Appendix 5.8
Atlin Hydro Expansion Study

REPORT

Atlin Hydro Expansion

Pre-Feasibility Study

Atlin, British Columbia

Presented to:

Atlin Tlingit Economic Limited Partnership

Project No. 5151214 June 5, 2015

Revised: June 23, 2016

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MORRISON HERSHFIELD

June 23, 2016 MH ref. 5151214

Stuart Simpson, General Manager,
Atlin Tlingit Economic LP
PO Box 408,
Atlin, BC
V0W1A0

Dear Mr. Simpson:

Re: Prefeasibility Study for Atlin Hydro Expansion Project – 2016 Update

Morrison Hershfield is pleased to provide our report on the above noted project. This is an updated version of the prefeasibility report completed in 2015. This 2016 update now includes the transmission line options assessment for connection to the Yukon electrical system and addresses Yukon Energy Corporation's comments. It continues to be a privilege to work with ATELP on this exciting and interesting renewable energy project.

We look forward to any opportunity to support you and your team in developing this important project. In the meantime, if we can be of further service, please do not hesitate to contact me at (867) 456-4747.

Yours truly,
Morrison Hershfield Limited

Forest Pearson

Forest Pearson, P.Eng.,
Geological Engineer / Project Manager

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1 PROJECT OVERVIEW

1.1 Background and Project Objective

On April 1st, 2009 the 2.1MW Atlin Hydro Project began commercial power production. The hydropower facility is owned by Xeitl Limited Partnership which is 100% owned by Taku River Tlingit First Nation. The project is located on Pine Creek and is approximately 4 km east of the community of Atlin, BC. Atlin is an isolated community located approximately 50 km south of the Yukon-British Columbia border. Atlin is only road accessible from the Yukon Territory.

Atlin is not connected to a regional electrical power grid and therefore all electrical needs of the community are generated locally. Power created by the current Atlin hydro project is sold to BC Hydro on a 25-year energy purchase agreement. Under this agreement, Xeitl has an obligation to provide up to 8.3 GWh/yr by 2032. The Atlin hydro project now meets all of the community's electrical power needs and has additional unutilized generating capacity. Backup power in case of outage is provided by diesel electric generation owned and operated by BC Hydro.

The current hydropower project only develops a portion of the hydropower potential of the site. The existing project utilizes approximately 107 m of head (drop) on Pine Creek. There remains another 55 m of head between the current powerhouse (located at the confluence of Pine and Spruce Creeks) and Atlin Lake. There is also additional undeveloped head upstream of the current head pond. As such, the existing project only utilizes a portion of the flow available in Pine Creek. There is then significant additional energy potential on Pine Creek that could be developed.

The Yukon Territory has an isolated electrical system that is largely supplied by hydroelectricity. Atlin is not currently connected to the Yukon's electrical grid. The Yukon is nearing capacity of its renewable energy system. Most recently public available forecasts suggest that the Yukon will have a renewable energy shortfall of over 80 GWh/yr by 2030[1]. Shortfalls in renewable energy will be met with fossil-fuel based electrical generation (diesel or natural gas fired generation).

In summer of 2014 the Taku River Tlingit First Nation's economic development corporation, the Atlin Tlingit Economic Limited Partnership (ATELP), secured funding from the Aboriginal Affairs and Northern Development Canada's ecoENERGY for Aboriginal and Northern Communities Program to conduct a pre-feasibility study of expanding the hydropower project. The current study provides a preliminary assessment of increasing hydropower production for export to the Yukon electrical grid. This study has been updated in 2016 to include a transmission connection assessment.

The community of Atlin, British Columbia is located on the Yukon Plateau physiographic region of northern BC, just east of the Coast Mountains. Pine Creek originates from Surprise Lake and then flows westward approximately 20 km to discharge into Atlin Lake. Much of the creek has been extensively mined for placer gold since the 1900's. A road from Atlin to Surprise Lake parallels the creek. Surprise Lake (32 km^2) is the headwaters for the creek and provides storage for the hydropower project. The current hydropower project has developed 107.6 m of head by conveying water through a penstock

[1] Yukon Energy Corporation, 2013:Yukon Energy Corporation Application for an Energy Project Certificate and Energy Operation Certificate Regarding the Proposed Whitehorse Diesel – Natural Gas Conversion Project. December 9, 2013.

over a distance of approximately 3.9 km around a set falls in a short canyon. The current powerhouse lies just upstream of the confluence with a significant tributary stream called Spruce Creek. Below the current powerhouse, Pine Creek flows another 4 km, dropping approximately 55 m before discharging to Atlin Lake.

The current study envisions expanding the current powerhouse with two additional turbines of 1.45MW each (bring the total powerhouse capacity to 5MW). A second, or lower, powerhouse could be developed on Atlin Lake, providing an additional 2.5 to 3MW of capacity. The capacity of the lower powerhouse is a function of available flows and head (see Section 4.3 of this report); the specific installed capacity will need to be refined during the next phase of study. A new transmission line of approximately 100 km would be required to connect the project with the Yukon Territory's electrical grid.

1.1.1 Project Objective

In general terms the goal of the project is twofold:

1. Estimate the scale of the hydropower opportunity readily available for development on Pine Creek. How much power could be generated if the full potential of the site was developed?

2. Is the expanded development of the site, for sale to the Yukon electrical grid, potentially economically viable?

The study is to determine the scale of the opportunity and if whether it is worthwhile to pursue. At this stage the development concepts have not taken into consideration environmental and social mitigations and only limited work has been done to optimize the project design. The design concepts presented in this study are preliminary in nature for the purpose of estimating project costs and are not necessarily representative of the ultimate design or layout of the project.

1.2 Scope of Work

The scope of work for the Atlin Hydro Expansion Project pre-feasibility study is as follows. The level of detail of the study is limited by the available budget; however the objective is to generate a preliminary project concept and a cost estimate at +/-30%. Power and energy estimates are evaluated based on available historical flow data on both Pine Creek and nearby rivers. The project work consists of two main phases:

1. Project conceptualization, to define the proposed layout and energy estimates:
   a. Project initiation, including review of previous work and previous studies and an initial site visit by the project team;
   b. Site definition including initial project layout concepts and acquisition of new 1-m contour mapping of the project study area;
   c. Hydrological and power studies including development of an updated synthetic flow series, power production estimates and a simplified flood frequency analysis.

2. Pre-feasibility engineering and design

    a. Preliminary design of the major works including dams, intake structures, control structures and spillways, water conveyance and powerhouse;

    b. Preparation of cost estimate (+/-30%) estimated from bill of quantities derived from the preliminary design drawings (class IV or better based on AACE framework). Also a preliminary construction schedule is presented.

    c. Completion of a transmission assessment to estimate electrical transmission and connection requirements to the Yukon's electrical system, including cost estimates.

    d. Preparation of this prefeasibility design report and a presentation.

Two other related phases of work are being conducted concurrently with this prefeasibility study:

a. A hydrometric monitoring program was established in late 2014 to determine actual water levels and stream flows in key water bodies relevant to the hydro expansion project. This consists of continuous monitoring of lake levels in Surprise Lake and flow in Pine and Spruce Creeks;

b. An environmental scoping is being completed consisting of an existing environmental data review, gap analysis and an assessment of regulatory approvals likely to be required.

1.3 Previous Work and Available Data

This study builds upon previous work and existing information. Some of the most relevant data includes:

- Surprise Lake Hydroelectric Project: Proposal for Supply of Electricity to BC Hydro at Atlin, prepared by Canadian Utilities, Limited, Synex Energy Resources Ltd and Yukon Development Corporation. 1990.
- Atlin Hydroelectric Project Hydrology Report. Prepared for Taku Land Corporation by Sigma Engineering Ltd. March, 2006.
- Stage-discharge data for Surprise Lake and Pine Creek. Spot flow and lake measurements collected between 1990 and 2005 for Yukon Energy Corporation.
- Stream flow data for Pine Creek collected at Water Survey of Canada (WSC) station (09AA008) which operated at the mouth of Pine Creek. This station has only 10 years of complete discharge data between 1956 and 1969 (1956-1961, 1966-1969).
- Presentation on Biological Assessment of the Atlin Small Hydro Project, Progress Report September 2005 prepared by Richard Erhardt for Taku Land Corp.
- Atlin Hydroelectric Project Environmental Impact Statement prepared by Taku Land Corporation August 2006.
- Atlin Hydroelectric Project As-Built Drawings by Sigma Engineering. Prepared for Taku Land Corporation, July 2009.

- Atlin BC to Yukon Interconnection Costing Study. Prepared by BBA Engineering for Yukon Energy Corporation. August 2011.
- BC Land Tenure from DataBC including: TANTALIS Crown Tenures, Crown Land Rights-of-way, Surveyed Parcels and Surveyed Right-of-way Parcels.
- Confidential construction data provided by Atlin Tlingit Economic Development Corporation for the existing hydroelectric project completed in 2009. This includes access to construction contracts and project cost details for the original project construction between 2007 and 2009.

1.3.1 Topographic Mapping

New 1-meter topographic mapping was obtained for the project and is used as the topographic base for the preliminary design. Underhill Geomatics of Whitehorse, Yukon was retained to generate the mapping. The mapping was created from 2010 1:20,000 scale aerial photography. The mapping includes 1 meter contour data, water bodies and an orthophoto. The extent of the mapping generally follows Pine Creek and extends from the current intake head pond down to Atlin Lake. Mapping data was provided digitally to ATELP in AutoCAD format and cartographic version of mapping is provided in Appendix B.

2 SITE VISIT & OBSERVATIONS

An initial site visit was conducted by the project team on September 24 and 25th, 2014. Forest Pearson (project manager / geological Engineer), David Morissette (hydrotechnical engineer) and Shaun Beatty (civil engineer) were part of the visit and were accompanied for portions of the visit by Stuart Simpson, ATELP General Manager. The site visit included a brief helicopter over flight of the potential project site followed by on the ground reconnaissance. A copy of the site visit memorandum is provided in Appendix C and a representative photo log is provided in Appendix D. The location of features described herein are shown on Figure 2-1.

The site visit included:

- Ground inspection of the Surprise Lake outlet and control structure with access via Surprise Lake road;
- Ground inspection of the existing Pine Creek intake structure. This included a brief visual reconnaissance of Spruce Creek for consideration of diversion into the existing head pond;
- Visual reconnaissance of the existing penstock and associated right of way;
- Site visit to the inside and outside of the existing powerhouse. This also included the bridge and potential new headpond area downstream of the existing powerhouse;
- A detailed on the ground reconnaissance of a potential lower powerhouse location on Atlin Lake, just south of the Monarch Mountain Trail parking lot. The hill-slope above this site was also inspected for ground and terrain conditions for the penstock route;
- A road-based reconnaissance from both the Art Centre Road and South Pine Drive of a potential higher penstock alignment to Atlin Lake;
- A ground traverse of the upper 1.5 km of the lower penstock alignment to assess potential intake locations, ground conditions and to determine topographic constraints to a penstock alignment.

The following main conclusions were gathered from the site visit:

Surprise Lake Control Structure

- The control structure at Surprise Lake can be readily modified to increase storage range on the lake by raising the existing sheet pile and rock fill control weir (see Photo 1). Work will need to be done to assess the suitability of the current outlet structure and fish way under higher and lower lake conditions.
- The channel between the lake and the control structure appears to be relatively shallow. It is likely the channel would need to be deepened to extract water from the lake at lower lake levels.

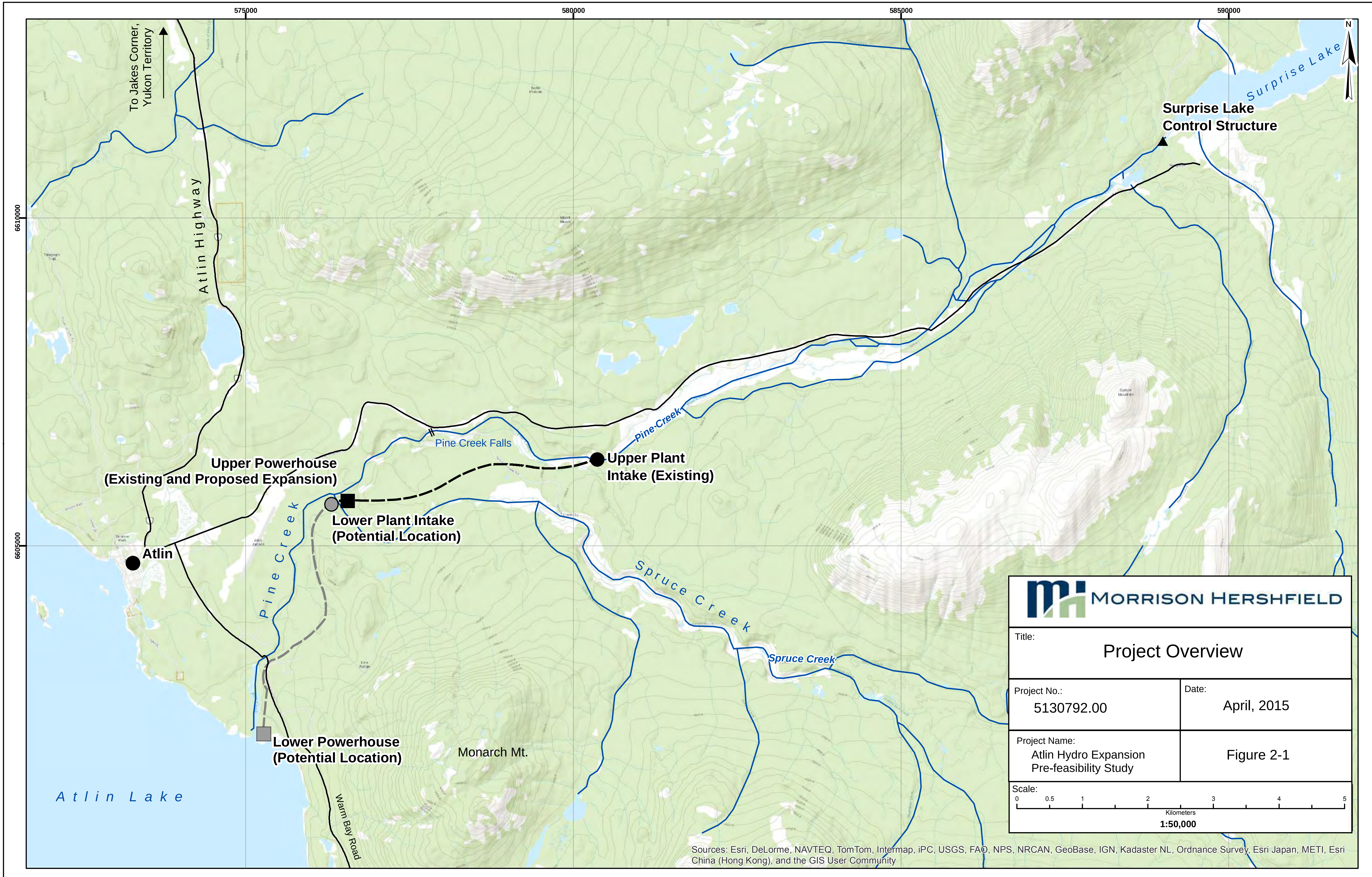

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Photo 1: Surprise Lake control structure with rock fill and sheet pile weir on the right.

Existing (Upper) Power Plant

- There appears to be adequate space at the existing head pond to accommodate a second intake structure to feed the powerplant expansion. The head pond is contained by bedrock outcrops on both sides of the creek (see Photo 2).
- The head pond itself is created by a concrete weir founded on bedrock. The weir appears to be in good condition, however has some minor leaks through the south abutment. These leaks do not appear to be problematic at this time.
- The head pond is reported to have issues with frazil ice accumulation in the winter. It is thought that this problem may be compounded by the presence of a submerged rockfill berm between the main pond area and the intake. This creates a depositional area that may exacerbate the accumulation of frazil ice. Furthermore, there is a reach of rapids on the creek immediately upstream of the head pond. These rapids not only limit the size of the head pond but are also likely to increase frazil ice generation in this reach..
- The existing clearing for the penstock is quite wide and should be able to accommodate a second penstock for most of the alignment with any further clearing. Ground conditions appear

to be glaciofluvial gravel for most of the route which is suitable for excavation and installation of a penstock (see Photo 4).

- Expanding the existing powerhouse appears reasonable. There is adequate space on the south side assuming some excavation of the hill side. Soils at the powerhouse are primarily sand and gravel with no bedrock outcrops anticipated near surface (see Photo 3).
- Sand and course gravel is abundant throughout the area and is readily available due to the extensive placer gold mining of the creeks.

Photo 2: Existing head pond and intake structure, looking west.

Photo 4. Existing penstock right of way, looking downstream (west). Penstock in on the left, service road on the right side of the clearing.

Photo 3. Existing powerhouse looking south towards Spruce Creek. Pine Creek is in foreground.

Lower Power Plant

- No obvious or natural containment for a head pond was identified. Topography is fairly flat and no deep natural pools near the desired intake location were observed. In the absence of any natural features, it is proposed that an excavated head pond be created immediately downstream of the existing powerhouse access road bridge (see Photo 3). Potential for tail water effects from a lower head pond on the existing powerhouse will need to be considered. Soils at this location are coarse alluvial gravel with no bedrock in the vicinity. This suggests that soils will be fairly porous should an impoundment be created in this area.
- The alignment for the lower penstock is significantly more complicated that the upper alignment. This is due to steep side slopes, varying terrain conditions (bedrock outcrops, wetland areas) and topographic constraints (see Photo 5).
- The upper 1.5 km of the potential penstock alignment is primarily alluvial sand and gravel terraces. A saddle between the mountain side and a bedrock hill was located and provide a convenient topographic feature for the penstock alignment approximately 1.5 km south of the head pond area.

Photo 5. View of lower penstock alignment terrain conditions looking north towards existing powerhouse.

- There are a number of titled properties along the lower segment of the potential penstock alignment (within the first kilometer upstream of the powerhouse). These are located along Warm Bay Road, Arts Centre road and either side of Pine Creek at the bridge. These properties conflict with some potential penstock routes.
- There appears to be adequate space for a powerhouse on the shore of Atlin Lake. Pine Creek itself has created a large alluvial fan extending out into Atlin Lake. The shallow gravel deposits extend out into the lake making the lake quite shallow near the mouth of the creek. The lake drops off more quickly from the shoreline south of the fan (see Photo 6). Sediment disposition from the creek affecting the potential tailrace should be considered.
- The hillside above the potential powerhouse location rises steeply to the east of the Warm Bay Road. The hillside is open rolling bedrock outcrop with very little tree cover.

Photo 6. View of potential lower powerhouse locations on Altin Lake. Pine Creek fan is on the left. Note exposed bedrock hillside above Warm Bay road.

3 PROPOSED LAYOUT

3.1 Project Components Overview

Multiple new hydro project components are required to maximize power production at Pine Creek. For the purposes of this study, the hydro expansion project layout is assumed to consist of the followings (see Figure 2-1):

1. Increased water storage range on Surprise Lake to increase water storage for seasonal power production. It will require modifications to the existing Surprise Lake control structure and weir.
2. Expanding the upper power house with additional generating capacity. It will require an additional penstock and intake structure to convey the additional water to the added turbine(s). It is not anticipated that the existing head pond will require modification other than the addition of a second intake structure for the new penstock. Modifications to help prevent frazil ice accumulation in the head pond are however warranted, especially with the proposed increase in winter flows.
3. A new powerhouse on or near Atlin Lake. It will require a new conveyance (penstock) and associated head pond and intake structure downstream of the existing powerhouse.
4. A transmission line from Atlin to the Yukon Territory's electrical grid. It has been assumed that the new transmission line would terminate at Jakes Corner based in the preliminary transmission options assessment completed as part of this study.

3.1.1 Spruce Creek Diversion

Spruce Creek is the largest tributary to Pine Creek. It joins Pine Creek immediately below the current powerhouse. Like Pine Creek, Spruce Creek has been extensively modified and affected by placer gold mining over the past century. Placer mining on both creeks continues to occur.

Flows from Spruce Creek can be utilized for power production at either the new lower power project or potentially by both power plants if the creek was diverted into the upper (existing) head pond. The current head pond has a normal water elevation of about 832.5 m. Diverting Spruce Creek would require intercepting the creek at approximately elevation 835 m and approximately 1.7 km of conveyance (ditch or pipe) to convey the water to the head pond. Given this topography there are a number of considerations that make diverting Spruce Creek into the upper head pond challenging:

- Construction of the conveyance may be challenging due to steep side-slope topography at the required intake elevation.
- Soils are very permeable gravels which would make a diversion ditch relatively porous and may even require a liner.
- An intake structure on Spruce Creek may be challenging due to high sediment load and frequent floods and variable flows resulting from upstream placer mining operations.

Preliminary estimates suggest that diverting Spruce Creek into the upper head pond could create an additional 2 to 3 GWh/yr of summer energy. Summer energy is of limited to low value to Yukon. Therefore the economic case for an upper diversion of Spruce Creek is difficult to envision at this time under conventional development approaches.

For the purposes of this study, it will be assumed that Spruce Creek will be utilized for the lower power plant only. A small diversion ditch will divert Spruce Creek into the new lower headpond just upstream up the mouth of the creek into Pine Creek.

3.2 Lower Powerhouse Alternatives

Several layout alternatives for the lower power plant were considered to determine the optimal arrangement and to address the physical constraints of the site. Specifically lower powerhouse locations and associated penstock alignment options were evaluated. The potential layout alternatives were developed based on on-site observations, topographic mapping and land ownership. Five potential powerhouse locations were identified jointly by the project team and ATELP. These options are shown on Figure 3-1.

Table 3-1 provides a qualitative evaluation of the project layout options for the lower power plant for a number of considerations. Location “E”, located on the Pine Creek fan near the Monarch Mountain trail parking lot was selected for preliminary design. This location was selected for the following reasons:

- Develops the maximum head for the site (maximize power potential)
- Penstock alignment largely avoids land tenure conflicts and powerhouse location largely avoids other potential land use conflicts.
- Site appears to be technically suitable from a construction perspective
- The hillside above the selected site provides opportunity for development of the required surge facility.

Figure 3-1: Lower Powerhouse & Penstock Alternatives

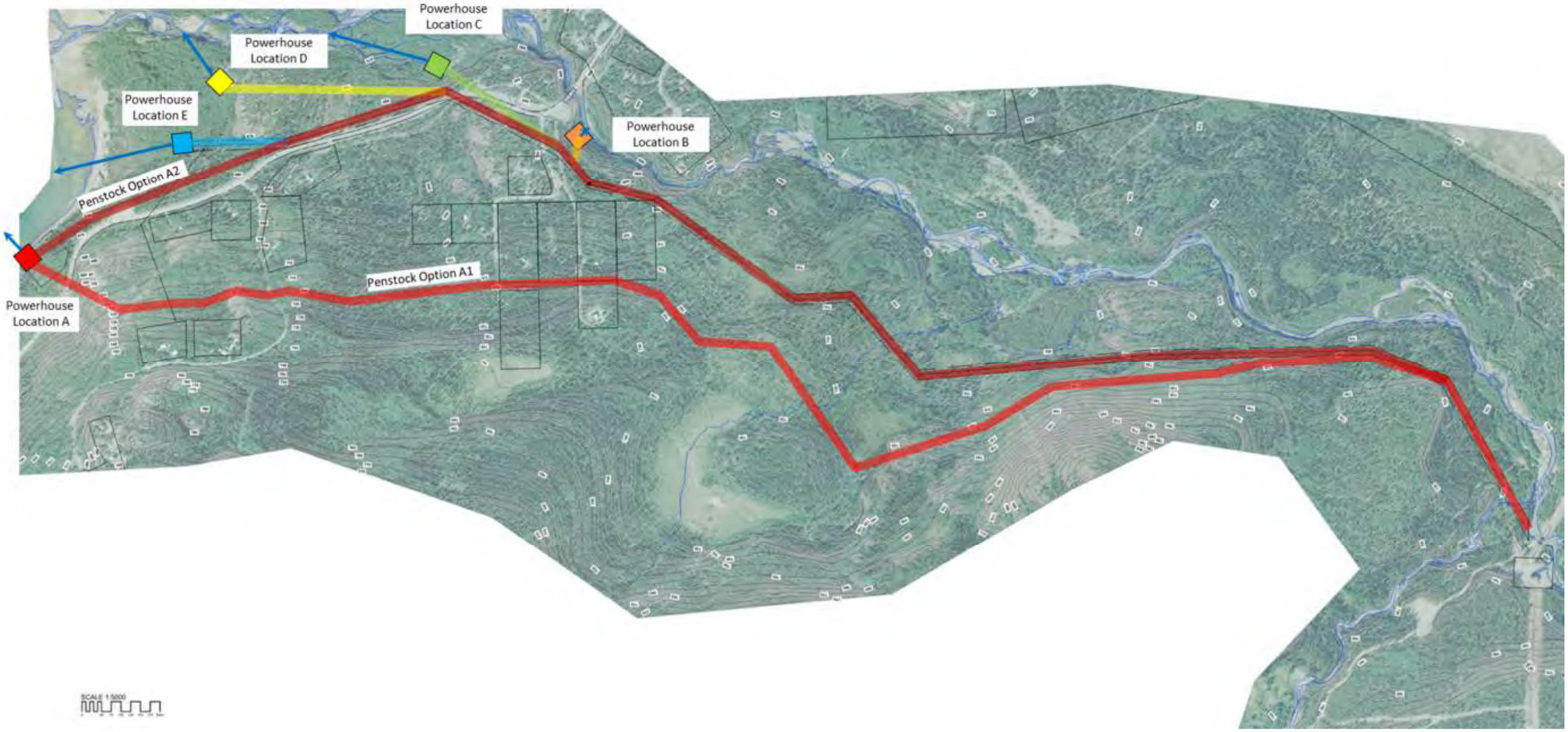


Table 3-1: Lower Powerhouse & Penstock Alignment Options

Green indicates Best for parameter, Red indicates Worst for parameter. **Bold** indicates preferred option.

Powerhouse Location	A. Atlin Lake		B. Pine Creek Above Bridge	C. Pine Creek Below Bridge	D. Upper Pine Creek Fan	E. Lower Pine Cr. Fan
Penstock Alignment	A1. Upper Alignment	A2. Lower Alignment along Warm Bay Road	B. Lower Alignment to Pine Creek Bridge	C. Lower Alignment to below Campground.	D. Lower Alignment to Pine Cr. fan	**E. Lower Alignment to Pine Cr. fan**
Penstock Length	4.4 km	4.4 km	3.0 km	3.4 km	3.8 km	**4.0 km**
Penstock Constructability	• Greatest length of potentially poorly drained/swampy soil • Significant lengths of side hill construction in rock • Significant rock work at end of alignment (Monarch Mt. Trail area)	• Less side hill & rock construction • Less poorly swampy areas crossed • Requires construction of 1.0 km along Warm Bay Road (either in ditch or under road surface)	• Less side hill & rock construction • Less poorly swampy areas crossed. • Does not cross Warm Bay Rd.	• Less side hill & rock construction • Less poorly swampy areas crossed.	• Less side hill & rock construction • Less poorly swampy areas crossed.	**• Less side hill & rock construction** **• Less poorly swampy areas crossed.**
Penstock Alignment Land Ownership	Likely land conflicts both at S. Pine Creek Drive and potentially along Art Centre Rd.	Avoids land conflicts – route pass below (north) of S. Pine Creek Dr. properties. Possible issues with constructing in Warm Bay Rd. right of way.	Avoids land conflicts – route pass below (north) of S. Pine Creek Dr. properties	Avoids land conflicts – route pass below (north) of S. Pine Creek Dr. properties	Avoids land conflicts – route pass below (north) of S. Pine Creek Dr. properties	**Avoids land conflicts – route pass below (north) of S. Pine Creek Dr. properties**
Gross Head	57.5 m (Lake elev. 667.5)		42 m (Creek elev. 683)	47.5 m (land surface elev. 676.5)	52.5 m (land surface elev. 671.5)	**56m** **(land surface elev. 669)**
Powerhouse Constructability	Hillside, sand and gravel over bedrock. Site is small but likely adequate.		Site is very small and difficult to access. Will likely require building powerhouse into hillside and bedrock excavation	Adequate space, extensive sand and gravel, well drained. Possible near-surface bedrock at base of hill.	Adequate space, extensive sand and gravel, well drained. No bedrock. May require creek deflection berm to prevent migration of creek into powerhouse area.	**Adequate space, extensive sand and gravel, well drained.** **Possible near-surface bedrock at base of hill.**
Tailrace Considerations	Excavation of tailrace in lake required (to accommodate lake level fluctuations		Negligible – direct discharge to creek	Requires 270 m long excavated tailrace in sand and gravel to Pine Creek.	Requires 100 m long excavated tailrace in sand and gravel to Pine Creek.	**Requires 200 m long excavated tailrace in sand and gravel to Atlin Lake**
Proximity of Private Property	Nearest residence: 400m.		160 m to campground and 110m nearest residence on S. Pine Drive and	100 m to campground. 320 m to nearest residence on Pine Dr. and S. Pine Dr.	330 m to nearest residence on Warm Bay Rd. 680 m to campground.	**220 m to nearest residence on Warm Bay Rd.**
Recreational Impacts	Likely conflicts/issues with crossing Monarch Mt. Trail		Potential construction noise/visual impacts to campground & neighbors	Potential construction noise/visual impacts to campground	No significant conflicts identified.	**Tailrace constructed through Pine Creek beach**

3.2.1.1 Upper Powerhouse Alternate Arrangement

There is a set of rapids on Pine Creek immediately upstream of the current head pond. Further upstream of the rapids, Pine Creek has been heavily disturbed and flows through approximately 5 km of placer gold mine workings. Between the upper end of the placer mining area and the existing head pond, the creek drops approximately 65 m. Therefore additional head potential exists upstream of the current plant. An alternative arrangement for the upper powerhouse has been identified as described below, but this option has not been assessed in detail as part of the current study. Generally, components of this alternate arrangement are described as follows:

There is an old diversion canal that at some time in the last century intercepted Pine Creek upstream (east) of the placer mining area and diverted the creek around the mines. Remnants of the diversion channel are clearly visible on the south side of the valley and the former canal comes within 1.5 km of the current head pond.

An alternative arrangement could be developed that would utilize the additional 65 m of head. This alternative arrangement could consist of intercepting Pine Creek upstream of the placer mines, building a 7.5 km long power canal following the old canal, plus a new 4.3 km penstock from the end of the power canal to the existing powerhouse (see Figure 3-2). This arrangement would require an entirely new penstock (the existing penstock could not be used due to higher pressures associated with the additional head) plus entirely new turbines to utilize the full flow and higher head. This would result in the existing infrastructure (head pond, penstock and powerhouse) being largely un-utilized.

Figure 3-2: Upper powerhouse alternate arrangement

There are two advantages to the alternate arrangement:

1. Increased annual energy production—depending on the specific installed capacity, it could produce on the order of an additional 17 GWh/yr of energy (on top of the energy production of the proposed layout); and
2. A potential reduction in frazil-ice related issues by avoiding the set of rapid upstream of the current head pond. It is suspected that this reach is generating most of the frazil ice that reaches the existing upper headpond.

The drawback of this alternate arrangement is the existing investment would not be well utilized. The existing plant would only be used for limited generation during late summer/fall months if there is surplus water in the creek and if there are outages on the new power plant.

The costs and technical challenges of this alternate arrangement, plus financial implications should be assessed at the next phase of study before advancing the final scheme for the hydro expansion project to feasibility level study.

4 HYDROLOGICAL AND POWER STUDIES

This section presents an analysis of the hydrology of Pine Creek watershed for the purpose of expanding hydroelectric generation in Pine Creek. The goal of the project is to increase energy generation by (1) developing additional head below the existing powerhouse (including the Spruce Creek catchment), and (2) optimize storage in Surprise Lake to maximize winter energy generation that is highly valuable to the Yukon.

The Atlin Tlingit Economic Limited Partnership (ATELP) currently owns and operates a 2.1 MW hydroelectric generation facility that utilizes flows in Pine Creek. The Atlin Hydro Expansion Project considers the possibility of increasing power generation on Pine Creek by developing additional head, expanding the existing facility and optimizing the storage in Surprise Lake to maximize winter generation. Surplus energy would be delivered to Yukon via a transmission line connecting Atlin to Jakes Corner.

The outflows of Surprise Lake are controlled by an overflow rock fill weir and a low level outlet operated with a slide gate. Water from Surprise Lake seasonally overtops the weir at the outlet. Otherwise, minimum flows are maintained in Pine Creek year-round with a fishway.

4.1 Hydrological Study

4.1.1 Geographic Setting and Climate

Pine Creek is located near Atlin in north western British Columbia. The regional climate of the catchment spans three different Biogeoclimatic Zones (Boreal White and Black Spruce, Spruce-Willow-Birch and Alpine Tundra). The nearest and continuously active meteorological station is located in Atlin (Environment Canada Station #1200560). This station is located approximately 7 km from the Pine Creek catchment at an elevation of 673.6 m ASL.

The Atlin station has records of daily temperature and precipitation beginning in August, 1905 to the present day. According to the 1980-2010 Canadian Climate normal set by Environment Canada, the station receives 365 mm of annual precipitation, with 201 mm falling as rain. Mean monthly temperatures fluctuate seasonally between -12.8°C (January) to 13.4°C (July) with a mean annual temperature of 1.1°C. The total monthly precipitation and mean temperature for Atlin are shown in Figure 4-1.

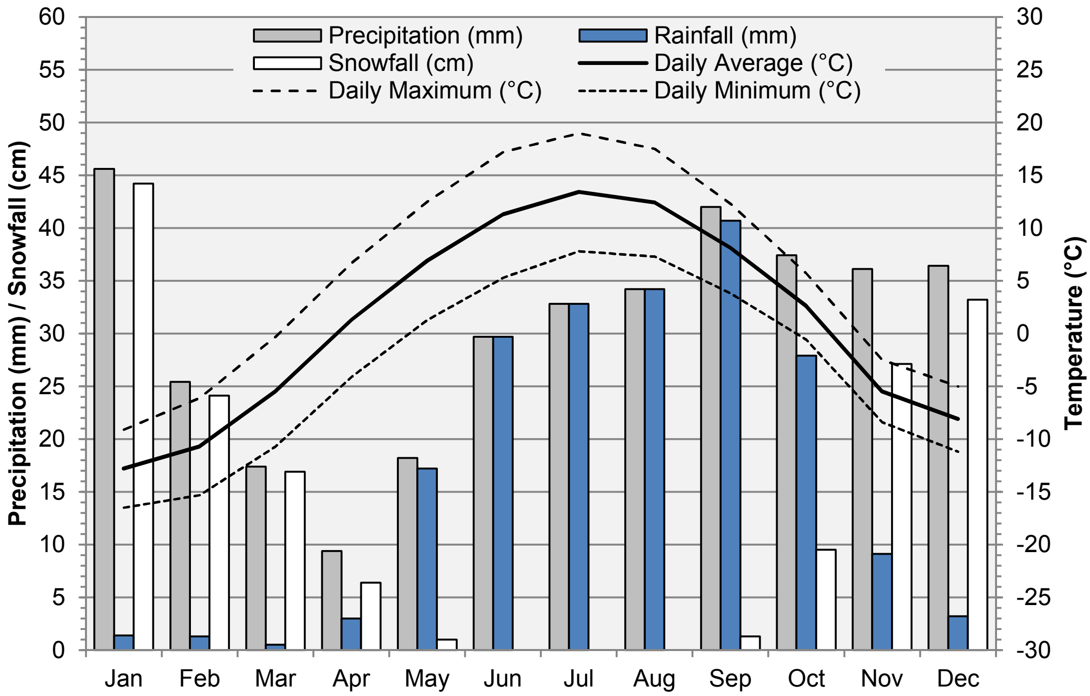


Figure 4-1: 1981 to 2010 climate normals for Atlin, BC (Environment Canada Station #1200560).

4.1.2 Previous Studies

A hydrological study was completed by PO Sjoman Hydrotech Consulting in 2003. This report was referenced in Sigma Engineering Hydrology Report (2006). The findings of this report were the basis for selecting the Gladys River WSC station as a representative data set for developing a long-term synthetic flow series for Pine Creek for the purpose of estimating the power potential of the existing power plant. This study included an assessment of eight Water Survey of Canada (WSC) stations proximal to the region. Due to an inability to retrieve PO Sjoman report, the report was not reviewed or evaluated as part of this assessment.

Sigma Engineering Ltd. completed a Hydrology Report for the Atlin Hydroelectric Project (2006). This report used a comparison of common period of record flows at the Gladys River and Pine Creek to determine a 'calibration factor' of 0.97. This was used to convert flows measured at the Gladys River to flows on Pine Creek at selected points within the catchment. The ratio of average annual unit discharge was used to synthesize flows at the intake location and outlet of Surprise Lake using a scaling factor based on the size of each catchment area. Using this data, the mean annual flow (MAF) was estimated at 4.06 m^3/s at the existing upper intake and 3.4 m^3/s at the outlet of Surprise Lake.

The flow series used by Sigma to estimate the power and energy potential of the site could not be retrieved. Verifications were made in the current study to confirm the selection of Glady's River as the reference hydrometric station to develop a flow series for Pine Creek.

4.1.3 Regional Stations

Five Water Survey of Canada (WSC) stations in proximity of Pine Creek were evaluated for suitability as surrogate flow records of Pine Creek. The catchment areas had to be no greater than four times that of Pine Creek, to be considered representative to develop a long term flow series. Table 4-1 summarizes the WSC stations considered, along with the number of complete years of record, mean annual flows and unit flows. Unit flows per square kilometer provides a way to compare watersheds of different sizes, by comparing flows on a common basis (over one kilometer square). A general description of each WSC station considered in this assessment and its ability to represent flow in Pine Creek is presented hereafter.

Table 4-1: Summary of nearby Water Survey of Canada hydrometric gauging stations.

Station	Name	Drainage Area (km^2)	Period	Complete years of record	Mean yearly flows (m^3/s)	Unit flows ($m^3/s/km^2$)
09AA008	Pine Creek near Atlin	697	1956-1969	10	5.1	0.0074
09AE004	Gladys River at outlet of Gladys Lake	1,910	1961-1993	32	14.8	0.0078
09AA012	Wheaton River near Carcross	864	1966-2011	41	7.9	0.0091
09AA009	Watson River near Carcross	1,150	1956-1973	9	5.1	0.0044
09AB008	McClintock River near Whitehorse	1,700	1957-1994	28	9.8	0.0058

Pine Creek

The Pine Creek station (09AA008) has a catchment area of 697 km^2 and operated near the mouth of Pine Creek on Atlin Lake from 1956 to 1969. There is 10 years of complete data between 1956-1961 and 1966-1969. Daily discharge records from this station represent all flows that originate within the project area. Daily mean discharges were selected from complete-year records and used as the basis for evaluating the ability of other regional stations to represent flows within this catchment. Mean annual discharge for the complete-year record is 5.1 m^3/s, representing an area-unit flow of 0.0074 $m^3/s/km^2$.

Gladys River

The Gladys River station (09AE004) is the catchment located immediately to the east of the Pine Creek basin. The record from this gauge location extends from 1961 to 1993 and contains 30 years of complete daily records. The station is located near the outlet of Gladys Lake and has mean annual flow of 14.8 m^3/s, with a unit flow of 0.0078 $m^3/s/km^2$. The Gladys River's catchment contains a similar percentage of surface water area as Pine Creek.

Wheaton River

The Wheaton River station (09AA012) is located approximately 90 km to the northwest of Atlin. Continuous daily flow measurement began at this station in 1966 and continues to the present. The station has a drainage area of 864 km^2 comprised primarily of high elevation terrain. Annual discharge at this gauge is dominated by snowmelt and rain events during the spring. No lakes, ponds or other surface water features that provide storage are present within the Wheaton River catchment.

Watson River

Also located to the northwest of Atlin, the record from the Watson River station (09AA009) spans 20 years between 1956 and 1973. This station represents a drainage area of 1,150 km^2 and has a mean annual discharge of 5.1 m^3/s. Similar to the Wheaton River, the Watson river catchment is dominated by upper elevation terrain but represents a much larger catchment area.

McClintock River

The McClintock River is located approximately 92 km to the north of Atlin, BC, with daily flow data collected between 1957 and 1994. The station represents a drainage area of 1,700 km^2 and has a mean annual flow of 9.8 m^3/s. This station was primarily considered as an alternative to represent flows from parts of the Pine Creek catchment that are not affected by the storage of Surprise Lake. This includes the areas that drain into Spruce Creek and the inflows into Surprise Lake.

A comparison was made between the five gauging stations over the common period of record from 1966 to 1969. Unit hydrographs averaged over the four years were plotted to compare the behavior of each catchment over the year.

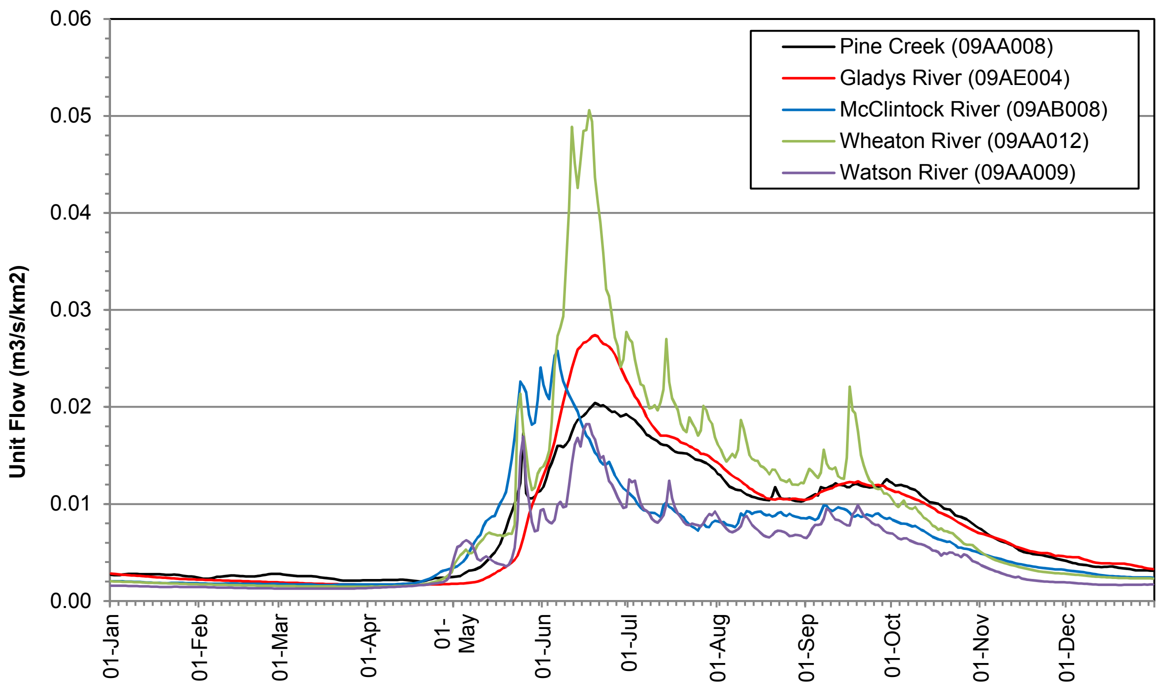


Figure 4-2: Mean daily unit flow comparison for selected regional WSC stations over the common period of record, 1966-1969.

The McClintock and Watson Rivers were rejected since their unit flow is significantly lower than the reference Pine Creek station’s unit flow. A comparison of the Wheaton River flows with the Pine

Creek and Gladys River flows was made to determine if it is a suitable reference station for the inflows to Surprise Lake (i.e. un-routed flows to the lake). Figure 4-3 shows the unit yearly hydrographs for the three stations over the common period of record.

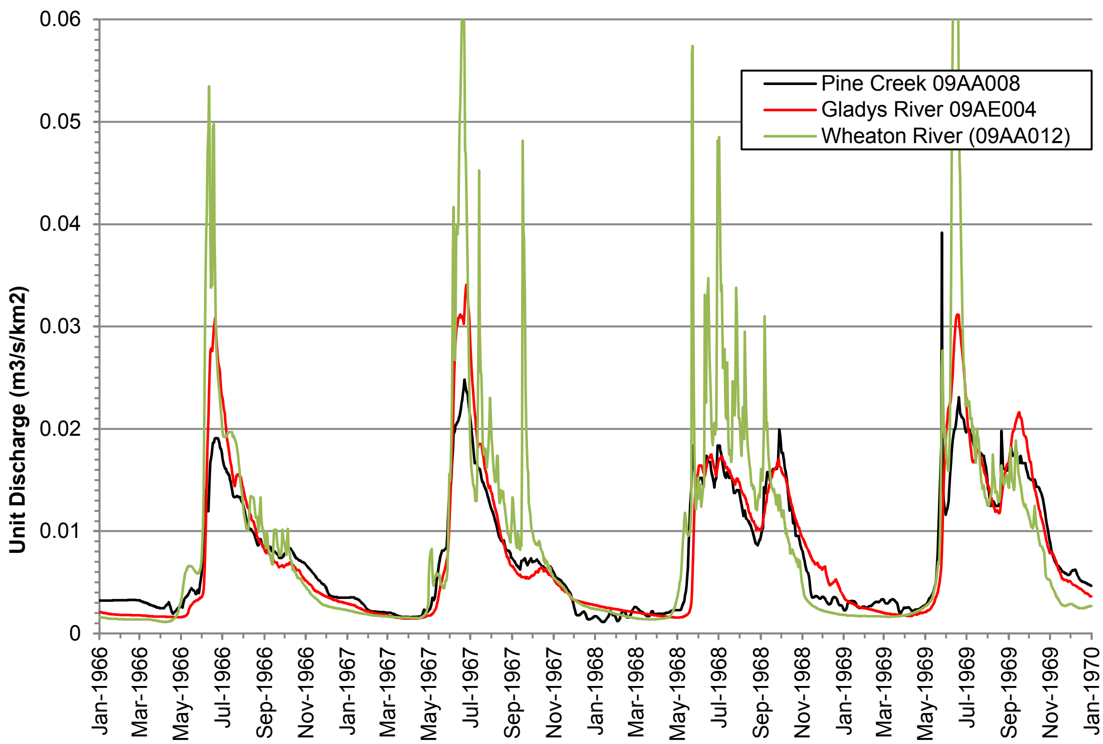


Figure 4-3: Daily unit flows for the period-of-record, 1966-1969

The Gladys River station is considered the most suitable station to develop long-term synthetic flow series in Pine Creek. Although the Wheaton River could also have been suitable to develop and inflow series to Surprise Lake based on the previous comparison, the Gladys River is retained for the following reasons:

- Use of Gladys River in previous hydrometric assessment for the purposes of electrical generation;
- Similarity of unit flows for Pine Creek and Gladys River (see Table 4-1);
- Both Gladys River and Pine Creek gauging stations capture water discharging from large surface water body at a similar elevation (Surprise Lake and Gladys Lake);
- Gladys River catchment is located adjacent to Pine Creek with the gauging stations located approximately 60 km from one another. Each station also demonstrates a similar timing of freshet and response to regional precipitation events.

4.1.4 Development of the flow series

A long-term flow series for Pine Creek was developed using the Gladys River flow record as described above. Flows from Gladys River were transferred directly to the various sub catchments of Pine Creek based on a ratio of catchment areas. Gladys River has generally higher summer flows than Pine Creek over the 4 years of common record (Figure 4-3) while flows during the fall and winter are generally lower. This is likely due to the larger percentage of the catchment that Surprise Lake represents compared to Gladys Lake, thus providing more significant routing of inflows. Continuous flow gauging on Pine Creek will allow to improve the quality of the inflow series and firm up power estimates. Overall Gladys River has a unit flow per kilometer square that is about 5% higher than Pine Creek. The Gladys River flow record is however more recent thus may capture better the potential effects of climate change on the catchment. At this stage of study and based on the available data, Gladys River represents the best proxy station to use to determin the power and energy potential of the Atlin Hydro Expansion Project.

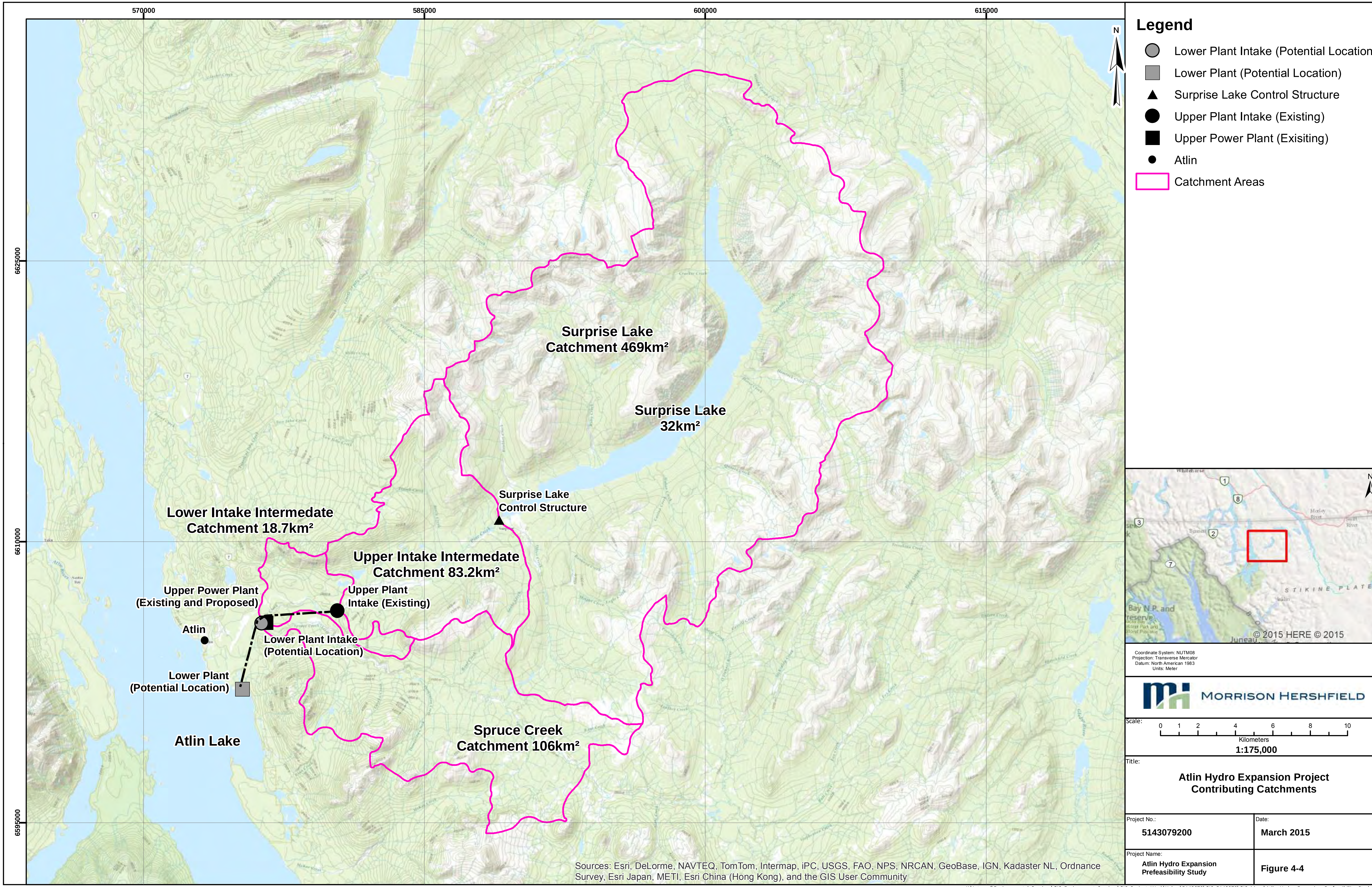
Inflows to Surprise Lake were first determined, following by inflows from the different intermediate sub-catchments. This approach is consistent with the one taken in previous hydrological studies of the Pine Creek catchment.

The proposed layout of the Atlin Hydro Expansion Project is presented in detail in Sections 3 and 5, as well as on the drawings in Appendix A. Based on the proposed layout, flows were determined at the following locations along Pine Creek to simulate the power and energy generation potential of the project:

- Surprise Lake at its outlet;
- Upper head pond/intake (existing, for the upper power plant);
- Lower head pond/intake (new, for the lower power plant);

Figure 4-4 illustrates the contributing catchments to each location. Inflows to Surprise Lake will be regulated based on the selected management scheme, while flows originating downstream of Surprise Lake will be unregulated. Both head ponds have minimal storage capacity and as a result is neglected in the power generation analysis.

The total catchment area at the outlet of Surprise Lake is 470 km^2. The upper and lower plants respectively have catchment areas of 553 and 678 km^2 at their intake


570000
585000
600000
615000
6625000
6610000
6595000
N
Surprise Lake
Catchment 469km²
Surprise Lake
32km²
Surprise Lake
Control Structure
Lower Intake Intermediate
Catchment 18.7km²
Upper Intake Intermediate
Catchment 83.2km²
Upper Power Plant
(Existing and Proposed)
Upper Plant
Intake (Existing)
Atlin
Lower Plant Intake
(Potential Location)
Lower Plant
(Potential Location)
Spruce Creek
Catchment 106km²
Atlin Lake
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, iPC, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community
Legend
Lower Plant Intake (Potential Location)
Lower Plant (Potential Location)
Surprise Lake Control Structure
Upper Plant Intake (Existing)
Upper Power Plant (Exisiting)
Atlin
Catchment Areas
STIKINE PLATEA
© 2015 HERE © 2015
Coordinate System: NUTM08
Projection: Transverse Mercator
Datum: North American 1983
Units: Meter
MORRISON HERSHFIELD
Scale:
0 1 2 4 6 8 10
Kilometers
1:175,000
Title:
Atlin Hydro Expansion Project
Contributing Catchments
Project No.:
5143079200
Date:
March 2015
Project Name:
Atlin Hydro Expansion
Prefeasibility Study
Figure 4-4
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Surprise Lake

Synthetic flow records of Pine Creek at the outlet of Surprise Lake were determined by scaling daily flows in the Gladys River between 1963 to 1993 (complete years only) to the Surprise Lake catchment area (470 km^2). This data was then reverse-routed through Surprise to determine an inflow series to Surprise Lake this is used to simulate reservoir operations. The reverse routing exercise was based on methods described by Zoppou (1999) for reverse routing of flows through a surface water body. Corresponding Surprise Lake elevations were determined by a stage-discharge relationship for the outlet of Surprise Lake that is based on measurements made by Yukon Energy Corporation (YEC) at the lake outlet between 1990 and 2006 (by Monty Alfred). Daily inflow volumes were determined by subtracting the outflows from changes in Surprise Lake storage (estimated area of 32 km^2). Daily inflow flow series to Surprise Lake were then routed through Surprise Lake to develop an outflow series. The two outflow series (synthetic and routed) compared well.

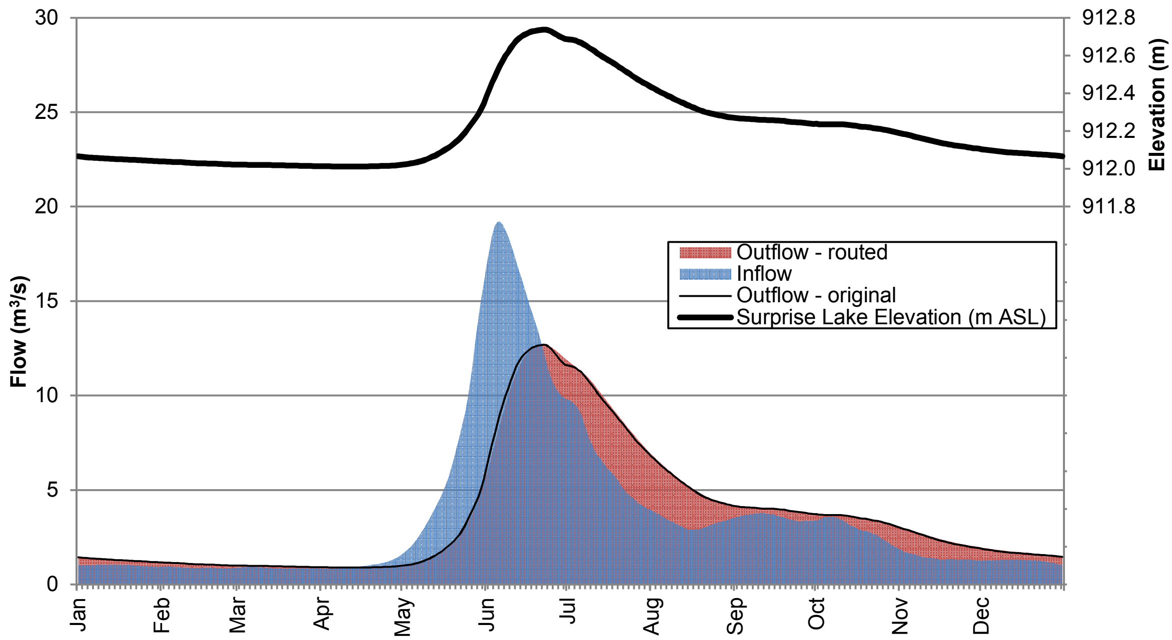
The resulting Surprise Lake inflow series does not reflect the effect of storage in the lake and is therefore considered representative of flows in other reaches of the Pine Creek catchment (i.e. Spruce Creek and intermediate catchment between the different structures) not affected by surface water bodies.

The average monthly inflows and outflows of Surprise Lake are presented in Figure 4-2. Average monthly inflows were calculated from daily inflows to Surprise Lake as a result of the reverse-routing exercise. Surprise Lake outflows were calculated from daily average inflows routed through Surprise Lake considering a natural outlet (without any outlet structure) for verification purposes. A graphical presentation of unregulated average daily flows and Surprise Lake water levels is shown in Figure 4-5.

Table 4-2: Mean monthly inflows and outflows of Surprise Lake, 1963 to 1993 (unregulated).

Month	Inflow (m^3/s)	Outflow (m^3/s)
January	1.1	1.4
February	1.0	1.2
March	1.0	1.1
April	1.1	1.0
May	6.4	2.3
June	14.9	11.0
July	6.4	9.5
August	3.3	5.2
September	3.6	4.0
October	2.9	3.5
November	1.5	2.5
December	1.3	1.7
Annual Mean	**3.7**	**3.7**

Figure 4-5: Surprise Lake synthetic hydrology (unregulated) based on reverse-routing of scaled Gladys River (WSC 09AE004) 1963-1993 hydrometric record.



Intermediate catchments below Surprise Lake

Flow series from the various intermediate sub-catchments below Surprise Lake were determined by scaling the synthetic inflow series to Surprise Lake to each of those catchments. The basin area for the intermediate catchments are presented in Table 4-3 below.

The intermediate catchment of Pine Creek between the Surprise Lake outlet and the upper head pond has a surface area of 83.2 km^2. The resulting average yearly inflows is estimated at 0.7 m^3/s, resulting in a total average yearly inflow of 4.4 m^3/s at the upper power plant intake.

Average yearly flows in Spruce Creek (catchment area of 107 km^2) were estimated at 0.8 m^3/s. Flows were also calculated for the intermediate catchment of Pine Creek between the existing intake and the mouth of Spruce Creek (catchment area of 19 km^2), yielded an average yearly flow of 0.2 m^3/s. The resulting total flow at the lower power plant intake is then of 5.4 m^3/s.

Table 4-3: Contributing catchments for the Upper and Lower Power Plant.

	Catchment	Basin area (km²)	Mean flow (m³/s)
Upper Plant	Surprise Lake	470	3.7
	Intermediate catchment above upper intake on Pine Creek	83	0.7
	Total	**553**	**4.4**
Lower Plant	Intermediate catchment below upper intake on Pine Creek	19	0.2
	Spruce Creek	107	0.8
	Total	**678**	**5.4**

4.1.5 Low Flow Analysis

Minimum flows occur in the late winter and are associated with base flow in the channel. A 7-day low flow analysis of the 2, 5, 10, and 25-year return periods was calculated for the synthetic Surprise Lake inflow and outflow (unregulated) series. This analysis is based on fitting the annual minimum flows for any seven consecutive days to a Log-normal Pearson Type III distribution function. This function is then solved for the associated recurrence probability (0.5, 0.2, and 0.1, 0.05, respectively) to estimate the 7-day low flows. Table 4-4 presents the low flows for Surprise Lake inflows, Pine creek at the outlet of Surprise Lake, Spruce Creek and Intake structures.

The 7-day low flows for the upper intake are slightly greater than previously reported by Sigma Engineering Ltd. (2006). Sigma estimated 1.1 m^3/s, 0.93 m^3/s, 0.85 m^3/s and 0.78 m^3/s for 2, 5, 10 and 25-year return periods using a slightly different methodology. It is expected that differences with the results presented in this report are a function of the different methods applied.

Table 4-4: Summary of 7-day low flow analysis for 2, 5, 10 and 25 year return periods, based on the Surprise Lake synthetic inflow and outflow series.

Return Period (years)		Empirical Probability	Surprise Lake Inflow (m³/s)	Surprise Lake Outlet (m³/s)	Upper Intake (m³/s)	Spruce Creek (m³/s)	Lower Intake (m³/s)
7Q2	2	50 %	1.3	1.0	1.2	0.3	1.6
7Q5	5	20 %	1.1	0.9	1.1	0.25	1.4
7Q10	10	10 %	0.9	0.9	1.1	0.22	1.3
7Q25	25	4 %	0.8	0.9	1.0	0.20	1.3

4.1.6 Flood Analysis

A simplified flood frequency analysis of Pine Creek was conducted to determine floods of different return period at various key locations for the project. Floods were determined at the following locations:

- Surprise Lake control structure (lake outlet)
- Upper head pond/intake
- Lower head pond/intake

The maximum flows at the outlet of Surprise Lake are dependent on the water level management scheme. Two sets of maximum daily annual flows over the duration of the flow series were retrieved: one from the synthetic Surprise Lake inflows and a second from the simulated outflows from Surprise Lake which occur prior to controlled releases from the reservoir (maximum flow between early May and end of October). Each set of maximum annual flows were fit to a Gumbel, Log Normal and Log-Pearson III type probability model. The average flow predicted by all three distribution models was taken as a representative flood flow for the respective return periods.

The flood frequency developed for the Surprise lake inflow series was scaled to the Spruce Creek and intermediate segments of the catchment below Surprise Lake using the respective catchment area ratios. Flood flows from the outlet of Surprise Lake were then combined with intermediate catchment and Spruce Creek flows to determine flood sizes at the Upper and Lower Intakes. The size, probability and return periods of flood flows are summarized in Table 4-5.

The 1: 100 year flood at the Surprise Lake outlet is estimated at 16.4 m^3/s. This flood translates to a 25.5 m^3/s and 39.3 m^3/s flow at the Upper and Lower Intakes, respectively. A number of similarly-sized flows (i.e. 0.8 m^3/s) at the outlet of Surprise Lake were excluded from the analysis since these values more strongly reflect the reservoir management scheme rather than actual peak flood flows at the Surprise Lake outlet.

Table 4-5: Summary of Flood Frequency Analysis for the Pine Creek catchment at the Surprise Lake control structure, Upper and Lower Intakes.

Return Period (years)	**Surprise Lake Control Structure** *(m^3/s)*	**Upper Intake** (m^3/s)	**Lower Intake** (m^3/s)
2	5	9	15
10	10	17	26
20	12	19	30
50	15	23	35
100	16	26	39
200	18	28	43
1000	22	34	53

4.2 Power and Energy Simulations

Simulations were run to estimate the long-term power and energy potential of the Atlin Hydro Expansion Project. The proposed layout of the project is discussed in more detail in Section 3 and 5. The layout is composed of two power plants:

1) The ***upper power plant,*** which includes the existing 2.1 MW facility augmented with a new 2.9 MW plant for a total installed capacity of 5 MW. The upper plant operates under a gross head of 107.6 m.

2) The ***lower power plant*** has an installed capacity of 2.8 MW. It operates under a gross head of 55.5 m. Its head pond is located approximately 200 m downstream of the tailrace of the upper plant.

4.2.1 Surprise Lake Storage

Surprise Lake is the reservoir for the existing power plant on Pine Creek and is currently managed within a 1.05 m operating range. The Atlin Hydro Expansion Project considers an increase in the storage range at Surprise Lake in order to increase and maximize winter energy generation from the system.

It is proposed to increase the Surprise Lake storage range to 2.5 m. Based on an approximate surface area of 32 km^2 for Surprise Lake, it would provide up to 80 Mm^3 of storage. This volumes stores most of the inflows to the lake (except for the summer releases for power generation and for minimum flow requirements), which were estimated to be on average 132 Mm^3 per year over the duration of the flow series.

Modifications to the Surprise Lake Control Structure would be required to accommodate the increase in storage range (discussed in Section 5.1). Table 4-6 summarizes the configuration of the existing and proposed control structure at the outlet of Surprise Lake.

Table 4-6: Parameters of Surprise Lake Control Structure

	Existing Configuration	Proposed Configuration
Overflow weir crest elevation (m)	913.1	913.85
Weir crest width (m)	32	32
Outlet control structure	1.8 m diameter culvert	1.8 m diameter culvert
Full Pond Level (m)	913.15	913.85
Low Pond Level (m)	912.10	911.35
Operational Range	1.05	2.5

The power simulation considers two new power plants. The upper power plant will be located adjacent to the existing generating station and will utilize all of the water available for generating at that site. The location of the lower power plant will be near Atlin Lake and utilize flows from the Pine Creek catchment below the upper Intake and outflows from the upper power plant. The location and layout of the proposed power plants are illustrated in Drawings 01 to 03 in Appendix A. Contributing catchment areas to each plant are presented on Figure 4-4 in Section 4.1.4.

Consideration was also given to a 2 m storage option (911.85 m to 913.85 m) in Surprise Lake for the power simulations. Results for this option are presented for the purpose of evaluating the benefits and environmental challenges of the 2.5 m storage range. The detail methodology for the 2 m storage option is not presented in the report, but similar operation rules as the 2.5 m storage range apply.

4.2.2 Surprise Lake Management

A model was created to simulate the management of Surprise Lake. The following rules and assumptions were incorporated into the model:

1) Maximize winter generation, where the majority of freshet and summer inflows are stored in Surprise Lake and released later in the winter for hydro generation. Summer releases are only to meet the Atlin electrical load (baseline taken as the 20 years forecast) and minimum flow requirements. The Atlin electrical load can be met with power production at both power plants (existing and expansion to upper power plant and new lower power plant). Unregulated inflows from the intermediate sub-catchments below Surprise Lake also provide additional water to both power plants during the summer months;

2) Regulated flow releases for the winter begin on November 1st and last until May 10th. Releases are kept as constant as possible during the winter period, except during the spring when power demand from the Yukon is expected to be lower. The objective is to discharge flows of approximately 6 m^3/s on average from Surprise Lake.

   The objective of the schedule of releases is to draw down Surprise Lake as close as possible to the LSL without going below this level in any of the simulated years. Gate operation rules were developed based on the water level in the lake to meet that objectives. The following gate openings are retained (in % opening):

Lake Elevation > than	% Open
913.85 m	*55 %*
913.60 m	*60 %*
912.10 m	70 %
911.45 m	80 %
911.35 m	25 %

3) The gate opening is set at a 10 % (18 cm) when the reservoir fills in the summer and fall. This opening maintains a minimum flow in Pine Creek of a least 10% of the mean annual discharge (MAD) of 3.7 m^3/s at the outlet of Surprise Lake. Inflows from the intermediate catchment areas below Surprise Lake and above the intake structures contribute additional flow to Pine Creek.

4) Floods are managed as close as possible to the full pond level by opening the low level outlet gate when the water level is above 913.75 m in Surprise Lake (10 cm below the full

pond level). Most floods can be managed without exceeding the full pond level by more than 10 cm.

Surprise lake water levels were simulated for the 2.5 m operational range as a result of the regulated flow releases for 30 years of synthetic flow records (1963 to 1993). Figure 4-6 and Table 4-7 presents the average yearly Surprises Lake water levels, inflows and outflows over the duration of the flow series. Maximum storage occurs in late October. The lake is drawn down to within 10 cm of the low pond level typically in early May, prior to lake infilling. Surprise Lake water levels for the entire simulation period are illustrated in Figure 4-7.

Surprise Lake reaches the full pond level in 23 of the 31 years of simulation. In the years when lake levels do not reach the full pond level, they are at least within 0.2 m with the exception of 1978 (the driest year). Management of Surprise Lake causes water levels to be drawn down in the spring to a level close to the low pond level and varies between 911.35 m and 911.5 m, depending on the timing of the start of reservoir infilling during the freshet. Water spills above the crest of overflow weir during the late summer and early fall in approximately one-half of the simulated years. This is a result of Surprise Lake reaching the proposed full supply elevation of 913.85 m.

Figure 4-6: Average yearly Surprise Lake operations for the proposed 2.5 m operational range.

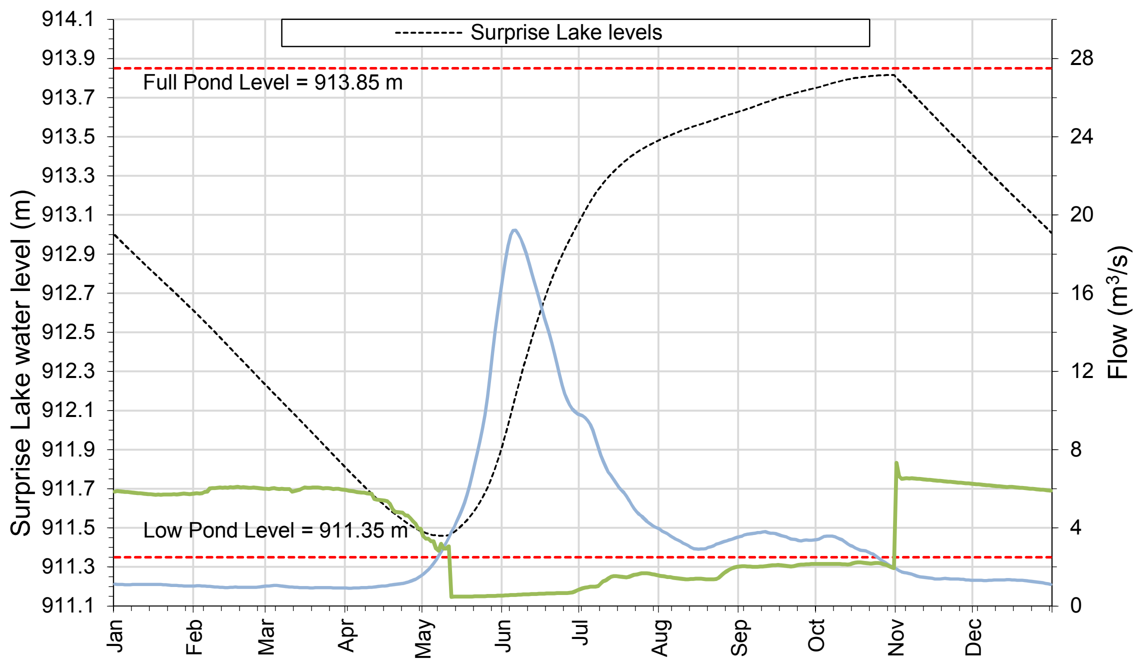
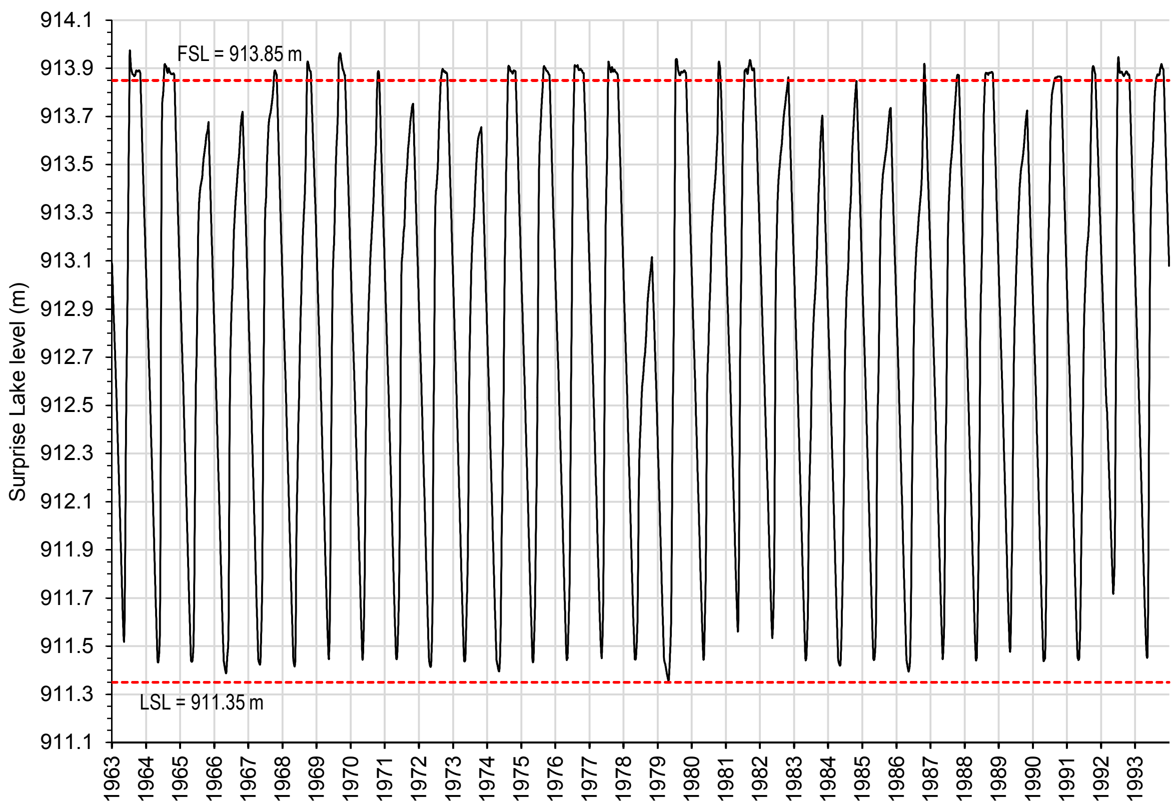


Table 4-7: Mean monthly Surprise Lake water levels, inflows and outflows during the simulated period

Month	Surprise Lake Level (m)	Inflows (m³/s)	Outflows (m³/s)
January	912.8	1.1	5.8
February	912.4	1.0	6.0
March	912.0	1.0	6.0
April	911.6	1.1	5.2
May	911.6	6.4	1.4
June	912.6	14.9	0.6
July	913.3	6.4	1.4
August	913.6	3.3	1.5

September	913.7	3.6	2.1
October	913.8	2.9	2.2
November	913.6	1.5	6.4
December	913.2	1.3	6.1

Figure 4-7: Simulated Surprise lake water levels under proposed 2.5 m operational range.



4.3 Power Generation

A power generation model was created to estimate the power and energy potential of the Atlin Hydro Expansion Project. The results that are presented in this section are for the total installed capacity on Pine Creek, including the existing 2.1 MW power plant.

Upper power plant

The existing 2.1 MW power plant is located approximately 10 km downstream of Surprise Lake on Pine Creek. The upper power plant has a gross head of 107.6 m and bypasses a reach of Pine Creek with a steep gradient containing several waterfalls. The proposed development is to construct an additional power plant adjacent to the existing 2.1 MW plant. A new penstock will convey water from the existing upper head pond to the new power plant adjacent to the existing plant and will operate under the same head. A new intake structure will be constructed in the existing upper head pond.

The power simulations for the upper plant include the operation of the existing and proposed power generation facilities. The power simulation of the upper power plant is a function of the synthetic flow series and management of the reservoir (Surprise Lake), with an additional contribution from the intermediate catchment between the outlet of Surprise Lake and the Upper Power Plant intake. The average yearly inflow to the upper intake is estimated at 4.4 m^3/s. A flow duration curve is also presented in Figure 4-8.

The existing plant is currently operated with a 1.22 m (48 inches) diameter high-density polyethylene (HDPE) diameter penstock that conveys water to the 2.1 MW power plant that operates under a turbine flow of 2.45 m^3/s. Based on the flow duration, a total turbine flow of 6 m^3/s is selected for the upper plant (existing and new plant combined) which corresponds to a flow with approximately 30% exceedance. The new upper plant will then have a turbine flow of 3.55 m^3/s which leads to an installed capacity of 2.9 MW. A new 1.52 m (60 inch) diameter HDPE penstock will convey water from the upper head pond to the new upper plant. Head losses were estimated for both friction along the penstock and at various singularities along the system. A Manning's coefficient of 0.010 was selected for the HDPE penstock.

A conservative constant 85% turbine efficiency was used for the power simulations. Higher turbine efficiency can however be achieved under optimal operating flows especially for Francis and Pelton turbines. The proposed Turgo turbines for the upper power plant expansion will however have a slightly lower efficiency. Detail turbine efficiency curves will be obtained from suppliers in the feasibility study and power simulations will be conducted with varying efficiency based on the operating flows to firm up the power estimates.

Power production simulation parameters and assumptions for the upper power plant are summarized in Table 4-8.

Lower power plant

The lower power plant will have a new intake constructed approximately 200 m downstream of the upper power plant tailrace. It will capture the inflows coming from Spruce Creek through a small diversion of the creek into the new lower head pond. A new penstock will convey water approximately 4 km to the lower power plant located adjacent to Pine Creek approximately 200 m upstream of its mouth on Atlin Lake.

Power simulations for the lower power plant utilized the regulated flows from the upper power plant (turbine flow and residual spill), and the unregulated flows from the intermediate catchment between the upper head pond and Spruce Creek, and from Spruce Creek itself. The average yearly flow at the lower intake is estimated at 5.4 m^3/s. A flow duration curve for flows at the lower power plant intake is presented in Figure 4-8.

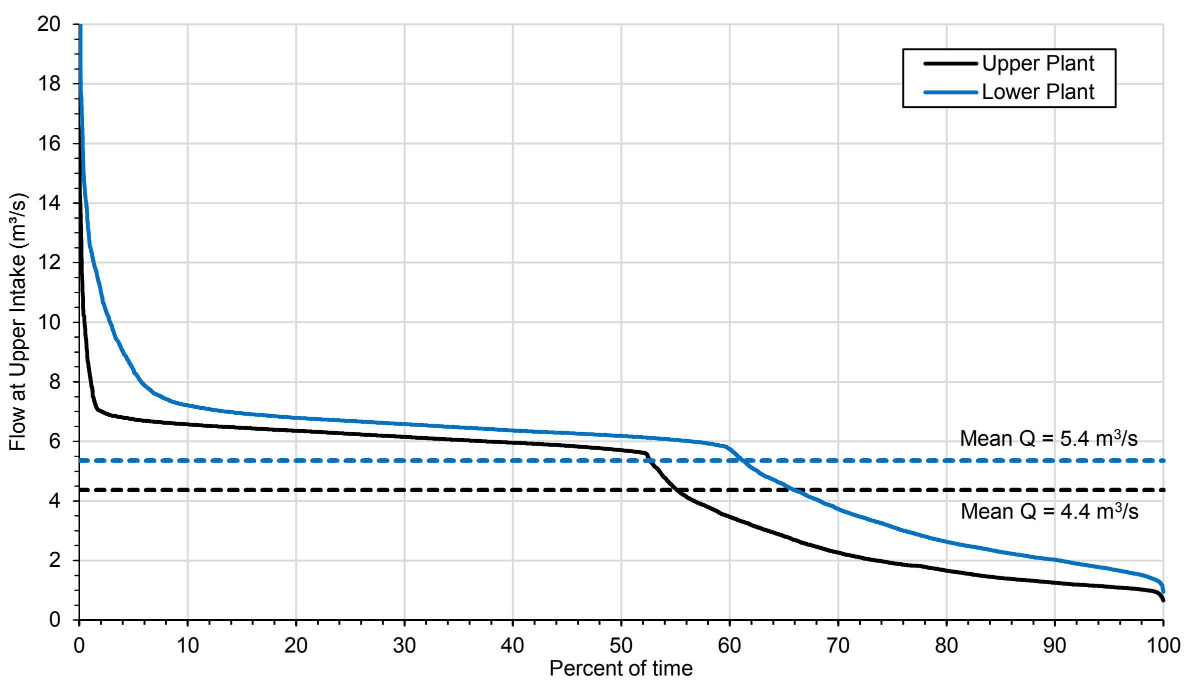
Based on the flow duration curve a turbine flow of 7 m^3/s is selected, which corresponds to a flow with approximately 20% exceedance. The new lower power plant will operate under a gross head of 55.5 m, which leads to an installed capacity of 2.8 MW. Two 1.52 m (60 inches) diameter HDPE penstock will convey water from the new lower head pond to the lower power plant. Head losses were estimated for both friction along the penstock and at various singularities along the system. A Manning's coefficient of 0.010 was selected for the HDPE penstock.

Power production simulation parameters and assumptions for the lower power plant are summarized in Table 4-8.

Table 4-8: Design Parameters and Assumptions for the Upper and Lower Power Plant.

Element	Upper Plant	Lower Plant
Gross Head	107.6 m	55.5 m
Penstock Size	1.5 m diameter (HDPE)	2 x 1.5 m diameter (HDPE)
Maximum Flow Velocity	2 m/s	2 m/s
Head Losses	Friction: 4.3 m Singularities: 3.0 m Total: 7.3 m	Friction: 4.2 m Singularities: 3.0 m Total: 7.2 m
Average yearly flow	4.4 m^3/s	5.4 m^3/s
Environmental Flow (10% MAF)	0.44 m^3/s	0.54 m^3/s
Turbine Flow	Existing Plant: 2.45 m^3/s New: 3.55 m^3/s Total: 6 m^3/s	New: 2 x 3.5 m^3/s Total: 7 m^3/s
Installed Capacity	Existing: 2.1 MW New: 2.9 MW Total: 5.0 MW	New: 2 x 1.4 MW Total: 2.8 MW
Turbine Efficiency	85%	85%

Figure 4-8: Flow duration curve for Upper and Lower Power Plant.



4.4 Simulation results

Power and energy generations were estimated on a daily basis at each power plant. A minimum flow of 10% of the mean annual flow at each plant is discharged from the head pond year-round. Monthly results were compiled for presentation in the report.

Figure 4-9 and Table 4-9 presents monthly power and energy generation for each plant. Figure 4-10 presents the total yearly generation over the duration of the 31-year synthetic flow series. This flow series does provide indication of the variability of power generation relative to the average power production. A low-flow assessment is also provided in Section 4.5 which gives indication of the firm power production. A more comprehensive percentile assessment of generation will be completed as part of the feasibility study and will be supported by flow data collected on Pine Creek since 2014.

Upper power plant

The mean annual power for the upper power plant is estimated 3.2 MW for an average capacity factor of 63%. The mean monthly capacity factor varies between close to 100% in November and December to as low as 30% in August. This corresponds with the timing and magnitude of controlled releases and infilling of the Surprise Lake reservoir.

Using the simulated flow series for Pine Creek (1963 to 1993), the total mean annual energy generation for the upper power plant is 28.2 GWh and varies between 23.7 GWh and 34.9 GWh over the simulated period.

Lower power plant.

The mean annual power for the lower power plant is 1.9 MW for an average capacity factor of 66%. The average monthly capacity factor varies on average between as high as 90% in November and December, and as low as 35% in August. The capacity factor of the lower plant is generally between 80% and 90% during the winter months.

The mean annual energy generation for the lower power plant is based on the synthetic flow records (1963 to 1993). Simulated mean annual energy generation for the Lower Power Plant is 16.3 GWh and varies between 13.6 and 20.3 GWh over the simulation period. Figure 4-10 presents the yearly total energy generation at the lower plant over the duration of the flow series. The spike in generation that is observed in June is a result of the freshet of the various intermediate sub-catchments below Surprise Lake (between power plants and Spruce Creek).

Figure 4-9: Upper and Lower Power Plant mean monthly power production (MW).

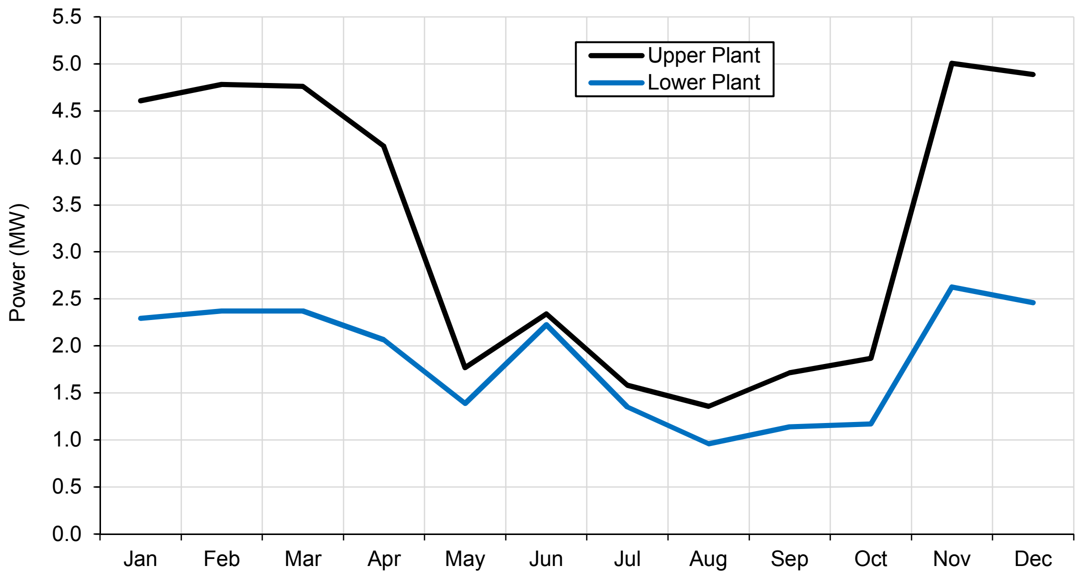
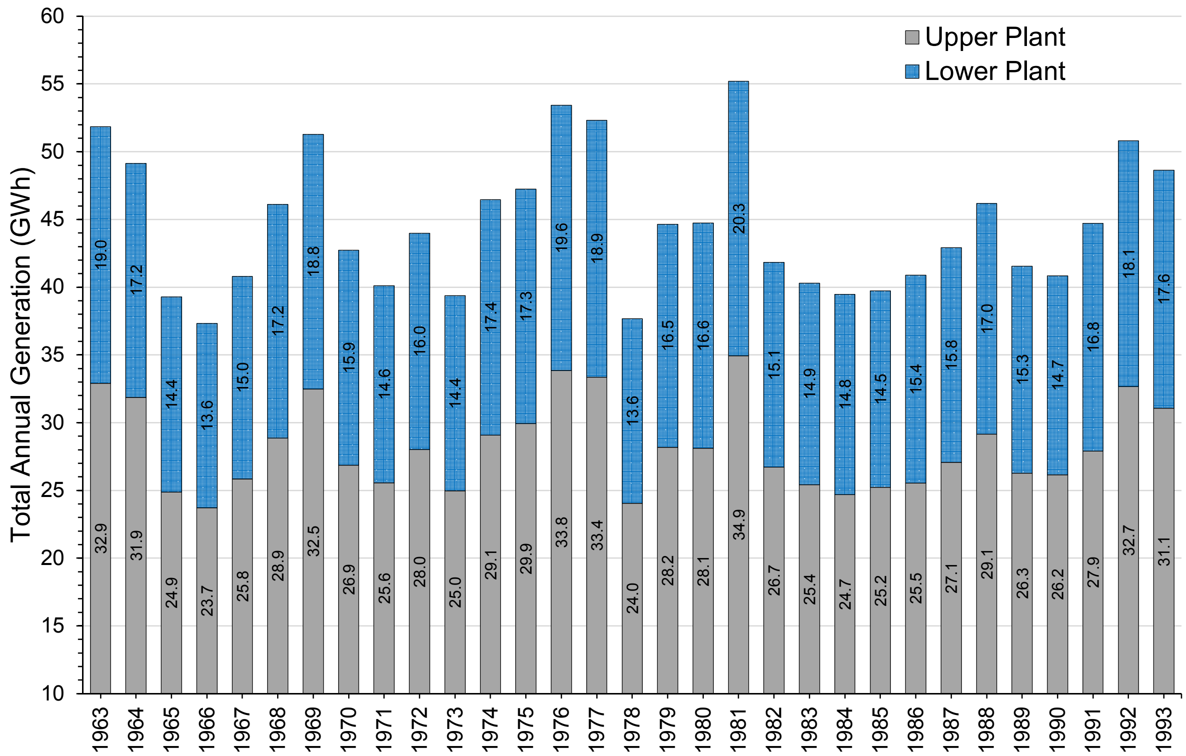


Table 4-9: Average monthly power and energy generation for the Upper and Lower plants (2.5 m storage)

Month	Upper Plant		Lower Plant		Total	
	MW	GWh	MW	GWh	MW	GWh
January	4.6	3.4	2.3	1.7	6.9	5.1
February	4.8	3.2	2.4	1.6	7.2	4.9
March	4.8	3.5	2.4	1.8	7.1	5.3
April	4.1	3.0	2.1	1.5	6.2	4.5
May	1.8	1.3	1.4	1.0	3.2	2.4
June	2.3	1.7	2.2	1.6	4.6	3.3
July	1.6	1.2	1.3	1.0	2.9	2.2
August	1.4	1.0	1.0	0.7	2.3	1.7
September	1.7	1.2	1.1	0.8	2.9	2.0
October	1.9	1.4	1.2	0.9	3.0	2.3
November	5.0	3.6	2.6	1.9	7.6	5.5
December	4.9	3.6	2.5	1.8	7.3	5.5
Annual Average	**3.2**	**28.2**	**1.9**	**16.3**	**5.1**	**44.6**

Figure 4-10: Total simulated annual power generation (GWh) from the Upper and Lower Power Plants.



Comparison with the 2 m storage option

The power and energy generation potential of the Atlin Hydro Expansion Project was estimated for a 2 m storage range in Surprise Lake as a potential alternative to the 2.5 m storage base case presented in this study. A 2 m storage range could either be implemented by raising the new proposed low pond level (thus reducing the required river excavation to accommodate the lower level) or by lowering the proposed new full pond level (thus reducing the increase in the overflow weir height and the increase in the maximum lake level). Average monthly energy generation for the 2 m storage range for both the upper and lower power plants is presented in Table 4-10. The difference in energy generation between the 2.5 m storage option is presented for comparison purposes.

Table 4-10: Average monthly power and energy generation for the Upper and Lower plants (2 m storage)

Month	Upper Plant			Lower Plant			Total		
	Power (MW)	Energy (GWh)	Diff. (GWh)	Power (MW)	Energy (GWh)	Diff. (GWh)	Power (MW)	Energy (GWh)	Diff. (GWh)
January	4.6	3.4	0	2.3	1.7	0	7.0	5.1	0
February	3.8	2.8	-0.4	1.8	1.2	-0.4	5.6	4.0	-0.8
March	3.4	2.5	-1.0	1.6	1.2	-0.5	5.0	3.8	-1.5
April	1.9	1.4	-1.6	1.0	0.7	-0.8	2.9	2.1	-2.4
May	1.6	1.2	-0.1	1.3	0.9	-0.1	2.9	2.1	-0.2
June	2.7	1.9	+0.2	2.2	1.6	0	4.9	3.5	+0.2
July	2.5	1.9	+0.7	1.7	1.2	+0.2	4.1	3.1	+0.9
August	2.0	1.5	+0.4	1.2	0.9	+0.2	3.2	2.4	+0.6
September	2.4	1.7	+0.5	1.4	1.0	+0.2	3.8	2.7	+0.7
October	2.5	1.8	+0.5	1.4	1.0	+0.2	3.9	2.9	+0.7
November	5.0	3.6	0	2.5	1.9	0	7.4	5.5	0
December	4.9	3.6	0	2.5	1.8	0	7.5	5.4	0
Average	**3.1**	**27.3**	**-0.9**	**1.7**	**15.3**	**-1.0**	**4.9**	**42.6**	**-1.9**

The 2 m storage range option in Surprise Lake produces on average 1.9 GWh less energy per year, which only represents a 4.5% drop in generation potential. The main effect of implementing a 2 m storage range compared to a 2.5 m storage range a reduction in the winter energy generation (when most needed by Yukon) and an increase summer generation. The reduction in winter energy is estimated at 4.7 GWh on average, being observed mostly from February to April based on the operation scheme that was defined for the purpose of the simulations.

Further optimization work should be done in the next project phase to determine the benefits of the additional winter energy associated with the 2.5 m operational range compared to the regulatory challenges that may result from a larger storage range on Surprise Lake.

4.5 Power Production Summary

The proposed Atlin Hydro Expansion Project power simulations are a function of synthetic flows developed for Pine Creek that are based on historical hydrometric records scaled from the Gladys River between 1963 and 1993. The simulation maximizes the storage available in Surprise Lake, optimizes generation potential at existing facilities and incorporates additional flows from Spruce Creek and intermediate catchments below the existing intake structures. Two additional power plants were incorporated into a power production simulation of the hydroelectric expansion. This resulted in a total 7.8 MW installed capacity on Pine Creek.

The storage range of 2.5 m in Surprise Lake is considered the most optimal range at this preliminary stage to maximize winter energy generation on Pine Creek. Such a range allows maximum storage of the inflows to the lake during an average hydrological year. The simulations were intended to maximize winter energy generation for the purpose of distributing to Yukon Energy during periods of greater energy demand. Consequently, this operation mode reduces generation in the summer months during the reservoir infilling period. Minimum energy delivery obligation for the community of Atlin (forecast 2032 load) are still met every month of the year over the duration of the synthetic flow series.

Figure 4-11 illustrates the average total monthly generation for the project while Figure 4-12 illustrates the minimum total monthly generation from both power plants combined over the duration of the flow series. It is important to note that careful adjustment of flows from Surprise Lake can be performed to meet, at a minimum, the future energy delivery obligation. Maximum energy generation is achieved in winter months (November through March) and minimum generation occurs in summer months (May through October) during reservoir infilling.

Total average yearly energy generation for the upper and lower power plants combined amounts to approximately 44.6 GWh with an average capacity factor close to 65%. This power simulation represents represent the upper range of generation from Pine Creek.

Figure 4-11: Simulated average monthly generation for the Upper and Lower Power Plant.

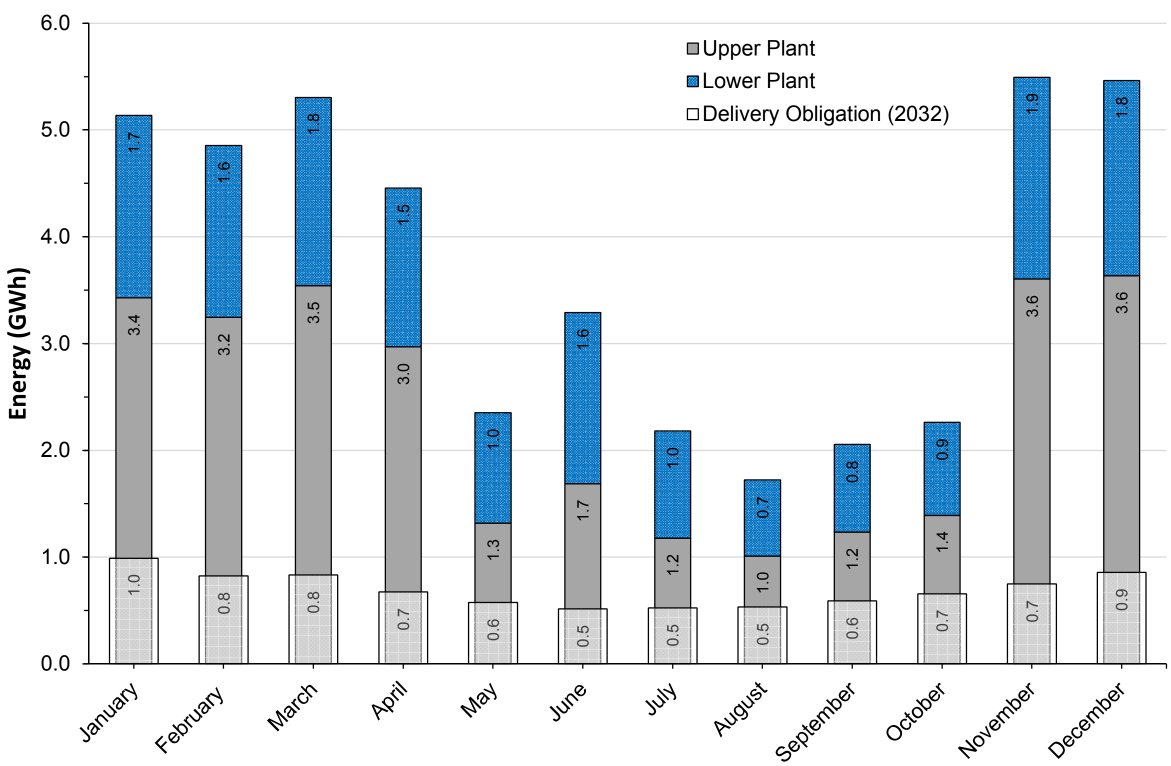
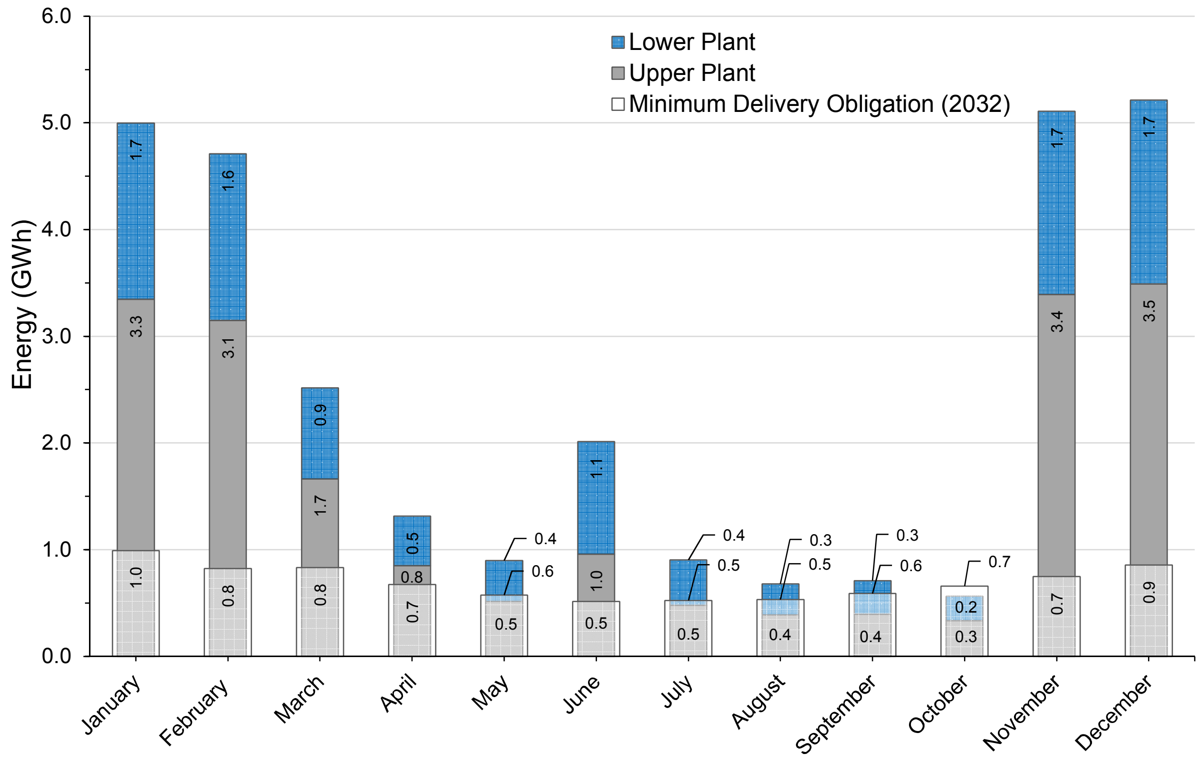


Figure 4-12: Simulated minimum monthly generation for the Upper and Lower Power Plant.



5 PRELIMINARY DESIGN

5.1 Design Criteria and Assumptions

The 1:100 years flood is selected as the design flood for the project at this stage. This corresponds to the inflow design flood recommended by the Canadian Dam Association for dams with a Low level of consequence in case of dam failure (no potential loss of life). Due to the small impoundment volume of both head ponds, it is expected that the effects of a potential dam break would be minimal and would dissipate rapidly as the flood wave migrates down river. This assumption will need to be confirmed in the feasibility study.

A preliminary flood study was conducted and is presented in detail in Section 4. The design flood flows retained for the hydraulic design of the spillway at each works are presented in Table 5-1.

Table 5-1: Design flood flows

Location	Design flow (m^3/s)
Surprise Lake control structure	16
Upper head pond	26
Lower head pond	39

It should be noted that the design flow at the Surprise Lake control structure represents the maximum outflow that can be expected at the lake outlet, considering the routing of inflows through the lake. Design flows for the upper and lower head pond are also based on the maximum outflows from Surprise Lake, with additional unregulated inflows coming from the various intermediate sub-catchments below Surprise Lake. If a smaller storage range at Surprise Lake was to be selected for the project, design flows would likely be increased due to increased spill at the Surprise Lake control structure resulting from the smaller storage volume being held in the lake.

Each of the three locations above will be designed to safely pass the inflow design flood.

Additional design criteria are selected for the water retaining structures.

- Minimum freeboard (embankment dam): 0.5 m (no wave action)
- Minimum freeboard (embankment dam): 1.0 m (potential wave action – Surprise Lake)
- Minimum freeboard (concrete dam): 0.5 m
- Minimum side slope (rock fill): 2H:1V

The Isbash equation was used to determine the appropriate size of rip rap/cobbles that is required to resist flow velocities, at different locations for the project (overflow weir at Surprise Lake control structure and lower head pond, stilling basin at lower head pond, Spruce Creek diversion ditch, etc.). Large quantities of cobbles are readily available near Pine Creek due to extensive placer mining that has taken place in the area. Cobbles can be used in location where fairly flat erosion protection is required. In sloped areas, riprap will need to be produced in order to stay in place. Cobbles would be at risk of rolling compared to angular rock.

The Isbash equation is widely used in engineering applications and relates the mean diameter of rip rap (D_{50} in mm) required to resist a given flow velocity:

$$D_{50} = \frac{V^2}{2g\, C^2 \left(\frac{\gamma_r - \gamma_e}{\gamma_e}\right) \cos\alpha}$$

Where,

> V is the flow velocity in m/s;
> g is the gravitational constant of 9.81 m^2/s;
> C is the Isbash coefficient for turbulence (0.86 for low turbulence, up to 1.2 for high turbulence where hydraulic jumps form);
> γ_r is the specific weight of rock, approximately equal to 2.65 x 9,810 N/m^3;
> γ_e is the specific weight of water, approximately equal to 1 x 9,810 N/m^3;
> α is the angle of repose of rip rap (based on side slope of channel).

Figure 5-1 presents curves for different turbulence coefficients for given velocities. A side slope of 2H:1V was used to determine the angle α, which is the slope proposed for the rip rap.

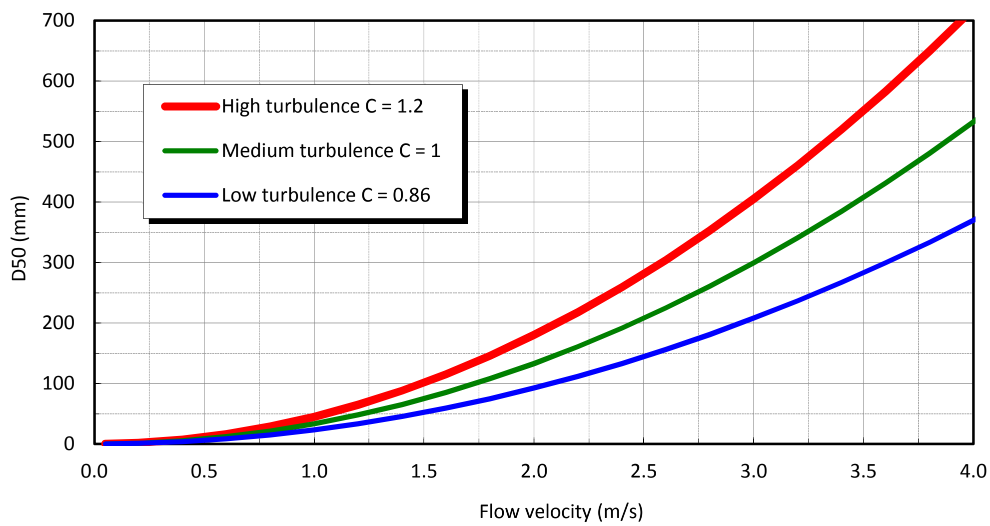


Figure 5-1: Required Rip Rap D_{50} to Resist a Given Flow Velocity

5.2 Surprise Lake Control Structure

The Surprise Lake control structure currently allows the management of water levels in the lake and to control outflows, especially during the winter period. Water is being stored during the summer and fall, and then being released during the winter months for power generation at the existing Upper Plant. The lake is currently managed between the following water levels:

- Existing full pond level: 913.15 m
- Existing low pond level: 912.10 m

1.05 m of storage is currently licensed in Surprise Lake, which is expected to be sufficient to meet the Atlin's electrical load for the next 20 years or more. The hydro project also currently includes a lake storage permits that allows flooding up to 913.85 m on Surprise Lake, which is not currently being fully utilized.

It should be noted that Surprise Lake uses a local datum derived from elevation on top of the concrete wall at the low level outlet intake (elevation of 913.75 m shown on Sigma Engineering as-built drawings). It is believed that this local datum was derived from old benchmarks left by Monty Alfred when doing water surveys more than a decade ago. For consistency between the existing works and operating water levels, it is decided to maintain the local datum at this stage. All licensed water levels refer to this local datum.

It was previously identified in Section 4 that a storage range of 2.5 m would provide an optimal storage range to maximize winter energy generation and store the vast majority of the yearly inflows. Based on a preliminary qualitative assessment of environmental constraints, it was decided to set the new pond level at the 913.85 m value that is current licensed and to develop additional top and bottom storage. The Lake Storage Permit will not require modification; only the Water License will need to be modified or appended to account for the larger storage volume that is being utilized.

The existing Surprise Lake control structure is composed of the following works:

- A ***rock fill overflow weir*** with a crest elevation of 913.15 m. A sheet pile cut-off wall and membrane provide seepage control for the structure. The weir is closed on each side with a higher secondary crest at elevation 914.15 m (1 m higher) than the main overflow section. Large riprap (D_{50} > 500 mm) is protecting the bridge abutments immediately downstream from the overflow weir;

Photo 7: Existing weir at Surprise Lake

- A ***low level outlet*** of 1.8 m diameter pipe on the left embankment, in the small head pond. It is closed with an Armtec vertical sliding gate (operated manually with a gearbox) mounted on a vertical concrete headwall of 0.5 m thickness and approximately 4 m in height. The headwall is founded on a concrete footing of 0.3 m thickness. The current invert elevation of the pipe is at elevation 909.80 m.

Photo 8: Existing outlet structure at Surprise Lake

- A ***fishway*** located on the left embankment, in the small head pond. The fishway is composed of a 1 m diameter culvert that travels under the road embankment. Downstream is a concrete fish passage structure with a total of six basins. Each basin is separated by a baffle that allows the fish to swim through each drop, which are estimated to have an approximate height of 20 to 30 cm. The culvert is permanently open but the fish passage concrete structure can be dewatered by closing the opening in the baffles and/or the downstream gate (operated with a hand wheel). The current invert elevation of the culvert is at elevation 911.10 m.

Photo 9: Existing fishway downstream of Surprise Lake control structure

The change in the full and low pond levels (increase in storage range in Surprise Lake) will require some modifications on the existing structures to effectively retain the water in the lake and discharge water downstream of the structure. The overflow weir will need to be raised, while the low-level outlet may require modification to be operational at higher and lower water levels. The fishway in its current state will remain operational for part of the year, when water levels in the lake vary between the existing storage limits. Additional studies will need to be done to determine the effectiveness of the fishway for higher and lower water levels and if it needs to be operational at all during that period. If required the fishway could be modified to accommodate the new operating water levels. Details about the proposed changes on each the structures are presented below and on Drawing 04 in Appendix A.

Overflow rockfill weir

It is proposed to raise the crest elevation of the rock fill weir from 913.15 m to 913.85 m (0.7 m increase). Additional class 1 riprap (D_{50} of 300 mm) will be placed on the downstream face of the weir while additional cobbles (D_{50} of 200 mm) will be placed on the upstream face of the weir, matching the materials of the existing structure. Class 1 riprap can resist flow velocities up to 3.5 m/s based on Isbash equation, which will be adequate under the inflow design flood scenario. The crest width of the overflow section will remain at 32 m and the longitudinal slopes will also remain the same as for the existing structure (4H:1V) downstream slope and 2.5H:1V upstream slope). To reduce seepage through the raised portion of the weir, it is proposed to extend the sheet-pile cut-off up to the new crest-elevation, by bolting on new sheet-pile onto the existing one. Additional membrane is not deemed necessary at this time. It was installed to prevent against internal erosion (piping) of the structure, and the small increase in the full pond level is not likely to modify significantly seepage flow under the structure.

Modifications to the overflow weir will take place in the dry as much as possible, with the flow being diverted through the low level outlet. Surprise Lake should be near its current low pond level at the time of construction.

Low level outlet

At this stage, it is assumed that the low level outlet will remain operational in its current configuration, with only a few minor modifications. The access catwalk will however need to be raised to accommodate the higher full pond level. The current gearbox will remain in place but will sit lower relative to the water level compared to current conditions but will still remain above the full pond level thus remaining operational.

A cursory verification of the existing vertical slide gate (Armtec) specifications was made. It was determined that the gate can adequately resist the increased pressure head (by up to 70 cm), and can operate adequately also under higher water levels.

The maximum hydraulic capacity of the low level outlet was estimated using the sluice gate equation to confirm that it can discharge the flows required for the project (on average 6 m^3/s during the winter season – see Section 4) for the range of operating water levels. Verification was made first to confirm that friction through the pipe was not controlling the discharge capacity of the low-level outlets. It is assumed that there is no downstream submergence effect at this stage. It will likely require downstream excavation in Pine Creek to lower the downstream water level and ensure an adequate hydraulic capacity near the low pond level. The equation is as follow:

$$Q = C_d A\sqrt{2gH}$$

Where,

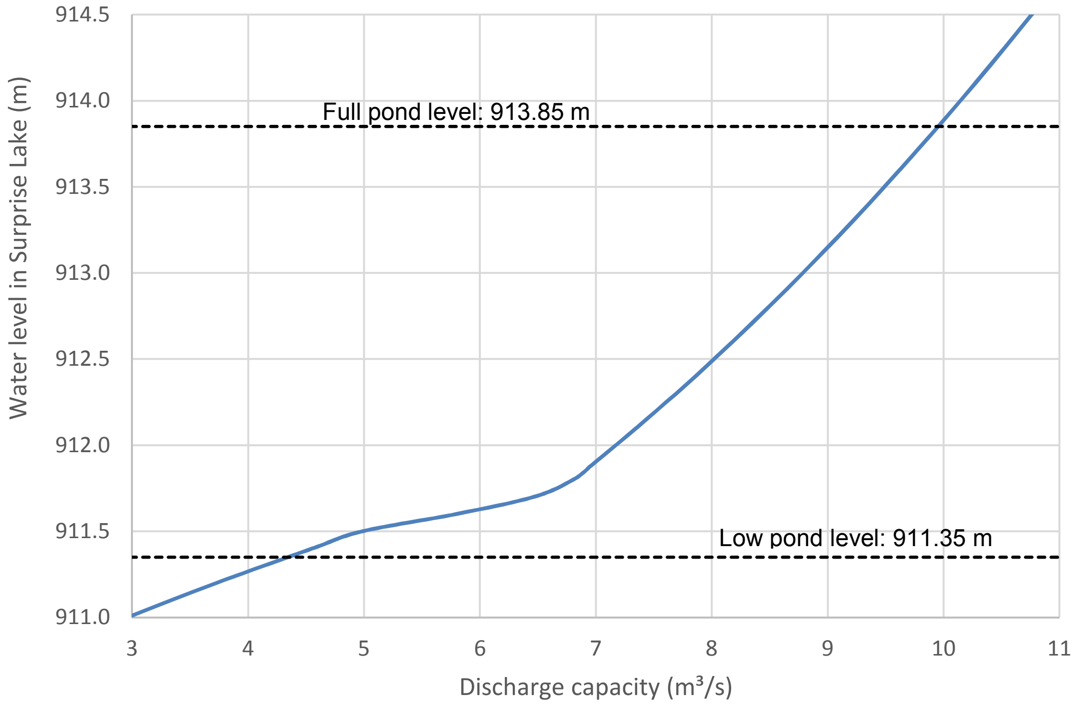
C_d is the discharge coefficient, taken as 0.5;
A is the cross-sectional area of the hydraulic passage;
g is the gravitational constant of 9.81 m^2/s;
H is the head above the invert elevation of the low level outlets (equal to the water surface elevation minus the invert elevation).

Figure 5-2 presents the discharge capacity curve of the low level outlet at full-opening. It should be noted that when water levels dip below 911.6 m (top of culvert), the conduit becomes partially submerged and behaves as open channel flow.

At the full pond level of 913.85 m, the low level outlet has a discharge capacity of approximately 10 m^3/s. Such a discharge capacity will allow for the effective management of floods near the full pond level with minimal increase in water level above the full pond level. With a design flow of 16 m^3/s (1:100 years flood), it means that only 6 m^3/s would pass over the rock fill weir assuming that the gate of the low-level outlet is fully open. This would translate to a maximum water level of approximately 914.1 m.

Near the low pond level of 911.35 m, approximately 4.5 m^3/s could be discharged from the low level outlet assuming no submergence effects. This will require river excavations downstream from the structure. In this case, the low level outlet would be partially submerged and open channel flow equations do apply.

Figure 5-2: Discharge capacity of low level outlet at full opening



Fishway

It is expected that the fishway culvert will be partially dewatered from mid-March to early-June due the proposed new low pond levels (911.35 m, or 0.75 m lower than in current conditions). There will however always be water conveying through the fishway (minimum depth at entrance of 0.25 cm). The fishway would also experience higher discharge and flow velocities when the lake level is above the current full pond level of 913.15 m due to the increased head. Surprise Lake water levels are expected to be higher than this value from early July to early December on average, when the lake is filled to the new full pond level of 913.85 m

At this stage it is assumed that the fishway will remain operational with only a few minor changes to the existing geometry. Modifications of the cross-sectional area of the openings between the basins and/or of the height of the sills are proposed at this stage to improve the efficiency of the fishway. Additional studies will need to be completed to determine if further changes are warranted based on the operation water levels.

Channel excavation

In order to accommodate the new low pond level of 911.35 m, channel excavations will be required both upstream and downstream of the Surprise Lake outlet structure.

In the current configuration, it was reported by ATELP that there is a head difference between the water level in Surprise Lake and immediately upstream of the control structure, when the lake is near its current low pond level of 912.10 m. That head difference is believed to vary between 10 and 20 cm, suggesting that there is a hydraulic control upstream of the structure. This control occurs in the shallow section that is easily seen from shore approximately 60 m upstream of the structure. Remnants and old wooden structure are also seen in the water at this location, contributing to the reduction in the conveyance capacity at this location at low water. The picture below shows this shallow section.

Photo 10: Remains of old wooden control structure at Surprise Lake outlet

An exploratory bathymetric survey was conducted by ATELP in the spring of 2015 to determine the elevation of the river bed at that location. Results showed that at numerous locations the water depth is on average only 0.8 to 1.0 m in the shallow sections (when the lake was approximately at elevation 912.80 m) thus suggesting that the river bed elevation is approximately 912.0-911.8 m. In order to adequately convey the flows in future conditions down to the low pond level of 911.35 m, it is recommended to excavate the lake outlet to elevation 910.35 m to provide a minimum of 1 m water depth. Excavation could take place mostly from shore. If a longer reach is required, either in-water excavation or access with a temporary rock fill berm is possible.

The following approximate ***upstream excavation*** dimensions are selected based on the available information:

- Length: 180 m
- Width: 10 m (assuming limited reach from the excavation equipment)
- Average depth: 2.0 m (1.5 m depth and 0.5 m additional excavation for erosion protection)

The riverbed is believed to be silty at this location such that protection against erosion will be warranted. Maximum flow velocities up to 1.5 m/s can be expected at that location under critical low water conditions. Cobbles with a minimum D_{50} of 100 mm will be adequate at this location. Such cobbles should be readily available in close proximity to the site.

It has also been identified that current water levels downstream of the structure will be too high in future conditions to accommodate the new low pond level. The current tailwater levels are believed to vary between 911.5 m and 912.0 m on average. It is expected water levels below 911.0 m are require to adequately discharge water from the lake when near the low pond level of 911.35 m. River excavations will be required downstream from the structure to lower the tailwater levels by up to 1 m. The picture below shows Pine Creek downstream of the outlet structure, with some riffles in the far end (approximately 100 m downstream of the structure).

Photo 11: Pine Creek looking downstream from Surprise Lake control structure

At this stage, the following preliminary ***downstream excavation*** dimensions are assumed for costing purposes.

- Length: 150 m
- Width: 10 m (assuming access from one shore or over-ice)
- Average depth: 1 m

As for the upstream excavation, erosion protection will be required for the downstream excavation if the river substrate following the excavations is too small. Maximum flow velocities between 2 and 2.5 m/s can be expected at this location, such that cobbles with a minimum D_{50} of 200 mm is required.

A bathymetric survey of Pine Creek below the structure will be required to further assess the downstream water levels at the control structure. Hydraulic modelling should be conducted to determine the extent of excavation that is required to adequately convey water out of the lake at the new low pond level. Environmental effects of river excavations on Pine Creek will also need to be assessed.

5.3 Upper Power Plant Expansion

The upper power plant expansion will be adjacent to the existing power plant. It will make use of the existing infrastructure, more specifically the headpond and clearing for the existing penstock and powerhouse. Details about the new infrastructures required for the expansion are described below.

5.3.1 Intake

A second concrete intake box is selected for the intake structure, located west of the current intake structure. The intake will utilize the existing head pond. The existing intake structure was assessed for suitability to supply both penstocks (existing and proposed new penstock) but was determined to have insufficient capacity. The proposed new intake structure will be identical to the current structure due to good reported operator experience with the existing structure. Furthermore using identical designs will facilitate ease of maintenance, parts and servicing of the two structures.

The proposed location is to take advantage of the former diversion channel that had been previously excavated through bedrock during the construction of the head pond weir (see Photo 12). It has since been backfilled. The new intake structure would be set back from the existing structure to allow for a small cofferdam/plug to remain, isolating the work area from the existing head pond and allow the head pond to remain operations during most of the construction.

Photo 12: Existing intake under construction with diversion channel to the right

The intake structure would be founded on bedrock. Its dimensions are approximately 2.1 m wide by 4m deep with an approximate height of 6 m. The walls and the floor of the structure will be 0.4 m thick, made of reinforced concrete.

The intake will be closed with a vertical sliding gate mounted on the upstream face of the wall of the intake box. The gate will be operated using a mechanical screw hoist. For winter operations a portable steam boiler can be used for potential de-icing operations, if required. Trashracks will be installed upstream of the gate, inside the intake box, to prevent debris from entering the penstock. Embedded steel guides in the concrete walls just downstream of the face of the structure will allow stoplogs to be inserted to dewater the intake box and remove debris when maintenance of the structure is required.

Concrete Wing Wall

A concrete wing wall is proposed to extend upstream from the east face of the new intake box. The wing wall can be constructed as part of the new intake box works. A sheet pile wall would then be installed connecting the wing wall to the west upstream end of the existing intake structure. The area between contained by these structures would then be backfilled to provide a work surface for mechanized removal of frazil ice from the vicinity of the intakes.

The concrete wing wall would be 0.8 m thick reinforced concrete with an approximate height of 6 m by 6 m long. The wall will be constructed on a concrete footing that will be founded on bedrock. Use of a sheet-pile retaining wall between the wing wall and the existing intake structure will allow the retaining wall to be installed without needing to dewater the headpond or existing intake.

A detail assessment of the frazil ice accumulation issue in the upper headpond will need to be conducted in the feasibility study. It will allow to determine potential mitigation solutions to reduce the accumulation of frazil ice in the headpond that currently require substantive maintenance activities each winter. The new proposed operational scheme at Surprise Lake will lead to higher winter flows in Pine Creek which could increase frazil ice generation.

5.3.2 Penstock

The proposed second penstock will parallel the existing penstock. It is proposed to install the penstock on the north side of the current penstock for ease of construction. As the current penstock is located on the southern half of the existing cleared right of way with a service road located on the north side. Installing the penstock on the north side will allow it to be installed without needing to routinely cross the existing penstock during construction.

A cross-over will be required near the powerhouse. Because there is insufficient space near the river to expand the existing powerhouse to the north. It is suggested that the new penstock cross the existing penstock where it is cut into the crest of the hill-slope above the powerhouse. This location allows the proposed new penstock to be readily installed above the existing pipe at this location.

The total length of the penstock is approximately 4 km with all but approximately 330 m (being sections for bedrock) running through sand and gravel. A trench will be excavated along the proposed route between the access road and the existing penstock. A typical cross-section is proposed through overburden as presented on Drawing 02 of Appendix A.

The cross-section through overburden will be excavated with side slopes of 1.5H:1V with a minimum horizontal clearance of 0.4 m on each side to facilitate compaction of backfill. It is proposed to install the penstock over a minimum layer of 0.15 m thickness of granular fill to ensure good drainage at the bottom of the trench. The penstock will then be backfilled first with select granular fill around and over the penstock. A minimum of 0.7 m of random fill will then be placed above the granular fill to reduce risk of freezing of the penstock in case of extended winter shut-down. The random fill will be graded to cover the whole width of the trench and prevent ponding of water at surface. It is expected that a large portion of the overburden materials excavated from the penstock trench will be used as random fill.

Penstock Selection Considerations

For the proposed arrangement, approximately 4 km of penstock will be required to convey flows to the powerhouse from the intake structure at the head pond. Typical head losses within a conveyance system are usually in the order of 5 to 10% of the total gross head, with this value usually being more critical for sites with relatively low elevation changes. In order to minimize friction losses that will occur over the length of the penstock, flow velocities are typically kept between 1.8 and 2.4 m/s.

Based on the design flows for the upper powerhouse expansion, a nominal 5 ft. (1.52 m) inner diameter penstock size was selected as most appropriate. At this diameter penstock is available in steel or in high-pressure HDPE alternatives, while steel is the only high-pressure alternative at larger diameters (2 m or more). Both steel and HDPE penstock is available in lengths of up to 15 m. When comparing supply costs, HDPE is a more cost effective alternative than steel and has some installation advantages due to lighter weight for handling and flexibility during installation and welding. In general the installation methods are very similar in terms of backfill and connection requirements. On this basis, plus considering the existing owner’s experience, HDPE penstock has been selected for the majority of the upper power plant conveyance system.

For the HDPE penstock option lighter wall weight would be used for the upper portion of the route, getting progressively thicker until the penstock elevation dropped to the point where transition to steel pipe would be required due to higher water pressures. Based on the existing penstock configuration, the following quantities of HDPE penstock are assumed (outside diameters are presented here):

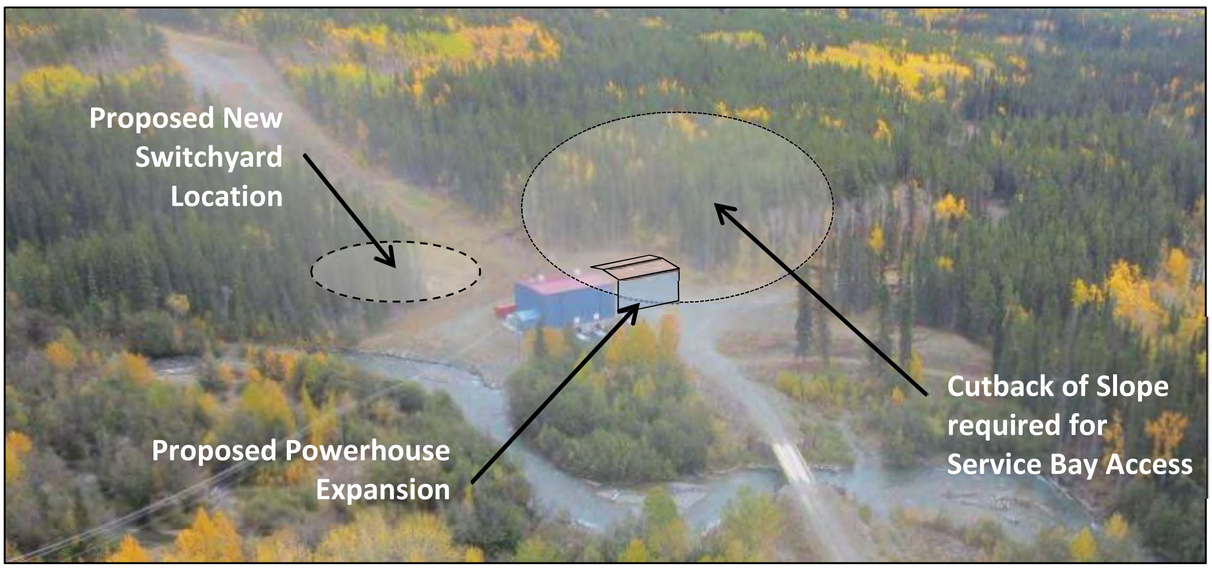
- 1,828 m of 63” DR41
- 256 m of 63” DR32.5 (50 PSI)
- 713 m of 63” DR26 (64 PSI)
- 768 m of 63” DR21(80 PSI)

As this site has 107 m of gross head, the lower 440 m of penstock would need to be steel pipe to resist the higher pressures. The steel penstock would then bifurcate to small steel pipes sections immediately upstream of the powerhouse expansion to feed the two new units.

5.3.3 Upper Powerhouse Expansion

The proposed powerhouse expansion will be located on the south side of the existing upper powerhouse and be constructed within the existing granular parking and turn around area. The powerhouse is expected to be constructed in the dry, with an overburden plug remaining within the tailrace to exclude the creek water from the foundation excavation during construction. This plug would be removed after the powerhouse had been completed, and the remainder of the tailrace would be completed in the wet. Limited inflows were experienced during the construction of the existing powerhouse. The powerhouse excavation was advanced to what was reported as a “hardpan” layer (likely glacial till). Based on this previous experience it is anticipated that only limited dewatering will be required. .

Figure 5-3: Layout of Upper Powerhouse Expansion



The powerhouse extension would be located on the south side of the existing powerhouse, as seen in the Figure 5-3 above and Drawing 06, and will require a cutback into the adjacent hill slopes to the southeast to facilitate adequate access into the service bay from the south side. The Pine Creek water elevation at this location will be regulated to approximately 723.5 m by the proposed lower headpond for the new lower power plant. The anticipated tailrace elevation would be approximately the same elevation as the creek with the existing tailrace channel widened to facilitate the increased flow.

The existing upstream head pond and intake structure maintains the forebay level at the penstock intake to approximately El. 832.5 m during normal operations, which provides a gross available head of approximately +/- 107 m for both the existing plant and the proposed expansion.

5.3.3.1 Foundation Considerations

Subsurface conditions at the proposed powerhouse extension are known with some confidence due to the construction of the previous powerhouse. Foundation conditions are expected to be course alluvial gravel similar to what can be observed at the surface in the area. The new powerhouse will be marginally deeper than the existing structure at the location of the draft tube and it is not expected that bedrock will be encountered. Due to the existing proximity of the powerhouse to Pine Creek, foundation dewatering may become an issue during construction. Currently sheet pile retaining walls have been shown along the downstream side of the new powerhouse to either side of the draft tubes to prevent washout or movement of fill from beneath the structure into the tailrace. A sheet pile cut off wall may be required around the perimeter of the structure if groundwater conditions prove difficult. Further analysis will be required to determine the appropriate foundation design and soil parameters at the powerhouse location moving forward.

5.3.3.2 Turbine / Generator Equipment Considerations

Turbine Selection

At this level of study, turbine design flows are typically selected for an exceedance of approximately 25% to 35%, which corresponds to a flow of approximately 6.2 m^3/s. As the existing 2.1 MW plant currently uses up to 2.45 m^3/s, a design flow of 3.6 m^3/s was selected to maximize the plant capacity providing an additional 2.9 MW with a gross head of approximately 107 m. When accounting for riparian flows these design values correspond to an exceedance of approximately 25% which was desired to provide as much power as was reasonable possible from the powerhouse expansion alone. The selected design flow and capacity of the expansion would require further analysis and refinement at later stages of study in order to optimize the cost of annual energy generation.

Pelton and Francis units were initially considered for the powerhouse expansion due to their ability to efficiently operate with lower flows and medium to high gross head, and their typical use in small hydro developments. Turgo units were also considered for this application as they overlapped the operational ranges of Pelton and Francis units considered for this application.

Turgo units are very similar to Pelton units in that they are impulse type turbines with the advantage that they can operate at higher flows than a similarly sized Pelton machine. Similar to a Pelton unit, the impulse energy from jets of water are used to drive the turbine wheel, except that in a Turgo unit the jets comes in at an angle to the wheel instead of perpendicular to the axis of rotation. For the same power produced a Turgo unit will typically have a runner half the size of a comparable Pelton unit and therefore twice the specific speed, which will in turn require a smaller, less expensive generator. Similar to Pelton units, a Turgo unit uses deflectors to prevent upsurge on a load rejection therefore eliminating the need for surge facilities.

Francis units were discarded from the selection process as the remaining flow available from Surprise Lake did not allow for efficient operation year round at lower flow levels. Due to their slower rotation speed, Francis units would require much larger and more expensive generators than what would be required for Pelton or Turgo units. Additionally, the selection of Francis units would have required a surge facility which would be difficult and costly at this powerhouse location.

As expected, Turgo and Pelton units were both acceptable solutions given the relatively low design flows and medium to high gross head. The combination of operational flow and head at this site are near the lower limit of Pelton operation, but Turgo units are well suited to the site conditions and operate at higher RPM than a comparable Pelton unit, and therefore require a smaller and less costly generator. Pelton units considered would have had to incorporate multiple jets or conversely operate at a slower speed, increasing the cost for either the turbine and/or generator respectively.

The preferred option utilizes two Turgo units to reduce equipment size and cost, and allows the existing powerhouse crane at the upper plant to be utilized to carry out installation and repairs. Although not necessary given the existing plant contains two units, the addition of two Turgo units provides additional generation reliability and better plant efficiencies over a wider range of flows. Additional studies of greater detail should revisit and confirm the selection of dual Turgo units.

The selected unit parameters of the 1.45 MW Turgo Turbines proposed are summarized below:

- Normal Head Pond Level: 832.5 m
- Tailwater Level: 724.0 m to 723.5 m
- Rated head: 107 m
- Penstock: Single 1.52m I.D. diameter HDPE penstock with a bifurcation to 0.9 m diameter steel penstocks at the powerhouse.

Layout Considerations

The powerhouse has been located immediately adjacent to the existing powerhouse to facilitate use of the existing powerhouse crane for maintenance and repairs. The service bay has been located on the south side of the new structure similar to the existing powerhouse as it provides the best means of access without extending the proposed building further than necessary beyond the expanded tailrace.

5.3.3.3 Transient Analysis and Surge Facility

A surge facility is not required as the design of Turgo units utilizes deflectors to prevent upsurge on a load rejection and allows for the dissipation of surge pressures without damage to the units, which is similar to the Pelton units installed in the existing powerhouse.

5.3.3.4 Powerhouse Configuration

Details for the development scheme for the expanded powerhouse with two Turgo units have been provided in Drawings 06, 07 and 08. A service bay for the powerhouse would be constructed on the south (access) side of the powerhouse at ground level and contain the new electrical and mechanical systems associated with the plant within an insulated, metal clad steel superstructure. It has been assumed that the existing control room can be modified to allow for operation of the units; however, there is additional room available in the new service bay to include a new control room if necessary.

The service bay has been sized such that the generating equipment can be brought in to the powerhouse on flatbed trucks and unloaded using the existing overhead crane running on extensions of the existing rails and crane supports. There is also room to work on the major unit components in the service bay during the initial installation and for any future maintenance work. The existing 23 tonne overhead bridge crane will be retained as it is sufficient for the heaviest lift associated with the new turbines which is the generator assembly. The existing crane will perform loading, unloading, insertion and removal of the generator rotor or the assembled generator stator onto or from a truck.

The new superstructure for the powerhouse building will be designed to match the envelope of the existing structure with crane rails extended to cover the new portions of the powerhouse. Modifications to the existing pre-engineered building will be required, including the removal of the end column and bracing on the south side to facilitate the travel of the existing crane into the new building. Further study will be required to verify that modifications can be made to the existing pre-engineered structure without compromising its integrity as the designs of pre-engineered structures are typically highly efficient and leave little room for changes in loading or load path.

Immediately upstream of the powerhouse expansion the single HDPE penstock would bifurcate into two steel penstocks. Turbine flows would enter the concrete powerhouse substructure through short sections of steel penstock and then exit through individual draft tubes to the tailrace and then into Pine Creek. A turbine inlet valve (TIV) would be provided immediately upstream of each turbine as a means of shutting off the flow in an emergency and for use as an isolation device during maintenance activities, in addition to the intake structure slide gate.

Floor elevations have been selected based on the assumed tailwater level and the setting of the Turgo unit. The centerline of the penstock bifurcation is dictated by the turbine setting, with the lower powerhouse levels designed to provide adequate clearances around the turbine inlet valves immediately upstream of the units. The service bay elevation is set to match the existing powerhouse and the surrounding parking and turnaround area. Unit settings would need to be confirmed following detailed hydraulic analysis and turbine selection in the next project phase.

5.3.3.5 Electrical Equipment Considerations

General Configuration

The basic proposed configuration is a 2.9 MW, two unit plant expansion which is anticipated to require two 1.81 MVA generators. The two generating units will be of the synchronous type, with a nominal rating of 1.81 MVA at 0.8 power factor (pf).

The remainder of the electrical systems will generally follow the electrical configuration with the following main characteristics:

- Static excitation systems.
- One generator step up transformer (GSU) for the entire plant, with voltage and power ratings matching the generating units.
- 15kV class, vacuum generator circuit breakers and arc resistant switchgears.
- Redundant station service system.
- Energy would be sent to the proposed switchyard located adjacent to the expanded powerhouse which would then distribute power north through a 69 kV transmission system to the Yukon’s electrical grid or have power stepped down for distribution to the community of Atlin.

Medium Voltage System

Each generating unit will have arc resistant switchgear that will feature draw out generator vacuum circuit breakers. As well, switchgear sections will house generator side Potential and Current

Transformers (PTs and CTs) and surge suppression equipment, tie off for the excitation system and GSU side PTs and CTs and will also include a tie off for the SSLC.

Interconnection between the generating units and the switchgear and between the switchgear and GSU will be by 15kV cable. The generator neutral leads will be connected to the neutral grounding equipment.

AC Station Services

Power for all auxiliary services and AC equipment required at each facility will be provided from the Powerhouse AC station service system.

Under normal operation, the station service power will be provided by the station's own generators. The station service system will allow power to be maintained during several types of equipment outages. The generator step-up transformer can energize the station service transformer from the high voltage network. The Generator circuit breaker will isolate the generator excitation transformers for this case.

If the units are shut down and power is not available from the HV network, the existing 50 kW generator that ATELP owns for the station service of the existing plant could be connected to the station service system. At this time we anticipate that a portable diesel generator would be available locally or from Whitehorse if needed, and the cost for purchasing one to keep at site has not been included in our estimates.

Dry-type transformers, switchgear line-ups, main breakers and tie breakers will be sized for the full load of the station.

The main incomings and tie-circuit breakers on each load center will be remotely controlled from the main control room and locally at the switchgear.

The AC distribution system will have a single 600V MCC, a single 600V panel, and a single 120/208V panel for both generating units and their auxiliaries, and at this time no redundancy has been provided.

Unit and GSU Protection

Generators and generator step up transformers will be protected by single multifunction digital relays. These relays, which will be powered by a single 125 VDC system, will provide the following minimum protections:

- Generator Reverse Power (32).
- Generator Thermal Protection (49).
- Inadvertent Energization (50/27).
- Breaker Failure Protection (50BF).
- Generator Turn Fault Protection (51SP).
- Generator Stator Ground Fault (59G).
- 100% Generator Stator Ground Fault (64S).
- Generator Field Ground (64F).
- Generator Under-frequency (81).
- Generator Differential (87G).

- Generator V/Hz (96G).
- Transformer Oil Temperature (26T).
- Transformer Winding Temperature (49WT).
- Transformer Overcurrent (50/51).
- Transformer Differential (87T).
- Transformer Restricted Ground Fault (87G).
- Transformer V/Hz (96T).

There will also be other standalone protection for mechanical generator or governor faults, such as overspeed and for GSU, such as oil level, oil temperature, etc.

Controls will be Programmable Logic Controller (PLC) based.

5.3.4 New Switchyard and Transmission

A new 4 km long 69 kV transmission system would be used to transmit energy from the proposed lower powerhouse to the new proposed switchyard located at the upper Atlin powerhouse. From this switchyard power would then be transmitted north to connect with the Yukon Territory's electrical grid or be stepped down for distribution to the community of Atlin. The new switchyard has been proposed to be located to the northeast of the upper powerhouse on slightly higher ground than the parking and turn around area adjacent to the upper powerhouse. A preliminary layout of the substation is provided in Appendix F.

Figure 5-4: New Switchyard Location

The generator step up transformers would be located in a switchyard adjacent to the Upper powerhouse. The high side voltage would be 69kV. A 69kV disconnects would also be located downstream of the transformer to provide isolation.

The switchyard would have a 69 kV SF6 circuit breaker and motorized disconnect with ground switches, potential transformers, current transformers and associated bus work and steel structures. This breaker would feed a single transmission line.

5.4 Lower Power Plant

5.4.1 Intake and Head Pond

An artificial head pond will need to be excavated for the intake structure of the lower powerhouse. A reconnaissance of lower Pine Creek (downstream of the existing powerhouse) was conducted both by air and foot to locate potential locations for the head pond. Pine Creek is mostly a shallow braided gravel-bed creek with some deeper pools that generally do not exceed 2 to 3 m in depth. The floodplain of the creek is also quite flat limiting the options to potentially raise the water level to form the head pond. It was determined that the optimal location to build the new head pond would be immediately downstream of the bridge located near the existing (upper) powerhouse. The following photo shows the location where it is proposed to excavate the lower head pond, as seen from the bridge when looking downstream.

Photo 13: Proposed location of lower head pond on Pine Creek, looking downstream

At this location, Pine Creek takes a sharp bend towards the north (to the right if looking downstream) and widens slightly over a short distance. Higher ground is located on the left bank (up to elevation 725 m) and the road closes the right bank at least to elevation 723.5 m. The headpond could then be naturally contained at least to elevation 723.5 m at this location, and higher if needed with only small closing dam being required. Spruce Creek enters Pine Creek about 50 m downstream of that location such that a small diversion will be required to have Spruce Creek connecting with the head pond. The approximate dimension of the proposed head pond will be 50 m by 60 m, which is limited by the space available.

The following works will composed the head pond:

- A concrete intake structure located on the left side of the head pond;
- A concrete wingwall adjacent to the intake structure;
- A rock fill overflow spillway, located over the natural creek bed, to control the head pond water levels;
- An rock fill closing dam on either side of the overflow spillway;
- An excavated slope on the upstream end of the head pond;

Diversion of Pine Creek during construction of the head pond will take place with a diversion channel on the right side of the creek. The diversion channel will be excavated through the existing access road to the upper power plant. Crossing of the road (if deemed necessary for access from the north side of the creek) could either be done by installing culverts or by moving the existing bridge Since filling of Surprise Lake will occur during the construction period of the lower head pond (summer season) flows are expected to be low. Spruce Creek diversion will only be built once all other works of the head pond are completed. For the purpose of preliminary sizing of the diversion channel, a maximum diversion flow of 10 m^3/s was assumed. A diversion channel with a base width of 5 m and a maximum depth of 2 m (1.5 m flow depth and 0.5 m freeboard) is selected. The diversion channel will need to be protected with rock fill (or cobbles) with a D_{50} of at least 100 mm.

The depth of the head pond was determined based on the minimum submergence criteria for the intake. Two 1.52 m diameter penstocks are proposed for the lower plant (discussed in more detail in Section 5.4.2). The following parameters were estimated for each penstock:

- Maximum flow: 3.5 m^3/s (total turbine flow 7 m^3/s)
- Maximum flow velocity: 2 m/s

The minimal submergence of the intake was determined based on Gordon equation (1970) developed based on observations on numerous existing generating stations in Quebec.

$$S_{min} = CVd^{0.5}$$

Where,

S_{min} is the minimum submergence
C is a coefficient to account for approach flow conditions (0.55 for linear and 0.72 for asymmetric)
V is the flow velocity in the penstock (in m^3/s)
d is the penstock diameter (in m)

A C coefficient of 0.72 was selected since approach flow conditions at the intake are not linear, thus increasing the risk of vortex formation. The resulting minimal submergence was calculated as 1.8 m.

In order to establish the head pond depth and the invert elevation of the intake (for each penstock), a minimum pond level was set based on the topographical constraints as well as based on the proposed geometry for the spillway (discussed further). The objective is also to maximize the head at the site without adversely impacting tailwater levels at the upper plant. . A minimum pond level of 723.0 m was selected. With a 1.52 m inside diameter (I.D.) diameter penstock and a minimum submergence of 1.8 m, the invert elevation of the intake has to be at least 3.4 m below the minimum pond level. The invert elevation of the intake was set at elevation 719.2 m which provides an additional 0.4 m of safety margin against submergence against potential entrainment of debris and ice in the small head pond. The bottom of the head pond is set at elevation 718.2 m, which is 1 m below the invert of the intake. It will reduce sediments from filling the bottom up to the intake elevation.

Intake structure and concrete retaining wall

A concrete intake box for the intake structure will be located on the left side of the overflow spillway, adjacent to the concrete wingwall. Since no bedrock is present at the site, it will be founded on overburden materials, such that a concrete pad will be required. Its dimensions will be approximately 6 m wide by 4 m deep, with an approximate height of 7 m. The structure should extend up to elevation 725 m to close the head pond. The walls and the floor of the structure will be 0.4 m thick, made of reinforced concrete.

The intake will be closed with a vertical sliding gate mounted on the upstream face of the downstream wall of the intake box. At this stage, it is expected that the gates will be operated using a mechanical screw hoist. For winter operations, a portable gas generator and steam boiler can be used for potential de-icing operations, if required. Power could also be easily provided to the lower head pond since the existing upper powerhouse is located within 300 m of the site. Thrash\racks will be installed upstream of the gate, inside the intake box, to prevent debris from entering the penstock. Embedded steel guides in the concrete walls just downstream of the upstream face of the structure will allow the insertion of stop-logs to dewater the intake box to remove debris or if maintenance of the structure is required.

A concrete retaining wall will be built on the left side of the intake box to close the south end of the head pond. The retaining wall will allow mechanized equipment to operate adjacent to the intake structure for removal of frazil ice, if needed. The wall will be 0.8 m thick reinforced concrete with an approximate maximum height of 7 m. It will be approximately 18 m long. The wall will be constructed on a concrete footing that will be founded on overburden materials. Rock fill will be used to backfill the wall on the downstream side, where a parking/turn-around area for access will be established.

Overflow spillway

Due to the small size of the head pond and for ease of operations, an overflow spillway is selected to pass the design flood without the need for any gate operations. The overflow spillway will also allow maintaining the minimum pond level. Since the head pond is mostly excavated into the ground, the spillway will only have a maximum height of approximately 3 m. An overflow rock fill weir was selected with a sheet pile cut-off wall to reduce seepage through and under the structure. It is proposed to extend the cut-off wall at least 6 m below the bottom elevation of the head pond to prevent internal erosion and seepage.

Two different crest elevations are proposed:

1. A lower crest at elevation 723.0 m, with a width of 4.5 m. This crest will pass normal summer excess flows and provide the minimum environmental flow;
2. A higher crest at elevation 723.7 m, with a width of 15 m. This crest will allow the passage of larger floods.

Side slopes of 4H:1V are selected along the crest of the overflow weir to provide vehicle access on the crest for maintenance activities, including mechanized frazil ice removal and sediment removal in the head pond if required. A 5 m crest width is selected to accommodate potential machinery traffic.

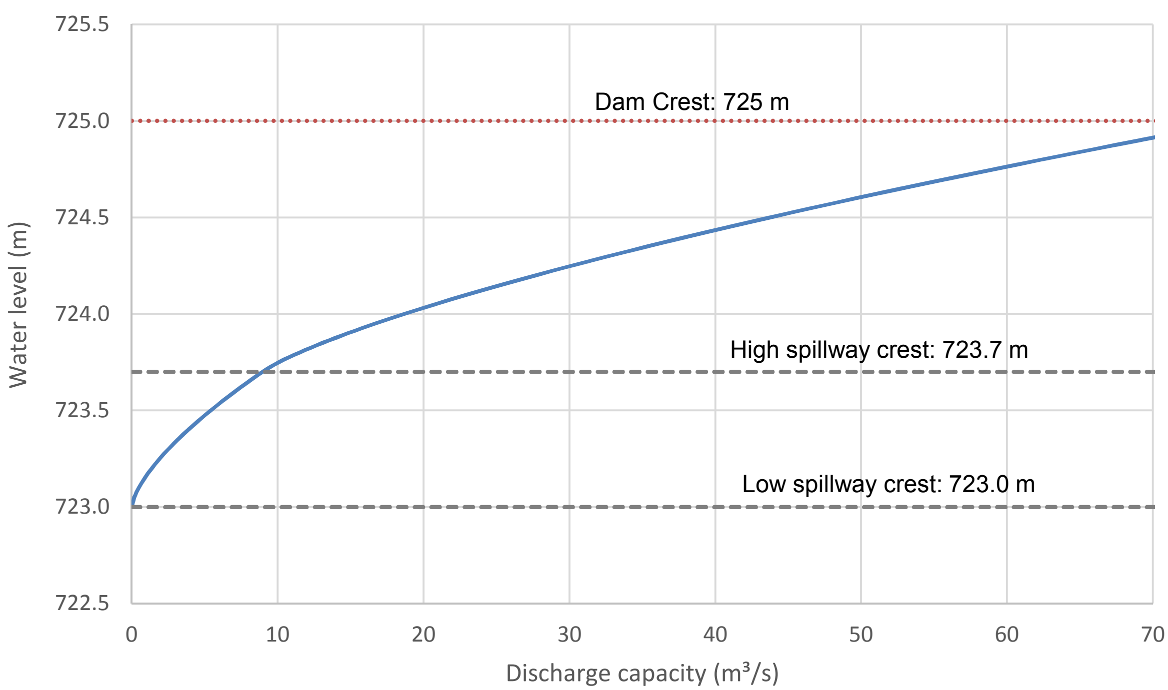
The overflow weir equation was used to determine the capacity of the proposed overflow spillway. A discharge capacity curve for the overflow spillway is presented below.

$$Q = C\sqrt{2g}LH^{3/2}$$

Where,

Q is the flow passing over the weir (in m^3/s)
C is the discharge coefficient, taken as 0.34 which is a conservative value for a long broad crested weir
g is the gravitational constant (9.81 m^2/s)
L is the crest width (in m)
H is the head above the crest (in m)

Figure 5-5: Discharge capacity curve of the overflow spillway of the lower head pond



The capacity of the low crest at the normal pond level of 723.5 m is estimated at 5.4 m^3/s, while it increases to 9 m^3/s up to the elevation of the higher crest (723.7 m). In the eventuality of the passage of the design flood (estimated at 39 m^3/s), the water level in the head pond would reach 724.4 m. Based on this calculated value for the maximum flood level, the crest elevation of the closing dam adjacent to the spillway is set at 725.0 m to provide the minimum 0.5 m freeboard criteria.

Maximum flow velocities over the crest of the spillway are estimated at 2.5 m/s under the design flood scenario. Rip rap with a D_{50} of 300 mm is selected (class 1), which can resist flow velocities up to 3 m/s based on Figure 5-1. The downstream slope of the overflow spillway is set at 10H:1V. This will provide flow velocities of approximately 1 m/s on average, which may be adequate to provide fish passage under most hydraulic conditions through the low crest of the spillway. A small stilling basin will be constructed at the toe of the spillway. The stilling basin will be 15 m long and 0.5 m deep. This will protect the river bed against scour and will allow the formation of a hydraulic jump in a controlled location. The stilling basin will be protected with rip rap with a D_{50} of 300 mm also.

Closing dam

A closing dam will be required on each side of the overflow spillway. Since the headpond is mostly excavated into the ground the dam will be small with a maximum height of 3 m near the bridge. The sheet pile cut off wall will extend into the dam. On the upstream side of the lower head pond, a work terrace will be built at elevation 723.5 m (normal pond operating level) to provide access for maintenance, especially mechanized ice removal if needed. Rip rap (class 1 D_{50} of 300 mm) should be installed up to elevation 724.5 m (maximum flood level) to protect the banks of the head pond against erosion.

As a summary, the following elevations and design parameters are selected for the lower head pond:

- Bottom of head pond: 718.2 m
- Intake invert elevation: 719.2 m
- Spillway crest elevation: 723.0 m (4.5 m width) and 723.7 m (15 m width)
- Normal pond level: 723.5 m
- Minimum pond level: 723.0 m
- Maximum flood level: 724.5 m
- Closing dam crest elevation: 725.0 m
- Rip rap: class 1 – 200-450 mm (D_{50} 300 mm)
- Spillway downstream slope: 10H:1V

5.4.2 Penstock

A preliminary discussion of the selected penstock route was provided in Section 3.2. The final alignment of the lower penstock selected for this study is shown on Drawing 03. The route is dictated by topographical constraints and substantively avoiding privately owned land. The alignment of the lower penstock traverses significantly more challenging terrain than the existing upper penstock.

The alignment is dictated by the following considerations:

1. Avoid crossing private land at South Pine Drive. The proposed alignment largely avoids this by skirting between the private land and Pine Creek's canyon above the Warm Bay Road Bridge. Crossing a small corner of private land may be unavoidable, but that will need to be determined in future studies.

2. Topographic constraints consisting of small bedrock hills at 2+000 and 2+900. The proposed alignment takes advantage of natural saddles between the hills and the side of Monarch Mountain. Alignment elevations were selected to minimize cut/fill requirements, especially of bedrock.

Over the length of the penstock, terrain and ground conditions vary as follows:

- Between 0+000 and 0+800 the penstock will follow the north side of Warm Bay Road. Soils are anticipated to be predominantly sand and gravel overburden with bedrock near surface.
- From 0+800 to 1+100 the alignment crosses a series of bedrock knobs.
- Terrain conditions from 1+100 to 2+000 are largely unknown, but are anticipated to be blanket of till over bedrock. Soils appear to be adequately drained along this hillside section.
- From 2+000 to 2+500 the alignment is anticipated to cross a challenging area of poorly drained soils. Organic and ice-rich soils (soil that have high ice content either as permafrost or are frozen for most of the year) may be present in this area.
- From 2+500 to 2+850 will be a side-cut into bedrock and talus slope.
- From 2+850 to 4+000 ground conditions are expected to be relatively more mild, consisting of glaciofluvial terraces/benches and alluvial plain materials with no significant bedrock outcrops. Soils appear to be predominantly sand and gravel and are well drained.

Of the total 4 km of the lower penstock, it is assumed a total of 500 m will be running through bedrock with the rest in overburden material. A typical cross section through overburden is presented on Drawing 03 in Appendix A.

The cross-section through overburden will be excavated with side slopes of 1.5H:1V with a minimum horizontal clearance on each side of 0.4 m to facilitate compaction of backfill. It is proposed to install the penstocks over a minimum layer of 0.15 m thickness of granular fill to ensure good drainage at the bottom of the trench. The penstocks will then be backfilled first with select granular fill around and over the penstock. A minimum of 0.7 m of random fill will then be placed above the granular fill to reduce risk of freezing of the penstock in case of extended winter shut-down. The random fill will be graded to cover the whole width of the trench and prevent ponding of water at surface. It is expected that a large portion of the overburden materials excavated from the penstock trench will be used as random fill.

Penstock Selection Considerations

Larger total design flows are required for the lower powerhouse because of the addition of flows from Spruce Creek for the proposed single turbine. A 2 m inside diameter penstock is required based on the considerations described previously in Section 5.3.2 (flow velocities between 1.8 and 2.4 m/s). At this diameter, steel pipe is the only readily available option.

The cost of the lower penstock is the largest cost item for the lower power plant. Therefore a preliminary cost optimization assessment was conducted to evaluate the potential for using two smaller diameter HDPE penstocks in lieu of a single large steel penstock. To meet the flow requirements for the lower power plant, twin 5 ft (1.52 m) I.D. penstocks would be required. The optimization included the costs of both excavation and backfill requirements in both overburden and bedrock sections of the alignment. The assessment concluded that twin HDPE penstocks would be approximately 10% lower material and installation cost with approximately equivalent excavation and backfill costs. However, it is believed that the HDPE option offers substantive constructability benefits as follows:

- Relatively shallower and wider excavations making excavations easier.
- Easier excavation due to typically more weathered and looser surface materials.
- Existing owner experience and comfort with using HDPE penstock.
- Easier handling, welding and installation of smaller diameter, more flexible HDPE pipe.
- Consistent material size with upper penstock may result in overall project savings and improved installation efficiency.

For the HDPE penstock alternative lighter wall weight would be used for the upper portion of the route, getting progressively thicker until the penstock elevation dropped to the point where transition to steel pipe would be required. Based on the elevations/pressures, the following quantities of HDPE penstock are assumed (outside diameters are presented here):

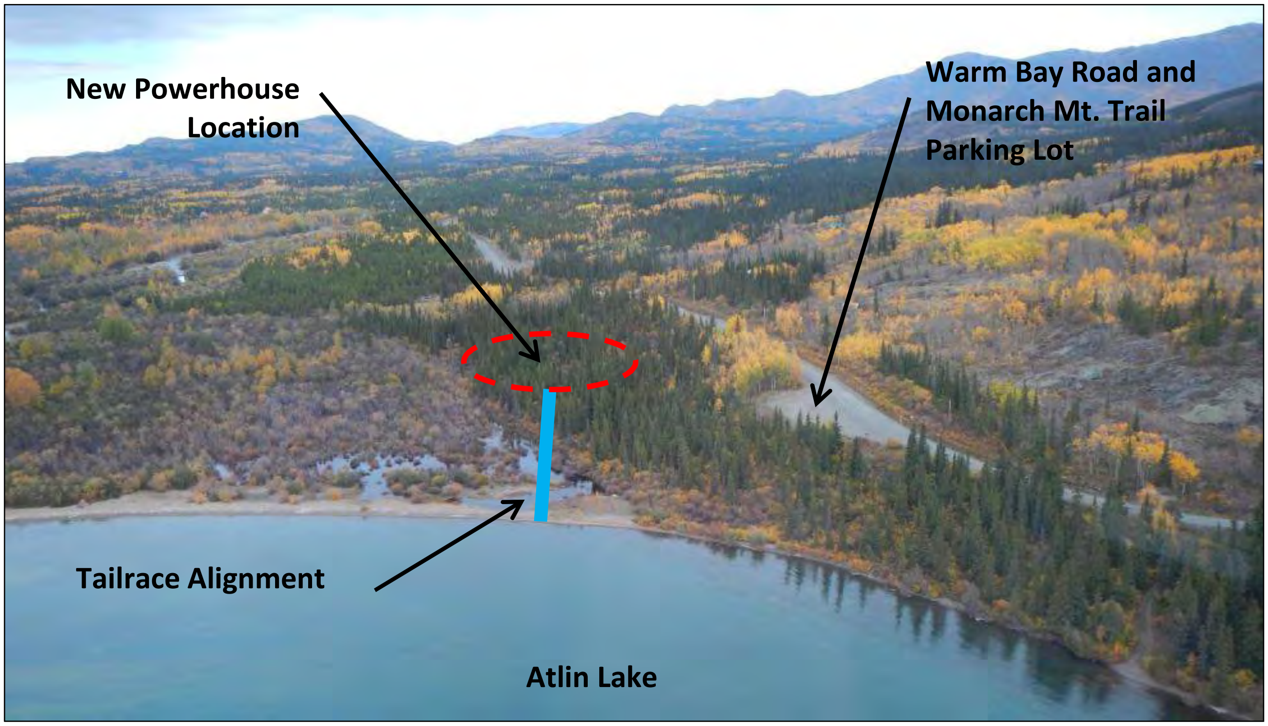
- 2x 3,025 m of 63” DR41
- 2x 375 m of 63” DR32.5 (50 PSI)

For the last 600 m it is assumed the penstock would transition to a 2 m diameter steel pipe. A reverse bifurcation would transition the twin HDPE penstocks to the larger diameter steel penstock.

5.4.3 Lower Powerhouse

The proposed new lower powerhouse will be located on the east side of Pine Creek, approximately 150 m north of Atlin Lake as shown on Drawing 11. The powerhouse would be constructed within the steeply sloped banks below Warm Bay Road in an effort to found the powerhouse in bedrock. The powerhouse will be constructed in the dry, with an overburden plug located within the tailrace to exclude lake water from the foundation excavation during construction. This plug would be removed after the powerhouse has been completed, and the remainder of the tailrace completed in the wet.

Figure 5-6: Layout of Lower Powerhouse



The powerhouse will be located west of Warm Bay Road as seen in the figure above, on the sloped hillside just north of the Monarch Mountain trail parking area. Atlin Lake levels vary through an approximate range from elevation 669.25 m to 666.85 m and the anticipated tailrace elevation would be approximately the same elevation since the tailrace channel would be designed to minimize head losses between the powerhouse and Atlin Lake.

For the preferred head pond and intake being considered, the head pond level would be maintained at approximately El. 723.5 m during normal operation, which would provide an assumed gross available head of approximately +/- 56 m.

5.4.3.1 Foundation Considerations

Subsurface conditions at the proposed powerhouse location are currently unknown. A visual inspection of the site shows significant areas of exposed bedrock immediately to the east of Warm Bay Road dipping down to the west and south underneath the road alignment. To the west of the road there is the Pine Creek alluvial fan which is likely to be composed of a saturated sand and gravel. The slopes west and below Warm Bay Road appear to be comprised at the surface of overburden (till) due to the significant tree cover. Due to the slope and proximity to large amounts of exposed bedrock it is expected that any overburden cover may be limited and has therefore been assumed to be approximately 2 m thick or less. Due to the depth of the structure and the amount of exposed bedrock present in close proximity it has been assumed that structures can be founded on bedrock in the chosen location, though design provisions could be made if there is no bedrock. Given the observed saturated sand and gravel condition of the alluvial fan, considerable groundwater inflow should be expected in any excavations in overburden at or below the lake level.

5.4.3.2 Turbine / Generator Equipment Considerations

Turbine Selection

At this level of study, hydroelectric design flows are typically selected at an exceedance of approximately 25% to 35%, which corresponds to a flow of approximately 6 to 7 m^3/s. On this basis a design flow of 7 m^3/s was selected to provide a maximum plant capacity of 2.8 MW with a gross head of approximately 56 m.

Pelton and Turgo units were also considered for the arrangement at the lower powerhouse location, but due to the relatively low gross head of 56 m for these types of units, an efficient or cost-effective turbine-generator arrangement was not possible. Operating speeds would be much slower and require a large and cost prohibitive generator. Due to this, Francis type units were determined to be the best solution. While two units are a viable option for providing the plant capacity of 2.8 MW and would provide increased reliability of station service power, the costs of providing two sets of turbines and generating equipment were considered to outweigh the potential benefits of a one unit solutions. Given the existing powerhouse upstream and its planned expansion, additional reliability for the community of Atlin was not deemed to have substantial value compared to the incremental cost of additional turbine and generator equipment.

Options with two units for this size of plant would also increase the complexity of electrical considerations and require a larger powerhouse footprint, which would increase the overall cost based on preliminary estimates even though the excavation depths for the smaller units are less than for a single large unit. The single unit's more compact footprint is desirable at this location due to the potential excavation required both into rock and the adjacent slope. While additional studies should be undertaken to confirm or optimize the number of units at the next level of study, a powerhouse with one unit has been selected at this time based on both the supply of equipment and potential construction costs.

The selected unit parameters of the 2.8 MW Horizontal Francis Turbine proposed is summarized below:

- Max headwater level: 724.0 m
- Full Supply Level (FSL): 723.0 m to 723.5 m
- Tailwater Range: 666.85 m to 669.25 m
- Rated head: 55.4 m
- Allowable upsurge: 40%
- Penstock: Dual 1.52 m I.D. diameter HDPE penstock with union to a single 2.0 m diameter steel penstock approximately 600 m upstream of the powerhouse.

Layout Considerations

For this size of Francis turbine, there are several equipment suppliers with vertical or horizontal shaft arrangements that would be suitable. In a comparison between vertical and horizontal arrangements for the chosen Francis turbines with such a diameter, we have reviewed the following considerations:

- A vertical shaft arrangement for Francis turbines would require a lower level under the generator floor for maintenance of the components in the turbine pit such as the distributor assembly, turbine bearings, servomotors, cooling water supply unit, and other facilities. The added lower floor will incur more civil cost which is not likely warranted for such a compact turbine.
- In comparison to a vertical unit, a horizontal shaft arrangement for a Francis turbine features: 1) fewer floors in the powerhouse; 2) decreased overall height of the powerhouse; 3) decreased depth of excavation; 4) decreased civil construction costs; and 5) is easier to monitor, maintain and overhaul the units.
- In general, common practice is to recommend using Francis turbines with a runner size less than 1.75 m diameter in a horizontal arrangement, and using a vertical arrangement for large capacity or large diameter Francis turbines. With a proposed runner diameter of 1.00 m this turbine falls well within the range of an acceptable horizontal unit size.
- On the basis of the considerations listed above, a single horizontal Francis unit has been selected for the proposed lower Atlin Powerhouse. For this type and size of unit, the centerline of the runner has been set approximately 1.7 m above the assumed tailwater level to obtain the correct submergence for the draft tube.

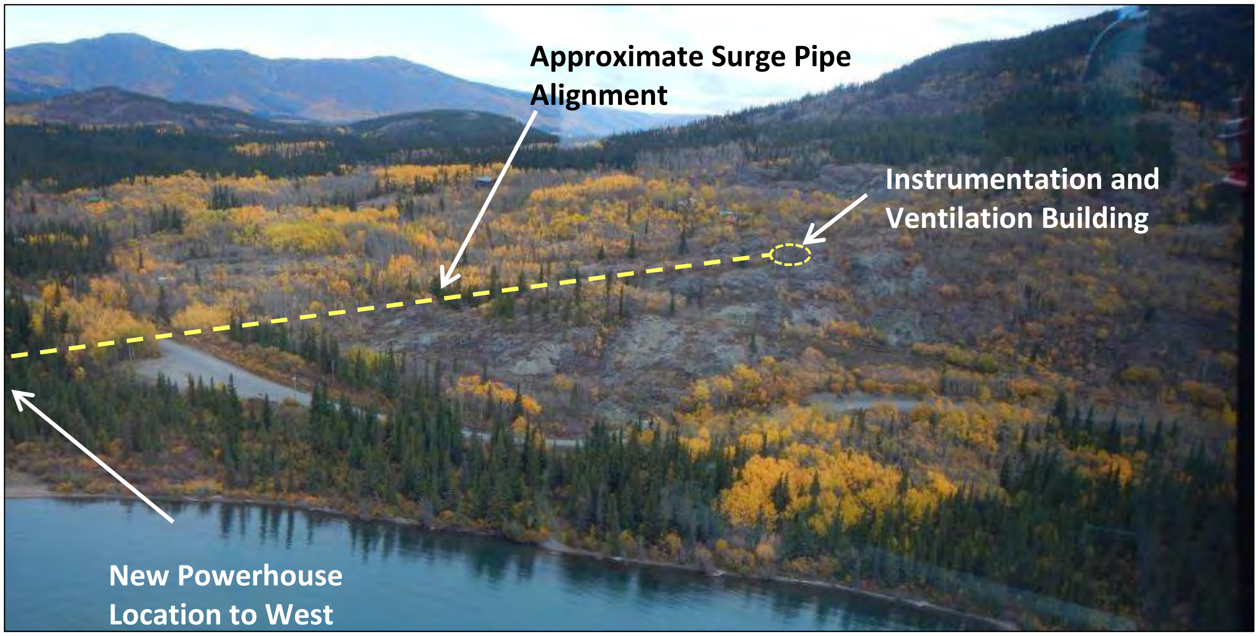
Transient Analysis and Surge Facility

To avoid unnecessary complication with addressing the inclusion of a surge facility it has been assumed the surge connection to the penstock will be provided downstream of the union of the dual HDPE penstocks at a distance of approximately 30 m from the powerhouse. A preliminary transient analysis has considered the following variables: the penstock diameter at the powerhouse, the flow velocity of 2.2 m/s at the rated plant capacity, the preferred head pond and intake location and relatively long length of penstock (4 km). The results of the preliminary transient analysis have indicated that to achieve an acceptable combination of unit governability, gate times, maximum overspeed and maximum penstock pressure during plant operations, there will be a need for a surge facility.

Assuming the construction of a vertical surge tanklocated within approximately 50 m of the powerhouse, it would require a diameter of 6.5 m with an active zone between elevations 713 to 732 m. As finished ground elevation is 670 m at the proposed powerhouse and the adjacent slopes only extend to approximately 680 m, the required surge tank would between 55 and 65 m high, be difficult to construct and be extremely expensive. Alternatively, we have assumed that a surge facility will connect to the steel penstock approximately 30 m upstream of the powerhouse, where it will be possible to extend an approximately 400 m section of steel surge pipe up the bedrock slopes to the east of the powerhouse that quickly rises to the required active zone elevations. Based on the required surface area to meet unit stability criteria, the surge facility could consist of sections of 2.0 m diameter pipe installed at an incline matching the ground profile at this location through the active zone. Ventilation for the shaft and monitoring instrumentation will be provided at a small building at the end of the surge shaft on the eastern slope. The conceptual arrangement of this surge facility is shown in Figure 5-7 and on Drawing 11. The alignment shown was selected to avoid crossing of privately owned land.

Since a surge facility will be located in relative proximity to the powerhouse, the generator's natural inertia will suffice to provide stable operation and good unit response. The maximum overspeed would be limited to approximately 60% of rated speed. While this is anticipated to be acceptable, a more detailed transient analysis would be required to confirm and optimize these values at the next stage of study.

Figure 5-7: Lower Powerhouse Surge Facility Location



Powerhouse Configuration

Details for the development scheme with a single horizontal Francis unit have been provided in Drawings 11, 12 and 13. A service bay for the powerhouse would be constructed on the east (access) side of the powerhouse at ground level, complete with a control room and overhead crane within an insulated, metal clad steel superstructure. A 30 tons overhead bridge crane with a span of approximately 10 meters will be needed for the selected unit, the heaviest component of which is the generator assembly. The selected crane will be able to perform loading, unloading, insertion and removal of the generator rotor or the assembled generator stator onto or from a truck.

The service bay has been sized such that the generating equipment can be brought in to the powerhouse on flatbed trucks and unloaded using the proposed overhead crane. There is also room to work on the major unit components in the service bay during the initial installation and for any future maintenance work.

Approximately 600 m upstream of the powerhouse the dual HDPE penstocks would transition to a single steel penstock supplying the Francis unit. Turbine flows would enter the concrete powerhouse substructure through a section of steel penstock and then exit through the draft tube to the tailrace and travel 150 m to Atlin Lake. A turbine inlet valve (TIV) would be provided immediately upstream of the turbine as a means of shutting off the flow in an emergency and for use as an isolation device during maintenance activities, in addition to the intake structure slide gate.

Floor elevations have been selected based on the assumed tailwater levels and the setting of the Francis unit. The centerline of the penstock is dictated by the turbine setting, with the lower powerhouse level designed to provide adequate clearances around the turbine inlet valves immediately upstream of the unit. The service bay elevation is set 1 m above the anticipated maximum tailwater level along with the surrounding parking and turnaround area, as shown on Drawing 13. The required elevations would need to be confirmed following subsequent surveys and detailed hydraulic analysis should this project proceed to later stages of study and development.

5.4.3.3 Electrical Equipment Considerations

General Configuration

The basic proposed configuration is a 2.8 MW, single unit plant which is anticipated to require one 3.5 MVA generator at 0.8 power factor (pf).

The remainder of the electrical systems will generally have the following main characteristics:

- Static excitation systems.
- One generator step up transformer (GSU) for the plant, with voltage and power ratings matching the generating unit.
- 15kV class, vacuum generator circuit breakers and arc resistant switchgears.
- Station service system.
- A 69 kV transmission system would be used to transport the energy to the proposed switchyard at the expanded upper Atlin Plant which would then transmit power north to connect with the Yukon's electrical grid or be stepped down for distribution to the community of Atlin.

Medium Voltage System

The generating unit will have arc resistant switchgear that will feature draw out generator vacuum circuit breakers. As well, switchgear sections will house generator side PTs, CTs and surge suppression equipment, tie off for the excitation system and GSU side PTs and CTs and will also include a tie off for the SSLC.

Interconnection between the generating units and the switchgear and between the switchgear and GSU will be by 15kV cable. The generator neutral leads will be connected to the neutral grounding equipment.

AC Station Services

Power for all auxiliary services and AC equipment required at the facility will be provided from the Powerhouse AC station service system. Under normal operation, the station service power will be provided by the station's own generators. The generator step-up transformer can energize its station service transformer from the high voltage network. The Generator circuit breaker will isolate the generator excitation transformers for this case. It has been assumed that a portable backup diesel generator will be available locally or from Whitehorse if required.

Dry-type transformers, switchgear line-ups, main breakers and tie breakers will be sized for the full load of the station.

The AC distribution system will have a single 600V MCC, a single 600V panel, and a single 120/208V panel for the generating unit and its auxiliaries.

Unit and GSU Protection

The Generator and generator step up transformer will be protected by single multifunction digital relays. These relays, which will be powered by a single 125 VDC system, will provide the following minimum protections:

- Generator Reverse Power (32).
- Generator Thermal Protection (49).
- Inadvertent Energization (50/27).
- Breaker Failure Protection (50BF).
- Generator Turn Fault Protection (51SP).
- Generator Stator Ground Fault (59G).
- 100% Generator Stator Ground Fault (64S).
- Generator Field Ground (64F).
- Generator Under-frequency (81).
- Generator Differential (87G).
- Generator V/Hz (96G).
- Transformer Oil Temperature (26T).
- Transformer Winding Temperature (49WT).
- Transformer Overcurrent (50/51).
- Transformer Differential (87T).
- Transformer Restricted Ground Fault (87G).
- Transformer V/Hz (96T).

There will also be other standalone protection for mechanical generator or governor faults, such as overspeed and for GSU, such as oil level, oil temperature, etc.

Controls will be PLC based.

6 TRANSMISSION LINE OPTIONS ASSESSMENT

A transmission line options assessment has been completed as follows to determine the technical requirements and associated costs to deliver power from the proposed Atlin Hydro Expansion project to the Yukon's electrical system. The transmission line options assessment consists of two components:

1. The line from the Atlin hydro facility to Jakes Corner, Yukon; and
2. The connection between the Atlin line and the Yukon electrical system, including new transmission line or upgrades required.

Work conducted as part of this assessment includes:

- the development of a cost estimate for a 69 kV transmission line (section 6.2);
- a system assessment study to determine interconnection/system upgrade needs (section 6.3) and
- development of a cost estimate for substations at either end of the transmission line (details provided in Appendix F).

Some of the options included consideration of 138 kV transmission line components. Costs for development of a 138 kV line were specified by Yukon Energy Corporation for the purposes of this study.

As part of this work a transmission options study was prepared by b7kennedy & Associates Inc. to assess electrical system requirements. This study is provided in Appendix E and provides a high-level assessment of transmission system needs and performance for connecting the Atlin hydro power project to the Yukon electrical system.

6.1 Overview of Transmission Line Connection

The new transmission line from Atlin is proposed to join the southern Yukon electrical system at Jakes Corner at the junction of the Alaska Highway and the Tagish Road. The existing Yukon system at this location is a 34.5 kV system owned primarily by ATCO Electric Yukon. The existing southern Yukon electrical system is illustrated schematically on Figure 6-1. Currently the line suppling power to the Southern Lakes area originates at Yukon Energy's substation S150 located at Whitehorse Rapid Generating Station (WRGS). This line is ATCO Electric Yukon's Southern Lakes distribution line (called line 9L). Substation S150 also provides power to three other ATCO Electric Yukon lines. Yukon Energy operates a 138 kV transmission system with a 138 kV bus at both S150 and the Riverside substation (S171) which is also at the WRGS. S171 is a ring bus to accommodate power generated from all YEC's generating assets (hydro and thermal plants)

Electrical load information for 2013 through late 2015 was provided by ATCO Electric Yukon for the Southern Lakes system. Peak loads are between 8 and 9 MW and occur in December, January and February. Peak loads by community are not known at this time, but ATCO staff have indicated that peak loads in Teslin are on the order of 1 MW. Annual energy consumption for this region has been

39.2 GWh and 38.8 GWh for 2013 and 2014 respectively. Figure 6-2 shows energy consumption in the Southern Lakes area on a monthly basis. Simulated electrical production from the Atlin Hydro Expansion project is shown as a dashed black line on Figure 6-2. See section 4.4 for a discussion of the simulated power production. As can be seen on this figure, the simulated generating profile of the Atlin Hydro Expansion project fits relatively well with the energy demand of the region. Because the generation during winter months is a function of reservoir (Surprise Lake) withdrawals, the operation can be optimized somewhat to match the loads on a seasonal basis.

Figure 6-1. Overview of Southern Lakes electrical system.

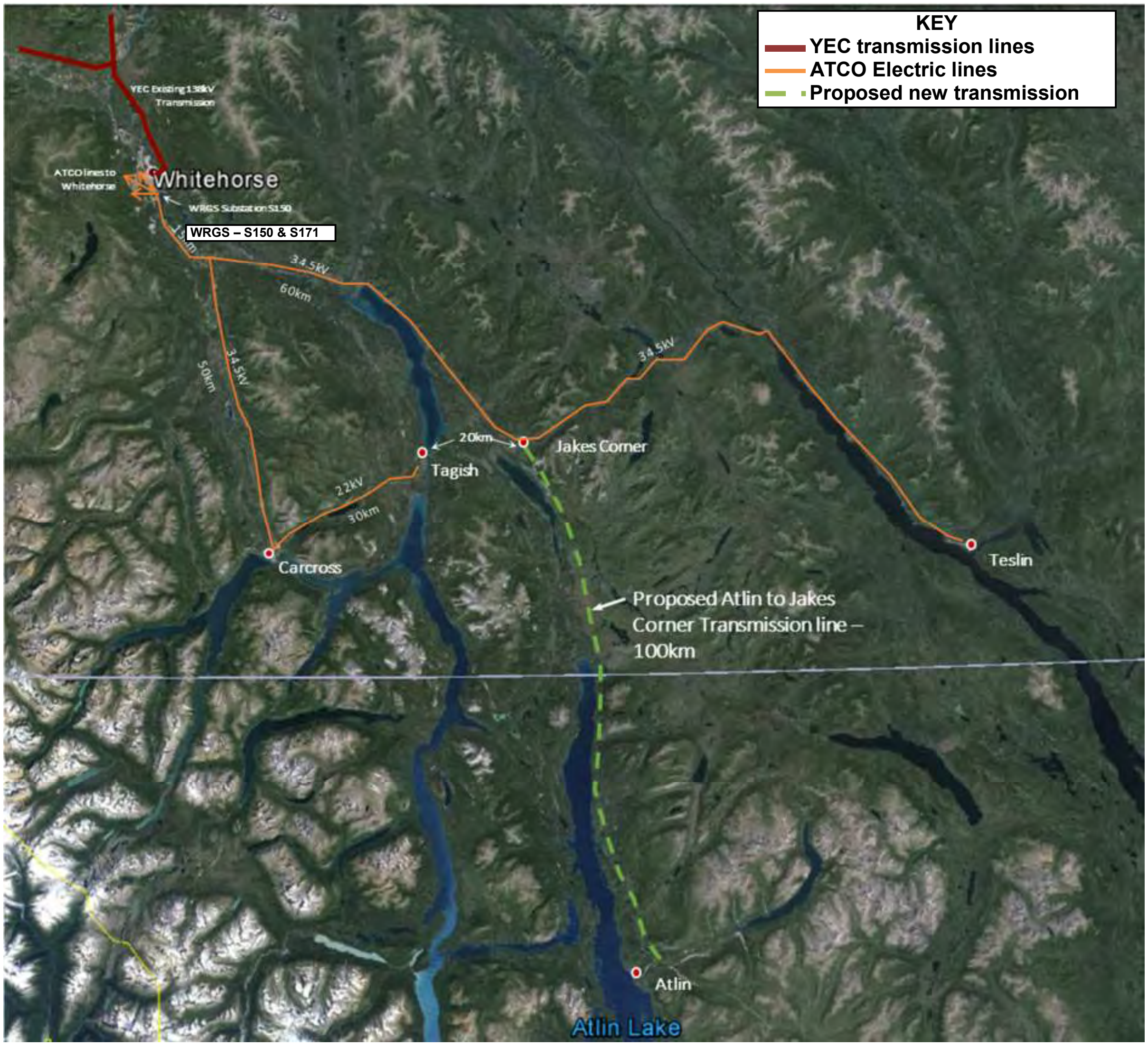
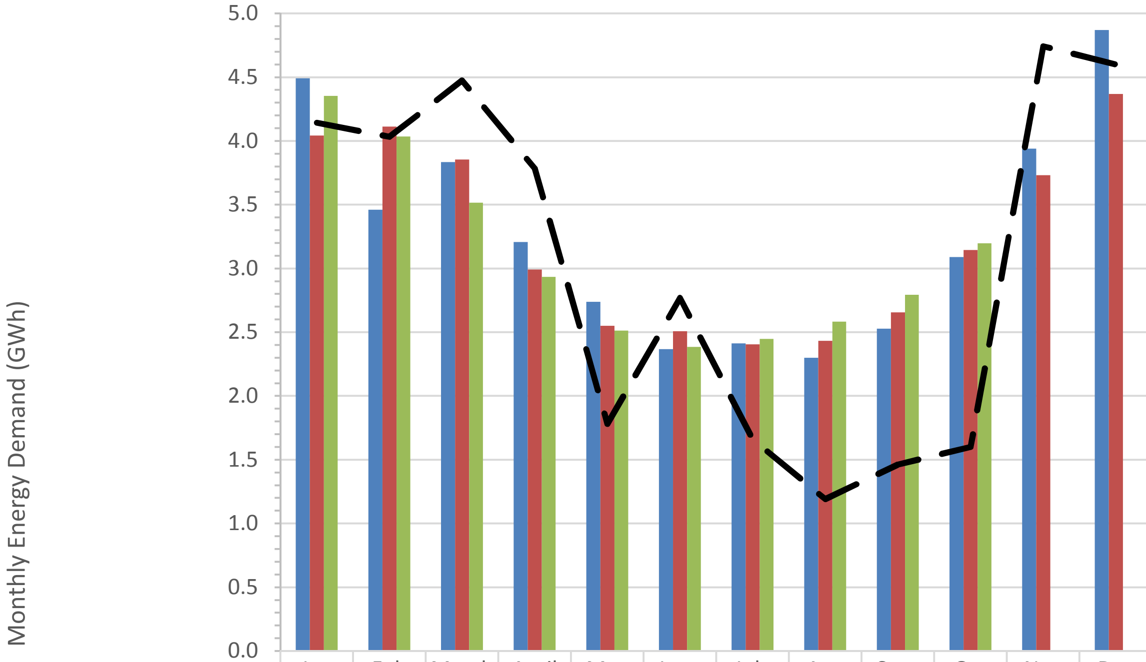


Figure 6-2. Southern Lakes monthly energy demand, 2013-2015.



	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
2013	4.5	3.5	3.8	3.2	2.7	2.4	2.4	2.3	2.5	3.1	3.9	4.9
2014	4.0	4.1	3.9	3.0	2.6	2.5	2.4	2.4	2.7	3.1	3.7	4.4
2015	4.4	4.0	3.5	2.9	2.5	2.4	2.4	2.6	2.8	3.2		
Atlin Hydro Gen.	4.1	4.0	4.5	3.8	1.8	2.8	1.7	1.2	1.5	1.6	4.7	4.6

6.2 Atlin to Jakes Corner Transmission Line: 69 kV and 138 kV Comparison

The base case assumption for the Atlin transmission line is a line at 69 kV. As an alternative, 138 kV has also been considered. The Transmission Options Assessment study by b7kennedy & Associates (Appendix E) confirmed that 69 kV performs adequately for the power being transferred over the line (on the order of 7 MW). At full-load, line losses for the 69 kV transmission line are estimated at 2.2%, or 0.16 MW; losses less than 5% are considered acceptable.

6.2.1 Construction Cost Estimates

Table 6-1 below provides a construction cost estimates for the 69 kV line and 138 kV alternative. The Atlin to Jakes Corner line length is assumed to be nominally 100 km with 50 km in BC and Yukon respectively. Further details on how these cost estimates were prepared are provided in the following sections.

Table 6-1 Atlin to Jakes Corner Transmission Line Options Cost Summary (2016$)

Transmission Line Cost Item	69 kV ($000 CAD)	138 kV ($000 CAD)
Line Construction (inc. OPGW)	21,319	33,444*
Clearing and Access	1,380	4,284
Subtotal Direct Costs	**22,699**	**37,728**
Planning	681	1,132
Property Acquisition & Permitting	1,589	2,641
Survey & Structure Staking	454	755
Engineering	1,816	3,018
Project Management	1,589	2,641
Construction Management	1,135	1,886
Owner's Costs	1,135	1,886
Subtotal Indirect Costs	**8,399**	**13,959**
Transmission Line	31,098	51,687
Overhead & Interest (0.95%)	295	491
Contingency (25%)	7,774	12,922
Total Cost	**39,167**	**65,100**

** Based on YEC provided 138 kV transmission line cost estimate, including optical ground wire (OPGW)*

6.2.1.1 69 kV Transmission Line Construction Cost Estimate

A cost estimate has been prepared for the transmission line component of the Atlin Hydro Expansion Project. This is expected to include the portion of the line between Atlin and Jake's Corner, as well as 69 kV options for other portions of the line towards Whitehorse (discussed further in Section 6.3). A cost estimate at +/- 30% level is presented, which is the level of precision that is typically achieved at a pre-feasibility study level, with no site-specific geotechnical investigations and limited opportunity for detailed project optimization. The cost estimate includes all direct construction costs, as well as indirect, lodging and travel, engineering and permitting studies, construction supervision and Owner's costs. The cost estimate values are presented in Canadian dollars, based on 2016 costs with no escalation for future work. A contingency of 25% was added to all project costs, including Owner's costs.

Further cost estimate details and assumptions for a 69 kV transmission line are presented below.

Line Design Assumptions

Preliminary assumptions were made regarding the technical details of the transmission line design in order to prepare the cost estimate. These assumptions were based on industry standard practices and historical information from a number of 69 kV projects completed by MH for BC Hydro over the past five years. These technical details are not intended to be the basis for future engineering design efforts; they are solely used for cost estimating purposes. The actual aspects of the transmission line design will need to be determined when the engineering for the project begins.

Structures and Framing

The 69 kV transmission line support structures are expected to be single wood poles. Fifty-five foot Class 2 Western Red Cedar poles were assumed as the basis for the estimate. The poles are expected to be direct-embedded into native soil, with standard embedment depths. The framing includes a single timber cross-arm in a triangular configuration. The conductors are expected to be supported by standard porcelain clamp insulators. A standard span length of 100 m between poles has been used for the estimate. For sections of the 69 kV circuit with a distribution underbuild, the pole has been changed to a 65 ft Class 1 Western Red Cedar at 90 m spans. Future work should give consideration for allowing for distribution underbuild at the north end of the transmission line (Jakes Corner to Little Atlin Lake area).

Detailed engineering design has not been performed on the poles, however basic preliminary assessments of the suitability for the poles to support the applied loads and meet vertical clearance requirements has been considered. The structural loading and clearance requirements were taken from CSA Standard C22.3 No.1-10 Overhead Systems.

Conductors

The conductor for the 69 kV circuit is assumed to be 397 kcmil “Ibis” ACSR. There would be three conductors in a triangular configuration on the wood poles. A fibre optic cable underbuild has also been included. The selected cable is a self-supporting optical ground wire (OPGW) attached to the pole below the conductor crossarm.

Terrain Considerations

For the purposes of this cost estimate, average terrain conditions (being typical rolling terrain with well-drained soil with limited areas of bedrock outcrop) were assumed for the length of the circuit. The portion of the line from Atlin to Jake’s corner is expected to generally follow Atlin Road (BC Highway #7) along the relatively low terrain adjacent to Atlin Lake. The route is expected to avoid the more rugged mountainous terrain further to the east of the highway. The highway follows relatively gradual rolling hills, and in general not particularly steep, so major excavation and blasting are not expected.

The soil conditions along the route are anticipated to be primarily well-drained till (unsorted glacially derived sediments) or sand and gravel. There will be underlying bedrock that is exposed at some locations. In the area adjacent to Atlin Road, there is expected to be adequate overburden for direct-embedment of wood poles for the majority of the route, without the need for rock extensive foundations. Detailed geotechnical information was not available at the time of the cost estimate, so these assumptions will need to be confirmed.

A right-of-way for the poles will need to be cleared, generally following the east side of Atlin Road. The right-of-way is assumed to be generally contiguous with the cleared road allowance. The clearing is expected to include light brush and small trees for most of the route, with little to no heavy timber. A 15 metre wide machine cleared right-of-way for the 69 kV circuit has been assumed for the cost estimate which is similar to ATCO's contemporary clearing practice in Yukon. The required total ROW required has not been determined at this time. The Atlin Road in BC has a 200 ft (61 m) total right-of-way of which approximately 24 m total width has been cleared (9.0 m road width plus 7.5 m cleared right of way on either side), as shown on Figure 6-3. According to BC Ministry of Transportation and Highways Technical Circular T-03/14 (2014), transmission lines can be accommodated in the road right-of-way subject to approved design. Similarly in the Yukon the transmission line can be placed in the road ROW (Government of Yukon, Transportation Engineering Branch, Utility Line Guideline, 2005)

It is assumed the poles will be placed 9 m from the road shoulder. This cleared area is assumed to be required for 100% of the circuit route in BC, and 25% of the route in the Yukon because the Yukon portion of the road has significantly wider existing clearing due to recent re-construction of the road in Yukon. The poles are assumed to be directly accessible from the Atlin Road. No separate access road has been included for the circuit.

There are no significant water crossings expected along Atlin Road. There are multiple small creeks (the specific number has not been determined in this stage of study) that will be accommodated by the typical span length of the wood poles. Similarly, no significant avalanche areas were identified along the route.

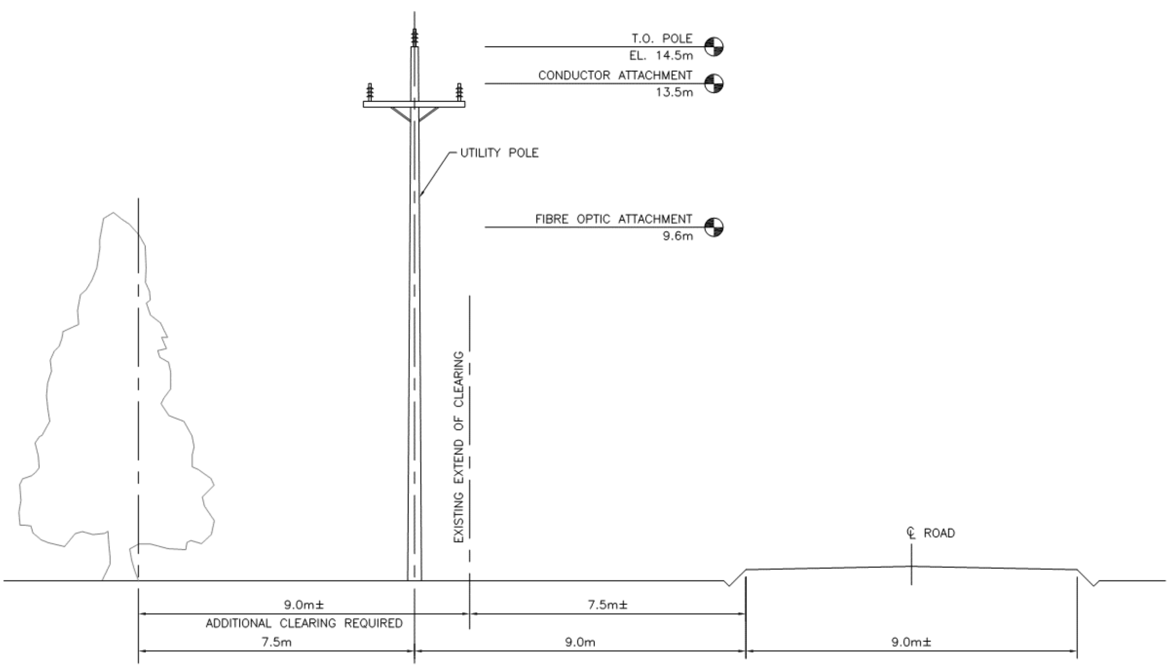


Figure 6-3. Typical 69 kV Pole configuration for BC portion of transmission line.

Indirect Costs

Indirect costs for the project include planning, property acquisition, permitting, survey and structure staking, engineering, project management, construction management, and owners' costs. Where more accurate data is not available these costs are based on historical values for similar transmission line projects in Yukon and British Columbia. Indirect costs are calculated as a percentage of the direct capital costs, and these are presented in Table 6-2 below.

Table 6-2. Indirect Costs as Percentage of Direct Costs

Indirect Cost	Percentage of Direct Costs
Planning	3%
Property Acquisition & Permitting	7%
Survey & Structure Staking	2%
Engineering	8%
Project Management	7%
Construction Management	5%
Owners' Costs	5%

Overhead, Interest and Contingency

The overhead and interest costs are based on historical values for similar transmission line projects in Yukon and British Columbia. They are taken to be 0.95% of the direct and indirect project costs. A 25% contingency has been applied to project components, including the transmission line, to account for unforeseen costs and additional items to be determined in the feasibility study.

6.2.1.2 138 kV Transmission Line Construction Cost Estimate

The cost of developing a 138 kV transmission line was provided by Yukon Energy Corporation (YEC) based on their previous work. In 2014 YEC completed an internal cost estimate for development of a 138 kV transmission line. This line assumes unit direct cost of $327,882 / km including optical ground wire (OPGW) for communication. The same indirect percentages as the 69 kV option were assumed.

The 138 kV line assume the standard wood-H pole design that is used in the Yukon. This requires a cleared right-of-way 30 m wide. In Yukon transmission lines of this size must be separate from the road right-of-way. For the purposes of this assessment it is assumed that the 138 kV transmission line would occupy a separately cleared 30 m right of way separated from the road by a vegetative (tree cover) barrier in both BC and Yukon.

6.2.1.3 Sources of Information

The estimates used data from the following sources:

- Information supplied by the YEC, including recent cost estimated completed for the 138 kV Stewart to Keno transmission line.

- Information contained in the Atlin BC to Yukon Interconnection Costing Study, August 9, 2011, prepared by BBA Engineering.

- Labour productivity values have been based on published data from the National Electrical Contractors Association (NECA) Manual of Labour Units. Factors have been applied to labour hours based on craft skill, worker availability, local conditions, potential winter work, rugged terrain, and complex work.

- RSMeans CostWorks 2015 cost estimating software and database

- Current in-house data and historical project data, available to Morrison Hershfield. This includes materials costs and contractor labour cost rates, typical for British Columbia and the Yukon.

6.2.1.4 Exclusions

- Applicable taxes
- Construction All Risk Insurance, liability insurance, or any other insurance types relevant to a construction project of this type
- Financing costs
- Fees and royalties
- Business development costs
- Removal of hazardous materials
- Public information forums
- Inspections and permits
- Allowance for funds used during construction (AFUDC)
- Overall site security, health and safety
- Ambulances and medical facilities
- Currency fluctuations beyond those specified in this Estimate
- Allowances for scope changes
- Event-driven risk
- Cost Escalations
- Escalation related to Owner’s cost.
- Operating and Maintenance costs

6.2.2 Regulatory Considerations

As per Schedule 1, Part 4, Section 1 of the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA) Assessable Activities, Exceptions and Executive Committee Projects Regulations, a 69 kV line of 50 km or less is subject to a Designated Office Evaluation. Under this assessment there is a requirement for an environmental and socio-economic impact assessment as per the Project

Proposal Form (provided by the Yukon Environmental Assessment Board (YESAB)). The form is submitted and subject to a three phase review process: Adequacy, Evaluation, and Recommendation.

Based on the criteria defined in Schedule 3 of the YESAA Regulations, a 138 kV line is anticipated to trigger an Executive Committee Review as the line is not likely to be contiguous to an existing right-of-way for its entire length. As per Schedule 3 of the Assessable Activities, Exceptions and Executive Committee Project Regulations, an Executive Committee Screening is required for the *"Construction or installation of a power line with a voltage of 138 kV or more or of a length of more than 50 km if the power line is not on a right of way developed for a power line, pipeline, railway line or road nor on a right of way contiguous to, for its whole length, a right of way developed for a power line, pipeline, railway line or road."*

Irrespective of whether a 69 kV or 138 kV line is selected, neither option would trigger environmental assessment requirements under the *British Columbia Environmental Assessment Act* (BCEAA), nor the *Canadian Environmental Assessment Act* (CEAA 2012).

Permitting requirements in British Columbia and Yukon are similar between the 69 kV and 138 kV options (additional permits for work within an existing right-of-way will be required for the 69 kV line, whereas the 138 kV will require other permits for development of a new utility right-of-way). With the larger disturbance footprint and separate right-of-way associated with the 138 kV line and Executive Committee level review, it should be expected that the permitting process will be more complicated and take more time than that expected for the 69 kV line.

6.2.3 Comparison Summary

As noted previously a 69 kV transmission line between Jakes Corner and Atlin is adequate for transferring the power from the Atlin Hydro Expansion project to the Yukon electrical system. 138 kV is a voltage that could be used for this line and is thought that this option could provide some benefits.

Advantages and disadvantages of the two options are summarized in Table 3 below.

Table 6-3. Comparison of 69 kV and 138 kV options for Yukon to Atlin transmission line.

Atlin to Jakes Corner Transmission Line Voltage	Advantages	Disadvantages
69 kV	• Lower cost; • Adequate capacity and acceptable line losses; • Can be accommodated in road right-of-way; • Relatively less clearing requirements; • Overall smaller project that has lower impact and simpler to maintain and operate. • Less complicated permitting, assessment and land acquisition requirements	• Requires a 69 kV to 34.5 kV or 138 kV substation in Yukon (either at Jakes Corner or Carcross).
138 kV	• Slightly lower line losses; • Potentially avoids a substation at Jakes Corner or Carcross, potentially saving $3,000,000; however increases substation cost in Atlin. • Significant additional transmission capacity (but is not likely to be required)	• Higher cost; • Requires separate right-of-way; • More complicated permitting & assessment requirements; • Twice as large clearing requirements and project footprint • Likely more complex and difficult to operate and maintain due to higher voltages.

The 69 kV line option is adequate for the proposed project needs and the advantages of the higher voltage option do not appear to outweigh the challenges and costs it possess. Therefore no further consideration of the a 138 kV line from Jakes Corner to Atlin is warranted at this time unless there are significant changes to power demands and supply in the Atlin region.

6.3 Yukon Connection Options Assessment

A set of three options for delivery and transmission of power from the Atlin Hydro Expansion project to the Yukon's electrical system have been considered. For the purposes of this assessment, each of these three options assumes a 69 kV transmission line from Atlin to Jakes Corner is required; therefore costs associated with this line (as presented in Section 1.2 above) are common to all options and not considered further in this assessment. The three primary options are:

1. connect to the existing ATCO's existing southern Yukon system at Jakes Corner;
2. connect to a new 138 kV transmission line in the Carcross valley; or
3. connect to a new transmission line along the Alaska Highway at Jakes Corner.

Each of the three options has two sub-options, described further in Sections 6.3.1to 6.3.3.

To assess these options, a high-level system study was completed by b7kennedy & Associates Inc. This report is provided in Appendix E. Substation costs for these options were prepared by Magna IV Engineering and can be found in Appendix F.

6.3.1 Option 1. Connect to Existing Electrical System

Option 1 looks to supply power to the southern Yukon making maximum utilization of the existing electrical infrastructure. The two sub-options are:

a) Connect to ATCO's line SL622 at Jakes Corner serving the Southern Lakes load as isolated. This assumes there is no interconnection to the existing Yukon electrical system at S150.

b) Connect to ATCO's line SL622 at Jakes Corner serving the Southern Lakes and is interconnected to the Yukon's electrical system via the 34.5kV line 9L to S150 in Whitehorse.

These options include the following new infrastructure (see Figure 6-1):

- A new substation with 69 kV bus at the upper Atlin hydro generating station;
- A 100 km long 69 kV transmission line to Jakes Corner; and
- A 69/34.5 kV substation at Jakes Corner.

The system study concludes that Option 1a) is not recommended because the Atlin Hydro Expansion project is not able to supply the entire Southern Lakes load under peak load conditions. Option 1b) which includes connection to the rest of the Yukon system at S150 is considered feasible and provides acceptable results from the point of view of voltage regulation and losses. Line losses to Jakes Corner at full generation (7.1 MW sent from Atlin) are estimated at 0.157 MW, or 2.2%. If it is assumed there is no load on the Southern Lakes system and all of the Atlin output is absorbed at Whitehorse, then line losses to Whitehorse would be at most 0.403 MW.

From a regulatory perspective, Option 1 is the simplest of the three options assessed, as it does not require any additional transmission infrastructure other than the Atlin to Jakes Corner transmission line itself.

Option 1b) is the simplest and lowest cost option because it does not require additional new transmission infrastructure other than the Atlin to Jakes Corner line and associated substations.

6.3.2 Option 2: Connect to a New 138 kV Transmission Line in Carcross Valley

Option 2 assumes connection to a new (future) 138 kV transmission line developed by Yukon Energy from their substation S171 in Whitehorse to Carcross. The two sub-options are:

a) The 69 kV interconnection to Jakes Corner is extended to Carcross and connected to the 138 kV system via a 138/69 kV substation in Carcross.

b) Extend the 138 kV line from Carcross to Jakes Corner and connect to the 138 kV system via a 138/69 kV substation in Jakes Corner.

These options include the following new infrastructure (Figure 6-4):

- A new substation with 69 kV bus at the upper Atlin hydro generating station;
- A 100 km long 69 kV transmission line to Jakes Corner;
- For Option 2a), a 69/34.5 kV substation at Jakes Corner; for Option 2b), a 69/34.5 kV substation and 69/138 kV substation at Jakes Corner;
- A 50 km long transmission line to Carcross at 69 kV for Option 2a), and 138 kV for Option 2b). The 69 kV assumes a distribution underbuild along the Tagish Road between Carcross and Tagish; and
- A 138 kV tap at an assumed pre-existing substation at Carcross.

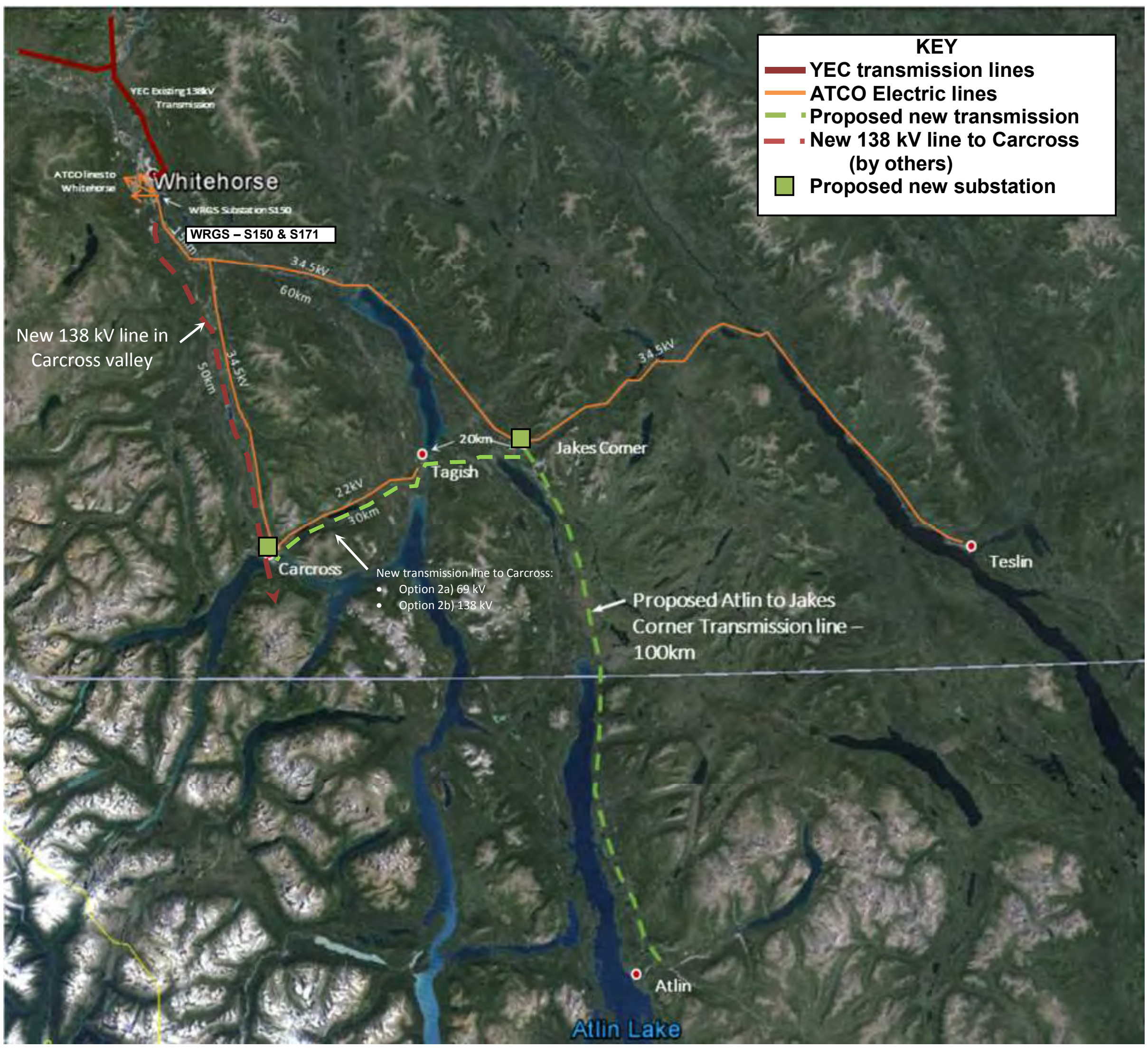
Options 2a) and 2b) assume that a 138 kV line has previously been built from Whitehorse (S171) to Carcross.

These options provide a connection both at Jakes Corner to ATCO's line SL622 and a connection of the future Carcross valley 138 kV line. It is assumed that the load is split between Jakes Corner and Carcross. Voltage regulation and line losses at full Atlin generation are similar to Option 1b), however with the split loads additional shunt compensation is required. From a performance perspective, Option 2 does not appear to provide any significant advantage, however there could be some system redundancy provided by connecting to the Yukon system at two points.

Assuming the 69 kV line would run within or contiguous to an existing right-of-way for its entire length, Option 2a) would be subject to a Designated Office Evaluation under YESAA. Conversely, it is assumed that a new 138 kV line would be in a separate right-of-way and therefore Option 2b) would be subject to an Executive Committee Screening. With respect to other permitting requirements, both Option 2a) and 2b) would have additional complexity relative to Option 1. Option 2a) would require permitting and development of an additional 20 km of new 69 kV line between Tagish and Jakes Corner, plus the replacement of 30 km of existing distribution line between Carcross and Tagish. The new line would require a 15 m wide cleared right-of-way and it is assumed the replacement line would occupy the same right-of-way as the existing distribution line. A more involved permitting process is anticipated for Option 2b) when compared with Option 2a) given the larger footprint associated with an additional substation as well as 50 km of new 138 kV transmission line, which includes a 30 m wide cleared right-of-way. This would be separate from the existing distribution infrastructure.

If it is assumed there is no load on the Southern Lakes system and all of the Atlin output is absorbed at Whitehorse, then total line losses to Whitehorse would be at most 0.261 MW and 0.246 MW for Options 2a) and 2b) respectively.

Figure 6-4. Yukon system connection Option 2 - connect to a new 138 kV transmission line in the Carcross valley.



6.3.3 Option 3: Connect to Whitehorse with New Transmission Line along Alaska Highway

Option 3 assumes a new transmission line from Jakes Corner directly to Yukon Energy's Riverside substation (S171) in Whitehorse. This additional line would be in total 75 km long and paralleling the Alaska Highway. The two sub-options are:

a) A new 69 kV transmission line from Jakes Corner to S171. At S171 a 138/69 kV transformer is installed.

b) A new 138 kV transmission line from Jakes Corner to S171. At Jakes Corner a 138/69 kV substation is established.

These options include the following new infrastructure (see Figure 6-5);

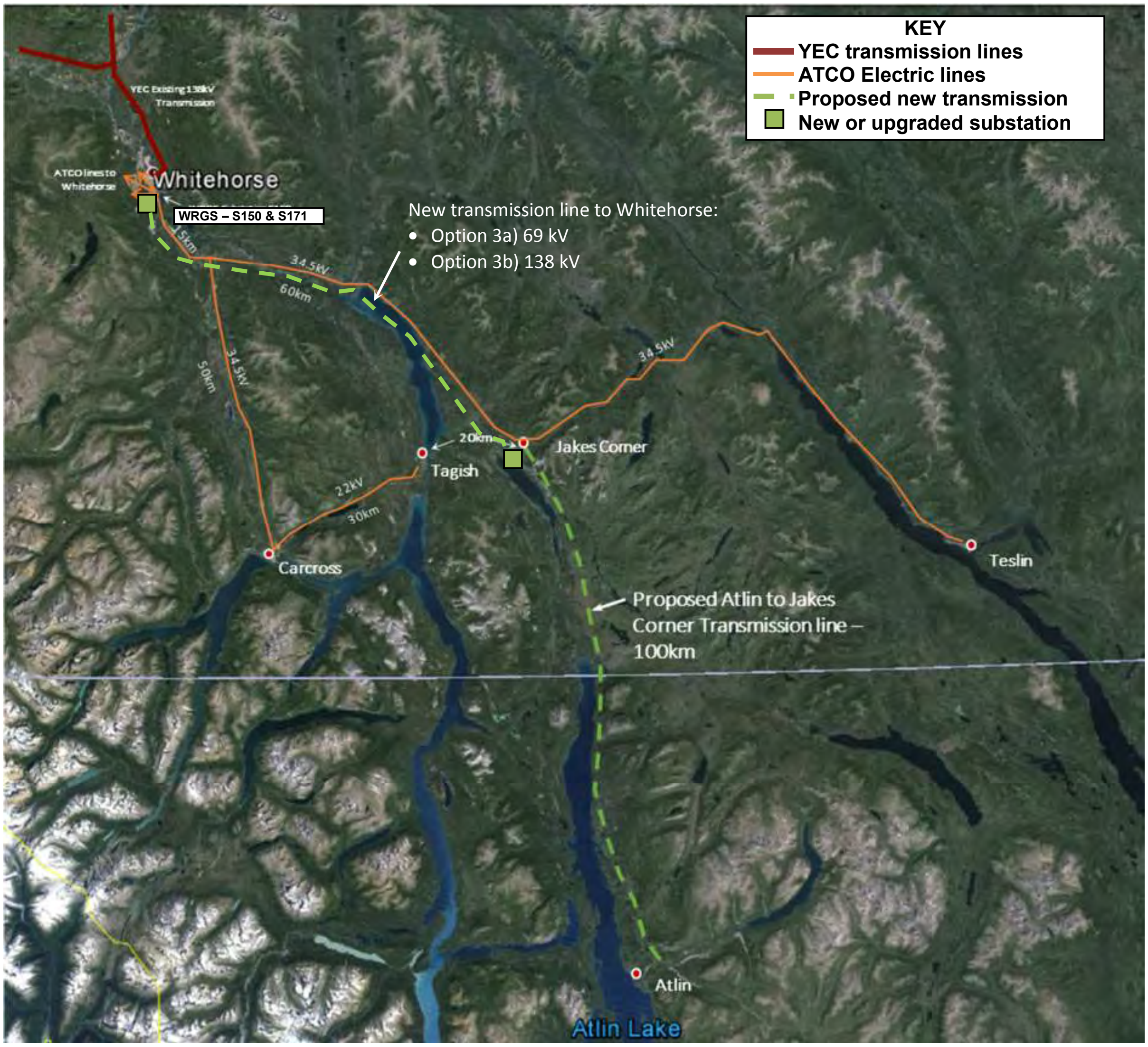
- A new substation with 69 kV bus at the upper Atlin hydro generating station;
- A 100 km long 69 kV transmission line to from Atlin to Jakes Corner;
- For Option 3a), a 69/34.5 kV substation at Jakes Corner; for Option 3b), a 69/34.5 kV substation and 69/138 kV substation at Jakes Corner;
- A 75 km long transmission line to Whitehorse at 69kV for Option 3a) and 138 kV for Option 3b). The 69kV assumes a distribution underbuild along the Alaska Highway between Jakes Corner and Whitehorse; and
- A 138 kV tap at S171 in Whitehorse.

These options provide a connection both at Jakes Corner to ATCO's line SL622 and a connection to S171 in Whitehorse. Shunt compensation is required at Jakes Corner for voltage support. Voltage regulation and line losses at full Atlin generation are similar to Option 1b). From a performance perspective, Option 3 does not appear to provide any significant advantage. Option 3a) assumes replacement of ATCO's aging distribution (34.5 kV) infrastructure along the Alaska Highway between Whitehorse and Jakes Corner. This may provide some infrastructure renewal benefit. Option 3b) does not replace ATCO's existing distribution infrastructure because it is assumed the new 138 kV line would be separate.

Assuming the 69 kV line would run within or contiguous to an existing right-of-way for its entire length, Option 3a) would be subject to a Designated Office Evaluation under YESAA. Conversely, it is assumed that a new 138 kV line would be in a separate right-of-way and therefore Option 3b) would be subject to an Executive Committee Screening. With respect to other permitting requirements, Option 3 would have additional complexity relative to Option 1. Option 3a) would require permitting and replacement of 75 km of existing distribution line between Jakes Corner and Whitehorse. The new line would require a 15 m wide cleared right-of-way and it is assumed the replacement line would occupy the same right-of-way as the existing distribution line. A more involved permitting process is anticipated for Option 3b) when compared with Option 3a) given the larger disturbance footprint associated with an additional substation as well as 75 km of new 138 kV transmission line, which includes a 30 m wide cleared right-of-way. This would be separate from the existing distribution infrastructure.

If it is assumed there is no load on the Southern Lakes system and all of the Atlin output is absorbed at Whitehorse, then total line losses to Whitehorse would be at most 0.275 MW and 0.187 MW for Options 3a) and 3b) respectively.

Figure 6-5. Yukon system connection Option 3 - connect to Whitehorse with new transmission line along Alaska Highway.



6.3.4 Yukon System Connection Options: Cost Estimate Summary

Table 6-4 below provides a summary of the estimated costs for the various options for connecting to the Yukon electrical system. This table details additional costs associated with the connection beyond the Atlin to Jakes Corner transmission line itself. Basis for transmission line cost estimates are provided in Sections 6.2.1.1 and 6.2.1.2 above. Substation costs were developed by Magna IV Engineering and details are provided in Appendix F.

Table 6-4. Yukon electrical system connection options cost summary (2016$).

Connection Cost Item	Option 1a ($000 CAD)	Option 1b ($000 CAD)	Option 2a ($000 CAD)	Option 2b ($000 CAD)	Option 3a [b] ($000 CAD)	Option 3b [b] ($000 CAD)
Additional Line Length	None	None	50 km	50 km	75 km	75 km
Additional Line Voltage	n/a	n/a	69 kV	138 kV	69 kV	138 kV
Direct Cost						
Additional Line Construction	Option not recommended	0 [c]	12,608	17,050	20,733	26,886
Clearing and Access		0	756	2,184	861	3,444
Subtotal Direct Costs		**0**	**13,364**	**19,234**	**21,594**	**30,330**
Indirect Cost						
Planning		0	401	577	648	910
Property Acquisition & Permitting		0	936	1,346	1,512	2,123
Survey & Structure Staking		0	267	385	432	607
Engineering		0	1,069	1,539	1,728	2,426
Project Management		0	936	1,346	1,512	2,123
Construction Management		0	668	962	1,080	1,517
Owner's Costs		0	668	962	1,080	1,517
Subtotal Indirect Costs		**0**	**4,945**	**7,117**	**7,990**	**11,222**
TOTALS						
Additional Transmission Line		0	18,309	26,350	29,584	41,553
Substation		1,446	2,690 [a]	2,501 [a]	2,690	2,501
Overhead & Interest (0.95%)		14	199	250	281	395
Contingency (25%)		362	5,250	7,213	8,068	11,013
Total Yukon Connection Cost	**n/a**	**1,821**	**26,449**	**36,315**	**40,623**	**55,462**

Notes: [a] this options assumes expanding an existing substation in Carcross or Whitehorse

[b] Option 3 assumes same substation costs as Option 2, but Carcross substation is located in Whitehorse.

[c] Option 1 does not require any additional transmission line beyond the primary Atlin to Jakes Corner line.

6.3.4.1 Yukon System Connection Options Conclusions

A summary of the various attributes for the six options are provided in Table 6-5. Based on this work, Option 1b) appears to be the most viable option. Connecting to the existing infrastructure at Jakes Corner is technically viable and should result in acceptable system performance. This option is the lowest cost and simplest to implement. The high-level system study has not identified significant upgrades to the existing grid required for this option beyond those costs presented herein.

Adding additional transmission infrastructure from Jakes Corner to Carcross or Whitehorse does not significantly improve transmission performance or reduce transmission losses from the Atlin Hydro Expansion project. Development of the additional transmission lines may have other benefits to the Yukon’s electrical transmission system and the utilities; however they do not appear to be required for the Atlin Hydro project to deliver electricity to the Yukon.

Table 6-5. Yukon system connection options assessment summary.

Yukon System Connection Option	Option 1a) Jakes Corner Southern Lakes, isolated	Option 1b) – Jakes Corner Southern Lakes connected	Option 2a) – Carcross 138 kV 69 kV Jakes Corner to Carcross	Option 2b) – Carcross 138 kV 138 kV Jakes Corner to Carcross	Option 3a) – Whitehorse 69 kV Jakes Corner to Whitehorse	Option 3b) – Whitehorse 138 kV Jakes Corner to Whitehorse
High-level capital cost of connection (total include contingency (25%) & overhead)	n/a	No additional line req'd Substation Only: $1,446,000 Total $1,821,000	Additional line: $18,309,000 Substations: $2,690,000 Total: $26,449,000	Additional line: $26,350,000 Substations: $2,501,000 Total: $36,315,000	Additional line: $29,584,000 Substations[2]: $2,690,000 Total: $40,623,000	Additional line: $41,553,000 Substations[2]: $2,501,000 Total: $55,462,000
Technical feasibility	No Peak loads of Southern Lakes cannot be met	Yes Voltage regulation and losses are within acceptable ranges.	Yes Voltage regulation and losses are within acceptable ranges.	Yes Voltage regulation and losses are within acceptable ranges.	Yes Voltage regulation and losses are within acceptable ranges.	Yes Voltage regulation and losses are within acceptable ranges.
Transmission losses (at full generation of 7 MW sent)[1]	n/a	0.157 to 0.403 MW	0.157 to 0.261 MW	0.156 to 0.246 MW	0.157 to 0.275 MW	0.158 to 0.187 MW
System benefits	n/a	No additional benefits other than generation provided to Southern Lakes at Jakes Corner.	• Atlin hydro generation supplied at both Jakes Corner and Carcross. • Replaces 30 km Carcross to Tagish distribution line with new infrastructure.	• Atlin hydro generation supplied at both Jakes Corner and Carcross. • Extends higher-voltage transmission infrastructure to Jakes Corner.	• Replaces 75 km Whitehorse to Jakes Corner distribution line with new infrastructure[3].	• Extends higher-voltage transmission infrastructure to Jakes Corner[3].
Regulatory & environmental considerations	n/a	• No additional considerations other than Atlin to Jakes Corner transmission line. • YESAB Designated Office Evaluation assumed (69 kV and line ≤ 50 km) for Atlin to Jakes Corner transmission line.	• YESAB Designated Office Evaluation if line is within or contiguous with an existing right-of-way for its entire length. • Option assumes a 138 kV line exists to Carcross. • Requires development of 20 km of new line plus re-construction of 30 km of existing line. • Additional project footprint is assumed to be 15 m x 20 km = 30 ha.	• YESAB Executive Committee Screening, as line is not likely to be contiguous with an existing right-of-way for its entire length. • Option assumes a 138 kV line exists to Carcross • Requires development of 50 km of new line in a separate right-of-way. • Routing could be challenging due to extensive land ownership in Tagish area. • Additional project footprint is assumed to be 30 m x 50 km = 150 ha.	• YESAB Designated Office Evaluation if line is within or contiguous with an existing right-of-way for its entire length • Requires re-construction of 75 km of existing line.	• YESAB Executive Committee Screening, as line is not likely to be contiguous with an existing right-of-way for its entire length. • Requires development of 75 km of new line in a separate right-of-way. • Routing could be challenging due to terrain and land ownership constraints at the north end of Marsh Lake. • Additional project footprint is assumed to be 30 m x 50 km = 225 ha.

Notes [1] Higher line loss value assumes all of Atlin hydro output is absorbed at Whitehorse and all loads at Jakes Corner/Teslin and Carcross are switched off.

[2] For Option 3, substation costs are assumed to be the same as Option 2 but the substation is located in Whitehorse, not Carcross.

[3] ATCO Electric Yukon has indicated that by putting new transmission between Whitehorse and Carcross they could contribute financially to the project's capital cost because they would avoid the upcoming replacement cost of their 34 kV "transmission" infrastructure. Presumably the same would hold true for the Whitehorse to Jakes Corner leg as well. However, this consideration will not be included in the assessment at this time.

7 COST ESTIMATE & CONSTRUCTION SCHEDULE

7.1 Cost Estimate

A cost estimate has been prepared for the Atlin Hydro Expansion Project. A cost estimate at +/- 30% level is presented, which is the level of precision that is typically achieved at a pre-feasibility study level, with no site-specific geotechnical investigations and limited opportunity for detailed project optimization. The cost estimate is considered to be at a class 4 level based on the AACE framework. Quotes were however obtained for some key items of the project such as the turbines providing a slightly higher level of precision than AACE recommends for a class 4 cost estimate. The cost estimate includes all direct construction costs, indirect, lodging and travel, engineering and permitting studies, construction supervision and Owner's costs. A contingency of 25% was added to all project costs, including Owner's costs. Details for the cost basis is presented below while the complete cost estimate is presented in Appendix G.

Unit prices were selected to include both direct and indirect costs (man power, equipment, camp, travel, etc). Unit costs were derived from recent experience by the project team on similar project and ATELP actual costs from 2007 to 2009 for building the existing power plant. It should be noted that the hydropower industry has experienced considerable cost escalation in the last five years. Project experience has shown costs have been escalating faster than inflation and have been on the order of 25% increase since 2009.

Some of the reference projects costs have been provided by KGS based on their recent relevant project experience, including:

New Post Creek (OPG)

- 28 MW plant in north-eastern Ontario with two horizontal Francis turbines
- Preliminary design and tender documents by KGS, currently acting as Owner's Engineer
- Currently negotiating final pricing with design-build contractor (detailed tender cost breakdowns have been provided for KGS review)

Tazi Twé (formerly Elizabeth Falls, SaskPower)

- 50 MW, 4-unit plant in northern Saskatchewan
- Currently proceeding with final design, in Alliance-style partnership with SaskPower and Contractor
- Assisting SaskPower negotiate final project pricing with Contractor (detailed bid price cost breakdowns provided for review)

Mayo B (Yukon Energy Corporation)

- 10 MW, two horizontal Francis units, first power in December 2011
- KGS completed final design and were contact administrators
- Involved in initial negotiations with contractor, administered the open-book construction contract (contractor invoices included details on direct unit prices, quantities, employee hours, indirects, overhead, travel, camp costs, and profit markups)

Wawaitin (OPG)

- 8 MW plant with two Francis units, first power in 2010
- KGS assisted design-build contractor with initial bid, completed final design

Northern Hydro Study (SaskPower)

- KGS conducting pre-feasibility study of 8 potential hydro sites in northern Saskatchewan (near Northwest Territories border) ranging from 5 to 25 MW
- Turbine suppliers solicited for bid pricing
- Contractor with extensive hydroelectric construction experience were retained to review and confirm direct unit prices, indirects, and other markups carried in study cost estimates

Sechelt (Conwest, now Regional Power)

- 16 MW plant in BC with two Pelton units, first power in 1997
- KGS completed final design, contract admin and site supervision

KGS Group has also been involved in several larger hydroelectric construction projects (200 MW +) for Manitoba Hydro, both ongoing and in recent years. They have conducted similar work in northern Canada for repair and construction of water-retaining structures, from conceptual studies to detailed design. From these projects KGS has an extensive and up-to-date cost database, from detailed unit price and equipment costs through to final project costs for various structures and sizes of generating stations. Additional cost information was also obtained from similar local projects from Yukon Government (Highways and Community Services) as well at ATCO Electric Yukon (transmission line costs and Fish Lake Hydro upgrade project).

The following key unit costs were used for the main cost items of the project. Specifics of some of the quantity assumptions are stated in Appendix E. Various components were estimated as lump sum items due to the lack of design information available at this time. For example, the majority of the powerhouse mechanical and electrical balance-of-plant components were estimated as lump sum items based on ratios established on previous construction projects. A total cost allowance of $500,000 was also included for potential environment mitigation works associated with the lower power plant (not including fishways). The specific cost basis for key items is as follows:

Land clearing

Assumed $20,000/ha based on recent construction cost estimate in central Yukon. Actual costs for existing Atlin hydro project could have been lower, but actual unit prices could not be determined at this time.

Access roads (permanent)

$100,000/km based on actual mining resource road costs in Keno, Yukon has been used. Other hydro projects have experienced access road costs as high as $350,000/km.

General Excavation (dry)

\$11.25/m^3 has been used based on 25% cost escalation of actual general excavation costs paid in 2009 as part of the Atlin hydro construction. Other projects have experienced general excavation costs ranging from \$20 to \$35/m^3. The relatively low cost for general excavation assumed in this estimate is probably reasonable due to abundance of earthmoving capability in the Atlin area as a result of the placer mining industry.

General Excavation (rock)

\$100/m^3 has been used based input from ATELP and their actual experience with the previous hydro project. Other projects have experienced rock excavation costs in the order of \$125/m^3

Rip rap (produce, haul & place)

\$112.50/m^3 has been used based on 25% cost escalation of actual rip rap costs paid in 2007 as part of the Atlin hydro's Surprise Lake control structure. At that time ATELP paid \$27/m^3 for produce rip rap plus \$63/m^3 to haul and place rip rap, including geotextile. Other projects have experienced rip rap costs ranging from \$120 to \$140/m^3.

Granular fill (supply and place)

\$81.25/m^3 has been used based on 25% cost escalation of actual supply and placement of drain rock costs paid in 2008 as part of the Atlin hydro construction (\$65/m^3 in 2008).

Random backfill (supply and place)

\$37.50/m^3 has been used based on 25% cost escalation of actual supply and placement of drain rock costs paid in 2008 as part of the Atlin hydro construction (\$65/m^3 in 2008).

Sheet Pile Cutoff Wall

\$295.10/m^2 has been used based on 25% cost escalation of actual sheet pile costs paid in 2007 as part of the Atlin hydro's Surprise Lake control structure. At that time ATELP paid \$227/m^3 for supply and install of the Surprise Lake weir sheet pile wall. Other projects have experienced sheet pile costs up to \$840/m^2.

1.52 m Ø I.D. HDPE Penstock

Penstock pricing was obtained from two suppliers: Uponor Infra Ltd of Mississauga Ontario and Wolseley Industrial of Langley BC. The latter was the HDPE penstock pipe supplier in 2009. Price for supply of pipe and freight to Atlin from Wolseley is (outside diameters are presented here):

63" DR41	\$249.00/ft (\$817/m)
63" DR32.5 (50 PSI)	\$287.00/ft (\$942/m)
63" DR26 (64 PSI)	\$332.00/ft (\$1089/m)
63" DR21(80 PSI)	\$385.00/ft (\$1263/m)

Plus installation costs:

- Joint welding = $3670 per day for 4 joints;
- Pipe haul and placement = Assumed $100/15 m using reduced price from Mayo-B;
- Indirect factor 1.25;
- Overhead and profit factor 1.12;

<u>1.52 m Ø I.D. Steel Penstock</u>

A price of $2,350/m for 3/8” coated steel pipe was used. This is based on the Mayo-B Hydro Project penstock prices which were $4.7/kg ($2016 using 5% escalation). This is for coated pipe, interior and exterior. This price is representative of the supply and installation of the pipe including welding and touch-up of the coating. The price does not include any excavation or filing. By way of comparison, in 2011 Mayo-B supply-only pipe was $2.5/kg which is $3.42/kg after escalation. However more current pricing for New Post hydro project is actually $7/kg supply and install, no backfill or excavation, no indirects or overhead and profit, however it is for a larger size pipe than was used in Mayo-B. Indirect factor of 1.25 plus overhead and profit factor of 1.12 have been added to the supply and install cost.

<u>2.0 m Ø Steel Penstock</u>

A price of $3,100/m for 3/8” coated steel pipe was used as per the considerations described for the 1.52 m penstock.

Volumes for penstock excavation and backfill were determined by using a typical cross section times the applicable length. Excavation and volume estimates for the lower head pond, dam and weir were determined using the preliminary design drawings as well as Civil 3D. Other excavation volumes were estimated based on the footprint of the proposed works and the assumed depths. Additional notes regarding the quantities estimated are presented with the detailed cost estimate in Appendix F.

Transmission line and substation costs were estimated for the 2016 report update and are provided in Section 6 of this report. A 2% inflation factor was applied to convert 2015 to 2016 prices.

Additional owner’s costs were added to the total project costs on a percentage basis of the direct/indirect costs. The following costs were included, with the percentage value that was used:

- Feasibility study: 1.5%
- Final design & procurement: 5%
- Assessment & licensing (including environmental studies): 3%
- Site assistance & quality assurance: 5%
- Other owner’s costs (including legal and financing): 4%

Table 7-1 presents a summary of the construction cost estimate of the Atlin Hydro Expansion Project. The hydroelectric generation project alone, without transmission is estimated at **79.7M$.** A total project cost of **120.7M$** is estimated including transmission required to connect with the Yukon's electrical grid at Jakes Corner.

A financial assessment was completed based on the project capital cost estimate. The total expanded Atlin Hydro project is estimated to produce on average 44.6 GWh/yr, of which between 6.2 and 8.3 GWh/yr is committed to BC Hydro by 2032. Therefore it is assumed the project will deliver 36.3 GWh/yr of energy to the Yukon's electrical grid (net of 2.2% line losses).

Table 7-1: Summary of Atlin Hydroelectric Expansion Project Estimated Construction Costs

Item		Cost (M 2016$)
SURPRISE LAKE CONTROL STRUCTURE UPGRADE		
1.	Site work	0.08
2.	Structures & Excavation	0.14
3.	Environmental & Mitigations	0.07
	Sub-total (1)	**0.3**
UPPER POWER PLANT EXPANSION		
1	Site Work	0.3
2.1	*Intake*	0.2
2.2	*Penstock*	10.7
2.3	*Powerhouse & Tailrace*	3.2
3	Turbine & Generator	3.9
4	Electrical & Mechanical Balance of Plant	4.0
	Sub-total (2)	**22.3**
LOWER POWER PLANT		
1.	Site Work	1.2
2.1	*Intake & Head Pond*	1.8
2.2	*Spruce Creek Diversion*	0.2
2.2	*Penstock (inc. surge facility)*	17.2
2.3	*Powerhouse & Tailrace*	3.0
3	Turbine & Generator	5.1
4	Electrical & Mechanical Balance of Plant	1.5
5	Transmission Line to Upper Powerhouse	0.9
6	Environmental & Mitigations	0.2
	Sub-total (3)	**31.0**
SUB-TOTAL DIRECT/INDIRECT COSTS (1-3)		**53.6**
	Engineering and Permitting (9.5 %)	5.3
	Construction supervision and owner's cost (9 %)	4.8
	Sub-total	**63.8**
	Contingency (25%)	15.9
HYDROELECTRIC PROJECT ONLY COSTS		**79.7**

Item	Cost (M 2016$)
TRANSMISSION LINE TO JAKES CORNER (4)	**24.1**
Planning, Engineering and Permitting (20%)	4.5
Project & Construction Management and owner's cost (18%)	4.1
Sub-total (4)	**32.7**
Contingency (25%)	8.2
TRANSMISSION LINE COSTS	**40.9**
TOTAL PROJECT COSTS W/ TRANSMISSION (1-4)	**120.7**

7.2 Schedule

Prior to the start of construction, all engineering and regulatory studies will have to be completed. A preliminary schedule is outlined based on the current state of the project and an optimistic development schedule (i.e. financial arrangements are in place). Additional details about engineering, environmental and regulatory studies are provided in section 7. It is assumed that funding will be made available to advance the required studies.

A preliminary construction sequence of the Atlin Hydro Expansion Project has been prepared. It is assumed that works are temporarily stopped during the middle of the winter period (mid-December to end of February). It is expected that construction would take 2 years to complete once all regulatory approvals are in place. It is assumed that work on the upper and lower power plants (and associated penstock) will be conducted simultaneously to achieve that schedule. If construction activities were to be conducted in sequence for each plant, it would likely require a third construction year to complete the project. The schedule that is currently proposed is the most optimal one to achieve the earliest in service date for the project.

Figure 7-1 provides an overview of the conceptual project schedule. A detailed construction schedule is provided in Appendix G.

Phase 1 – Surprise Lake Control Upgrade - Year 1 (March to May)

Work on upgrading the Surprise Lake Control structure should be done at a low-lake level period: March to May. The lake should be drawn down to the lowest level possible before commencing works. This phase could be conducted as early as the year before work on the power plants is initiated should regulatory approvals be in place. Commissioning the expanded operating range on Surprise Lake prior to downstream instream works is desirable because the lake's storage volume can be utilized to manage/minimize flows during downstream works. Work would include:

- Prepare shoreline access (snow / ice road) for excavation of upstream and downstream channel deepening;
- Raise overflow weir;
- Upgrade the fishway;
- Some reservoir clearing of low-area at west end of lake and other locations may be warranted.

Phase 2 –Upper & Lower Power Plants Year 1 (Feb to December)

Year 1 work consists primarily of site preparation and access, excavation and penstock construction. The construction is initiated during the winter with mobilization to site and preparation for the upcoming summer season. The following tasks will take place.

- Mobilization
- All falling and clearing work for intake pond, penstock and powerhouses should be conducted in late winter/spring so that it is completed prior to breading bird season;
- Develop access along the lower penstock and to lower powerhouse;
- Build lower penstock and lower powerhouse access roads;
- Excavation for penstocks and surge facility (overburden and rock);
- Install upper penstock and partially install lower penstock;
- Foundation preparation and excavation for both powerhouse;
- Construction of both powerhouses concrete substructure;
- Install superstructure for upper powerhouse (it should be possible to advance construction of the upper powerhouse faster because of its relatively lower complexity);

Phase 3 – Upper & Lower Power Plants - Year 2 (April to December)

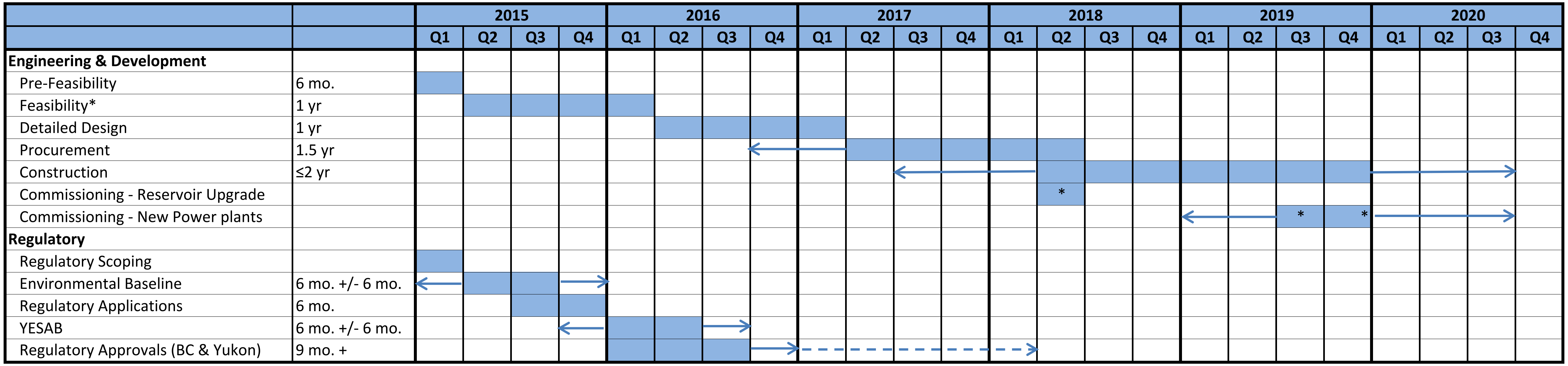
Complete construction of all main works:

- Surprise Lake should be drawn down to lowest level possible prior to spring freshet to allow summer flows in Pine Creek to be attenuated by the lake;
- Construction of the second intake structure at the upper head pond – this should be done in spring when flows in Pine Creek are lowest;
- Excavation of the lower powerhouse tailrace should be done when Atlin Lake is at its lowest level: April and May.
- Excavation and construction of the lower head pond;
- Complete installation of penstock and surge pipe;
- Lower powerhouse superstructure construction;
- Turbines installation;
- Installation of mechanical and electrical balance of plant equipment;
- Construction of transmission line from lower powerhouse to switch yard at upper powerhouse;
- Filling of Surprise Lake up to the new full pond level;
- Commissioning of the upper power plant should be possible by the autumn of year 2 in time for winter generating period. Commissioning of the lower plant should be possible by the end of year two.

It is estimated that the construction of the transmission line to connect with the Yukon grid will take approximately 12 months to complete. It will take place at the same time as the construction of the project: over two summer/fall seasons approximately running from early May to end of October with any clearing done in the proceeding winter/early spring to avoid breeding bird conflicts. Completion of the transmission line should be scheduled to coincide with the commissioning of the upper power plant.

Figure 7-1. Overview Project Development Schedule

Atlin Hydro Expansion Prefeasibility Study



Notes: → *Arrows indicate range of schedule timing for item.*

** requires site investigation summer 2015.*

8 SUMMARY AND RECOMMENDATIONS

8.1 Summary

A simplified pre-feasibility study of the Atlin Hydroelectric Expansion Project has been completed. Pine Creek near Atlin, BC has been previously developed in 2009 as a 2.1 MW hydropower project to service the community's electrical needs. The objectives of this current study are:

1. Estimate the scale of the hydropower opportunity readily available for development on Pine Creek. How much power could be generated if the full potential of the site was developed? and
2. Is the expanded development of the site, for sale to the Yukon electrical grid, potentially economically viable?

The study is intended to determine the scale of the opportunity and determine if it is worthwhile to pursue. At this stage the development concepts have not taken into consideration environmental and social mitigations and only limited optimization of the project design has been completed. The design concepts presented in this study are preliminary in nature for the purpose of estimating project costs and are not necessarily representative of the ultimate design or layout of the project.

The study was supported by obtaining new 1-m topographic mapping of Pine Creek from the existing intake to Atlin Lake. A site visit was conducted in September 2014 that included a fly-over of the project site as well as a ground reconnaissance of the location of the proposed works, including a portion of the lower penstock alignment. The study did not include any geotechnical investigations on-site. Foundation condition assumptions for the proposed structures and penstock were determined based on site observations as well as past project experience at the site.

It is proposed to develop a total of 7.8 MW at Pine Creek, consisting of expanding the existing (upper) 2.1 MW powerhouse with an additional two turbines to bring the total installed capacity to 5 MW plus the addition of a second, or lower, powerhouse near Atlin Lake with an installed capacity of 2.8 MW. The upper power plant operates under a gross head of approximately 107 m and the lower plant has a gross head of approximately 56 m.

For the expansion of the upper power plant, a second 4 km long HDPE penstock will be required to convey a maximum flow of 3.55 m^3/s from the existing head pond to the powerhouse. The penstock will require the excavation of a trench, mainly through overburden materials except some limited bedrock excavations near the intake structure. The lower power plant requires 4 km of twin HDPE penstocks to convey a maximum flow of 7 m^3/s. A new excavated head pond just downstream of the existing (upper) powerhouse is required to supply the lower penstocks. Spruce Creek would be diverted into the lower head pond such that flows from Spruce Creek can be used to increase electrical generation at the lower power plant.

Increased storage in Surprise Lake to maximize winter electrical generation will be developed by modifying the existing control structure at the lake outlet. It is proposed to increase the storage range from 1.1 m to 2.5 m by increasing both top and bottom storage by approximately 0.7 m. This operating scheme would not require modification of the project's existing Permit Over Crown Land which allows storage of water up to elevation 913.85. The storage of water allows the project to generate approximately 70% of its annual average energy production during winter months (November through April). Winter energy is of highest value to the Yukon's electrical grid.

In consideration of the existing hydropower infrastructure the Atlin Hydro Expansion Project has the potential to produce on average 44.6 GWh/yr of energy, of which at 36 to 38 GWh/yr is available for export to the Yukon after the community of Atlin's needs are met. Cost for the hydroelectric development only (without transmission) are estimated at **79.7M$** million. A total project cost of **120.7M$** estimated including a 69kV transmission line to connect with the Yukon's electrical grid at Jakes Corner.

8.2 Recommendations for Future Work

The financial analysis conducted as part of this study concludes that the Atlin Hydro Expansion Project appears to be potentially economically viable and therefore the project should be advanced to the feasibility stage. The feasibility study will need to confirm assumptions made in the current study and optimize technical and economic aspects of the project.

The following tasks should be conducted, in order, to confirm the project concept at the onset of the feasibility study:

1. Continue to operate year-round the flow and lake level monitoring program established in late 2014. The flow gauging program requires routine site visits to download the data and perform maintenance on the stations. Approximately 3 to 4 summer visits and at least 2 winter visits are warranted. Additional flow gauging should also be conducted at high water to refine the rating curves. In late 2015 update power estimates once the additional site-specific flow and water level data becomes available. The hydrology program should be continued until the project is completed.

2. Perform a preliminary geotechnical investigation program to determine foundation conditions at the location of the proposed lower powerhouse. This should initially consist of test pits and seismic surveys to determine soil conditions, groundwater levels and depth to bedrock. Follow-up geotechnical investigations (test pits) should look at foundation conditions at the upper powerhouse expansion, the lower head pond location and the lower penstock alignment. Additionally geotechnical drilling at the lower and upper powerhouse should be conducted to assess deep ground conditions.

3. Assess the economics of the alternative upper power plant arrangement that considers fully utilizing available head on upper Pine Creek. This alternate scheme may result in reduced utilization of the existing powerhouse, but could result in overall greater annual average power production.

4. With the additional data, complete a feasibility study based on the results of the geotechnical investigations, with further optimization of the proposed layouts. Additional attention should be given to the following elements:
    - Optimize operation of Surprise Lake with respect to environmental considerations and seasonal energy production. Optimize installed turbine capacity based on preferred operating schedule for Surprise Lake.

- Further assess the upgrade and outlet (hydraulic capacity) excavation needs for Surprise Lake control structure;
- Further assess the construction requirements for the lower head pond, specifically foundation conditions and impermeability of structures / foundation. Assess hydraulic performance of the lower head pond during winter conditions.
- Refine design of the lower penstock to address varied terrain conditions along the route.
- Optimization of design of the surge facility for the lower powerhouse.

5. Initiate supporting studies such as environmental baseline, land tenure assessment and regulatory matters.

6. Continue discussions regarding commercial arrangements for supply of energy to Yukon Territory's electrical grid.

Report Prepared and Reviewed by:

Forest Pearson, P.Eng.
Geological Engineer
Morrison Hershfield Ltd.

PROFESSIONAL
PROVINCE OF
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42097
BRITISH COLUMBIA
ENGINEER
JUNE 23, 2016

With the Collaboration of:

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Water Resource Engineer
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Greg McNeill, M.Eng., P.Eng.
Structural Engineer
Morrison Hershfield Ltd.

Shaun Beatty, P.Eng.
Civil Engineer
KGS Group

9 REFERENCES

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Atlin BC to Yukon Interconnection Costing Study. Prepared for Yukon Energy Corporation. Vancouver, B.C. Report No. 5954014-001

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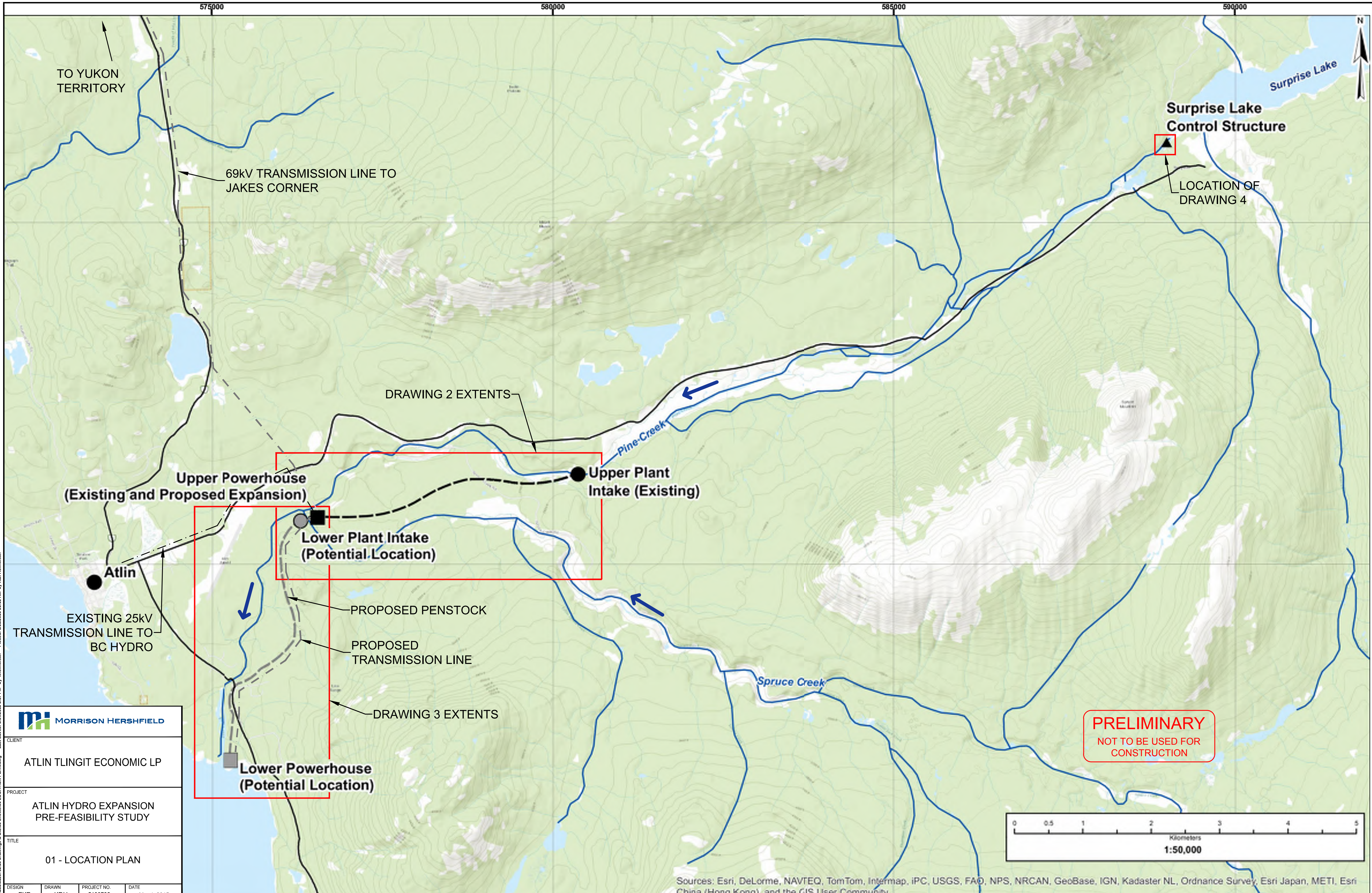
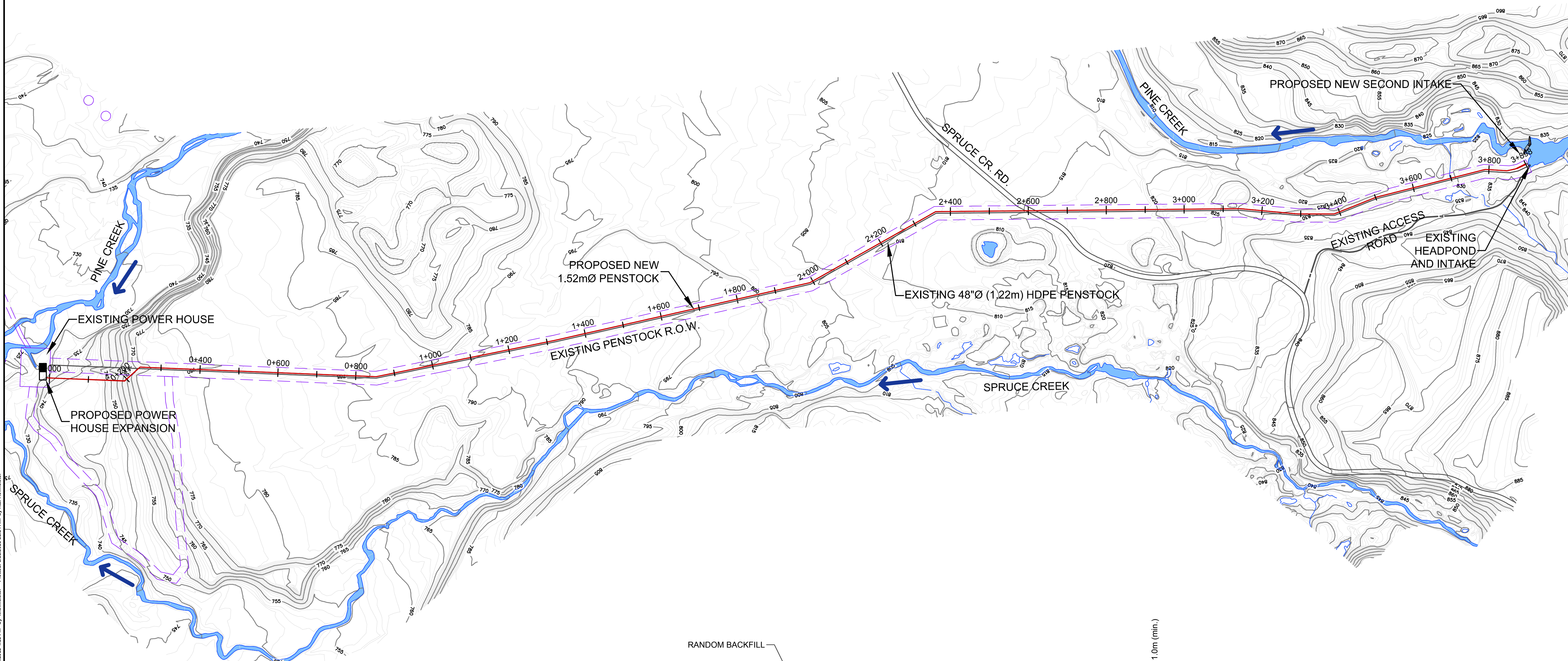
Zoppou, C. 1999:
Reverse Routing of Flood Hydrographs Using Level Pool Routing. Journal of Hydrological Engineering, 4 (2), 184-188

APPENDIX A:
Preliminary Design Drawings


575000
580000
585000
590000
N
TO YUKON TERRITORY
69kV TRANSMISSION LINE TO JAKES CORNER
Surprise Lake
Surprise Lake Control Structure
LOCATION OF DRAWING 4
DRAWING 2 EXTENTS
Pine Creek
Upper Powerhouse (Existing and Proposed Expansion)
Upper Plant Intake (Existing)
Lower Plant Intake (Potential Location)
Atlin
EXISTING 25kV TRANSMISSION LINE TO BC HYDRO
PROPOSED PENSTOCK
PROPOSED TRANSMISSION LINE
DRAWING 3 EXTENTS
Spruce Creek
Lower Powerhouse (Potential Location)
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
0 0.5 1 2 3 4 5
Kilometers
1:50,000
Sources: Esri, DeLorme, NAVTEQ, TomTom, Intermap, iPC, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), and the GIS User Community
MORRISON HERSHFIELD
CLIENT
ATLIN TLINGIT ECONOMIC LP
PROJECT
ATLIN HYDRO EXPANSION PRE-FEASIBILITY STUDY
TITLE
01 - LOCATION PLAN
DESIGN FKP
DRAWN KDH
PROJECT NO. 5130792
DATE March 2015



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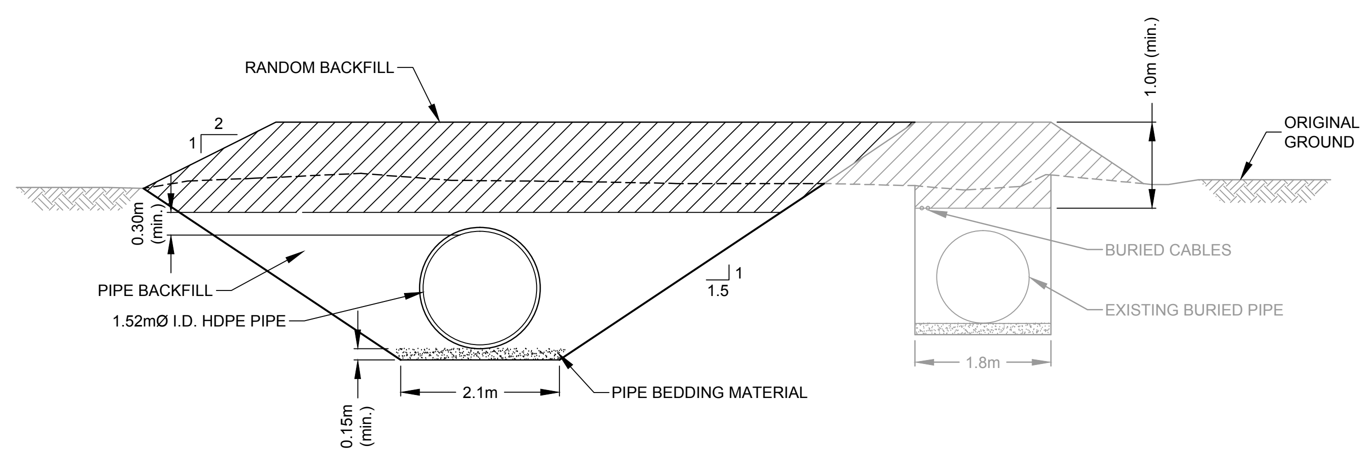

UPPER PENSTOCK TYPICAL SECTION

SCALE: 1:100

PROPERTY BOUNDARIES

LEASES & LICENSES

MORRISON HERSHFIELD

CLIENT

ATLIN TLINGIT ECONOMIC LP

PROJECT

ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE

02 - SITE PLAN - UPPER POWER PLANT EXPANSION

DESIGN	DRAWN	PROJECT NO.	DATE
FKP	KDH	5130792	March 2015

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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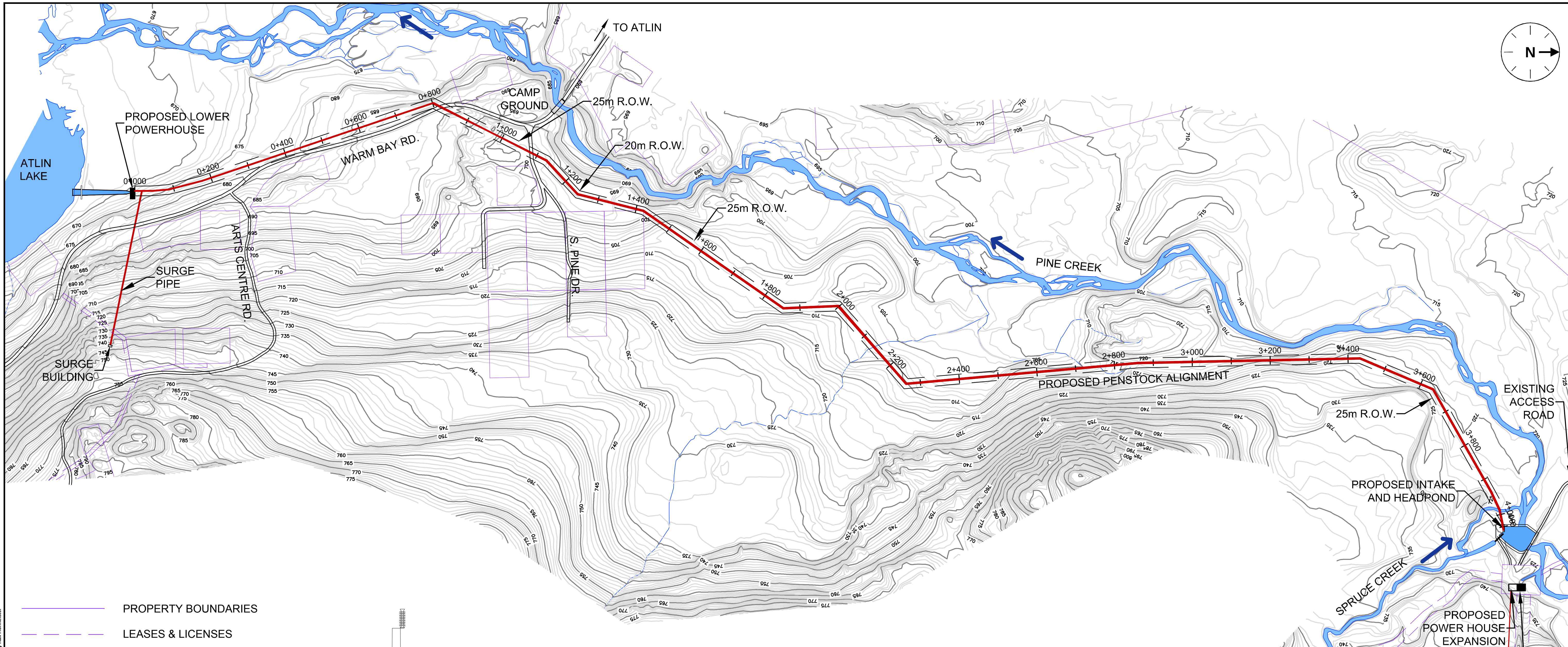

PROPERTY BOUNDARIES

LEASES & LICENSES

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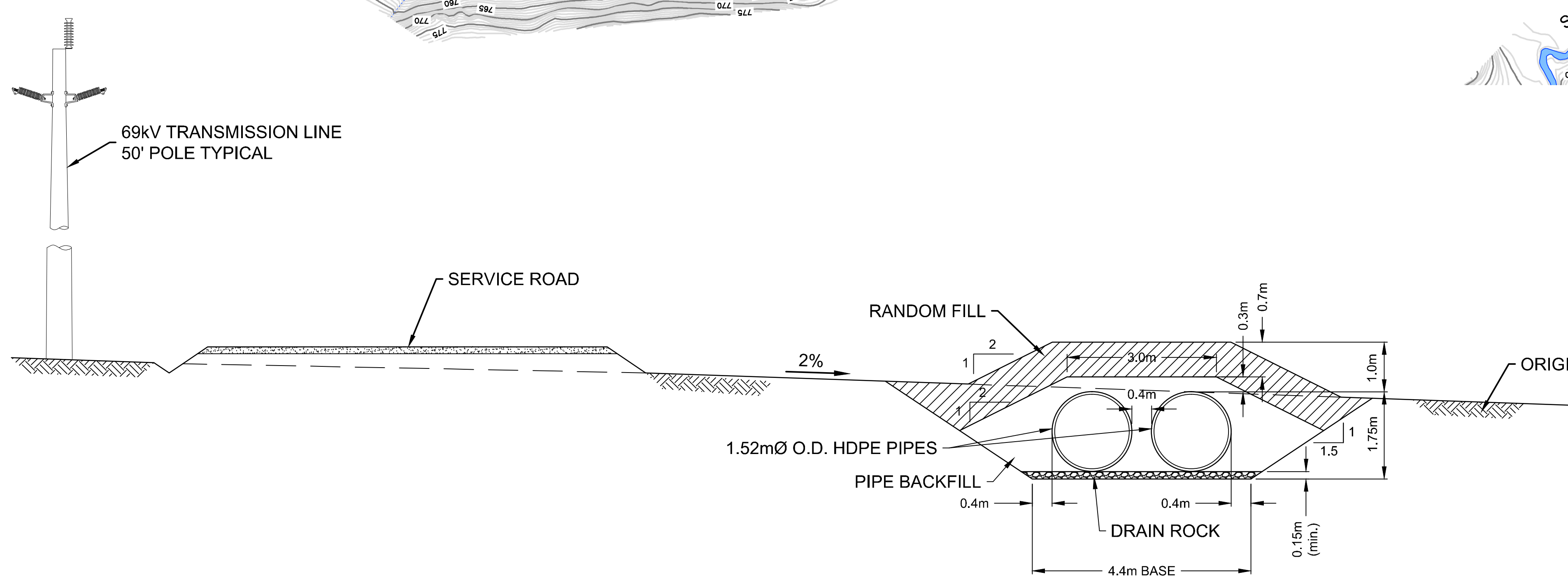

LOWER PENSTOCK TYPICAL SECTION

SCALE: 1:125

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

MORRISON HERSHFIELD

CLIENT
ATLIN TLINGIT ECONOMIC LP

PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE
03 - SITE PLAN - LOWER PLANT

DESIGN	DRAWN	PROJECT NO.	DATE
FKP	KDH	5130792	March 2015

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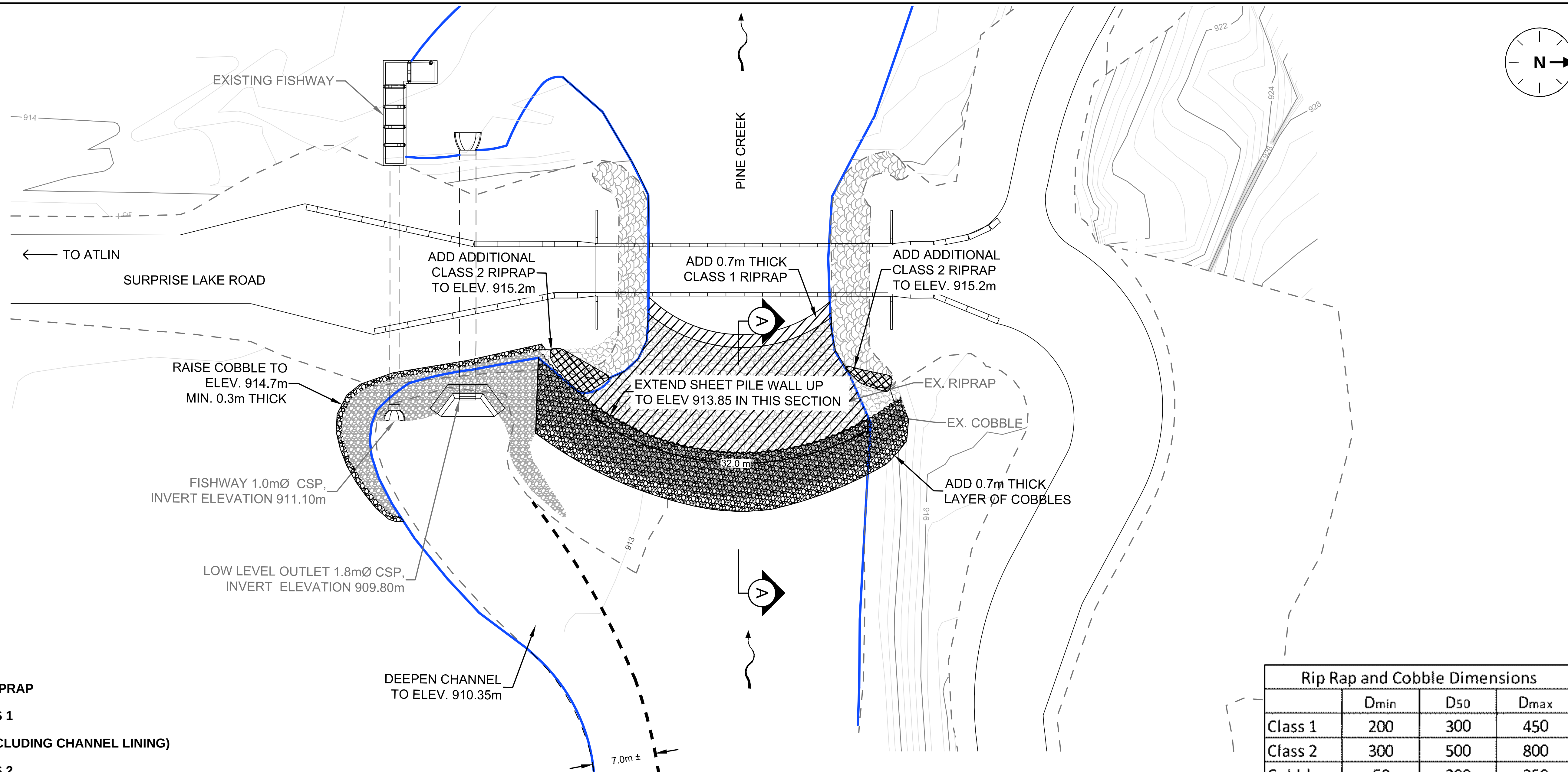


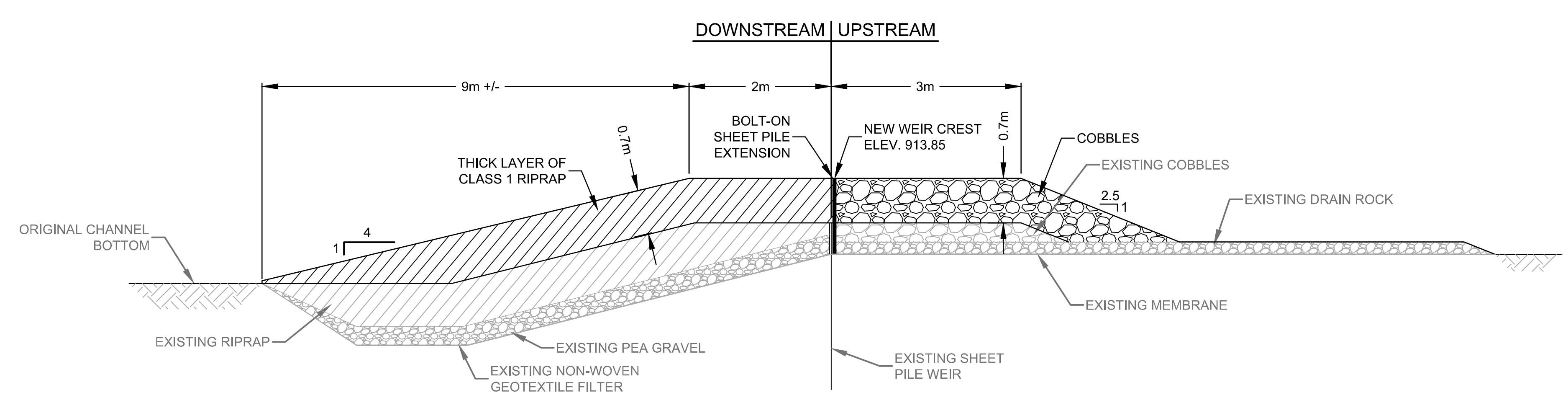
LEGEND

- AREA OF EXISTING LARGE RIPRAP
- AREA OF NEW RIPRAP CLASS 1
- AREA OF NEW COBBLES (EXCLUDING CHANNEL LINING)
- AREA OF NEW RIPRAP CLASS 2

Rip Rap and Cobble Dimensions			
	Dmin	D50	Dmax
Class 1	200	300	450
Class 2	300	500	800
Cobbles	50	200	350

SCALE 1:500

0 1 2 3 4 5 10 15 20m



SECTION A-A

SCALE: 1:100

- 914.2 MAX FLOOD LEVEL
- 913.85 PROPOSED FULL POND LEVEL
- 913.15 CURRENT FULL POND LEVEL
- 912.10 CURRENT LOW POND LEVEL
- 911.35 PROPOSED LOW POND LEVEL

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

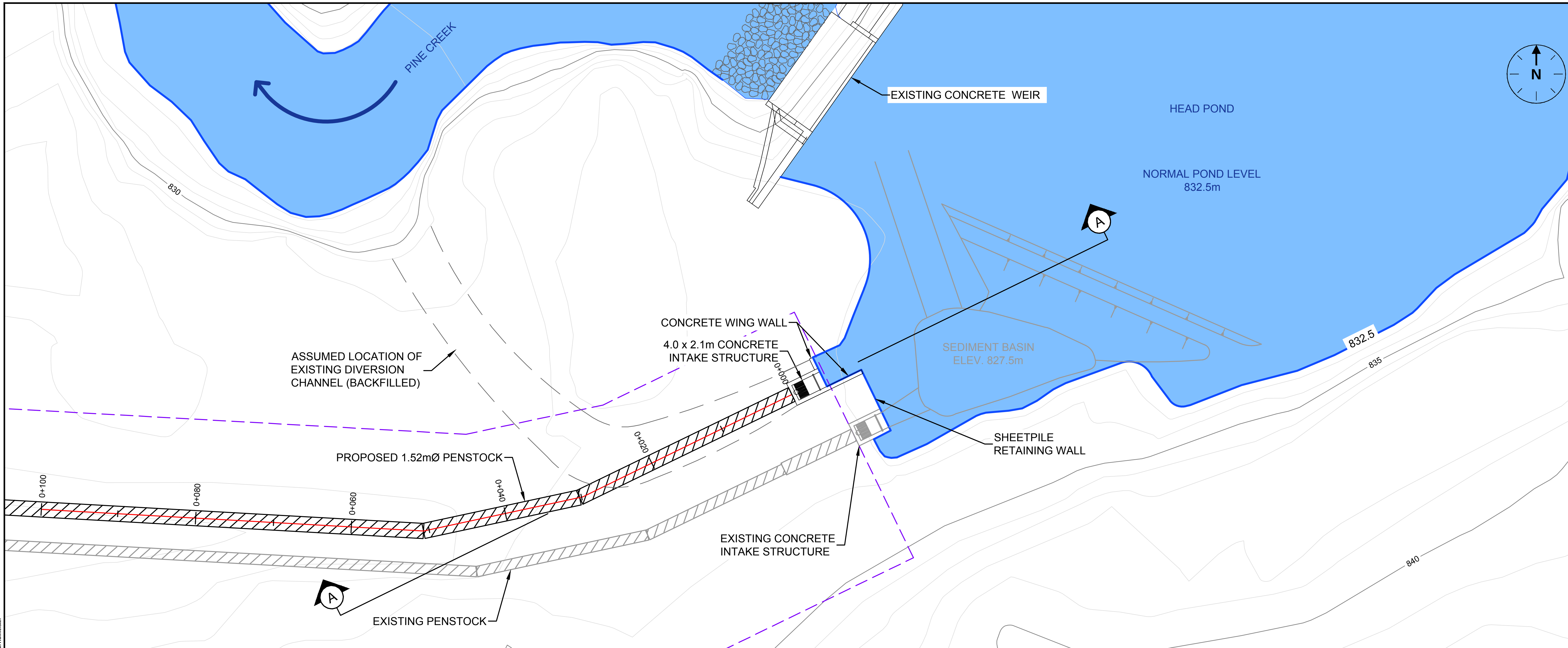
MORRISON HERSHFIELD

CLIENT
ATLIN TLINGIT ECONOMIC LP

PROJECT
ATLIN HYDRO EXPANSION PRE-FEASIBILITY STUDY

TITLE
04 - SURPRISE LAKE CONTROL STRUCTURE

DESIGN	DRAWN	PROJECT NO.	DATE
FKP	KHD	5130792	March 2015



PRELIMINARY
NOT TO BE USED FOR
CONSTRUCTION

SCALE 1:500
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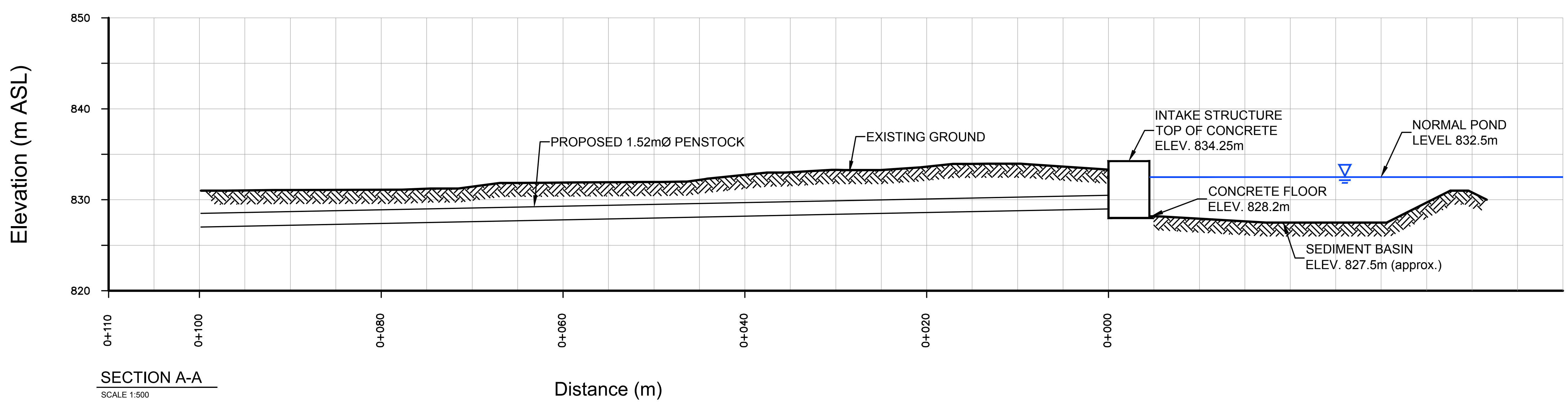
MORRISON HERSHFIELD

CLIENT
ATLIN TLINGIT ECONOMIC LP

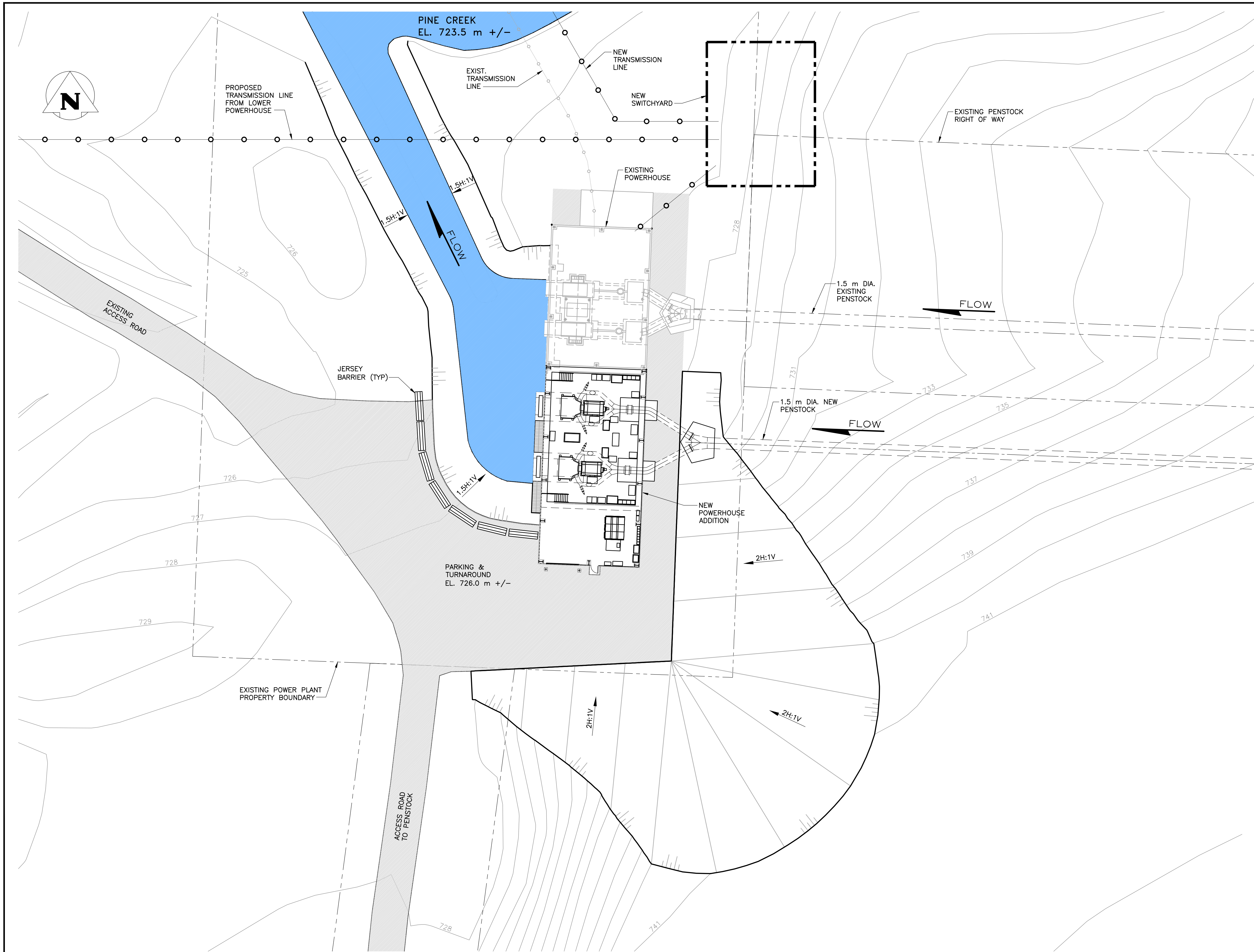
PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE
05 - UPPER PLANT INTAKE

DESIGN	DRAWN	PROJECT NO.	DATE
FKP	KDH	5130792	March 2015



SECTION A-A
SCALE 1:500



KGS GROUP | CONSULTING ENGINEERS

MORRISON HERSHFIELD

CLIENT

ATLIN TLINGIT ECONOMIC LP

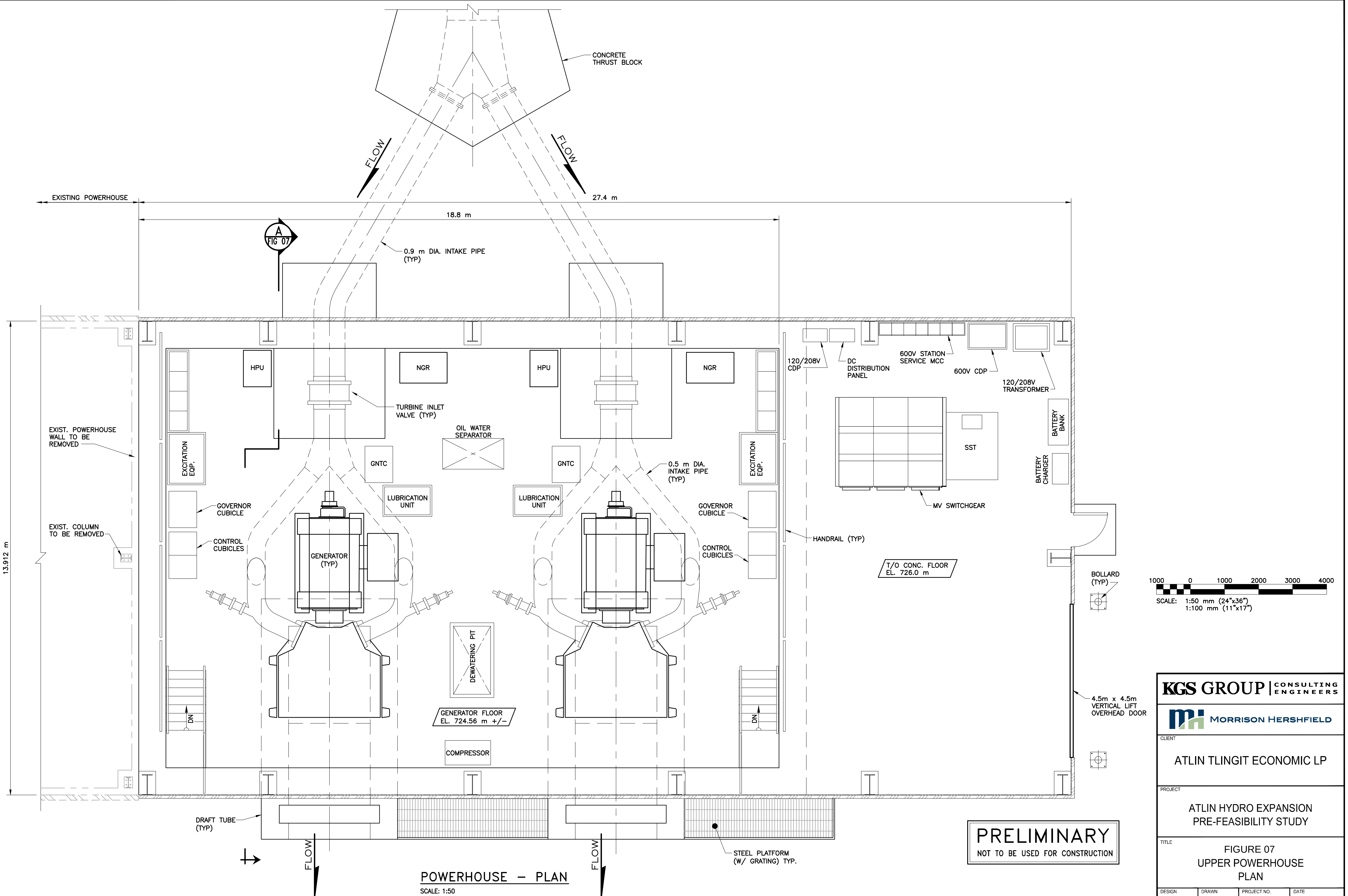
PROJECT

ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE

FIGURE 06
GENERAL ARRANGEMENT
UPPER POWERHOUSE DEVELOPMENT

DESIGN	DRAWN	PROJECT NO.	DATE
	ABk		2015 04 17



PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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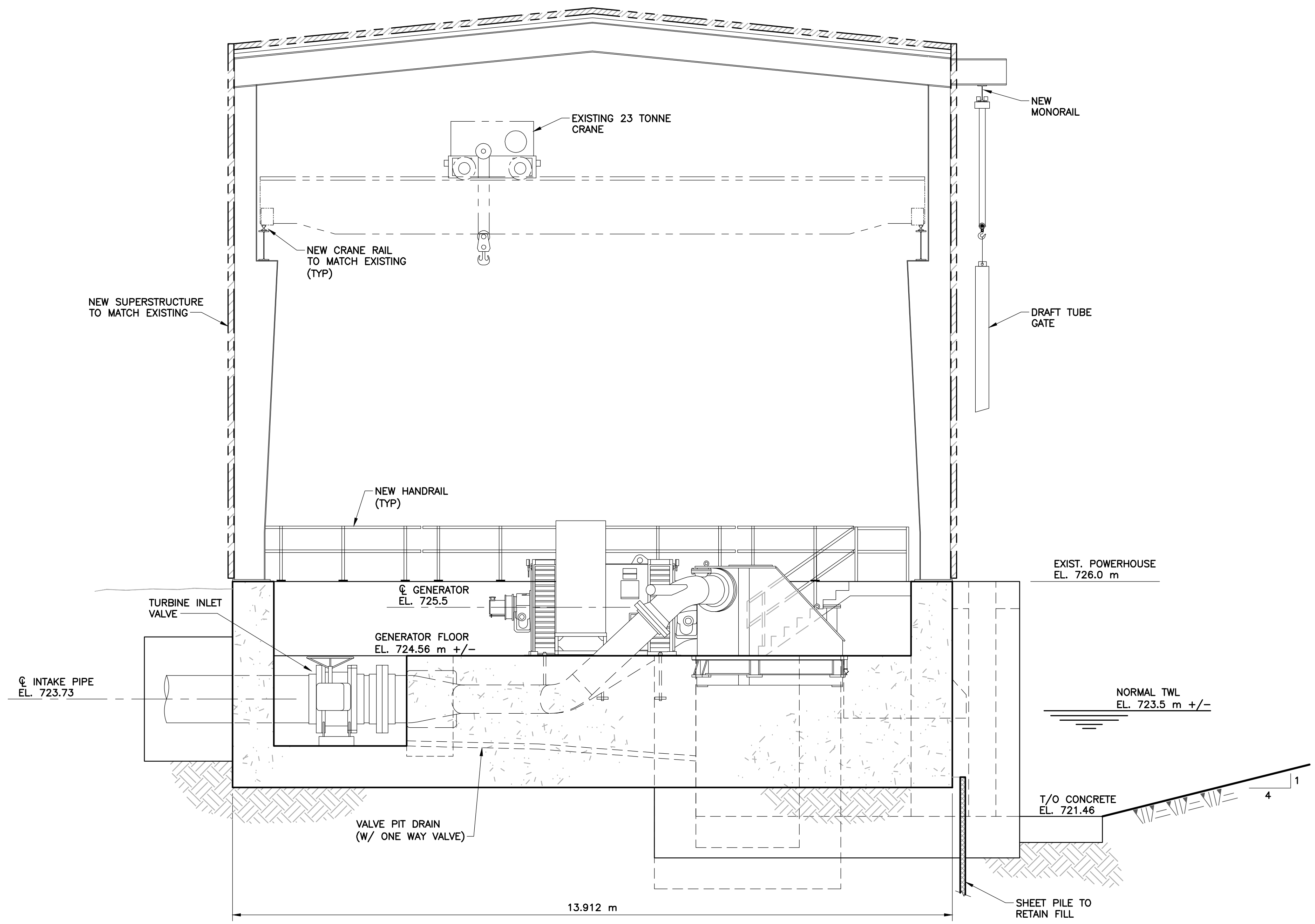
MORRISON HERSHFIELD

CLIENT	ATLIN TLINGIT ECONOMIC LP
PROJECT	ATLIN HYDRO EXPANSION PRE-FEASIBILITY STUDY
TITLE	FIGURE 07 UPPER POWERHOUSE PLAN

DESIGN	DRAWN	PROJECT NO.	DATE
	ABk		2015 04 17



A FIG 06 POWERHOUSE – SECTION

SCALE: 1:50

NOTE: MISCELLANEOUS ELECTRICAL EQUIPMENT IS NOT SHOWN FOR CLARITY

1000 0 1000 2000 3000 4000

SCALE: 1:50 mm (24"x36")
1:100 mm (11"x17")

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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CLIENT
ATLIN TLINGIT ECONOMIC LP

PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE
FIGURE 08
UPPER POWERHOUSE
SECTION

DESIGN	DRAWN	PROJECT NO.	DATE
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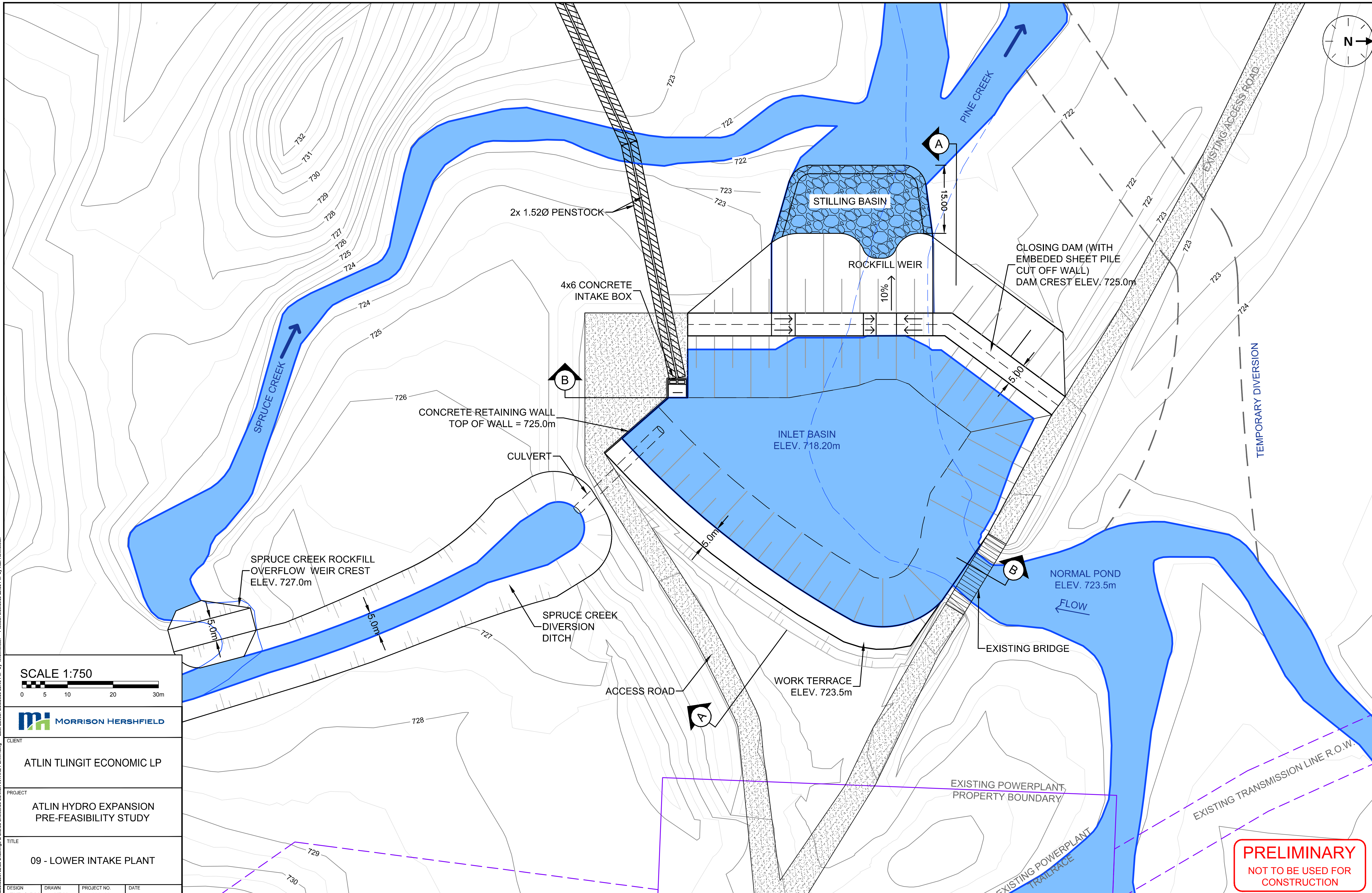

N
PINE CREEK
SPRUCE CREEK
EXISTING ACCESS ROAD
TEMPORARY DIVERSION
STILLING BASIN
15.00
ROCKFILL WEIR
10%
2x 1.52Ø PENSTOCK
4x6 CONCRETE
INTAKE BOX
CLOSING DAM (WITH
EMBEDED SHEET PILE
CUT OFF WALL)
DAM CREST ELEV. 725.0m
5.00
INLET BASIN
ELEV. 718.20m
CONCRETE RETAINING WALL
TOP OF WALL = 725.0m
CULVERT
5.0m
NORMAL POND
ELEV. 723.5m
FLOW
EXISTING BRIDGE
SPRUCE CREEK ROCKFILL
OVERFLOW WEIR CREST
ELEV. 727.0m
SPRUCE CREEK
DIVERSION
DITCH
ACCESS ROAD
WORK TERRACE
ELEV. 723.5m
EXISTING POWERPLANT
PROPERTY BOUNDARY
EXISTING POWERPLANT
TRAILRACE
EXISTING TRANSMISSION LINE R.O.W.
A
B
722
723
724
725
726
727
728
729
730
731
732
PRELIMINARY
NOT TO BE USED FOR
CONSTRUCTION
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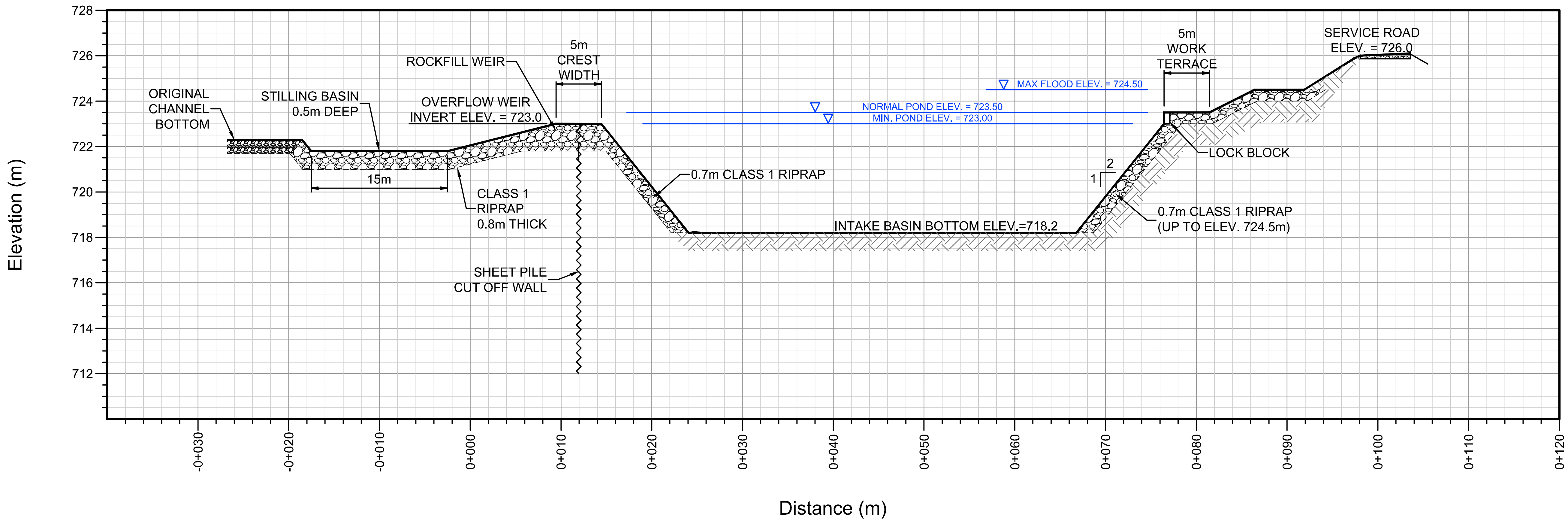
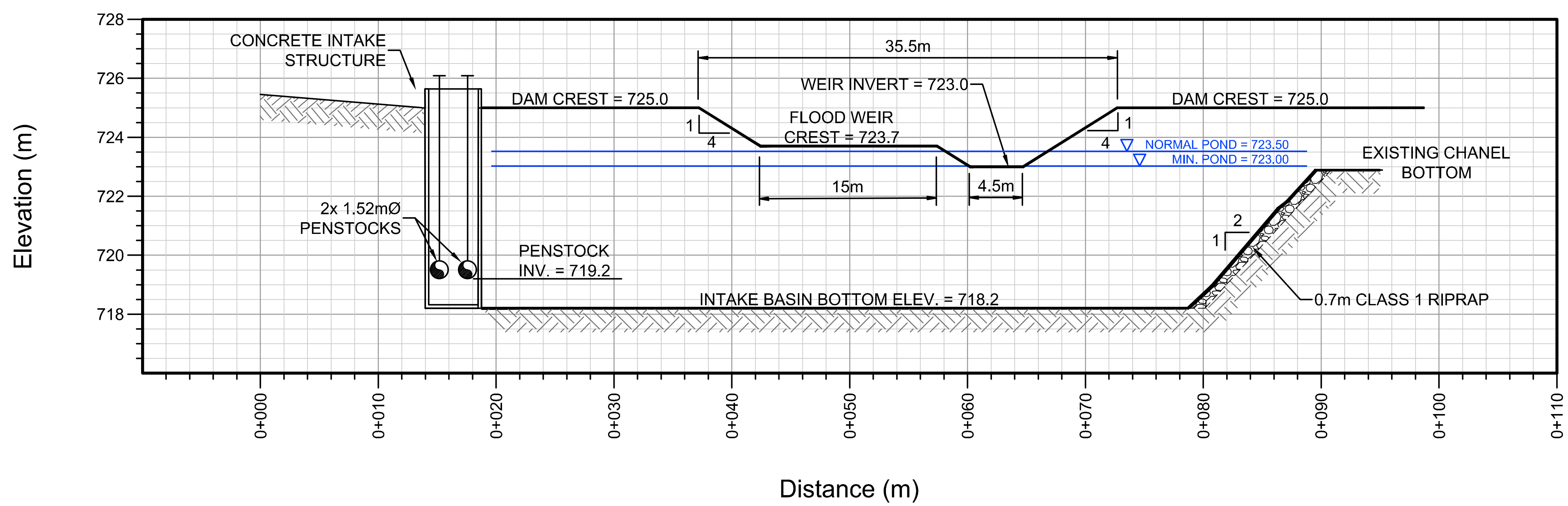
MORRISON HERSHFIELD
CLIENT
ATLIN TLINGIT ECONOMIC LP
PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY
TITLE
09 - LOWER INTAKE PLANT
DESIGN FKP & DM
DRAWN KDH
PROJECT NO. 5130792
DATE March 2015



SECTION A-A LOWER INTAKE POND

SCALE: HORZ.=50 VERT.= 200



SECTION B-B LOWER INTAKE POND

SCALE: HORZ.=50 VERT.= 200

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

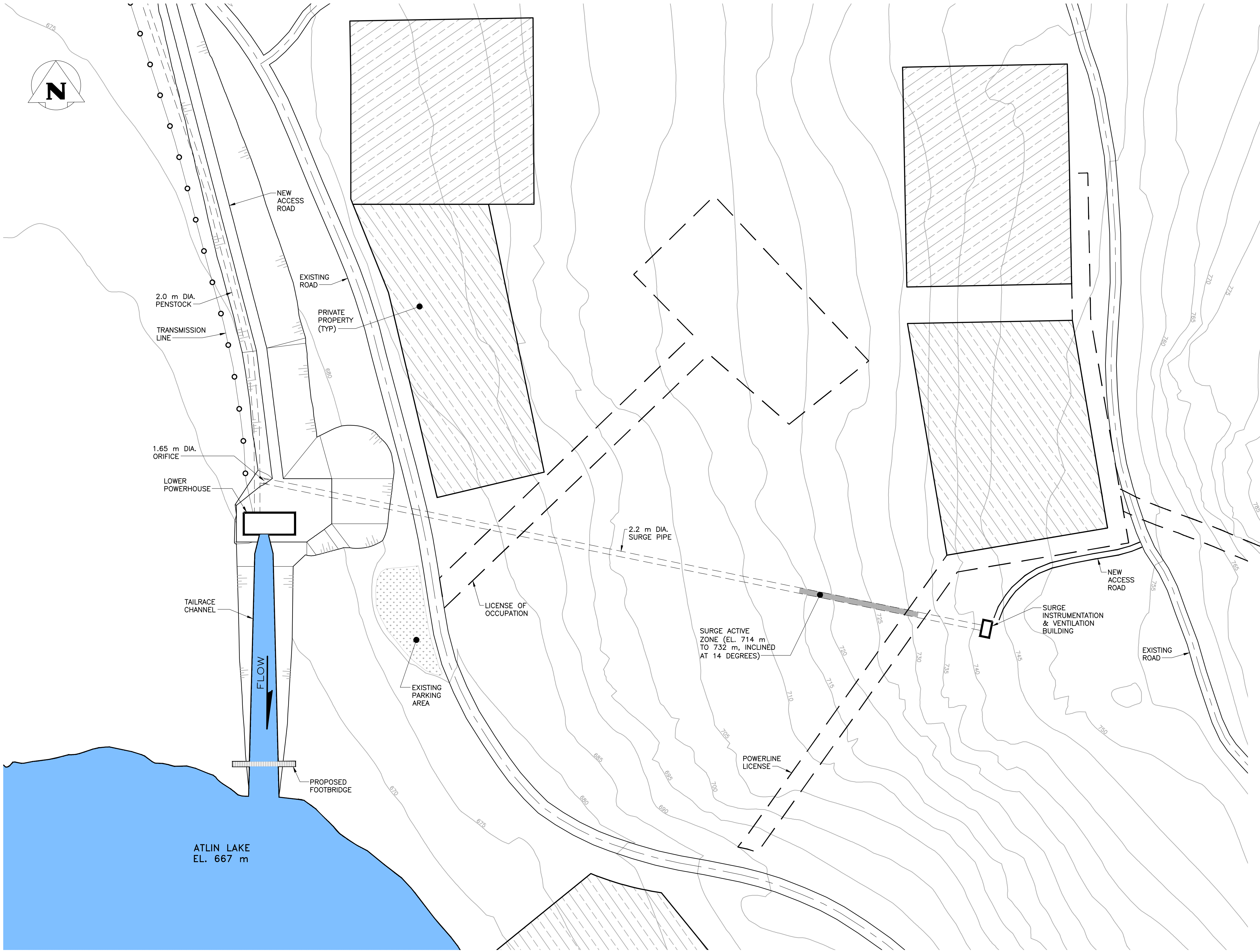
MORRISON HERSHFIELD

CLIENT: ATLIN TLINGIT ECONOMIC LP

PROJECT: ATLIN HYDRO EXPANSION PRE-FEASIBILITY STUDY

TITLE: 10 - LOWER INTAKE SECTIONS

DESIGN	DRAWN	PROJECT NO.	DATE
FKP & DM	KDH	5130792	March 2015



PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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MORRISON HERSHFIELD

CLIENT
ATLIN TLINGIT ECONOMIC LP

PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE
FIGURE 11
GENERAL ARRANGEMENT
LOWER POWERHOUSE DEVELOPMENT

DESIGN	DRAWN	PROJECT NO.	DATE
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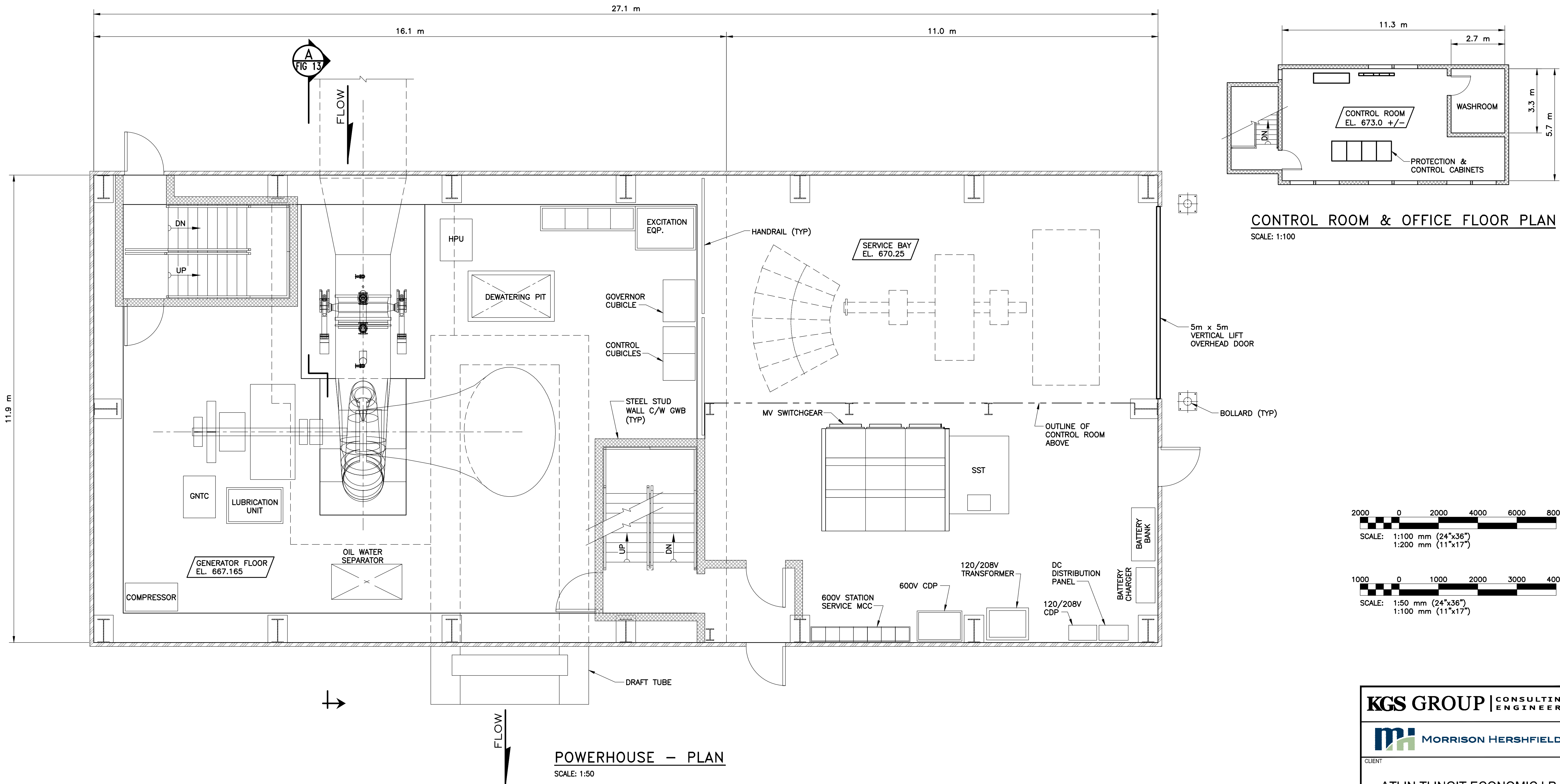

CONTROL ROOM & OFFICE FLOOR PLAN

SCALE: 1:100

POWERHOUSE – PLAN

SCALE: 1:50

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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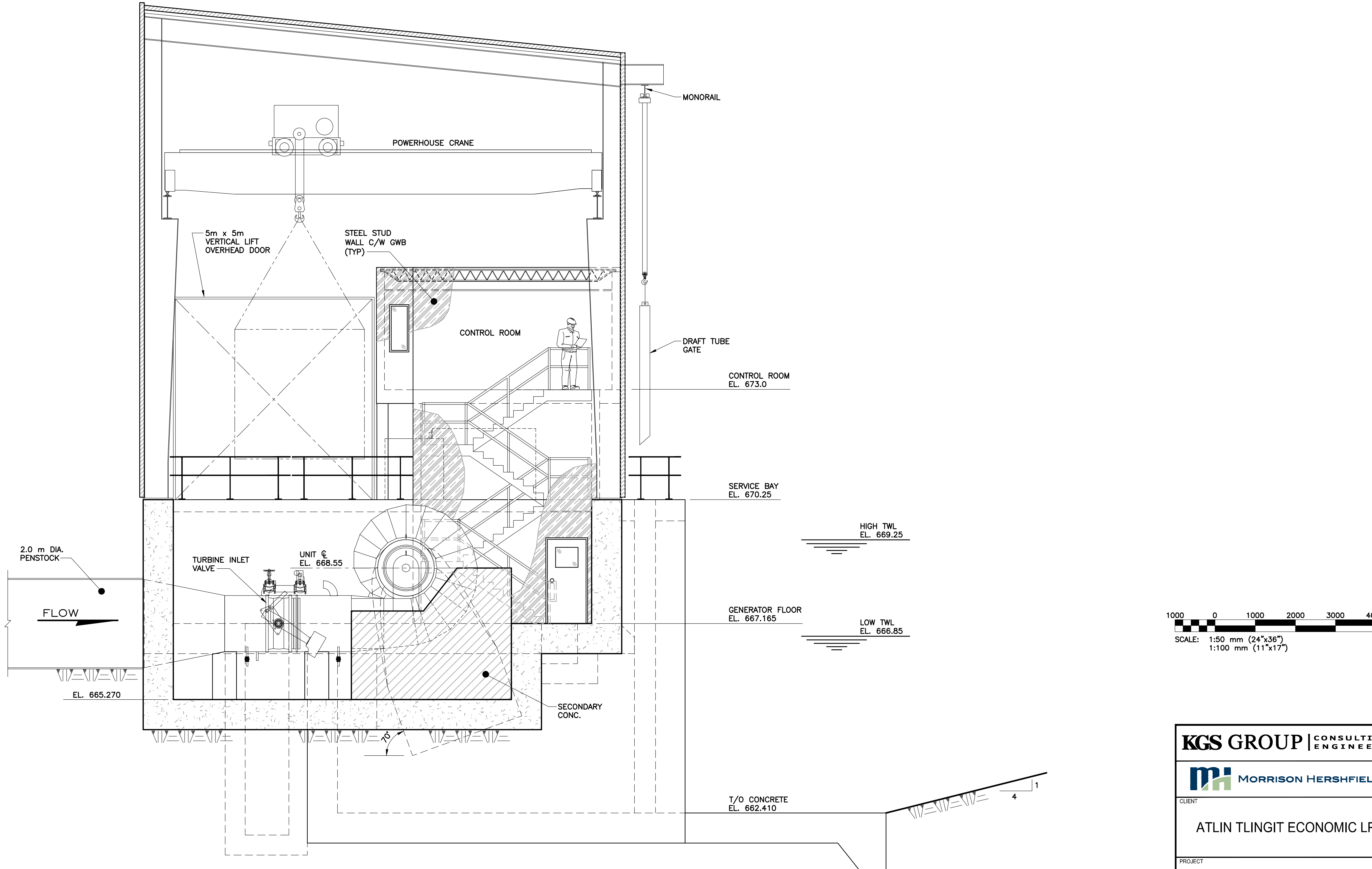
MORRISON HERSHFIELD

CLIENT
ATLIN TLINGIT ECONOMIC LP

PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE
FIGURE 12
LOWER POWERHOUSE
PLAN

DESIGN	DRAWN	PROJECT NO.	DATE
	ABk		2015 05 20



A FIG 12 POWERHOUSE – SECTION
SCALE: 1:50

PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION

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MORRISON HERSHFIELD

CLIENT
ATLIN TLINGIT ECONOMIC LP

PROJECT
ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE
FIGURE 13
LOWER POWERHOUSE
SECTION

DESIGN	DRAWN	PROJECT NO.	DATE
	ABk		2015 05 20

APPENDIX B:
Topographic Mapping

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MORRISON HERSHFIELD

CLIENT

ATLIN TLINGIT ECONOMIC LP

PROJECT

ATLIN HYDRO EXPANSION
PRE-FEASIBILITY STUDY

TITLE

02 - SITE PLAN - UPPER POWER PLANT EXPANSION

DESIGN	DRAWN	PROJECT NO.	DATE
_ _ _	KDH	5130792	Apr 16, 2015

MORRISON HERSHFIELD

CLIENT			
ATLIN TLINGIT ECONOMIC LP			
PROJECT			
ATLIN HYDRO EXPANSION PRE-FEASIBILITY STUDY			
TITLE			
03 - SITE PLAN - LOWER PLANT			
DESIGN	DRAWN	PROJECT NO.	DATE
_ _ _	KDH	5130792	Apr 16, 2015

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APPENDIX C:
Site Visit Memorandum

MEMORANDUM

TO:	File	ACTION BY:	-
FROM:	Forest Pearson, Project Manager	FOR INFO OF:	ATELP
PROJECT:	Atlin Hydro Expansion Pre	PROJECT No.:	5130792.02
RE:	Site Visit Memo	DATE:	September 26, 2014

M:\PROJ\5130792\09 DESIGN & DEVELOPMENT\SITE VISIT\MEMO-PREFEAS SITE VISIT_FKP-5130792-20140926.DOCX

Site visit to Atlin conducted by F. Pearson, Project Manager Morrison Hershfield, David Morissette, Water Resource Engineering Access Consulting Group; and Shaun Beatty, Structural Engineer KGS Group on September 24-25, 2014.

- Weather on both days clear, cool (0^oC up to 10^oC) fall weather. No precipitation, but heavy rain over the previous weekend.
- Site visit to visually observe Surprise Lake control structure 7-8pm September 24, 2014.
- Site visit to visually observe intake weir and potential Spruce Creek diversion location 9-10am Sept. 25, 2014.
- Kickoff meeting at ATELP office with Peter Kirby, TJ Esquiro & Stuart Simpson 10:15-12:15
- ½ hr overview flight with Discovery Helicopters (pilot Paula) with S. Simpson, D. Morissette, S. Beatty & F. Pearson. Observed lower power house location, Pine Creek, lower conveyance alignment, potential Spruce Creek diversion location and alternate upper conveyance alignment to lower powerhouse. 1:15-1:45pm.
- Site visit to potential lower power house location on Atlin Lake w/ S. Simpson. Looked at potential penstock drop down rock bluff near Monarch Mt. trail. Quickly observed alignment crossing over Art Centre road.
- Briefly looked at South Pine Drive and highest property (L1252) in this neighborhood. Encountered two local residents (names unknown). Stuart knew them and had discussion of land-owners in neighborhood.
- Visited existing powerhouse w/ S. Simpson
- Conducted 1.5km traverse (see Figure 1) downstream from existing powerhouse along upper portion of potential lower penstock to look at terrain & soil conditions and potential intake locations. Soils generally well drained, course gravel terraces. Large bedrock hill at south end of traverse with saddle on east side that maybe sufficiently low to accommodate penstock alignment. 4-5:30pm.

Staff Gauge Readings:

- Surprise Lake gauge: 0.35m @ 7pm Sept. 24, 2014
- Pine Creek intake weir gauge: 0.53m @ 9:30 am Sept. 15, 2014
- Spruce Creek gauge – not read.

MEMORANDUM

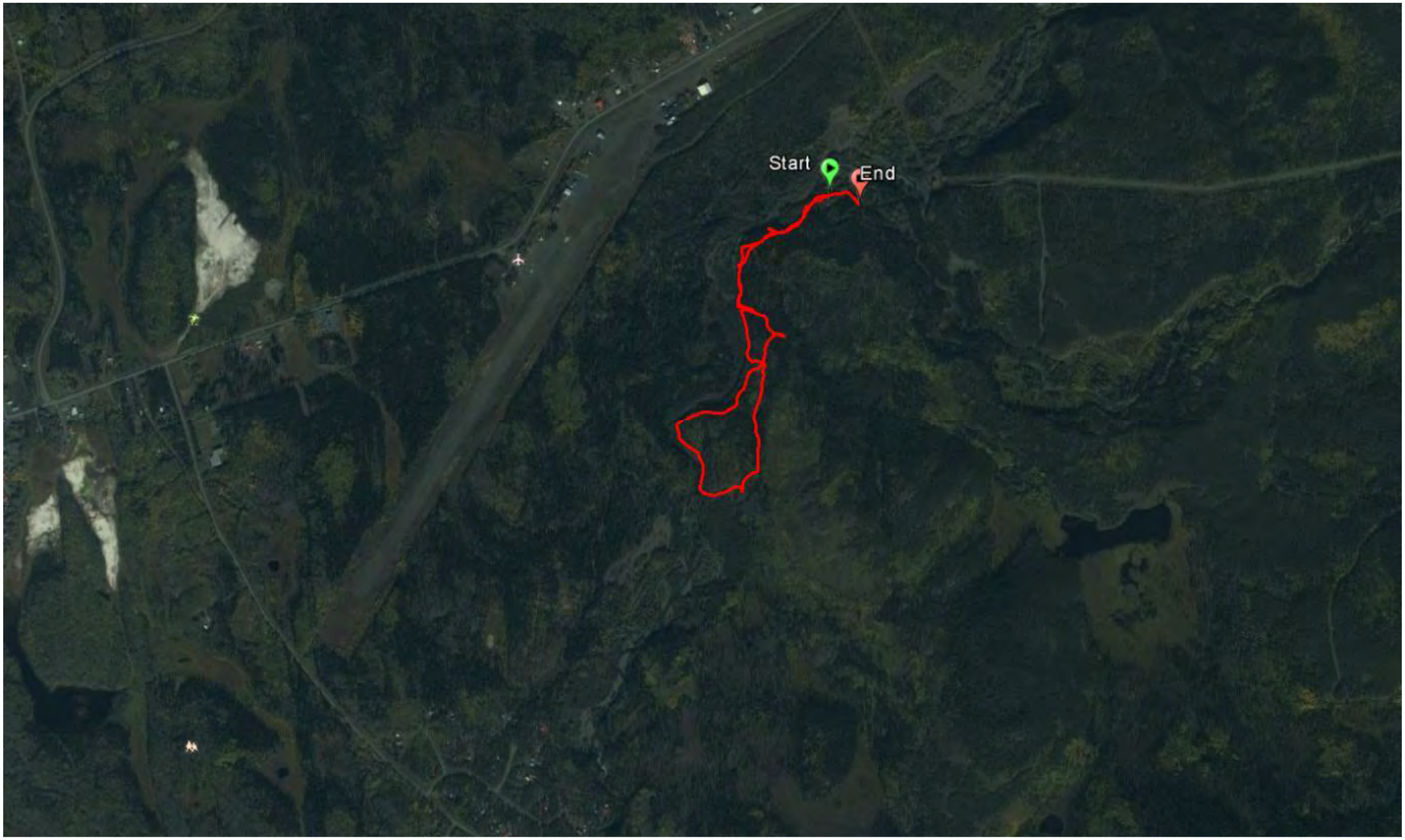

Figure 1. Lower penstock alignment traverse track - September 25, 2014

APPENDIX D:
Photo Log

SURPRISE LAKE CONTROL STRUCTURE

Photo 1: Existing rockfill weir looking downstream. Outlet structure on the left.

Photo 2: Surprise Lake rockfill weir, looking north.

Photo 3: Surprise Lake rockfill weir, looking south towards outlet structure

Photo 4: Existing outlet structure at Surprise Lake.

Photo 5: Existing fishway at Surprise Lake, looking downstream.

UPPER HEAD POND

Photo 1: Existing (upper) head pond, looking upstream. Note placer mine workings upstream.

Photo 2: Existing head pond, weir and existing intake structure, looking downstream.

Photo 3: Existing head pond, weir and existing intake structure, looking west.

Photo 4: Existing intake structure.

Photo 5: Existing intake structure.

Photo 6: Upstream side of weir.

Photo 7: Downstream side of weir.

Photo 8: North abutment of weir.


Photo 9: Overflow section of weir.


Photo 10: South side of weir. Note minor seepage and efflorescence.

EXISTING POWERHOUSE

Photo 1: Existing penstock right of way looking west towards powerhouse

Photo 2: Existing penstock right of way looking northwest

Photo 3: Existing powerhouse looking east towards penstock right of way

Photo 4: Existing powerhouse looking west from penstock right of way

Photo 5: Overview of existing powerhouse area and access road.

Photo 6: Tailrace exiting powerhouse towards Pine Creek

Photo 7: Tailrace confluence with Pine Creek, looking east. Existing powerhouse is to right of photo

Photo 8: Interior of existing powerhouse showing turbines and crane, looking north. Control room is to the right.

Photo 9: Interior view of south wall of powerhouse.

SPRUCE CREEK

Photo 1: Spruce Creek looking upstream towards possible upper diversion location

Photo 2: Possible upper diversion location on Spruce Creek


Photo 3: View of Spruce Creek looking upstream

Photo 1: Proposed lower head pond location downstream of existing access road bridge

Photo 2: Pine Creek looking upstream to proposed lower head pond location.

Photo 3: Proposed lower penstock alignment on south side of Pine Creek (left side), looking downstream. Note the low saddle between hill in mid-ground and mountain side on left side of photo.

Photo 4: Middle section of proposed lower penstock alignment on south side of Pine Creek (left side of photo), looking downstream

Photo 5: Middle section of proposed lower penstock alignment on south side of Pine Creek (right side of photo), looking upstream towards existing powerhouse. Note area of poorly drained soils in foreground.

Photo 6: Lower cascade on Pine Creek, looking upstream. Proposed lower penstock alignment would be on right side of photo.


Photo 7: Bottom portion of lower penstock alignment, looking east. Warm Bay Road in foreground with Arts Centre Road on the right.

LOWER POWERHOUSE

Photo 1: Mouth of Pine Creek

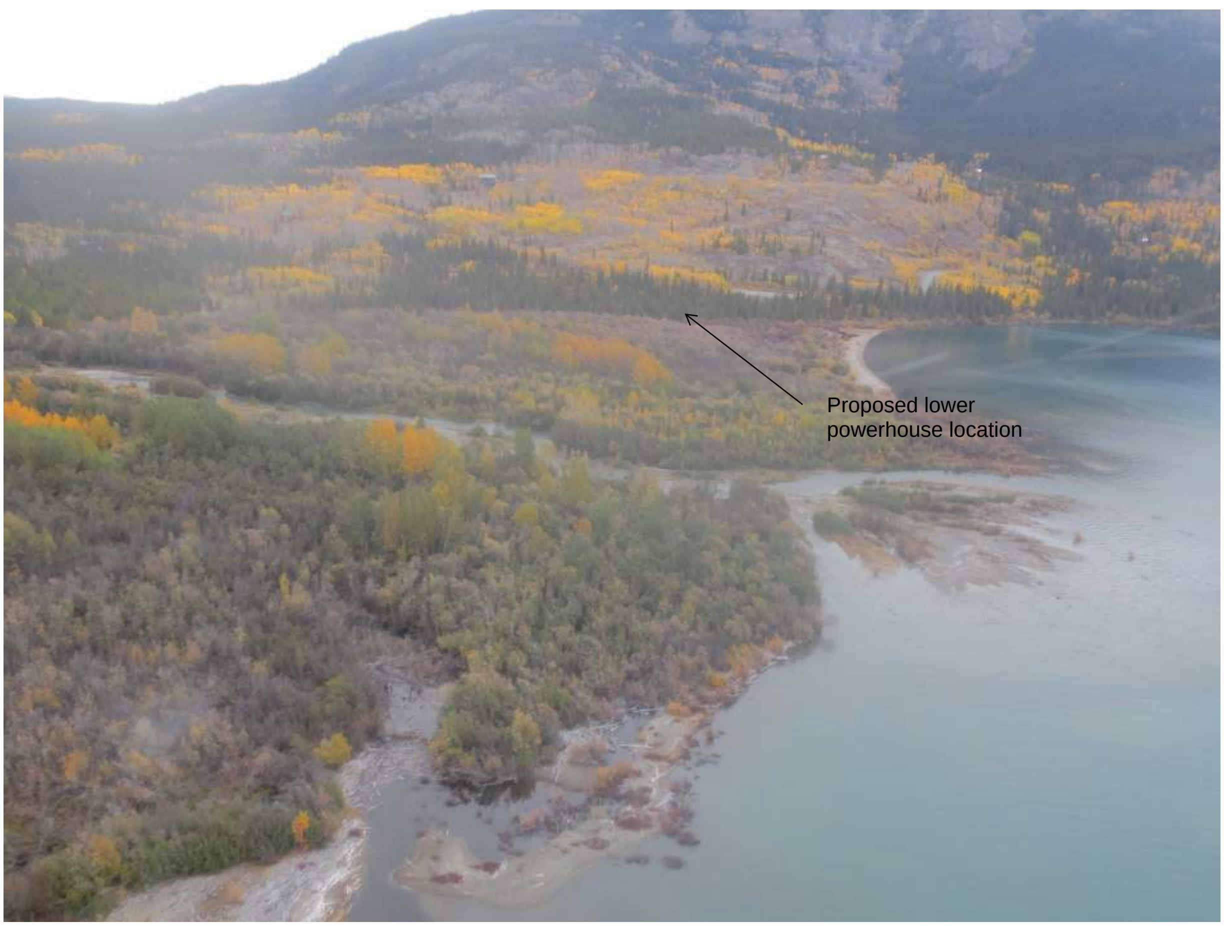

Photo 2: Mouth of Pine Creek looking south towards proposed lower powerhouse location.

Photo 3: Proposed lower powerhouse location, looking northeast. Alternate location considered is on the right hand side of photo.

Photo 4: Proposed lower powerhouse location, looking east Proposed penstock alignment in background.

Photo 5: Proposed lower powerhouse location, looking north.

Photo 6: Overview of proposed lower powerhouse location at base of hill below (north) of parking lot.

Photo 7: View of beach on Atlin Lake and location of proposed tailrace

Photo 8: Hillside above proposed lower powerhouse. Location of proposed surge facility.


Photo 9: Location of proposed surge facility, looking southeast. Note exposed bedrock


Photo 10: Looking down towards proposed lower powerhouse along surge pipe alignment.

Photo 11: View of alternate (southern most) powerhouse location considered.


Photo 12: Looking south along higher penstock alignment option. Note existing land uses.


Photo 13: Lower Pine Creek looking upstream from Warm Bay Road bridge.

APPENDIX E:
Transmission Options Assessment Study

b7kennedy & Associates Inc.

Transmission Options Assessment

Feasibility Study

Atlin to Jakes Corner 69 kV Transmission

Prepared for:

Morrison Herschfield
&
Magna IV

by

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W.O. (Bill) Kennedy, P.Eng., FEIC
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December 21st, 2016

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Legal Notice

This feasibility study reports the results of examination of six possible transmission scenarios for the interconnection of new and existing generation at Atlin, BC to Jakes Corner, YK via a 69 kV transmission line between Atlin and Jakes Corner. The results are based on third party information which the author believes is credible and the author's experience in conducting feasibility studies.

Given the nature of the assumptions made for the study the results should not be relied on without further detailed study of the proposed interconnection.

Neither b7kennedy & Associates Inc. nor Morrison Herschfield nor Magna IV accepts any responsibility or liability for use of the information provided in this report outside of the report's stated purpose, that is, a feasibility study of transmission options to connect Atlin generation to the Southern Lakes load.

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Executive Summary

Six transmission scenarios were examined for the Atlin interconnection with Yukon Electric. For all options the transmission line from Atlin to Jakes Corner was 69 kV using Ibis, 397 MCM conductor.

- Option 1a – the new interconnection serves the Southern Lakes load as isolated. That is, there is no interconnection to the existing Yukon electric system.
- Option 1b – the new interconnection serves the Southern Lakes load and is interconnected to the Yukon electric system via a 34.5 kV line to Whitehorse S150.
- Option 2a – Yukon develops 138 kV transmission south from Whitehorse existing station S171. The 69 kV interconnection to Jakes Corner is extended to Carcross and interconnected to the 138 kV system via a 138/69 kV transformer.
- Option 2b – the 69 kV transmission line between Jakes Corner and Carcross is replaced by a 138 kV interconnection between Jakes Corner and Carcross.
- Option 3a – a 138/69 kV transformer in installed at S171 and a 69 kV transmission line is constructed to Jakes Corner to interconnect with the new line from Atlin.
- Option 3b – a 138 kV line is constructed from S171 to Jakes Corner and a 138/69 kV transformer is installed at Jakes Corner to interconnect with the new line from Atlin.

With the exception of Option 1a, all other options are feasible and provide acceptable results from the point of view of voltage regulation and losses.

The preliminary conclusion is Option 1b provides the best interconnection for this project.

In addition, a number of issues have been identified for further study.

Additional work using more complete models of the two systems is required to firm up the preliminary conclusions and to develop equipment specifications.

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Table of Contents

Introduction

Tlingit Homeland Energy Limited Partnership is proposing to develop additional run of the river hydro in the Atlin area of British Columbia. The expanded generation will consist of two 1.45 MW and one 2.8 MW generators. The generators are assumed to be rated at 0.85 pf. In addition, an existing 2.1 MW hydro set serves the community of Atlin.

This study examined the construction of 100 km of 69 kV transmission to interconnect Atlin with Jakes Corner, Yukon. The conductor of choice was Ibis, 397 MCM. Jakes Corner is in the southern part of Yukon. The area is known as the Southern Lakes and consists of four load centers Carcross, Tangish, Jakes Corner and Teslin with a peak load of 8 MW. For the purposes of this study, the load was lumped at Jakes Corner or divided between Jakes Corner and Carcross. The latter was used for Options 2a and 2b, load at Carcross and Jakes Corner. The load power is 0.95 pf. This is based on the winter heating load.

Study Scenarios

Six study scenarios were developed for this study.

- Option 1a – the new 69 kV interconnection serves the Southern Lakes load as isolated. That is, there is no interconnection to the existing Yukon electric system.
- Option 1b – the new 69 kV interconnection serves the Southern Lakes load and is interconnected to the Yukon electric system at the existing 34.5 kV bus in station S150.
- Option 2a – Yukon develops 138 kV transmission south from Whitehorse existing station S171 to Carcross. The 69 kV interconnection to Jakes Corner is extended to Carcross and interconnected to the 138 kV system via a 138/69 kV transformer.
- Option 2b – the 69 kV transmission line between Jakes Corner and Carcross is replaced by a 138 kV interconnection between Jakes Corner and Carcross. A 138/69 kV transformer is installed at Jakes Corner.
- Option 3a – Yukon develops 69 kV transmission south from Whitehorse existing station S171 to interconnect with the 69 kV transmission from Atlin. A 138/69 kV transformer is installed at S171.
- Option 3b – Yukon develops 138 kV transmission south from Whitehorse existing station S171 to interconnect with the 69 kV transmission line from Atlin. A 138/69 kV transformer is installed at Jakes Corner.

For all options studied, the 69 kV development and generation at Atlin, the 100 km 69 kV transmission line from Atlin to Carcross and the 69/34.5 kV transformer at Jakes Corner are common.

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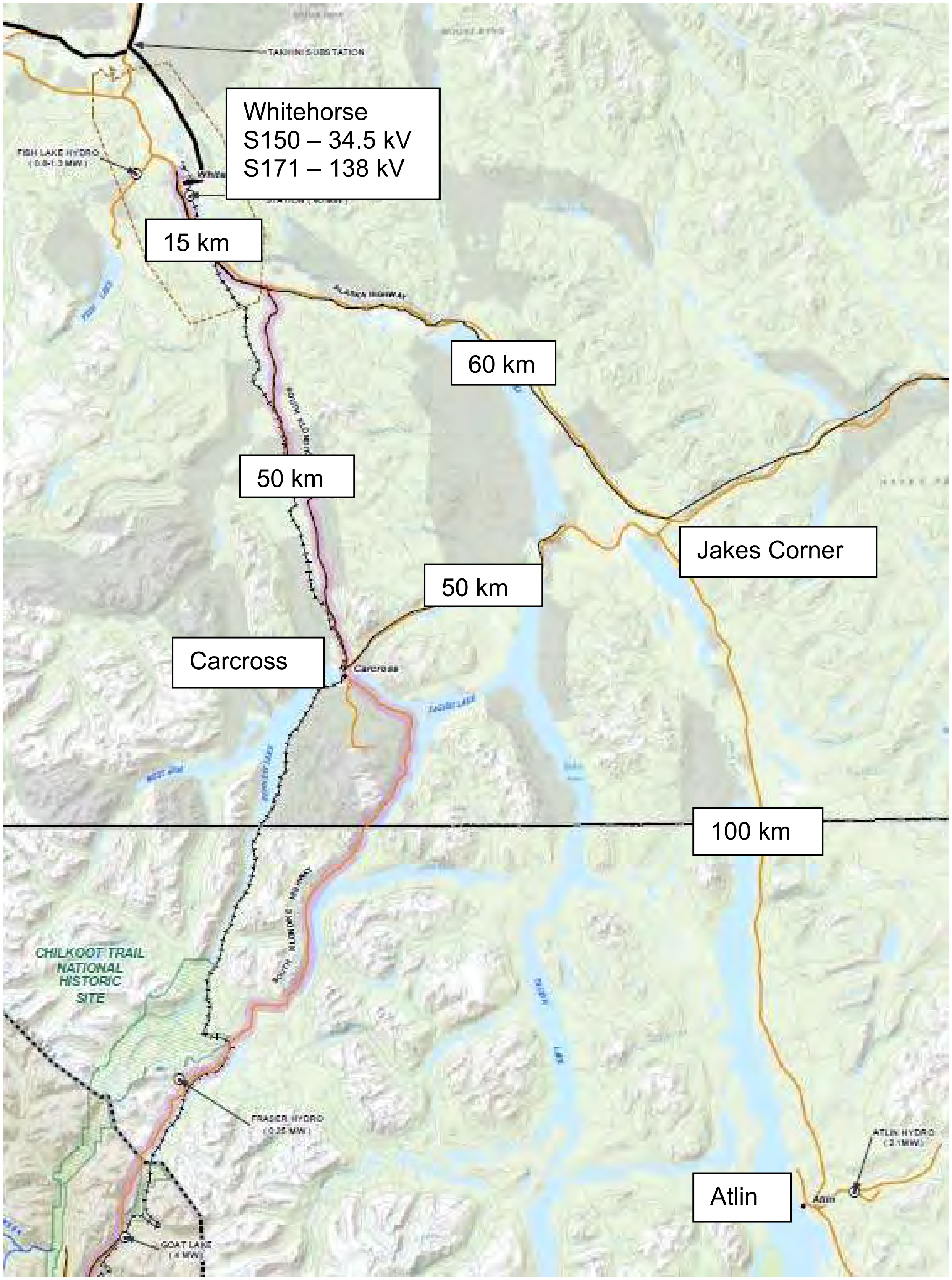
Figure 1 gives an overview of study area.

Figure 1: Map of the Study Area



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The existing system feeding the Southern Lakes consists of 34.5 kV transmission from S150 located in Whitehorse. A single circuit line extends south from S150 15 km where it bifurcates to supply Carcross and Jakes Corner. The Carcross section is 50 km and the Jakes Cromer section is 60 km. For this study the 34.5 kV to Jakes Corner from S150 was assumed to be single circuit 75 km in length. There is no interconnection between Carcross and Jakes Corner. The same distance was assumed for the 69 kV and 138 kV options from S171.

Model Development

Referring to Figure 2, a model was developed for Atlin Hydro expansion. The single line shown is Option 2b, the 69 kV interconnection of Jakes Corner to Carcross and the 138 kV interconnection to S171. The pie charts in the single line give an indication of the equipment loading based on line SIL or estimated maximum loading or typical transformer ratings. For example, 138 kV lines have a 50 MW SIL.

At Whitehorse there are two interconnection points; 34.5 kV at S150 and 138 kV at S171. With the exception of Option 1a, S150 or S171 was the swing bus for these studies. For Option 1a, one of the new generators at Atlin was made the swing bus.

Atlin Hydro Development. A new 69 kV bus and infrastructure was developed at Atlin, ATLIN TRM. The three new generators are connected in parallel to the new 69 kV station through their own transformers. Three new generators, two 1.45 MW and one 2.8 MW units are planned. An interconnection between ATLIN TRM and the existing ATLIN 25 kV was developed to allow the excess active power from the existing 2.1 MW hydro generation to the 69 kV bus. In addition, should the existing 2.1 MW be off line for any reason, the new generation can supply the 0.7 MW Atlin load. Finally, the single line shows existing BC Hydro diesel generation at Atlin. This generation was assumed off line for all of the studies.

69 kV Transmission Line. 100 km of transmission line with Ibis, 397 MCM, conductor connects ATLIN TRM to a new station called JAKES COR_69. To complete the interconnection, 69/34.5 kV 9 MVA transformer is installed to supply the Jakes Corner load.

Load Model. The Southern Lakes load is lumped as 8 MW with a power factor of 0.95 pf at Jakes Corner.

Interconnection to Yukon. Finally, the existing 34.5 kV transmission line up to S150 was modeled – see Figure 4. For this study, generation connected to either S150 or S171 was made the swing or slack bus. Figure 2 shows the development of 138 kV transmission from S171 to Carcross and the 69 kV transmission from Carcross to Jakes Corner..

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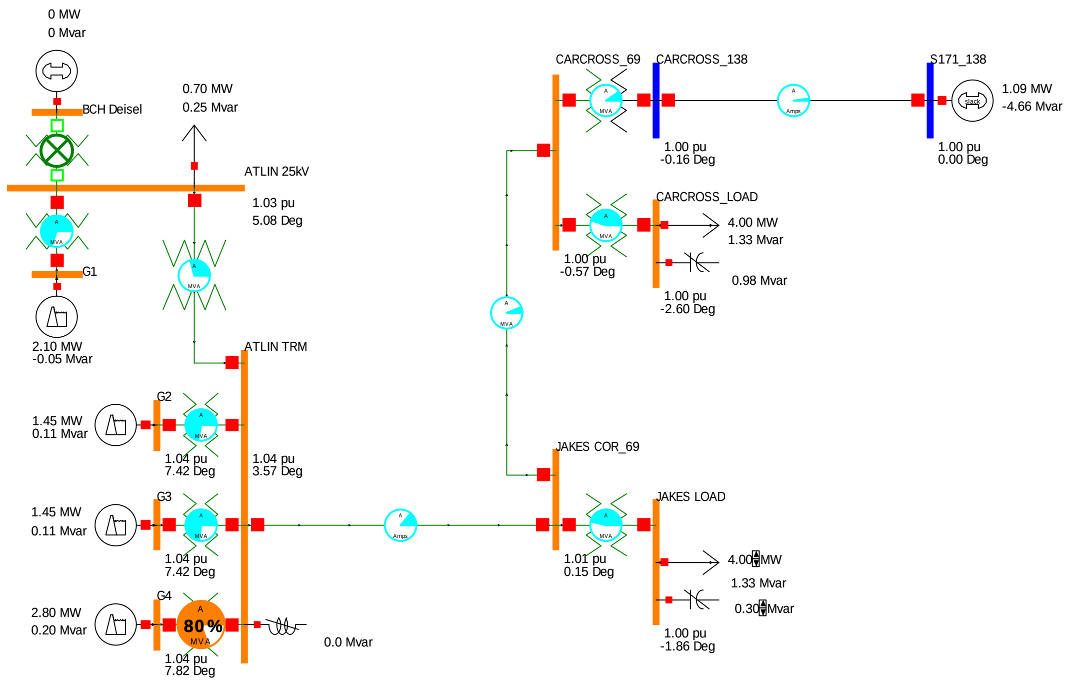
Figure 2: Basic System Studied – 138 kV Connection to S171



Study Parameters

Loading of transmission lines can be divided into three steps. For lines up 80 km in length, the thermal characteristics of the conductor predominate. Between 80 km and 230 km, NERC voltage drop criteria predominate. NERC commonly used criteria is to maintain an absolute voltage drop of no more than 5% between the sending and receiving end terminals during normal operating conditions, commonly called NERC A. Above 230 km, the steady state criterion predominates. These criteria state that the maximum angle across the transmission system between its equivalent Thevenin voltage sources is limited to 45^{o} electrical.

For this study, NERC voltage criteria were used along with keeping line losses to less than 5% of the active power transferred.

The results are presented in a series of tables. Generation at Atlin was increased in increments based on the generator size – 1.45 MW, 2.9 MW, 5 MW and 7.8 MW. The sending and receiving end voltages and active powers were measured along with the transmission line losses. Line losses are calculated as a percentage of sending end active power. In addition, if any shunt compensation was required, this is noted in the tables.

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Option 1a

Table 1, presents the results and the single line is shown in Figure 3. For this option, Jakes Corner load was treated as isolated. That is, there was no interconnection between the Southern Lakes Load and the existing Yukon system at either S150 or S171.

Figure 3: Atlin Transmission Supplying Isolated Southern Lakes Load

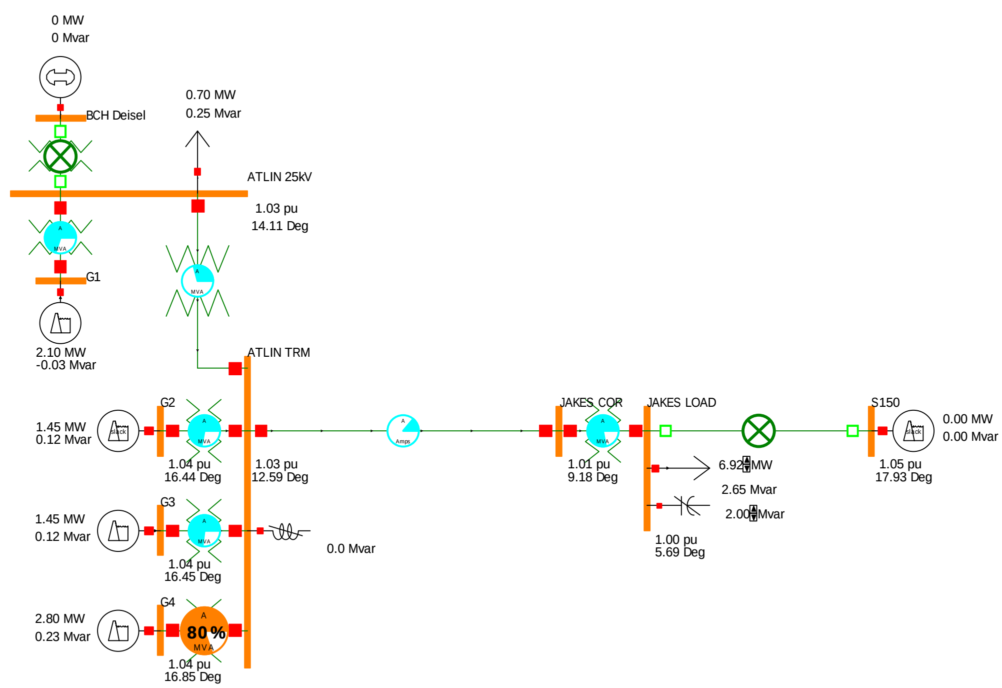

Table 1: Option 1a Results

Atlin Gen	Send Power (MW)	Rec Power (MW)	Vsend (pu)	Vrec (pu)	Vdrop (%)	Loss (MW)	Loss (%)	Comp Send (MVAr)	Comp Rec (MVAr)
1.45	0.74	0.74	1.03	1.02	1	0.004	0.54	0.00	0.86
2.9	2.20	2.18	1.03	1.02	1	0.018	0.82	0.00	0.91
5.0	4.29	4.23	1.03	1.01	2	0.059	1.38	0.00	1.35
7.8	7.09	6.93	1.03	1.01	2	0.157	2.21	0.00	2.00

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For this option, the load at Jakes Corner was adjusted to match the available generation at Atlin.

The results show that losses are less than 5% at full generation and voltage drop is limited to 2% at full generation. In addition, there is a requirement for shunt compensation at the load because there is no support from Yukon generation. However, Atlin generation is not able to supply the entire 8 MW Southern Lakes load under peak load conditions. This option is not recommended.

Option 1b

Table 2 gives the results and the single line is shown in Figure 4. For this case, Atlin is connected to Yukon at S150.

Figure 4: Atlin Transmission Supplying Integrated Southern Lakes Load

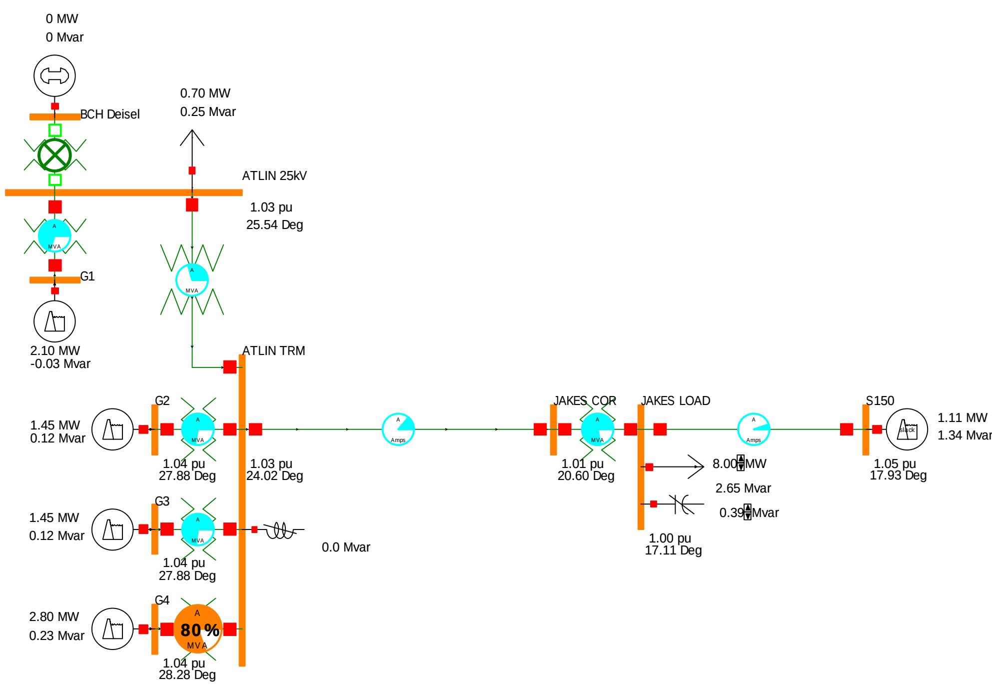

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Table 2: Option 1b Results

Atlin Gen	Send Power (MW)	Rec Power (MW)	Vsend (pu)	Vrec (pu)	Vdrop (%)	Loss (MW)	Loss (%)	Comp Send (MVAr)	Comp Rec (MVAr)
1.45	0.75	0.74	1.03	1.02	1	0.004	0.53	0.00	2.33
2.9	2.20	2.18	1.03	1.02	1	0.018	0.82	0.00	1.53
5.0	4.29	4.23	1.03	1.01	2	0.059	1.38	0.00	0.90
7.8	7.09	6.93	1.03	1.01	2	0.157	2.21	0.00	0.39

With the addition of source at Whitehorse, S150, losses are similar to the isolated case. That is losses are limited to 2.2% at full Atlin generation. Voltage regulation is the same is the same with the interconnection to Yukon. In addition, with a reactive source at S150, shunt compensation at the load reduces as the generation from Atlin increases.

The requirement for shunt compensation at the sending end is clarified in the section Other Issues of this report.

Option 2a

For this option, a 50 km 69 kV line is inserted between Jakes Corner and Carcross using Ibis, 397 MCM, conductor. It is expected that the section of line between Atlin and Jakes Corner will be constructed first making this option the most likely. In addition, there is no interconnection between Carcross and Jakes Corner. At Carcross, the 138 kV line from S171 is tapped and a 138/69 kV station is established. Hawk, 477 MCM, conductor has been assumed for 138 kV lines. In addition, the load was split between Jakes Corner and Carcross. The single line is shown in Figure 5 and the results in Table 3.

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Figure 5: Option 2a Single Line

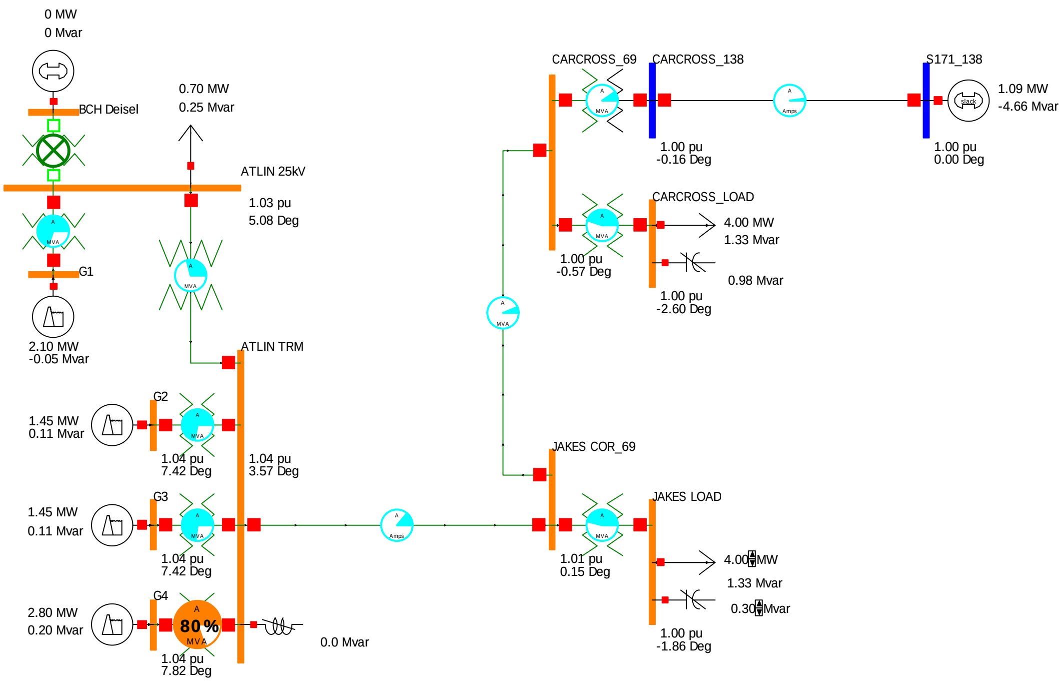

Table 3: Option 2a Results

Atlin Gen	Send Power (MW)	Rec Power (MW)	Vsend (pu)	Vrec (pu)	Vdrop (%)	Loss (MW)	Loss (%)	Comp Send (MVAr)	Comp Rec (MVAr)
1.45	0.75	0.74	1.02	1.01	1	0.005	0.67	0.00	1.30
2.9	2.20	2.18	1.03	1.01	2	0.019	0.86	0.00	1.08
5.0	4.29	4.23	1.03	1.01	2	0.060	1.40	0.00	1.11
7.8	7.09	6.93	1.04	1.01	3	0.157	2.21	0.00	1.28

The results are similar to Option 1b. Shunt compensation is required at the loads. Voltage regulation is within the 5% and losses maximize at full Atlin generation output of 2.2%.

Option 2b

A second option had the 69 kV line between Carcross and Jakes Corner replaced by a 138 kV line. Load was modeled as for Option 2a. At Carcross a 138/34.5 kV transformer was added and at Jakes Corner a 138/69 kV transformer was added. A secondary option, not tested, was to build initially the Jakes Corner to Carcross line with 138 kV construction and energize the line at 69 kV. The single line for the 138 kV option between Carcross and Jakes Corner is shown in Figure 6 and the results in Table 4.

Figure 6: Option 2b Single Line

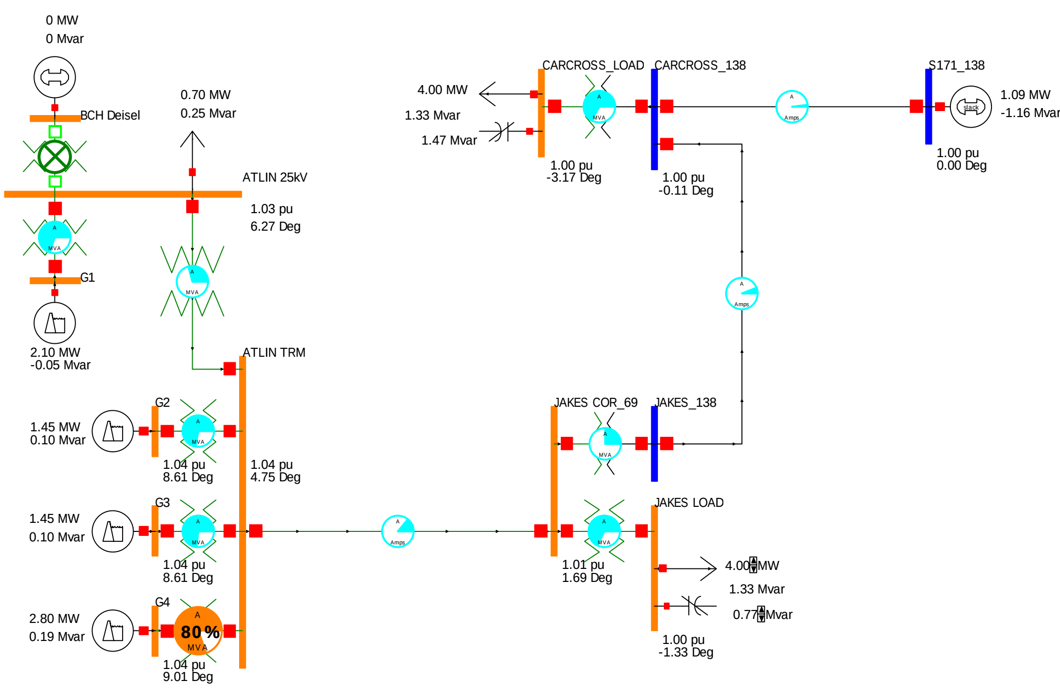

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Table 4: Option 2b Results

Atlin Gen	Send Power (MW)	Rec Power (MW)	Vsend (pu)	Vrec (pu)	Vdrop (%)	Loss (MW)	Loss (%)	Comp Send (MVAr)	Comp Rec (MVAr)
1.45	0.75	0.74	1.02	1.01	1	0.005	0.67	0.00	2.39
2.9	2.20	2.18	1.03	1.01	2	0.018	0.82	0.00	2.21
5.0	4.29	4.23	1.03	1.01	2	0.050	1.17	0.00	2.19
7.8	7.09	6.93	1.04	1.01	3	0.156	2.20	0.00	2.24

The results are similar to Option 2a. That is voltage regulation and losses are similar. However, with the split loads, additional shunt compensation is required for the laods.

Option 3a

Option 3a sees a 69 kV transmission line from S171 established. At S171, a 138/69 kV transformer is installed. Shunt compensation is installed at Jakes Corner for voltage support. The results are presented in Table 4 and the single line is shown in Figure 6.

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Figure 6 Option 3a Single Line

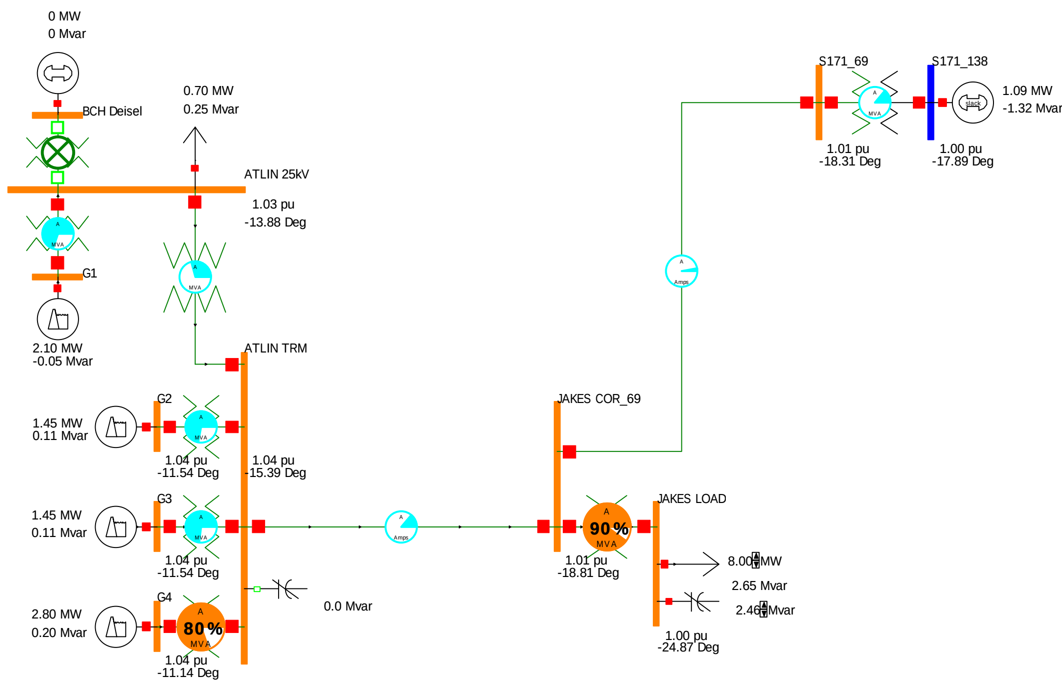

Table 4: Option 3a Results

Atlin Gen	Send Power (MW)	Rec Power (MW)	Vsend (pu)	Vrec (pu)	Vdrop (%)	Loss (MW)	Loss (%)	Comp Send (MVAr)	Comp Rec (MVAr)
1.45	0.75	0.74	1.02	1.01	1	0.005	0.67	0.00	2.78
2.9	2.20	2.18	1.03	1.01	2	0.019	0.86	0.00	2.55
5.0	4.29	4.23	1.03	1.01	2	0.060	1.40	0.00	2.48
7.8	7.09	6.93	1.04	1.01	3	0.157	2.21	0.00	2.46

For this option voltage drop at maximum transfer from Atlin is maximum at 3% and losses are slightly higher.

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Option 3b

Option 3b sees a 138 kV line from S171 to Jakes Corner. At Jakes Corner a 138/69 kV transformer is installed. Shunt compensation is installed for the load.

Figure 8: Option 3b Single Line

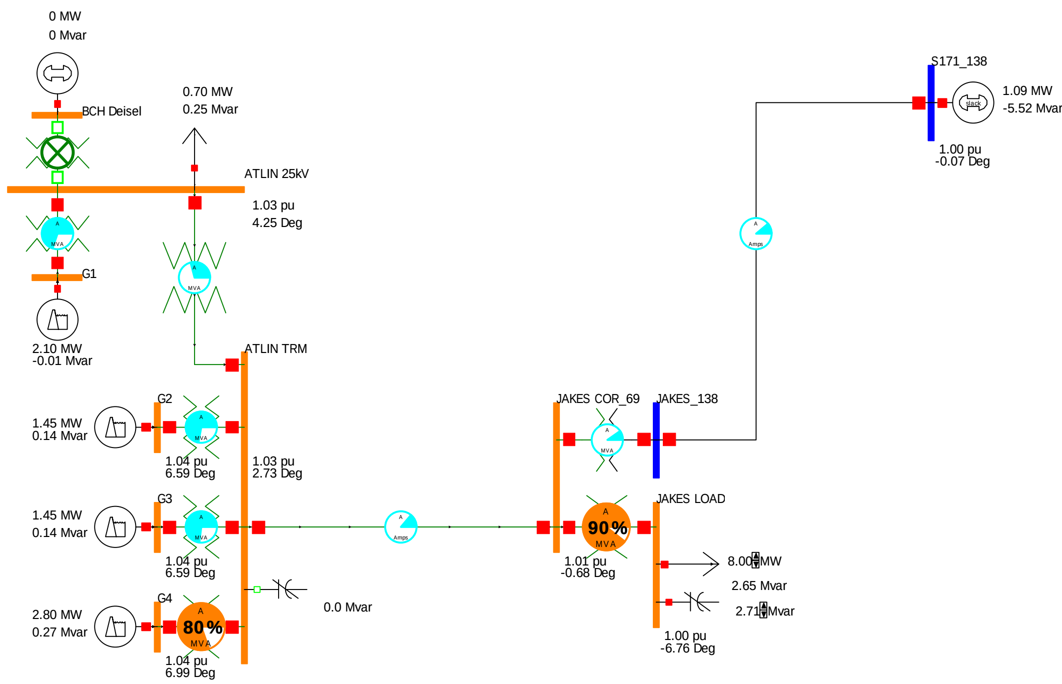

Table 6: Option 3b Results

Atlin Gen	Send Power (MW)	Rec Power (MW)	Vsend (pu)	Vrec (pu)	Vdrop (%)	Loss (MW)	Loss (%)	Comp Send (MVAr)	Comp Rec (MVAr)
1.45	0.75	0.74	1.02	1.01	1	0.005	0.67	0.00	2.68
2.9	2.20	2.18	1.03	1.01	2	0.019	0.86	0.00	2.59
5.0	4.29	4.23	1.03	1.01	2	0.060	1.40	0.00	2.62
7.8	7.09	6.93	1.03	1.01	3	0.158	2.22	0.00	2.71

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For this option voltage regulation and losses are similar to Option 3a.

Losses Atlin to Whitehorse

For all of the options studied except 1a, a calculation of the total losses was made for the case where all of Atlin output is absorbed at Whitehorse S150 or S171 as the case may be and the load at Jakes Corner and Carcross was switched off. For all options, Atlin was dispatched at maximum output of 7.8 MW. Table 7 presents the results

Table 7 Losses Atlin to Whitehorse

	Losses (MW)		
Case	Atlin to Jakes Corner	Jakes Corner to Whitehorse	Total
1b	0.108	0.295	0.403
2a	0.154	0.107	0.261
2b	0.154	0.092	0.246
3a	0.154	0.121	0.275
3b	0.157	0.030	0.187

Other Issues

This study used Ibis, 397 MCM, conductor for the 69 kV line. It's recommended that Partridge, 266 MCM, and Hawk, 477 MCM, be evaluated from a financial point of view. Conductor size influences lines costs between 30% to 50%.

Protection of the new 69 kV line can be accomplished using impedance protection. Use of high accuracy current and voltage transformers will allow the Zone 1 reach at each end to be set to 90% of line length. Effectively, this makes the line protection independent of telecommunications, although telecommunications, if available, should be used to enable the line differential protection function of the relay. High-speed autoreclose should be investigated, but may not be applicable to the interconnection.

With full development of Atlin generation, there will be an overfrequency condition when the line to Jakes Corner trip during a transient fault or other condition. The overfrequency or overspeed condition results when the generation exceeds the connected load. Anti-islanding protection will need to be applied for two cases.

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- Assume all generation is in service and the line trips. The 69/25 kV interconnecting transformer will need to be tripped and the 2.1 MW generator run back to 0.7 MW plus any losses. Hydro generators need to be tripped when their overspeed reaches 125% of rated speed. Assuming an inertia factor, H, of 2, this overspeed will be reached in approximately 0.750 seconds. Assuming a relay plus tripping time of 0.250 seconds, the overfrequency protection needs to initiate tripping within 0.500 seconds. It must be noted that these times are estimates and need further study.
- Assume the 2.1 MW generator is out of service and the remaining generation is in service. For this case to maintain load at Atlin a scheme needs to be devised to determine which generators are tripped and which generator has the runback scheme. A similar tripping scheme as noted above needs to be developed.

Operationally, with Yukon Energy being the larger generation source, the effect of normal load oscillations in Yukon and their effect on Atlin needs to be investigated. This may require additional controls on the Atlin generators, effectively Automatic Generation Control (AGC) to damp out the isolations between the two systems. Additionally, Yukon may need to adjust its AGC controls.

Transformer voltage control at the sending end can be accomplished by off-load transformer taps and the voltage adjusted automatically by the generators. Generators are typically run slightly overexcited. For this study, Atlin generation was operated at 104% voltage. Additional study of the preferred operating conditions is required.

At the receiving end an on-load tapchanger with a suitable range should be investigated.

System synchronization should take place at Atlin, however this needs to be discussed and agreed with Yukon Energy.

Running the Southern Lakes load isolated can be accomplished during times when the Southern Lakes load is below approximately 7 MW. Further study is required for this operating scenario.

Generators with automatic voltage regulation (AVR) have the ability to control their terminal voltage. This is accomplished by increasing or decreasing the rotor voltage. Typically, a generator has the capability to increase its reactive power, overexcited condition, output in the range of 50% of the generator's active power rating. For the underexcited condition, the range is 25%. Energizing the 69 kV transmission line from the Atlin end will require the Atlin generators to operate in their underexcited mode. For the 1.45 MW machines, this is approximately 0.35 MVAr. The charging reactive power of the 69 kV line is 2.0 MVAr. This requirement is greater than the estimated total reactive power capabilities of all four machines at Atlin. To compensate for this a 1.5 MVAr shunt reactor was connected to the 69 kV Atlin bus was added. Additional work needs to be done to determine the reactor size and its controls.

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Energizing the 69 kV line from the Yukon end and synchronizing at Atlin is the preferred method of connecting Atlin to Yukon. The capabilities of the Yukon generators need to be assessed.

The generation profile needs to be developed at Atlin to determine the energy profile.

The keraunic level for the area needs to be determined to determine the frequency and duration of transient line trips.

Conclusions

This feasibility study examined six scenarios for connecting Atlin generation to the Southern Lakes load in Yukon. All options gave acceptable voltage regulation and loss performance.

Option 1a is not recommended as Atlin generation cannot supply all of the Southern generation under maximum load conditions.

Regardless of the option chosen, the performance of the 69 kV interconnection was similar.

As noted above, Options 1b, 2a and 2b give acceptable performance. Option 1b is the recommended option since it will require the least construction to accomplish the interconnection. A 69/34.5 kV substation is required at Jakes Corner along with shunt reactor of 1.5 MVAr at Atlin.

Other issues identified include:

- Line protection
- Communication
- Anti-islanding and overfrequency protection
- Effect of Yukon load fluctuations on Atlin load.
- Sizing of transformers and the tapchanger requirements.
- Synchronization of the two systems.

Additional study using a full model of Yukon Electric system is required to confirm these results, optimize equipment, develop equipment specifications and identify other technical issues.

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APPENDIX F:
Atlin Substation Cost Estimate

Superior client service. Electrical confidence.

MORRISON HERSHFIELD

ATLIN

SUBSTATION COST ESTIMATE

ATLIN GENERATING STATIONS

January 28, 2016 File: M1457-16

1103 Parsons Road SW

Edmonton, Alberta, Canada

780 462 3111

Project Manager: Duane Grzyb, P. Eng.

TYPE OF REPORT FOR WHAT PROJECT

AMENDMENT RECORD			NAME	NAME	NAME
A	2016-01-29	Issue for Review	D Grzyb		
REV.	DATE	DESCRIPTION OF CHANGE(S)	PREPARED	REVIEWER	APPROVER

TABLE OF CONTENTS

1 EXECUTIVE SUMMARY

1.1 Magna has prepared the following Class 5 estimates (-30/+50%) for substations at Atlin Upper Generation Station, Atlin Lower Generating Station and Jake's Corner. Three options have been considered at Jakes Corner, which include an interconnect line to Carcross at 69 kV, a 138 kV interconnect line, and no interconnect to Carcross at all. Estimated installed costs are in Canadian dollars, including GST, PST, Engineering and contractor profits for the Substations are as follows:

Atlin Upper Substation	$ 4,240,000 CAD
Atlin Lower Substation	$ 1,118,000 CAD
Jakes Corner (Option 1b)	$ 1,620,000 CAD
Jakes Corner (Option 2a)	$ 2,800,000 CAD
Jakes Corner (Option 2b)	$ 3,013,000 CAD

1.2 As a comparison, a budget quotation was requested from a US vendor for prepackaged substations. The budget quote received included freight to site, but did not included GST and PST as do the figures above. Prices are in US dollars. Scope of work does not include fencing, site preparations, any required civil works, sub grade grounding etc. Although the initial pricing appears attractive, with currency exchange and the required site works that have not been included, it is inconclusive at this time if this is truly a less expensive option. What the pricing does effectively do, is corroborate the estimating performed in the previous paragraph, and we believe the pricing provided above, considering total installed price falls within the Class 5 estimate range specified.

Atlin Upper Substation	$ 1,919,000 USD
Atlin Lower Substation	$ 908,000 USD
Jakes Corner (Option 1b)	$ 1,987,000 USD
Jakes Corner (Option 2a)	$ 1,531,000 USD
Jakes Corner (Option 2b)	$ 1,545,000 USD

2 DATA SOURCES

2.1 Interconnection and sizing of equipment is based on the report prepared by b7kennedy & associates Inc.

2.2 The adjusted pricing included in the Magna estimate and the US prepackaged vendor quote date is Q1 2016.

2.3 Cost data in the Magna portion of the estimate has been drawn from several sources.

2.3.1 Sources prefixed with a 12 digit identification number have been taken from RSMeans Electrical Cost Data 2014 (January) edition. (Entries are highlighted green in the attached estimates) The "Anywhere USA" material, labour and equipment costs have been adjusted for Whitehorse construction location, using the "City" factors listed in the RSMeans book. This factor is 134.3 for materials and 69.8 for equipment and labour. Values highlighted in green located in columns "Extended Material, Estimated Labour and Equipment" are factored with these two values, as well as an inflation factor 1.25% per year for the year 2014 and 2015.

2.3.2 Data sources prefixed with "MIV" are deemed to be current Q1 2016 costs in Canadian dollars. These values are entered as estimated values using internal Magna information based on similar projects and vendor budget quotations.

2.3.3 Items prefixed with "MH" are unit rates that have been provided by Morrison Hershfield specific to this project as of January 2016.

2.4 Costs in the Dis-Tran provided quotation are provided by Dis-Tran and their origins are unknown, except that a number of sub-vendor names have been provided in the equipment lists, such as ABB, S&C, Tyco, Ohio Brass etc.

3 WHAT'S INCLUDED (IN THE MAGNA ESTIMATES)

3.1 Substations for Atlin Upper and Atlin lower are unaffected by various options considered at Jake's Corner.

3.2 Jake's Corner substation estimates are presented in three configurations, options 1b, 2a and 2b. These configurations are defined in the report provided by b7kennedy and associates.

3.3 Division 1 costs for the installation contractor, such as mobilize, demobilize, site costs, have been included at 7% of the itemized bare costs.

3.4 Installation contractor profit of 15% has been included.

3.5 Engineering has been included at 10% of the factored material, labour, equipment, contractor Division 1 costs and contractor profit.

3.6 PST at 7% has been included on installation cost and engineering.

3.7 GST at 5% has been included on installation cost and engineering.

4 CONSTRUCTION METHODS

4.1 The base estimates have been compiled based on stick built construction at the location, with the exception of:

4.1.1 Modularized substation building for Jakes corner, constructed in an Alberta or BC city.

4.1.2 Protection panels pre-constructed in a panel shop in Alberta or BC city.

4.2 Transformers 2 MVA or larger are to be placed on field constructed slab on grade concrete pads.

4.3 Substation equipment, transmission line dead ends, and other HV equipment is to be supported by fabricated steel structures, attached to screw in steel piles.

4.4 The following support structures are assumed:

4.4.1 34.5 kV disconnecting switches are assumed to be supported on single pole structures. These may be wood or steel.

4.4.2 69 and 138 kV disconnecting switches, circuit switchers, ct sets, etc. are assumed to be supported on two screw pilings with fabricated steel supports spanning the piles and supporting the equipment.

4.4.3 34.5 kV circuit switchers are supported on two screw piles with fabricated steel supports.

4.4.4 Dead end structures for 34.5, 69, and 138 kV are assumed to be supported on 4 screw piles. Dead end structures will also support integrated disconnecting switches where required.

4.4.5 Double dead end structure for 69 kV at Atlin Upper Substation is assumed to be supported by 4 screw piles, although they will likely need to be larger. Piling costs for varying pile sizes were not differentiated in the estimate.

4.5 Generator output cables will be underground, buried 1 meter, in DBII conduit.

4.6 Protection control panels will be located in a self-contained, prefabricated control building at the Jake's Corner substation. Costs for the building and placement have been included.

5 ASSUMPTIONS

5.1 Dual generator output transformers for generators G2 and G3 have been combined into a single generator transformer and 69 kV circuit switcher. Separate transformers and circuit switchers would add considerable cost to the substation and are not deemed necessary.

5.2 Atlin Upper and Atlin Lower substations are assumed to be located on disturbed (placier mining) earth, consisting of modest size rocky earth fill. As such ground wells have been allowed for, due to the likelihood of poor connection of typical 15 foot driven ground rods.

5.3 Jakes corner substation is assumed to be located on undisturbed land, consisting of earth and a lesser amount of rocks, thus negating the requirement of drilled ground wells. A traditional array of driven ground rods is assumed to provide adequate grounding.

5.4 Protection control panels will be located in owner provided space in Atlin Upper Generating Building and Atlin Lower Generating Building.

5.5 125 VDC supplied by station batteries and chargers is assumed to be supplied by the generating stations for the Upper and Lower substations.

5.6 125 VDC batteries and charging equipment shall be supplied by the scope of this estimate for Jake's Corner substation.

5.7 General earthworks will be provided by others. The assumed starting points for substation construction will be level, drained, compacted earth, with access roads provided. No pre-construction clearing or ground preparation costs are carried.

5.8 Costs for ground grid construction, fence construction, washed rock substation backfill, cable trenching and backfill have been included in the estimate.

5.9 Connection from the G1 generator output to the Upper Atlin Substation shall be underground, using insulated cables.

5.10 A lump sum of $85000, bare cost is carried for the connection of the G1 generator output to the Upper Atlin Substation tie transformer. $30,000 bare cost is carried for modifications to the existing G1 protective relay systems for the inclusion of the tie connections. This connection is not well defined at this time and may cost more or less.

6 SCOPE

6.1 Transmission line connection end of scope is the substation dead end. All line construction charges, right of ways, wires, hardware, poles etc are by others.

6.2 No equipment has been allowed for SCADA or other communications. Substations have no visibility to one another or any remote locations. Fibre optic equipment is not included.

6.3 Power metering for electricity sale has not be defined or included. Additional revenue class current transformers, potential transformers and metering equipment will be required at the locations determined by the sale contract.

7 SPECIAL CONSIDERATIONS

7.1 Carcross currently has no 138 kV systems in place.

7.2 Carcross currently has no 138 kV substation in place.

7.3 Equipment supplied for the "Carcross 138 kV substation" as part of estimates 2a and 2b (Jake's Crossing Substation options 2a and 2b) are "loose supplied" "free issue" equipment. The equipment supplied does in no way constitute a complete and working 138 kV substation. Specifically missing from the Carcross location are earthworks, fence, foundations, protection panels, protection equipment, wiring, 125 VDC batteries, 125 VDC chargers, station services, lighting, grounding, etc. The supplied equipment includes the power transformer, circuit switchers, support stands, dead end structures and disconnect switches. As the eventual scope at Carcross is undetermined at this time, attempting to provide necessary infrastructure for a small portion of an overall substation at Carcross would be misleading.

8 ALTERNATE CONSIDERED SOLUTIONS

8.1 The general remote location of the installation may benefit from pre-constructing skid units remotely and transferring them to site for interconnection. Pricing in US dollars, fob site is included in the appendix. Regrettably, the quotation provided did not include general arrangement details, size details, or much other information other than a BOM. As such, it is not possible to determine if this is a cost effective alternative to the stick built solution proposed by Magna. Specific items that are not included in the prepackaged alternative are site preparation, fencing, reactors grounding, connections to generators, connections to remote mounted protection panels, to name a few things. Further investigation will need to be done to determine the cost benefits / disadvantage of this route in upcoming phases of design and estimation.

9 CONCLUSIONS

9.1 The pricing shown in section 1.1 of this report, is believed to be accurate within the Class 5 estimate tolerances, subject to the conditions and assumptions listed.

10 REFERENCES

10.1 RSMeans Electrical Cost Data, 37th Annual Edition, 2014. ISBN 978-1-940238-04-3

11 DRAWINGS AND TECHNICAL INFORMATION

11.1 Single Line Diagram

11.2 Sketch of Atlin Upper Substation Layout

11.3 Sketch of Atlin Lower Substation Layout

11.4 Sketch of Jake's Corner Substation – Option 2b (only)

11.5 Estimate Worksheet - Atlin Upper Substation – Stick Built

11.6 Estimate Worksheet - Atlin Lower Substation - Stick Built

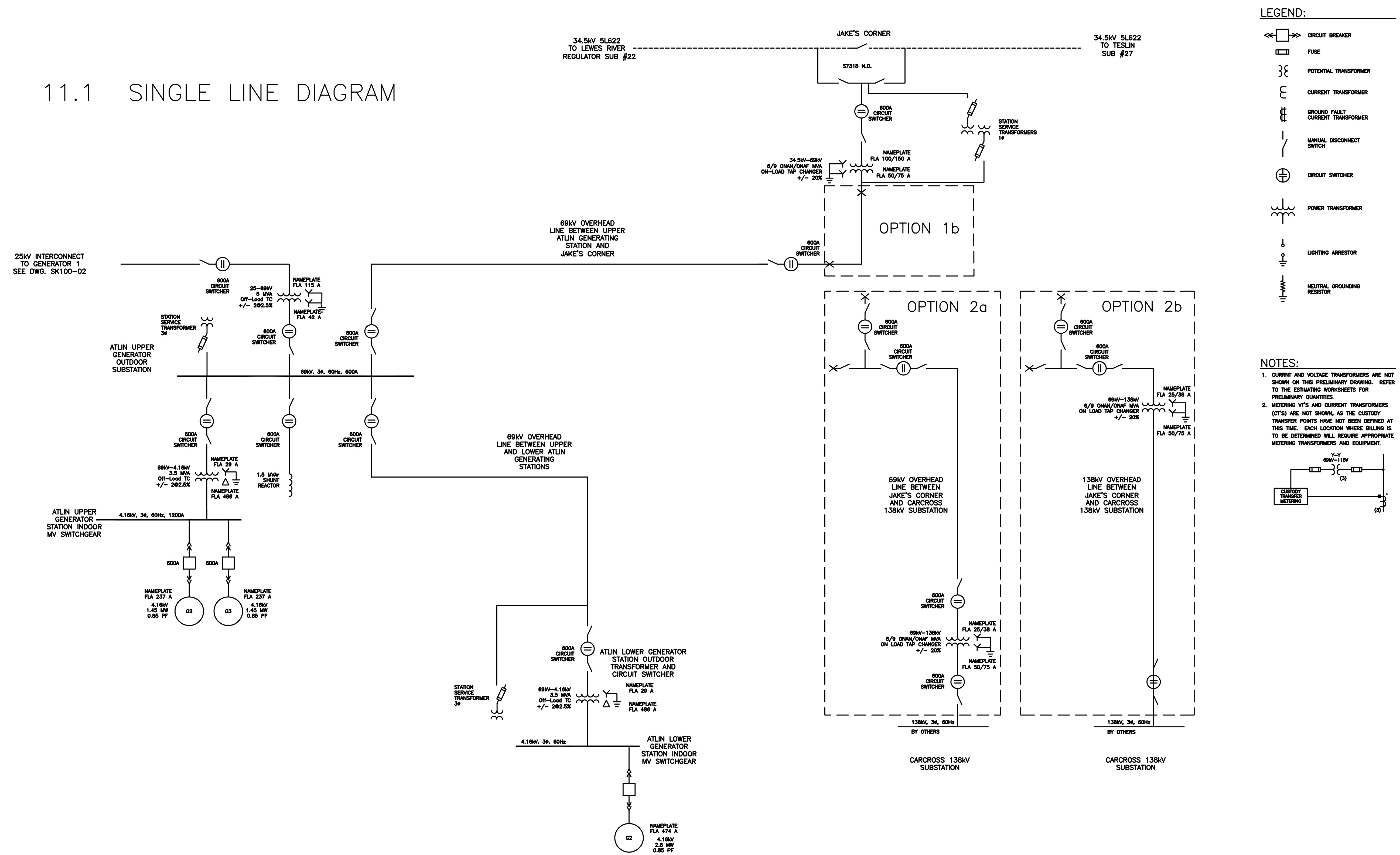
11.7 Estimate Worksheet - Jake's Corner – Option 1b

11.8 Estimate Worksheet - Jake's Corner – Option 2a

11.9 Estimate Worksheet - Jake's Corner – Option 2b

11.10 Quotation Documents from DISTRAN Packaged Substations

11.1 SINGLE LINE DIAGRAM



DRAWING No.	DRAWING TITLE	No.	DESCRIPTION	DATE	BY
------	------	B	Prefeasibility Estimate	29/Jan 16	DG
		A	Prefeasibility Estimate	11/Jan/16	DG
REFERENCE DRAWING		REVISION			

PERMIT STAMP:

ENGINEERING STAMP:

CLIENT: MORRISON HERSHFIELD People • Culture • Capabilities

CONSULTANT: MAGNA IV ENGINEERING INC.

SCALE:	NTS	DATE
DRAWN BY:	DG	11/Jan/16
DESIGNED BY:	DG	11/Jan/15
APPROVED BY:	---	--/---/--

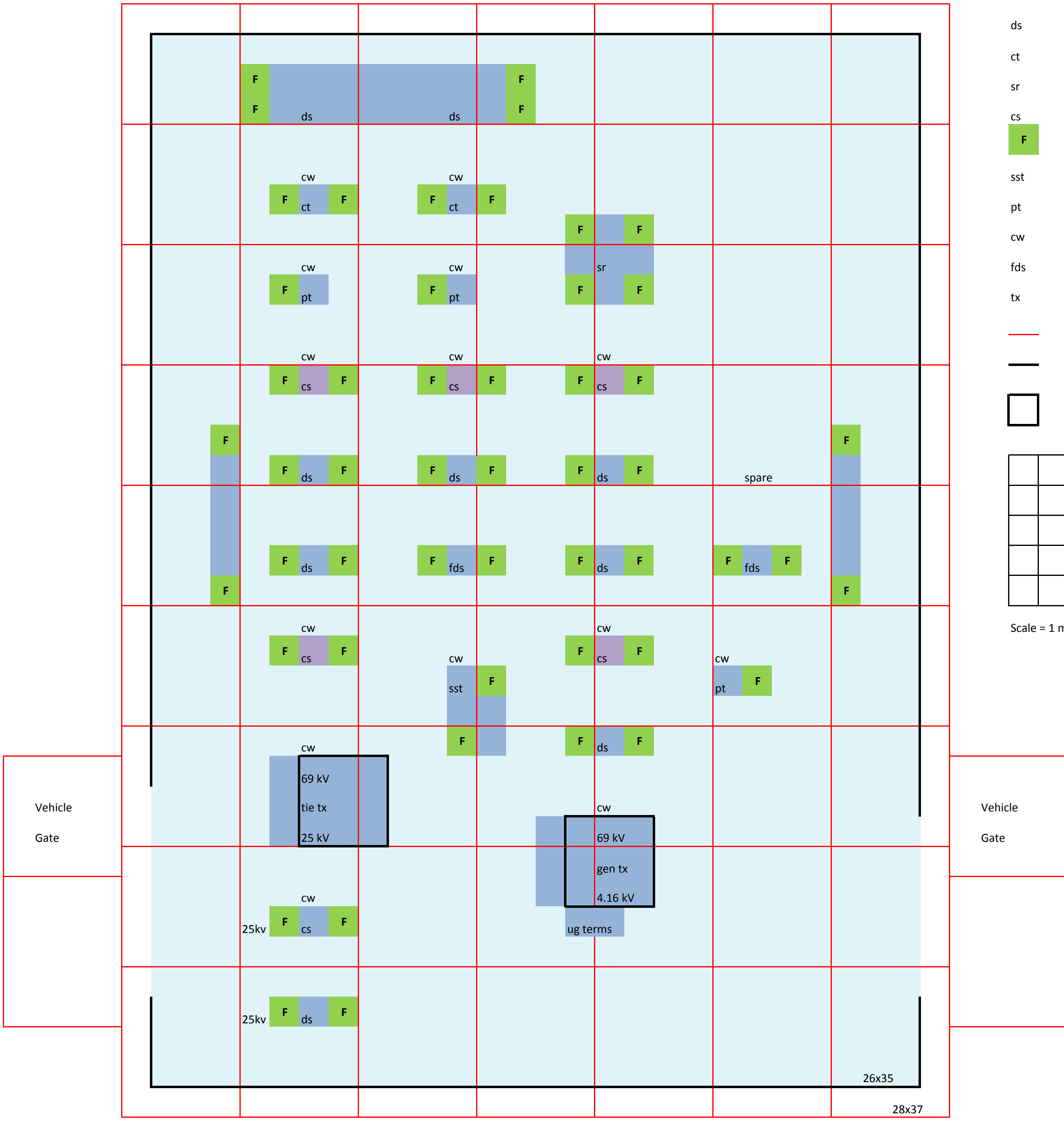
LOCATION: --- SITE: ---

PROJECT NAME: ATLIN HYDRO EXPANSION

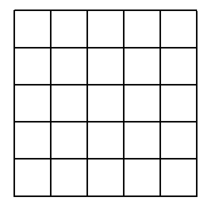
DRAWING TITLE: SINGLE LINE DIAGRAM

PROJECT No.	DRAWING No.	SHEET NO.	OF SHEET	REV.
M1457-16	1457-16-E001	--	---	B

11.2 UPPER ATLIN SUB, FENCED SIZE 26 X 35 METERS

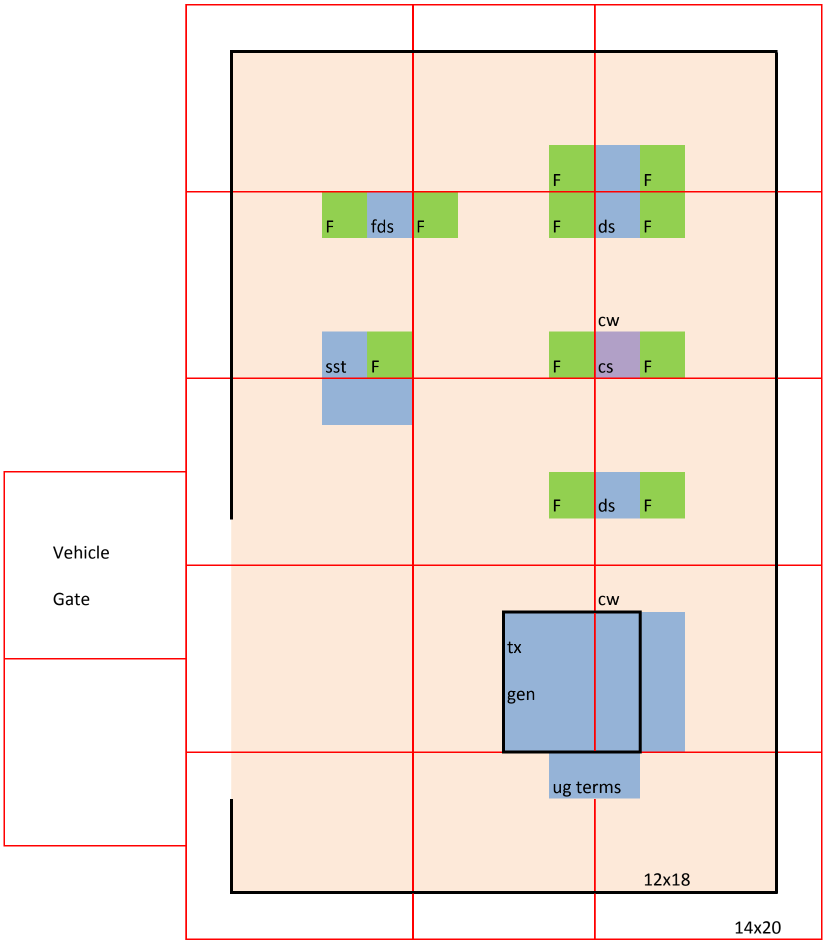


ds	disconnect switch
ct	current transformer
sr	shurnt reactor
cs	circuit switcher
F	screw pile foundation
sst	station service transformer
pt	potential transformer
cw	control wiring required
fds	fuse disconnect switch
tx	transformer
(red line)	buried ground wire
(black line)	fence
(box)	cast in place slab on grade

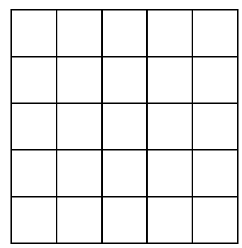


Scale = 1 meter blocks, 5 x 5 meters shown

11.3 LOWER ATLIN SUB, FENCED SIZE 12 X 18 METERS



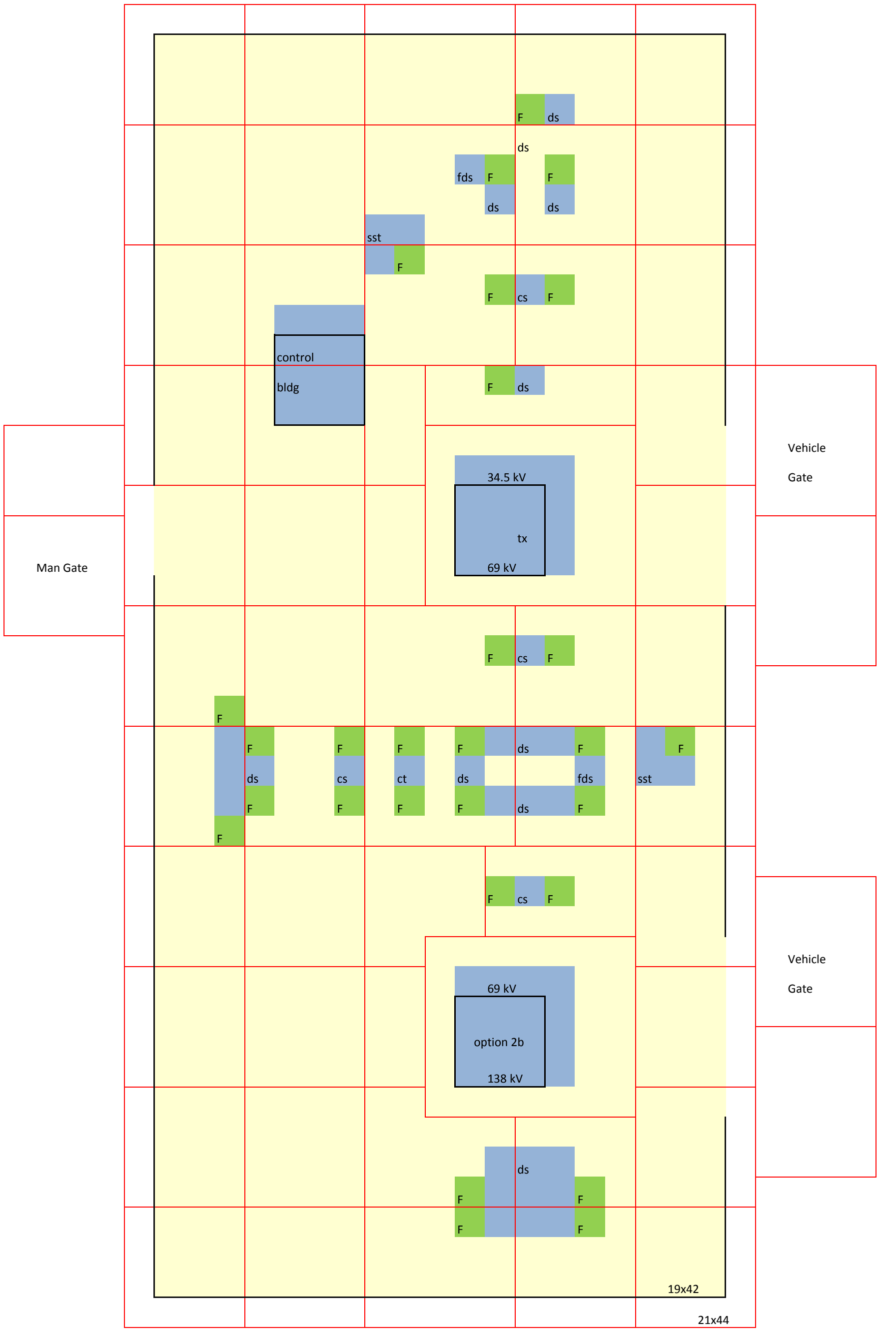
ds	disconnect switch
ct	current transformer
sr	shurnt reactor
cs	circuit switcher
F	screw pile foundation
sst	station service transformer
cw	control wiring required
tx	transformer
fds	fuse disconnect switch
(red line)	buried ground wire
(black line)	fence
(square)	cast in place slab on grade



Scale = 1 meter blocks, 5 x 5 meters shown

11.4 JAKE'S CORNER SUB, FENCED SIZE 19 X 42 METERS

Layout shows equipment for option 2b, which is the largest arrangement. Various equipment is deleted for other options.



ds disconnect switch
ct current transformer
sr shurnt reactor
cs circuit switcher
F screw pile foundation
sst station service transformer
pt potential transformer
cw control wiring required
fds fuse disconnect switch
tx transformer
buried ground wire
fence
cast in place slab on grade

Scale = 1 meter blocks, 5 x 5 meters shown

11.5 ESTIMATE WORKSHEET - ATLIN UPPER SUBSTATION - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MH		Substation Fence 26 x 35 m	110	m	$4,950	$4,950	$1,100	100/m, 45, 45, 10/m M,L,E
MH		Substation Vehicle Gates 6m	12	m	$540	$540	$120	100/m, 45, 45, 10/m M,L,E
26 05 26 80 1000	4/0 wire and placement	Substation Grounding Grid 28 x 37 m x	630	m	$9,505	$3,100	$0	
26 05 26 80 2760	4/0 to 4/0 exothermic	Connectors	80	ea	$640	$4,880	$0	
26 05 26 80 5195	40' with hole clay rod clamp	Ground Wells	4	ea	$12,100	$1,700	$0	
26 05 26 80 0130	15' 3/4" cc steel	Ground Rods Driven	20	ea	$1,270	$2,140	$0	
33 75 53 13 3250	HV Switches Disconnecting Circuit Switcher <161kV	69 kV circuit switchers	5	ea	$457,500	$55,200	$10,875	
MIV		Circuit Switcher Stand	5	ea	$25,000	$5,000	$1,500	
33 75 53 13 3080	HV Switches Disconnecting Manual Operation 69kV	69 kv disconnect switches	8	ea	$202,400	$28,400	$8,880	
MIV		disconnect switch support / stand	8	ea	$16,000	$4,000	$800	
33 75 13 13 2100	HV Circuit Breaker Air CB 13-26kV	25 kv circuit switcher	1	ea	$59,000	$40,400	$1,575	
MIV		Circuit Switcher Stand 25 kv	1	ea	$4,000	$800	$250	
33 75 53 13 3060	HV Switches Disconnecting Manual Operation <26kV	25 disconnect switch	2	ea	$27,200	$13,800	$1,080	
MIV		mods to connect to G1 outputs with above	1	lot	$35,000	$35,000	$15,000	
		mods to protecton panels and settings for G1	1	lot	$5,000	$25,000		rev 2
MIV		69 kv current transformers set of 3	3	ea	$54,000	$10,500	$1,500	rev 2 - was qty 1
MIV		current transformer stand	3	ea	$6,000	$1,500	$300	rev 2 - was qty 1
MIV		69 kv current transformers set of 3 (high accurac	1	ea	$22,000	$3,500	$500	
MIV		current transformer stand	1	ea	$2,000	$500	$100	
MIV		69 kv pt's set of 3	3	sets	$99,000	$10,500	$1,500	
MIV		pt transformer stand	3	ea	$6,000	$1,500	$300	rev 2 - was qty 1
MIV		69 kv fuse disconnect outdoor	2	ea	$30,000	$3,000	$500	
MIV		69 kv fuse disconnect support structure	2	ea	$4,000	$1,000	$200	
33 75 39 13 8050	<26 kV Surge Arrestor	25 kv Surge Arrestor	3	ea	$4,575	$456	$143	
MIV		25 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 75 39 13 8070	69 kv Surge Arrestor	69 kv Surge Arrestors	12	ea	$63,600	$3,036	$954	
MIV		69 kv Surge Arrestor Support	12	ea	$9,000	$3,600	$2,400	
33 73 23 20 1070		T2 25 - 69 kV Tie Transformer 5MVA	5	MVA	$95,500	$4,550	$1,425	
33 73 23 20 1070		T3 Generator Output Transformer	3	MVA	$57,300	$2,730	$855	
26 12 19 10 0300	500 kva 15 kV pad mount	SST2 - Station Services Transformer	1	ea	$18,000	$2,650	$350	
MIV - Trench Quote		SR1 - Shunt Reactor 69 kV, .6 MVA	3	ea	$117,450	$5,000	$3,000	
MIV		Support Shunt Reactor Steel & Insulators	3	ea	$9,000	$2,250	$600	
MIV		69 kV Dead Ends	4	ea	$100,000	$30,000	$4,000	
MIV		ACSR	500	m	$4,000	$2,000	$2,000	
MIV		ACSR Connectors	150	ea	$9,000	$6,000	$1,500	
26 56 36 55 0120	Led Flood 90 watt	Outdoor Lighting	6	ea	$9,000	$642	$180	
MIV	Lighting Wiring	2c12 teck, in concrete wireway & up poles	150	m	$600	$300	$0	
MIV		Lightning crosswires	400	m	$800	$600	$800	
MIV		Lightning corner poles	4	ea	$3,000	$1,200	$800	
26 05 19 20 0400	Means price 3c#6 average cable cost	Field Control Wiring	8450	m	$126,108	$38,248	$0	
MIV		Generator Output Wiring	300	m	$34,500	$6,000	$1,500	
MIV		Terminations Small	800	ea	$0	$2,400	$0	
MIV		Terminations Generator	6	ea	$510	$510	$240	
MIV		Teck Connectors Small Average	160	ea	$1,600	$4,240	$0	
MIV		Teck Connectors Generator	6	ea	$510	$510	$0	
MIV		Protection Panel 1, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		B1 - Bus Differential Relay	1	ea	$7,500			SEL-487B
MIV		T2 - Atlin Tie TX Protection Relay	1	ea	$3,500			SEL-787

11.5 ESTIMATE WORKSHEET - ATLIN UPPER SUBSTATION - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MIV		T3 - GSU Protection Relay	1	ea	$3,500			SEL-787
MIV		Protection Panel 2, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		L1 - Jake's Corner Line Prot. Relay	1	ea	$5,500			SEL-311L
MIV		L2 - Atlin Lower Line Prot. Relay	1	ea	$5,500			SEL-311L
MIV		Sat. Clock, anttenna	1	ea	$2,000			SEL-2407
MIV		Commissioning	1	lot		$40,000	$10,000	
MH		Washed Rock	150	m^3	$9,000	$1,500	$1,500	
MIV		Foundations Small Screw Pile	51	ea	$31,875	$18,360	$12,240	
MIV		Survey	1	lot		$35,000		
MH	4m x 4m x .33m	Gen Tx Foundation	5.3	m^3	$13,332	$5,333	$2,666	
MH	4m x 4m x .33m	Tie Tx Foundation	5.3	m^3	$13,332	$5,333	$2,666	
MH	4m x 12m x .2m	Shunt Reactor Foundation	9.6	m^3	$24,000	$9,600	$4,800	
MIV	1m x 1m	Trench and backfill for gen cables	75	m		$1,875	$1,875	
MIV		Generator Output Conduits	300	m	$1,200	$600	$300	
MIV	.6m x .2m	Trench and backfill for sub grounding	630	m		$1,890	$1,890	
MIV	600 x 300 x 1000	Precast Concrete Trenchway with Lid (in sub)	160	m	$32,000	$16,000	$16,000	
MIV	600 x 300 x 1000	Precast Concrete Trenchway with Lid (sub to gs)	70	m	$14,000	$7,000	$7,000	
MIV	24" Aluminum Ladder	Cable Tray in Building for Control Cables	25	m	$2,500	$1,250	$500	
MIV	.6m x .4m	Excavation for Trenchway	230	m		$1,380	$1,380	**TOTALS**
				SUBTOTAL	**$1,841,115**	**$504,924**	**$93,833**	**$2,439,873**
RSMeans Adjustment Factors for Inflation and Location on all RS Means Indexed Items								
2014 Escalation compounded / yr on RS Means amounts			1.25%		**$29,651.63**	**$5,960.31**	**$1,039.37**	**$36,651**
RSMeans Adjustment Factors for Whitehorse and CDN conversion		**Electrical 134.3 M / 69.8 L**			**$404,293.50**	**-$71,553.37**	**-$12,477.58**	**$320,263**
				SUBTOTAL	**$2,275,060**	**$439,331**	**$82,395**	**$2,796,786**
Division 01	**General Requirements @ 7%**				**$159,254**	**$30,753**	**$5,768**	**$195,775**
	General Contractor Overhead and Profit	**GC O & P 15%**			**$365,147**	**$70,513**	**$13,224**	**$448,884**
	Engineering	**Engineering @ 10%**			**$279,946**	**$54,060**	**$10,139**	**$344,145**
				SUBTOTAL	**$3,079,408**	**$594,657**	**$111,525**	**$3,785,590**
	GST	**GST @ 5%**			**$153,970**	**$29,733**	**$5,576**	**$189,280**
	PST	**PST @ 7%**			**$215,559**	**$41,626**	**$7,807**	**$264,991**
					GRAND TOTAL		**CDN$**	**$4,239,861**

Data Sources:
Where prefixed with a line number, data for material cost, labour cost and equipment cost is taken from 2014 RSMeans data
Where prefixed with MIV the data is estimated value from Magna IV Engineering internal sources and best practices
Where prefixed with MH the values are estimated values provided from Morrison Hershfiield
*Unadjusted anywhere usa" Rsmeans estimating values shown in green highlight cells only

11.6 ESTIMATE WORKSHEET - ATLIN LOWER SUBSTATION - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MH		Substation Fence 26 x 35 m	42	m	$1,890	$1,890	$420	100/m, 45, 45, 10/m M,L,E
MH		Substation Vehicle Gates 6m	6	m	$270	$270	$60	100/m, 45, 45, 10/m M,L,E
26 05 26 80 1000	4/0 wire and placement	Substation Grounding Grid 28 x 37 m x	170	m	$2,565	$836	$0	
26 05 26 80 2760	4/0 to 4/0 exothermic	Connectors	25	ea	$200	$1,525	$0	
26 05 26 80 5195	40' with hole clay rod clamp	Ground Wells	4	ea	$12,100	$1,700	$0	
26 05 26 80 0130	15' 3/4" cc steel	Ground Rods Driven	12	ea	$762	$1,284	$0	
33 75 53 13 3250	HV Switches Disconnecting Circuit Switcher <161kV	69 kV circuit switchers	1	ea	$91,500	$55,200	$2,175	
MIV		Circuit Switcher Stand	1	ea	$5,000	$1,000	$300	
33 75 53 13 3080	HV Switches Disconnecting Manual Operation 69kV	69 kv disconnect switches	2	ea	$50,600	$28,400	$2,220	
MIV		disconnect switch support / stand	2	ea	$4,000	$1,000	$200	
MIV		69 kv pt's set of 3	1	sets	$33,000	$3,500	$500	
MIV		pt transformer stand	1	ea	$2,000	$500	$100	
MIV		69 kv fuse disconnect outdoor	1	ea	$15,000	$1,500	$250	
MIV		69 kv fuse disconnect support structure	1	ea	$2,000	$500	$100	
33 75 39 13 8070	69 kv Surge Arrestor	69 kv Surge Arrestors	3	ea	$15,900	$759	$239	
MIV		69 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 73 23 20 1070		T3 Generator Output Transformer	3.5	MVA	$66,850	$3,185	$998	
26 12 19 10 0300	500 kva 15 kV pad mount	SST2 - Station Services Transformer	1	ea	$18,000	$2,650	$350	
MIV		69 kV Dead Ends	1	ea	$25,000	$7,500	$1,000	
MIV		ACSR	80	m	$640	$320	$320	
MIV		ACSR Connectors	30	ea	$1,800	$1,200	$300	
26 56 36 55 0120	Led Flood 90 watt	Outdoor Lighting	2	ea	$3,000	$214	$60	
MIV	Lighting Wiring	2c12 teck, in concrete wireway & up poles	80	m	$320	$160	$0	
MIV		Lightning crosswires	100	m	$200	$150	$200	
MIV		Lightning corner poles	2	ea	$1,500	$600	$400	
26 05 19 20 0400	Means price 3c#6 average cable cost	Field Control Wiring	1000	m	$14,924	$4,526	$0	
MIV		Generator Output Wiring	300	m	$34,500	$6,000	$1,500	
MIV		Terminations Small	100	ea	$0	$300	$0	
MIV		Terminations Generator	6	ea	$510	$510	$240	
MIV		Teck Connectors Small Average	20	ea	$200	$530	$0	
MIV		Teck Connectors Generator	6	ea	$510	$510	$0	
MIV		Protection Panel 1, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		TX1 - Atlin Lower TX Protection Relay	1	ea	$3,500			SEL-787
MIV		L1 - Atlin Upper Line Protection Relay	1	ea	$5,500			SEL-311L
		Sat. Clock	1	ea	$2,000			SEL-2407
MIV		125 VDP Battery, Charger, PDP	1	ea	$5,000	$1,500	$100	
MIV		Commissioning	1	lot		$25,000	$5,000	
MH		Washed Rock	50	m^3	$3,000	$500	$500	
MIV		Foundations Small Screw Pile	11	ea	$6,875	$3,960	$2,640	
MIV		Survey	1	lot		$10,000		
MH	4m x 4m x .33m	Gen Tx Foundation	5.3	m^3	$13,332	$5,333	$2,666	
MIV	1m x 1m	Trench and backfill for gen cables	75	m		$1,875	$1,875	
MIV		Generator Output Conduits	300	m	$1,200	$600	$300	
MIV	.6m x .2m	Trench and backfill for sub grounding	170	m		$510	$510	
MIV	4 parallel runs	Multiconduits Sub to GS	100	m	$2,000	$2,000	$400	
MIV	.6m x 1m	Conduit Excavation and Backfill	100	m		$1,500	$1,500	
MIV	individual runs 4	Conduits to each equipment in sub	80	m	$480	$480	$160	
MIV	.2m x 1m	Conduit Excavation and Backfill	100	m		$1,500	$1,500	**TOTALS**

11.6 ESTIMATE WORKSHEET - ATLIN LOWER SUBSTATION - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MIV	24" Aluminum Ladder	Cable Tray in Building for Control Cables	25	m	$2,500	$1,250	$500	
				SUBTOTAL	$451,198	$190,413	$23,437	$665,048
RSMeans Adjustment Factors for Inflation and Location on all RS Means Indexed Items								
2014 Escalation compounded / yr on RS Means amounts			1.25%		$6,953.21	$2,522.66	$151.97	$9,628
RSMeans Adjustment Factors for Whitehorse and CDN conversion		**Electrical 134.3 M / 69.8 L**			$94,805.53	-$30,284.50	-$1,824.38	$62,697
				SUBTOTAL	$552,957	$162,651	$21,765	$737,372
Division 01	**General Requirements @ 7%**				$38,707	$11,386	$1,524	$51,616
	General Contractor Overhead and Profit	**GC O & P 15%**			$88,750	$26,105	$3,493	$118,348
	Engineering	**Engineering @ 10%**			$68,041	$20,014	$2,678	$90,734
				SUBTOTAL	$748,455	$220,156	$29,460	$998,070
	GST	**GST @ 5%**			$37,423	$11,008	$1,473	$49,904
	PST	**PST @ 7%**			$52,392	$15,411	$2,062	$69,865
						GRAND TOTAL	CDN$	$1,117,839

Data Sources:
Where prefixed with a line number, data for material cost, labour cost and equipment cost is taken from 2014 RSMeans data
Where prefixed with MIV the data is estimated value from Magna IV Engineering internal sources and best practices
Where prefixed with MH the values are estimated values provided from Morrison Hershfiield
*Unadjusted anywhere usa" Rsmeans estimating values shown in green highlight cells only

11.7 ESTIMATE WORKSHEET - JAKE'S CORNER SUB OPTION 1b - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MH		Substation Fence 19 x 25 m	82	m	$3,690	$3,690	$820	100/m, 45, 45, 10/m M,L,E
MH		Substation Vehicle Gates 6m	6	m	$270	$270	$60	100/m, 45, 45, 10/m M,L,E
26 05 26 80 1000	4/0 wire and placement	Substation Grounding Grid 21 x 27 x	450	m	$6,790	$2,214	$0	
26 05 26 80 2760	4/0 to 4/0 exothermic	Connectors	46	ea	$368	$2,806	$0	
26 05 26 80 5195	40' with hole clay rod clamp	Ground Wells	0	ea	$0	$0	$0	
26 05 26 80 0130	15' 3/4" cc steel	Ground Rods Driven	14	ea	$889	$1,498	$0	
33 75 53 13 3250	HV Switches Disconnecting Circuit Switcher <161kV	69 kV circuit switchers	1	ea	$91,500	$55,200	$2,175	
MIV		Circuit Switcher Stand	1	ea	$5,000	$1,000	$300	
33 75 53 13 3080	HV Switches Disconnecting Manual Operation 69kV	69 kv disconnect switches	1	ea	$25,300	$28,400	$1,110	
MIV		disconnect switch support / stand	1	ea	$2,000	$500	$100	
33 75 13 13 2100	HV Circuit Breaker Air CB 13-26kV	34.5 kv circuit switcher	1	ea	$59,000	$40,400	$1,575	
MIV		Circuit Switcher Stand 34.5 kv	1	ea	$4,000	$800	$250	
33 75 53 13 3060	HV Switches Disconnecting Manual Operation <26kV	34.5 disconnect switch	3	ea	$40,800	$13,800	$1,620	
MIV		69 kv current transformers set of 3 (high accura	1	ea	$22,000	$3,500	$500	
MIV		current transformer stand	1	ea	$2,000	$500	$100	
MIV		69 kv pt's set of 3	2	sets	$66,000	$7,000	$1,000	rev 2 - was 1
MIV		pt transformer stand	2	ea	$4,000	$1,000	$200	rev 2 - was 1
MIV		69 kv fuse disconnect outdoor	1	ea	$15,000	$1,500	$250	
MIV		69 kv fuse disconnect support structure	1	ea	$2,000	$500	$100	
33 75 39 13 8050	<26 kV Surge Arrestor	34.5 kv Surge Arrestor	3	ea	$4,575	$456	$143	
MIV		34.5 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 75 39 13 8070	69 kv Surge Arrestor	69 kv Surge Arrestors	3	ea	$15,900	$759	$239	
MIV		69 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 73 23 20 1070		6/9 MVA 69 - 34.5 kV Transformer	6	MVA	$114,600	$5,460	$1,710	
33 73 23 20 1070	add 10% for 138 kV	6/9 MVA 69 - 138 kV Transformer	0	MVA	$0	$0	$0	
26 12 19 10 0300	500 kva 15 kV pad mount	SST2 - Station Services Transformer	1	ea	$18,000	$2,650	$350	
MIV		69 kV Dead Ends	1	ea	$25,000	$7,500	$1,000	
MIV		138 kV Dead Ends	0	ea	$0	$0	$0	
MIV		ACSR	100	m	$800	$400	$400	
MIV		ACSR Connectors	50	ea	$3,000	$2,000	$500	
26 56 36 55 0120	Led Flood 90 watt	Outdoor Lighting	3	ea	$4,500	$321	$90	
MIV	Lighting Wiring	2c12 teck, in concrete wireway & up poles	80	m	$320	$160	$0	
MIV		Lightning crosswires	120	m	$240	$180	$240	
MIV		Lightning corner poles	4	ea	$3,000	$1,200	$800	
26 05 19 20 0400	Means price 3c#6 average cable cost	Field Control Wiring	900	m	$13,432	$4,074	$0	
MIV		Terminations Small	200	ea	$0	$600	$0	
MIV		Teck Connectors Small Average	100	ea	$1,000	$2,650	$0	
MIV		Protection Panel 1, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		TX1 - Jake's Corner TX Protection Relay	1	ea	$3,500			SEL-787
MIV		L1 - Atlin Upper Line Protection Relay	1	ea	$5,500			SEL-311L
MIV		Protection Panel 2, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		L2 - Utility Line Protection Relay	1	ea	$5,500			SEL-311L
MIV		SCADA, Teleprotection	1	lot	$7,000			SEL-3530, 2730M
MIV		Sat. Clock	1	ea	$2,000			SEL-2407
MIV		125 VDP Battery, Charger, PDP	1	ea	$8,000	$2,000	$80	
MIV		Commissioning	1	lot		$25,000	$7,000	
MH		Washed Rock	70	m^3	$4,200	$700	$700	
MIV		Survey	1	lot		$25,000		

11.7 ESTIMATE WORKSHEET - JAKE'S CORNER SUB OPTION 1b - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MIV		Foundations Small Screw Pile	18	ea	$11,250	$6,480	$4,320	
MH	5m x 5m x .4m	6/9 tx Foundation 34.5 kV	10.0	m^3	$25,000	$10,000	$5,000	
MH	5m x 5m x .4m	6/9 tx Foundation 138 kV	0.0	m^3	$0	$0	$0	
MH	4m x 8m x .333m	Building Foundation	8.0	m^3	$20,000	$8,000	$4,000	
MIV		3 x 5 building, heat,			$175,000	$30,000	$40,000	
MIV	.6m x .2m	Trench and backfill for sub grounding	450	m		$1,350	$1,350	
MIV	600 x 300 x 1000	Precast Concrete Trenchway with Lid (in sub)	75	m	$15,000	$7,500	$7,500	
MIV	.6m x .4m	Excavation for Trenchway	75	m		$450	$450	**TOTALS**
				SUBTOTAL	**$641,423**	**$293,968**	**$33,931**	**$969,322**
RSMeans Adjustment Factors for Inflation and Location on all RS Means Indexed Items								
2014 Escalation compounded / yr on RS Means amounts			1.25%		**$9,953.15**	**$3,975.64**	**$226.68**	**$14,155**
RSMeans Adjustment Factors for Whitehorse and CDN conversion		**Electrical 134.3 M / 69.8 L**			**$135,709.05**	**-$47,727.40**	**-$2,721.32**	**$85,260**
				SUBTOTAL	**$787,085**	**$250,216**	**$31,436**	**$1,068,738**
Division 01	**General Requirements @ 7%**				**$55,096**	**$17,515**	**$2,201**	**$74,812**
	General Contractor Overhead and Profit	**GC O & P 15%**			**$126,327**	**$40,160**	**$5,046**	**$171,532**
	Engineering	**Engineering @ 10%**			**$96,851**	**$30,789**	**$3,868**	**$131,508**
				SUBTOTAL	**$1,065,359**	**$338,680**	**$42,551**	**$1,446,590**
	GST	**GST @ 5%**			**$53,268**	**$16,934**	**$2,128**	**$72,329**
	PST	**PST @ 7%**			**$74,575**	**$23,708**	**$2,979**	**$101,261**
					GRAND TOTAL		**CDN$**	**$1,620,181**

Data Sources:
Where prefixed with a line number, data for material cost, labour cost and equipment cost is taken from 2014 RSMeans data
Where prefixed with MIV the data is estimated value from Magna IV Engineering internal sources and best practices
Where prefixed with MH the values are estimated values provided from Morrison Hershfiield
*Unadjusted anywhere usa" Rsmeans estimating values shown in green highlight cells only

11.8 ESTIMATE WORKSHEET - JAKE'S CORNER SUB OPTION 2a - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MH		Substation Fence 19 x 42 m	110	m	$4,950	$4,950	$1,100	100/m, 45, 45, 10/m M,L,E
MH		Substation Vehicle Gates 6m	12	m	$540	$540	$120	100/m, 45, 45, 10/m M,L,E
26 05 26 80 1000	4/0 wire and placement	Substation Grounding Grid 21 x 44 x	600	m	$9,053	$2,952	$0	
26 05 26 80 2760	4/0 to 4/0 exothermic	Connectors	72	ea	$576	$4,392	$0	
26 05 26 80 5195	40' with hole clay rod clamp	Ground Wells	0	ea	$0	$0	$0	
26 05 26 80 0130	15' 3/4" cc steel	Ground Rods Driven	20	ea	$1,270	$2,140	$0	
33 75 53 13 3250	HV Switches Disconnecting Circuit Switcher <161kV	69 kV circuit switchers	4	ea	$366,000	$55,200	$8,700	1 free issue at carcross*
MIV		Circuit Switcher Stand	4	ea	$20,000	$4,000	$1,200	1 free issue at carcross
33 75 53 13 3080	HV Switches Disconnecting Manual Operation 69kV	69 kv disconnect switches	5	ea	$126,500	$28,400	$5,550	2 free issue at carcross*
MIV		disconnect switch support / stand	5	ea	$10,000	$2,500	$500	2 free issue at carcross
33 75 13 13 2100	HV Circuit Breaker Air CB 13-26kV	34.5 kv circuit switcher	1	ea	$59,000	$40,400	$1,575	
MIV		Circuit Switcher Stand 34.5 kv	1	ea	$4,000	$800	$250	
33 75 53 13 3060	HV Switches Disconnecting Manual Operation <26kV	34.5 disconnect switch	3	ea	$40,800	$13,800	$1,620	* free issue materials at carcross do not include protection devices, station services, earthwork, grounding, fence, control building etc. All supplied as part of greater substation by others
MIV		69 kv current transformers set of 3 (high accura	2	ea	$44,000	$7,000	$1,000	
MIV		current transformer stand	2	ea	$4,000	$1,000	$200	
MIV		69 kv pt's set of 3	2	sets	$66,000	$7,000	$1,000	
MIV		pt transformer stand	2	ea	$4,000	$1,000	$200	
MIV		69 kv fuse disconnect outdoor	1	ea	$15,000	$1,500	$250	
MIV		69 kv fuse disconnect support structure	1	ea	$2,000	$500	$100	
33 75 39 13 8050	<26 kV Surge Arrestor	34.5 kv Surge Arrestor	3	ea	$4,575	$456	$143	
MIV		34.5 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 75 39 13 8070	69 kv Surge Arrestor	69 kv Surge Arrestors	3	ea	$15,900	$759	$239	
MIV		69 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 73 23 20 1070		6/9 MVA 69 - 34.5 kV Transformer	6	MVA	$114,600	$5,460	$1,710	
33 73 23 20 1070	add 10% for 138 kV	6/9 MVA 69 - 138 kV Transformer	6	MVA	$126,060	$6,006	$1,881	
26 12 19 10 0300	500 kva 15 kV pad mount	SST2 - Station Services Transformer	1	ea	$18,000	$2,650	$350	
MIV		69 kV Dead Ends	1	ea	$25,000	$7,500	$1,000	
MIV		138 kV Dead Ends	1	ea	$30,000	$8,500	$1,200	
MIV		ACSR	200	m	$1,600	$800	$800	
MIV		ACSR Connectors	100	ea	$6,000	$4,000	$1,000	
26 56 36 55 0120	Led Flood 90 watt	Outdoor Lighting	6	ea	$9,000	$642	$180	
MIV	Lighting Wiring	2c12 teck, in concrete wireway & up poles	150	m	$600	$300	$0	
MIV		Lightning crosswires	200	m	$400	$300	$400	
MIV		Lightning corner poles	4	ea	$3,000	$1,200	$800	
26 05 19 20 0400	Means price 3c#6 average cable cost	Field Control Wiring	1800	m	$26,863	$8,148	$0	
MIV		Terminations Small	360	ea	$0	$1,080	$0	
MIV		Teck Connectors Small Average	180	ea	$1,800	$4,770	$0	
MIV		Protection Panel 1, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		TX1 - Jake's Corner TX Protection Relay	1	ea	$5,500			SEL-387
MIV		L1 - Atlin Upper Line Protection Relay	1	ea	$5,500			SEL-311L
MIV		Protection Panel 2, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		TX2 - Carcross TX Protection Relay	1	ea	$5,500			SEL-387
MIV		L3 - Carcross Line Protection Relay	1	ea	$5,500			SEL-311L
MIV		Protection Panel 3, misc. devices	1	lot	$5,000	$15,000		panel, fab., wiring
MIV		L2 - Utility Line Protection Relay	1	ea	$5,500			SEL-311L
MIV		SCADA, Teleprotection	1	lot	$7,000			SEL-3530, 2730M
		Sat. Clock	1	ea	$2,000			SEL-2407
MIV		125 VDP Battery, Charger, PDP	1	ea	$10,000	$3,000	$100	

11.8 ESTIMATE WORKSHEET - JAKE'S CORNER SUB OPTION 2a - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MIV		Commissioning	1	lot		$40,000	$10,000	
MH		Washed Rock	120	m^3	$7,200	$1,200	$1,200	
MIV		Survey	1	lot		$30,000		
MIV		Foundations Small Screw Pile	26	ea	$16,250	$9,360	$6,240	
MH	5m x 5m x .4m	6/9 tx Foundation 34.5 kV	10.0	m^3	$25,000	$10,000	$5,000	
MH	5m x 5m x .4m	6/9 tx Foundation 138 kV	10.0	m^3	$25,000	$10,000	$5,000	
MH	4m x 8m x .333m	Building Foundation	10.7	m^3	$26,640	$10,656	$5,328	
MIV		3 x 6 building, heat,			$200,000	$40,000	$50,000	
MIV	.6m x .2m	Trench and backfill for sub grounding	630	m		$1,890	$1,890	
MIV	600 x 300 x 1000	Precast Concrete Trenchway with Lid (in sub)	100	m	$20,000	$10,000	$10,000	
MIV	.6m x .4m	Excavation for Trenchway	100	m		$600	$600	**TOTALS**
				SUBTOTAL	**$1,275,537**	**$371,005**	**$56,807**	**$1,703,349**
RSMeans Adjustment Factors for Inflation and Location on all RS Means Indexed Items								
2014 Escalation compounded / yr on RS Means amounts			1.25%		**$23,098.39**	**$4,311.89**	**$552.10**	**$27,962**
RSMeans Adjustment Factors for Whitehorse and CDN conversion		**Electrical 134.3 M / 69.8 L**			**$314,941.57**	**-$51,764.17**	**-$6,627.99**	**$256,549**
				SUBTOTAL	**$1,613,577**	**$323,552**	**$50,731**	**$1,987,860**
Division 01	**General Requirements @ 7%**				**$112,950**	**$22,649**	**$3,551**	**$139,150**
	General Contractor Overhead and Profit	**GC O & P 15%**			**$258,979**	**$51,930**	**$8,142**	**$319,052**
	Engineering	**Engineering @ 10%**			**$198,551**	**$39,813**	**$6,242**	**$244,606**
				SUBTOTAL	**$2,184,057**	**$437,944**	**$68,667**	**$2,690,668**
	GST	**GST @ 5%**			**$109,203**	**$21,897**	**$3,433**	**$134,533**
	PST	**PST @ 7%**			**$152,884**	**$30,656**	**$4,807**	**$188,347**
						GRAND TOTAL	**CDN$**	**$3,013,549**

Data Sources:
Where prefixed with a line number, data for material cost, labour cost and equipment cost is taken from 2014 RSMeans data
Where prefixed with MIV the data is estimated value from Magna IV Engineering internal sources and best practices
Where prefixed with MH the values are estimated values provided from Morrison Hershfiield
*Unadjusted anywhere usa" Rsmeans estimating values shown in green highlight cells only

11.9 ESTIMATE WORKSHEET - JAKE'S CORNER SUB OPTION 2b - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MH		Substation Fence 19 x 42 m	95	m	$4,275	$4,275	$950	100/m, 45, 45, 10/m M,L,E
MH		Substation Vehicle Gates 6m	6	m	$270	$270	$60	100/m, 45, 45, 10/m M,L,E
26 05 26 80 1000	4/0 wire and placement	Substation Grounding Grid 21 x 44 x	525	m	$7,921	$2,583	$0	
26 05 26 80 2760	4/0 to 4/0 exothermic	Connectors	65	ea	$520	$3,965	$0	
26 05 26 80 5195	40' with hole clay rod clamp	Ground Wells	0	ea	$0	$0	$0	
26 05 26 80 0130	15' 3/4" cc steel	Ground Rods Driven	18	ea	$1,143	$1,926	$0	
33 75 53 13 3250	HV Switches Disconnecting Circuit Switcher <161kV	69 kV circuit switchers	3	ea	$274,500	$55,200	$6,525	
MIV		Circuit Switcher Stand	3	ea	$15,000	$3,000	$900	
33 75 53 13 3080	HV Switches Disconnecting Manual Operation 69kV	69 kv disconnect switches	3	ea	$75,900	$28,400	$3,330	
MIV		disconnect switch support / stand	3	ea	$6,000	$1,500	$300	
33 75 13 13 2100	HV Circuit Breaker Air CB 13-26kV	34.5 kv circuit switcher	1	ea	$59,000	$40,400	$1,575	
MIV		Circuit Switcher Stand 34.5 kv	1	ea	$4,000	$800	$250	
33 75 53 13 3060	HV Switches Disconnecting Manual Operation <26kV	34.5 disconnect switch	3	ea	$40,800	$13,800	$1,620	
MIV		69 kv current transformers set of 3 (high accura	2	ea	$44,000	$7,000	$1,000	rev 2 - was 1
MIV		current transformer stand	2	ea	$4,000	$1,000	$200	rev 2 - was 1
MIV		69 kv pt's set of 3	1	sets	$33,000	$3,500	$500	
MIV		pt transformer stand	1	ea	$2,000	$500	$100	
MIV		69 kv fuse disconnect outdoor	1	ea	$15,000	$1,500	$250	
MIV		69 kv fuse disconnect support structure	1	ea	$2,000	$500	$100	
33 75 39 13 8050	<26 kV Surge Arrestor	34.5 kv Surge Arrestor	3	ea	$4,575	$456	$143	
MIV		34.5 kv Surge Arrestor Support	3	ea	$2,250	$900	$600	
33 75 39 13 8070	69 kv Surge Arrestor	69 kv Surge Arrestors	4	ea	$21,200	$1,012	$318	1 set free issue carcross
MIV		69 kv Surge Arrestor Support	4	ea	$3,000	$1,200	$800	
33 73 23 20 1070		6/9 MVA 69 - 34.5 kV Transformer	6	MVA	$114,600	$5,460	$1,710	
33 73 23 20 1070	add 10% for 138 kV	6/9 MVA 69 - 138 kV Transformer	6	MVA	$126,060	$660	$1,320	free issue to carcross sub
26 12 19 10 0300	500 kva 15 kV pad mount	SST2 - Station Services Transformer	1	ea	$18,000	$2,650	$350	
MIV		69 kV Dead Ends	3	ea	$75,000	$22,500	$3,000	1 free issue at carcross
MIV		138 kV Dead Ends	0	ea	$0	$0	$0	
MIV		ACSR	180	m	$1,440	$720	$720	
MIV		ACSR Connectors	90	ea	$5,400	$3,600	$900	
26 56 36 55 0120	Led Flood 90 watt	Outdoor Lighting	6	ea	$9,000	$642	$180	
MIV	Lighting Wiring	2c12 teck, in concrete wireway & up poles	150	m	$600	$300	$0	
MIV		Lightning crosswires	160	m	$320	$240	$320	
MIV		Lightning corner poles	4	ea	$3,000	$1,200	$800	
26 05 19 20 0400	Means price 3c#6 average cable cost	Field Control Wiring	1400	m	$20,894	$6,337	$0	
MIV		Terminations Small	300	ea	$0	$900	$0	
MIV		Teck Connectors Small Average	150	ea	$1,500	$3,975	$0	
MIV		Protection Panel 1, misc. devices	1	ea	$5,000	$15,000		panel, fab., wiring
MIV		TX1 - Jake's Corner TX Protection Relay	1	ea	$5,500	$5,500		SEL-387
MIV		L1 - Atlin Upper Line Protection Relay	1	ea	$5,500	$5,500		SEL-311L
MIV		L3 - Carcross Line Protection Relay	1	ea	$5,500	$5,500		SEL-311L
MIV		Protection Panel 2, misc. devices	1	ea	$5,000	$15,000		panel, fab., wiring
MIV		L2 - Utility Line Protection Relay	1	ea	$5,500	$5,500		SEL-311L
MIV		SCADA, Teleprotection	1	lot	$7,000	$7,000		SEL-3530, 2730M
		Sat. Clock	1	ea	$2,000	$2,000		SEL-2407
MIV		125 VDP Battery, Charger, PDP	1	ea	$10,000	$3,000	$100	
MIV		Commissioning	1	lot		$35,000	$8,000	
MH		Washed Rock	100	m^3	$6,000	$1,000	$1,000	

11.9 ESTIMATE WORKSHEET - JAKE'S CORNER SUB OPTION 2b - Stick Built

Data Source	RSMeans Description Jan 2014	MIV Description	Qty	Unit	Extended Material	Extended Labour	Equipment	Comments
MIV		Survey	1	lot		$35,000		
MIV		Foundations Small Screw Pile	26	ea	$16,250	$9,360	$6,240	
MH	5m x 5m x .4m	6/9 tx Foundation 34.5 kV	10.0	m^3	$25,000	$10,000	$5,000	
MH	5m x 5m x .4m	6/9 tx Foundation 138 kV	0.0	m^3	$0	$0	$0	none - carcross scope
MH	4m x 8m x .333m	Building Foundation	10.7	m^3	$26,640	$10,656	$5,328	
MIV		3 x 6 building, heat,			$200,000	$40,000	$50,000	
MIV	.6m x .2m	Trench and backfill for sub grounding	525	m		$1,575	$1,575	
MIV	600 x 300 x 1000	Precast Concrete Trenchway with Lid (in sub)	90	m	$18,000	$9,000	$9,000	
MIV	.6m x .4m	Excavation for Trenchway	90	m		$540	$540	**TOTALS**
	No protection devices, station services provided at carcross, must be supplied by larger substation installation. Same goes for fence, grounding, earthworks etc.	138 kV circuit switchers	2	ea	$219,600	$400	$1,000	free issue at carcross end
		Circuit Switcher Stand	2	ea	$12,000	$200	$100	unload equipment only
		138 kV disconnect switches	2		$55,660	$31,240	$2,442	free issue at carcross end
		138 kV disconnect stands	2		$4,400	$1,100	$220	unload equipment only
				SUBTOTAL	**$1,094,418**	**$377,231**	**$49,161**	**$1,520,809**
RSMeans Adjustment Factors for Inflation and Location on all RS Means Indexed Items								
2014 Escalation compounded / yr on RS Means amounts			1.25%		**$26,398.28**	**$4,908.76**	**$516.02**	**$31,823**
RSMeans Adjustment Factors for Whitehorse and CDN conversion		**Electrical 134.3 M / 69.8 L**			**$359,934.87**	**-$58,929.55**	**-$6,194.78**	**$294,811**
				SUBTOTAL	**$1,480,751**	**$323,210**	**$43,482**	**$1,847,443**
Division 01	**General Requirements @ 7%**				**$103,653**	**$22,625**	**$3,044**	**$129,321**
	General Contractor Overhead and Profit	**GC O & P 15%**			**$237,661**	**$51,875**	**$6,979**	**$296,515**
	Engineering	**Engineering @ 10%**			**$182,206**	**$39,771**	**$5,350**	**$227,328**
				SUBTOTAL	**$2,004,270**	**$437,481**	**$58,855**	**$2,500,606**
	GST	**GST @ 5%**			**$100,214**	**$21,874**	**$2,943**	**$125,030**
	PST	**PST @ 7%**			**$140,299**	**$30,624**	**$4,120**	**$175,042**
						GRAND TOTAL	**CDN$**	**$2,800,679**

Data Sources:
Where prefixed with a line number, data for material cost, labour cost and equipment cost is taken from 2014 RSMeans data
Where prefixed with MIV the data is estimated value from Magna IV Engineering internal sources and best practices
Where prefixed with MH the values are estimated values provided from Morrison Hershfiield
*Unadjusted anywhere usa" Rsmeans estimating values shown in green highlight cells only

APPENDIX G:
Cost Estimate

Table G.1 Atlin Hydro Expansion Cost Summary

Atlin Hydro Expansion Prefeasibility Study

Hydroelectric Generation Project Only

Item #	Items	Cost (2016$)	Notes
DIRECT COSTS			
1	Surprise Lake Control Structure Upgrade	$ 291,357	
2	Upper Powerplant Expansion	$ 22,328,547	
3	Lower Powerplant	$ 30,981,824	
	SUB-TOTAL DIRECT COSTS	$ 53,601,728	
ADDITIONAL OWNER COSTS			
	Prefeasibility Study	$ 226,700	Current study actual cost plus hydrology & regulatory scan.
	Feasibility Study	$ 825,725	Assume 1.5% of Direct Costs
	Final Design	$ 2,680,086	Assume 5% of Direct Costs
	Assessment & Licensing	$ 1,608,052	Assume 3% of Direct Costs
	Site Assistance & Quality Assurance	$ 2,680,086	
	Other Owner Costs	$ 2,144,069	Assume 4% of Direct Costs
	SUB-TOTAL COSTS	$ 63,766,447	
	Contingency (25%)	$ 15,941,612	
TOTAL HYDRO GENERATION PROJECT COSTS		**$ 79,708,059**	

Transmission Line

4	Transmission Line to Jakes Corner (inc. substations)	$ 22,699,000	69 kV from MH 2016
5	Jakes Corner Substation	$ 1,446,590	From MagnaIV 2016, including engineering
ADDITIONAL OWNER COSTS (Tranmssion line only)			
	Planning	$ 680,970	3%
	Property Aquisiton & Permitting	$ 1,588,930	7%
	Survey & Structure Staking	$ 453,980	2%
	Engineering	$ 1,815,920	8%
	Project Management	$ 1,588,930	7%
	Construction Management	$ 1,134,950	5%
	Other Owner Costs	$ 1,350,591	5.95%
	SUB-TOTAL COSTS	$ 32,759,861	
	Contingency (25%)	$ 8,189,965	
TOTAL TRANSMISSION LINE COSTS		**$ 40,949,826**	

TOTAL PROJECT COSTS (GENERATION + TRANSMISSION) **$ 120,700,000**

Table G.2 Surprise Lake Control Structure Upgrade Cost Details

Atlin Hydro Expansion Pre-feasibility Study

Item #	Items	Unit	Quantity	Unit Cost	Cost (2014$)	Notes
1. SITEWORK						
1.1	**Mobilization**	LS	1	$ 50,000	$ 50,000	
1.2	**Clearing**					
	Inlet channel	ha	0.2	$ 20,000	$ 3,800	
	Re-vegetation	LS	1	$ 2,000	$ 2,000	Assuming re-seeding only.
1.3	**Diversion & dewatering**	LS	0	$ 65,000	$ -	Dewatering intake for replacement of gates.
1.4	**Remove & replace fencing, log boo**	LS	1	$ 8,000	$ 8,000	
1.5	**Misc. traffic control, etc.**	LS	1	$ 15,000	$ 15,000	
2. STRUCTURES & EXCAVATION						
2.1	**Inlet channel excavation**					
	Excavation	m^3	2600	$ 18	$ 47,320	Assume ~7m wide x 190m long x aver 2m depth excavation
	Supply & place cobble/riprap	m^3	270	$ 113	$ 30,375	Assume 0.2m thick layer
2.2	**Intake upgrade**				$ -	
	Raise intake platform	LS	1	$ 10,000	$ 10,000	Allowance raising walkway, fencing, etc.
2.3	**Weir upgrade**				$ -	
	Extend sheet pile weir	m^2	45	$ 295	$ 13,220	Assume 1.4m extension by 32m long
	Supply & place rip rap	m^3	364	$ 113	$ 40,929	0.7 m thick Class 1 over 500m2 plus 16m2 Class 2 at bridge abutments
6. ENVIRONMENTAL & MITIGATION ITEMS						
6.1	**Other**	LS	1	$ 15,000	$ 15,000	Environmental measures, during works
6.2	**Upgrade of Fishway**	LS	1	$ 50,000	$ 50,000	Add additional basins & modifications to openings

TOTAL COSTS **$ 285,644.22**

Note all rates are blended with idirects and OH& Profit

Table G.3 Upper Power Plant Expansion Cost Details
Atlin Hydro Expansion Pre-feasibility Study

Item #	Items	Unit	Quantity	Unit Cost	Cost (2015$)	Notes
1. SITEWORK						
1.1	**Mobilization**	LS	0.5	$ 400,000	$ 200,000	Mob for lower power plant project - cost split with upper plant
1.2	**Clearing**					
	Penstock	ha	0.45	$ 18,000.00	$ 8,100	Assumed expanded clearing down the hill to powerhouse expansion - 300m x 15m
	Powerhouse & tailrace	ha	0.375	$ 18,000.00	$ 6,750	Assumed hillside clearing 50m x 75m
	Contractor laydown area	ha	0	$ 18,000.00	$ -	Assumed existing areas will be used and no new laydowns required
1.3	**Access Road**					
	Powerhouse	m	100	$ 50.00	$ 5,000	Additional road around powerhouse
1.4	**Dewatering**					
	Head pond	months	2	$ 20,000.00	$ 40,000	
	Powerhouse	months	0	$ 20,000.00	$ -	Assume no dewatering needed for powerhouse
1.5	**Foundation Preparation**					
	Intake	sq metre	22	$ 32.00	$ 704	2.1x5m for intake box + 6m of wing-walls
	Powerhouse	sq metre	364	$ 32.00	$ 11,648	footprint of 26m x 14m powerhouse
2. STRUCTURES & EXCAVATION						
2.1	**Intake**					
	General excavation	cubic metre	450	$ 11.25	$ 5,063	re-excavation of diversion channel (6m wide, 15m long, 5 m deep)
	Rock excavation	cubic metre	0	$ 100.00	$ -	assume no rock excavation due to previous diversion ex.
	Retaining wall - sheet pile	m2	30	$ 295.10	$ 8,853	sheet pile between intake boxes
	Retaining wall - concrete	cubic metre	25	$ 2,500.00	$ 62,500	Assume 10m of wing wall
	General backfill	cubic metre	450	$ 37.50	$ 16,875	
	Intake structure & trash racks	LS	1	$ 113,750.00	$ 113,750	
	Gates	ea	1	$ 36,250.00	$ 36,250	
2.2	**Penstock**					
	General excavation	cubic metre	37821	$ 11.25	$ 425,484	Assume general excavation from 0+00 to 3+698
	Rock excavation	cubic metre	6600	$ 100.00	$ 660,000	Assume 330 m requires rock excavation - 4x5m
	Supply & Install 1.5 m Φ DR41 HDPE penstock	m	1828	$ 1,239.00	$ 2,264,892	
	Supply & Install 1.5 m Φ DR32.5 HDPE penstock	m	256	$ 1,414.00	$ 361,984	
	Supply & Install 1.5 m Φ DR26 HDPE penstock	m	713	$ 1,619.80	$ 1,154,917	
	Supply & Install 1.5 m Φ DR21 HDPE penstock	m	768	$ 1,863.40	$ 1,431,091	
	Supply & Install 1.5 m Φ steel penstock	m	438	$ 2,300.00	$ 1,007,400	based on current all in pricing from New Post Creek minimum handling thickness
	Granular fill	cubic metre	33523	$ 81.25	$ 2,723,728	
	Random backfill	cubic metre	11109	$ 37.50	$ 416,599	Based on typical cross section providing 0.7m of cover over granular fill.
	Bifurcation	LS	1	$ 40,000.00	$ 40,000	
2.3	**Powerhouse**					
	General excavation	cubic metre	11600	$ 11.25	$ 130,500	clearing for PH and new parking and lay down area to 726 with 2:1 slopes up hill. Neat line for depth of powerhouse
	Reinforced concrete	cubic metre	800	$ 2,500.00	$ 2,000,000	
	Superstructure and architectural finishes	LS	1	$ 410,000.00	$ 410,000	
	Draft tube gates/mechanical	LS	1	$ 100,000.00	$ 100,000	
	Crane supply & install	LS	1	$ 50,000.00	$ 50,000	extension of crane rails from existing building into new
	Miscellaneous embedded and non-embedded items	LS	1	$ 400,000.00	$ 400,000	Assumes existing crane and control room will be used
2.4	**Tailrace**					
	General excavation	cubic metre	1300	$ 11.25	$ 14,625	expand tailrace to 6 m base width, at Elv 723 (1 to 1.5 m depth of flow), expand over plan area shown on drawing to encompass both PH tailraces, less existing 3m wide 1.5:1 tailrace.
	Riprap - supply & place	cubic metre	440	$ 112.50	$ 49,500	assumed new riprap over extents of area 0.4m deep
3. TURBINE - GENERATOR UNIT						
3.1	**Turbine**	ea	2	$ 357,000.00	$ 714,000	
3.2	**Generator**	ea	2	$ 273,000.00	$ 546,000	
3.3	**Turbine Inlet Valve (TIV)**	ea	2	$ 105,000.00	$ 210,000	
3.4	**Auxiliary Systems**	LS	1	$ 210,000.00	$ 210,000	
3.5	**Project Service & Install**	LS	1	$ 2,145,000.00	$ 2,145,000	includes all installation, i.e. electrical, controls, mechanical, hydraulic, and commissioning costs
4. ELECTRICAL & MECHANICAL BALANCE OF PLANT						
4.1	**Mechanical Balance of Plant**	LS	1	$ 130,000.00	$ 130,000	
4.2	**Electrical Balance of Plant**	LS	1	$ 250,000.00	$ 250,000	
4.3	**Switchyard (Supply)**	LS	1	$ 3,529,520.10	$ 3,529,520	From MagnaIV 2016 (not including engineering), inflation adjusted to 2015.
6. ENVIRONMENTAL & MITIGATION ITEMS						
6.1	**Other**	LS	0		$ -	

TOTAL DIRECT COSTS $ 21,890,732

Note all rates are blended with idirects and OH& Profit

Table E.4 Lower Power Plant Cost Details
Atlin Hydro Expansion Pre-feasibility Study

Item #	Items	Unit	Quantity	Unit Cost	Cost (2015$)	Notes
1. SITEWORK						
1.1	**Mobilization**	LS	0.5	$ 400,000	$ 200,000	Mob for lower power plant project - cost split with upper plant
1.2	**Clearing**				$ -	
	Head pond	ha	0.5	$ 20,000	$ 10,800	Triangular area 105m x 90m + 30x45m triangle on N side of creek - scaled off drawing S
	Spruce Creek Diversion	ha	0.3	$ 20,000	$ 6,000	Assumed 100m long x 30m wide
	Penstock & surge pipe	ha	10.8	$ 20,000	$ 216,650	4.0km x 25m wide + 340m x 25m for surge pipe
	Powerhouse & tailrace	ha	1.1	$ 20,000	$ 21,100	4700 m2 for powerhouse plus 130m long tailrace @ 45m wide clearing
	Contractor laydown area	ha	0	$ 20,000	$ -	Assumed existing areas will be used and no new laydowns required
	Stumpage Fee	LS	1	$ 8,100	$ 8,100	Assumed to be the same as 2009 project
1.3	**Access Road**					
	Penstock	m	4000	$ 100.00	$ 400,000	access/service road paralleling penstock
	Powerhouse	m	175	$ 100.00	$ 17,500	75m to powerhouse + 100m to surge bldg.
1.4	**Dewatering**					
	Head pond	months	3	$ 15,000.00	$ 45,000	
	Powerhouse	months	17	$ 15,000.00	$ 255,000	Dewatering will be required over the length of construction
1.5	**Foundation Preparation**					
	Intake	sq metre	58	$ 32.00	$ 1,856	KGS to provide - assume 5x5m for intake box + 33m of wing-walls
	Powerhouse	sq metre	336	$ 32.00	$ 10,752	KGS to provide - assumed footprint of 28m x 12m powerhouse
2. STRUCTURES & EXCAVATION						
2.1	**Head pond**					
	Pine Creek temporary diversion	cubic metre	2160	$ 11.25	$ 24,300	Assumes 120 m long x 2m deep by 5m base width
	Cobbles for temporary diversion	cubic metre	324	$ 112.50	$ 36,450	Assume 0.3m thick cobbles
	Access over temporary diversion	LS	1	$ 50,000.00	$ 50,000	Assumes culverts/temporary bridge or temporary relocation of existing bridge
	Head pond Excavation	cubic metre	14859	$ 11.25	$ 167,158	pond volume from Civil3D + 2600m3 subcut for 0.7m thick riprap
	Stilling basin	cubic metre	683	$ 11.25	$ 7,678	inc. subcut for riprap - 15m x 35m x 1.3m deep
	Embankment sub-cut	cubic metre	2700	$ 11.25	$ 30,375	Assume 90m long x 30m wide by 1 m subcut.
	Rock fill embankment	cubic metre	4600	$ 112.50	$ 517,500	1900 m3 from Civil 3D plus 1 m subcut volume of 2700
	Sheet pile cutoff wall	sq metre	1288	$ 295.10	$ 380,089	92m long x 14m deep
	Riprap - supply & place	cubic metre	1859	$ 112.50	$ 209,081	0.7m thick on back slope of pond. Dam/weir riprap included in above
	Intake structure	LS	1	$ 113,636.36	$ 113,636	Includes concrete
	Trash racks	LS	1	$ 70,000.00	$ 70,000	Supply & install, double wide
	Gates	ea	2	$ 42,000.00	$ 84,000	for 2 gates
	Fishway	LS	1	$ 95,450.00	$ 95,450	Escalated cost from Surprise Lake fishway
2.2	**Spruce Creek Diversion**				$ -	
	Diversion ditch excavation	cubic metre	2400	$ 11.25	$ 27,000	Assume 4m wide, ave. depth 3m @80 long
	Diversion rock fill weir	cubic metre	190	$ 112.50	$ 21,375	Assume 20m long x 5m wide crest c/w 0.5 m subcut.
	Culvert - supply & install	LS	1	$ 80,500.00	$ 80,500	Assuming 1.5m CSP c/w 2 sets of headwalls.
	Riprap - supply & place	cubic metre	307.2	$ 112.50	$ 34,560	1000m2 x 0.3m thick class 1 riprap
2.3	**Penstock (inc. surge pipe)**					Penstock typ. section should be optimized to reduce volumes.
	General excavation	cubic metre	45679	$ 11.25	$ 513,883	4.4km minus rock segments below
	Rock excavation	cubic metre	3947	$ 100.00	$ 394,740	Assumed rock ex. from 0+800 to 1+075, 2+500 to 2+725 & 310 for surge pipe: total 810m
	Supply & Install 2 m Φ penstock steel	m	1000	$ 3,040.00	$ 3,040,000	
	Supply & Install 2x 1.6m Φ penstock DR41 HDPE	m	3025	$ 2,478.00	$ 7,495,950	
	Supply & Install 2x 1.6m Φ penstock DR26 HDPE	m	375	$ 3,240.00	$ 1,215,000	
	Granular fill	cubic metre	30674	$ 81.25	$ 2,492,279	
	Random backfill	cubic metre	35158	$ 37.50	$ 1,318,440	Based on typical cross section providing 0.7m of cover over granular fill.
	Bifurcation	LS	1	$ 50,000.00	$ 50,000	
	Surge facility (vents and instrumentation)	LS	1	$ 300,000.00	$ 300,000	surge section only, vent structure and instrumentation building
2.4	**Powerhouse**					
	General excavation	cubic metre	19700	$ 11.25	$ 221,600	includes tailrace and road excavation out along penstock route, 3:1 slopes
	Rock excavation	cubic metre	1000	$ 100.00	$ 100,000	assumes rock below 270.25 in PH footprint only
	Reinforced concrete	cubic metre	450	$ 2,500.00	$ 1,125,000	
	Superstructure and architectural finishes	LS	1	$ 465,000.00	$ 465,000	
	Draft tube gates/mechanical	LS	1	$ 100,000.00	$ 100,000	set of stop logs, guides, small hoist
	Crane supply & install	LS	1	$ 350,000.00	$ 350,000	
	Miscellaneous embedded and non-embedded items	LS	1	$ 400,000.00	$ 400,000	
2.5	**Tailrace**					
	General excavation	cubic metre	6000	$ 11.25	$ 67,500	Based on 140 m long tailrace, 5.4 m deep, 8 m wide at base w/ 2.5H:1V slopes
	Riprap - supply & place	cubic metre	1264	$ 112.50	$ 142,200	Class 1 riprap 0.4m thick
3. TURBINE - GENERATOR UNIT						
3.1	**Turbine**	ea	1	$ 1,143,528.10	$ 1,143,528	
3.2	**Generator**	ea	1	$ 1,567,600.00	$ 1,567,600	
3.3	**Turbine Inlet Valve (TIV)**	ea	1	$ 361,753.92	$ 361,754	
3.4	**Auxiliary Systems**	LS	1	$ 482,338.60	$ 482,339	
3.5	**Project Service & Install**	LS	1	$ 1,430,000.00	$ 1,430,000	
4. ELECTRICAL & MECHANICAL BALANCE OF PLANT						
4.1	**Mechanical Balance of Plant**	LS	1	$ 260,000.00	$ 260,000	
4.2	**Electrical Balance of Plant**	LS	1	$ 250,000.00	$ 250,000	
4.3	**Switchyard and Interconnection**	LS	1	$ 929,575.00	$ 929,575	From MagnaIV 2016 (not including engineering) , inflation adjusted to 2015.
5. TRANSMISSION LINE						
5.1	**Clearing**	ha	0	$ 20,000.00	$ -	Clearing assumed to be included in lower penstock ROW
5.2	**Transmission Line**	km	4	$ 209,009.80	$ 836,039	69 kV from MH 2016 estimate, inflation adjusted to 2015.
6. ENVIRONMENTAL & MITIGATION ITEMS						
6.1	**Footbridge over tailrace**	LS	1	$ 30,000.00	$ 30,000	Assumed wooden, locally built by ATELP
6.2	**Other**	LS	1	$ 100,000.00	$ 100,000	Environmental monitoring
6.3	**Tree Planting and Landscaping**	LS	1	$ 50,000.00	$ 50,000	Cosmetic fixes near residential areas and campground to accelerate reclaimation of cleared areas

TOTAL DIRECT COSTS **$ 30,374,337**

Note all rates are blended with idirects and OH& Profit