2012 Integrated Resource Plan

BC hydro

Appendix

3E

North Coast Pumped Storage Report
BC HYDRO
EVALUATION OF PUMPED STORAGE HYDROELECTRIC POTENTIAL IN THE NORTH COAST REGION OF BRITISH COLUMBIA
SCREENING ASSESSMENT
(REF. NO. VA103-313/2-1)

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EXECUTIVE SUMMARY

BC Hydro engaged Knight Piésold Ltd. (KPL) to conduct a screening assessment of the pumped storage potential in the North Coast Region of British Columbia. The purpose of this assessment was to determine whether there are potentially viable greenfield pumped storage hydroelectric sites in the North Coast Region of British Columbia. This report illustrates that there are a number of potentially viable sites, all of which are freshwater.

The assessment was limited to an area within 50 km of BC Hydro’s two main transmission lines within the North Coast Region (2L101 and 2L99). Within the area surrounding 2L99, sites of up to 1000 MW capacity were assessed, while sites were limited to 500 MW in the region near 2L101. In addition, potential pumped storage sites were assessed along a likely transmission corridor from the West Coast of Banks Island to Douglas Channel, given the high potential for wind resources in the area.

Potential basins were identified using a combination of existing lakes and/or man-made reservoirs. Using these potential candidate basins, an in-house GIS screening tool identified sites that could provide storage for 16 or 48 hours of continuous generation with a minimum dam embankment construction volume. In addition, potential saltwater sites were identified. The 120 potential sites identified using Knight Piésold’s in-house GIS screening tool were then ranked using a cost estimation spreadsheet in order of levelised capital cost ($/kW-year).

From the list of possible sites, a total of 33 were identified as having the potential to provide 16 hrs of continuous generation at either 500 MW or 1000 MW capacity below a threshold of $200/kW-yr. In addition, 29 sites were identified as having the ability to provide 48 hrs of continuous generation below a threshold of $500/kW-yr. The 25 best sites had estimated costs ranging from $83/kW-yr to $140/kW-yr for 16 hours of continuous generation, and $181/kW-yr to $430/kW-yr for 48 hours of continuous generation. While a number of potential saltwater sites were identified, it appears that development of freshwater pumped storage sites would be more cost effective. The saltwater pumped storage sites identified ranged in cost between $267 – 490/kW-yr. In addition, the development of freshwater pumped storage sites will likely have a reduced environmental impact in comparison to saltwater pumped storage.

The North Coast Region of British Columbia has a high technical potential for freshwater pumped storage development due to the steep topography and existence of many natural lakes and other suitable basins for constructing pumped storage reservoirs. The development costs appear to be similar to the Lower Mainland and Vancouver Island, but with fewer viable sites, due to the relative lack of existing hydropower reservoirs in the region. Based on the potential for pumped storage in the North Coast, and the projected increase in loads and renewable energy in the region, we recommend further assessment of these sites, commencing with estimation of transmission, access and interconnection costs.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>SECTION</th>
<th>CONTENT</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>INTRODUCTION</td>
<td>1</td>
</tr>
<tr>
<td>2.0</td>
<td>SCREENING METHODOLOGY</td>
<td>3</td>
</tr>
<tr>
<td>3.0</td>
<td>SCREENING ASSESSMENT RESULTS</td>
<td>7</td>
</tr>
<tr>
<td>4.0</td>
<td>CONCLUSIONS AND RECOMMENDATIONS</td>
<td>8</td>
</tr>
<tr>
<td>5.0</td>
<td>REFERENCES</td>
<td>9</td>
</tr>
<tr>
<td>6.0</td>
<td>CERTIFICATION</td>
<td>10</td>
</tr>
</tbody>
</table>
TABLES

Table 2.1 Rev 0  Development Cost Distribution by Pumped Storage Type
Table 3.1 Rev 0  Summary of Sites with Storage for 16 hrs of Continuous Generation
Table 3.2 Rev 0  Summary of Sites with Storage for 48 hrs of Continuous Generation

FIGURES

Figure 2.1 Rev 0  Study Area
Figure 2.2 Rev 0  Salmon Bearing Waterways in the Study Area
Figure 2.3 Rev 0  Potential Locations for Saltwater Reservoirs
Figure 2.4 Rev 0  Potential Locations for Freshwater Reservoirs
Figure 2.5 Rev 0  Conceptual Development Schedule
Figure 3.1 Rev 0  Cost of Cumulative Installed Capacity – Storage for 16 hrs Continuous Generation
Figure 3.2 Rev 0  Cost of Cumulative Installed Capacity – Storage for 48 hrs Continuous Generation
Figure 3.3 Rev 0  Cost of Cumulative Installed Capacity – Saltwater Sites
Figure 3.4 Rev 0  Location of Pumped Storage Sites for 16 hrs of Continuous Generation
Figure 3.5 Rev 0  Location of Pumped Storage Sites for 48 hrs of Continuous Generation
1.1 INTRODUCTION

BC Hydro engaged Knight Piésold Ltd. (KPL) to conduct a screening assessment of the pumped storage potential in the North Coast Region of British Columbia. This report discusses the results of the assessment.

1.2 PREVIOUS STUDIES

KPL previously conducted a similar study for the Lower Mainland and Vancouver Island region of southwest British Columbia, in 2010. KPL have adopted a similar methodology in the current report, and have adapted the same screening and assessment tools that were developed for that study.

1.3 BACKGROUND TO PUMPED STORAGE

The concept of pumped storage is the generation of electricity by capturing the energy of water being transferred from a higher elevation upper reservoir, through turbine/generator units, into a lower elevation reservoir. The system is then reversed and the water from the lower reservoir is pumped back to the upper reservoir. Though the system is a net consumer of energy, it can be advantageous to developers/utilities by:

- Providing additional capacity during high-load hours when the cost of energy is greatest
- Increasing profitability by using low-value base load energy to pump water to the upper reservoir during low-load hours
- Providing grid stability by reducing the generation differential between high-load and low-load periods,
- Relieving constrained transmission components
- Providing voltage regulation, especially at the end of long transmission systems (relevant to the North Coast Region of BC)
- Providing storage for intermittent renewable energy sources that cannot be dispatched on demand
- Providing backup capacity in the event of a planned or unplanned outage of another significant generation source connected to the grid, and/or
- Providing capacity for export.

Pumped storage projects can be either freshwater or saltwater. Nearly all pumped storage projects worldwide to date are freshwater pumped storage projects. As of 2009, it was estimated that more than 127,000 MW of pumped storage capacity was operating worldwide.
The concept of saltwater pumped storage is the same as that of freshwater pumped storage, with the exception that seawater is exchanged between the ocean and an upper reservoir instead of a freshwater lower reservoir. The advantage of saltwater pumped storage over freshwater pumped storage is that construction of only one reservoir is needed, which can significantly reduce the capital cost of the development. There is currently only one saltwater pumped storage project operating worldwide. This is located in Okinawa, Japan, and has been operating for more than 10 years. There are also numerous saltwater tidal power projects around the world. However, in BC there are numerous fresh water lakes that could also act as the lower reservoir, without the additional complications of salt water corrosion, marine growth issues and added environmental permitting risk of a saltwater development.
SECTION 2.0 - SCREENING METHODOLOGY

2.1 SPATIAL LIMITATIONS

The study area was limited to the North Coast Region of British Columbia, limited to a 50 km boundary on either side of the 2L99 and 2L101 transmission lines of BC Hydro’s grid. Within the study area, the following spatial limitations apply:

- Terrestrial parks and reserve areas are excluded from the study area
- Marine parks are included in the study area
- Private land is included in the study area, and
- Indian Reserves are included in the study area.

A summary of the study area is shown on Figure 2.1.

In addition, potential pumped storage sites were assessed along a likely transmission corridor from the West Coast of Banks Island to Douglas Channel, given the high potential for wind resources in the area.

2.2 LIMITATIONS ON GENERATION CAPACITY

Only sites that have an installed capacity of 500 MW were considered along the 2L101 corridor. Sites with either 500 MW or 1000 MW of installed capacity were considered along the 2L99 corridor. In instances where the defined study areas along 2L99 and 2L101 intersect, the requirements for 2L99 applied.

It is assumed that the additional sites along potential transmission line routes from Banks Island to Kitimat would follow the same requirements for the 2L99 region.

2.3 MINIMUM STORAGE REQUIREMENTS

Two sets of sites were identified. The first set included sites that have storage for 16 continuous hours of generation. The second set included sites that have storage for 48 hours of continuous generation. These equate to an energy storage of 8,000 MWh and 24,000 MWh for the 500 MW sites, and 16,000 MWh and 48,000 MWh for the 1,000 MW sites respectively. The volume of water required to store this amount of energy varies by project, depending on the available head.

2.4 ENVIRONMENTAL LIMITATIONS

Salmon bearing rivers were excluded from the study. The Fish Information Summary System (FISS) from the BC Ministry of Environment was used as the basis for known fish distribution data. Rivers with historical observances of Chinook, Sockeye, Chum, Coho, Pink and/or Steelhead were not considered in the screening assessment.

Existing lakes with historical observances of Salmon were included in the assessment. Only one salmon bearing lakes was identified as a potential pumped storage site, and this was not one of the more cost effective sites. Another two salmon bearing lakes (Kitsumkalum Lake and Lakelse Lake) were identified in the study area as potentially good pumped storage reservoir locations. However, these were excluded...
as it would be likely that construction of a pumped storage facility at other of these locations would require the creation of a reservoir that would impact salmon habitat on the rivers upstream of the lake. A summary of the fish distribution data for the salmon species mentioned above are shown on Figure 2.2.

2.5 TECHNICAL CONSTRAINTS

For each of the two sets of sites (16 hours storage and 48 hours of storage), a maximum of 25 sites were identified. A preliminary cost estimate for each of the 120 potential sites identified by the screening was undertaken in order to rank the sites in order of levelised capital cost. Only the 25 highest ranked sites for each of the two sets of sites were included in the report. Where a potential site was ranked highly for both 500 MW or 1000 MW capacity, only the lower cost (levelised capital cost) configuration was included in the list of potential sites. In order to determine the real levelised cost ($/kW-year), the following was assumed:

- Design Life = 70 years, and
- Discount Rate = 6%

2.5.1 Freshwater Lake to Lake Sites

The North Coast Region of British Columbia has an abundance of small lakes in combination with the steep topography. Due to this high number of potential sites, lakes with the most attractive characteristics were targeted, and were included in the pool of candidate basins for further assessment. All existing lakes within the study area were screened as follows:

- Lakes > 2 ha were assessed as potential reservoir basins.
- Existing lakes within a 10 km horizontal distance that could be used as an upper and lower reservoir respectively (i.e. waterway length is limited to approximately 10 km or less).
- For existing lakes, all water storage was assumed to be constructed above the natural lake water level.

A total of approximately 100 “existing lake” basins were identified using an automated GIS searching tool.

2.5.2 Man-Made Reservoir Sites

Due to the relatively undisturbed nature of the North Coast Region, there are few existing reservoirs, and large existing lakes are concentrated towards the west coast. For this reason, it was necessary to assess the potential of new man-made reservoirs to serve as potential upper and/or lower reservoirs. A visual assessment was undertaken using TRIM mapping to manually identify potential reservoir basins. For each potential basin, a “nominal” reservoir size was calculated using GIS, including the dam height and crest length, reservoir storage volume, and reservoir elevation. A total of approximately 200 “man-made reservoir” basins were identified using a visual assessment of the entire study area.
2.5.3 **Saltwater Pumped Storage Sites**

The same constraints for the freshwater “man-made reservoir” sites were applied to the screening assessment of saltwater pumped storage sites. Additionally, freshwater lakes were not considered as upstream reservoirs, due to the high environmental impact of pumping saltwater into a freshwater ecosystem. In some instances, upstream reservoirs were proposed in areas that contained either wetland or small ponds. Since it is difficult to determine at what size threshold this may not be permissible, a certain amount of judgement was required to satisfy this constraint. Only sites whose watershed flows directly to the ocean were considered and any saltwater site that would flow into an existing lake or salmon bearing river was not considered. Using visual assessment, a total of approximately 20 potential saltwater basins were identified in the study area. These potential basins are shown on Figure 2.3.

2.5.4 **Screening Assessment**

From the above, a list of 320 potential basins for freshwater reservoirs was created as shown on Figure 2.4. A screening was undertaken using an automated GIS tool to choose the best combinations of freshwater basins that would lead to viable pumped storage sites. This tool identifies any two basins within approximately 10 km. In some cases, two basins slightly more than 10 km apart were assessed. Between any two basins, the GIS tool will assess the gross head between the two sites and will calculate the storage volume required to meet the project assessment requirements. The GIS tool then determines whether the two basins can be constructed as a potential pumped-storage facility with a dam embankment construction volume below a certain threshold. This threshold was chosen as dam embankment construction can potentially add up to 33% or more of project construction costs, and so minimising dam embankment volume appears to be a useful mechanism to screen some of the best sites from the pool of potentially infinite combinations of sites between the basins identified. The GIS assessment tool was used with the following two constraints:

- A total dam embankment construction volume of 1,000,000 m³, with a reservoir storage capacity for 48 hrs of continuous generation.
- A total dam embankment construction volume of 500,000 m³, with a reservoir storage capacity for 16 hrs of continuous generation.

Using these constraints, the GIS tool flagged a total of 120 potential pumped-storage sites.

2.5.5 **Site Characterisation and Costing**

Using the 120 potential sites flagged by the GIS tool, each site was characterised in order to determine the project properties, which were then used as the basis of the cost estimate for each alternative. The main parameters of the characterisation include overall project parameters (gross head, design flow, capacity), reservoir parameters (required storage volume, reservoir area, embankment height and length, embankment volume), and waterway parameters (length, diameter, lining requirements). Due to the coarse resolution of the data, and the automated nature of the calculations, some of the site parameters (such as dam
height, crest length and reservoir area) may vary once each site is assessed in greater detail on an individual basis.

Cost estimates were prepared for each identified pumped-storage site by using a cost template of unit rates for project components. The unit rates used in the costing were based on experience from other pumped storage and hydroelectric projects that KPL has experience in. To provide comparison, these were the same costs as were adopted for the Assessment of Pumped Storage Potential in South-West BC, so all costs are in 2010 dollars. The capital cost estimates do not include transmission, interconnection or access to the site. As such, it would not be prudent to compare the sites based purely on a cost basis until these additional costs have been determined. The cost of transmission, interconnection and access will favour those sites closer to load centres or transmission lines.

The costs for each site are presented as loaded capital costs (based on the schedules presented in Figure 2.5, a discount rate of 6% and cost distributions as presented in Table 2.1). Cost per MW installed, cost per MWh stored, and levelized capital cost ($/kW-yr) were also determined.

Annual Operation and Maintenance costs were also estimated for each site. These costs are estimated as a percentage of the total estimated capital cost as follows;

- Freshwater pumped storage sites, 1000 MW – 1.0%
- Freshwater pumped storage sites, 500 MW – 1.5%, and
- Saltwater pumped storage sites, 500 MW – 2.0%.
SECTION 3.0 - SCREENING ASSESSMENT RESULTS

3.1 FRESHWATER SITE IDENTIFICATION

A total of 33 potential freshwater sites with storage for 16 hrs of continuous generation and levelised capital cost below $200/kW-yr were identified. These included;

- Four sites with costs less than $100/kW-yr
- Fourteen sites with costs between $100 – 125/kW-yr
- Eleven sites with costs between $125 – 150/kW-yr, and
- Ten sites with costs greater than $150/kW-yr.

The cost of cumulative installed capacity is indicated on Figure 3.1. The characteristics and costs of the 25 sites with the lowest estimated levelised cost are shown in Table 3.1 and Figure 3.4.

A total of 29 potential freshwater sites with storage for 48 hrs of continuous generation and levelised capital cost below $500/kW-yr were identified. These included;

- Three sites with costs less than $200/kW-yr
- Eleven sites with costs between $200 – 300/kW-yr
- Nine sites with costs between $300 – 400/kW-yr, and
- Six sites with costs greater than $400/kW-yr.

The cost of cumulative installed capacity is indicated on Figure 3.2. The characteristics and costs of the 25 sites with the lowest estimated levelised cost are shown in Table 3.2 and Figure 3.5.

3.2 SALTWATER SITE IDENTIFICATION

A total of 12 potential saltwater sites with storage for 16 hrs of continuous generation and levelised capital cost below $500/kW-yr were identified. These included;

- Three sites with costs less than $300/kW-yr
- Four sites with costs between $300 – 400/kW-yr, and
- Five sites with greater than $400/kW-yr.

The cost of cumulative installed capacity is indicated on Figure 3.3. No saltwater sites with potential for storage for 48 hrs continuous generation were identified. The lists of the lowest estimated cost sites (Tables 3.1 and 3.2), did not include any saltwater sites.
SECTION 4.0 - CONCLUSIONS AND RECOMMENDATIONS

The North Coast Region of British Columbia has a high technical potential for freshwater pumped storage development due to the steep topography and existence of many natural lakes and other suitable basins for constructing pumped storage reservoirs. The potential appears to be slightly less than in the Lower Mainland and Vancouver Island, primarily due to the relatively undisturbed nature of the landscape and the lack of many existing hydropower and other man-made reservoirs suitable for use as part of a pumped storage facility. In addition, it appears that larger lakes are concentrated in the western portion of the region, where there are a large number of parks and few suitable high elevation basins for use as an upper reservoir. These factors appear to limit the total number of sites, however the most cost effective sites appear to be similar in terms of unit cost ($/kW-yr) to the best sites in the Lower Mainland.

A total of 33 sites were identified with the potential to provide 16 hrs of continuous generation at either 500 MW or 1000 MW capacity. In addition, 29 sites were identified having the ability to provide 48 hrs of continuous generation. The 25 best sites had estimated costs ranging from $83/kW-yr to $140/kW-yr for 16 hours of continuous generation, and $181/kW-yr to $430/kW-yr for 48 hours of continuous generation. Of the top 25 sites for 48 hours of continuous generation, all were of 500 MW capacity. While some sites can be developed to 1000 MW capacity, it appears to be more cost effective to constrain these larger sites to 500 MW. Still, it is likely that it would be more cost effective to develop some of the best sites to a capacity of 1000 MW than to develop two lower ranked sites to a capacity of 500 MW each.

While a number of potential saltwater sites were identified, it appears that development of freshwater pumped storage sites would be more cost effective. The saltwater pumped storage sites identified ranged in cost between $267 – 490/kW-yr. In addition, the development of freshwater pumped storage sites will likely be easier to permit, and pose fewer technical challenges in comparison to construction of saltwater pumped storage sites.

Should BC Hydro wish to further pursue pumped storage potential in BC, KPL recommends the items below. KPL is aware that some of these items are underway already;

- Estimate the costs of transmission, interconnection and access to each of the sites identified in order to meaningfully compare each potential project.
- Conduct a system-wide study to determine the benefits/impacts of integrating pumped storage into the BC Hydro grid.
- Determine the “ideal” characteristics of a pumped storage facility, in terms of providing the maximum benefits to the BC Hydro system, improving export opportunities and firming of renewable energy (especially wind power).
- Conduct a screening assessment for the remaining portions of the province where there is a high resource potential of intermittent loads or renewable energy sources such as wind, run-of-river hydro, solar, tidal and/or wave energy.
- Conduct a more detailed assessment of the most favourable sites identified in this assessment.
SECTION 5.0 - REFERENCES


SECTION 6.0 - CERTIFICATION

This report was prepared, reviewed and approved by the undersigned.

Prepared:

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Project Engineer

Reviewed:

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Power Services Manager

Approved:

Jeremy Haile, P.Eng.
President

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### TABLE 2.1

**BC HYDRO**  
**NORTH COAST PUMPED STORAGE ASSESSMENT**

**DEVELOPMENT COST DISTRIBUTION BY PUMPED STORAGE TYPE**

<table>
<thead>
<tr>
<th>Year</th>
<th>Development Cost Distribution</th>
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<tr>
<td></td>
<td>Freshwater</td>
<td>Saltwater</td>
<td></td>
</tr>
<tr>
<td>Year 1</td>
<td>0%</td>
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<td>Year 2</td>
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<td></td>
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<tr>
<td>Year 3</td>
<td>5%</td>
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<td>Year 4</td>
<td>10%</td>
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<td></td>
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<td>10%</td>
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<td>Year 6</td>
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<td>30%</td>
<td></td>
</tr>
<tr>
<td>Year 8</td>
<td>5%</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>Year 9</td>
<td>--</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td></td>
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Note: The data for Year 8 and Year 9 are not provided in the table.
### TABLE 3.1

**NORTH COAST PUMPED STORAGE ASSESSMENT**

**SUMMARY OF SITES WITH STORAGE FOR 16 HRS OF CONTINUOUS GENERATION**

<table>
<thead>
<tr>
<th>Name</th>
<th>Latitude</th>
<th>Longitude</th>
<th>Capacity</th>
<th>Location</th>
<th>Upper Lower Reservoir</th>
<th>Upper Reservoir Length</th>
<th>Lower Reservoir Length</th>
<th>Upper Reservoir Loss</th>
<th>Lower Reservoir Loss</th>
<th>Upper Reservoir Storage</th>
<th>Lower Reservoir Storage</th>
<th>Storage Location</th>
<th>Reservoir Characteristics</th>
<th>Installed Capacity</th>
<th>Design Flow (GPM)</th>
<th>Daily Flow (%)</th>
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<tr>
<td>Upper Clore</td>
<td>54.212</td>
<td>-127.932</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.184</td>
<td>-127.975</td>
<td>1000</td>
<td>2L99</td>
<td>580</td>
<td>164.2</td>
<td>48.5</td>
<td>11,287,120</td>
<td>1,199,967</td>
<td>1,364,446</td>
<td>17.2</td>
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<td>Hirsch</td>
<td>54.027</td>
<td>-128.380</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.033</td>
<td>-128.334</td>
<td>1000</td>
<td>2L99</td>
<td>567</td>
<td>223.8</td>
<td>46.1</td>
<td>8,165,150</td>
<td>1,408,032</td>
<td>1,600,146</td>
<td>31.1</td>
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<tr>
<td>Upper Falls</td>
<td>54.005</td>
<td>-128.465</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>53.702</td>
<td>-128.488</td>
<td>1000</td>
<td>2L99</td>
<td>74.0</td>
<td>700</td>
<td>37.4</td>
<td>13,705,788</td>
<td>1,481,452</td>
<td>1,683,584</td>
<td>21.7</td>
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<td>Kitimat 1</td>
<td>54.044</td>
<td>-128.449</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.049</td>
<td>-128.484</td>
<td>1000</td>
<td>2L99</td>
<td>67.2</td>
<td>114.0</td>
<td>36.5</td>
<td>8,852,894</td>
<td>1,638,901</td>
<td>1,862,153</td>
<td>9%</td>
</tr>
<tr>
<td>Lower Hirsch</td>
<td>54.027</td>
<td>-128.487</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.017</td>
<td>-128.446</td>
<td>1000</td>
<td>2L99</td>
<td>56.3</td>
<td>1140</td>
<td>4.6</td>
<td>8,342,654</td>
<td>1,564,033</td>
<td>1,777,433</td>
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<tr>
<td>Lower Hirsch</td>
<td>54.098</td>
<td>-128.484</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.033</td>
<td>-128.334</td>
<td>1000</td>
<td>2L99</td>
<td>77.7</td>
<td>1340</td>
<td>3.8</td>
<td>6,852,894</td>
<td>1,638,581</td>
<td>1,862,153</td>
<td>9%</td>
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<tr>
<td>Kitimat 2</td>
<td>54.070</td>
<td>-128.123</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.049</td>
<td>-128.032</td>
<td>1000</td>
<td>2L99</td>
<td>64.0</td>
<td>1300</td>
<td>35.0</td>
<td>9,840,053</td>
<td>1,652,999</td>
<td>1,878,538</td>
<td>12%</td>
</tr>
<tr>
<td>Upper Lukes</td>
<td>54.125</td>
<td>-128.986</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.196</td>
<td>-128.884</td>
<td>1000</td>
<td>2L99</td>
<td>90.2</td>
<td>980</td>
<td>38.1</td>
<td>11,287,120</td>
<td>1,811,572</td>
<td>2,058,323</td>
<td>11%</td>
</tr>
<tr>
<td>Lower Lukes</td>
<td>54.147</td>
<td>-128.733</td>
<td>1000</td>
<td>2L99</td>
<td>70% of (Loaded Dam)</td>
<td>54.196</td>
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NOTES:
1. BASE MAP: BC HYDRO MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES.
3. SCALE OF FIGURE IS 1:750,000 FOR 11x17 (TABLOID) PAPER. 
   ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTING OR PRINTED PAPER SIZE.
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

BC HYDRO
NORTH COAST PUMPED STORAGE ASSESSMENT
SALMON BEARING WATERWAYS
IN THE STUDY AREA
NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.
NOTES:
1. BASE MAP: BC.gov GIS NAV MAPPING SERVICES AND BING MAPS.
2. COORDINATE GRID IS IN METRES.
COORDINATE SYSTEM: NAD 1983 VANCOUVER HORIZONTAL / WGS 1984 VERTICAL.
3. THIS FIGURE IS PRODUCED AT A NOMINAL SCALE OF 1:750,000 FOR 11x17 (TABLOID) PAPER. ACTUAL SCALE MAY DIFFER ACCORDING TO CHANGES IN PRINTER SETTINGS OR PRINTED PAPER SIZE.

LEGEND:
- STUDY AREA
- NOT Киurator
- FRESHWATER SITES
- POTENTIAL RESERVOIR LOCATION
- GENERAL LOCATION
- PROVINCIAL PARK OR PROTECTED AREA
- LAKE
- SCALE

POTENTIAL LOCATIONS FOR FRESHWATER RESERVOIRS

Kitimat
Hartley Bay
Prince Rupert
Port Edward
Lax Kw'alaams
Oona River
K'omoks
Kitsumaat Village
Terrace
Hornby

5,950,000 5,950,000
6,000,000 6,000,000
6,050,000 6,050,000
400,000 400,000
450,000 450,000
500,000 500,000
550,000 550,000
350,000 350,000

BC HYDRO
NORTH COAST PUMPEO STORAGE ASSESSMENT

2012 Integrated Resource Plan
Appendix 3E

May 2012
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<th>Task Name</th>
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<td>Fri 11/16/12</td>
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NOTES:
1. COSTS DO NOT INCLUDE ACCESS TO SITE, OR TRANSMISSION AND INTERCONNECTION.
2. POTENTIAL SITES ARE OF EITHER 500 MW OR 1000 MW CAPACITY
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NOTES:
1. COSTS DO NOT INCLUDE ACCESS TO SITE, OR TRANSMISSION AND INTERCONNECTION.
2. POTENTIAL SITES ARE 500 MW CAPACITY, WITH STORAGE FOR 16 hrs OF CONTINUOUS GENERATION.
LOCATION OF PUMPED STORAGE SITES FOR 48 hrs OF CONTINUOUS GENERATION

NOTES:
1. BASE MAP: GEO BC WEB MAPPING SERVICE AND BING MAPS.
2. COORDINATE GRID IS IN METRES.
3. COORDINATE SYSTEM: WGS 1984 UTM ZONE 9N.
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LEGEND:
- BUSINESS ROAD
- WATER CONVEYANCE TUNNEL TO UPPER RESERVOIR
- TRAFFIC ROADS
- BRIDGES
- LAKE
- LOWER RESERVOIR LOCATION
- UPPER RESERVOIR LOCATION
- LOWER RESERVOIR LOCATION
- UPPER RESERVOIR LOCATION
- STUDY AREA
- PROVINCIAL PARK OR PROTECTED AREA
- STATION PLATFORM
- STATION PLATFORM
- TRANS. LINE 2L99
- TRANS. LINE 2L101
- STUDY BOUNDARY
- GENERAL TRANSMISSION LINE - 2L99
- STUDY BOUNDARY
- GENERAL TRANSMISSION LINE - 2L101
- PROVINCIAL PARK OR PROTECTED AREA
- WATER CONVEYANCE TUNNEL TO UPPER RESERVOIR
- BUSINESS ROAD
- STATION PLATFORM
- STATION PLATFORM
- UNKOWN