdown. This Pathway is Valid.

17.5.6.4.2 Flow Management: Bank Rrosion / Deposition as it Relates to Habitat Structure and Cover

Flows would ramp up during re-start of the turbines. Flows would initially increase by 50 m^3/s when the first turbine is re-started and the South Gorge Spillway is closed. The next turbine would not be re-started until the ramped flow from the first turbine start-up has subsided (four to six hours later). Re-start of the second turbine would increase the flow by roughly 80 m^3/s above the pre-outage flow. The third and final turbine would not be re-started until flow again subsides to pre-outage levels. Thus, the maximum ramped flow would be 80 m^3/s above the pre-outage flow. This equates to an increase in water level of roughly 0.3 m above for approximately ten hours. The change in flow during full outage ramp up is equal to the change during a scheduled partial outage. These fluctuations are within the realm of natural variability and are not anticipated to have any effect on fish; see Section 13.9 for re-start ramping events during scheduled outages.

The effects on erosion, deposition/sedimentation and fish are presented in Section 13.4 (Water Quality) and Section 13.9 (Fish) for ramp up during the open water season and Section 13.6 (Ice Structure) when ice is still on Trudel Creek and the lower Taltson River.

17.5.6.5 EFFECTS ANALYSIS

The anticipated effects of the identified Valid pathways discussed in detail below.

17.5.6.5.1 Flow management as it relates to displacement or stranding of fish (ramping)

This pathway would effect the survival of northern pike eggs and larval fish. Inherent to this discussion is a consideration of the preferred spawning habitat used by northern pike.

The spawning habitat used by pike would likely be mats of dead emergent vegetation; the remnants of the previous year's growth. On de-watering, these mats would retain water for a period of time, and it is likely that eggs, larvae and/or very small fish could survive while the mats retain water. The duration these mats might retain water and thus support eggs, larvae and small fish would depend on factors such as the characteristics of the vegetation itself, the external temperature, exposure to sunlight, etcetera.

Thus, while such shutdown events pose risks to northern pike reproductive success, it is not an absolute risk because the potential effects could be mitigated by the characteristics of the preferred spawning substrate and by the duration of the reduced water levels; 10 hours at the minimum, 8 hours from initial rise to pre-outage levels. However, it is likely that there would be some effect on reproductive success and, if this were incurred in most years during the time while the young northern pike are vulnerable and with occur with high frequency, then there would be a long-term reduction in spawning success. The most likely instigating event is loss of transmission capacity because of lightning strikes – and lightning is most common in July and August (T. Vernon, personal communication, 2008).

The geographic extent of the changes in water levels and thus the effect on fish would be observed from Elsie Falls to Tsu Lake. Beyond Tsu Lake the effects would be buffered and thus no changes in water levels are predicted.

There is much less risk to fish if such an event happened in winter because over wintering habitat for all fish in the system is deep water. It is not clear just how deep that would be but it would clearly be more than 1 meter and, therefore, it is unlikely fish in deep pools would be affected.

Therefore, this pathway is of primary concern to northern pike and specifically the implications to its reproductive success during total shutdown events which happen between May and August.

17.5.6.6 EFFECTS CLASSIFICATION

Based on the incremental effects of unscheduled full ramping during operations of the Expansion Project, two pathways – Flow management as it relates to displacement or stranding of fish (ramping) and Flow management; Bank erosion/ deposition as it relates to habitat structure and cover – are anticipated to have effects on the ecosystem of the Taltson River watershed relative to current conditions.

Given the uncertain nature of the events in question it is impossible to do more than present "worst-case" discussions. In the worst case – if an outage happened in late

May/early June (when northern pike reproductive success is most vulnerable) then it would almost certainly have an effect on the recruitment into the population (i.e. a portion of the young-of-year would not survive). Clearly, if this happened every year then this would have long-term, adverse consequences to that population of northern pike.

The possible incremental effects of total shutdown events on the northern pike, lake whitefish and lake trout populations within the Taltson River watershed are presented in Table 17.35.

17.5.6.7 OVERALL SIGNIFICANCE OF PROJECT EFFECTS

The overall significance of the potential effects of the Project (including Accidents and Malfunctions) is presented in Table 17.36.

Table 17.35 — Incremental Effects Classification for Pathways to Valued Components

Valued Component	Pathway	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Overall Residual Effect
Northern pike	Flow management as it relates to displacement or stranding of fish (ramping)	Adverse	High	Zone 3: downstream of Twin Gorges	Medium-term	Reversible	Continuous	High	High
Lake trout	Flow management as it relates to displacement or stranding of fish (ramping)	Adverse	Low	Zone 3: downstream of Twin Gorges	Medium-term	Reversible	Continuous	High	Low
Lake whitefish	Flow management as it relates to displacement or stranding of fish (ramping)	Adverse	Low	Zone 3: downstream of Twin Gorges	Medium-term	Reversible	Continuous	High	Low

Table 17.36 — Significance of Potential Effects to the Valued Components

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
Northern pike	Fish mortality	Obstruction as it relates to entrainment	Low/Adverse	Not significant	Medium
	Changes in fish access over Tronka Chua gap and the Nonacho Lake spillway	Flow management as it relates to migration and/or access to habitats	Low/Adverse		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate/Adverse		
	Changes in food supply	Flow management as it relates to food supply	Low/Adverse		
	Displacement or stranding of fish	Flow management as it relates to displacement or stranding of fish (ramping events from scheduled and unscheduled full and partial outages); Trudel and Taltson	Moderate-high/Adverse		
	Changes to Depositional Zones	Flow management as it relates to fish habitat structure and cover; Trudel	Low/Adverse		
Lake trout	Fish mortality	Obstruction as it relates to entrainment	Low/Adverse	Not significant	Medium
	Changes in fish access over Tronka Chua gap and the Nonacho Lake spillway	Flow Management as it relates to migration and/or access to habitats	Low/Adverse		
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Low/Adverse		
	Changes in food supply	Flow management as it relates to food supply	Low/Adverse		
Lake whitefish	Fish mortality	Obstruction as it relates to entrainment	Low/Adverse	Not significant	Medium
	Changes in fish access over Tronka Chua gap and the Nonacho Lake spillway	Flow management as it relates to migration and/or access to habitats	Low/Adverse		

Valued Component	Assessment Endpoint	Pathway	Overall Residual Effect	Overall Significance	Uncertainty
	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate/Adverse		
	Changes in food supply	Flow management as it relates to food supply	Low/Adverse		
	Changes to Depositional Zones	Flow management as it relates to fish habitat structure and cover (Trudel Creek)	Low/Adverse		
	Displacement or stranding of fish	Flow management as it relates to displacement or standing of fish (ramping events from scheduled and unscheduled full and partial outages)) (Trudel Creek)	Low/Adverse		
Walleye (Trudel Creek)	Changes in habitat structure and cover	Flow management as it relates to fish habitat structure and cover	Moderate/Adverse	not significant	Medium
	Changes to Depositional Zones	Flow management as it relates to fish habitat structure and cover	Low/Adverse		
	Displacement or stranding of fish	Flow management as it relates to displacement or standing of fish (ramping events from scheduled and unscheduled full and partial outages))	Low/Adverse		

Table 17.36 presents the residual effects identified during a full outage ramping event as well as the residual effects under normal operating conditions within Trudel Creek (sections 14.8) and the entire Taltson River watershed (section 13.9) and full outage ramping events within Trudel Creek (Section 17.4). The residual effects identified for the effects assessment of normal operating conditions were considered when determining the overall significance of effects on the Valued Components northern pike, lake trout, lake whitefish and walleye. The key residual effects that were considered were changes to habitat structure and cover associated with a decreased water level and changes to incubating egg mortality during scheduled and unscheduled ramping events.

The "*Changes in riparian habitats*" and "C*hanges in accessibility of riparian habitats and vegetation comprising those habitats"* endpoints both relate to the effect of lowered water levels on the riparian vegetation. This lowering would decrease fish access to riparian habitats and, in the longer term, alter the characteristics of those habitats because the vegetation comprising them is dependant on the water level. As the location of current habitats is a result of previous alterations in water levels, in 1966 and in 1986, it is almost certain that the vegetation would similarly re-establish at the appropriate new elevations in response to the water management regime within five to ten years.

Shallow water riparian habitats are used by northern pike for spawning and rearing. Current research indicates that, while these are preferred habitats, northern pike would also use other available habitats (Casselman and Lewis, 1996). It is expected that the alternate habitats would be sufficient until the riparian vegetation becomes re-established.

The *Changes in fish movement (into and out of Nonacho Lake)* endpoint also relates to the lowering of the water level in Nonacho Lake. The water flow over the spillway or through Tronka Chua Gap would stop during some parts of the year, restricting fish passage from Nonacho Lake to downstream lakes. Changes in Tronka Chua Gap flows represent return to the pristine conditions, as it is unlikely that there was regular flow through the Gap prior to the initial development.

The overall effect of changes in flows over Nonacho spillway is low. Prior to the initial development, the river channel at the outlet of Nonacho Lake was likely an impediment or a barrier to fish movement, as it was either a waterfall or a steep cascade (T. Vernon & D. Grabke, personal communication, 2008). Therefore, fish movement through this channel was likely directed primarily downstream. It is anticipated that there would be flows over the Nonacho lake spillway in approximately one out of every four years, allowing some downstream fish movement.

It is important to note that the fish species of the Taltson River system do not need to migrate into or out of Nonacho Lake to complete a part of their lifecycle (unlike arctic char, which must migrate upstream to spawn). The fish species would have access to the critical habitats throughout their life cycle independent of their location relative to Nonacho Lake control structure.

The residual effect is isolating the fish populations on either side of the control structure. There is no indication that these populations are not self-sustaining, so this change is not anticipated to have any lasting effect.

In the event that incubating northern pike eggs and/or larval fish become dewatered, during a full outage event, the magnitude of the effect would be high; however, it is not anticipated to affect the entire year class. At the time of writing, the anticipated frequency with which unscheduled ramping events could affect incubating eggs in the Taltson River between Elsie Fall and Tsu Lake is one in five years. Additionally, the possible effect would only be incurred if that outage happened during a three to four week period (in late May/early June) when the incubating eggs and/or larval fish were immobile and in water less than 2.7 m deep. Thus, the potential dewatering is not anticipated to occur on an annual basis, or even with every full outage event. Therefore, the effect to northern pike populations would be reversible over the intervening years (i.e. 3 to 10+ years). As such, no significant adverse effects to northern pike, lake whitefish or walleye as a resulted of dewatered incubating eggs were predicted.

17.5.6.8 UNCERTAINTY

There are a few areas of uncertainty in this discussion. The first uncertainty is whether the riparian vegetated habitats would become re-established in response to the lowered water level and altered water management regime in Nonacho Lake. The second is associated with the effect of the isolation of Nonacho Lake fish populations on the overall fish populations of the Taltson River system. The added uncertainty relates to the potential effect to northern pike spawning success, and it is discussed below.

17.5.6.8.1 Northern Pike

The potential effect to northern pike spawning success relates to the reduction in water level in the Taltson River between Elsie Falls and Tsu Lake. The anticipated water level drop is over a meter. Northern pike lay their eggs on emergent vegetation in water less than 0.3 m deep and the eggs and larval fish are immobile for two to three weeks. So, if a full outage occurs during that critical period there would, almost certainly, be some direct mortality. There are a number of mitigating factors (short duration of water level reduction, water retention of spawning substrate, etc.) which suggests that the degree of mortality would be less than 100%.

There are two sources of uncertainty pertinent to this discussion: firstly, the timing and frequency of a full power outage, and secondly, the timing and distribution of northern pike spawning in that section of the river. These are presented below.

1. the timing and frequency of a full power outage. This analysis is done on the information that a full outage is a one in five year event and could happen at any time. The potential effect arises from the scenario of a full power outage in late May/early June. If a full power outage happens at some time other than late May/early June, then the frequency of an event that would effect northern pike becomes even rarer. Clearly, the possible effect to the northern pike populations is much less if it happens once in the lifetime of the Project than if it happens 8 times in the life of the Project, or not at all. Therefore, the "one in five" year assumption should be further tested and refined by further analysis of existing transmission data.

2 the timing and distribution of northern pike spawning in that section of the river. The potential effect to northern pike spawning success would also depend on exactly where and when northern pike spawn in that section of the Taltson River. Further field work should be done to assess the population of northern pike in that section of the Taltson River, specifically, where and when they spawn and the characteristics of their preferred substrate. This information would be used to further refine the estimated effect of the Project on that population.

17.5.6.8.2 Riparian Vegetation

The proposed water management regime would aim to generally store Nonacho freshet in Nonacho Lake while the Tazin River freshet would be used for power production. Water from Nonacho Lake would be released when the Tazin freshet water can no longer generate the needed power. Nonacho Lake would be held at higher water levels through the early summer (anticipated peak is July-August) with water being released slowly in the fall.

Water Survey Canada data for the years 1998 through 2007 show that the water level usually peaks in June and then gradually decreases until late September or October. The range of high water varies from 323.9 m to 323.2 m. Under the proposed water management regime, average high water would occur in July and would be 322.6 m. However, the longitudinal hydrograph model output indicates that high water could vary from 322.0 to 323.8 m in any particular year, with the water level of 322.4 m or lower in the majority of the years. The hydrograph also indicates that there would be years when the water level would be higher than 323 m and that these events would generally occur two or more years apart. Therefore, some high water events would cause water level to be up to 1.5 m higher than the average 322.6 cm. It is likely that most of the riparian vegetation would be inundated during these events. Some uncertainty is associated with whether the plants can survive that amount of inundation. More detailed analysis of the pre-existing water level changes as compared to the proposed water level regime in Nonacho Lake would decrease this uncertainty. If the pre-existing year-to-year variation is comparable to the variation anticipated under the proposed water management regime, it can be expected that the existing vegetation would re-establish with time.

The quality of vegetated riparian habitats is an issue for northern pike, which use these habitats preferentially for spawning and rearing. Research indicates that while these habitats are preferred, northern pike would use other habitats if emergent vegetation is not available. This suggests that the northern pike population in Nonacho Lake is not completely dependant on riparian vegetation and a reduction in the amount of that habitat might not adversely affect the fish population in the long term.

17.5.6.8.3 Isolating Nonacho Lake Fish Populations from Downstream Populations

There is uncertainty associated with the isolation of fish populations in Nonacho Lake from the downstream populations. It seems likely that both populations are self-sustaining and that anticipated isolation would result in reversion to pristine conditions. However, it is recognized that this would change the potential corridor for fish movement used for the last 20 years. It is likely that the fluvial conditions at the pristine outlet of Nonacho Lake comprised an impediment or a barrier to fish migration; however, it is difficult to determine this at the given time.

17.5.6.9 MONITORING

A monitoring program would be developed in detail with regulatory agencies that focuses on the key areas of concern and areas that are predicted to experience the greatest change from current conditions. Following review of the DAR, the areas of greatest concern would be identified via discussions with the Board, federal and territorial agencies, Aboriginal groups and the public.

17.5.7 Wildlife

17.5.7.1 INTRODUCTION

In the event of a full power outage of the Twin Gorges power facility, water would stop flowing through the turbines leading to water level increases in the Forebay. Levels would increase until reaching the crest of the SVS and spill over to Zone 5. Peak water levels in the Forebay would be reached approximately eight hours and last for the duration of the outage.

Downstream of the Twin Gorges power facility water flow would decrease rapidly after a full outage. The South Gorge Spillway would be opened in the event of an outage to release a maximum flow of 30 m^3/s to the tailrace to ensure flow in this area. In the lower Taltson River a substantial decrease in water level would also be experienced in the initial hours after a full power outage. The water from the Forebay would be redirected over the SVS into Zone 5, and would require approximately 10 hours to reach the Taltson River confluence with Trudel Creek and 18 hours to reach peak flows. In the lower Taltson River, water levels would return to near pre-outage levels within 18 hours of the outage.

The following section describes the potential effect of ramping flows and water levels to wildlife in the event of a full power outage. The rationale for selecting species or wildlife communities as VCs was presented in Section 13.10.2. The species and wildlife VCs selected for a full outage scenario were: furbearers (muskrats and beavers), moose, waterfowl, shorebirds, whooping crane, rusty blackbird and northern leopard frog. The assessment endpoints for each VC was presented in Section 13.10.2 for the preservation of wildlife populations, habitat and harvesting opportunities. The assessment boundaries (i.e. spatial and temporal boundaries) were described in Section 13.10.3 and includes a local assessment boundary of 500 m from the hydrological zone of Zone 5, which is appropriate for assessing wildlife dependent on riparian habitat (i.e. wetlands) over the projected 40 year lifetime of the proposed Project when a full outage could occur. The Project components that were considered for a full outage was presented in Section 13.10.4.

The following section describes the effect to wildlife dependent on riparian regions in the event of a full outage during 56 MW operating conditions. A full outage could occur at anytime of the year. The duration of an unexpected outage could last from minutes up to a month. A full outage lasting up to tens of minutes would have no effect to wildlife because the flow would be absorbed by the Forebay and no additional flows would be redirected over the SVS. Therefore, momentary full outages lasting tens of minutes were not considered for this assessment.

The assessment considers the worst-case scenario, defined as a full outage occurring in a dry year with low flows (i.e. low flow year). The water levels in Zone 3 under a worst-case full outage scenario was compared to levels during normal 56 MW operating conditions and the existing baseline conditions.

17.5.7.2 PATHWAY ANALYSIS

The general pathways that could affect the wildlife assessment endpoints due to a complete power outage are direct mortality and reduced reproductive success. The VCs, assessment endpoints and pathways are presented in Table 17.37. The following section describes the pathways for each VC.

17.5.7.2.1 Furbearers

Beaver and muskrat rely on riparian and aquatic habitat for all their life history stages and requirements including foraging, shelter, and reproduction. The pathway for ramping that pertains to both these species is direct mortality leading to reduced population abundance (Table 17.37). Direct mortality to furbearers could occur due to elevated or lowered water levels in relation to lodges, food caches, and shelter entranceways.

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 base conditions during the winter, freeze-out can occur where there is insufficient water under the ice for survival of beavers and muskrat (OFMF 2008). Muskrats require 30 cm to 60 cm of water so that freeze out does not occur. Shallow water levels are associated with lowered overwintering success for muskrats (Messier et al., 1990). Winter drought conditions can also cause water to freeze deeper and cut off access to food resources that become frozen in the water and mud (Erb and Perry Jr. 2003). Muskrat populations are shown to decline following dam creation due to the loss of overwintering habitat in shallow marshes (Rosenberg et al. 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 attributed as the cause of the muskrat disappearance and has been found to increase with lowered water levels (Proulx et al. 1987). Entranceways to muskrat bank burrows would be particularly susceptible to lowered water levels since 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 et al., 2008; Nolet and Rosell 1998). Lowered winter water levels led to increased foraging activity away from lodges for beavers, decreased condition of juveniles and spring abandonment of lodges (Smith and Peterson, 1991). Smith and Peterson (1991) recommended that overwinter drawdowns be maintained from 50 cm to 70 cm at the most.

Table 17.37 — Wildlife Assessment Pathways in Zone 3

Valued Component	Assessment Endpoint	Pathway
Furbearers	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance through higher water levels
		Direct mortality leading to reduced population abundance through lower water levels
Moose	Preservation of moose harvesting opportunities	Direct mortality leading to reduced population abundance through higher water levels
		Direct mortality leading to reduced population abundance through lower water levels
Waterfowl and shorebirds	Preservation of waterfowl harvesting opportunities	Direct mortality leading to reduced population abundance through higher water levels
		Direct mortality leading to reduced population abundance through lower water levels
		Reduced reproductive success leading to reduced population abundance through higher water levels
		Reduced reproductive success to reduced population abundance through lower water levels
Rusty blackbird	Preservation of habitat and populations	Direct mortality leading to reduced population abundance through higher water levels
Whooping crane	Preservation of habitat and populations	Direct mortality leading to reduced population abundance through higher water levels
Northern leopard frog	Preservation of habitat and populations	Direct mortality leading to reduced population abundance through higher water levels
		Direct mortality leading to reduced population abundance: lower water levels during winter when frogs are potentially overwintering in riparian areas

17.5.7.2.2 Moose

The pathway associated with complete power outages for moose is direct mortality due to increased water levels. Rapidly rising water levels could lead to mortality, particularly of calves, if moose are within the riparian zone when increased water levels occur associated with a full power outage. Riparian areas are important to moose for foraging during the spring and summer as well as calving and seasonal cover.

17.5.7.2.3 Birds

Identified pathways that could affect waterfowl, shorebirds, rusty blackbird and whooping crane are presented in Table 17.37.

Direct mortality due to elevated water levels and reduced reproductive success due to elevated or lowered water levels were identified as pathways. Water levels that rise over a short time period could flood nests and wash away young. Water levels that drop quickly could strand nests and expose them to increased predation. 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.

17.5.7.2.4 Northern Leopard Frog

The pathway identified for northern leopard frogs was direct mortality due to lowered water levels during the winter (Table 17.37). Mortality of northern leopard frogs during the winter due to insufficient oxygen levels, freezing, disease, and toxic exposures have been reported (Seburn and Seburn, 1998). The Northern leopard frog is the only frog in NT that overwinters under water. Individuals are more vulnerable to winterkill by drought conditions, as shallower wetlands may be more prone to freeze completely to the bottom.

17.5.7.3 Mitigation

Effects of full outage ramping can be minimised through Project design mitigation and mitigation practise. These mitigation measures were presented in Section 17.4.3.

Artificial nest platforms can be used for waterfowl management in order 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; Zenner et al., 1992; Evers, 2004). Under a full power outage reproductive success of ground-nesting waterfowl would be negatively affected by ramping as water levels could drop up to 250 cm in the lower Taltson River and rise 0.6 m on the Forebay. These water level changes could leave nests inundated and/or stranded and exposed to increased predation in Zone 3. Common loons nest most successfully when water levels do not increase more than 15 cm or decrease more than 30 cm during the nesting season (Evers, 2004). Without mitigation, the change in water levels due to ramping would have adverse effects on all ground-nesting waterfowl.

Construction, deployment, monitoring, and maintenance of artificial nesting platforms could mitigate for this alteration of water levels. The lower Taltson River should first be surveyed during the waterfowl and shorebird breeding season to determine which species are breeding in the area and at what abundance. Boat and ground-based surveys to count either breeding pairs, nests or broods would provide a more accurate estimate of waterfowl breeding in Zones 3 and 5 (RIC, 1999). Establishing which species would be candidates for using 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 necessitate the same design requirement (Zenner et al., 1992; Evers, 2004). This survey would also identify areas where placement of 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.

17.5.7.4 PATHWAY VALIDATION

Table 17.38 presents the pathway validation for wildlife VCs that were identified. The following section provides a rationale for the validation or invalidation of each pathway for a full outage scenario in Zone 3.

17.5.7.4.1 Furbearers

17.5.7.4.1.1 Direct Mortality due to Higher Water Levels

Muskrat

This pathway is Valid for muskrat for Forebay due to ramping as the difference between low flow water levels and a complete outage is 60 cm. This is greater than the height of some muskrat lodges, which can be only 40 cm high.

The increase water level on the lower Taltson during re-start of the turbines is addressed in Section 13.10.

Beaver

Direct mortality of beaver through higher water levels is a Minor pathway for Twin Gorges Forebay as beaver are a larger mammal than muskrats, have more permanent shelters and young can swim at birth.

17.5.7.4.1.2 Direct Mortality due to Lower Water Levels

This is a Valid pathway for both muskrat and beaver downstream of Twin Gorges where water levels could drop up to 250 cm under a full outage scenario.

17.5.7.4.2 Moose

17.5.7.4.2.1 Direct Mortality Due to Altered Water Levels

Changes to water levels due to complete power outages are considered a Minor path for moose for all zones. Since moose are not a riparian or aquatic dependent species they can avoid changing water levels by moving into a different area.

17.5.7.4.3 Birds

17.5.7.4.3.1 Direct Mortality and Reduced Reproductive Success due to Higher Water Levels

This pathway is Minor for Twin Gorges Forebay due to mitigation measures. Increases in water levels in the lower Taltson River during re-start of the turbines is addressed in Section 13.10. The pathway is Invalid during ramping conditions for rusty blackbirds as they do not nest on the ground within the riparian zone. It is Invalid for whooping cranes as they are not known to breed in the Project area.

17.5.7.4.3.2 Direct Mortality and Reduced Reproductive Success due to Lower Water Levels

Reduced reproductive success is a Valid pathway for the lower Taltson River as water levels could drop up to 250 cm and leave nests stranded and more susceptible to predation.

Table 17.38 — Pathway Validation for Wildlife Effects in Zone 3

Valued Component	Pathway	Valid	Invalid
Furbearers	Direct mortality leading to reduced population abundance through higher water levels	Twin Gorges Forebay (muskrat)	Lower Taltson River
	Direct mortality leading to reduced population abundance through lower water levels	Lower Taltson River	Twin Gorges Forebay (muskrat)
Moose	Direct mortality leading to reduced population abundance through higher water levels		Lower Taltson River Twin Gorges Forebay
	Direct mortality leading to reduced population abundance through lower water levels		Lower Taltson River Twin Gorges Forebay
Waterfowl and shorebirds	Direct mortality leading to reduced population abundance through higher water levels		Lower Taltson River Twin Gorges Forebay
	Direct mortality leading to reduced population abundance through lower water levels		Lower Taltson River Twin Gorges Forebay
	Reduced reproductive success leading to reduced population abundance through higher water levels	Twin Gorges Forebay (Minor with Mitigation)	Lower Taltson River
	Reduced reproductive success leading to reduced population abundance through lower water levels	Lower Taltson River (Minor with Mitigation)	Twin Gorges Forebay
Rusty blackbird	Direct mortality leading to reduced population abundance through higher water levels		Lower Taltson River Twin Gorges Forebay
Whooping crane	Direct mortality leading to reduced population abundance through higher water levels		Lower Taltson River Twin Gorges Forebay
Northern leopard frog	Direct mortality leading to reduced population abundance through higher water levels		Lower Taltson River Twin Gorges Forebay

Valued Component	Pathway	Valid	Invalid
	Direct mortality leading to reduced population abundance: lower water levels during winter when frogs are potentially overwintering in riparian areas		Twin Gorges Forebay

Direct mortality is a Minor pathway for all areas being considered under the complete outage scenario. Reduced reproductive success due to lowered water levels is Invalid for Twin Gorges Forebay where water levels were modelled to increase.

17.5.7.4.4 Northern Leopard Frog

17.5.7.4.4.1 Direct Mortality due to Higher Water Levels

This pathway is for Twin Gorges Forebay where water levels were modelled to increase by 60 cm and the lower Taltson River where water levels would be lowered.

17.5.7.4.4.2 Direct Mortality due to Lower Water Levels

This is a Valid pathway for the lower Taltson River where water levels are modelled to drop up to 250 cm due to a complete power outage. If water levels dropped during the winter when northern leopard frogs would be overwintering in the riparian areas this could lead to mortality.

This pathway is Invalid for Twin Gorges Forebay where water levels were modelled to increase due to a complete power outage.

17.5.7.5 Effect Classification

The effects classification is based on a worse-case scenario in the event of a full outage. The definition of the worse-case scenario for wildlife effects would be a full outage during periods when pre-outage water levels are at the minimum in the Twin Gorges Forebay under the 56 MW operating scenario. Changes in water level would be the most substantial during low flow periods, where rapid rises would be experienced in the Twin Gorges Forebay and decreases would be experienced in the lower Taltson River.

Table 17.39 presents the wildlife effects classification during a full outage. The effects would be limited to Zone 3 from the power facilities to Tsu Lake. The duration of the full outage would also affect the magnitude of effects on wildlife. A full outage would typically be an isolated incident resulting from an accident, malfunction or environmental disturbance (e.g. lightning, forest fire). The effect to wildlife increases as the duration of the full outage increase. The duration of a full outage ranged from a few hours up to a month.

Ramping flows under the 36 MW scenario would be lower in magnitude because less water would be flowing into the Forebay to maintain the lower power generation at the Twin Gorges power facility. Therefore, a full outage under the 36 MW scenario would experience water level increases of a lesser magnitude than a 56 MW full outage.

Table 17.39 — Wildlife Effects Classification in Zone 3 During a Full Outage

Pathway	Zone	Direction	Magnitude	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Residual Effect
Effects on Furbearers									
Direct mortality through higher water levels leading to reduced population abundance (muskrat)	Twin Gorges Forebay	Adverse	Muskrat-Moderate	Zone 3 (Forebay only)	Short-term	Reversible	Isolated	Likely	Low
Direct mortality through lower water levels leading to reduced population abundance	Lower Taltson River	Adverse	Muskrat-High Beaver-Moderate	Zone 3 (Lower Taltson River)	Short-term	Reversible	Isolated	Likely	Moderate
Effects on Northern Leopard Frogs									
Direct mortality leading to reduced population abundance: Lower water levels during winter	Lower Taltson River	Adverse	Moderate	Zone 3 (Lower Taltson River)	Short-term	Reversible	Isolated	Likely	Moderate

17.5.7.5.1 Furbearers

17.5.7.5.1.1 Direct Mortality

Direct mortality because of higher water levels in the Twin Gorges Forebay was classified with a moderate magnitude for muskrat. Water levels are modelled to rise by 60 cm which is greater than the height of some muskrat lodges. The rising water levels could drown young in particular that are in lodges. Muskrat young are confined to nests within lodges for two to three weeks after being born. This effect on the muskrat population would be short-term and reversible given that the population would recover in subsequent years given that the frequency of the ramping event is low (1 in 5 year event). The overall residual effect was assessed as low.

The effect on furbearers of decreased water levels in the lower Taltson River due to ramping was assessed as moderate and high magnitude for beaver and muskrat, respectively. This would be particularly detrimental to furbearers during the winter. This effect would be short-term and reversible given that the population would recover in subsequent years given that the frequency of the ramping event is low.

17.5.7.5.2 Northern Leopard Frog

Direct mortality due to lower water levels during a ramping event, was assessed as likely in the lower Taltson River with a moderate magnitude (Table 17.39). Water levels were modelled to drop up to 250 cm. Any frogs overwintering under the ice would be caught in a dewatered area and this would probably lead to freezing prior to water levels rising again. This effect would be short-term and reversible given that the population would recover in subsequent years given that the frequency of the ramping event is low. The overall residual effect was assessed as moderate.

17.5.7.6 SIGNIFICANCE DETERMINATION

Significance of the effects of ramping on furbearers and northern leopard frogs was determined by considering all Valid pathways to effects on these VCs within the Taltson River watershed (Table 17.40). That is, effects resulting from Valid pathways identified during construction, during normal operating conditions within Trudel Creek and the Taltson River watershed and during full outage ramping events were evaluated as a summation of effects on the VC assessment endpoints.

17.5.7.6.1 Furbearers

Considering the residual effects on furbearers during construction (section 15.2 Canal Construction), normal operations along Trudel Creek (Chapter 14), normal operations within the Taltson River watershed (Chapter 13), unscheduled power outages along Trudel Creek (Section 17.4) and unscheduled power outages in Zone 3 of the Taltson River watershed (Section17.5), no significant adverse effect to the preservation of furbearer harvesting opportunities within the Taltson River watershed are predicted. However, the Valid pathways would likely lead to direct loss of individuals via freeze-out, drowning, starvation, increased predation, etc. These effects were deemed reversible in the short- to medium-term as subsequent generations replace the lost individuals. A key component to this assumption is that habitat would be of high quality and thus future generations would populate available habitat so that abundance and distribution are similar to baseline conditions. The uncertainty in the prediction of high quality habitat in the medium-term following disturbance is low given that the Taltson River watershed has demonstrated the ability to adjust to past changes in the hydrologic regime.

Another key component to the not significant rating of effects is the frequency of occurrence of ramping events Both scheduled and unscheduled ramping events would have effects on furbearers and individuals would likely be lost. These ramping events are predicted to be infrequent enough that effects on furbearers would be reversed prior to the next ramping event. The Taltson River watershed may become 'sink' habitat in that migrants my move in to the area following a ramping event and thus maintain the population but the migrants may be lost during the next ramping event. The possibly of such a cycle is reduced given the beneficial effect of stabilized water levels, relative to baseline conditions, during normal operations. The beneficial effects may elevation furbearer populations between ramping events. A ramping event would then have less of an effect relative to baseline and thus may not present an opportunity for migrants to inhabit in the area.

Table 17.40 — Significance and Uncertainty of Wildlife Effects in Zone 3

Valued Component	Assessment Endpoint	Pathways	Geographic Extent of Effect	Overall Residual Effect	Significance	Uncertainty
Furbearer	Preservation of furbearer harvesting opportunities	Direct mortality leading to reduced population abundance (higher and lower water levels; includes scheduled and unscheduled ramping)	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Moderate/Adverse	Not significant	Medium
		Sublethal effect (changes to diet/submerged aquatic plant community) leading to reduced population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Riparian habitat loss/modification leading to change in population abundance.	Nonacho, Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		
		Stabilized water levels leading to increased abundance.	Zone 2, 3, 4 and 5 (Trudel Creek)	Moderate/Beneficial		
Northern leopard frog	Preservation of habitat and population	Riparian habitat loss/modification leading to change in population abundance.	Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse	Not significant	Medium
		Direct mortality leading to reduced population abundance: drawdown of water level during winter when frogs are potentially overwintering in riparian areas.	Zone 1, 2, 3 and 5 (Trudel Creek)	Low/Adverse		

17.5.7.6.2 Northern Leopard Frog

The assessment endpoints of preservation of habitat and populations for northern leopard frogs would not be significantly affected by the Project. The individual overall residual effect for the pathways for this VC were not considered high, and the summation of residual effect were not predicted to affect the long-term sustainability of northern leopard frogs.

17.5.7.7 UNCERTAINTY

17.5.7.7.1 Furbearers

The uncertainty level for furbearers in Zone 3 is medium as baseline surveys have not been conducted for muskrats in zone outside of the Twin Gorges Forebay and beaver surveys are not current. Aerial surveys were conducted in 2000 and 2003 along the Forebay, which showed beaver lodge densities of 0.18 lodges/linear kilometre and 6.3 active lodges per survey hour, respectively. The density of muskrats detected was 0.225 muskrat push-ups per linear kilometre of shoreline. For muskrats, a density of 0.185 muskrat push-ups per linear kilometre of shoreline was detected.

17.5.7.7.2 Northern Leopard Frog

Uncertainty levels for northern leopard frogs in Zone 3 are high since no baseline data has been collected in this area to determine how the frogs are using the available riparian habitat. However, even if baseline studies were conducted determining if northern leopard frogs use this area of the Taltson River as overwintering habitat would be a difficult task to achieve.