Appendix 5.16
Pumped Storage Assessment
(Knight Piesold 2016)

YUKON ENERGY CORPORATION
PUMPED-STORAGE ASSESSMENT



PRELIMINARY ASSESSMENT

PREPARED FOR:

Yukon Energy Corporation
#2 Miles Canyon Road Box 5920
Whitehorse, Yukon
Y1A 6S7

PREPARED BY:

Knight Piésold Ltd.
Suite 1400 – 750 West Pender Street
Vancouver, BC V6C 2T8 Canada
p. +1.604.685.0543 • f. +1.604.685.0147

Knight Piésold
CONSULTING
www.knightpiesold.com

VA103-556/2-1
Rev 1
September 30, 2016

FS 64925
EMS 550121
OHS 550122

YUKON ENERGY CORPORATION
PUMPED-STORAGE ASSESSMENT

PRELIMINARY ASSESSMENT
VA103-556/2-1

Rev	Description	Date
0	Issued in Final	June 30, 2016
1	Issued with Revisions	September 30, 2016

Knight Piésold Ltd.
Suite 1400
750 West Pender Street
Vancouver, British Columbia Canada V6C 2T8
Telephone: (604) 685-0543
Facsimile: (604) 685-0147
www.knightpiesold.com

EXECUTIVE SUMMARY

Knight Piésold (KP) has undertaken an assessment of pumped storage hydroelectric potential for Yukon Energy Corporation (YEC). The study focussed on identifying viable pumped storage facilities within a 25 km radius of existing and proposed transmission infrastructure (excluding sites located in existing parks and protected areas). The pumped-storage sites are intended to provide seasonal pumping from May through to September, along with seasonal generation from October through to April. The intention of this assessment is to determine the Levelized Cost of Energy (LCOE) and Levelized Cost of Capacity (LCOC) for pumped-storage hydro and compare these values with other potential fossil fuel and renewable generation options that may be available to YEC. The current study identified sites with the following technical constraints:

- 15 MW Capacity and 50 GWh energy storage
- 15 MW capacity and up to 100 GWh energy storage
- 25 MW capacity and 50 GWh energy storage, and
- 25 MW capacity and up to 100 GWh energy storage.

An initial screening assessment was undertaken using KP's in-house GIS and spreadsheet screening tools. This process identified 473 potential reservoir basins in the study area, and approximately 200 sites that were found to be technical viable pumped-storage sites. By ranking these sites by inferred construction cost, the top five (preferred) sites were identified for each of the 50 GWh and 100 GWh energy storage configurations. This resulted in a list of seven sites that were selected for further evaluation. These sites are as follows:

- Tutshi-Moon, near Tutshi Lake, BC
- Atlin-Black Mountain, near Atlin, BC
- Racine-Moon, near Racine Lake, BC
- Racine-Mt. Brown, near Racine Lake, BC
- Lindeman-Fraser, near Fraser, BC
- Squanga-Dalayee, between Johnson's Crossing and Jake's Corner, YT, and
- Canyon-Ittlemit, near Canyon Lake and the Aishihik Hydro Facility, YT.

Further analysis was undertaken to prepare AACE Class 5 cost estimates for the preferred sites, as well as a preliminary financial model for the proposed projects. Using YEC's assumed (real) cost of capital of 3.38%, the following results were obtained:

- 15 MW capacity and 50GWh storage configuration has a minimum $0.28/kWh LCOE and $900/kW-yr LCOC for the Tutshi-Moon facility
- 15 MW capacity and 100GWh storage configuration has a minimum $0.19/kWh LCOE and $1,300/kW-yr LCOC for the Tutshi-Moon facility
- 25 MW capacity and 50GWh storage configuration has a minimum $0.32/kWh LCOE and $650/kW-yr LCOC for the Tutshi-Moon facility, and
- 25 MW capacity and 100GWh storage configuration has a minimum $0.21/kWh LCOE and $840/kW-yr LCOC for the Tutshi-Moon facility.

In all cases, the Tutshi-Moon pumped-storage project was evaluated as the most cost-effective. The Atlin-Black Mt. and Racine-Mt. Brown facilities also have competitive cost profiles. The Racine-Moon and Lindeman-Fraser have technical constraints that make them less promising. The Squanga-Dalayee and Canyon-Ittlemit facilities are less cost effective, but have the advantage of being relatively closer to existing YEC infrastructure. It is not known at this stage whether a viable project configuration can be found for the Canyon-Ittlemit facility that does not negatively impact the existing Aishihik hydro facility, but this should be investigated in future project stages.

The lowest LCOE ($0.19/kWh) is achieved with the 15 MW/100 GWh configuration. Conversely, the lowest LCOC ($650/kW-yr) is achieved with the 25 MW/50 GWh configuration, suggesting that there is a trade-off between cost of stored energy and capacity for pumped-storage facilities. Reducing energy storage further may provide a lower cost of capacity and would be more in line with the development trend in pumped-storage facilities worldwide (short duration storage of hours to days).

If further assessment of the pumped-storage projects is warranted by YEC, KP recommend the following next steps prior to proceeding with prefeasibility and feasibility studies:

1. Preliminary site visits to the following projects to evaluate technical viability further:
    - Tutshi-Moon
    - Atlin-Black Mt.
    - Racine-Mt. Brown
    - Squanga-Dalayee, and
    - Canyon-Ittlemit.
2. Acquisition of more detailed topographic data (such as PhotoSat) to provide better estimates of dam construction costs and reservoir storage potential.
3. Screening assessment of social and environmental permitting constraints.

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1 – INTRODUCTION

1.1 BACKGROUND

Knight Piésold (KP) have undertaken this study in response to a Request for Proposals (RFP) from Yukon Energy to identify potential pumped-storage sites within a 25 km radius of existing and proposed (transmission) infrastructure. The pumped-storage sites are intended to provide seasonal pumping from May through to September, along with seasonal generation from October through to April. The intention of this assessment is to compare the cost of energy and installed capacity with other potential fossil fuel and renewable options that may be available to YEC, including conventional small hydro <20 MW, wind, diesel and natural gas-fired generation. In order to achieve this aim, the current study identified sites with the following technical constraints:

- 15 MW Capacity and 50 GWh energy storage
- 15 MW capacity and up to 100 GWh energy storage
- 25 MW capacity and 50 GWh energy storage, and
- 25 MW capacity and up to 100 GWh energy storage.

Where consideration of other combinations of installed capacity and energy storage may be beneficial, explanation has been included in this report.

1.2 PREVIOUS STUDIES

From the information provided to KP by YEC for the Pumped-Storage and Small Hydro screening assessments, the only document relating specifically to pumped-storage was the 2015 report into the proposed Moon Lake Pumped-Storage Project completed by Midgard Consultants. The report assessed the viability of the project under three possible scenarios:

1. Conventional storage with generation from November to May and a capacity of 7.5 MW.
2. Pumped-storage with a total of 48 GWh of energy storage and a capacity of 20 MW.
3. Pumped-storage with a total of 70 GWh of energy storage and a capacity of 26 MW.

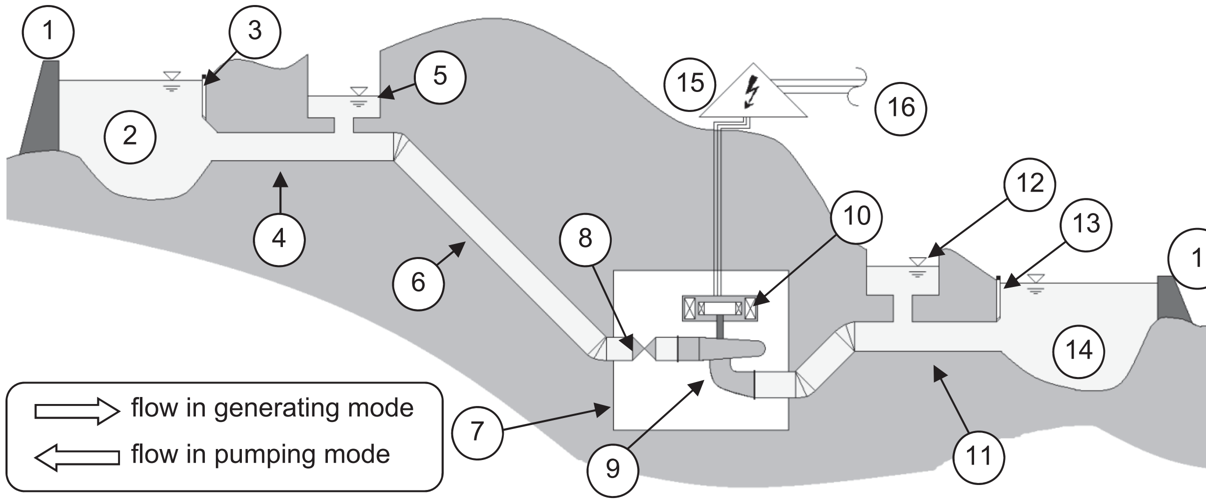
The study found that the facility is limited by the available pumping energy, with more storage capacity than could be pumped during the summer months. The estimated capital costs for these projects ranged from approximately $155 million for the 7.5 MW conventional storage project to $262 million for the 70 GWh pumped-storage project. The estimated levelized cost of energy was estimated at $0.21/kWh for 48 GWh of annual generation (90% capacity factor).

This study aims to provide a comprehensive screening assessment of pumped-storage potential in the Yukon Territory that will, among other things, determine whether there are other pumped-storage sites that might be equally or more attractive than the Moon Lake site.

1.3 OVERVIEW OF PUMPED-STORAGE

Pumped storage differs from conventional hydroelectric systems in that they operate not as a source of energy, but as a form of energy storage and reliable capacity. The conceptual arrangement of a pumped-storage facility is shown on Figure 1.1. Typical applications have included providing peak capacity in systems with a high portion of conventional thermal generating units such as coal and nuclear facilities, which are less amenable to rapid response to match load fluctuations. Increasingly in recent years pumped-storage facilities have been developed and deployed with a view to managing the integration of intermittent renewable energy such as wind and solar. There is growing worldwide interest in the use of pumped storage to provide reliability for small, isolated grids with at least three of the Hawaiian islands in various stages of developing pumped storage. YEC are considering an alternative arrangement that is intended to shift excess hydroelectric energy available in the summer runoff and shift it to the winter to match the load. Typically, pumped storage facilities provide energy storage durations in the order of hours to days, KP is not aware of any precedents for development of pumped-storage facilities to provide long-term (seasonal) energy storage as is being proposed by YEC for the current report.

Technology for pumped-storage facilities varies depends on the site-specific conditions for a given facility. The use of reversible pump-turbines coupled with synchronous motor-generators is the most common arrangement. The units are optimised for the best round-trip efficiency, so are slightly less efficient than an equivalent conventional Francis turbine. The pumping mode is less efficient than the generating mode, and when coupled with the head losses in the water conveyance system typically result in a round-trip efficiency in the order of 70 to 80% (depending on penstock losses). The round-trip efficiency indicates the portion of pumping energy input to a pumped-storage system that can then be delivered back to the grid in generation mode, with pumped-storage facilities being overall net users of energy. Pumped-storage compares quite well with other grid-scale storage technologies, being both more efficient and more cost-effective on both a per MW capacity and per MWh stored energy basis. While pumped-storage has traditionally been used to shift a block of energy from off-peak to peak load hours, the emerging trend is for more rapid response, particularly using variable-speed units, which make a facility able to provide grid stability, frequency control, voltage regulation, spinning reserve and other grid support ancillary services.



1 Dam
2 Upper Reservoir
3 Intake (generating mode)
4 Head-race
5 Head-race surge chamber
6 Penstock
7 Powerhouse
8 Turbine inlet valve
9 Pump-turbine
10 Motor-generator
11 Tail-race
12 Tail-race surge chamber
13 Intake (pumping mode)
14 Lower reservoir
15 Substation
16 Electrical grid

Figure 1.1 Typical Components of a Pumped-Storage Hydropower System

1.4 YUKON'S ELECTRICITY SYSTEM

1.4.1 Current Capacity

YEC currently owns and operates approximately 131 MW of installed capacity, consisting of 92 MW of hydro, 0.8 MW of wind, and 37.8 MW of thermal (diesel and natural gas). Yukon Electrical Company Ltd. (YECL), owned by ATCO, supplies approximately 1.3 MW of hydroelectricity and 6.8 MW of diesel power.

YEC's hydroelectric generating capacity is comprised of:

- 37 MW Aishihik Generating Station, 150 km west of Whitehorse
- 15 MW Mayo Generating Station, 450 km north of Whitehorse
- 40 MW Whitehorse Generating Station, located on the Yukon River at Whitehorse, and
- 1.3 MW Fish Lake Generating Station (YECL).

1.4.2 Power Grid

The Yukon power grid is shown on Figure 1.2 and comprises the following major components:

- 138 kV Whitehorse / Aishihik / Faro (WAF) grid
- 69 kV Mayo / Dawson transmission line, and
- 138 kV Carmacks / Stewart transmission line, connecting the WAF grid and the Mayo / Dawson transmission line.

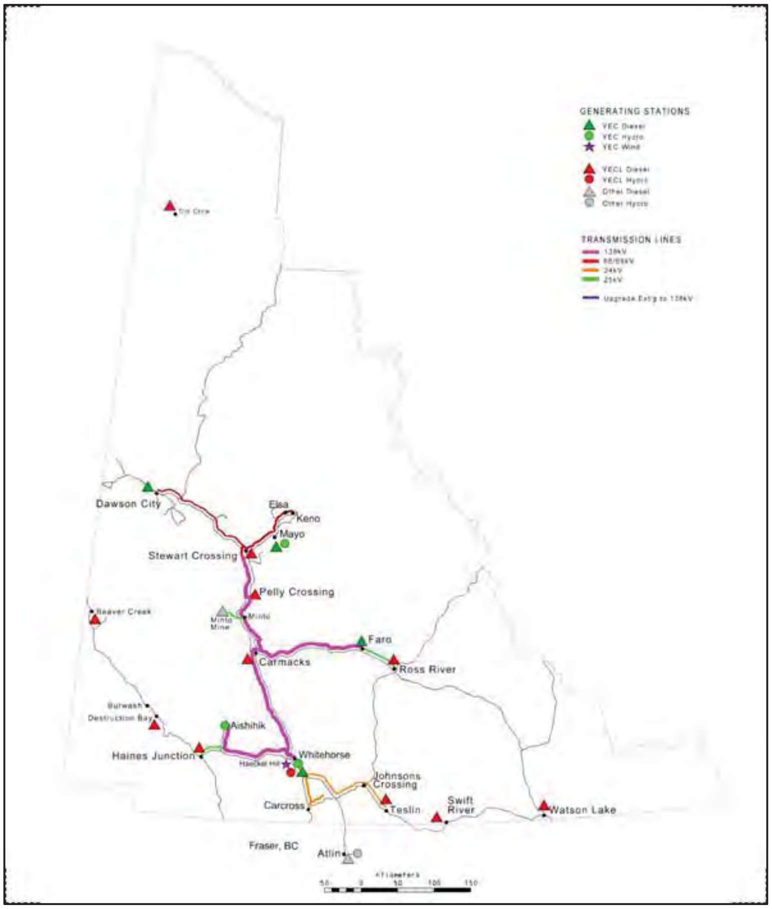


Figure 1.2 Yukon Electricity Network

The Yukon electricity network is an isolated grid, with no connection to other jurisdictions (BC, Alaska, Alberta or Northwest Territory). The Yukon grid currently services all Yukon communities except for Watson Lake, Burwash Landing/Destruction Bay, Beaver Creek, and Old Crow [YDC, 2015].

1.4.3 Proposed Transmission Lines

The following major transmission line extensions have been considered by YEC:

- Aishihik to Destruction Bay
- Skagway to Whitehorse
- Atlin to Whitehorse
- Teslin to Whitehorse, and
- Faro to Watson Lake.

2 – PRELIMINARY SCREENING

2.1 SCREENING METHODOLOGY

2.1.1 Spatial Limitations

The pumped-storage screening assessment for the Yukon was limited to a 25 km buffer from existing and planned transmission lines in the Territory. Within that area, terrestrial parks were excluded, but First Nations settlement land were included. Fish bearing habitat was not specifically excluded, but would be assessed for permitting viability in more detailed assessment phases for any identified projects. A map showing the study area is shown on Figure 2.1.

2.1.2 Generation and Storage Capacity

This study evaluates potential pumped-storage facilities that are able to provide energy generation through the winter months of October through April. This requires pumping through the summer from May through to September in order to provide the stored energy in the upper reservoir ready for the winter months. The pumping in the summer months can be supplemented through runoff through the freshet and summer, thereby reducing the total pumping energy required. Runoff was not included in the assessment at the preliminary screening stage, but was included in the assessment of the 'preferred sites'. The screening study assessed the following four combinations of power generation and energy storage capacity:

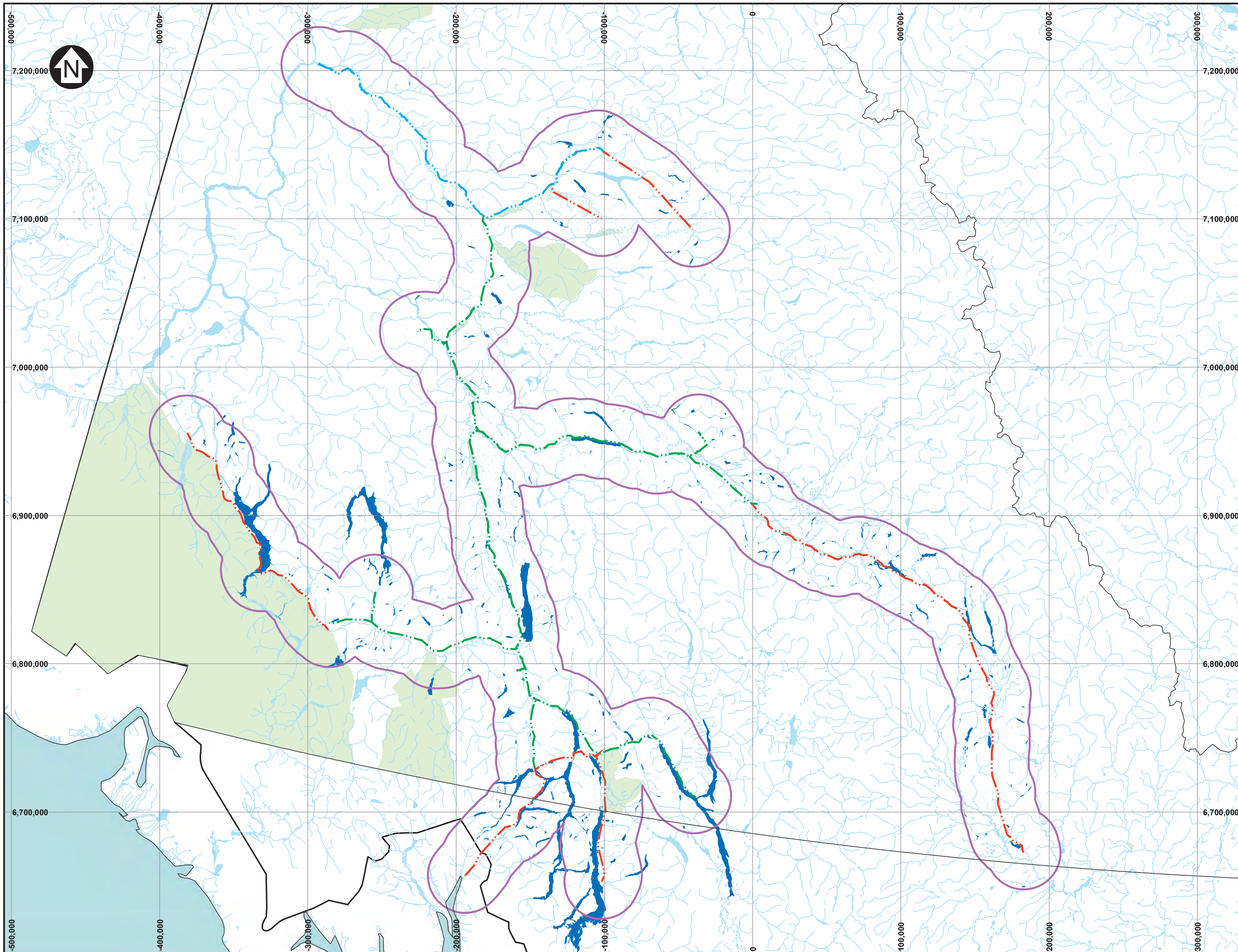
- 15 MW capacity and 50 GWh energy
- 15 MW capacity and 100 GWh energy
- 25 MW capacity and 50 GWh energy, and
- 25 MW capacity and 100 GWh energy.

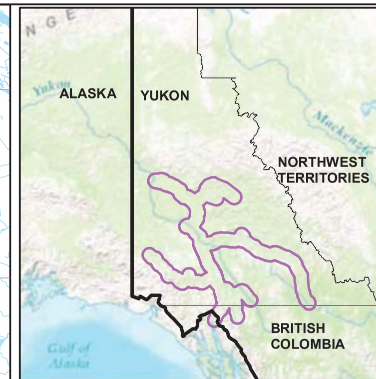
In contrast to typical pumped-storage facilities, the proposed sites in the Yukon are intended for seasonal storage, whereas most applications for pumped-storage are for daily peaking operations. This will increase their overall cost, due to the increased dam size required to provide adequate water storage volume in the upper and lower reservoirs. Daily peaking facilities (with 8-10 hours of storage or less) are the most common configuration for pumped-storage facilities, and KP's prior experience shows reductions in levelized cost of capacity for facilities with shorter storage durations.

2.1.3 Identifying Potential Reservoirs

Construction of a pumped-storage facility requires use of two reservoirs at different elevations which can alternately store and discharge water as the facility moves from pumping to generating modes and vice-versa. Identifying suitable storage basins was one of the more complex portions of this study; there are potentially thousands of locations where water could be stored in such a large geographic area that was covered in this assessment.

All existing lakes within the study area greater than 50 ha in area were included as potential storage basins in the assessment. Potential dam construction locations on existing lakes were sited at the outlet of the lake. In addition, artificial reservoir locations were identified by manually assessing the study area using Google Earth to identify potential storage basins.





LEGEND:

GENERAL
- RIVER
- LAKE
- OCEAN
- STUDY AREA
- RESERVOIR

TRANSMISSION LINE
- 69 KV
- EXISTING
- PROPOSED

NOTES:

1. BASE MAP: NATIONAL TOPOGRAPHIC DATABASE.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:2,596,368 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

20 10 0 20 40 60 80 100 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL - POTENTIAL STORAGE RESERVOIR BASINS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1

FIGURE 2.1 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	MGP	KK	KLA

SAVED: M:\1\03\00556\02\A\GIS\Figs\1- Pumped Storage\Rev0\Fig2-1_PumpedStorage_Reservoirs_r0.mxd; Jun 24, 2016 10:09 AM; kkrauszova

Using the combination of the existing natural lakes and the artificial reservoirs, the storage potential of the reservoir basin for an approximately 30 m dam height was determined from the following:

$$S = A_L \times D + \frac{(A_R - A_L) \times D}{3}$$

Where:

$$S = A_L \times D + \frac{(A_R - A_L) \times D}{3}$$

$$A_L = Area\ of\ existing\ (natural)\ lake\ (zero\ for\ artificial\ reservoirs)$$

$$A_R = Area\ of\ reservoir\ formed\ with\ a\ 40\ m\ high\ dam$$

$$D = Dam\ height\ (30\ m)$$

The above equation assumes a prismatic shape to the reservoir storage volume. For the first phase of screening, it is sufficient to estimate the order of magnitude water storage volume potential of a particular basin based in comparison to the dam height and length, allowing identification of the most promising sites in the study area. This allowed for the development of a more efficient GIS screening tool than fully developing a depth-area-capacity (DAC) curve for all ~500 potential storage basins.

The assessment of potential reservoir basins was complicated by the low resolution of the data available to KP for completion of this study. YEC provided topographic data with 100 ft. (30 m) contours, which was insufficient to create a complete digital elevation model of the study area that could reliably determine drainage basins automatically. Some potential storage basins have likely been inadvertently excluded from this study due to the poor quality of topographic data. This also may have led to inaccuracies in estimating embankment volumes/water storage ratios. Some spurious data were generated, and most but not all was excluded manually prior to the screening assessment. Nevertheless, KP are confident that despite these data limitations the most promising pumped-storage locations have been included and correctly identified, and that only sites who have less favourable characteristics have been excluded as a result of the low resolution input topographic data.

2.1.4 Technical Constraints

While the identified facilities are smaller than typical pumped-storage facilities, some of the well-recognised hydroelectric generating equipment manufacturers (Voith, Andritz, Alstom) nevertheless have experience in manufacturing reversible pump-turbines of this capacity. Due to the level of design standardisation of generating equipment for small hydro facilities, it may be more cost-effective to adopt conventional turbines and standard pumps in place of reversible pump-turbines for a facility of this size. Determining the trade-off between the two is recommended for future project stages. For the current screening assessment, the use of reversible pump-turbines has been assumed and equipment costs have been extrapolated from published generating equipment costs for reversible pump-turbines.

For the purposes of this screening study, it is not possible to determine what form of water conveyance system (buried or surface penstock, tunnel) would be most appropriate, therefore a buried penstock is assumed for all sites, with a straight line between the upper and lower reservoirs. A maximum straight line water conveyance length of 20 km is assumed between the upper and lower reservoirs. While it is KP's experience that this exceeds the typical water conveyance length for typical hydro plants, the intention was not to unnecessarily exclude potential sites early in the screening process. A more detailed review of penstock alignment is included for the preferred sites in the next Section of this report. Similarly, determination of the transmission lines distances assumed a straight line between the powerhouse and the nearest existing or planned transmission line was assumed for the preliminary screening and ranking of potential pumped-storage sites. A more detailed assessment of transmission line routing was undertaken for the top-ranked (preferred) sites.

Using the nominal reservoir storage volume calculated in Section 2.1.3, a relationship between dam height, dam crest length and reservoir storage volume can be determined. This allowed the screening tool to extrapolate the approximate dam size to meet a given water volume storage required as need for the screening process. It should be noted that this process is an "order of magnitude" process at best, and the dam dimensions were examined in greater detail for the preferred sites in the following Section of this report. Dams are assumed to be concrete-faced rockfill dams (CFRD). Future project studies may result in evaluations showing that alternate dam designs may be more appropriate for individual facilities, but this construction method was selected on the basis of its wide applicability. It is therefore reasonable to assume all dams are CFRD embankments for the purposes of this initial assessment.

2.1.5 Screening Assessment

From the above method, a total of just under 500 potential storage basins (473) were identified as shown on Figure 2.1. An in-house GIS screening tool developed by KP was used to select the best combinations of freshwater basins (upper and lower reservoirs) that would lead to viable pumped-storage sites. This tool identifies any two basins within 20 km, and then determines if the basins are able to store the required water volume, which is dependent on the elevation difference (head) between the two storage basins. If one or both of the two basins is unable to store the required water volume, that combination of basins is eliminated as a potential candidate pumped-storage site. To minimise the extremely high number of potential combinations, a maximum threshold of 10 Mm^3 was set for the total dam embankment construction volume between the reservoirs.

While the threshold of 20 km for the water conveyance distance and 10 Mm^3 for the embankment construction volume may both be beyond the size expected for an economical facility, the intent was not to screen out any sites prematurely, and thus to set the threshold above what would ordinarily be expected. This allows screening and ranking of the most promising sites before selection of the five preferred sites.

2.1.6 Preliminary Characterisation and Inferred Cost

Using the GIS-based screening tool, combinations of reservoir basins where a pumped-storage site could be developed were identified. A total of 250 sites were identified meeting the 50 GWh storage requirement, and 190 sites meeting the 100 GWh storage requirement. There is no suggestion that these sites are economically viable sites, simply that it is theoretically possible to construct them under the minimum thresholds of embankment construction volumes and penstock distance.

In order to identify the most economically attractive sites, data from the sites flagged using the GIS screening tool were imported to an in-house spreadsheet model that calculates inferred project costs based on overall project details (gross head, design flow, capacity), reservoir information (required storage volume, reservoir area, embankment height and length, embankment volume), and waterway parameters (length, diameter). Due to the coarse resolution of the data, the automated nature of the calculations, and the extrapolation method used to determine some of the key site parameters (such as dam height, crest length and reservoir area) the tool is considered valid only for a broad ranking of sites and should not be considered accurate for an absolute estimation of cost.

2.2 SCREENING ASSESSMENT RESULTS

2.2.1 Candidate Reservoir Sites

Figure 2.1 shows the location of all 473 candidate reservoir sites included in the pumped-storage screening assessment. These potential storage basins vary from very large existing lakes, such as the 780 km^2 Atlin Lake on the Yukon/BC border in the south of the study area, down to small alpine cirques with no existing lake, but in which an artificial reservoir could be constructed.

2.2.2 Candidate Pumped-storage Facilities

The top 15 sites as ranked by KP's pumped-storage screening tools are included in Table 2.1 through Table 2.4. A minimum level of quality control was applied to the sites before including facilities on the Tables showing the top 15 sites, namely deletion of sites that were identified through manual inspection as overlapping a higher ranked site. It is apparent that some of the highest ranked sites appear in each of the four combinations of energy storage and installed capacity. Figure 2.3 shows the location of all sites that appear in these four Tables.

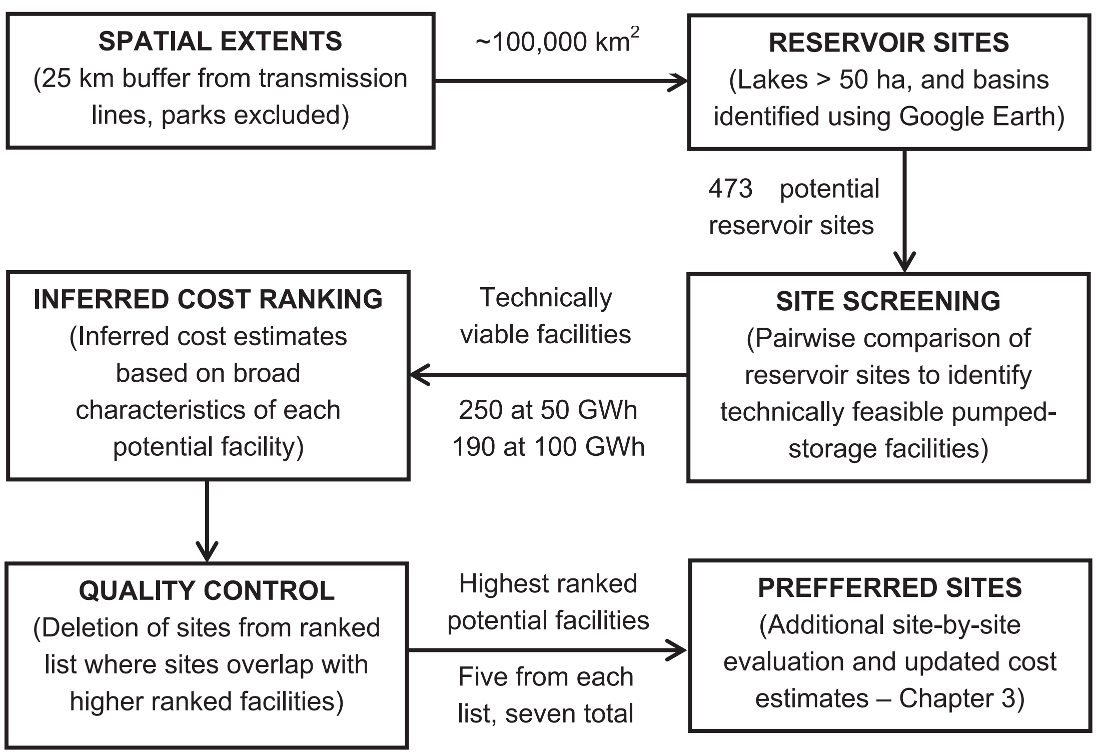


Figure 2.2 Flow chart of the pumped-storage assessment process.

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TABLE 2.1

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

SCREENING AND RANKING OF POTENTIAL PUMPED STORAGE SITES
HIGHEST RANKED SITES - 15 MW, 50 GWh

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SITE ID	SITE NAME	INFERRED CAPITAL COST ($ M)	UPPER RESERVOIR			LOWER RESERVOIR		
			LATITUDE (°)	LONGITUDE (°)	ELEVATION (m)	LATITUDE (°)	LONGITUDE (°)	ELEVATION (m)
447-437	Tutshi-Moon	$220,000,000	59.84	-134.59	1109	59.86	-134.77	715
436-434	Atlin-Black Mt.	$247,000,000	59.94	-133.76	1197	59.95	-133.80	669
443-107	Racine-Mt. Brown	$300,000,000	59.82	-134.44	1511	59.76	-134.50	710
443-437	Racine-Moon	$316,000,000	59.84	-134.59	1109	59.76	-134.50	710
445-289	Lindeman-Fraser	$331,000,000	59.71	-135.10	1112	59.79	-135.07	677
384-383	Squanga-Dalayee	$337,000,000	60.38	-133.62	950	60.45	-133.60	770
6-314	Rainbow-Dezadeash	$338,000,000	60.73	-137.15	1330	60.67	-137.24	715
447-444	Tutshi-Skelly	$345,000,000	59.76	-134.77	866	59.86	-134.77	715
60-55	Granite-Moose Peak	$408,000,000	60.71	-136.88	1472	60.70	-137.06	860
445-458	Lindeman-Long Lake	$411,000,000	59.77	-135.12	866	59.79	-135.07	677
447-124	Tutshi-Jack Peak	$430,000,000	59.90	-134.63	1367	59.86	-134.77	715
454-320	Canyon-Ittlemit	$447,000,000	61.14	-137.07	1136	61.13	-137.03	892
444-437	Skelly-Moon	$480,000,000	59.84	-134.59	1109	59.76	-134.77	866
436-115	Atlin-McDonald	$508,000,000	59.70	-133.61	933	59.69	-133.75	669
60-314	Granite-Dezadeash	$530,000,000	60.73	-137.15	1330	60.70	-137.06	860

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Cost Ranking\[15 MW, 50 GWh r0.xlsx]SUMMARY

NOTES:

1. THE DATA SHOWN IN THIS TABLE HAS BEEN PRODUCED BY KP'S IN-HOUSE AUTOMATED GIS AND SPREADSHEET SCREENING TOOL.
2. QUALITY CONTROL ON THE DATA PRODUCED BY THE SCREENING TOOL HAS BEEN APPLIED BEFORE INCLUSION OF SITES ON THIS RANKED SHORT-LIST.
3. QUALITY CONTROL UNDERTAKEN ON SITES ON THIS LIST INCLUDES DELETION OF SITES THAT ARE NOT TECHNICALLY VIABLE OR THAT OVERLAP HIGHER RANKED SITES. QUALITY CONTROL ON THIS LIST DOES NOT INCLUDE MODIFICATION OF DAM ARRANGEMENT, PENSTOCK OR TRANSMISSION LINE ROUTE WHICH IS PERFORMED ONLY ON THE TOP 5 PREFERRED SITES IN A SEPARATE ANALYSIS.
4. THE TOOL RELIES ON EXTRAPOLATIONS AND SIMPLIFICATIONS TO PROVIDE INFERRED, ORDER OF MAGNITUDE COSTS FOR EACH SITE.
5. THE INDICATIVE (INFERRED) CAPITAL COSTS ARE NOT CONSIDERED RELIABLE COST ESIMATES, BUT ARE INTENDED ONLY FOR RELATIVE RANKING OF PROJECTS.
6. REFER TO SEPARATE TABLES AND COST ESTIMATES IN ASSESSMENT REPORT FOR AACE CLASS 5 COST ESTIMATES AND FINANCIAL ANALYSIS OF TOP 5 PREFFERED SITES.
7. THE GIS SCREENING TOOL FLAGGED OVER 100 SITES AS POTENTIALLY TECHNICALLY VIABLE, ONLY THE TOP 15 ARE SHOWN HERE DUE TO THE QUALITY CONTROL REQUIRED FOR INCLUDING RANKED SITES.

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TABLE 2.2

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

SCREENING AND RANKING OF POTENTIAL PUMPED STORAGE SITES
HIGHEST RANKED SITES - 15 MW, 100 GWh

6/29/2016 16:22

SITE ID	SITE NAME	INFERRED CAPITAL COST ($ M)	UPPER RESERVOIR			LOWER RESERVOIR		
			LATITUDE	LONGITUDE	ELEVATION (m)	LATITUDE	LONGITUDE	ELEVATION (m)
447-437	Tutshi-Moon	$364,000,000	59.84	-134.59	1109	59.86	-134.77	715
443-437	Racine-Moon	$519,000,000	59.84	-134.59	1109	59.76	-134.50	710
384-383	Squanga-Dalayee	$577,000,000	60.38	-133.62	950	60.45	-133.60	770
436-434	Atlin-Black Mt.	$752,000,000	59.94	-133.76	1197	59.95	-133.80	669
454-320	Canyon-Ittlemit	$801,000,000	61.14	-137.07	1136	61.13	-137.03	892
447-444	Tutshi-Skelly	$817,000,000	59.76	-134.77	866	59.86	-134.77	715
443-107	Racine-Mt. Brown	$819,000,000	59.82	-134.44	1511	59.76	-134.50	710
355-461	Little Salmon-Drury	$845,000,000	62.27	-134.50	722	62.20	-134.51	530
6-314	Rainbow-Dezadeash	$874,000,000	60.73	-137.15	1330	60.67	-137.24	715
445-289	Lindeman-Fraser	$879,000,000	59.71	-135.10	1112	59.79	-135.07	677
60-55	Granite-Moose Peak	$1,190,000,000	60.71	-136.88	1472	60.70	-137.06	860
445-458	Lindeman-Long Lake	$1,229,000,000	59.77	-135.12	866	59.79	-135.07	677
445-459	Lindeman-Homan	$1,382,000,000	59.87	-135.19	820	59.79	-135.07	677
437-107	Moon-Mt. Brown	$1,461,000,000	59.82	-134.44	1511	59.84	-134.59	1109
444-437	Skelly-Moon	$1,495,000,000	59.84	-134.59	1109	59.76	-134.77	866

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Cost Ranking\[15 MW, 100 GWh r0.xlsx]SUMMARY

NOTES:

1. THE DATA SHOWN IN THIS TABLE HAS BEEN PRODUCED BY KP'S IN-HOUSE AUTOMATED GIS AND SPREADSHEET SCREENING TOOL.
2. QUALITY CONTROL ON THE DATA PRODUCED BY THE SCREENING TOOL HAS BEEN APPLIED BEFORE INCLUSION OF SITES ON THIS RANKED SHORT-LIST.
3. QUALITY CONTROL UNDERTAKEN ON SITES ON THIS LIST INCLUDES DELETION OF SITES THAT ARE NOT TECHNICALLY VIABLE OR THAT OVERLAP HIGHER RANKED SITES. QUALITY CONTROL ON THIS LIST DOES NOT INCLUDE MODIFICATION OF DAM ARRANGEMENT, PENSTOCK OR TRANSMISSION LINE ROUTE WHICH IS PERFORMED ONLY ON THE TOP 5 PREFERRED SITES IN A SEPARATE ANALYSIS.
4. THE TOOL RELIES ON EXTRAPOLATIONS AND SIMPLIFICATIONS TO PROVIDE INFERRED, ORDER OF MAGNITUDE COSTS FOR EACH SITE.
5. THE INDICATIVE (INFERRED) CAPITAL COSTS ARE NOT CONSIDERED RELIABLE COST ESIMATES, BUT ARE INTENDED ONLY FOR RELATIVE RANKING OF PROJECTS.
6. REFER TO SEPARATE TABLES AND COST ESTIMATES IN ASSESSMENT REPORT FOR AACE CLASS 5 COST ESTIMATES AND FINANCIAL ANALYSIS OF TOP 5 PREFFERED SITES.
7. THE GIS SCREENING TOOL FLAGGED OVER 100 SITES AS POTENTIALLY TECHNICALLY VIABLE, ONLY THE TOP 15 ARE SHOWN HERE DUE TO THE QUALITY CONTROL REQUIRED FOR INCLUDING RANKED

0	28JUN'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	RVW'D

Knight Piésold CONSULTING

TABLE 2.3

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

SCREENING AND RANKING OF POTENTIAL PUMPED STORAGE SITES
HIGHEST RANKED SITES - 25 MW, 50 GWh

6/29/2016 16:23

SITE ID	SITE NAME	INFERRED CAPITAL COST ($ M)	UPPER RESERVOIR			LOWER RESERVOIR		
			LATITUDE	LONGITUDE	ELEVATION (m)	LATITUDE	LONGITUDE	ELEVATION (m)
447-437	Tutshi-Moon	$250,000,000	59.84	-134.59	1109	59.86	-134.77	715
436-434	Atlin-Black Mt.	$267,000,000	59.94	-133.76	1197	59.95	-133.80	669
443-107	Racine-Mt. Brown	$322,000,000	59.82	-134.44	1511	59.76	-134.50	710
443-437	Racine-Moon	$358,000,000	59.84	-134.59	1109	59.76	-134.50	710
445-289	Lindeman-Fraser	$366,000,000	59.71	-135.10	1112	59.79	-135.07	677
6-314	Rainbow-Dezadeash	$372,000,000	60.73	-137.15	1330	60.67	-137.24	715
384-383	Squanga-Dalayee	$382,000,000	60.38	-133.62	950	60.45	-133.60	770
447-444	Tutshi-Skelly	$382,000,000	59.76	-134.77	866	59.86	-134.77	715
445-458	Lindeman-Long Lake	$434,000,000	59.77	-135.12	866	59.79	-135.07	677
60-55	Granite-Moose Peak	$442,000,000	60.71	-136.88	1472	60.70	-137.06	860
447-124	Tutshi-Jack Peak	$454,000,000	59.90	-134.63	1367	59.86	-134.77	715
454-320	Canyon-Ittlemit	$486,000,000	61.14	-137.07	1136	61.13	-137.03	892
444-437	Skelly-Moon	$513,000,000	59.84	-134.59	1109	59.76	-134.77	866
436-115	Atlin-McDonald	$547,000,000	59.70	-133.61	933	59.69	-133.75	669
60-314	Granite-Dezadesh	$555,000,000	60.73	-137.15	1330	60.70	-137.06	860

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Cost Ranking\[25 MW, 50 GWh.xlsx]SUMMARY

NOTES:

1. THE DATA SHOWN IN THIS TABLE HAS BEEN PRODUCED BY KP'S IN-HOUSE AUTOMATED GIS AND SPREADSHEET SCREENING TOOL.
2. QUALITY CONTROL ON THE DATA PRODUCED BY THE SCREENING TOOL HAS BEEN APPLIED BEFORE INCLUSION OF SITES ON THIS RANKED SHORT-LIST.
3. QUALITY CONTROL UNDERTAKEN ON SITES ON THIS LIST INCLUDES DELETION OF SITES THAT ARE NOT TECHNICALLY VIABLE OR THAT OVERLAP HIGHER RANKED SITES. QUALITY CONTROL ON THIS LIST DOES NOT INCLUDE MODIFICATION OF DAM ARRANGEMENT, PENSTOCK OR TRANSMISSION LINE ROUTE WHICH IS PERFORMED ONLY ON THE TOP 5 PREFERRED SITES IN A SEPARATE ANALYSIS.
4. THE TOOL RELIES ON EXTRAPOLATIONS AND SIMPLIFICATIONS TO PROVIDE INFERRED, ORDER OF MAGNITUDE COSTS FOR EACH SITE.
5. THE INDICATIVE (INFERRED) CAPITAL COSTS ARE NOT CONSIDERED RELIABLE COST ESIMATES, BUT ARE INTENDED ONLY FOR RELATIVE RANKING OF PROJECTS.
6. REFER TO SEPARATE TABLES AND COST ESTIMATES IN ASSESSMENT REPORT FOR AACE CLASS 5 COST ESTIMATES AND FINANCIAL ANALYSIS OF TOP 5 PREFFERED SITES.
7. THE GIS SCREENING TOOL FLAGGED OVER 100 SITES AS POTENTIALLY TECHNICALLY VIABLE, ONLY THE TOP 15 ARE SHOWN HERE DUE TO THE QUALITY CONTROL REQUIRED FOR INCLUDING RANKED SITES.

1	28JUN'16	ISSUED WITH REPORT VA103-556/2-1	MGP	SRM
REV	DATE	DESCRIPTION	PREP'D	CHK'D

Knight Piésold CONSULTING

TABLE 2.4

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

SCREENING AND RANKING OF POTENTIAL PUMPED STORAGE SITES
HIGHEST RANKED SITES - 25 MW, 100 GWh

6/29/2016 16:24

SITE ID	SITE NAME	INFERRED CAPITAL COST ($ M)	UPPER RESERVOIR			LOWER RESERVOIR		
			LATITUDE (°)	LONGITUDE (°)	ELEVATION (m)	LATITUDE (°)	LONGITUDE (°)	ELEVATION (m)
447-437	Tutshi-Moon	$394,000,000	59.84	-134.59	1109	59.86	-134.77	715
443-437	Racine-Moon	$560,000,000	59.84	-134.59	1109	59.76	-134.50	710
384-383	Squanga-Dalayee	$621,000,000	60.38	-133.62	950	60.45	-133.60	770
436-434	Atlin-Black Mt.	$772,000,000	59.94	-133.76	1197	59.95	-133.80	669
454-320	Canyon-Ittlemit	$840,000,000	61.14	-137.07	1136	61.13	-137.03	892
443-107	Racine-Mt. Brown	$841,000,000	59.82	-134.44	1511	59.76	-134.50	710
447-444	Tutshi-Skelly	$854,000,000	59.76	-134.77	866	59.86	-134.77	715
355-461	Little Salmon-Drury	$891,000,000	62.27	-134.50	722	62.20	-134.51	530
6-314	Rainbow-Dezadeash	$907,000,000	60.73	-137.15	1330	60.67	-137.24	715
445-289	Lindeman-Fraser	$913,000,000	59.71	-135.10	1112	59.79	-135.07	677
60-55	Granite-Moose Peak	$1,224,000,000	60.71	-136.88	1472	60.70	-137.06	860
445-458	Lindeman-Long Lake	$1,251,000,000	59.77	-135.12	866	59.79	-135.07	677
445-459	Lindeman-Homan	$1,435,000,000	59.87	-135.19	820	59.79	-135.07	677
437-107	Moon-Mt. Brown	$1,497,000,000	59.82	-134.44	1511	59.84	-134.59	1109
444-437	Skelly-Moon	$1,528,000,000	59.84	-134.59	1109	59.76	-134.77	866

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Cost Ranking\[25 MW, 100 GWh r0.xlsx]SUMMARY

NOTES:

1. THE DATA SHOWN IN THIS TABLE HAS BEEN PRODUCED BY KP'S IN-HOUSE AUTOMATED GIS AND SPREADSHEET SCREENING TOOL.
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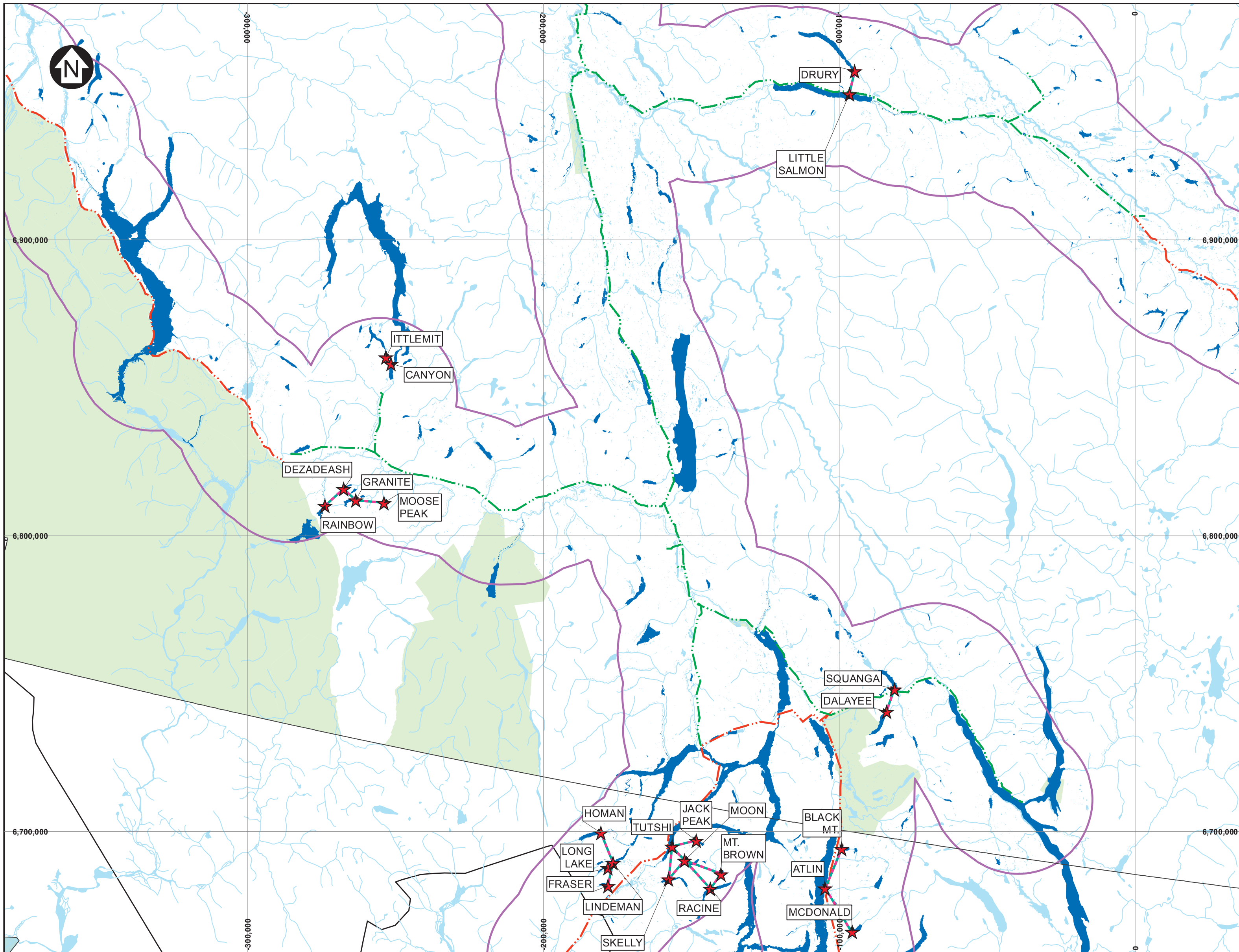
6. REFER TO SEPARATE TABLES AND COST ESTIMATES IN ASSESSMENT REPORT FOR AACE CLASS 5 COST ESTIMATES AND FINANCIAL ANALYSIS OF TOP 5 PREFFERED SITES.
7. THE GIS SCREENING TOOL FLAGGED OVER 100 SITES AS POTENTIALLY TECHNICALLY VIABLE, ONLY THE TOP 15 ARE SHOWN HERE DUE TO THE QUALITY CONTROL REQUIRED FOR INCLUDING RANKED SIT

0	28MAR'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	RVW'D



LEGEND:

GENERAL
- RIVER
- LAKE
- PARK/PROTECTED AREA
- STUDY AREA
- RESERVOIR

TRANSMISSION LINE
- 69 KV
- EXISTING
- PROPOSED

TOP-RANKED SITES
- PUMPED STORAGE RESERVOIR SITES (UPPER OR LOWER)
- TOP RANKED PUMPED STORAGE SITES

NOTES:

1. BASE MAP: NATIONAL TOPOGRAPHIC DATABASE.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 10N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:1,300,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

20 10 0 20 40 60 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL - TOP-RANKED STORAGE RESERVOIR BASINS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1

FIGURE 2.3	REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	MGP	KK	KLA

SAVED: \\KPL\VA-Prj$\1\03\00556\02\A\GIS\Figs\1- Pumped Storage\Rev0\Fig2-3_PumpedStorage_TopRanked_r0.mxd; Jun 30, 2016 3:58 PM; cczembor

3 – EVALUATION OF PREFERRED SITES

3.1 SELECTION OF PREFERRED SITES

By examining the top five ranked sites in each of Table 2.1 through Table 2.4, it is apparent that the following three sites appear in the top five for both the 50 GWh and 100 GWh options:

1. Tutshi-Moon
2. Atlin-Black Mt.
3. Racine-Moon

For the 50 GWh option – the following are the top five pumped-storage sites:

1. Tutshi-Moon
2. Atlin-Black Mt.
3. Racine-Moon
4. Racine-Mt. Brown (also ranked number six by a very small margin for the 25 MW, 100 GWh storage option)
5. Lindeman-Fraser

For the 100 GWh option – the following are the top five pumped-storage sites:

1. Tutshi-Moon
2. Atlin-Black Mt.
3. Racine-Moon
4. Squanga-Dalayee
5. Canyon-Ittlemit

3.2 HYDROLOGY

Hydrological characteristics are less of a consideration for pumped-storage facilities as compared to conventional hydro plants. Nevertheless, the long duration of seasonal pumping in the summer months from May through to September warranted an investigation into the likely Mean Annual Runoff to the catchments of the upper reservoirs. Any inflow to the upper reservoir at any point throughout the year can be considered water that does not need to be pumped from the lower reservoir during the summer. Note that inflow into lower reservoirs has not been evaluated. Inflow into the lower reservoirs does not reduce pumping requirements, but sufficient inflow may alleviate the need for dam construction on the lower reservoir(s). In addition, inflow may reduce the size requirement for the upper reservoir dams, and would be a useful aspect for evaluation in future.

Data from a total of 46 Water Survey of Canada (WSC) gauges with catchment areas between 10 and 7,000 km^2 were reviewed to develop an understanding of regional trends in measured runoff for catchments of varying sizes and regions. The data were used to develop estimates of Mean Annual Discharge (MAD) at the upper reservoir for all of the preferred project sites assessed here in Section 3 of this report. No analysis of the expected distribution of flow throughout the year was undertaken for the pumped-storage sites, as all inflow at any stage of the year is assumed to be captured.

Where no previous hydrology information could be obtained, KP has developed estimates on the basis of the Mean Annual Unit Discharge (MAUD) values from the WSC gauges in the region. These gauges are dispersed across the majority of the Yukon and provide a reasonable means of assessing hydrologic patterns throughout the region. Some of the basic trends evident in the data are as follows:

- MAUD appears to decrease in a south-westerly direction along the border between the Yukon and Northwest Territories (NWT), with lower unit discharge values evident in the dry, lower relief interior zones versus the mountainous terrain along the eastern provincial border, and
- In the south-western corner of the Yukon, MAUD appears to be relatively high due to the onshore movement of moist maritime air from the Pacific Coast. The effects of this moisture influx extends slightly beyond the Coastal Mountain Range, and then drops off markedly due to a 'precipitation shadow' effect that results in a progressive reduction in MAUD moving east.

MAUD values were selected for the project sites on the basis of proximity and similarity of catchment size to the WSC stations. Commonly, there are two to three local gauge stations that provide a basis for estimating unit discharge. Where applicable, consideration was also given to the MAUD values reported for various project sites.

Additional regional considerations when determining a site's MAUD included;

- Glaciers in a watershed, which generally increase MAUD due to melt during the warm summer months
- Lakes in a watershed, which generally decrease MAUD due to greater evaporation, and
- The local relief, with higher elevation watersheds generally having higher precipitation and correspondingly higher MAUD.

3.3 PROJECT CONFIGURATIONS

Using the preliminary site information identified in Section 2 of this report, a more advanced assessment of each of the preferred sites was undertaken, including:

- Selection of a realistic penstock alignment that considers local topographic constraints and most efficient routing. These routes are longer than the straight-line distances between the upper and lower reservoir determined by the automated screening tool in Section 2
- Selection of a realistic transmission line alignment that considers local topographic constraints. These routes are longer than the straight-line distances between the powerhouse and nearest transmission line determined during the automated screening process in Section 2
- Optimisation of dam configuration (including height and length) based on the required water storage volume. This required a site by site assessment of topography and dam construction locations to supersede the dam configurations determined automatically by extrapolation during the screening process in Section 2 of this report, and
- Assessment of whether any saddle dams are required to provide the required storage.

It is apparent that the above changes will alter the anticipated cost for each project site, so the relative ranking of the top projects changes slightly with the benefit of this updated analysis. Technical attributes for all facilities are summarised in Table 3.1 through Table 3.4.

TABLE 3.1

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT TECHNICAL ATTRIBUTES - 15 MW, 50 GWh

04/07/2016 14:44

ITEM	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
Upper Reservoir Area (ha)	500	230	210	484	190
Upper Reservoir Elevation (m)	1117	1217	1523	1117	1095
Upper Reservoir Dam Height (m)	14	26	29	16	41
Upper Reservoir Dam Crest Length (m)	470	940	320	350	940
Upper Reservoir Saddle Dam Height (m)	0	0	3	0	0
Upper Reservoir Saddle Dam Length (m)	0	0	140	0	0
Lower Reservoir Area (ha)	5400	79100	1120	1120	477
Lower Reservoir Elevation (m)	660	639	726	726	654
Lower Reservoir Dam Height (m)	3	0	5	7	0
Lower Reservoir Dam Crest Length (m)	500	0	500	870	0
Gross Head (m)	457	578	797	392	441
Design Flow - Generation (m^3/s)	3.9	3.1	2.2	4.5	4.0
Design Flow - Pumping (m^3/s)	2.7	2.1	1.6	3.2	2.8
Installed Capacity (MW)	15	15	15	15	15
Energy Storage (GWh)	50	50	50	50	50
Assumed Efficiency, Generating (%)	87	87	87	87	87
Assumed Efficiency, Pumping (%)	81	81	81	81	81
Penstock Length (km)	5.8	2.5	6.5	9.5	16.0
Transmission Line Length (km)	2.6	0.8	24.0	20.0	5.0
Reservoir Storage Volume ($x10^6$ m^3)	46.4	36.7	26.6	54.2	48.1
Upper Reservoir Catchment Area (km^2)	59	9.1	12	59	13
Upper Reservoir Approximate Unit Runoff ($l/s/km^2$)	15	5	12	15	12
Upper Reservoir Approximate Mean Annual Discharge (m^3/s)	0.879	0.046	0.144	0.879	0.156
Instream Flow Requirements, Assumed 5% of MAD (m^3/s)	0.044	0.002	0.007	0.044	0.008
Annual Generating Energy (GWh)	50.0	50.0	50.0	50.0	50.0
Annual Pumping Flow ($x10^6$ m^3)	20.0	35.3	22.3	27.8	43.5
Annual Pumping Energy (MWh)	26.7	59.5	51.8	31.8	55.8
Generation Duration to Completely Empty Reservoir (Days)	177	141	148	170	144
Pumping Duration to Completely Fill Reservoir (Days)	152	194	182	157	188

M:\1\03\00556\02\A\Report\1 - Pumped Storage\Rev 0\Tables\[Cost_Technical_Financial_15 MW, 50 GWh.xlsx]Technical Summary

NOTES:

1. TECHNICAL ATTRIBUTES ARE PRELIMINARY BASED ON A DESKTOP LEVEL SCREENING ASSESSMENT ONLY.
2. GENERATION AND PUMPING DURATIONS ASSUME MEAN ANNUAL DISCHARGE INFLOWS INTO THE RESERVOIR CONTINOUSLY WITH NO ALLOWANCE FOR SEASONAL VARIATION.

REV	DATE	DESCRIPTION	PREP'D	CHK'D
0	12APR'16	ISSUED WITH REPORT	MGP	KLA

Knight Piésold CONSULTING

TABLE 3.2

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT TECHNICAL ATTRIBUTES - 15 MW, 100 GWh

13/04/2016 14:56

ITEM	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
Upper Reservoir Area (ha)	610	315	290	1300	1275
Upper Reservoir Elevation (m)	1117	1217	1523	975	1160
Upper Reservoir Dam Height (m)	22	42	43	21	33
Upper Reservoir Dam Crest Length (m)	830	1140	470	1300	970
Upper Reservoir Saddle Dam Height (m)	0	5	30	0	32
Upper Reservoir Saddle Dam Length (m)	0	800	400	0	650
Lower Reservoir Area (ha)	5600	79100	1130	1600	1538
Lower Reservoir Elevation (m)	660	639	726	792	904
Lower Reservoir Dam Height (m)	4	0	6	20	16
Lower Reservoir Dam Crest Length (m)	600	0	600	2000	1520
Gross Head (m)	457	578	797	183	256
Design Flow - Generation (m^3/s)	3.9	3.1	2.2	9.7	6.9
Design Flow - Pumping (m^3/s)	2.7	2.1	1.6	6.8	4.8
Installed Capacity (MW)	15	15	15	15	15
Energy Storage (GWh)	100	100	100	100	100
Assumed Efficiency, Generating (%)	87	87	87	87	87
Assumed Efficiency, Pumping (%)	81	81	81	81	81
Penstock Length (km)	5.8	2.5	6.5	7.8	2.0
Transmission Line Length (km)	2.6	0.8	24.0	0.8	13.9
Reservoir Storage Volume ($x10^6$ m^3)	92.8	73.4	53.2	232	165.9
Upper Reservoir Catchment Area (km^2)	59	9.1	12	68	57
Upper Reservoir Approximate Unit Runoff ($l/s/km^2$)	15	5	12	3.6	2.9
Upper Reservoir Approximate Mean Annual Discharge (m^3/s)	0.879	0.046	0.144	0.2	0.2
Instream Flow Requirements, Assumed 5% of MAD (m^3/s)	0.044	0.002	0.007	0.0	0.0
Annual Generating Energy (GWh)	100.0	100.0	100.0	100.0	100.0
Annual Pumping Flow ($x10^6$ m^3)	66.4	72.0	48.9	224.7	160.9
Annual Pumping Energy (MWh)	88.5	121.3	113.6	119.7	119.9
Generation Duration to Completely Empty Reservoir (Days)	354	282	296	285	284
Pumping Duration to Completely Fill Reservoir (Days)	303	389	365	384	384

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Preferred Sites\[Cost_Technical_Financial_15 MW, 100 GWh.xlsx]Cost Summary

NOTES:

1. TECHNICAL ATTRIBUTES ARE PRELIMINARY BASED ON A DESKTOP LEVEL SCREENING ASSESSMENT ONLY.
2. GENERATION AND PUMPING DURATIONS ASSUME MEAN ANNUAL DISCHARGE INFLOWS INTO THE RESERVOIR CONTINOUSLY WITH NO ALLOWANCE FOR SEASONAL VARIATION.

0	12APR'16	ISSUED WITH REPORT	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

Knight Piésold CONSULTING

TABLE 3.3

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT TECHNICAL ATTRIBUTES - 25 MW, 50 GWh

13/04/2016 14:55

ITEM	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
Upper Reservoir Area (ha)	500	230	210	484	190
Upper Reservoir Elevation (m)	1117	1217	1523	1117	1095
Upper Reservoir Dam Height (m)	14	26	29	16	41
Upper Reservoir Dam Crest Length (m)	470	940	320	350	940
Upper Reservoir Saddle Dam Height (m)	0	0	3	0	0
Upper Reservoir Saddle Dam Length (m)	0	0	140	0	0
Lower Reservoir Area (ha)	5400	79100	1120	1120	477
Lower Reservoir Elevation (m)	660	639	726	726	654
Lower Reservoir Dam Height (m)	3	0	5	7	0
Lower Reservoir Dam Crest Length (m)	500	0	500	870	0
Gross Head (m)	457	578	797	392	441
Design Flow - Generation (m^3/s)	6.4	5.1	3.7	7.5	6.7
Design Flow - Pumping (m^3/s)	4.5	3.6	2.6	5.3	4.7
Installed Capacity (MW)	25	25	25	25	25
Energy Storage (GWh)	50	50	50	50	50
Assumed Efficiency, Generating (%)	87	87	87	87	87
Assumed Efficiency, Pumping (%)	81	81	81	81	81
Penstock Length (km)	5.8	2.5	6.5	9.5	16.0
Transmission Line Length (km)	2.6	0.8	24.0	20.0	5.0
Reservoir Storage Volume ($x10^6$ m^3)	46.4	36.7	26.6	54.2	48.1
Upper Reservoir Catchment Area (km^2)	59	9.1	12	59	13
Upper Reservoir Approximate Unit Runoff ($l/s/km^2$)	15	5	12	15	12
Upper Reservoir Approximate Mean Annual Discharge (m^3/s)	0.879	0.046	0.144	0.879	0.156
Instream Flow Requirements, Assumed 5% of MAD (m^3/s)	0.044	0.002	0.007	0.044	0.008
Annual Generating Energy (GWh)	50.0	50.0	50.0	50.0	50.0
Annual Pumping Flow ($x10^6$ m^3)	20.0	35.3	22.3	27.8	43.5
Annual Pumping Energy (MWh)	26.7	59.5	51.8	31.8	55.8
Generation Duration to Completely Empty Reservoir (Days)	96	84	87	94	85
Pumping Duration to Completely Fill Reservoir (Days)	100	118	113	103	115

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Preferred Sites\[Cost_Technical_Financial_25 MW, 50 GWh.xlsx]Cost Summary

NOTES:

1. TECHNICAL ATTRIBUTES ARE PRELIMINARY BASED ON A DESKTOP LEVEL SCREENING ASSESSMENT ONLY.
2. GENERATION AND PUMPING DURATIONS ASSUME MEAN ANNUAL DISCHARGE INFLOWS INTO THE RESERVOIR CONTINOUSLY WITH NO ALLOWANCE FOR SEASONAL VARIATION.

0	12APR'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

Knight Piésold CONSULTING

TABLE 3.4

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT TECHNICAL ATTRIBUTES - 25 MW, 100 GWh

13/04/2016 15:01

ITEM	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
Upper Reservoir Area (ha)	610	315	290	1300	1275
Upper Reservoir Elevation (m)	1117	1217	1523	975	1160
Upper Reservoir Dam Height (m)	22	42	43	21	33
Upper Reservoir Dam Crest Length (m)	830	1140	470	1300	970
Upper Reservoir Saddle Dam Height (m)	0	5	30	0	32
Upper Reservoir Saddle Dam Length (m)	0	800	400	0	650
Lower Reservoir Area (ha)	5600	79100	1130	1600	1538
Lower Reservoir Elevation (m)	660	639	726	792	904
Lower Reservoir Dam Height (m)	4	0	6	20	16
Lower Reservoir Dam Crest Length (m)	600	0	600	2000	1520
Gross Head (m)	457	578	797	183	256
Design Flow - Generation (m^3/s)	6.4	5.1	3.7	16.1	11.5
Design Flow - Pumping (m^3/s)	4.5	3.6	2.6	11.3	8.1
Installed Capacity (MW)	25	25	25	25	25
Energy Storage (GWh)	100	100	100	100	100
Assumed Efficiency, Generating (%)	87	87	87	87	87
Assumed Efficiency, Pumping (%)	81	81	81	81	81
Penstock Length (km)	5.8	2.5	6.5	7.8	2.0
Transmission Line Length (km)	2.6	0.8	24.0	0.8	13.9
Reservoir Storage Volume ($x10^6$ m^3)	92.8	73.4	53.2	232	165.9
Upper Reservoir Catchment Area (km^2)	59	9.1	12	68	57
Upper Reservoir Approximate Unit Runoff ($l/s/km^2$)	15	5	12	3.6	2.9
Upper Reservoir Approximate Mean Annual Discharge (m^3/s)	0.879	0.046	0.144	0.2	0.2
Instream Flow Requirements, Assumed 5% of MAD (m^3/s)	0.044	0.002	0.007	0.0	0.0
Annual Generating Energy (GWh)	100.0	100.0	100.0	100.0	100.0
Annual Pumping Flow ($x10^6$ m^3)	66.4	72.0	48.9	224.7	160.9
Annual Pumping Energy (MWh)	88.5	121.3	113.6	119.7	119.9
Generation Duration to Completely Empty Reservoir (Days)	191	168	173	169	169
Pumping Duration to Completely Fill Reservoir (Days)	201	235	226	233	234

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Preferred Sites\[Cost_Technical_Financial_25 MW, 100 GWh.xlsx]Technical Summary

NOTES:

1. TECHNICAL ATTRIBUTES ARE PRELIMINARY BASED ON A DESKTOP LEVEL SCREENING ASSESSMENT ONLY.
2. GENERATION AND PUMPING DURATIONS ASSUME MEAN ANNUAL DISCHARGE INFLOWS INTO THE RESERVOIR CONTINOUSLY WITH NO ALLOWANCE FOR SEASONAL VARIATION.

0	12APR'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

3.4 PROJECT DESCRIPTIONS

3.4.1 Tutshi-Moon

This site is located between Tutshi and Moon Lakes in British Columbia. The configuration is relatively straight forward, with a dam downstream of the outlet on Moon Lake. Since inflows into the project site were not considered in sizing the upper and lower reservoir dams, our analysis indicated that a low dam would be required at the outlet of Tutshi Lake in order to ensure the required storage volume in the lake. The inflows may be sufficient to alleviate the requirement for this dam in a final project configuration.

The penstock route selected for the analysis runs along the eastern side of the valley from Moon Lake down to the powerhouse on Tutshi Lake. The transmission line then heads north across Tutshi Lake to the proposed Yukon-Skagway transmission line that will run along the north-west shore. Without construction of this line, the distance to the nearest point of interconnection increases by approximately 35 km.

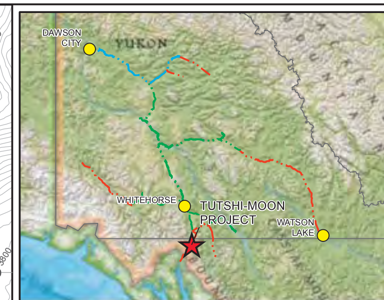
This is the same site assessed by Midgard in their 2015 conceptual study report. KP’s configuration and analysis for this site is useful in benchmarking KP’s analysis and cost assessment for all project sites with the more detailed analysis prepared by Midgard for Moon Lake. The current analysis was completed using KP’s own methods without reference to the Midgard report, but yielded similar cost results as those obtained by Midgard. This provides a level of confidence and credibility in the results of the current report, given their similarity to Midgard’s estimates which were prepared using different methods and a more detailed level of information.

3.4.2 Atlin-Black Mountain

This project uses the very large Atlin Lake in British Columbia as a lower reservoir and a small lake perched in a hanging valley approximately 2.5 km to the east of Atlin Lake, adjacent to Black Mountain. The upper reservoir requires a saddle dam on the west side in order to achieve the 100 GWh of storage, although no saddle dam is required for the 50 GWh storage arrangement.

The natural drainage direction from the small alpine lake is to the east. The penstock route assumes a deep channel excavation on the west side of the lake in order to minimise penstock length (approximately 2.5 km length as compared to a length of over 12 km for a penstock route that follows the natural terrain to the east of the small lake). Further analysis will be required to determine the technical viability of excavating a deep trench to overcome the terrain limitation, but it appears that the project still remains “competitive” with some of the top ranked projects, even with the assumption of digging a deep channel of approximately 130 m in length to accommodate the penstock drainage. The transmission line distance for this project is short (<1 km) provided that the Atlin-Yukon transmission line is constructed as it would run immediately adjacent to the proposed powerhouse location. Without the proposed transmission line, this site would be over 40 km to the nearest point of interconnection.

No dam is required on the lower reservoir, as the entire 100 GWh energy storage volume would result in a level fluctuation in Atlin Lake of only 10 cm. Given the long duration over which the energy is both stored and discharged, this artificial fluctuation will likely be small compared to background natural fluctuations in lake level.



LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE
- LAKE

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- DAM AND INTAKE
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:60,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - TUTSHI-MOON

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1

	REV
FIGURE 3.1	0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	KK	KLA

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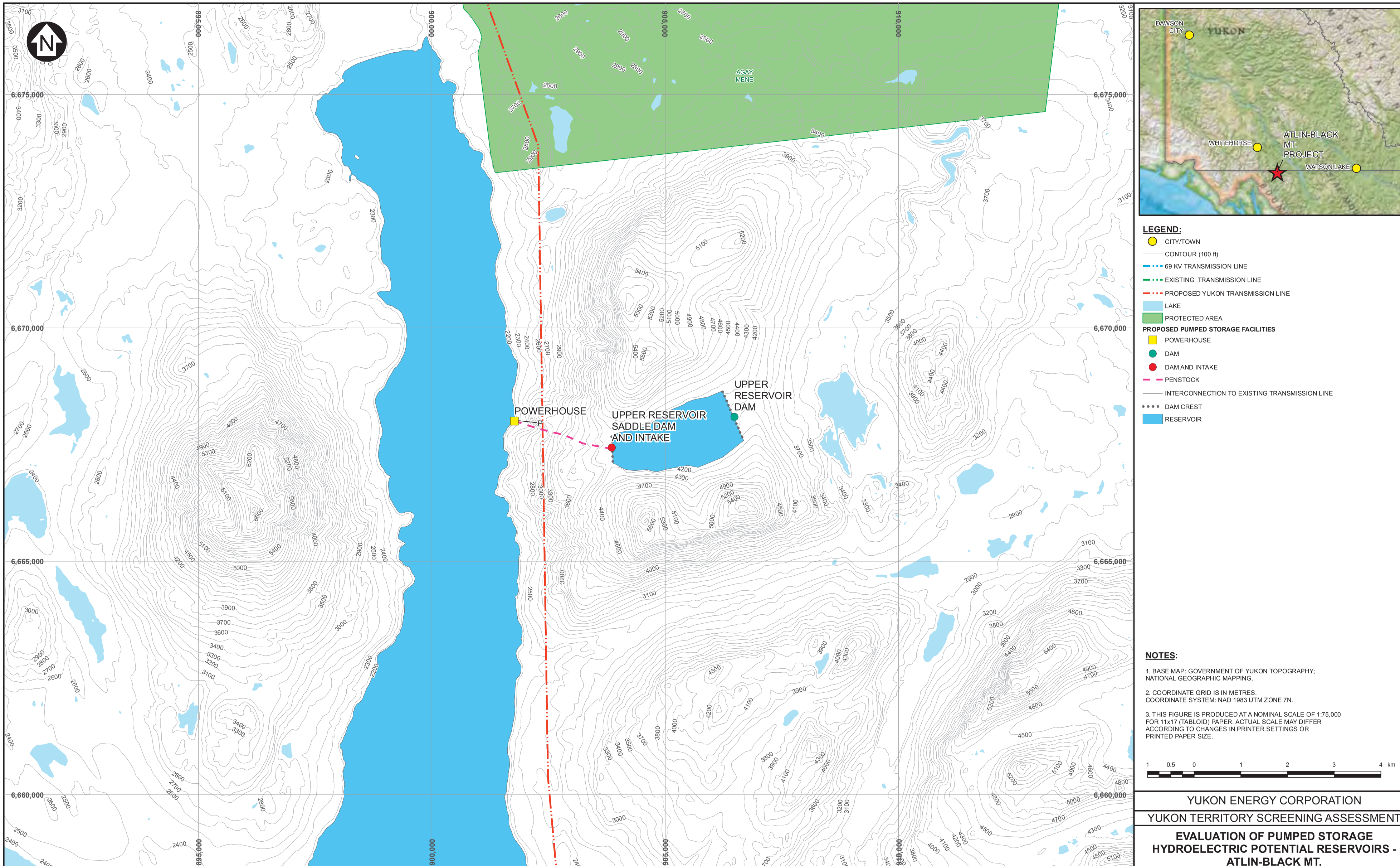

LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE
- LAKE
- PROTECTED AREA

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- DAM
- DAM AND INTAKE
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:75,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 4 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - ATLIN-BLACK MT.

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1
FIGURE 3.2	REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	KK	KLA

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3.4.3 Racine-Moon

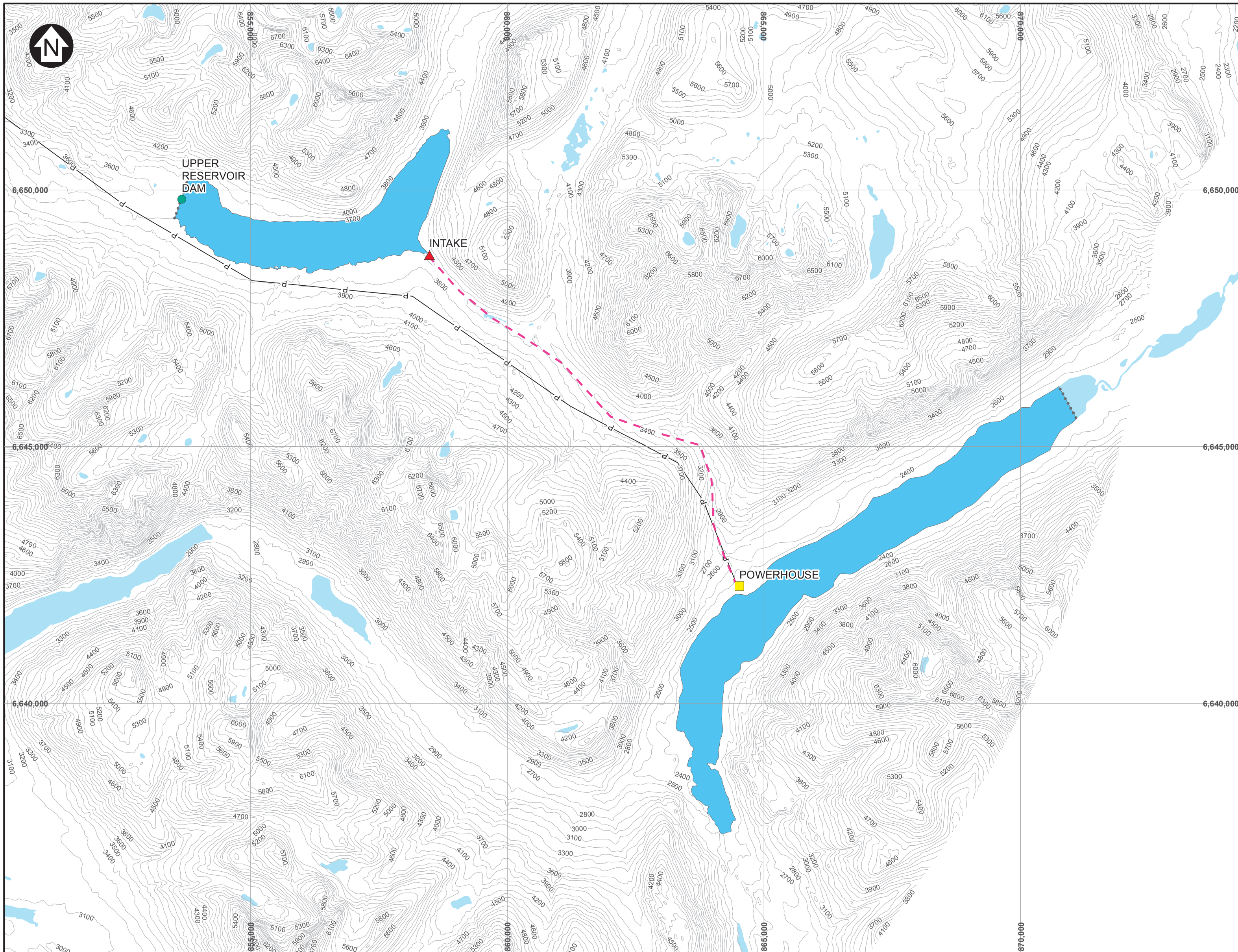
This site utilises Moon Lake as an upper reservoir, but with Racine Lake as a lower reservoir in lieu of Tutshi Lake. The proposed penstock would run along the valley which lies directly between these two lakes. The elevation of this valley lies above the upper surface level of Moon Lake. Much like for the Atlin-Black Mt. site, a section of trench would need to be excavated to maintain a constant downward slope from Moon Lake to Racine Lake. However, unlike for the Atlin-Black Mt. site, this trench section would be quite long at approximately 3,000 m, thereby making this site much less attractive than was predicted by the automated screening tool. Furthermore, it is difficult to envision a situation where this would be constructed in lieu of, or in addition to the Tutshi-Moon pumped-storage facility. This site was ranked in the top five sites for both the 50 GWh and 100 GWh storage configurations during the screening assessment in Section 2 of this report. However, the site was excluded from the 100 GWh analysis in lieu of the Racine-Mt. Brown site due to the high water conveyance system cost making it relatively unfavourable.

The powerhouse is located on the north shore of Racine Lake, and the transmission line would run along the valley to the north of the lake, towards Moon Lake, and then crossing Tutshi Lake. On the north-west shore of Tutshi Lake, the project's transmission line would connect to the proposed transmission line between the Yukon and Skagway, Alaska. Without construction of the proposed line, the nearest point of interconnection for this project would be a further 35 km away from the proposed facility.

3.4.4 Racine Mt. Brown

This site features a small alpine lake at high elevation to the north of Racine Lake. A penstock route would follow along the north-west slope of the ridge separating the two lakes. For the 100 GWh storage option, a saddle dam would be required to create water volume needed for the upper reservoir, while no saddle dam is needed for 50 GWh of storage.

The powerhouse is located on the north shore of Racine Lake, and the transmission line would run along the valley to the north of the lake, towards Moon Lake, and then crossing Tutshi Lake. On the north-west shore of Tutshi Lake, the project's transmission line would connect to the proposed transmission line between the Yukon and Skagway, Alaska. Without construction of the proposed line, the nearest point of interconnection for this project would be a further 35 km away from the proposed facility.



LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE
- LAKE

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- INTAKE
- DAM
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:75,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 4 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - RACINE-MOON

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1

	REV
FIGURE 3.3	0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	KK	KLA

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LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- DAM
- DAM AND INTAKE
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:75,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 4 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - RACINE-MT. BROWN

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1
FIGURE 3.4	REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	KK	KLA

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3.4.5 Lindeman-Fraser

This site consists of Lindeman Lake as a lower reservoir, with the upper reservoir formed in an alpine valley to the west of the town of Fraser. The penstock route is long, and follows to the east of a mountain that separates the two lakes, while the transmission line runs in a south-easterly direction to connect with the proposed new transmission line to Skagway, Alaska. Without the construction of this proposed line, the required transmission line distance would be approximately 50 km to the nearest point of interconnection.

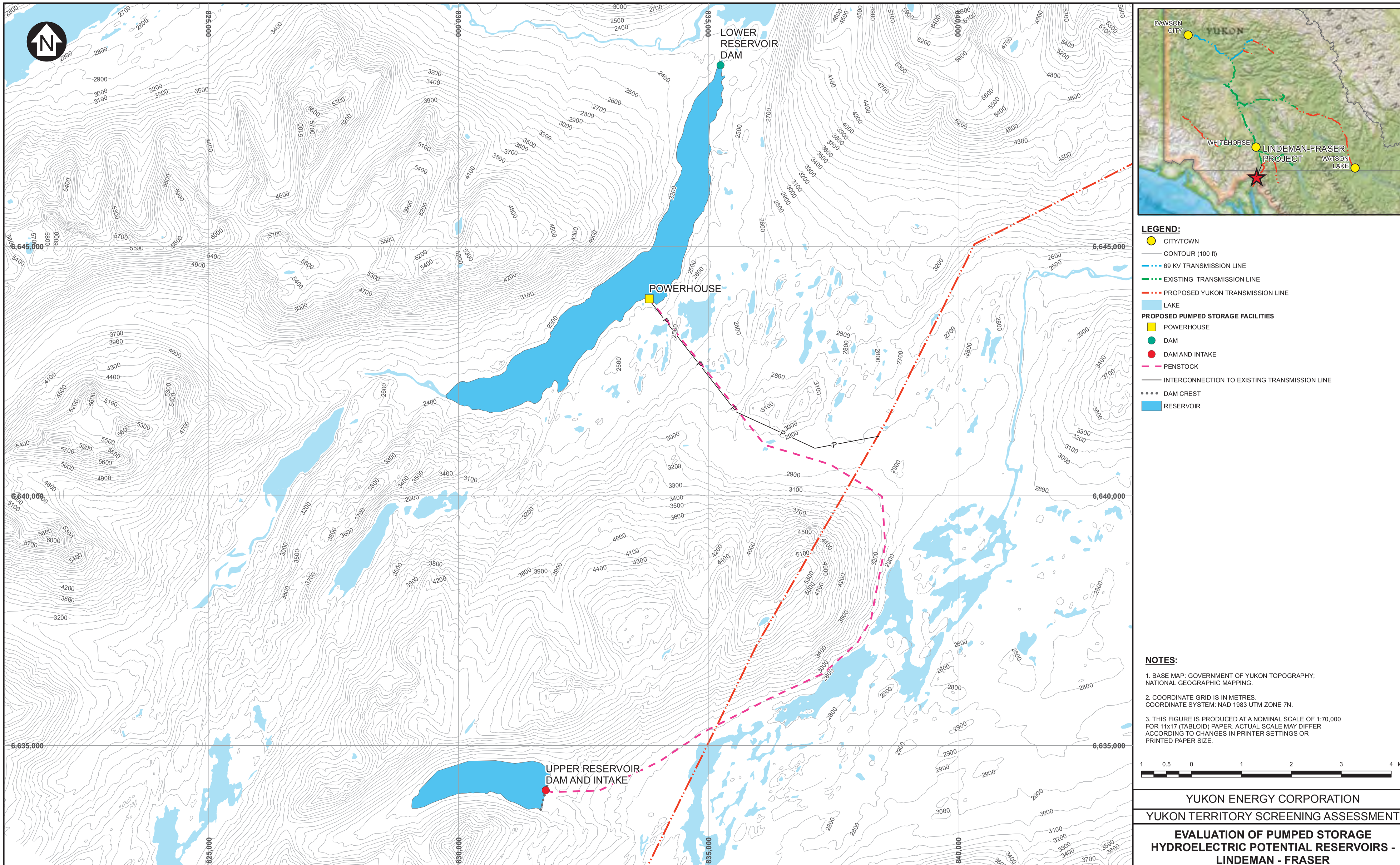
The long penstock route and the large dam required on the upper reservoir both put this site at a disadvantage. KP briefly assessed whether a tunnel through the mountain to the north of the upper reservoir may reduce overall costs by shortening the water conveyance distance. However, due to the minimum size required for tunnel construction, the small project capacity would result in a tunnel much larger than would otherwise be needed, and construction of a tunnel may actually increase, rather than decrease construction costs.

3.4.6 Squanga-Dalayee

This proposed facility is located between Squanga and Dalayee Lakes between Johnson's Crossing and Jake's Corner in the Yukon Territory. While the head is lower than some of the other highly ranked sites, the large existing lakes and short transmission distances offset the technical disadvantage of a lower head facility somewhat. The dams are relatively low (at approximately 20 m each for 100 GWh of storage), but are long due to the relatively wide valleys in which the lake outlets are situated. The penstock is a relatively direct route to the powerhouse located on the shore of Squanga Lake, less than 2 km from the nearest transmission line. The location of this facility relatively close to Whitehorse would provide advantages relative to the sites located in British Columbia at a greater distance from the Yukon's major load centre.

3.4.7 Canyon-Ittlemit

This project is located on Canyon Lake, with the upper reservoir formed by a conglomeration of a number of higher elevation lakes, including Ittlemit Lake. For the 100 GWh storage configuration, a large saddle would be required, adding to the cost of the facility. A major extension to the existing Canyon Lake dam would be required to allow construction of this facility, which will be difficult to manage without negatively impacting on flows through the Aishihik hydroelectric facility downstream. The penstock route between the two reservoirs is direct, and the transmission line would run along the western shore of Canyon Lake and the Aishihik River to the point of interconnection at the Aishihik substation. While integrating this facility on the same lake as an existing hydro facility would be challenging, it may provide potential benefits in providing additional regulation to the Aishihik hydroelectric facility. Determining the exact extent and configuration of a pumped-storage facility on Canyon Lake that would not impact the existing Aishihik facility would need to be investigated further in future project stages to determine whether it is possible.



LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE
- LAKE

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- DAM
- DAM AND INTAKE
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:70,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 4 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - LINDEMAN - FRASER

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1
FIGURE 3.5	REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	CAC	KLA

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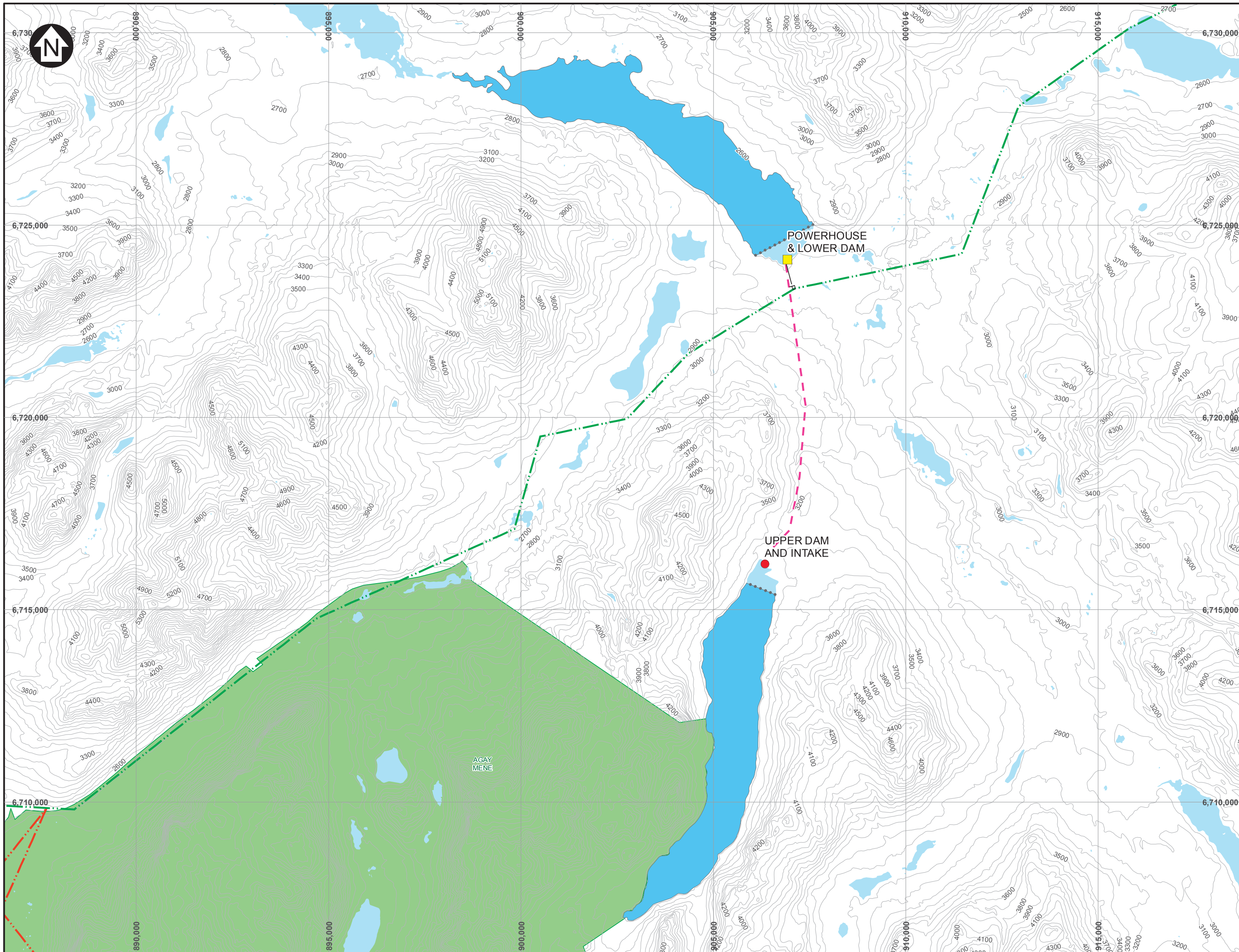

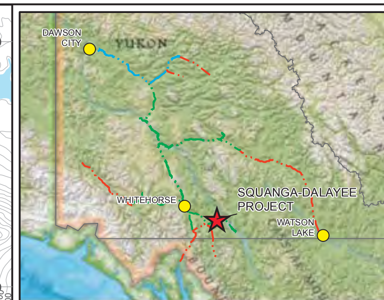

LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE
- LAKE
- PROTECTED AREA

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- DAM AND INTAKE
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:100,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 4 5 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - SQUANGA-DALAYEE

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1

FIGURE 3.6 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	KK	KLA

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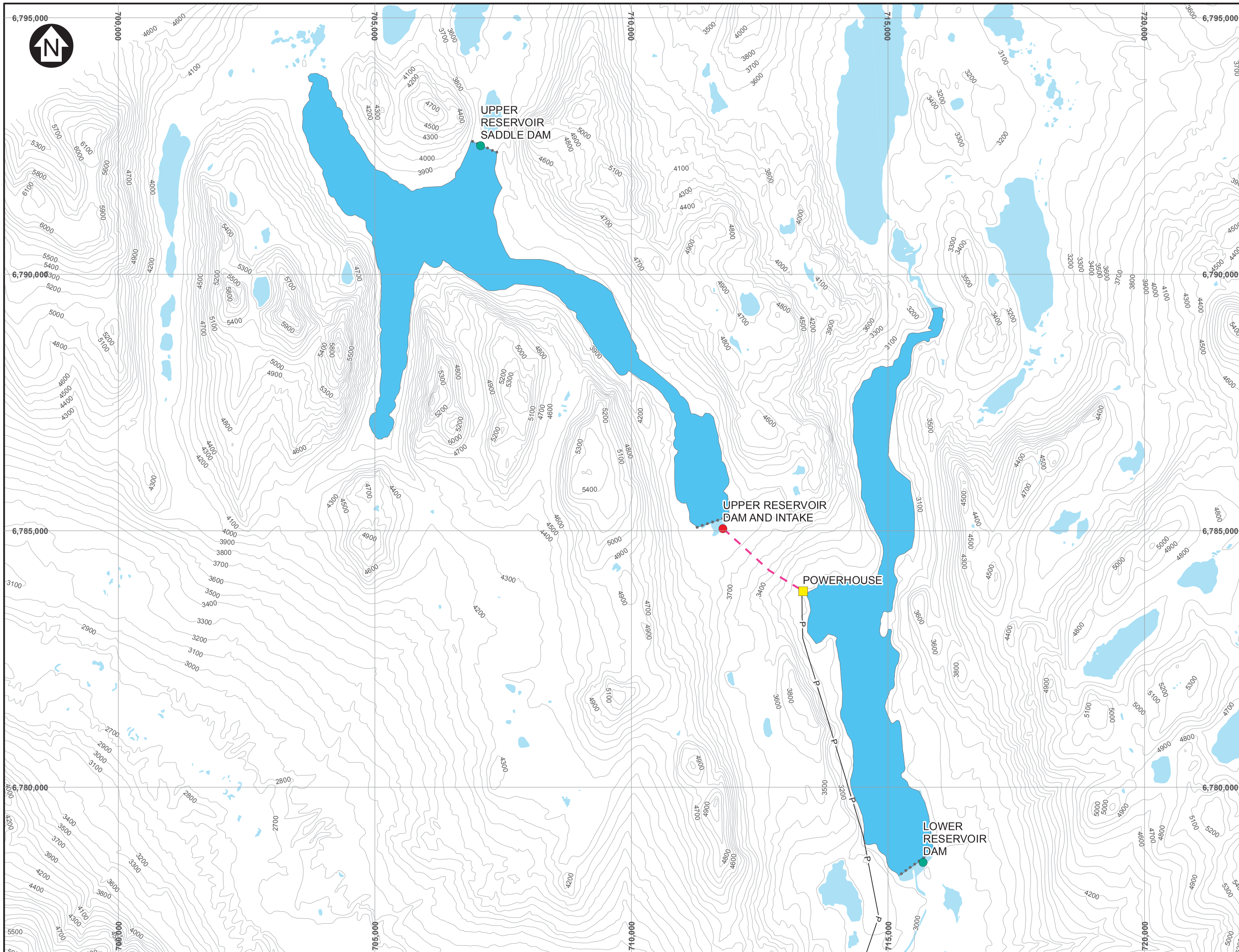

LEGEND:

- CITY/TOWN
- CONTOUR (100 ft)
- 69 KV TRANSMISSION LINE
- EXISTING TRANSMISSION LINE
- PROPOSED YUKON TRANSMISSION LINE
- LAKE

PROPOSED PUMPED STORAGE FACILITIES

- POWERHOUSE
- DAM
- DAM AND INTAKE
- PENSTOCK
- INTERCONNECTION TO EXISTING TRANSMISSION LINE
- DAM CREST
- RESERVOIR

NOTES:

1. BASE MAP: GOVERNMENT OF YUKON TOPOGRAPHY; NATIONAL GEOGRAPHIC MAPPING.
2. COORDINATE GRID IS IN METRES. COORDINATE SYSTEM: NAD 1983 UTM ZONE 7N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:75,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

1 0.5 0 1 2 3 4 km

YUKON ENERGY CORPORATION

YUKON TERRITORY SCREENING ASSESSMENT

EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL RESERVOIRS - CANYON-ITTLEMIT

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA103-00556/02	1

FIGURE 3.7 REV 0

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
0	24JUN'16	ISSUED WITH REPORT	AJB	KK	KLA

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3.5 TRANSMISSION LINE CONSIDERATIONS

For this study it has been assumed the transmission lines from each project would interconnect to the closest possible point along an existing or future proposed transmission line via “Tee-Tap” type interconnection that would require expensive substation and/or switching station infrastructure. A indicative interconnection arrangement is depicted in Figure 3.8 below:

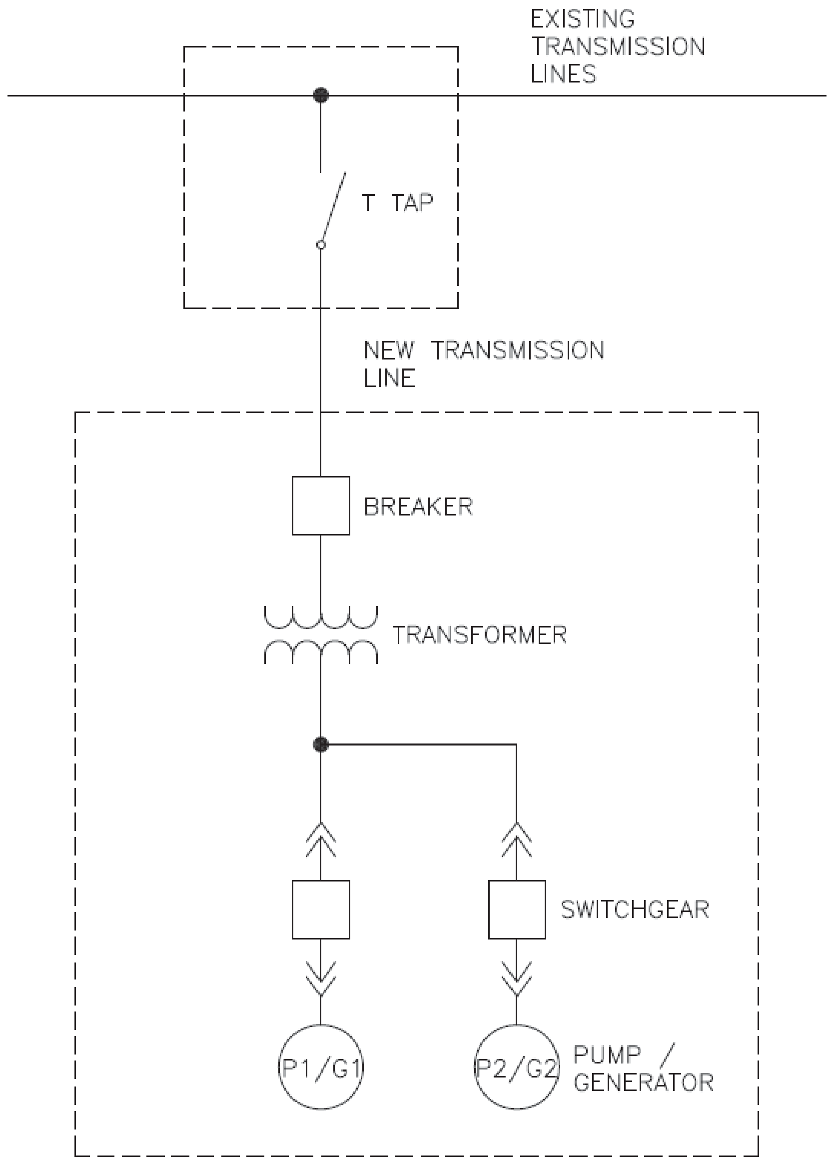

Figure 3.8 Indicative Interconnection Arrangement

However, there may be a few sites where a cheaper option exists to extend the transmission line slightly further to interconnect at an existing substation. In this case the avoided costs of building a new substation or switching station could outweigh the cost of extending the transmission line. This was not considered in this study, but should be in the next level of study.

3.6 CAPITAL COST EVALUATION

The capital cost estimates are based on the project configurations as outlined in Section 3.3. The Project Technical Attributes outlined in Table 3.1 through Table 3.4 were used to establish a size of project components, quantities and constructability. These technical attributes were used to estimate approximate material volumes for excavation, backfill, embankment material and reinforced concrete. Electrical and mechanical equipment requirements were estimated based on empirical data from KP's prior projects and published in industry technical reports.

The capital cost estimate includes an allowance for the Contractor's preliminary and general costs (overheads, insurance, bonus and profit etc.), an allowance for EPCM costs, and a variable contingency.

Unit rates for material production, equipment procurement and installation costs relied on KP's internal costing database including recent, relevant experience with similar sized hydroelectric projects in Western Canada and the Yukon Territory. KP's hydro project cost database also offered an "order of magnitude check of total estimated costs for individual facility components and complete facilities, based on projects with comparable characteristics such as, design flow, penstock pipe characteristics (length, diameter, etc.), gross head, generating capacity, powerhouse area, excavation quantities, reinforced concrete volumes, backfill quantities, switchyard capacity and transmission line capacity and length. Generating equipment costs are based on installed capacity, head and flow, while switchyard costs are interpolated based on installed capacity. Adjustments to reflect the higher construction costs in the Yukon Territory were included where appropriate. All dollars are shown in 2015 Canadian Dollars (CAD).

It is likely that capital costs will vary as more detailed assessments are undertaken. While the level of technical analysis is still preliminary, the estimates have been prepared with sufficient detail for a preliminary AACE Class 5 estimate. The analysis herein should be considered the minimum level required for an AACE Class 5 estimate, and the uncertainty in cost is likely at the higher end of the range for that Class of estimate (±50%). These costs should be used as a relative comparison estimate for other development options, rather than a reliable indication of the actual construction costs for any of these facilities.

A detailed summary of the estimated capital cost breakdown for the alternate pumped-storage project arrangements are presented in Appendix A, while the overall estimated costs for each project configuration are shown in Table 3.5.

3.7 OPERATION & MAINTENANCE COST

Operation and Maintenance (O&M) Costs have been assessed as fixed and variable (generation and pumping) costs. Fixed costs are estimated at a rate of 2.0% of the total project capital cost based on the methodology used in the BC Hydro's 2013 Resource Options Report[(1)]. This methodology assumed an estimated O&M cost at a rate of 1% of the total project capital cost for 1000 MW fresh water pumped storage sites and 1.5% for 500 MW fresh water pumped storage sites. By linear extrapolation of percent of capital versus project capacity there is a marginal difference between 15MW and 25 MW pumped storage sites, and a single value of 2.0% has been assumed.

1. Reference. Appendix 9A Section 3.2.4, viewed at: http://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/regulatory-planning-documents/integrated-resource-plans/current-plan/ror-update-appx-9a-20130802.pdf.

It should be noted that estimating fixed operating costs based on a percentage of capital cost is considered a reasonable approach for a conceptual level study. Once final general arrangement layouts of the various alternatives have been developed a more accurate estimation of fixed operating costs can be made that would typically include cost items such as:

- YEC Corporate Overhead
- Operations Staff Salaries and Benefits
- Provincial/Territory Resource Fees: Water Rental (Capacity, Energy Charge, Water Storage Charges), Land Rents and annual operating permits
- Regularly Scheduled Operations and Maintenance Costs
- Insurance, and
- Property and Corporate Taxes.

Variable O&M costs include the cost of energy to pump water from the lower reservoir to the upper reservoir at \$0.05/kWh and the cost of generation and an equivalent value of \$0.05/kWh. These values are estimated based on KP's experience and actual costs will depend on generation to pumping ratios which vary depending on pump-turbine technology and manufacturer.

3.8 FINANCIAL EVALUATION

KP has developed an in house financial model to assess the Levelized Cost of Energy (LCOE) and Levelized Cost of Capacity (LCOC) for the pumped-storage project configurations. The basic parameters used in the financial model include:

- Capital Cost Estimate — Varies by alternative
- Annual Fixed Operating Costs — 2.0% of initial capital cost
- Variable Operating Costs — 0.5¢/kWh of either pumping or generating
- Annual Generating Energy — 50 or 100 GWh
- Annual Pumping Energy — Varies by alternative
- Construction Period — 48 months
- Project Life — 65 years

No time value of money nor escalation/inflation is included in the financial evaluation, but interest rates are assumed for the real cost of capital as follows:

- YEC resource options — 3.38%
- IPP resource options — 4.61%
- High interest scenario — 8.82%

The loaded capital cost, or net present cost at Commercial Operation Date (COD) is calculated to take into account any interest accrued during construction, using the following formula:

$$C = \sum_{\mathrm{yr}=0}^{\mathrm{n}} \mathrm{c}(1+i)^{\mathrm{n}-\mathrm{yr}}$$

Where:

$$C = loaded\ capital\ cost$$
$$c = construction\ cost\ in\ given\ year\ of\ interest$$
$$yr = construction\ year\ of\ interest$$

$$n = total\ number\ of\ years\ of\ construction\ (4)$$
$$i = interest\ rate$$

Next, the levelized capital cost per year is calculated using the capital recovery factor formula:

$$LC = \frac{iC(1+i)^N}{(1+i)^N - 1}$$

Where:

$$LC = levelized\ capital\ cost\ per\ year$$
$$N = total\ project\ life$$

A summary of the project financial attributes is included in Table 3.5, and further detail is provided in Appendix B. Note that the summary Table 3.5 only provides levelized cost results for the assume YEC development real cost of capital rate of 3.38%. Refer to the detail provided in Appendix B for the evaluation undertaken using alternate interest rates.

TABLE 3.5

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

COST, ENERGY AND FINANCIAL SUMMARY

9/27/2016 12:51

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser	Squanga-Dalayee	Canyon-Ittlemit
15 MW 50 GWh	Installed Capacity (MW)	15	15	15	15	15	-	-
	Annual Generation (GWh)	50	50	50	50	50	-	-
	Annual Pumping (GWh)	26.7	59.5	51.8	31.8	55.8	-	-
	Overnight Capital Cost ($)	$220,000,000	$235,000,000	$263,000,000	$438,000,000	$448,000,000		
YEC Rate (3.38%)	**LCOE ($/kWh)**	**$0.28**	**$0.30**	**$0.33**	**$0.54**	**$0.56**	-	-
	LCOC ($/kW-yr)	**$900**	**$1,000**	**$1,100**	**$1,800**	**$1,900**	-	-
IPP Rate (4.61%)	**LCOE ($/kWh)**	**$0.33**	**$0.36**	**$0.40**	**$0.66**	**$0.67**	-	-
	LCOC ($/kW-yr)	**$1,100**	**$1,200**	**$1,300**	**$2,200**	**$2,200**	-	-
High Rate (8.82%)	**LCOE ($/kWh)**	**$0.36**	**$0.38**	**$0.43**	**$0.70**	**$0.72**	-	-
	LCOC ($/kW-yr)	**$1,200**	**$1,300**	**$1,400**	**$2,300**	**$2,400**	-	-
15 MW 100 GWh	Installed Capacity (MW)	15	15	15	-	-	15	15
	Annual Generation (GWh)	100	100	100	-	-	100	100
	Annual Pumping (GWh)	88.5	121.3	113.6	-	-	119.7	119.9
	Overnight Capital Cost ($)	$300,000,000	$411,000,000	$420,000,000	-	-	$525,000,000	$621,000,000
YEC Rate (3.38%)	**LCOE ($/kWh)**	**$0.19**	**$0.26**	**$0.27**	**-**	**-**	**$0.34**	**$0.49**
	LCOC ($/kW-yr)	**$1,300**	**$1,800**	**$1,800**	**-**	**-**	**$2,200**	**$3,300**
IPP Rate (4.61%)	**LCOE ($/kWh)**	**$0.23**	**$0.32**	**$0.32**	**-**	**-**	**$0.41**	**$0.59**
	LCOC ($/kW-yr)	**$1,500**	**$2,100**	**$2,100**	**-**	**-**	**$2,700**	**$3,900**
High Rate (8.82%)	**LCOE ($/kWh)**	**$0.25**	**$0.34**	**$0.34**	**-**	**-**	**$0.43**	**$0.63**
	LCOC ($/kW-yr)	**$1,600**	**$2,200**	**$2,300**	**-**	**-**	**$2,900**	**$4,200**
25 MW 50 GWh	Installed Capacity (MW)	25	25	25	25	25	-	-
	Annual Generation (GWh)	50	50	50	50	50	-	-
	Annual Pumping (GWh)	26.7	59.5	51.8	31.8	55.8	-	-
	Overnight Capital Cost ($)	$257,000,000	$262,000,000	$301,000,000	$490,000,000	$515,000,000		
YEC Rate (3.38%)	**LCOE ($/kWh)**	**$0.32**	**$0.33**	**$0.38**	**$0.61**	**$0.64**	-	-
	LCOC ($/kW-yr)	**$650**	**$660**	**$760**	**$1,200**	**$1,300**	-	-
IPP Rate (4.61%)	**LCOE ($/kWh)**	**$0.39**	**$0.40**	**$0.46**	**$0.73**	**$0.77**	-	-
	LCOC ($/kW-yr)	**$780**	**$800**	**$900**	**$1,500**	**$1,500**	-	-
High Rate (8.82%)	**LCOE ($/kWh)**	**$0.42**	**$0.43**	**$0.49**	**$0.79**	**$0.83**	-	-
	LCOC ($/kW-yr)	**$830**	**$850**	**$1,000**	**$1,600**	**$1,700**	-	-
25 MW 100 GWh	Installed Capacity (MW)	25	25	25	-	-	25	25
	Annual Generation (GWh)	100	100	100	-	-	100	100
	Annual Pumping (GWh)	88.5	121.3	113.6	-	-	119.7	119.9
	Overnight Capital Cost ($)	$329,000,000	$430,000,000	$450,000,000	-	-	$568,000,000	$640,000,000
YEC Rate (3.38%)	**LCOE ($/kWh)**	**$0.21**	**$0.27**	**$0.29**	**-**	**-**	**$0.36**	**$0.53**
	LCOC ($/kW-yr)	**$840**	**$1,100**	**$1,100**	**-**	**-**	**$1,400**	**$2,100**
IPP Rate (4.61%)	**LCOE ($/kWh)**	**$0.25**	**$0.33**	**$0.34**	**-**	**-**	**$0.44**	**$0.63**
	LCOC ($/kW-yr)	**$1,000**	**$1,300**	**$1,400**	**-**	**-**	**$1,700**	**$2,500**
High Rate (8.82%)	**LCOE ($/kWh)**	**$0.27**	**$0.35**	**$0.37**	**-**	**-**	**$0.47**	**$0.68**
	LCOC ($/kW-yr)	**$1,100**	**$1,400**	**$1,500**	**-**	**-**	**$1,900**	**$2,700**

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NOTES:

1. FINANCIAL SUMMARY ASSUMES REAL COST OF CAPITAL OF 3.38%, 4.61% AND 8.82% FOR YEC, IPP AND HIGH INTEREST DEVELOPMENT SCENARIOS RESPECTIVELY.
2. NO ASSESSMENT OF THE TIME VALUE OF MONEY IS INCLUDED.

2	24SEP'16	ISSUED WITH REPORT	TJB	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

3.9 DEVELOPMENT SCHEDULE

A high level development schedule has been developed to illustrate the relative time lines for completing critical tasks associated with developing any pumped-storage project. Since the relative timelines for completing the major development tasks is similar for each pumped-storage project described above, this schedule should be taken as indicative. The major development tasks and time lines are listed below and presented in as a Gantt chart on Figure 3.9.

1. Feasibility Study – 1 year
    - Will require on site hydrology data that will require a minimum of one year of data collection
2. Environmental Assessment (Permitting and Baseline Studies) – 2 years (will start concurrent with Feasibiltiy Study)
    - Will include fisheries, hydrological and wildlife/terrestrial studies that will be inputs to the Environmental Assessment for each project
3. EPC Tendering Process – 1 year
    - EPC tender design can start immediately after Feasibility Study
4. Construction – 4 years
    - Will commence once Environmental Assessment Certificate is received and EPC contractor is selected
5. Commissioning – 4-6 months
    - Can start after Construction
6. Operations – 65 years

The minimum total development duration from the start of the Feasibility Study through to the end of Commissioning is approximately 6.5 years.

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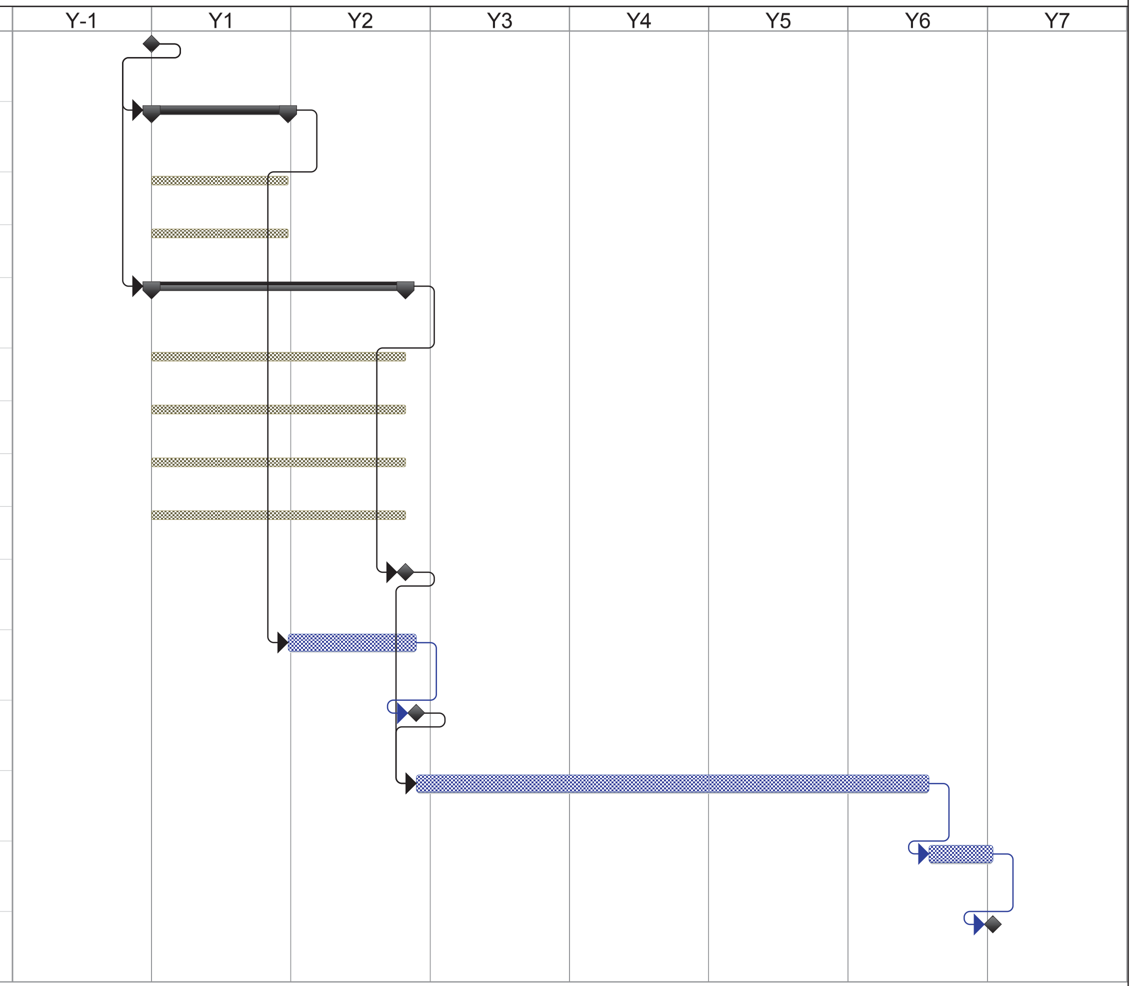
FIGURE 3.9

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT
DEVELOPMENT SCHEDULE - MAJOR TASKS

Print: Thu 6/30/16 2:59 PM

ID	WBS	Task Name
1	1	Notice to Proceed
2	2	Feasibility Study
3	2.1	Prefeasibility Engineering
4	2.2	Hydrology Assessment
5	3	Environmental & Social Assessment
6	3.1	Fisheries Studies
7	3.2	Wildlife & Terrestrial Studies
8	3.3	First Nations Consultation
9	3.4	Stakeholder Consultation
10	4	Environmental Certificate
11	5	EPC Tendering Process
12	6	Award EPC Contract
13	7	Construction
14	8	Commissioning
15	9	Commence Operation (65 Year Duration)



Project: VA103-00556/02-A/1
Date: Thu 6/30/16
By: Daniel Rohn

Task — Milestone — Task with Subtask(s) — Subtask

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4 – CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

A screening assessment of pumped-storage potential in the Yukon Territory has been undertaken and has examined a large area of the territory for potential sites. A total of 473 potential reservoir basins were assessed, yielding over 200 sites that were shown to be technically viable. The top ranked (preferred) sites were evaluated further, yielding the following results:

- 15 MW capacity and 50GWh storage configuration has a minimum $0.28/kWh LCOE and $900/kW-yr LCOC for the Tutshi-Moon facility
- 15 MW capacity and 100GWh storage configuration has a minimum $0.19/kWh LCOE and $1,300/kW-yr LCOC for the Tutshi-Moon facility
- 25 MW capacity and 50GWh storage configuration has a minimum $0.32/kWh LCOE and $650/kW-yr LCOC for the Tutshi-Moon facility, and
- 25 MW capacity and 100GWh storage configuration has a minimum $0.21/kWh LCOE and $840/kW-yr LCOC for the Tutshi-Moon facility.

In all cases, the Tutshi-Moon pumped-storage project was evaluated as the most cost-effective, which is encouraging given that it appears this is the facility for which YEC has currently expended the most effort in evaluating. The Atlin-Black Mt. and Racine-Mt. Brown facilities also have similarly competitive costs, particularly for the 50 GWh configurations. The Racine-Moon facility has technical constraints that make it less promising, as does the Lindeman-Fraser facility. The Squanga-Dalayee and Canyon-Ittlemit facilities are less cost effective than the Tutshi-Moon, Atlin-Black Mt. and Racine-Mt. Brown facilities, but warrant further investigation due to their relative proximity to existing YEC infrastructure, in comparison to the three projects located south of the BC border. It is not known at this stage whether a viable project configuration can be found for the Canyon-Ittlemit facility that does not negatively impact the existing Aishihik hydro facility, but this should be investigated further in future project stages.

The lowest LCOC ($650/kW-yr) is achieved with the 25 MW/50 GWh configuration (Table 4.1), suggesting that there is a trade-off between cost of stored energy and capacity for pumped-storage facilities. Conversely, the lowest LCOE ($0.19/kWh) is achieved with the 15 MW/100 GWh configuration (Table 4.2), suggesting that increasing storage volume and lowering installed capacity tends to optimise cost of stored energy. In contrast to typical pumped-storage facilities where daily or hourly load shaping is targeted, YEC requested KP to evaluate seasonal storage durations. Much lower LCOC could be achieved by reducing the energy storage requirement to a shorter period (10 days for example). Such a facility would not provide seasonal storage and shifting of energy from summer to winter months (as desired by YEC), but would provide additional security against unexpected outages of a key YEC hydro facility or transmission lines in the high-demand winter period.

TABLE 4.1

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT SUMMARY - LOWEST COST CAPACITY

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
	Installed Capacity (MW)	25	25	25	25	25
	Dependable Capacity (MW)	25	25	25	25	25
	Annual Generation (GWh)	50	50	50	50	50
	Annual Pumping (GWh)	26.7	59.5	51.8	31.8	55.8
	Monthly Generation, Winter (GWh)	7.1	7.1	7.1	7.1	7.1
	Monthly Pumping, Summer (GWh)	5.3	11.9	10.4	6.4	11.2
	Overnight Capital Cost ($)	$257,000,000	$262,000,000	$301,000,000	$490,000,000	$515,000,000
	Fixed O&M Costs ($/yr)	$5,140,000	$5,240,000	$6,020,000	$9,800,000	$10,300,000
	Variable O&M Costs ($/yr)	$384,000	$548,000	$509,000	$409,000	$529,000
	Transmission Line Length to Point of Interconnection (km)	2.6	0.8	24.0	20.0	5.0
YEC Rate (3.38%)	**LCOE ($/kWh)**	**$0.32**	**$0.33**	**$0.38**	**$0.61**	**$0.64**
	LCOC ($/kW-yr)	**$650**	**$660**	**$760**	**$1,200**	**$1,300**
IPP Rate (4.61%)	**LCOE ($/kWh)**	**$0.39**	**$0.40**	**$0.46**	**$0.73**	**$0.77**
	LCOC ($/kW-yr)	**$780**	**$800**	**$900**	**$1,500**	**$1,500**
High Rate (8.82%)	**LCOE ($/kWh)**	**$0.44**	**$0.45**	**$0.52**	**$0.83**	**$0.88**
	LCOC ($/kW-yr)	**$880**	**$910**	**$1,000**	**$1,700**	**$1,800**

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NOTES:

1. FINANCIAL SUMMARY ASSUMES REAL COST OF CAPITAL OF 3.38%, 4.61% AND 8.82% FOR YEC, IPP AND HIGH INTEREST DEVELOPMENT SCENARIOS RESPECTIVELY.
2. NO ASSESSMENT OF THE TIME VALUE OF MONEY IS INCLUDED.

2	24SEP'16	ISSUED WITH REPORT	TJB	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

TABLE 4.2

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT SUMMARY - LOWEST COST OF ENERGY

9/27/2016 12:12

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
	Installed Capacity (MW)	15	15	15	15	15
	Annual Generation (GWh)	100	100	100	100	100
	Annual Pumping (GWh)	88.5	121.3	113.6	119.7	119.9
	Monthly Generation, Winter (GWh)	14.3	14.3	14.3	14.3	14.3
	Monthly Pumping, Summer (GWh)	17.7	24.3	22.7	23.9	24.0
	Overnight Capital Cost ($)	$300,000,000	$411,000,000	$420,000,000	$525,000,000	$621,000,000
	Fixed O&M Costs ($/yr)	$6,000,000	$8,220,000	$8,400,000	$10,500,000	$12,420,000
	Variable O&M Costs ($/yr)	$943,000	$1,107,000	$1,068,000	$1,099,000	$1,100,000
	Transmission Line Length to Point of Interconnection (km)	2.6	0.8	24.0	0.8	13.9
YEC Rate (3.38%)	**LCOE ($/kWh)**	**$0.19**	**$0.26**	**$0.27**	**$0.33**	**$0.39**
	LCOC ($/kW-yr)	**$1,300**	**$1,800**	**$1,800**	**$2,200**	**$2,600**
IPP Rate (4.61%)	**LCOE ($/kWh)**	**$0.23**	**$0.32**	**$0.32**	**$0.40**	**$0.47**
	LCOC ($/kW-yr)	**$1,500**	**$2,100**	**$2,100**	**$2,700**	**$3,100**
High Rate (8.82%)	**LCOE ($/kWh)**	**$0.25**	**$0.34**	**$0.34**	**$0.43**	**$0.50**
	LCOC ($/kW-yr)	**$1,600**	**$2,200**	**$2,300**	**$2,800**	**$3,400**

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NOTES:

1. FINANCIAL SUMMARY ASSUMES REAL COST OF CAPITAL OF 3.38%, 4.61% AND 8.82% FOR YEC, IPP AND HIGH INTEREST DEVELOPMENT SCENARIOS RESPECTIVELY.

2. NO ASSESSMENT OF THE TIME VALUE OF MONEY IS INCLUDED.

2	24SEP'16	ISSUED WITH REPORT	TJB	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

4.2 RECOMMENDATIONS

Further evaluation of pumped-storage facilities will depend on YEC's desired mix of generation options in the future. While the most effective sites have been identified, the financial viability would have to be assessed by evaluating the potential for any pumped-storage facility to offset diesel, LNG or other costly fuel sources, which KP understand currently only constitute a small percentage of YEC's generation. If it is expected that a pumped-storage facility will offset a significant amount of costly diesel or LNG fuel in the future, further assessment of pumped-storage projects may be warranted.

It is recommended that the following steps be undertaken as part of further assessing the preferred pumped-storage facilities identified in this study:

1. Preliminary site visits to the following projects to evaluate technical viability further:
    - Tutshi-Moon
    - Atlin-Black Mt.
    - Racine-Mt. Brown
    - Squanga-Dalayee
    - Canyon-Ittlemit
2. Prepare depth-area-capacity curves and dam construction volume vs. height curves for these five facilities to better estimate dam construction volumes and costs. This would require the acquisition of more detailed topographic data, such as PhotoSat satellite topographic data.
3. Update Capital Cost estimates based on more accurate construction quantities.
4. Screening assessment of social and environmental permitting constraints at each of the five proposed facilities.

Should the above assessment indicate that there are no technical or environmental showstoppers, further evaluation of the sites through detailed prefeasibility and feasibility studies should be pursued to prove the business case for construction of any of the proposed facilities.

5 – CERTIFICATION

This report was prepared and reviewed by the undersigned.

PROFESSIONAL
30 September 2016
YUKON
TRAVIS JESS BROWN
TERRITORY
ENGINEER

Prepared:

Travis Brown, P.Eng.
Senior Engineer

Reviewed:

Keith Ainsley, P.Eng.
Senior Engineer

Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX A

COST ESTIMATE SUMMARIES

(Pages A-1 to A-4)

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TABLE A.1

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

CAPITAL COST ESTIMATE OF PREFERRED SITES
SUMMARY OF RESULTS - 15 MW, 50 GWh

13/04/2016 14:58

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
100	MOB, DEMOB, INSURANCE, BONDS, OVERHEADS, CONTRACTOR'S PROFIT	$ 37,000,000	$ 39,000,000	$ 44,000,000	$ 73,000,000	$ 75,000,000
200	ACCESS AND SITE PREPARATION	$ 6,000,000	$ 3,000,000	$ 18,000,000	$ 18,000,000	$ 15,000,000
300	INTAKE, FOREBAY, HEADRACE AND TAILRACE	$ 20,000,000	$ 16,000,000	$ 18,000,000	$ 19,000,000	$ 18,000,000
400	WATER CONVEYANCE SYSTEM	$ 25,000,000	$ 21,000,000	$ 22,000,000	$ 129,000,000	$ 70,000,000
500	POWERHOUSE AND ANCILLARY SERVICES	$ 11,000,000	$ 11,000,000	$ 11,000,000	$ 11,000,000	$ 11,000,000
600	POWER GENERATION EQUIPMENT (WATER TO WIRE)	$ 9,000,000	$ 9,000,000	$ 9,000,000	$ 9,000,000	$ 9,000,000
700	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	$ 5,000,000	$ 4,000,000	$ 20,000,000	$ 18,000,000	$ 7,000,000
800	UPPER STORAGE DAM(S) AND RESERVOIR	$ 29,000,000	$ 66,000,000	$ 38,000,000	$ 23,000,000	$ 119,000,000
900	LOWER STORAGE DAM AND RESERVOIR	$ 17,000,000	$ 1,000,000	$ 11,000,000	$ 18,000,000	$ 1,000,000
	SUB-TOTAL	**$ 159,000,000**	**$ 170,000,000**	**$ 191,000,000**	**$ 318,000,000**	**$ 325,000,000**
	EPCM ENGINEERING COST (8 % of ESTIMATED CONSTRUCTION COST)	$ 13,000,000	$ 14,000,000	$ 15,000,000	$ 25,000,000	$ 26,000,000
	CONTINGENCY (30 % of ESTIMATED CONSTRUCTION COST)	$ 48,000,000	$ 51,000,000	$ 57,000,000	$ 95,000,000	$ 97,000,000
	TOTAL ESTIMATED CAPITAL COST	**$ 220,000,000**	**$ 235,000,000**	**$ 263,000,000**	**$ 438,000,000**	**$ 448,000,000**

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NOTES:
1. TOTAL ESTIMATED CAPITAL COST DOES NOT INCLUDE UPFRONT ENVIRONMENTAL, PERMITTING AND OWNERS COSTS.
2. TOTAL ESTIMATED CAPITAL COSTS DO NOT INCLUDE APPLICABLE SALES TAXES.
3. EPCM COSTS INCLUDE DETAILED ENGINEERING, TENDERING OF CIVIL AND WATER-TO-WIRE CONTRACTS, SITE SUPERVISION, OVERALL PROJECT MANAGEMENT AND ENVIRONMENTAL MONITORING.
4. COSTS ARE PRELIMINARY AND ARE CONSIDERED EQUIVALENT TO AN AACE CLASS 5 ESTIMATE.

0	12APR'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

Knight Piésold CONSULTING

TABLE A.2

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

CAPITAL COST ESTIMATE OF PREFERRED SITES
SUMMARY OF RESULTS - 15 MW, 100 GWh

13/04/2016 14:53

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
100	MOB, DEMOB, INSURANCE, BONDS, OVERHEADS, CONTRACTOR'S PROFIT	$ 50,000,000	$ 69,000,000	$ 70,000,000	$ 88,000,000	$ 104,000,000
200	ACCESS AND SITE PREPARATION	$ 6,000,000	$ 3,000,000	$ 18,000,000	$ 7,000,000	$ 9,000,000
300	INTAKE, FOREBAY, HEADRACE AND TAILRACE	$ 20,000,000	$ 16,000,000	$ 19,000,000	$ 19,000,000	$ 25,000,000
400	WATER CONVEYANCE SYSTEM	$ 25,000,000	$ 21,000,000	$ 22,000,000	$ 50,000,000	$ 11,000,000
500	POWERHOUSE AND ANCILLARY SERVICES	$ 16,000,000	$ 16,000,000	$ 16,000,000	$ 16,000,000	$ 16,000,000
600	POWER GENERATION EQUIPMENT (WATER TO WIRE)	$ 9,000,000	$ 9,000,000	$ 9,000,000	$ 9,000,000	$ 9,000,000
700	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	$ 5,000,000	$ 4,000,000	$ 20,000,000	$ 4,000,000	$ 13,000,000
800	UPPER STORAGE DAM(S) AND RESERVOIR	$ 56,000,000	$ 159,000,000	$ 115,000,000	$ 76,000,000	$ 172,000,000
900	LOWER STORAGE DAM AND RESERVOIR	$ 30,000,000	$ 1,000,000	$ 16,000,000	$ 112,000,000	$ 91,000,000
	SUB-TOTAL	**$ 217,000,000**	**$ 298,000,000**	**$ 305,000,000**	**$ 381,000,000**	**$ 450,000,000**
	EPCM ENGINEERING COST (8 % of ESTIMATED CONSTRUCTION COST)	$ 17,000,000	$ 24,000,000	$ 24,000,000	$ 30,000,000	$ 36,000,000
	CONTINGENCY (30 % of ESTIMATED CONSTRUCTION COST)	$ 66,000,000	$ 89,000,000	$ 91,000,000	$ 114,000,000	$ 135,000,000
	TOTAL ESTIMATED CAPITAL COST	**$ 300,000,000**	**$ 411,000,000**	**$ 420,000,000**	**$ 525,000,000**	**$ 621,000,000**

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Preferred Sites\[Cost_Technical_Financial_15 MW, 100 GWh.xlsx]Cost Summary

NOTES:
1. TOTAL ESTIMATED CAPITAL COST DOES NOT INCLUDE UPFRONT ENVIRONMENTAL, PERMITTING AND OWNERS COSTS.
2. TOTAL ESTIMATED CAPITAL COSTS DO NOT INCLUDE APPLICABLE SALES TAXES.
3. EPCM COSTS INCLUDE DETAILED ENGINEERING, TENDERING OF CIVIL AND WATER-TO-WIRE CONTRACTS, SITE SUPERVISION, OVERALL PROJECT MANAGEMENT AND ENVIRONMENTAL MONITORING.
4. COSTS ARE PRELIMINARY AND ARE CONSIDERED EQUIVALENT TO AN AACE CLASS 5 ESTIMATE.

0	12APR'16	ISSUED WITH REPORT VA103.-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

Knight Piésold CONSULTING

TABLE A.3

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

CAPITAL COST ESTIMATE OF PREFERRED SITES
SUMMARY OF RESULTS - 25 MW, 50 GWh

13/04/2016 14:55

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
100	MOB, DEMOB, INSURANCE, BONDS, OVERHEADS, CONTRACTOR'S PROFIT	$ 43,000,000	$ 44,000,000	$ 50,000,000	$ 82,000,000	$ 86,000,000
200	ACCESS AND SITE PREPARATION	$ 6,000,000	$ 3,000,000	$ 18,000,000	$ 18,000,000	$ 15,000,000
300	INTAKE, FOREBAY, HEADRACE AND TAILRACE	$ 20,000,000	$ 16,000,000	$ 18,000,000	$ 20,000,000	$ 18,000,000
400	WATER CONVEYANCE SYSTEM	$ 34,000,000	$ 24,000,000	$ 31,000,000	$ 145,000,000	$ 95,000,000
500	POWERHOUSE AND ANCILLARY SERVICES	$ 16,000,000	$ 16,000,000	$ 16,000,000	$ 16,000,000	$ 16,000,000
600	POWER GENERATION EQUIPMENT (WATER TO WIRE)	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000
700	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	$ 6,000,000	$ 5,000,000	$ 21,000,000	$ 19,000,000	$ 8,000,000
800	UPPER STORAGE DAM(S) AND RESERVOIR	$ 29,000,000	$ 66,000,000	$ 38,000,000	$ 23,000,000	$ 119,000,000
900	LOWER STORAGE DAM AND RESERVOIR	$ 17,000,000	$ 1,000,000	$ 11,000,000	$ 18,000,000	$ 1,000,000
	SUB-TOTAL	**$ 186,000,000**	**$ 190,000,000**	**$ 218,000,000**	**$ 356,000,000**	**$ 373,000,000**
	EPCM ENGINEERING COST (8 % of ESTIMATED CONSTRUCTION COST)	$ 15,000,000	$ 15,000,000	$ 17,000,000	$ 28,000,000	$ 30,000,000
	CONTINGENCY (30 % of ESTIMATED CONSTRUCTION COST)	$ 56,000,000	$ 57,000,000	$ 66,000,000	$ 106,000,000	$ 112,000,000
	TOTAL ESTIMATED CAPITAL COST	**$ 257,000,000**	**$ 262,000,000**	**$ 301,000,000**	**$ 490,000,000**	**$ 515,000,000**

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Preferred Sites\[Cost_Technical_Financial_25 MW, 50 GWh.xlsx]Cost Summary

NOTES:

1. TOTAL ESTIMATED CAPITAL COST DOES NOT INCLUDE UPFRONT ENVIRONMENTAL, PERMITTING AND OWNERS COSTS.
2. TOTAL ESTIMATED CAPITAL COSTS DO NOT INCLUDE APPLICABLE SALES TAXES.
3. EPCM COSTS INCLUDE DETAILED ENGINEERING, TENDERING OF CIVIL AND WATER-TO-WIRE CONTRACTS, SITE SUPERVISION, OVERALL PROJECT MANAGEMENT AND ENVIRONMENTAL MONITORING.
4. COSTS ARE PRELIMINARY AND ARE CONSIDERED EQUIVALENT TO AN AACE CLASS 5 ESTIMATE.

0	12APR'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

Knight Piésold CONSULTING

TABLE A.4

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

CAPITAL COST ESTIMATE OF PREFERRED SITES
SUMMARY OF RESULTS - 25 MW, 100 GWh

13/04/2016 15:01

ITEM	DESCRIPTION	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
100	MOB, DEMOB, INSURANCE, BONDS, OVERHEADS, CONTRACTOR'S PROFIT	$ 55,000,000	$ 72,000,000	$ 75,000,000	$ 95,000,000	$ 107,000,000
200	ACCESS AND SITE PREPARATION	$ 6,000,000	$ 3,000,000	$ 18,000,000	$ 7,000,000	$ 9,000,000
300	INTAKE, FOREBAY, HEADRACE AND TAILRACE	$ 20,000,000	$ 16,000,000	$ 19,000,000	$ 19,000,000	$ 25,000,000
400	WATER CONVEYANCE SYSTEM	$ 34,000,000	$ 24,000,000	$ 31,000,000	$ 67,000,000	$ 15,000,000
500	POWERHOUSE AND ANCILLARY SERVICES	$ 16,000,000	$ 16,000,000	$ 16,000,000	$ 16,000,000	$ 16,000,000
600	POWER GENERATION EQUIPMENT (WATER TO WIRE)	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000	$ 15,000,000
700	SWITCHYARD, TRANSMISSION AND INTERCONNECTION	$ 6,000,000	$ 5,000,000	$ 21,000,000	$ 5,000,000	$ 14,000,000
800	UPPER STORAGE DAM(S) AND RESERVOIR	$ 56,000,000	$ 159,000,000	$ 115,000,000	$ 76,000,000	$ 172,000,000
900	LOWER STORAGE DAM AND RESERVOIR	$ 30,000,000	$ 1,000,000	$ 16,000,000	$ 112,000,000	$ 91,000,000
	SUB-TOTAL	**$ 238,000,000**	**$ 311,000,000**	**$ 326,000,000**	**$ 412,000,000**	**$ 464,000,000**
	EPCM ENGINEERING COST (8 % of ESTIMATED CONSTRUCTION COST)	$ 19,000,000	$ 25,000,000	$ 26,000,000	$ 33,000,000	$ 37,000,000
	CONTINGENCY (30 % of ESTIMATED CONSTRUCTION COST)	$ 72,000,000	$ 94,000,000	$ 98,000,000	$ 123,000,000	$ 139,000,000
	TOTAL ESTIMATED CAPITAL COST	**$ 329,000,000**	**$ 430,000,000**	**$ 450,000,000**	**$ 568,000,000**	**$ 640,000,000**

M:\1\03\00556\02\A\Data\Task 300 - Pumped Storage\Preferred Sites\[Cost_Technical_Financial_25 MW, 100 GWh.xlsx]Cost Summary

NOTES:
1. TOTAL ESTIMATED CAPITAL COST DOES NOT INCLUDE UPFRONT ENVIRONMENTAL, PERMITTING AND OWNERS COSTS.
2. TOTAL ESTIMATED CAPITAL COSTS DO NOT INCLUDE APPLICABLE SALES TAXES.
3. EPCM COSTS INCLUDE DETAILED ENGINEERING, TENDERING OF CIVIL AND WATER-TO-WIRE CONTRACTS, SITE SUPERVISION, OVERALL PROJECT MANAGEMENT AND ENVIRONMENTAL MONITORING.
4. COSTS ARE PRELIMINARY AND ARE CONSIDERED EQUIVALENT TO AN AACE CLASS 5 ESTIMATE.

REV	DATE	DESCRIPTION	PREP'D	CHK'D
0	12APR'16	ISSUED WITH REPORT VA103-556/2-1	MGP	KLA

APPENDIX B

FINANCIAL EVALUATION SUMMARIES

(Pages B-1 to B-4)

TABLE B.1

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT FINANCIAL ATTRIBUTES - 15 MW, 50 GWh

9/26/2016 13:32

ITEM	Rate	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
Project Life (Yrs)	65					
Real Cost of Capital (YEC)	3.38%					
Real Cost of Capital (IPP)	4.61%					
Real Cost of Capital - High Rate Scenario	8.82%					
Installed Capacity (MW)		15.0	15.0	15.0	15.0	15.0
Annual Generation (GWh)		50.0	50.0	50.0	50.0	50.0
Annual Pumping Energy (GWh)		26.7	59.5	51.8	31.8	55.8
Monthly Generation, Winter (GWh)		7.1	7.1	7.1	7.1	7.1
Monthly Pumping, Summer (GWh)		5.3	11.9	10.4	6.4	11.2
Overnight Capital Cost ($)		**$220,000,000**	**$235,000,000**	**$263,000,000**	**$438,000,000**	**$448,000,000**
Construction Cost, Yr. 1	10%	$22,000,000	$23,500,000	$26,300,000	$43,800,000	$44,800,000
Construction Cost, Yr. 2	30%	$66,000,000	$70,500,000	$78,900,000	$131,400,000	$134,400,000
Construction Cost, Yr. 3	40%	$88,000,000	$94,000,000	$105,200,000	$175,200,000	$179,200,000
Construction Cost, Yr. 4	20%	$44,000,000	$47,000,000	$52,600,000	$87,600,000	$89,600,000
Fixed O&M Costs (% of Capital)	2.0%	$4,400,000	$4,700,000	$5,260,000	$8,760,000	$8,960,000
Variable Costs, Generation	0.5¢/kWh	$250,000	$250,000	$250,000	$250,000	$250,000
Variable Costs, Pumping	0.5¢/kWh	$134,000	$298,000	$259,000	$159,000	$279,000
YEC Rate Scenario						
Interest During Construction		$17,586,000	$18,785,000	$21,024,000	$35,013,000	$35,812,000
Loaded Capital Cost, at End of Construction Period ($)		**$237,586,000**	**$253,785,000**	**$284,024,000**	**$473,013,000**	**$483,812,000**
Levelized Capital Cost		$9,076,000	$9,695,000	$10,850,000	$18,070,000	$18,483,000
Levelized Annual Cost		$13,860,000	$14,943,000	$16,619,000	$27,239,000	$27,972,000
Capital Cost of Energy Storage	$/MWh	$4,800	$5,100	$5,700	$9,500	$9,700
Capital Cost of Capacity	$/kW-yr	$15,800	$16,900	$18,900	$31,500	$32,300
Levelized Cost of Energy	**$/kWh**	**$0.28**	**$0.30**	**$0.33**	**$0.54**	**$0.56**
Levelized Cost of Capacity	**$/kW-yr**	**$900**	**$1,000**	**$1,100**	**$1,800**	**$1,900**
IPP Rate Scenario						
Interest During Construction		$24,230,000	$25,882,000	$28,966,000	$48,240,000	$49,341,000
Loaded Capital Cost, at End of Construction Period ($)		**$244,230,000**	**$260,882,000**	**$291,966,000**	**$486,240,000**	**$497,341,000**
Levelized Capital Cost		$11,894,000	$12,705,000	$14,219,000	$23,681,000	$24,221,000
Levelized Annual Cost		$16,678,000	$17,953,000	$19,988,000	$32,850,000	$33,710,000
Capital Cost of Energy Storage	$/MWh	$4,900	$5,200	$5,800	$9,700	$9,900
Capital Cost of Capacity	$/kW-yr	$16,300	$17,400	$19,500	$32,400	$33,200
Levelized Cost of Energy	**$/kWh**	**$0.33**	**$0.36**	**$0.40**	**$0.66**	**$0.67**
Levelized Cost of Capacity	**$/kW-yr**	**$1,100**	**$1,200**	**$1,300**	**$2,200**	**$2,200**
High Interest Rate Scenario						
Interest During Construction		$47,988,000	$51,260,000	$57,367,000	$95,540,000	$97,721,000
Loaded Capital Cost, at End of Construction Period ($)		**$267,988,000**	**$286,260,000**	**$320,367,000**	**$533,540,000**	**$545,721,000**
Levelized Capital Cost		$13,052,000	$13,941,000	$15,602,000	$25,984,000	$26,578,000
Levelized Annual Cost		$17,836,000	$19,189,000	$21,371,000	$35,153,000	$36,067,000
Capital Cost of Energy Storage	$/MWh	$5,400	$5,700	$6,400	$10,700	$10,900
Capital Cost of Capacity	$/kW-yr	$17,900	$19,100	$21,400	$35,600	$36,400
Levelized Cost of Energy	**$/kWh**	**$0.36**	**$0.38**	**$0.43**	**$0.70**	**$0.72**
Levelized Cost of Capacity	**$/kW-yr**	**$1,200**	**$1,300**	**$1,400**	**$2,300**	**$2,400**

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NOTES:

1. INTEREST RATES ARE REAL COST OF CAPITAL AS PROVIDED BY YEC. NOMINAL RATES HAVE NOT BEEN INCLUDED.

2	24SEP'16	ISSUED WITH REPORT	TJB	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

TABLE B.2

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT FINANCIAL ATTRIBUTES - 15 MW, 100 GWh

9/26/2016 13:42

ITEM	Rate	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
Project Life (Yrs)	65					
Real Cost of Capital (YEC)	3.38%					
Real Cost of Capital (IPP)	4.61%					
Real Cost of Capital - High Rate Scenar	8.82%					
Installed Capacity (MW)		15.0	15.0	15.0	15.0	15.0
Annual Generation (GWh)		100.0	100.0	100.0	100.0	100.0
Annual Pumping Energy (GWh)		88.5	121.3	113.6	119.7	119.9
Monthly Generation, Winter (GWh)		14.3	14.3	14.3	14.3	14.3
Monthly Pumping, Summer (GWh)		17.7	24.3	22.7	23.9	24.0
Overnight Capital Cost ($)		**$300,000,000**	**$411,000,000**	**$420,000,000**	**$525,000,000**	**$621,000,000**
Construction Cost, Yr. 1	10%	$30,000,000	$41,100,000	$42,000,000	$52,500,000	$62,100,000
Construction Cost, Yr. 2	30%	$90,000,000	$123,300,000	$126,000,000	$157,500,000	$186,300,000
Construction Cost, Yr. 3	40%	$120,000,000	$164,400,000	$168,000,000	$210,000,000	$248,400,000
Construction Cost, Yr. 4	20%	$60,000,000	$82,200,000	$84,000,000	$105,000,000	$124,200,000
Fixed O&M Costs (% of Capital)	2.0%	$6,000,000	$8,220,000	$8,400,000	$10,500,000	$12,420,000
Variable Costs, Generation	0.5¢/kWh	$500,000	$500,000	$500,000	$500,000	$500,000
Variable Costs, Pumping	0.5¢/kWh	$443,000	$607,000	$568,000	$599,000	$600,000
YEC Rate Scenario						
Interest During Construction		$23,981,000	$32,854,000	$33,574,000	$41,967,000	$49,641,000
Loaded Capital Cost, at End of Construction Period ($)		**$323,981,000**	**$443,854,000**	**$453,574,000**	**$566,967,000**	**$670,641,000**
Levelized Capital Cost		$12,377,000	$16,956,000	$17,328,000	$21,660,000	$25,620,000
Levelized Annual Cost		$19,320,000	$26,283,000	$26,796,000	$33,259,000	$39,140,000
Capital Cost of Energy Storage	$/MWh	$3,200	$4,400	$4,500	$5,700	$6,700
Capital Cost of Capacity	$/kW-yr	$21,600	$29,600	$30,200	$37,800	$44,700
Levelized Cost of Energy	**$/kWh**	**$0.19**	**$0.26**	**$0.27**	**$0.33**	**$0.39**
Levelized Cost of Capacity	**$/kW-yr**	**$1,300**	**$1,800**	**$1,800**	**$2,200**	**$2,600**
IPP Rate Scenario						
Interest During Construction		$33,041,000	$45,266,000	$46,258,000	$57,822,000	$68,395,000
Loaded Capital Cost, at End of Construction Period ($)		**$333,041,000**	**$456,266,000**	**$466,258,000**	**$582,822,000**	**$689,395,000**
Levelized Capital Cost		$16,220,000	$22,221,000	$22,708,000	$28,385,000	$33,575,000
Levelized Annual Cost		$23,163,000	$31,548,000	$32,176,000	$39,984,000	$47,095,000
Capital Cost of Energy Storage	$/MWh	$3,300	$4,600	$4,700	$5,800	$6,900
Capital Cost of Capacity	$/kW-yr	$22,200	$30,400	$31,100	$38,900	$46,000
Levelized Cost of Energy	**$/kWh**	**$0.23**	**$0.32**	**$0.32**	**$0.40**	**$0.47**
Levelized Cost of Capacity	**$/kW-yr**	**$1,500**	**$2,100**	**$2,100**	**$2,700**	**$3,100**
High Interest Rate Scenario						
Interest During Construction		$65,438,000	$89,650,000	$91,613,000	$114,517,000	$135,457,000
Loaded Capital Cost, at End of Construction Period ($)		**$365,438,000**	**$500,650,000**	**$511,613,000**	**$639,517,000**	**$756,457,000**
Levelized Capital Cost		$17,798,000	$24,383,000	$24,917,000	$31,146,000	$36,841,000
Levelized Annual Cost		$24,741,000	$33,710,000	$34,385,000	$42,745,000	$50,361,000
Capital Cost of Energy Storage	$/MWh	$3,700	$5,000	$5,100	$6,400	$7,600
Capital Cost of Capacity	$/kW-yr	$24,400	$33,400	$34,100	$42,600	$50,400
Levelized Cost of Energy	**$/kWh**	**$0.25**	**$0.34**	**$0.34**	**$0.43**	**$0.50**
Levelized Cost of Capacity	**$/kW-yr**	**$1,600**	**$2,200**	**$2,300**	**$2,800**	**$3,400**

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NOTES:

1. DISCOUNT RATES ARE REAL COST OF CAPITAL AS PROVIDED BY YEC. NOMINAL RATES HAVE NOT BEEN INCLUDED.

2	24SEP'16	ISSUED WITH REPORT	TJB	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D

TABLE B.3

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT FINANCIAL ATTRIBUTES - 25 MW, 50 GWh

9/27/2016 12:12

ITEM	Rate	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Racine-Moon	Lindeman-Fraser
Project Life (Yrs)	65					
Real Cost of Capital (YEC)	3.38%					
Real Cost of Capital (IPP)	4.61%					
Real Cost of Capital - High Rate Scenari	8.82%					
Installed Capacity (MW)		25.0	25.0	25.0	25.0	25.0
Annual Generation (GWh)		50.0	50.0	50.0	50.0	50.0
Annual Pumping Energy (GWh)		26.7	59.5	51.8	31.8	55.8
Monthly Generation, Winter (GWh)		7.1	7.1	7.1	7.1	7.1
Monthly Pumping, Summer (GWh)		5.3	11.9	10.4	6.4	11.2
Overnight Capital Cost ($)		**$257,000,000**	**$262,000,000**	**$301,000,000**	**$490,000,000**	**$515,000,000**
Construction Cost, Yr. 1	10%	$25,700,000	$26,200,000	$30,100,000	$49,000,000	$51,500,000
Construction Cost, Yr. 2	30%	$77,100,000	$78,600,000	$90,300,000	$147,000,000	$154,500,000
Construction Cost, Yr. 3	40%	$102,800,000	$104,800,000	$120,400,000	$196,000,000	$206,000,000
Construction Cost, Yr. 4	20%	$51,400,000	$52,400,000	$60,200,000	$98,000,000	$103,000,000
Fixed O&M Costs (% of Capital)	2.0%	$5,140,000	$5,240,000	$6,020,000	$9,800,000	$10,300,000
Variable Costs, Generation	0.5¢/kWh	$250,000	$250,000	$250,000	$250,000	$250,000
Variable Costs, Pumping	0.5¢/kWh	$134,000	$298,000	$259,000	$159,000	$279,000
YEC Rate Scenario						
Interest During Construction		$20,544,000	$20,944,000	$24,061,000	$39,170,000	$41,168,000
Loaded Capital Cost, at End of Construction Period ($)		**$277,544,000**	**$282,944,000**	**$325,061,000**	**$529,170,000**	**$556,168,000**
Levelized Capital Cost		$10,603,000	$10,809,000	$12,418,000	$20,216,000	$21,247,000
Levelized Annual Cost		$16,127,000	$16,597,000	$18,947,000	$30,425,000	$32,076,000
Capital Cost of Energy Storage	$/MWh	$5,600	$5,700	$6,500	$10,600	$11,100
Capital Cost of Capacity	$/kW-yr	$11,100	$11,300	$13,000	$21,200	$22,200
Levelized Cost of Energy	**$/kWh**	**$0.32**	**$0.33**	**$0.38**	**$0.61**	**$0.64**
Levelized Cost of Capacity	**$/kW-yr**	**$650**	**$660**	**$760**	**$1,200**	**$1,300**
IPP Rate Scenario						
Interest During Construction		$28,305,000	$28,856,000	$33,151,000	$53,967,000	$56,721,000
Loaded Capital Cost, at End of Construction Period ($)		**$285,305,000**	**$290,856,000**	**$334,151,000**	**$543,967,000**	**$571,721,000**
Levelized Capital Cost		$13,895,000	$14,165,000	$16,274,000	$26,492,000	$27,844,000
Levelized Annual Cost		$19,419,000	$19,953,000	$22,803,000	$36,701,000	$38,673,000
Capital Cost of Energy Storage	$/MWh	$5,700	$5,800	$6,700	$10,900	$11,400
Capital Cost of Capacity	$/kW-yr	$11,400	$11,600	$13,400	$21,800	$22,900
Levelized Cost of Energy	**$/kWh**	**$0.39**	**$0.40**	**$0.46**	**$0.73**	**$0.77**
Levelized Cost of Capacity	**$/kW-yr**	**$780**	**$800**	**$900**	**$1,500**	**$1,500**
High Interest Rate Scenario						
Interest During Construction		$56,059,000	$57,149,000	$65,656,000	$106,882,000	$112,335,000
Loaded Capital Cost, at End of Construction Period ($)		**$313,059,000**	**$319,149,000**	**$366,656,000**	**$596,882,000**	**$627,335,000**
Levelized Capital Cost		$15,247,000	$15,543,000	$17,857,000	$29,069,000	$30,552,000
Levelized Annual Cost		$20,771,000	$21,331,000	$24,386,000	$39,278,000	$41,381,000
Capital Cost of Energy Storage	$/MWh	$6,300	$6,400	$7,300	$11,900	$12,500
Capital Cost of Capacity	$/kW-yr	$12,500	$12,800	$14,700	$23,900	$25,100
Levelized Cost of Energy	**$/kWh**	**$0.42**	**$0.43**	**$0.49**	**$0.79**	**$0.83**
Levelized Cost of Capacity	**$/kW-yr**	**$830**	**$850**	**$1,000**	**$1,600**	**$1,700**

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NOTES:

1. DISCOUNT RATES ARE REAL COST OF CAPITAL AS PROVIDED BY YEC. NOMINAL RATES HAVE NOT BEEN INCLUDED.

REV	DATE	DESCRIPTION	PREP'D	CHK'D
2	24SEP'16	ISSUED WITH REPORT	TJB	KLA

TABLE B.4

YUKON ENERGY CORPORATION
PUMPED STORAGE ASSESSMENT

PROJECT FINANCIAL ATTRIBUTES - 25 MW, 100 GWh

9/26/2016 13:56

ITEM	Rate	Tutshi-Moon	Atlin-Black Mt.	Racine-Mt. Brown	Squanga-Dalayee	Canyon-Ittlemit
Project Life (Yrs)	65					
Real Cost of Capital (YEC)	3.38%					
Real Cost of Capital (IPP)	4.61%					
Real Cost of Capital - High Rate Scenario	8.82%					
Installed Capacity (MW)		25.0	25.0	25.0	25.0	25.0
Annual Generation (GWh)		100.0	100.0	100.0	100.0	100.0
Annual Pumping Energy (GWh)		88.5	121.3	113.6	119.7	119.9
Monthly Generation, Winter (GWh)		14.3	14.3	14.3	14.3	14.3
Monthly Pumping, Summer (GWh)		17.7	24.3	22.7	23.9	24.0
Overnight Capital Cost ($)		**$329,000,000**	**$430,000,000**	**$450,000,000**	**$568,000,000**	**$640,000,000**
Construction Cost, Yr. 1	10%	$32,900,000	$43,000,000	$45,000,000	$56,800,000	$64,000,000
Construction Cost, Yr. 2	30%	$98,700,000	$129,000,000	$135,000,000	$170,400,000	$192,000,000
Construction Cost, Yr. 3	40%	$131,600,000	$172,000,000	$180,000,000	$227,200,000	$256,000,000
Construction Cost, Yr. 4	20%	$65,800,000	$86,000,000	$90,000,000	$113,600,000	$128,000,000
Fixed O&M Costs (% of Capital)	2.0%	$6,580,000	$8,600,000	$9,000,000	$11,360,000	$12,800,000
Variable Costs, Generation	0.5¢/kWh	$500,000	$500,000	$500,000	$500,000	$500,000
Variable Costs, Pumping	0.5¢/kWh	$443,000	$607,000	$568,000	$599,000	$600,000
YEC Rate Scenario						
Interest During Construction		$26,300,000	$34,373,000	$35,972,000	$45,405,000	$51,160,000
Loaded Capital Cost, at End of Construction Period ($)		**$355,300,000**	**$464,373,000**	**$485,972,000**	**$613,405,000**	**$691,160,000**
Levelized Capital Cost		$13,573,000	$17,740,000	$18,565,000	$23,434,000	$26,404,000
Levelized Annual Cost		$21,096,000	$27,447,000	$28,633,000	$35,893,000	$40,304,000
Capital Cost of Energy Storage	$/MWh	$3,600	$4,600	$4,900	$6,100	$6,900
Capital Cost of Capacity	$/kW-yr	$14,200	$18,600	$19,400	$24,500	$27,600
Levelized Cost of Energy	**$/kWh**	**$0.21**	**$0.27**	**$0.29**	**$0.36**	**$0.40**
Levelized Cost of Capacity	**$/kW-yr**	**$840**	**$1,100**	**$1,100**	**$1,400**	**$1,600**
IPP Rate Scenario						
Interest During Construction		$36,235,000	$47,359,000	$49,562,000	$62,558,000	$70,488,000
Loaded Capital Cost, at End of Construction Period ($)		**$365,235,000**	**$477,359,000**	**$499,562,000**	**$630,558,000**	**$710,488,000**
Levelized Capital Cost		$17,788,000	$23,248,000	$24,330,000	$30,709,000	$34,602,000
Levelized Annual Cost		$25,311,000	$32,955,000	$34,398,000	$43,168,000	$48,502,000
Capital Cost of Energy Storage	$/MWh	$3,700	$4,800	$5,000	$6,300	$7,100
Capital Cost of Capacity	$/kW-yr	$14,600	$19,100	$20,000	$25,200	$28,400
Levelized Cost of Energy	**$/kWh**	**$0.25**	**$0.33**	**$0.34**	**$0.43**	**$0.49**
Levelized Cost of Capacity	**$/kW-yr**	**$1,000**	**$1,300**	**$1,400**	**$1,700**	**$1,900**
High Interest Rate Scenario						
Interest During Construction		$71,764,000	$93,795,000	$98,157,000	$123,896,000	$139,601,000
Loaded Capital Cost, at End of Construction Period ($)		**$400,764,000**	**$523,795,000**	**$548,157,000**	**$691,896,000**	**$779,601,000**
Levelized Capital Cost		$19,518,000	$25,510,000	$26,696,000	$33,697,000	$37,968,000
Levelized Annual Cost		$27,041,000	$35,217,000	$36,764,000	$46,156,000	$51,868,000
Capital Cost of Energy Storage	$/MWh	$4,000	$5,200	$5,500	$6,900	$7,800
Capital Cost of Capacity	$/kW-yr	$16,000	$21,000	$21,900	$27,700	$31,200
Levelized Cost of Energy	**$/kWh**	**$0.27**	**$0.35**	**$0.37**	**$0.46**	**$0.52**
Levelized Cost of Capacity	**$/kW-yr**	**$1,100**	**$1,400**	**$1,500**	**$1,800**	**$2,100**

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NOTES:

1. DISCOUNT RATES ARE REAL COST OF CAPITAL AS PROVIDED BY YEC. NOMINAL RATES HAVE NOT BEEN INCLUDED.

2	24SEP'16	ISSUED WITH REPORT	TJB	KLA
REV	DATE	DESCRIPTION	PREP'D	CHK'D