TABLE OF CONTENTS

1. INTRODUCTION ..................................................................................................... 1
   1.1 Background ................................................................................................. 1
   1.2 History of Proposed Hydroelectric Development at Dunvegan ................. 2
2. PROJECT DEVELOPMENT STRATEGY ............................................................... 4
   2.1 Project Need and Market ............................................................................. 4
   2.2 Design Rationale ......................................................................................... 7
   2.3 New Information ........................................................................................... 9
   2.4 Glacier’s Commitments .............................................................................. 11
3. PROJECT DESCRIPTION .................................................................................... 14
   3.1 Project Components .................................................................................. 14
   3.2 Project Design Elements ........................................................................... 17
   3.3 Construction Plan ...................................................................................... 41
   3.4 Start-up ...................................................................................................... 62
   3.5 Project Operations ..................................................................................... 63
   3.6 Adaptive Management for Fish Passage ................................................... 68
   3.7 Plant Closure and Abandonment ............................................................... 72
   3.8 Accidents, Malfunctions, Safety Prevention and Features ......................... 73
   3.9 Waste Management ................................................................................... 73
   3.10 Environmental Management and Design Features .................................. 74
4. REFERENCES ...................................................................................................... 77

LIST OF TABLES

Table 3-1: Key Design Parameters ........................................................................... 19
Table 3-2: Summary of Flow Design ......................................................................... 38
Table 3-3: Project Design and Construction Milestones ......................................... 42
Table 3-4: Estimated Dunvegan Construction Traffic ............................................ 53
Table 3-5: Operating Rule Curve Data ..................................................................... 65
Table 3-6: Summary of Adaptive Management Strategies ..................................... 71

LIST OF FIGURES

Figure 3.1-1: General Overall Site Layout Plan ...................................................... 15
Figure 3.1-2: General Headworks Plan ................................................................. 16
Figure 3.2-1: General Headworks Elevations ....................................................... 21
Figure 3.2-2: General Powerhouse Plan ............................................................... 22
Figure 3.2-3: General Powerhouse Sections & Water Levels ............................... 23
Figure 3.2-4: General Spillway Section and Water Levels................................. 26
Figure 3.2-5: General Boat Lock Plan and Sections ........................................ 29
Figure 3.2-6: General Headpond Inundation Levels Plan – Sheet 1 of 5............. 32
Figure 3.2-7: General Headpond Inundation Levels Plan – Sheet 2 of 5............. 33
Figure 3.2-8: General Headpond Inundation Levels Plan – Sheet 3 of 5............. 34
Figure 3.2-9: General Headpond Inundation Levels Plan – Sheet 4 of 5............. 35
Figure 3.2-10: General Headpond Inundation Levels Plan – Sheet 5 of 5.......... 36
Figure 3.2-11: General Typical Power Line Poles............................................. 40
Figure 3.3-1: Construction Sequence April to October, Year 1 Plan – Sheet 1 of 7... 43
Figure 3.3-2: Construction Sequence April to November, Year 2 Plan – Sheet 2 of 7 44
Figure 3.3-3: Construction Sequence April to November, Year 3 Plan – Sheet 3 of 7 45
Figure 3.3-4: Construction Sequence April to November, Year 4 Plan – Sheet 4 of 7 46
Figure 3.3-5: Construction Sequence June, Year 4 Plan – Sheet 5 of 7............... 47
Figure 3.3-6: Construction Sequence July, Year 4 Plan – Sheet 6 of 7............... 48
Figure 3.3-7: Construction Sequence August, Year 4 Plan – Sheet 7 of 7........... 49
1. INTRODUCTION

1.1 Background

Glacier Power Ltd. (Glacier Power) is proposing to construct a 100 MW hydroelectric facility on the Peace River near Dunvegan, Alberta.

The Peace River flows through three major jurisdictional boundaries, namely, the Province of British Columbia, Province of Alberta and Wood Buffalo National Park. The majority of the remaining hydro power potential falls within Alberta’s jurisdictions.

Communities located immediately adjacent to the Peace River include Fort St. John and Taylor in British Columbia; Dunvegan, Peace River, and Fort Vermilion, as well as Ft. Chipewyan within the Peace-Athabasca Delta in Alberta.

Several First Nations communities and reserve land exists along the Peace River between the Project and the Peace-Athabasca Delta. The closest reserve to the Dunvegan Project is the Duncan’s First Nation located near the community of Berwyn, Alberta.

The Peace River is controlled by two hydroelectric facilities; the G.M. Shrum Generating Station at the W.A.C. Bennett Dam (Bennett Dam) and the Peace Canyon Dam (Peace Canyon, both located in British Columbia (B.C.). Construction of the Bennett Dam was completed in 1967, water storage in Williston Reservoir began in 1967, and normal operating procedures were initiated in 1972. Williston Reservoir has a volume of 70 million dam$^3$, equivalent to 1.5 to 2 years of flow at Hudson Hope located 20 km downstream of the Bennett Dam. The Shrum Generating Station contains ten units, each capable of producing 260 to 311 MW of power at a discharge of 170 to 195 m$^3$/s each. The system is designed to operate with a minimum of five units at any one time, so that total outflows can range from 850 m$^3$/s to 1960 m$^3$/s. The system has a total generating capacity of 2730 MW.

The Peace Canyon Dam, completed in 1980, forms Dinosaur Lake near Hudson-Hope. The Williston Reservoir provides storage while the Dinosaur Lake functions as a run-of-river reservoir. These two dams operate together to generate 3430 MW of hydroelectric power.

Prior to regulation, the Peace River displayed seasonal flow patterns similar to other northern rivers dominated by snowmelt runoff, that of high spring and summer flows and low flows in late fall and winter. The Bennett Dam has significantly affected the timing of
these flows. Winter flows are now nearly 5 times higher than natural winter flows. To the contrary, flows during the early summer period are 5 times lower than natural flows due to Williston Reservoir refilling. Tributaries downstream of Bennett and Peace Canyon Dams now have greater influence on the flow regime during summer months but account for only 40% of winter flow at Dunvegan, and 48% (due to Smoky River inflows) at the Town of Peace River. In the late summer and fall, when tributary flows are near base flow, and in many cases dry, the hydrographs at downstream stations reflect closely that of the Bennett Dam releases. Fluctuations in Bennett Dam releases generally result in changes to flows at Dunvegan two days later and at the Town of Peace River three days later (i.e. one day for flow travel time from Dunvegan to the Town of Peace River).

1.2 History of Proposed Hydroelectric Development at Dunvegan

Numerous studies have been carried out over the years to investigate hydroelectric potential at the Dunvegan Site. In 1977, Feasibility Studies were completed by the Alberta Hydro Committee for the Dunvegan Hydro Power Site, located immediately upstream of the Highway 2 bridge crossing of Peace River at Dunvegan. These studies were commissioned in accordance with Terms of Reference provided by the Alberta Government in 1974. The purpose of these studies was to assess the engineering feasibility and environmental effects of three development alternatives: low (41-m), intermediate (69-m), and high (120-m) head dam structures with associated storage reservoirs. The high-head dam alternative would have a $23.9 \times 10^6$ dam$^3$ reservoir covering 518 km$^2$ and back water 250 km into British Columbia to Hudson’s Hope. The Dunvegan site was not considered suitable for development of large dam structures due to the difficult foundation conditions present at the site, as a result the Project was abandoned.

In 1998, Glacier Power initiated feasibility studies for the Dunvegan Hydroelectric Project (Dunvegan Project), a low-head, modular, run-of-river hydroelectric development which would minimize flooding and resultant environmental effects.

Conceptual plans and preliminary feasibility studies were completed in December 1998 on the basis of the present regulated flow regime in Peace River. Subsequently, conceptual design engineering, environmental programs, and public and First Nations information programs were implemented throughout 1999 and into 2000.

On June 19, 2000 Glacier Power submitted an Environmental Impact Assessment to Alberta Environment (AENV). At the same time Glacier Power submitted to the Natural Resources Conservation Board (NRCB) and the Alberta Energy and Utilities Board (EUB)
an application to construct and operate a 40 MW run-of-river hydroelectric project on the Peace River approximately 2 km upstream of the Dunvegan Bridge on Highway 2.

A Supplementary Information Response (SIR) Report was submitted in March 2001 in response to queries from provincial agencies, public stakeholders, and the EUB-NRCB Joint Review Panel. The SIR report also described the updated design of the plant which increased its capacity to 80 MW. Public Hearings were held in October 2002 and the EUB-NRCB Joint Review Panel announced their decision not to support the Project in March 25, 2003.

The EUB-NRCB Joint Review Panel stated in their report (Decision Report dated March 25, 2003) that “significant uncertainty remains with respect to the relationship between the potential benefits and costs of the Project.”, and that, “The Panel is also not convinced by the available evidence that there are reasonable opportunities to ameliorate or mitigate these potential negative effects.” The two issues that played a major role in the application being denied were:

- the understanding of the effects of the Project on the Peace River ice regime and, consequently, its effects on the Town of Peace River and the operations of the ferry at Shaftesbury; and
- the effect of the Project on fish resources in the Peace River.

As the development of renewable, low impact electrical energy coupled with sensitive environmental design is a top priority for Glacier Power, and its parent company Canadian Hydro Developers, Inc., it was considered that the concerns identified by the EUB-NRCB Joint Review Panel could be resolved by providing additional information on the project. This has been accomplished through further project optimization, additional studies, cooperative agreements with stakeholders, and the development of specific monitoring, adaptation, mitigation, and compensation strategies. Glacier Power has put a substantial effort into developing a single, comprehensive ice model for the Peace River. Additional information has also been collected on fisheries resources as well as mitigation and compensation strategies. Refinements have been implemented to project design based on these studies.
2. PROJECT DEVELOPMENT STRATEGY

The Project has evolved to an advanced conceptual design level in consideration of the market need for power, and alternatives from engineering, environmental, and cost perspectives. The design, construction and operation of the Project incorporates environmental and adaptive management and contingencies into all components (powerhouse, spillway, boat lock, fishways, power transmission line, and access roads).

2.1 Project Need and Market

The purpose for the Dunvegan Project is to build and operate a hydroelectric generation facility in the northwest area of the province, which is presently undergoing significant economic growth accompanied by a deficit in local electrical generation. Glacier Power has conducted a market and need assessment for the Project. Many of the statements made here are taken from that study conducted by EDC Associates (EDC Associates, 2005A, 2005B, 2006).

As a result of the deregulation of Alberta’s electric power industry, in Alberta today, the decision to develop a power project lies solely with the investor (once all approvals and permits have been obtained), which contrasts to development in the past under the previous regulated environment. Even in a competitive environment the decision to develop one project over another requires a comprehensive cost-benefit analysis to assess the better investment. Any project that provides a substantial net-benefit should be considered in the public interest and is therefore “needed”. In addition to the direct project, economic, social, and environmental cost-benefits, the “need” for any electric generating facility can also be supported by other or indirect benefits (externalities) associated with any positive impact on:

- market fundamentals relating to electricity supply, demand and price;
- electrical system benefits relating to technical interconnection and delivery; and
- other factors such as government policy relating to environmental objectives and standards.

A substantial portion of Alberta’s electric generating capacity will reach the end of its useful life in the foreseeable future. At the end of 2004, Alberta’s total gross installed generating capacity was approximately 13,000 MW (10,500 MW net-to-grid) of which almost 25% will reach retirement age in the next 15 years and just under 40% will reach retirement age in the next 25 years. Replacing generating capacity that will reach retirement age in the next 15 to 25 years, plus the need to meet rising new demand, will be a formidable challenge in Alberta. It will be complicated by potential opposing forces of
competition to reduce cost and environmental pressures to reduce emissions associated with energy use and production—particularly Green House Gases (GHG).

Alberta total electric energy sales, as measured by Alberta Internal Load (AIL), have grown by an Annual Compound Growth Rate (ACGR) of 3.4% per year over the last 15 years (1987-2003) and is anticipated to grow by 2.7% ACGR per year over the next 15 years (2004-2018). The majority of incremental load growth is expected to continue to be a result of domestic industrial activity, particularly as it relates to further resource development in the oil, gas, petrochemicals and forestry sectors. This level of demand growth coupled with retirements would necessitate the development of between about 4500 to 6000 MW of new electric generation capacity or approximately 50% of today’s total capacity to replace retired units and to meet the expected demand over the next 12 to 15 years.

The future electricity generation changes in the Northwestern quadrant of Alberta have been outlined by the Alberta Electric System Operator (AESO) in their Need Identification Report, October 2005. Currently, the NW regional total coincident peak load is approximately 1,142 MW. Over the next 10 years it is expected to grow to 1,310 MW, an incremental load of 168 MW by 2015. The anticipated growth is due to normal residential and industrial load growth. Currently, the total installed capacity in the NW is 695 MW; therefore only about 60 percent of the energy requirement is provided within the region. The NW region is located relatively far from Alberta’s primary generation centers, and has a weak transmission system. Therefore it has to rely on transmission must run (“TMR”) generation to provide real and reactive power support in the region.

Net reductions in load in the Northwest quadrant of the transmission system will increase the need for regional, reliable, economic, development of generation capacity. The power purchase agreements (PPA) for Rainbow Lake units 1,2 and 3 expired at the end of 2005, and the future of these units as a generation source is uncertain at this time. Sturgeon units 1 & 2 have been forecast to be retired at the end of 2006. The HR Milner plant located in the Grande Cache area has a significant impact on operations in the NW. Milner Power Inc. has indicated that this plant will retire around the year 2020.

Given the expected pattern of supply and demand for electricity in northwest Alberta over the next 10 to 15 years, and the subsequent transmission enhancements that will be required, Glacier Power’s proposed plant will defer the need for transmission-related capital costs to be incurred in this region. In some cases in Alberta, generation development can provide benefit to the regional transmission system by reducing system losses and by providing voltage support as an interim measure prior to other transmission development. The AESO has indicated that the northwest transmission area typically
requires a significant amount of Transmission Must-Run (TMR) generation to maintain the system integrity. The AESO currently expends approximately $40 to $50 million per year on TMR payments, the majority of which are in northwest Alberta. The Dunvegan Project, because of the expected nature of its operations, could reduce northwest Alberta area transmission losses and TMR requirements by approximately $5 million per year, which would result in a direct reduction in AESO transmission costs by 11 percent.

Significant advances made in lower capital cost and higher fuel efficiency of natural gas-based technologies over the last couple of decades have increased the level of natural gas fired generation. However in today’s deregulated market, while capital investment risk is placed on the investor, fuel cost risk is passed on to the consumer through the marginal price of the energy spot market. This new risk profile in the market clearly supports the development of smaller, more efficient and relative lower capital cost projects at the expense of high fuel costs. With a low and stable fuel cost, it is estimated that the market impact of the development of the Dunvegan Hydroelectric Project could be a reduction in the all-hour average pool price by approximately $1 to $2/MWh in the first one or two years of service relative to the price that might be expected without the Dunvegan project – all other things being equal.

The Dunvegan Hydroelectric Project could provide a significant reduction in green house gas emissions in Alberta in the order of 500,000 Tonnes annually (assuming 0.8 Tonnes per MWh) by displacing other thermal generation sources. This reduction is anticipated to save the electric industry approximately $5 million dollars per year in potential CO₂ offset costs assuming a cost of $10/Tonne.

As a result of the foregoing facts, reasonable capital cost projects, particularly those with lower operating costs, such as the Dunvegan Hydroelectric Project, are in the best interest of electricity consumers in Alberta. In addition, further diversification of the power sectors fuel supply in Alberta can only provide additional value to the electricity consumer by mitigating long term fuel supply risk. Direct and indirect technical benefits potentially arise from the interconnection of Dunvegan Hydroelectric facility in the northwest Alberta transmission grid that will benefit both regional and system wide issues, Project constructability, and the ability to decommission and remove the Project at the end of its Project life.

The design approach was also intended to further technological advancements towards sustainable power by the development of low head, low environmental impact designs. Finally, the environmental attributes of the Dunvegan Hydroelectric Project will provide a long lasting benefit with respect to the issue of global warming through reduced GHG emissions in Alberta, which is clearly in the public interest.
2.2 Design Rationale

The rationale adopted for the design of the Project was to justify the need for the development and to help meet future market requirements. The Project siting and sizing described below was based on providing a technically “simple, clean, and sound” eloquent solution that takes into consideration environmental, social, economic, and hydrotechnical

2.2.1 Project Siting

Dunvegan Project site selection took into consideration several important factors required for an economically feasible and environmentally sensitive hydroelectric development. The following factors were taken into consideration:

- Technically the physical characteristics of the site provide an ideal location for the Project. The Project fits within the natural river channel banks and pre-Bennett flood conditions such that inundation due to the headpond is minimized.
- The foundation conditions of the river channel banks and bed are well suited to support the headworks structure. Although the valley walls show signs of active surficial erosion and slumping, deep-seated failure of the bedrock is highly unlikely.
- Ice formation and break-up through the Dunvegan area is not a deterrent to project development and the post Project ice regime could potentially have a beneficial effect on downstream communities such as the Town of Peace River.
- The Dunvegan site is ideally located near Highway 2, a main transportation route, with a well-developed municipal road network providing access to both sides of the river and local materials such as gravel pits.
- The existing 144-kV power line is within 4 km of the site, providing a short distance between the site and the point of interconnection to the grid.
- A trained labour force is available in the Grande Prairie-Fairview-Peace River region, however, it may be necessary to supplement the local labour force from elsewhere given the current high labour demand.
- The majority of supplies and services are available from main centres such as Grande Prairie, Fairview, Grimshaw, and Peace River.

2.2.2 Engineering Design

As described earlier, the Project was initially envisaged as a 40 MW (later increased to 80 MW) facility with the overall objectives of minimizing adverse environmental effects and keeping structures to a low visual profile. As the Project evolved through discussions with equipment suppliers, it became evident that the capacity of the plant could be increased without affecting the design or size of the headworks structure and headpond, thus
retaining the overall objectives. As a result, the plant capacity was increased to 100 MW and will generate approximately 600 GWh/annum while still operating as a run-of-river facility producing power from the flow of the river without storing water, and therefore without regulating or changing the flow regime downstream of the facility.

Simple bulb propeller turbine generator units were selected as they provide unmatched efficiency for compact generating sets of this size, with low maintenance requirements.

To optimize generation, the operational plan adopted for the 100 MW plant maximizes the operating head (differential between the headpond elevation and the tailwater level) on the units without changing the size of the headworks structure. By operating at a more stable headpond level while allowing water levels downstream of the structure to continue to fluctuate based on the available flows in the river, the greatest average head is achieved, thus increasing the energy output. Water levels downstream of the structure are unaffected and will be the same pre and post-Dunvegan.

### 2.2.3 Constructability

The constructability of the structure was assessed and a construction approach was adopted that would minimize the effects on the environment while allowing the development to be constructed as per the construction sequence and schedule described in Section 3.

### 2.2.4 Ice

The effects of the Project on the ice regime was an important issue identified in the 2003 Board Decision Report. A winter ice data collection program was initiated as a joint study effort between Glacier Power, BC Hydro, and Alberta Environment immediately following the October 2002 Public Hearing. A total of three winters (2002/03, 2003/04, and 2004/05) of ice data has been collected, which has vastly improved confidence and understanding of the ice regime and the potential incremental effects of the Project. Continuation of the collaborative ice data collection effort through construction and operation of the Project is likely.

### 2.2.5 Environmental Considerations

Environmental considerations have been incorporated into the Project design from the beginning. They have played a key role in Project siting, as discussed in Section 2.2.1. The findings from the environmental studies (air, geotechnical [especially slope stability], hydrology, ice, fish, vegetation, wildlife, historical resources, land and water use, health
and safety, land and water use and socio-economics) have all been considered in Project
design, selection of construction techniques and scheduling, and operations planning.
Hydraulic scale modeling studies, which had been initiated during the preparation of the
previous (year 2000) environmental assessment and application to assist with Project
headworks and fish passage design, has been completed. The results of these studies
have refined the Project from a design and operations perspective. Modeling the ice
process on the river has provided a better understanding of the potential effects on the
physical, social, public interest, and transportation aspects of the Project, and the results
of the ice process modeling have been considered during the design of the Project.

2.3 New Information

Glacier Power commissioned numerous environmental and engineering studies over the
past eight years designed to identify project effects and uncertainties as well as assess

In addition, it was considered that a single ice model developed using the most advanced
technologies and specifically calibrated for the Peace River would provide the most
reliable results and help identify the potential effects of the Project.

Glacier Power commissioned the developers of the RICE and TRICEP models used in the
2000 Application to work jointly in order to develop a single comprehensive state-of-the-art
numeric ice model. As a result, the Peace River Ice (PRICE) model was developed. The
model was calibrated against winter ice data collected in 2002/03 and 2003/04, coupled
with observed ice conditions over the past twenty years, available measured records, and
analogous years for pre-Dunvegan conditions. The Project was then inserted as a
boundary condition in the PRICE model and post-Dunvegan conditions were run to
quantify the incremental effects to the ice regime between pre and post-Dunvegan.

Project operations and economics are not affected by the post-Dunvegan ice regime.

2.3.1 Fish Movement and Sustainability

Fisheries related studies have been conducted and documents prepared to improve
Glacier Power’s understanding of the fisheries resource and the mitigation and
compensation strategies including:
- fish movement;
- fish community baseline;
- fish passage;
- fish habitat; and,
- fish monitoring.
A major component of this work included numeric modeling coupled with physical hydraulic scale modeling studies to optimize the fish passage structures at the headworks for both upstream and downstream passage of fish. The physical scale models as well as 2D numerical models were used to develop fish passage facilities and operations strategies to mitigate fish passage concerns. These studies were carried out in close consultation with DFO and ASRD.

A Fish Passage Rationale (nhc, 2006) document was prepared, which summarizes the results of the hydraulic scale and 2-D numeric modeling programs. This document provides a chronology of testing sequence, the rationale for advancing the modeling program, and illustrates how operational flexibility and adaptability of the facility were incorporated into the modeling program.

Modifications to the headworks structure as well as additional infrastructure were required to mitigate upstream and downstream fish passage. This included two fishway ramps (one on each bank) for upstream passage, ten fish sluices distributed across the structure for downstream passage, and trashrack sizing to minimize impingement and entrainment of fish into the turbines. In addition, the most significant modification to the structure in order to maintain downstream fish passage corridors was the redistribution of the powerhouse units. The initial design consisted of all forty units on the right side (looking downstream) of the river and the spillway on the left side. In order to optimize attraction flow near the entrance to the ramp fishways, ten units were relocated to the left side and the spillway was moved between the thirty right bank units and the ten left bank units.

### 2.3.2 Additional New Information

In addition to the ice and fish studies, which were considered to be of the highest priority, studies that were also undertaken to enhance the understanding of the Project and its effects included the following:

- wildlife movement;
- constructability review;
- Shaftesbury Crossing – review of mitigation options;
- Highway #2 fog and bridge icing at Dunvegan.
- Sediment transport and deposition; and,
- Historic resources along the Powerline route

The findings from these studies did not affect the overall design of the structure or operation of the facility. However, the constructability review examined the construction sequencing and methodology for constructing the Project within the construction windows.
available, which improved Glacier Power’s understanding of Project construction and capital costs.

### 2.4 Glacier’s Commitments

Glacier Power, a wholly owned subsidiary of Canadian Hydro Developers, Inc., is committed to mitigating and resolving environmental and social issues or concerns related to the Dunvegan Project development, and has been working diligently with government and stakeholders to ensure the Project is successful. The following sections outline the steps Glacier Power has taken and is committed to.

#### 2.4.1 Ice

The ice regime on the Peace River is controlled by flow regulation from large scale hydroelectric facilities upstream of the Project. Glacier’s consultants developed a highly specialized ice model (PRICE Model) to simulate pre and post-Dunvegan ice regimes. This model was calibrated using two years of open water and ice observations and detailed data collected under a cooperative program among Glacier Power, AENV, and BC Hydro. The calibration has been scrutinized by several ice experts and stakeholders with direct interest in the Project during a series of technical workshops. A total of five (5) technical ice workshops over the course of one and a half years were used to discuss the PRICE model calibrations, to gain consensus on the model’s capacity to act as an analogue of the Peace River ice regime, and to assess the ability of the model to simulate the post-Dunvegan ice regime. The workshops were also effective in providing a forum for discussing the following concerns and methods to resolve those concerns including:

- Risk of ice-jam related flooding at the Town of Peace River during freeze-up and break-up.

The post-Dunvegan ice regime will not increase the risk of experiencing high ice-related water levels during freeze-up. Due to the slower advance of the ice cover through the Town of Peace River, and the overall reduced length of the ice cover upstream of the Town, the post-Dunvegan ice regime may reduce the risk of secondary consolidation events. The ice regime will remain unchanged during break-up. This will likely result in an overall reduction in the risk of annual ice-jam flooding at the Town of Peace River. Glacier has also entered into an agreement with the Town of Peace River, in which Glacier has committed to provide funding during construction and through operation of the Project for the Town to invest in improvements to flood management programs and infrastructure.

Risk of basement flooding in Lower West Peace due to freeze-up water levels
The post-Dunvegan ice regime will cause the initial base freeze-up levels to increase by approximately 0.5 m above present. The funding mentioned in the aforementioned agreement between Glacier and the Town will allow the Town to complete infrastructure improvements that will help to mitigate this problem.

BC Hydro flow control criteria.

Glacier has worked closely with BC Hydro and Alberta Environment to help to develop explicit process-based flow control criteria. The development of these criteria has resulted in large part from the detailed ice data collection program that has been undertaken over the last three winters. The Joint Task Force on Peace Ice has indicated that it is open to changes to flow control criteria where those changes are scientifically rational and defensible, and conservative with respect to protection of the safety of the Town of Peace River.

In 2005, the JTF agreed to implement new process-based flow control criteria on a trial basis. The 2005 criteria invoked the same initiation criteria, in terms of the control and rendezvous points, as have historically been used. Once initiated, flow controls would be in place until a 10 km long reach of river upstream of the McLeod Cairn (~2 km upstream of the Smoky River confluence) develops 0.40 m of thermal ice cover (which will be sufficient to prevent the passage of a consolidating ice cover past the McLeod Cairn). Given the expected characteristics of the ice cover and its slower rate of advance post-Dunvegan, a slight adjustment to the control and rendezvous point criteria would also be reasonable. Should this adjustment to the criteria be accepted, on average the Dunvegan Project would result in an increase of flow control durations of 1 day, as compared with the current 2005 criteria. Although Glacier Power is not currently a member of the JTF and cannot make decisions on present or future flow control criteria, Glacier is committed to working with the JTF and its members as required to develop defensible flow control criteria that are in the best interests of all parties.

Shaftesbury Ferry crossing and ice bridge

The Project is predicted to reduce the availability of an ice bridge crossing on average by approximately two to three weeks per year. Glacier Power is working with a local stakeholder group and Alberta Infrastructure and Transportation to develop a strategy to mitigate or compensation for this reduction.
2.4.2 Fisheries

Glacier Power is committed to protecting the fisheries resources in the Peace River. In keeping with this commitment, Glacier Power has been working with Alberta Sustainable Resource Development (SRD) and the Fisheries and Oceans Canada (DFO) throughout the Project approvals phase with the objective of obtaining provincial permits and Sections 32 and 35 Authorizations under the federal *Fisheries Act*.

Glacier Power incorporated mitigation and adaptive management strategies into the design of fish passage facilities, construction, and operational plans for fish passage facilities and habitat compensation works. Glacier Power based the design management strategies of those facilities and works on extensive hydraulic modeling programs and fish passage rationale, fish community baseline and movement studies, monitoring programs, and fish habitat no net loss and compensation plans.
3. PROJECT DESCRIPTION

3.1 Project Components

3.1.1 Design Considerations and Approach

The magnitude of the Project’s effect on the environment depends upon Glacier Power’s ability to avoid significant negative impacts by examining alternatives and implementing environmentally sensitive designs, construction techniques, and operational plans.

The proposed Project has evolved to a preliminary design level in consideration of alternatives from engineering, environmental, and cost perspectives. Each of the Project components including the powerhouse, spillway, boat lock, fishways, power transmission line and access roads, has been planned with environmental management and contingencies built into the design, construction, and operations plan. Figure 3.1-1 illustrates the overall site layout for the Project along with road access.

Run-of-river hydroelectric projects are positioned and sized to fit the environment in which they are to operate. Since the overall objective of run-of-river projects is to provide low impact, green energy from running water, a renewable resource, they must adhere to several engineering and environmental criteria.

The Dunvegan Project location was selected for several reasons. These included the physical characteristics of the river and valley configurations, transportation and access, proximity of an existing power line, and availability of a nearby labour force, supplies and services.

3.1.2 Components and Layout

The Project entails constructing a spillway and powerhouse across the Peace River approximately 2 km upstream of the Highway 2 Bridge crossing at Dunvegan. The Project is designed to increase the water level in the river at the headworks by 6 m on average to create adequate differential for the operation of a 100 MW low-head hydroelectric facility. The facility is a run-of-river hydro plant that produces power from the flow of the river without storing water, and therefore does not regulate or change the flow regime downstream of the facility. Figure 3.1-2 shows the headworks plan.
The powerhouse will consist of 30 turbine units arranged side by side extending from the south bank of the main channel and 10 turbine units arranged side by side extending from the north bank of the main channel for a total of 40 turbines contained in the powerhouse extending a total length of 285 m. A crest gated spillway will extend between the north and south sets of powerhouse units across the remaining 110 m of channel width to maintain sufficient water level differential across the structure. Based on mapping of the local Project area at 2-m contour intervals using orthographic air photos, the headpond created by the headworks structure will extend up to approximately 26 km upstream of the powerhouse and spillway. The increase in water level will result in a new water-bank interface zone that will inundate between 106 ha and 215 ha when comparing the pre and post Dunvegan 5% and 95% exceedance conditions, respectively. The total extent of inundation is approximately equal to the current 1:100 year flood level.

The facility incorporates a boat lock for upstream and downstream passage of river traffic and a boat launch upstream of the headworks to provide direct access to the headpond. The ramp fishways will be placed on each bank to provide for upstream fish migration and ten fish sluices will be placed between groups of five powerhouse units for downstream fish migration.

The Project powerhouse, fish sluices, and spillway are located within the present wetted portion of the river channel, whereas the headworks abutments at each end of the headworks structure, the boat lock, boat launch and the two ramp fishways are outside the present wetted channel on Crown land.

Power will be transmitted along a new 144-kV line for approximately 4.3 km to the southeast of the Project to interconnect at the existing ATCO (7L73-1) 144-kV line.

Access to the Project site will be available along both sides of the river through a combination of private and Crown land.

3.2 Project Design Elements

3.2.1 Design Concept

Successful hydro plant development is accomplished through selecting the critical balance between the capitalization of the river regime, facility costs, construction risks and proven technical solutions. The hydro power capacity and configuration of the Project was determined based on a number of key factors:
The gross head (water differential from upstream to downstream of the powerhouse), which ranges between 5.5 and 7.6 m, was selected based on ensuring the headpond level increase was contained within the river’s natural banks below pre-Bennett flood levels. The gross head varies in relation to the incoming flows in the river. For example, during low flow conditions the headpond water levels are held constant and the downstream water levels fluctuate based on inflows at the upstream end of the headpond resulting in a higher gross head and increased energy production. When inflows are high, the headpond levels are maintained but there is reduced gross head because tailwater levels will be higher to match inflows to the headpond. This was determined to be the optimum operating regime for energy production and minimal environmental effects. Lower head levels would have required a significantly wider powerhouse and decreased spillway width, which would result in substantially more frequent overtopping of the powerhouse and shutdown of operations, and therefore was not suitable. As well, submergence requirements of ultra low-head units would require significant riverbed excavation and costly instream channel work. Higher heads would have required a larger structure which would make design and construction considerably more difficult and costly with the existing foundation conditions, and would have resulted in an increased inundation area in the headpond.

The capacity of the plant was determined based on the available gross head and river flow. The plant capacity at the design flow of 1800 m$^3$/s is 100 MW. The 100 percent available flow is 390 m$^3$/s, which corresponds to a minimum output capacity of 19 MW. The operable turbine flow for each unit is between 42.5 m$^3$/s and 46.3 m$^3$/s. The units will typically operate at full capacity at a flow of 45 m$^3$/s each.

Turbine unit size was selected on the basis of submergence requirements: the larger the unit, the deeper the required setting due to higher unit flow. Turbine setting is the depth of the horizontal turbine shaft axis below the downstream tailwater level. A 2.5-MW unit capacity at the design head requires a setting of about 3 m. Normal tailwater depth at the site is about 4 m at full operational flow; therefore, the unit centreline is set about 1 m above bed level.

The turbine units selected are based on a modular concept using 40 identical units. The turbines are simple bulb propeller turbines (i.e., similar to Kaplan turbines without regulated blades) based on the idea that if low river flow occurs, instead of throttling down all of the turbines, some turbines will be shut down entirely. This will allow the remaining turbines to operate at their full capacity and peak efficiency. By having 40 identical units, economies of scale come into play and less spare parts inventories are required. The units will be manufactured as complete packages including turbine, generator, turbine housing, and draft tube. This will enable rapid assembly on a flat concrete slab foundation ready for concrete encasement without significant time-consuming alignment requirements.
The spillway will be a concrete overflow structure with an adjustable gate installed on the spillway crest. The gates will be lowered during flood events so that they do not impede flow. This is ideal for this application, given the size of the river, the trees and other large debris it carries, and the ice regime at this site.

The key hydraulic design parameters for the facility are shown in Table 3-1.

<table>
<thead>
<tr>
<th>Table 3-1: Key Design Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>River</strong></td>
</tr>
<tr>
<td>River Valley Width</td>
</tr>
<tr>
<td><strong>Powerhouse</strong></td>
</tr>
<tr>
<td>Combined Powerhouse Width (40 units) including fish sluices</td>
</tr>
<tr>
<td>Top of Powerhouse Elevation</td>
</tr>
<tr>
<td><strong>Spillway, Boat Lock and Fishways</strong></td>
</tr>
<tr>
<td>Total Spillway Length</td>
</tr>
<tr>
<td>Fixed Spillway Crest Elevation</td>
</tr>
<tr>
<td>Maximum Movable Spillway Crest Elevation</td>
</tr>
<tr>
<td>Boat Lock Width</td>
</tr>
<tr>
<td>Boat Lock Length</td>
</tr>
<tr>
<td>Boat Lock Depth (minimum)</td>
</tr>
<tr>
<td>Ramp Fishway (upstream fish passage)</td>
</tr>
<tr>
<td>Width</td>
</tr>
<tr>
<td>Length</td>
</tr>
<tr>
<td>Fish Sluices (downstream fish passage)</td>
</tr>
<tr>
<td>Width</td>
</tr>
<tr>
<td>Length</td>
</tr>
<tr>
<td><strong>Turbine Flow</strong></td>
</tr>
<tr>
<td>Turbine Flow per Unit</td>
</tr>
<tr>
<td>Total Turbine Flow</td>
</tr>
</tbody>
</table>
3.2.2 Powerhouse

The powerhouse will contain the modular turbine units. Figure 3.2-1 illustrates the general arrangement elevation of the headworks and shows 40 units (each 6.2 m wide) with each unit comprising 2500-kW (2.5-MW) propeller type turbines. Figures 3.2-2 and 3.2-3 illustrate the powerhouse features in plan and section views, respectively.

The powerhouse will be constructed on the riverbed at elevation 337 m and a top elevation of 348.4 m giving the structure a total height of 11.4 m. The powerhouse will be designed to overtop if flows exceed about the 1 in 2 year flood. On average powerhouse overtopping will occur 1.3 days/year varying between zero and 9 days under normal historic Bennett Dam operating and tributary inflow conditions between Bennett Dam and Dunvegan. It is anticipated that the turbines may need to be shutdown once significant overtopping occurs and the differential head results in conditions where the head is outside of the operating range for the units.

The facility is designed to pass extreme flood events up to and including the estimated Probable Maximum Flood (PMF) of 28,000 m³/s. A concrete and riprap apron extends 38 m downstream of the structure to prevent riverbed scour in the turbulent tailrace flow regime zone.
Figure 3.2-3 shows the powerhouse with the key upstream and downstream water levels.

The selected turbines, which have four fixed-pitch blades and a runner diameter of 2.6 m, will rotate at about 170 rpm. The turbines and housing will pass suspended sediment and bed material up to 25 mm in size. Flow regulation by Bennett Dam has substantially reduced the frequency of mobilization and size of bed material being transported by the Peace River. Sediment transport studies indicate that formation of the Project headpond will result in approximately 700,000 m³/annum of sediment deposition. Bed material larger than 2 mm in size will be deposited in the upper portion of the headpond and the Peace River is predicted to become generally sand bedded downstream of Km 18 after 10 years of project operation. This pattern of sediment deposition will minimize the potential for coarse sediment accumulation in the vicinity of the turbine intakes.

The headworks structure containing the powerhouse and spillway will be constructed using a barge and caisson construction method. Figures 3.2-3 and 3.2-4 show the barges in their final positions upstream and downstream of the main concrete structures. The barge and caisson construction concept involves the construction of precast concrete barges, which will be floated and sunk in place to form the permanent upstream and downstream sections of the structure. Construction will be conducted in flowing water conditions without any other form of cofferdam, however, dredging will be required in order to achieve the proper bottom elevations for the barges. It is estimated that approximately 53,000 m³ of river gravels will need to be dredged. Dredging will be carried out during periods when high levels of suspended sediment transport occur and outside of critical fisheries periods in order to minimize the incremental increase in sediment levels over background levels. In addition, appropriate dredging equipment will be selected to minimize the amount of suspended sediment introduced into the river during dredging operations. It is anticipated that a suction dredge with mechanized means for loosening the material would be used. The cutting/suction head would have a cover on it and would operate much the same as a vacuum cleaner.

The barges will also be used as working platforms in order to drive sheet piles to create working cells to allow for the construction of the main sections of the powerhouse and spillway structures. Once the sheet pile cells are complete, the water level within the cell will be lowered slightly to create a positive head differential between the river water levels and the water levels in the cells. This will prevent dredged material from entering the river.

Construction within the cells will involve excavation of river bed material to the depths required for the construction of the substructure for the powerhouse and spillway. The excavation must be carried out in wet conditions in order to maintain the stability of the cells. Controlled removal of the excavated material using a conveyor system will be used...
to transport material to a storage facility on shore and prevent material from entering the river.

Similarly, the foundation concrete will need to be poured in the cell in wet conditions. This will be done using tremie concrete. Tremie concrete is a special mix that allows the concrete to be pumped through a pipe and can be used to place concrete underwater. The tremie concrete is placed in the water to provide structure cutoff and anchorage and to maintain the stability of the sheet pile walls. Once the foundation tremie slab is in place the cell will be dewatered and the structural portion of the powerhouse constructed in the dry with no standing water present in the works. Seepage water entering the construction site will be pumped to settling infiltration ponds near the works and tested for acceptable water quality before being released back to the river. Settling ponds will likely be located in the existing inactive gravel pits located nearby on each bank. The ponds will be lined as required and include appropriate settling, skimming, decanting, and treatment features.

Construction activities in the river will be initiated in mid-summer and extend into the late fall, into initial freeze-up depending upon weather conditions and BC Hydro releases from the Bennett Dam.

3.2.3 Spillway

The 110-m long spillway has a fixed crest elevation of 344.4 m (Figure 3.2-4). The spillway crest will be separated into seven sections by piers extending from the upstream face to the start of the energy dissipater. Adjustable gates will be installed between the piers on the ogee crest in order to achieve a headpond elevation of 347.9 m. The gates will be lowered during flood events so that they do not impede flow. This is ideal for this application, given the size of the river, the trees and other large debris it transports, and the significant ice flow at this site.
NOTES:
1. ALL DIMENSIONS ARE IN METRES AND ELEVATIONS ARE
   IN M.T.
2. BASED ON L&M ENGINEERING LTD. DRAWING SW1426 / TG 1.4

PLAN
1:250

SECTION A
1:250

SCALE: 1:250
0  2.5  5  7.5  10  12.5
METRES

GLACIER POWER LTD.
DUNVEGAN PROJECT
GENERAL SPILLWAY
SECTION AND WATER LEVELS
FIG. 3.2.4
3.2.4 Boat Lock and Boat Launch

Provisions for maintaining navigability of the river in both upstream and downstream directions are required under the *Navigable Waters Protection Act*. Boaters wishing to pass upstream or downstream of the facility will use the proposed boat lock incorporated into the headworks structure. Boaters wishing to initiate travel upstream of the facility will be able to use the proposed boat ramp located approximately 100 m upstream of the powerhouse. Parking facilities will be provided for boat trailers and vehicles near the boat launch ramp. Final design of the boat launch and boat lock will consider input from local boaters and boating clubs.

An 8.5-m wide x 18.0 m long boat lock will be installed adjacent to the fishway ramp structure to retain navigability along the river. The style of lock will be such that frequent users could operate the facility unassisted if desired. A common goal for low-lift lock designs such as at Dunvegan is fill or empty the lock in an 8 minute time frame. Therefore, for the worst case scenario where a boat arrives just as another boat has just started to move through the lock, it is estimated that there would be less than a half hour wait (i.e. 8 minutes to fill, 8 minutes to empty, enter the lock, and 8 minutes to lift/lower the boat). The number of boats that can pass through the lock at any one time depends on the size of the boats. Assuming the boats are 5 m long by 2.5 m wide (roughly the size of an average jet boat), it would be possible to load at least six boats at any one time.

Dual safety booms, signs, and navigational aids will be in place upstream and downstream of the headworks to guide boaters to the boat lock and boat ramp. As an added safety feature, guide walls will be provided in the immediate vicinity of the powerhouse to isolate boats from the powerhouse. Boat safety, rescue, and education programs will be implemented in local communities and in conjunction with local boating clubs.

Boat lock operation during flood events will be dependent on the conditions in the river at the time with respect to debris and hazardous conditions. It is anticipated that during flood events equivalent to the 1 in 2 year flood event or higher when overtopping of the powerhouse section commences that conditions at the entrance to the boat lock will likely be too turbulent to allow for safe access to the area.

A boat launch ramp providing access for upstream or downstream river travel is currently located 2.5 km downstream of the Project on the south river bank immediately below the Dunvegan Bridge. The proposed Project boat ramp will be located in the headpond upstream of the headworks structure, and will be about 6 m wide and 40 m long with
about 20 m submerged to ensure operation even with the headpond drawn down to the fixed crest level (Figure 3.2-5).

### 3.2.5 Ramp Fishways and Fish Sluices

Fishways will be required to provide safe passage of fish migrating upstream and downstream of the Project. Fish passage facilities consisting of two ramp fishways (one on each bank) for upstream passage have been designed and incorporated into the headworks.

Each ramp fishway is comprised of two structural components; the ramp portion and the submerged vertical slot headworks portion. The ramp section of the fishway is 10 m wide x 132 m long and consists of a series of riffle/pool sequences with rock riprap along the edges. Riffles are created by a double row of v-baffles, offset to provide the hydraulic conditions suitable for fish >150 mm in length. The pool sections provide resting areas for fish between the riffle sections. The riprap along the fishway margins provides a combination of cover and hydraulic conditions for fish smaller than 150 mm. The ramp section design flow of 1.8 m$^3$/s is controlled by gated openings in the submerged orifice headworks fishway and operates at the full range of headpond elevations, except flood conditions. The submerged orifice headworks is also designed to allow fish to exit the fishway regardless of headpond level. Hydraulic conditions in the lower section of the ramp can be adjusted by an auxiliary water supply system in combination with the adjacent fish sluice flows to provide a range of attraction flows best suited to guiding fish to the fishway entrance. Figure 3.2-5 illustrates the general arrangement plan.

Fish sluices will be required to provide safe passage of fish migrating downstream of the facility. There are ten fish sluices located across the width of the structure. One at either abutment adjacent to the fishway ramps, two between the spillway and the powerhouse, and the remainder located between every set of five powerhouse units. Each of the fish sluices consist of an upper (400 mm) and lower (600 mm) gated conduit for conveying fish from the headpond to the downstream tailrace except for the fish sluice at the south abutment, which does not have an upper gated conduit. The design flows for the upper and lower gated conduits are 0.75 m$^3$/s and 20 m$^3$/s respectively. The lower conduit is incorporated into a vertical lift gate. Therefore, if additional capacity is required the discharge from the lower gated conduit can be increased from 20 m$^3$/s to approximately 50 m$^3$/s depending on the flow conditions. Guidewalls extend out from the downstream end of the fish sluice for about 20 m to guide fish towards the ramp fishway entrance and away from the turbulent tailrace zone.
3.2.6 Headpond

3.2.6.1 Flooding and Alteration of Flow Regime

The Project will not affect the flow regime of Peace River downstream of the structure and flooding effects in the headpond will be minimal. All water entering the headpond will flow directly through the powerhouse and/or over the spillway with no regulation of downstream flows. Flows within the headpond will be deeper and therefore slower than present flow velocities. At present, the mean annual flow of approximately 1540 m$^3$/s has a flow velocity of between 1.05 and 1.59 m/s at the proposed project location. Under these conditions, flow takes approximately five hours to pass through the proposed headpond section of the river. During operation of the headpond, this time will increase to approximately eight hours. Once the development is in place, the velocity through the headpond for the mean annual flow will range from 1.27 m/s at the upstream end to 0.37 m/s at the headworks.

Figures 3.2-6 to 3.2-10 show the extent of the inundated area of the headpond. Only the rare shallow sloped bank sections, some islands and side channel areas are affected. The increase in water level will result in a new water-bank interface zone that will inundate between 106 ha and 215 ha when comparing the pre and post Dunvegan 5% and 95% exceedance conditions, respectively. The total extent of inundation is approximately equal to the current 1:100 year flood level. This represents an average of less than 20 m on either side of the river valley bottom along the headpond. The effects of flooding will diminish towards the top of the headpond. At approximately 26 km upstream of the headworks structure, headpond levels are within 0.5 m of the present daily water level fluctuations. Within the headpond area, inundation will occur along the channel margins and will not overtop the existing riverbanks except in some low lying areas, however, the normal operating levels will be below the 1 in 100 year Pre-Bennett flood inundation levels.

The headpond will require a minimum of site preparation since the majority of its newly wetted area is contained in the natural river channel. Minor clearing of some trees may be required along shoreline areas closest to the facility and potentially in some low lying areas.

3.2.6.2 Tributary Streams

The main tributaries in the Project area include the Hamelin, Dunvegan, Hines, and Boucher Creeks and the Ksituan, Saddle (Burnt), and Leith Rivers. Several unnamed tributaries are also present. The only named tributaries with their confluence located
within the proposed headpond are the Ksituan River and Hamelin Creek. A large sand and gravel bar is located in the mainstem, immediately downstream of the mouth of the Ksituan River, and extends towards the headworks structures. The headpond will inundate 1000 m into the lower Ksituan River. Hamelin Creek is located near the upstream limit of the headpond and has a steep gradient at the confluence with Peace River; therefore, only the fan at its mouth will be inundated by the headpond.
3.2.7 Design Water Balance

The Project is a run-of-river hydroelectric facility with the powerhouse an integral part of the headworks structure. Consequently, the natural flow of the river remains relatively unaltered with flows entering the Project headpond and passing directly through the headworks structure. The design rules and guidelines adopted for the proposed Project account for the fact that the river discharges vary considerably from day to day and even hour to hour depending on the releases from Bennett Dam. In addition to the operational rules and guidelines for power generation, operational rules are required to accommodate upstream and downstream fish passage and boat navigation through the Project.

The guiding principles to accommodate the following project premises:

- The powerhouse discharge capacity is approximately 1,800 m$^3$/s; 40 turbine units at a capacity of between 42 m$^3$/s and 46.5 m$^3$/s for differential heads of 5.7 m and 7.6 m, respectively. The width of the powerhouse is 285.7 m.
- Two submerged orifice/ramp fishways, one per riverbank, are provided for upstream fish passage. The design discharge for each fishway is 1.8 m$^3$/s. An auxiliary water system (AWS) will also be provided within the fishways to introduce attraction flows into the ramp at different locations depending on tailwater levels. The AWS would have a capacity of 100 m$^3$/s per fishway, and operates during the upstream fish migration period only. At low river flows (i.e. 95% exceedance), the AWS design discharge is 3 to 5 m$^3$/s per fishway. At the 50% exceedance flow, the AWS discharge is 10 m$^3$/s per fishway and 25 to 30 m$^3$/s per fishway at the 5% exceedance flow.
- The upstream fish migration season is primarily from April to June; however, the submerged orifice ramp fishways are operated during the open water season (April 1 to October 31st). Fishway attraction flow is provided by the adjacent turbine units with guidance flow being provided via a guidewall located at the downstream end of the powerhouse to direct a portion of the tailwater flow towards the fishway entrance.
- Fish sluices consisting of ten lower and nine upper gated conduits are located within the powerhouse to provide for downstream fish passage. The lower gated conduits are sized to convey approximately 20 m$^3$/s. The upper gated conduits consist of a 400 mm diameter conduit capable of discharging 0.75 m$^3$/s.
- The spillway consists of seven 14.3 m wide bays with a fixed ogee crest and overshot gates. The fixed crest elevation is 344.4 m and the gates are 3.5 m high. The total spillway length is 110.3 m.
- In combination with the AWS system, the fish sluice adjacent to the ramp fishway is required to pass 5 to 10 m$^3$/s per sluice at the 95% exceedance flow, 14 m$^3$/s at the 50% exceedance flow, and 40 to 45 m$^3$/s at the 5% exceedance flow.
• The downstream fish migration season is from August to October during which time flows of up to 60 m$^3$/s will be provided to the fish sluices. At peak sluice capacity this results in three sluices being operated at any given time. The distribution of flows between the fish sluices will vary depending on the presence of fish and the river flow volumes and it may be possible that all the fish sluices are operated at the same time with a flow of 6 m$^3$/s per sluice. Unit operation adjacent to the operating sluices will be selected to provide optimum entrainment flows. Hydraulic modeling was carried out to develop operational criteria and adaptive measures that will be field verified and based on operations monitoring of fish passage.

Table 3.2 summarizes the discharge capacity of the various elements of the Project.

<p>| | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Table 3-2: Summary of Flow Design</td>
<td></td>
</tr>
<tr>
<td>River</td>
<td></td>
</tr>
<tr>
<td>Flow Range (95% to 5% exceedance)</td>
<td>753 to 2500 m$^3$/s</td>
</tr>
<tr>
<td>Powerhouse</td>
<td></td>
</tr>
<tr>
<td>Turbine Flow (one unit)</td>
<td>45 m$^3$/s</td>
</tr>
<tr>
<td>Total Turbine Flow (40 units operating)</td>
<td>1800 m$^3$/s</td>
</tr>
<tr>
<td>Spillway</td>
<td></td>
</tr>
<tr>
<td>Gate Flow (one gate) at El. 348.4 m</td>
<td>220 m$^3$/s</td>
</tr>
<tr>
<td>Total Spillway Flow (all 5 gates) at El. 348.4 m</td>
<td>1540 m$^3$/s</td>
</tr>
<tr>
<td>Boat Lock (Volume/Passage)</td>
<td>775 m$^3$</td>
</tr>
<tr>
<td>Fishways</td>
<td></td>
</tr>
<tr>
<td>Fishway Ramp (each ramp)</td>
<td>1.8 m$^3$/s</td>
</tr>
<tr>
<td>Auxiliary Water Supply (AWS) system (each ramp)</td>
<td>5 to 45 m$^3$/s</td>
</tr>
<tr>
<td>Fish Sluices</td>
<td></td>
</tr>
<tr>
<td>Lower gated conduit (each sluice)$^1$</td>
<td>20 to 50 m$^3$/s</td>
</tr>
<tr>
<td>Upper gated conduit (each sluice)$^1$</td>
<td>0.75 m$^3$/s</td>
</tr>
</tbody>
</table>

Notes:

1 Fish sluices are not operating at design capacity at all times, sluice operation will be on a rotational basis to optimize fish passage location preference based on monitoring program.
3.2.8 Access Roads and Bridges

Permanent roads are required on the north and south banks of the river to provide access to the powerhouse and boat lock for construction, operations and boat access to the headpond. Access roads will cross a combination of Crown and private land, in accordance with landowner and leaseholder agreements. As much as possible, access will be routed along existing roads to minimize new road construction.

Access roads, as shown in Figure 3.1-1, include 2.6 km of new gravel road, one bridge across Hines Creek, one bridge across Dunvegan Creek, and 0.4 km of road upgrades. Roads will be constructed according to municipal standards and will include a 20 m wide right-of-way.

The results of slope stability studies in the facility area have been incorporated into the design of the access roads. Detailed final design of access roads will occur in coordination with landowners and Alberta Infrastructure and Transportation.

3.2.9 Transmission Line

The energy produced by the Project will be carried along a 4.3 km long 144-kV power line from the powerhouse to the interconnection point with the existing grid. A 20 m wide right-of-way will be provided along the transmission line route. Figure 3.1-1 illustrates the proposed power line route, which interconnects with the ATCO 144-kV line 7L73 at NE 31-79-4-W6. The Project’s 144-kV power line will use single wooden pole construction similar to existing ATCO lines in the area. Figure 3.2-11 illustrates the single wooden pole design concept of the transmission line. For the most part, the powerline follows existing road allowances or cultivated land, the exception being where the line follows the new south access road from the plant substation to the crossing of Dunvegan Creek.

3.2.10 Facilities Visibility

The Project has a low profile that will minimize visual and aesthetic concerns as a result of:

- the headworks structure being relatively small compared to the size of the river and valley depth;
- only portions of the Project being visible by the public for short durations while travelling on the highway and from a limited number of vantage points;
- access to the facilities utilizing existing roads and trails as much as possible; and
- the powerline following the access roads, and existing and former trails.
PROPOSED POWERLINE

RESIDENTIAL  69 KV
138 KV
230 KV
500 KV
3.3 Construction Plan

3.3.1 General

Construction of the Project will require four years – one to prepare and complete access roads and shore-based (outside of the wetted channel) components followed by two years of instream work and then the final year for completing the structures and commissioning.

In order to achieve this objective it will be necessary to mobilize construction, complete site preparation work, construct access roads and prepare the entire site in the year prior to undertaking instream work on the powerhouse and spillway. Major consideration will be given to pre-assembly and precasting of various components in order to minimize the amount of instream work required. This will involve pre-assembly of the turbines and turbine housing and the precasting and pre-fabrication of the barges that will not only provide access for construction but will form an integral part of the spillway and powerhouse structural components.

Construction of the major instream works - the powerhouse and spillway - will be substantially completed during two summer construction seasons (April to October). This key timing is necessary in order to avoid ice forces being imposed on the uncompleted structure.

3.3.2 Construction Schedule

The project schedule has been developed to accomplish a number of project objectives as follows:

- undertake engineering field investigations and survey in 2007;
- complete preliminary engineering in 2007;
- procure turbine and long delivery items in 2007 upon final Project approval;
- complete detailed engineering by early-2009;
- mobilize site, undertake site preparation work, and construct access roads, boat lock and fishways in spring/summer, 2008;
- tender and award major construction work in 2007 upon final Project approval;
- construct major instream work (powerhouse and spillway) from spring to fall, 2009 and 2010; and
- complete and commission plant in 2011.

The approach adopted for this Project allows sufficient contingency to accommodate weather and other external factors preventing unnecessary winter construction. Table 3-3 is a summary of schedule milestones.
Table 3-3: Project Design and Construction Milestones

<table>
<thead>
<tr>
<th>Item</th>
<th>Start</th>
<th>Complete</th>
</tr>
</thead>
<tbody>
<tr>
<td>EIA &amp; EUB/NRCB Application Review and Approval</td>
<td>September 2006</td>
<td>September 2007</td>
</tr>
<tr>
<td>Detailed Engineering</td>
<td>October 2007</td>
<td>December 2008</td>
</tr>
<tr>
<td>Tender, Award and Engineer Turbine and Major Equipment</td>
<td>September 2007</td>
<td>April 2009</td>
</tr>
<tr>
<td>Manufacture Turbine &amp; Major Equipment</td>
<td>February 2008</td>
<td>January 2009</td>
</tr>
<tr>
<td>Pre-assembly of Turbine</td>
<td>April 2009</td>
<td>August 2010</td>
</tr>
<tr>
<td>Site Preparation, Abutments, Boat Lock and Fishways</td>
<td>April 2008</td>
<td>July 2009</td>
</tr>
<tr>
<td>Construction</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Construct Powerhouse/Spillway</td>
<td>April 2009</td>
<td>September 2011</td>
</tr>
<tr>
<td>Complete Mechanical/Electrical Construction</td>
<td>September 2009</td>
<td>November 2010</td>
</tr>
<tr>
<td>Commission Plant</td>
<td>August 2011</td>
<td>September 2011</td>
</tr>
<tr>
<td>Commercial Operation</td>
<td>September 2011</td>
<td></td>
</tr>
</tbody>
</table>

Construction sequencing drawings outlining the proposed construction program and the sequencing of instream construction work are included as Figures 3.3-1 to 3.3-7. Details of the construction program are provided in the following sections.
NOTES:
1. ICE ON RIVER FROM NOVEMBER TO MARCH
2. MAXIMUM UPSTREAM 10% EXCEEDENCE FLOW - APRIL TO NOVEMBER = 2560 m³/s
NOTE:
1. MAXIMUM UPSTREAM 10% EXCEEDENCE FLOW = JULY ±2400cfs
3.3.3 Construction Contracting

The major construction contract packages envisaged at this time are:

1) Site Works
   • site preparation work including construction of access roads, laydown areas and gravel stockpiling

2) Instream Works
   • sheet piling and concrete work for boat lock and fishway
   • turbine pre-assembly
   • barge construction and installation, sheet piling and dewatering
   • concrete works - powerhouse/spillway (may include boat lock and fishway)

3) Equipment Installation
   • mechanical installation/commissioning
   • electrical installation/commissioning

4) Interconnection
   • transmission line
   • substation

Instream works associated with the installation of the barges and driving of the sheet piles will be restricted to open water periods only. This is the only construction constraint in terms of construction scheduling associated with climatic conditions.

It is understood that the Dunvegan historic pit has been depleted, however, other existing gravel borrow pits will be utilized wherever possible.

Other miscellaneous contracts will be required for small components of the work.

Construction contracting packages will vary depending on the scheduling and design issues, contractor availability, site-specific conditions and weather factors.

3.3.4 General Construction

A construction program will be designed to minimize potential adverse environmental effects and enhance project benefits. Best practices and procedures will be implemented to further reduce potential environmental effects associated with construction. A program
will be in place during the construction phase to monitor the implementation of these practices.

Construction activities are not expected to effect the operation of the Shaftesbury Ferry downstream of the Project until year three of the construction phase, when the flow in the river is expected to be sufficiently constricted that ice lodgement will occur in the headpond. At this point in time the ice front scenario that will prevail post-Dunvegan would occur, and delay of the arrival of the ice front at the Shaftesbury Crossing is possible. By the end of year four, construction will be complete, and plant commissioning and operation will commence.

Prior to lodgement of ice at the structure in year three, it is expected that only local effects on ice formation due to the impingement of the structures on the river width will be experienced and hydraulic conditions should return to normal within a 1000 m of the Project. The Project will have no effect on ice conditions any locations or ice bridges downstream of Sunny Valley during either construction or operation.

3.3.4.1 Construction Yard/Staging Area

Several construction laydown and staging areas will be required for the Project. It is currently envisaged that four areas are required: one on each side of the river adjacent to the proposed works, one area for the pre-assembly of the turbine units and barge construction and one for contractor plant and offices. Size and location of the turbine pre-assembly and barge construction area has not been estimated at this time (Figures 3.3-1 to 3.3-8). The contractor plant and office area may be combined with one of the laydown areas adjacent to the proposed works.

3.3.4.2 Construction Camp

The workforce required will average about 125 workers on site with a peak of 300 workers in years two and three of construction. The Dunvegan Project site is approximately 10 km from the Towns of Rycroft and Spirit River, 20 km from the Town of Fairview, 100 km from the Town of Peace River, and 60 km from Grande Prairie. It is anticipated that bussing of construction workers from these locations is likely but contractors may also consider construction camps for part of the workforce depending on shifts, costs and logistical details. The construction camps, if used, will likely be located on nearby private land, and will undergo appropriate review and approvals from regulatory agencies. Interest in hosting a construction camp has been expressed by some nearby landowners.
3.3.4.3 Traffic Control and Access

Construction of the Project will occur over a four-year period; primarily spring to fall. Although traffic on secondary highways will increase slightly, it is anticipated that disruption to the general public will be minimal.

Estimates of the volume of truck traffic involving delivery of concrete and gravel materials are provided in Table 3-4. Procedures will be implemented for the protection of the general public (e.g., flag persons, signage and lights). Road maintenance and dust control will also be implemented and discussed further with Alberta Infrastructure and Transportation.

Site access will be constructed to both sides of the river (Figure 3.1-1). The south access road will be constructed from Highway 2 utilizing the existing access to an abandoned gravel pit (deeded land). The intersection and road through the gravel pit will be upgraded and new road construction will be required across Dunvegan Creek and to the Project site. The north access road will utilize the existing intersection at the entrance to Dunvegan Historic Park and extend from the west end of Dunvegan Historic Park along an existing road on the Peace River floodplain (formerly used to access an abandoned borrow pit on the Hines Creek fan) that will require upgrading. Although the north access road does not pass through the Maples Day Use area of the park, construction traffic will be controlled to minimize interference with recreational use of the Maples area and a residence located at the west end of the Maples area. Dust-control measures will be employed if necessary to further minimize disruption to these areas.

3.3.4.4 Construction Traffic Volumes

Table 3-4 outlines the flow of construction related traffic currently anticipated during construction of the Project. These traffic volumes are for vehicles arriving at the Project site. At this time it is not possible to determine from which direction (Grande Prairie or Town of Peace River) the majority of traffic may originate. The direction that the traffic originates from will impact the amount of increased bridge use. All traffic will use Highway 2 and access the Project site by both the north and south access roads.
### Table 3-4: Estimated Dunvegan Construction Traffic

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Passenger Vehicles &amp; Pickups</th>
<th>Buses</th>
<th>Single Unit Trucks</th>
<th>Tractor /Trailer Combinations</th>
<th>TOTAL Daily Two-Way Traffic</th>
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<td>Concrete Trucks</td>
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## 3.3.4.5 Hazardous Goods

All hazardous goods will be transported and stored as required by current government regulations. This will be the responsibility of the individual contractors.

Explosives, if required for excavation, will be transported to the site by a contractor and stored in approved, locked magazine(s). Transport, storage and handling of all explosives will be in compliance with regulations (*Transportation of Dangerous Goods Act* - Schedule 2: List 1) and by qualified persons. Safety requirements for the transportation, storage and handling of dangerous goods will be adhered to as stipulated by the Act.

Temporary diesel fuel storage will be necessary at the construction site. Portable steel tanks will be placed onto an impermeable base (concrete pad or compacted gravel/sand pad with plastic liner), which will be bermed and designed to hold at least 110 percent of the capacity of the tank within the berm. Fuel storage will be a minimum of 100 m from any stream and will not be located within a floodplain. Construction personnel will be instructed on safe fuelling methods.

Maintenance of heavy equipment will be done so that petroleum products (oil, grease, fuel) do not wash towards any watercourse. Any waste oil or grease will be collected and removed from the sites and sent for recycling/disposal at an approved facility.

<table>
<thead>
<tr>
<th>Month/Year</th>
<th>Passenger Vehicles &amp; Pickups</th>
<th>Buses</th>
<th>Single Unit Trucks</th>
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<td>Misc.</td>
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<td>294</td>
<td>1434</td>
<td>1190</td>
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Spill contingency plans will be compiled to address any accidental fuel or oil spills. Absorbent and collection materials will be on hand at any fuel tank location or where equipment maintenance is carried out. This will include absorbent pads, sand, or straw bales; impermeable PVC liners for temporary holding; and portable tanks, hoses and pumps for transferring spilled hydrocarbons.

All handling of concrete will follow Health and Safety precautions as provided on Material Safety Data Sheets. Handling concrete will require watertight forms, spill contingencies, and designated truck clean-out pits. CO₂ canisters and diffusers will be on hand in the event of a concrete spill.

Construction crews will receive orientation in spill containment and handling. The spill contingency plan will be posted at the work sites and available for inspection by agencies.

### 3.3.4.6 Sewage, Domestic and Solid Waste

Contractors may establish a camp on private land near the Project site (camps are mentioned at 3.3.4.2), and offices at the Project site during construction. Disposal of sewage at the Project site during the construction period will be handled by portable toilets serviced by a contractor. Permits for establishing a camp, should one be required, along with related permits for management of camp sewage and waste, will be the responsibility of the contractors.

Domestic waste and wastewater generated at the site will be deposited in containers and removed from the site on a daily or weekly basis as necessary.

Solid waste disposal during the construction period will be handled by a waste disposal contractor. Bins will be set at the site and hauled to the authorized landfill for disposal. Material will be recycled as much as possible.

### 3.3.4.7 Borrow and Waste Material Sites

Numerous existing borrow areas for gravel and backfill, all within 30 km of the Project site, have been identified for the Project. Final selection of the appropriate borrow areas will depend on the material requirements identified in the detailed design and material testing/suitability.

Materials excavated for the Project will be reused or disposed of in accordance with current government regulations. It is anticipated that some unused fill material will be
disposed of in existing borrow pits near the Project site. All waste disposal areas will be restored \textit{(i.e.,} topsoil placement and seeding).\textit{)}

### 3.3.5 Site Preparation and Reclamation Work

Site preparation work will commence in the spring of 2007. Work will involve clearing and earthwork, and the construction of access roads and laydown/construction yard areas. Access road locations are as shown on the site layout plan (Figure 3.1-1).

Vegetation cover will be removed for the new and portions of the upgraded access roads, laydown areas and transmission line. Removal of mature forest may be required. The areas involved are relatively small (less than 3 ha). Merchantable timber will be salvaged while non-merchantable timber and slash will be burned according to government regulations. The determination of timber to be removed will be finalized during final design.

Vegetation, particularly trees, shrubs, and grasses, stabilizes slopes and protects soils from erosion. During construction, unnecessary disturbance and erosion of disturbed areas will be reduced by:

- delaying the removal of vegetation to minimize the length of time that soils are exposed prior to excavation and earthworks \textit{(i.e.,} clear immediately prior to excavation rather than weeks or months ahead of time);\textit{)}
- limiting the areal extent of disturbance by restricting vehicles and equipment to the work site, right-of-way boundaries, and designated access roads;
- protecting vegetation in adjoining areas or environmentally sensitive sites by restricting access and managing drainage courses;
- installing temporary control measures such as settling basins; and
- covering slopes prone to erosion with geotextiles or coco mats.

Where possible, vegetation, particularly mature or potential wildlife trees, will be left intact and root systems undisturbed. Debris and slash will be disposed of in a manner that minimizes fire hazard, preserves site aesthetics, promotes re-vegetation and restoration, and does not compromise future use of the site. The volume of smoke generated during burning will be reduced by minimizing the amount of soil that is mixed into the slash during clearing operations. The use of fire accelerators will also be avoided, particularly in the vicinity of the headworks due to its proximity to the river.

Stripping of topsoil will be carried out where practical. Any piles of soil formed due to construction will be placed well back from any watercourse and will not impede drainage. The release of large quantities of accumulated surface water from the construction site
into adjacent watercourses during high rainfall or runoff events is a potential source of sediment loss during stripping. Excavations will be stopped during intense rainfall events or when the ground becomes saturated with water.

Before construction begins, mitigation works such as sediment traps and pumping systems will be installed at key locations, as determined during detailed design.

Reclamation of disturbed sites will be on-going throughout the construction phase. Disturbed areas will be re-vegetated to establish plant cover and assist in controlling erosion and stabilizing slopes. Due to the paucity of top soil at the site, soil may have to be brought in or special techniques such as coco matting and/or hydroseeding used for reclamation. At this point of conceptual planning, it is too early to identify exactly what will be needed in the way of reclamation. A complete reclamation plan will be developed following approvals but prior to commencement of any site preparation or construction activities.

3.3.6 Headworks Construction

3.3.6.1 General

Construction of the powerhouse will start simultaneously from each shore as shown on Figure 3.3-1. It is anticipated that no more than 30 percent of the river flow will be restricted at any one time. Water depths at the Project site will be approximately 3 m prior to the start of construction and are expected to rise 1 m with 30 percent river blockage. Sheet piling will be designed and installed to allow for 1 m of freeboard above 1:20 year construction flood levels. Given the thickness of sediment over bedrock in the river bed, no blasting is expected except possibly at the abutment terminations outside of the instream regime.

The headworks components including the abutments, boat lock, and fishways are currently planned to be constructed in the first year. Fish movement and boating traffic will be unaffected during year 1. Numeric modeling conducted by NHC indicates that upstream fish passage should be possible for at least part of the spring upstream migration period in year 2, however upstream migration will be restricted in years 3 and 4, due to high flow velocities between the construction cells as they are built out from either bank. Fish passage and the boat lock facilities will be working by the end of year 4 of construction, when headpond levels are raised and commissioning of these facilities can take place.
Fish collection and transfer methods are viable methods to facilitate fish passage during construction (Mainstream Aquatics, 2006). During years 2, 3, and 4, the fish community monitoring program (radio-tagged fish and fish capture programs) will identify if and when upstream passage becomes blocked during construction, and to identify areas of fish concentration. Flows will be passed through the fish sluices, turbine ports, and boat lock in order to provide attraction flows for upstream migrating fish. Water will also be pumped down the fishways to mimic attraction flow conditions that will exist once the fishways are fully operational. Attraction of fish away from the high velocity areas mid-channel to these lower velocity areas downstream of the works will facilitate safe and efficient fish collection.

Downstream fish passage during construction is not considered to be an issue as the fish sluices will be in place and operational when final closure of the structure is achieved.

3.3.6.2 Powerhouse Construction

The powerhouse, which is 285 m long, will be constructed in four stages. Each stage will be about 70 m long and involve ten turbine units. Construction will commence from the north and south shores starting in April 2008.

The turbines will be pre-assembled on or near the jobsite. The access gallery containing switchgear, control cabling, transformers, compressed air, water, etc will be pre-assembled in compartments and cast in place. Once the concrete structure has been completed each 2.5-MW turbine will be installed.

Initial instream work involves dredging and the placement of the precast concrete barges. The barges will form part of the permanent works and will also provide a temporary work platform for the installation of sheet piling. The barges will be placed completely across the river immediately upstream and downstream of the powerhouse and spillway structure.

Once four barges have been placed to form a working cell, sheet piling work will commence. One row of sheet piles will be installed upstream of the powerhouse. Sheet piling will be driven to a depth of about 7 m and will protrude 1 m above the 1:20 year construction flood water level including an allowance for backwater effects. A second row of sheet piling will be driven immediately downstream. Once the sheet piling has been extended out from shore sufficiently to contain a ten-unit powerhouse section, a third row of sheet piles will be installed at right angles to the first two rows, connecting both and creating a containment area (cell) in the river. The material in this cell will be excavated and replaced with tremie concrete in the wet cell in order to maintain the stability of the
sheet piles. The excavated material will be integrated into the works as ballast or abutment backfill or placed in designated waste areas nearby. Upon completion of the excavation and tremie concrete work, the cell will be dewatered and construction of the concrete superstructure will commence. Once the concrete has set, the sheet piling immediately adjacent to the turbine water passages (inlets and draft tubes) will be removed to allow flow through the structure.

While work is proceeding in the first cell, sheet piling will be driven outwards into the river for a second cell and so on for the third, fourth and subsequent cells. The same sequence of work will occur in each cell until the entire powerhouse and spillway are constructed. It is anticipated that five separate cells will be required and that no more than two will block the river flow at any one time.

Excavation, turbine installation and concrete encasement of the second and subsequent cells will be undertaken either by barge or by access over the previously constructed powerhouse structure. Upon completion of the structure, work will then proceed with completion of mechanical and electrical work on each of the turbine units.

3.3.6.3 Spillway Construction

The spillway structure, which is approximately 110 m in length, will be constructed in a similar fashion and sequence to the procedure previously outlined for the powerhouse, using a barge and caisson approach. The spillway will be constructed in a single large cell requiring 14 barges to be set in place prior to commencing sheet pile installation. Following the excavation and tremie concrete work, the cell will be dewatered and the base slab and spillway piers will be constructed. Once the concrete piers have set, the sheet piles will be removed and water will be allowed to flow through the spillway between the piers. The spillway will be left like this until the entire powerhouse has been completed.

Upon completion of the powerhouse, flow between the piers will be cut off with the installation of bulkhead gates between the piers. The area will then be dewatered and the concrete ogee sections cast in place. This process will continue across the bays until the spillway has been completed.

3.3.6.4 Boat Lock Construction

The boat lock located on the south bank will be a concrete structure poured between sheet piling. The sheet piling will form the inside and outside faces of the lock walls. These sections will then be dewatered and filled with reinforced concrete.
It is currently envisaged that the boat lock structure will be constructed during year one (i.e., in 2007). This will allow water passage through the structure while construction of the powerhouse and spillway takes place. A bridge will be designed and installed over the boat lock to provide access to the powerhouse structure for both construction and operations.

While construction of the boat lock will be completed during the summer of 2007, the boat lock will not be operational until final closure of the river is achieved. Boat traffic past the Project will be regulated during construction primarily while barges are being set in place. Once the barges are in place and sheet pile driving is underway, boat traffic can pass through the unobstructed portion of the river. When final closure of the river is being carried out, boat traffic on the river past the Project will not be available. It is anticipated that boat traffic will need to be transported past the Project for approximately one year while final closure and commissioning are completed.

3.3.6.5 Fishway Construction

The ramp fishways, located on both the north and south banks, will be concrete structures poured between sheet piling. The sheet piling will be driven forming the inside and outside faces of the fishway walls. These sections will then be dewatered and filled with reinforced concrete. Construction of the fish sluices will be incorporated into the adjacent turbine unit cells.

It is currently envisaged that the fishways will be constructed over a two year period with the North Fishway being completed in 2007 and the South Fishway in 2008. A bridge will be designed and installed over the fishways to provide access to the powerhouse and spillway for both construction and operations.

Final commissioning of the fishways will be completed in Year 4 (i.e. 2011).

3.3.7 Access Road Construction

Permanent access roads are required on both the north and south sides of Peace River to provide access to the powerhouse and other Project facilities. Both north and south access roads cross Crown and private land in accordance with landowner agreements.

The proposed alignments of both access roads will not impinge on any existing areas of instability along Highway 2 and hence it will not have any effects on the stability of the main highway.
The access road design will endeavour to minimize disturbance to the existing soil and groundwater regime. This will include minimizing the removal of any existing trees and vegetation and avoidance of any deep cuts or fills. It is anticipated that culverts will be used extensively to avoid disruption to existing surface water drainage paths. It is anticipated that the detailed road design will include extensive use of geogrids and geotextile fabrics to achieve a stable subgrade without extensive subexcavating and importing of granular material. If significant fill is required in some areas, consideration will be given to the use of lightweight fill or to retaining structures.

Special measures will be implemented to control erosion both in the short term during construction and in the long term, particularly near any creek crossings. These will include rip rap armouring at the bridge structures (eg. Dunvegan and Hines creeks). Other erosion control measures could include hydroseeding of any cut or fill slopes, as well as the use of hay bales, wattle fencing, or other synthetic erosion control products, as required. The specific measures will be determined during final design and will be incorporated into the Environmental Protection Plan for the Project.

Upgrades are proposed to the existing intersections on Highway No. 2 to facilitate construction traffic including semi-truck traffic. Final design will incorporate the results of consultation with Alberta Infrastructure and Transportation.

Proposed upgrades to the existing north access road intersection include the following:
- A northbound pullout/right-turning lane will be constructed to safely accommodate traffic coming from the south over the Dunvegan bridge turning right onto the north access road;
- Northbound traffic from the north access road will require a widened right turn and merge lane;
- Highway No. 2 would be widened, in the vicinity of the existing intersection, to facilitate a left-turn lane for southbound traffic on Highway No. 2;
- A temporary flashing overhead light would be installed at the intersection. Temporary construction signs, including construction zone, trucks turning, and possible speed reduction signs would be provided;
- Temporary street lighting at the intersection could be installed if required.

Proposed upgrades to the existing south access road intersection include the following:
- A southbound pullout/right-turning lane will be constructed from Highway No. 2 to the south access road to safely accommodate construction and permanent traffic;
- The access road would be upgraded to provide sufficient turning radii for a right turn onto Highway No. 2;
• Highway No. 2 would be widened, in the vicinity of the existing intersection, to facilitate a left-turn lane for northbound traffic on Highway No. 2 onto the south access road;
• A temporary flashing overhead light would be installed at the intersection. Temporary construction signs, including construction zone, trucks turning, and possible speed reduction signs would be provided;
• Temporary street lighting at the intersection could be installed if required.

Dust-control measures will be implemented during construction, particularly in the vicinity of the highway, near residences, and Project facilities.

Road upgrades to Highway No. 2 and the north and south access roads would be completed in Year 1. Temporary construction signage would be installed in prior to construction. Construction signage and possible speed reductions would remain in place until Project completion in 2010.

3.3.8 Powerline and Substation Construction

The powerline will be constructed during the summer of 2007 and, once appropriate approvals have been applied for and received, will be used to provide construction power. The powerline will be constructed in accordance with government and utility regulations and in an environmentally sensitive manner. The powerline right-of-way will be adjacent to the proposed access road and existing roads and trails.

The substation will be constructed in the fall of 2009 and will include all necessary protection and switching equipment required to tie into the provincial grid. The substation will also be completely fenced in for public safety.

3.4 Start-up

Once the powerhouse and spillway closure segment has been constructed, the river will continue to flow through the turbine water passages. The turbine gates will be closed sequentially in each turbine water passage to slowly fill the headpond. The flow will eventually begin overtopping the spillway crest with the adjustable spillway gates in the fully lowered position. The time to fill the headpond is estimated to be in the order of a few hours, however, environmental ramping procedures may extend this time. The final mechanical installations and dry commissioning will be done for each turbine runner by sequentially bulkheading off each unit upstream and downstream. Once the final mechanical installations have been completed, the spillway gates will be raised in order to raise the headpond level to its normal operating level. Wet commissioning activities will
then be done sequentially for each turbine unit. In the event that start-up problems are experienced during commissioning, flows would be redirected from the units to the spillway which would be lowered or allowed to overtop to maintain flows in the river. Therefore, no loss or alteration of flows downstream are expected during start-up.

Once the headpond level increases to the spillway crest level, the fishways and boat lock will be commissioned and made fully operational. The permanent safety boom and associated navigational warning systems will be put in place and the temporary construction safety boom systems will be removed.

3.5 Project Operations

3.5.1 Powerhouse Operations

The Project will operate to meet all or part of a sustained and constant portion of the electrical load (base-load plant). As it is a run-of-river project, operation of the plant will be continuous throughout all seasons based on the flow available in the river. An important point to remember regarding the operation of the Project is that water is not diverted. All water in the river remains in the original river channel and flows through the turbines or over the spillway structure. As a result, flows downstream of the headworks will remain the same as flows entering the headpond as per the present regulated regime. Flows are not regulated by the Project, however, local conditions below the structure will likely result in a turbulent regime that extends approximately 60 m downstream with residual eddies and boils extending as far as 150 m under some high flow conditions.

The powerhouse will contain full control systems including Supervisory Control And Data Acquisition (SCADA) systems. During transmission grid outages, the turbines will be shut down and flow will continue over the spillway section. The hydro plant will be manned 24 hours a day (likely with three operator-shift rotations per day). Maintenance will be undertaken daily, and turbines will be shut down for maintenance on a routine rotational basis.

The turbine inlets will be protected by removable trash racks. A 25-mm bar rack spacing will be provided during the period of downstream migration to physically exclude adult fish. The predominant migratory period for downstream passage of goldeye and walleye is late August to the end of October. This period also coincides with the Peace River containing the least amount of debris and suspended sediment and makes the operation of the fine bar rack possible with increased maintenance and cleaning. After the migration period, the overlay fine bar rack (exclusion rack with 25 mm spacing) will be removed leaving a coarse debris rack with an open spacing of 100 mm. Due to potential frazil ice problems,
the 100 mm trash rack will be removed prior to freeze up (end of November), leaving the rack supports in place, and then replaced after ice breakup (end of March).

A trash rack cleaner operating on an integrated rail system will be able to travel along the powerhouse to remove debris from each turbine inlet. Debris will be collected and placed on shore for disposal. If desirable for biological reasons, at certain times of the year debris can be cast back in the river immediately downstream of the powerhouse. The cleaner will be parked above the high-water mark during high flow events and will be used for other maintenance duties such as installing dewatering bulkheads for major turbine repairs.

### 3.5.2 Spillway Operations

The spillway will be designed to maintain a gross head differential (headwater minus tailwater) of between 5.5 and 7.6 m at the powerhouse under the majority of flow conditions. During low flow conditions, which occur about 10 percent of the time, such as late summer and fall, the net head will be maximized to 7.6 m. When flows exceed the lowest recorded river flow of 386 m$^3$/s, the headpond level will be raised to maintain the maximum possible net head up to 7.6 m without overtopping the spillway. When flows exceed approximately 1850 m$^3$/s, water would be flowing through all of the powerhouse units and the crest gates on the spillway would be lowered as required to maintain steady headpond levels. It is anticipated that during these high flow conditions the turbulent regime will extend approximately 60 m downstream with residual eddies and boils extending as far as 150 m.

During freeze-up, a portion of frazil ice moving downstream will continue through the turbines and over the spillway, while border ice will begin to build up along the edge of the river or in the headpond. Eventually, the headpond will freeze over and the plant will continue to operate utilizing under-ice flow. Table 3-5 presents operating rule curve data for the facility.
Table 3-5: Operating Rule Curve Data

<table>
<thead>
<tr>
<th>% Exceedance and Flood Events</th>
<th>River Discharge (m³/s)</th>
<th>Turbine Status</th>
<th>Normal Operating Headwater (m)</th>
<th>Tailwater (m)</th>
<th>Normal Operating Conditions Gross Head (m)</th>
<th>Spillway Open/Units Shutdown Gross Head (m)</th>
<th>Spillway Open/Units Shutdown Gross Head (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100%</td>
<td>425</td>
<td>Operating</td>
<td>347.1</td>
<td>339.5</td>
<td>7.6</td>
<td>346.1</td>
<td>6.6</td>
</tr>
<tr>
<td>95%</td>
<td>753</td>
<td>Operating</td>
<td>347.7</td>
<td>340.1</td>
<td>7.6</td>
<td>346.8</td>
<td>6.7</td>
</tr>
<tr>
<td>90%</td>
<td>905</td>
<td>Operating</td>
<td>347.9</td>
<td>340.4</td>
<td>7.5</td>
<td>347.1</td>
<td>6.7</td>
</tr>
<tr>
<td>80%</td>
<td>1120</td>
<td>Operating</td>
<td>347.9</td>
<td>340.7</td>
<td>7.2</td>
<td>347.6</td>
<td>6.9</td>
</tr>
<tr>
<td>70%</td>
<td>1290</td>
<td>Operating</td>
<td>347.9</td>
<td>340.9</td>
<td>7.0</td>
<td>347.9</td>
<td>7.0</td>
</tr>
<tr>
<td>60%</td>
<td>1430</td>
<td>Operating</td>
<td>347.9</td>
<td>341.1</td>
<td>6.8</td>
<td>348.1</td>
<td>7.0</td>
</tr>
<tr>
<td>50%</td>
<td>1540</td>
<td>Operating</td>
<td>347.9</td>
<td>341.2</td>
<td>6.7</td>
<td>348.3</td>
<td>7.1</td>
</tr>
<tr>
<td>40%</td>
<td>1640</td>
<td>Operating</td>
<td>347.9</td>
<td>341.4</td>
<td>6.5</td>
<td>348.5</td>
<td>7.1</td>
</tr>
<tr>
<td>30%</td>
<td>1750</td>
<td>Operating</td>
<td>347.9</td>
<td>341.5</td>
<td>6.4</td>
<td>348.6</td>
<td>7.1</td>
</tr>
<tr>
<td>20%</td>
<td>1880</td>
<td>Operating</td>
<td>347.9</td>
<td>341.6</td>
<td>6.3</td>
<td>348.7</td>
<td>7.1</td>
</tr>
<tr>
<td>10%</td>
<td>2150</td>
<td>Operating</td>
<td>348.4</td>
<td>341.9</td>
<td>6.5</td>
<td>349.0</td>
<td>7.1</td>
</tr>
<tr>
<td>5%</td>
<td>2500</td>
<td>Operating</td>
<td>348.4</td>
<td>342.2</td>
<td>6.2</td>
<td>349.2</td>
<td>7.0</td>
</tr>
<tr>
<td>At Overtopping</td>
<td>3380</td>
<td>Operating</td>
<td>348.4</td>
<td>343.0</td>
<td>5.4</td>
<td>349.8</td>
<td>6.8</td>
</tr>
<tr>
<td>Overtopping</td>
<td>3380</td>
<td>Shut Down</td>
<td>343.0</td>
<td>349.8</td>
<td>6.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:2 yr.</td>
<td>3680</td>
<td>Shut Down</td>
<td>343.2</td>
<td>349.9</td>
<td>6.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:5 Year</td>
<td>4920</td>
<td>Shut Down</td>
<td>344.1</td>
<td>350.6</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:10 Year</td>
<td>5750</td>
<td>Shut Down</td>
<td>344.6</td>
<td>351.0</td>
<td>6.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:20 Year</td>
<td>6540</td>
<td>Shut Down</td>
<td>345.1</td>
<td>351.4</td>
<td>6.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:50 Year</td>
<td>7570</td>
<td>Shut Down</td>
<td>345.7</td>
<td>351.9</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>7600</td>
<td>Shut Down</td>
<td>345.7</td>
<td>351.9</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:100 Year</td>
<td>8300</td>
<td>Shut Down</td>
<td>346.0</td>
<td>352.2</td>
<td>6.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:200 Year</td>
<td>9100</td>
<td>Shut Down</td>
<td>346.4</td>
<td>352.5</td>
<td>6.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:500 Year</td>
<td>10100</td>
<td>Shut Down</td>
<td>346.9</td>
<td>352.9</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1:1000 Year</td>
<td>10900</td>
<td>Shut Down</td>
<td>347.2</td>
<td>353.2</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* At 3380 m³/s the Plant is on verge of overtopping. For greater flows the turbines are shut down.

3.5.3 Headpond Operations

The operation of the powerhouse will be continuous throughout all seasons. As a run-of-river facility, no water is diverted during operations - all water in the river remains in the river and flows through the turbines and/or over the spillway structure. The headpond
formed behind the headworks will be 6 m deeper just upstream of the structures under mean annual flow conditions. This is equivalent to roughly 6 m above present river water levels and 0.6 m above the normal (pre-Bennett Dam) 1 in 100 year flood level. Total water depth at the powerhouse will be in the range of 10 to 12 m. The water depth eventually reduces to the original water level approximately 14 km upstream of the headworks. Under flood conditions, water levels increase and the effect will extend approximately 26 km upstream. The headpond will not operate as a storage reservoir, nor will flows be regulated. River flows entering the headpond will equal river flows below the structure.

The gate on top of the fixed crest spillway will be raised or lowered depending upon flow conditions in the river (dependent upon releases from Williston Reservoir and contributions from tributary streams). At high flow or flood conditions, the spillway gate will be in its lowered position. During normal and low flow conditions, such as late summer and fall, the spillway gates will be fully raised in order to maximize the net head available for power generation. In this case, water will be flowing through the powerhouse units with none going over the spillway.

3.5.4 Boat Lock Operations

The exact dimensions of the boat lock will be confirmed at a later stage of development, however, initial consultations with the boating community (paddlers, power boaters, etc.) indicate that a boat lock 6 m wide by 18 m long would be reasonable. This size could accommodate up to six average size jet boats at 2.5 m (8 ft) wide by 5 m (16 ft) long. As the Project progresses, the design and operation of the boat lock will be determined based on further consultation with the boating community to determine the needs of river users (i.e., volume of traffic, type of vessels using the river, and safety considerations) and discussions with the Canadian Coast Guard with respect to meeting the requirements of the *Navigable Waters Protection Act* and navigational aids. Glacier Power expects the boat lock will be operational throughout the open water season (less than 20% ice concentration in the river) and during periods of darkness or reduced visibility so as not to limit navigation on the river. The basic concept is shown in Figure 3.2-5. The lock will have hydraulically operated main gates and electrically activated watering and dewatering valves. Pumping of water is not required since a head differential at the headworks allows for gravity flow of water into the lock to raise and lower the water levels. This type of lock has been used extensively and successfully in Ontario, the United States, and elsewhere around the world.

Boat lock operation will be dependent on flow conditions in the river (i.e. debris and flood conditions). As discussed in Section 3.2.4, it is anticipated that during flood events of
1 in 2 year magnitude or greater when river flows are discharging over the powerhouse the boat lock would not be operational. Similarly if there is a substantial amount of debris in the river then boat lock operation would not be available. Boat operation on the river during periods of high debris flow is generally difficult and unsafe, and therefore boat traffic is usually low during debris events. Debris management will be in place for normal river flows however after a flood event when debris is mobilized it may take some time to clear the entrance to the boat lock.

The boat lock will have all the necessary lighting and signage to meet navigational standards and to assist boaters in locating the entrances even during the night.

### 3.5.5 Fishway Operation

The rationale behind fishway facilities operation is based on a combination of fish passage modeling and adaptive management strategies incorporated into the modeling program discussed in the Fish Passage Rationale prepared by Northwest Hydraulics Consultants (2005). A total of 60 m$^3$/s has been dedicated to manage fish passage. This flow is distributed according to need at each of the fish passage structures.

The ramp fishways, because they have designated design flows of 1.8 m$^3$/s, will operate independently from the powerhouse or spillway during the open water season from about the first of April to the end of November annually. The fishways will not be used during the winter ice cover period. De-watering the ramps from late fall to early spring and then re-opening the ramps immediately after ice is clear of the headpond will allow the ramps to work more effectively in early spring during the upstream migration period. The ramps will not function properly beyond a 1:10 year flood because the headworks structure will be overtopped and there will be no way to control flows in the ramps. The auxiliary water supply system in combination with the adjacent fish sluices will be operated to provide optimum guidance flows at the fishway entrance.

Fish sluices will be operated to convey fish downstream of the headworks structure. Although the lower gated conduits in the fish sluices are operated within a design range of 20-50 m$^3$/s and will operate throughout the open water period, particular attention will be paid to operating the fish sluices to accommodate downstream fish migration from the beginning of August to end of October annually. During this time frame, the plant is not operating at full capacity. This means turbines adjacent to the sluices can be selectively shut down, which will enhance the influence of the guidance flows towards the sluices making the sluice entrance easier to locate. The intent is to cycle sluice operations across the face of the headworks structure. This cycling process will be fine tuned based on results of the monitoring program. For example, if the monitoring program confirms fish
moving downstream congregate in front of a particular sluice, that sluice will become the default for downstream passage and will be operated to provide optimum attraction and passage conditions for fish.

3.6 Adaptive Management for Fish Passage

The fish passage hydraulic modeling studies demonstrated the flexibility of the plant and fish passage facilities to adjust to variable conditions while continuing to provide optimum fish passage opportunities, all while maintaining the economic viability of the project.

Providing passage for fish species present in the Peace River has not previously been demonstrated, adding a degree of uncertainty to the fish passage mitigation proposed for the Project. Rigorous modeling and collaboration from many experts on the fish passage strategy has produced a thoroughly researched and well understood fish passage strategy that includes significant operational flexibility to allow for adaptive management of fish passage in conjunction with a detailed monitoring program. Adaptive management strategies were implemented and assessed during the fishway modeling program and subsequently included in overall operational planning, ensuring the capacity to provide a wide range of choices and conditions for upstream and downstream fish passage. This range of passage and hydraulic conditions is possible as a result of the ability to selectively turn turbines on or off to change the influence of fish guidance flows, to vary upstream fishway attraction flows, and to selectively turn on or off or vary the flows through fish sluices. The proposed monitoring program will provide essential information to measure passage success and identify preferred and default operational settings.

3.6.1 Plant Operation

The powerhouse contains 40 turbine units that can be turned on or off depending on the availability of river flows. The turbine units have a discharge capacity varying between 42 m$^3$/s and 46.5 m$^3$/s for differential heads of 5.7 m and 7.6 m, respectively. The 40 turbine units are simple propeller turbines (i.e. Kaplan turbines without regulated blades or wicket gates) and do not have the capability of fine discharge control. Each turbine either operates at full output, or is shut completely off. Consequently, depending on flows available in the river, turbine operation alone will likely not be able to exactly convey all of the river flow without resulting in minor changes in headpond level. To allow fine discharge control, while maintaining a more constant headpond level, the operational plan assumes that one or several of the fish sluices are operated to match the river inflow. The fish sluice adjacent to the ramp fishways are operated preferentially for fine discharge control while providing guidance/attraction flow to each ramp fishway.
Secondly, the preferential operation of the turbines is dependant on the following guidelines:

- During the upstream fish migration period (April through July), the turbine units and fish sluice adjacent to the fishway ramp (nhc, 2005) and the auxiliary water system will be operated to provide optimum guidance/attraction flow. During the downstream fish migration period (August through October), the turbine units and the fish sluices will be operated to obtain optimum attraction and entrainment flow into the fish sluices.
- Whenever possible, turbine units will be shutdown for a practical minimum period. That is, the operational plan for the turbines attempts to limit the degree of operation required by minimizing the number of start/stops for all of the units. The current assumption is that, as much as practicable, the turbine units will be shutdown for a minimum consecutive two week period.
- The sequencing of selective turbine operation will be determined to run all of the turbines for approximately the same length of time (i.e. the percentage of time each turbine is operating is relatively the same on an annual basis) to equalize wear on the equipment.

When the inflows exceed powerhouse and fish sluice capacity, the spillway is then used to maintain headpond levels.

In the event of a load rejection (i.e. all turbines shut down), the sequence of operation will be dependant on the inflow at the time of the event. If the inflows are greater than the total fish sluice capacity, the spillway will be the primary release facility.

The turbine units, upper gated conduits in the fish sluices, and the submerged orifice/ramp fishways auxiliary water system are shutdown when river flows overtop the powerhouse at the 1:10 year flood.

3.6.2 Upstream Fish Passage

Upstream fish passage is accommodated in the current Project configuration via the submerged orifice/ramp fishway structures located on each riverbank. The submerged orifice fishway design discharge is 1.8 m$^3$/s. The flows into the submerged orifice fishways are dependant on the headpond level; therefore, a trimming gate is proposed adjacent to the submerged orifice intake to maintain the 1.8 m$^3$/s design flow and/or to augment flows in the fishway ramp if required (see Figure 3.2-5). In this way, flows in the ramp fishway can be adjusted to optimize hydraulics for fish passage and improve attraction flows at the fishway entrance. During the modelling studies, ramp fishway flows were increased to 6 m$^3$/s without changing the fishway hydraulics.
Fishway attraction/guidance flows are provided via the ramp fishway, the adjacent fish sluice located between the ramp fishway and the powerhouse, the auxiliary water system within the ramp fishway, and the guidewall consisting of submerged orifice conduits designed to direct tailrace flows towards the fishway entrance. The operational rule for the critical upstream fish passage season of April to June is to run selected turbine units, adjacent to the ramp fishways the auxiliary water system, and fish sluice closest to the fishway throughout the upstream fish passage season. In instances when the river discharge is less than full powerhouse discharge, turbine units located away from the fishways (i.e. in the middle of the powerhouse) would be selectively shutdown.

Based on the modeling studies, each of these hydraulic conditions and adaptive measures were optimized for the 95%, 50%, and 5% exceedence flows. These are described in detail in the Fish Passage Rationale (nhc, 2005).

3.6.3 Downstream Fish Passage

Similar to upstream fish passage, the key to providing safe and efficient downstream fish passage is a combination of attraction flow to guide fish to the fish sluices and hydraulics that capture and ensure fish are not able to return to the headpond once inside the sluice.

Downstream fish passage is accommodated in the current Project configuration via:
- Fish sluices consisting of ten lower and nine upper gated conduits distributed across the headworks;
- The submerged orifice/ramp fishways;
- For larger river flows that exceed powerhouse capacity, via the overflow spillway; and,
- For small fish, via fish-friendly turbines.

Three of the ten fish sluices are operated during the critical downstream fish passage season (August 1 to October 31 annually) in a cyclical manner across the headworks. The selection of which fish sluices are utilized will be dependant upon fish monitoring and the location of fish in front of the structure. When possible, the turbine units adjacent to the operating fish sluice will be selected and operated to improve guidance/attraction flow to the fish sluice. Hydraulic and adaptive measures were optimized during the modeling studies, and are described in detail in the Fish Passage Rationale (nhc, 2005) as well as being summarized below in Table 3-6.
3.6.4 Summary of Adaptive Management Strategies

A range of operating conditions and scenarios were evaluated during the modeling program. As a result a detailed understanding of the effects of various operational adjustments was achieved and documented. These adjustments form the basis of an adaptive management strategy that will see operational changes invoked depending on the observations of the fish monitoring program developed by Mainstream (2006). The objectives, potential fish passage concerns or observations during operations, and adjustments that can be made to alter hydraulic conditions and improve success of fish passage are summarized in Table 3-6.

Table 3-6: Summary of Adaptive Management Strategies

<table>
<thead>
<tr>
<th>Objective</th>
<th>Fish Passage Concerns and/or Observed Conditions</th>
<th>Hydraulic Adjustment Available</th>
</tr>
</thead>
</table>
| 1. Guide fish to ramp fishway ramp entrance | a. Fish are unable to locate the fishway entrance | i. Adjust flow in ramp fishway optimum: 1.8 m$^3$/s range: 1.8 to 6 m$^3$/s  
ii. Adjust flow in auxiliary water supply system optimum: 5 to 20 m$^3$/s range: 0 to 45 m$^3$/s  
iii. Adjust fish sluice flow adjacent to ramp fishways optimum: 20 to 50 m$^3$/s range: 0 to 60 m$^3$/s  
iv. Operate turbines adjacent to fishways to provide flow via guidewall (range 0 to 45 m$^3$/s) |
| b. Cyclical flow or eddies occur downstream of ramp fishway entrance (causes confused attraction pattern and unclear entrance location) | | |
| c. Fish are congregating at ramp fishway entrance but not entering the fishway | | |

<table>
<thead>
<tr>
<th>Objective</th>
<th>Fish Passage Concerns and/or Observed Conditions</th>
<th>Hydraulic Adjustment Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Fish are unable to locate the fishway entrance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Cyclical flow or eddies occur downstream of ramp fishway entrance (causes confused attraction pattern and unclear entrance location)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Fish are congregating at ramp fishway entrance but not entering the fishway</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
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<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>d.</strong> Fish are moving upstream towards the adjacent guidewall and fish sluice entrance</td>
<td><strong>i.</strong> Increase barrier flow in fish sluice adjacent to the ramp fishway (range 20 to 50 m³/s)</td>
<td><strong>ii.</strong> Reduce flow in sluiceway to remove attraction</td>
</tr>
<tr>
<td><strong>2. Move fish through the ramp fishway and into the headpond</strong></td>
<td><strong>a.</strong> Fish are stalling in the ramp fishway or are not moving through the entire ramp fishway length and return downstream to the river</td>
<td><strong>i.</strong> Adjust flows in the ramp fishway up or down by opening or closing the low level gate in the submerged orifice section of the fishway</td>
</tr>
<tr>
<td><strong>3. Downstream passage through fish sluices</strong></td>
<td><strong>a.</strong> Fish are congregating along the upstream face of the powerhouse and appear to be having difficulty finding the entrance to the fish sluices</td>
<td><strong>i.</strong> Cycle sluice operation across the headworks</td>
</tr>
<tr>
<td></td>
<td><strong>b.</strong> Fish enter the fish sluices but turn around and move back out into the headpond</td>
<td><strong>iv.</strong> Open fish sluice fully to ensure fish are captured and entrained by the sluice flow</td>
</tr>
</tbody>
</table>

### 3.7 Plant Closure and Abandonment

The Project has a minimum life span of 100 years. A significant feature of this design concept is that each of the components can be replaced as necessary. However, in the event that closure becomes necessary, a closure plan will be prepared for regulatory agency approval. The plan will describe methods to remove all components from the river channel as well as timing considerations for removal. Many of the machine components such as the turbines, hydraulic lifts for the lock, and the adjustable spillway gate will be removed. The protruding concrete structures will be demolished and hauled to an approved landfill site.
3.8 Accidents, Malfunctions, Safety Prevention and Features

The powerhouse, spillway, boat lock, and fishways are designed to withstand the anticipated water, ice and debris loading and extreme flood and seismic events, so the potential for failure is extremely low. An initial dam safety hazard consequence evaluation, prepared in accordance with the Canadian Dam Association Guidelines, indicates the hazard potential is “low”; however, it is intended to design this facility to a “high” hazard potential standard. Given the intrinsic design of the overtopping powerhouse and spillway, even extreme floods such as the Probable Maximum Flood (PMF) of 28,300 m³/s can be passed. In the unlikely event that structural failure did occur, a preliminary estimate is that the resulting flood wave would have a maximum 3 m high crest at Dunvegan that would attenuate to less than a 1-m high crest at the Town of Peace River. The structures themselves would likely not be carried downstream, although channel bed and bank scour could occur. Recreational boaters could be affected depending upon the time of year and proximity to the structure. Markers, buoys and safety lines will be located around the structure to warn boaters of the potential dangers and to direct boat traffic to the boat lock. During flood events there is a potential for debris in the river and it is unlikely that there would be any boat traffic in the river due to the naturally occurring unsafe conditions. Debris during these flood events would be passed over the spillway and/or powerhouse therefore conditions upstream and downstream of the Project will be similar to what would occur naturally.

Failure of the adjustable spillway gate could release the upper 2.5 m of the headpond causing a minor flood wave of about 1 m at the structure dissipating to less than 0.3 m at the Town of Peace River. This flow would be about 1780 m³/s which is well within the normal daily flows in the river.

The potential for fluid spills is minimal because the turbines and associated equipment use very small quantities of hydraulic fluids. The hydraulic fluids used in the powerhouse will be environmentally friendly biodegradable oil. These plants will be well maintained and designed with drains and sumps capable of retaining more than the full volume of 200 L contained in each unit. Drums of hydraulic fluids will be stored in a secure, properly designed building located on shore, well back from the 1:500 year flood level.

3.9 Waste Management

Wastes generated during construction will include packaging (wood, metal and plastic) of the facility components; rock and soil associated with road construction and upgrading, and transmission line construction; solids and fluids associated with equipment operation; and domestic waste and sewage from the construction workers. All solid wastes will be
collected on site and recycled or reused where possible. Solid waste that cannot be recycled or reused will be disposed of in an approved landfill. A contractor will be hired to remove the waste. Portable toilets will be used during construction and a contractor will be responsible for the removal and disposal of sewage. Other liquid wastes such as lubricants for the equipment will be collected and disposed of at an approved facility.

Waste material generated at hydroelectric facilities during operations are typically limited to office supplies, low quantities of hydraulic and lubrication fluids, and minor quantities of solid waste material (i.e., metals, wood etc.).

3.10 Environmental Management and Design Features

The Project has been located and will be designed to provide a clean sustainable source of electrical energy using a renewable resource with minimal effects to the environment. The following list outlines the elements that have been or will be incorporated into the Project to minimize potential environmental effects:

- The Project has been sited in the most stable geology found along the length of Peace River between the Alberta/British Columbia border and the confluence with the Slave River.
- The Project is a run-of-river plant that does not change or regulate flows downstream.
- The Project fits into the active floodplain in the bottom of the valley. Headpond inundation range from 95 percent to 5 percent exceedence is within the active floodplain and does not extensively flood the surrounding areas.
- The Project powerhouse machinery will use small quantities of biodegradable oils which can be easily changed and handled inside the plant.
- The Project turbines will be designed to be fish friendly to the extent possible while being able to utilize the low-head differential to generate electricity.
- The Project trash racks will be designed to minimize entrainment of fish and provide guidance. Physical hydraulic modeling has been used to evaluate guidance flows for safe downstream passage.
- The Project spillway will be designed to prevent or minimize the formation of supersaturated water downstream of the spillway to the extent possible. Fish can usually tolerate supersaturated water of less than 110 per cent near the surface of the water.
- The Project incorporates fishways and fish sluices to provide for upstream and downstream fish passage.
- The Project access roads and powerline use existing trail and road corridors as much as possible.
- The Project incorporates a boat lock to pass boaters past the headworks structure.
- The Project incorporates a boat launch on the upstream side of the headworks structure.
• The Project powerline is designed as a single wood pole, similar to other powerlines in the area.
• The Project headworks construction will integrate sheet piles into the structure rather than cofferdams, which cause extensive disturbance to the channel bottom and tend to generate high sediment into the water column during installation and decommissioning.
• The Project incorporates safety booms on both the upstream and downstream side of the structure to minimize the risk to boaters of being carried over the spillway or into the powerhouse.
• The Project components blend into the river valley causing minimal visual impact.
• The majority of construction access will be via each bank abutment, thereby minimizing instream equipment.
• The Project scale will not pose a strain on surrounding infrastructure or the environment.

Best practices will be incorporated into the design, construction, operation, and decommissioning of the Project. A set of environmental protection procedures will be developed outlining the types of standard practices that would be implemented to minimize Project effects. These standard practices will be revised to fit the context of the Project during final design and the development of environmental management programs.

3.10.1 Environmental Management Program

The Environmental Management Program encompasses several aspects of environmental protection and emergency response planning and implementation, compensation works, and monitoring. An Environmental Protection Plan (EPP) will be developed for the Project. The EPP will outline the protection measures developed by the proponent in consultation with the regulatory agencies to address environmental considerations associated with the design, construction, and operation of the Project. The EPP is a dynamic document that will be updated as required to address new protection and reporting procedures, throughout the life of the Project and according to the principles of adaptive management.

The document will present standard, good environmental practices and the environmental protection requirements of provincial and federal environmental departments. The information presented within the document will be used as an internal environmental management tool to meet Environment, Health and Safety Management Systems, with applications for training and educating personnel involved in the Project.

More specifically, the purpose of the EPP will be to:
• design, build and construct the Project in accordance with the requirements of a green energy project;
• present the owners commitment to environmental stewardship;
• document environmental concerns and appropriate protection measures;
• provide clear and concise instructions to relevant Project personnel regarding procedures for protecting the environment and minimizing environmental effects; and
• provide a reference document for personnel when planning or conducting specific activities.

The environmental management program for the Project is discussed in greater detail in the EIA.
4. REFERENCES


