Yukon Next Generation Hydro and Transmission Viability Study: Site Screening Inventory (Part 2 of 2)

Submitted By: Midgard Consulting Incorporated

Date: January 26, 2015

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Executive Summary

The Yukon Development Corporation ("**YDC**") has commissioned Midgard Consulting Incorporated ("**Midgard**") and its team of sub-consultants to complete the *Yukon Next Generation Hydro and Transmission Viability Study*. The study, delivered through a series of technical papers, is intended to help inform the decisions necessary to fill the territory's growing energy gap and to support Yukon's continued economic growth and development.

The *Site Screening Inventory* has the goal of identifying, evaluating, categorizing, and ranking potential hydroelectric projects in the context of current economic, environmental, and societal expectations. The main objective of the *Site Screening Inventory* is as follows:

> ***OBJECTIVE: Identify a group of hydroelectric sites that represent the best potential for development in the Yukon Territory so that through further study project sizing can be matched to balance the need for electricity with project impacts.***

It is important to emphasize that no work to balance needs and impacts has been completed at this stage of study; therefore previously identified hydroelectric projects have not yet been modified to better match current societal, environmental, and economic expectations. Future studies under the broader *Yukon Next Generation Hydro and Transmission Viability Study* will address the balancing process. The purpose of the *Site Screening Inventory* is to consolidate and screen previously identified hydroelectric projects to locate the top sites for further investigation.

To facilitate feedback, refinement, and transparency, the *Site Screening Inventory* is divided into two parts:

1) ***Part 1 (Completed on November 24, 2014)*** – At the end of three stages of screening (Screen 0, Screen 1, and Screen 2) 16 projects of interest remained for further study. The initial three screening stages include: reconciliation of known sites, screening for fundamental development barriers, and screening for fundamentally uneconomic sites.
2) ***Part 2 (This Report)*** – Taking the 16 projects identified in Part 1, Part 2 contains a ranking based on the following four areas of study: Environmental Considerations (Area 1), Surface / Subsurface Tenure Considerations (Area 2), Constructability Considerations (Area 3), and Economic Considerations (Area 4). The findings are combined to rank the 16 projects of interest identified at the end of Part 1 and a recommendation is made to "Short List" ten (10) sites for further study.

The *Site Screening Inventory (Part 1)* began with over 200 identified potential hydroelectric projects and now 10 recommended sites remain at the conclusion of *Site Screening Inventory (Part 2).* The progression of site screening and refinement is detailed below in Table 1.

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Table 1: Site Screening Inventory Stages and Resulting Site Refinement

Part	Description	Refinement
1	Screen 0: Reconciliation of Known Project Sites	200+ → 108
	Screen 1: Fundamental Development Barrier Project Screen	108 → 47
	Screen 2: Fundamentally Uneconomic Project Screen	47 → 16
2	Ranking 3: Initial Project Ranking & Variation Consolidation	16 → 10

Table 3 (located on the following page) provides the final summary of the *Site Screening Inventory* results. Note that the 16 projects of interest (identified in the Part 1 report) are consolidated into the 10 underlying site locations they represent. In addition, supporting information and findings are included:

- Range of Installed Capacity (as per previous study designs)
- Summary of site pros and cons with recommendations for further study
- Summary of Development Constraints noted, as per the four areas of study (for more details, see Section 4):
    - Area 1 - Environmental Considerations (split into Fisheries, Aquatic Species-at-Risk ("**SAR**"), and Terrestrial SAR)
    - Area 2 - Surface/Subsurface Tenure Considerations
    - Area 3 - Constructability Considerations
    - Area 4 - Economic Considerations (split into the projects ability to meet long term electricity need, and an assessment to determine if the project configuration is appropriately sized)

A colour-coded scoring system is implemented in Table 3 (and throughout this report) to identify the severity of constraints to development. The three-colour system is detailed in Table 2 below.

Table 2: Site Screening Inventory Scoring System

Score	Description
H	Parameter poses significant development constraint
M	Parameter poses moderate development constraint
L	Parameter poses no/minor development constraint

There are two final notes to highlight:

1) Many of the sites contain previously designed projects that appear too large for the future needs of the Yukon Territory. This does not necessarily indicate a bad site, but rather an over-sized design. Future studies will reduce project sizes to better balance the needs of and impacts to the Yukon.
2) Regardless of project, there will always be challenges when developing a hydroelectric site. These challenges include environmental and socio-economic impacts, surface and subsurface tenure issues, design, engineering, constructability planning, and the overall economics of a major capital project.

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Table 3: Site Screening Inventory Summary Table and Recommendations

<table>
<tr><th>Site Info</th><th>Pros, Cons, and Recommendations</th><th colspan="4">Development Constraint Findings</th></tr>
<tr><td rowspan="8">Name:
Detour Canyon (with or without Fortin Lake Dam)

Estimated Maximum Size:
65 → 100 MW</td><td rowspan="8">Pros:
▪ No Aquatic Species-at-Risk noted
▪ Good ability to meet long term outlook (50 year) future energy gaps
▪ Terrestrial Species-at-Risk noted, but no major constraints expected
Cons:
▪ River deemed as having a high suitability for fish habitat (in both the Detour Canyon and Fortin Lake areas)
▪ Anvil Creek (which is flooded) is a Special Consideration zone for fisheries
▪ Presence of Land Tenure, First Nations Settlement Lands, and Interim Projected Lands
▪ Potential Transboundary issues as per Yukon River Salmon Agreement with USA
▪ The 100 MW version (with Fortin Dam) is likely oversized
▪ Fortin Lake Dam Only: Terrestrial SAR flagged as having moderate mitigation issues
▪ Fortin Lake Dam Only: Constructability risks deemed high
Recommendation: Study further, including scalability analysis to re-evaluate project size (likely resulting in a smaller project)</td><td colspan="2">Area of Study</td><td>Without Fortin Dam</td><td>With Fortin Dam</td></tr>
<tr><td rowspan="3">1</td><td>Enviro. (Fisheries)</td><td>H</td><td>H</td></tr>
<tr><td>Enviro. (Aquatic SAR)</td><td>L</td><td>L</td></tr>
<tr><td>Enviro. (Terrestrial SAR)</td><td>L</td><td>M</td></tr>
<tr><td>2</td><td>Surface/Subsurface Tenure</td><td>H</td><td>H</td></tr>
<tr><td>3</td><td>Constructability</td><td>M</td><td>H</td></tr>
<tr><td rowspan="2">4</td><td>Economic (Meeting Gap)</td><td>L</td><td>L</td></tr>
<tr><td>Economic (Size vs. Need)</td><td>M</td><td>H</td></tr>
<tr><td rowspan="8">Name:
False Canyon

Estimated Maximum Size:
58 MW</td><td rowspan="8">Pros:
▪ Constructability risks deemed low
▪ Good ability to meet long term outlook (50 year) future energy gaps
Cons:
▪ Relocation of existing highways and bridges required
▪ Frances Lake (which is flooded) is noted as fisheries Conservation Waters with depressed fisheries stocks
▪ Frances River is flagged for potential Transboundary fisheries issues
▪ Aquatic Species-at-Risk present in watershed
▪ Terrestrial Species-at-Risk flagged as having moderate mitigation issues
▪ Presence of Land Tenure and Interim Projected Lands noted
Recommendation: Study further, including scalability analysis to re-evaluate project size</td><td colspan="2">Area of Study</td><td colspan="2">False Canyon</td></tr>
<tr><td rowspan="3">1</td><td>Enviro. (Fisheries)</td><td colspan="2">H</td></tr>
<tr><td>Enviro. (Aquatic SAR)</td><td colspan="2">H</td></tr>
<tr><td>Enviro. (Terrestrial SAR)</td><td colspan="2">M</td></tr>
<tr><td>2</td><td>Surface/Subsurface Tenure</td><td colspan="2">H</td></tr>
<tr><td>3</td><td>Constructability</td><td colspan="2">L</td></tr>
<tr><td rowspan="2">4</td><td>Economic (Meeting Gap)</td><td colspan="2">L</td></tr>
<tr><td>Economic (Size vs. Need)</td><td colspan="2">M</td></tr>
<tr><td rowspan="8">Name:
Fraser Falls (High & Low)

Estimated Maximum Size:
100 → 300 MW</td><td rowspan="8">Pros:
▪ No Aquatic Species-at-Risk noted
▪ Good ability to meet long term outlook (50 year) future energy gaps
Cons:
▪ River deemed as having a high suitability for fish habitat
▪ Horseshoe Slough (which is flooded) is deemed a Habitat Protection Area
▪ Potential Transboundary issues as per Yukon River Salmon Agreement with USA
▪ Terrestrial Species-at-Risk flagged as having moderate mitigation issues
▪ Presence of Land Tenure (for High option only) and First Nations Settlement Lands noted
▪ Constructability risks deemed high
▪ Both the 100 MW and 300 MW versions are likely oversized
Recommendation: Study further, including scalability analysis to re-evaluate project size (likely resulting in a smaller project)</td><td colspan="2">Area of Study</td><td>Low Version</td><td>High Version</td></tr>
<tr><td rowspan="3">1</td><td>Enviro. (Fisheries)</td><td>H</td><td>H</td></tr>
<tr><td>Enviro. (Aquatic SAR)</td><td>H</td><td>H</td></tr>
<tr><td>Enviro. (Terrestrial SAR)</td><td>M</td><td>M</td></tr>
<tr><td>2</td><td>Surface/Subsurface Tenure</td><td>H</td><td>H</td></tr>
<tr><td>3</td><td>Constructability</td><td>H</td><td>H</td></tr>
<tr><td rowspan="2">4</td><td>Economic (Meeting Gap)</td><td>L</td><td>L</td></tr>
<tr><td>Economic (Size vs. Need)</td><td>H</td><td>H</td></tr>
<tr><td rowspan="8">Name:
Granite Canyon (Large & Small)

Estimated Maximum Size:
80 → 254 MW</td><td rowspan="8">Pros:
▪ No Aquatic Species-at-Risk noted
▪ Good ability to meet long term outlook (50 year) future energy gaps
Cons:
▪ River deemed as having a high suitability for fish habitat
▪ Needlerock and Mica Creek are Special Consideration Zones
▪ Potential Transboundary issues as per Yukon River Salmon Agreement with USA
▪ Terrestrial Species-at-Risk flagged as having significant mitigation issues
▪ Presence of Land Tenure and First Nations Settlement Lands noted
▪ Constructability risks deemed high
▪ Both the 80 MW and 254 MW versions are likely oversized
Recommendation: Study further, including scalability analysis to re-evaluate project size (likely resulting in a smaller project)</td><td colspan="2">Area of Study</td><td>Small Version</td><td>Large Version</td></tr>
<tr><td rowspan="3">1</td><td>Enviro. (Fisheries)</td><td>H</td><td>H</td></tr>
<tr><td>Enviro. (Aquatic SAR)</td><td>L</td><td>L</td></tr>
<tr><td>Enviro. (Terrestrial SAR)</td><td>H</td><td>H</td></tr>
<tr><td>2</td><td>Surface/Subsurface Tenure</td><td>H</td><td>H</td></tr>
<tr><td>3</td><td>Constructability</td><td>H</td><td>H</td></tr>
<tr><td rowspan="2">4</td><td>Economic (Meeting Gap)</td><td>L</td><td>L</td></tr>
<tr><td>Economic (Size vs. Need)</td><td>H</td><td>H</td></tr>
<tr><td>Name:
Hoole Canyon + Fortin Lake Dam

Estimated Maximum Size:
40 MW</td><td>Pros:
▪ No Aquatic Species-at-Risk noted
▪ Able to meet majority of future energy gaps, although limitations noted when approaching 50 year outlook
Cons:
▪ River deemed as having a high suitability for fish habitat
▪ Potential Transboundary issues as per Yukon River Salmon Agreement with USA
▪ Terrestrial Species-at-Risk flagged as having moderate mitigation issues noted
▪ Presence of Land Tenure and First Nations Interim Protected Lands noted
▪ Constructability risks deemed high
Recommendation: Study Further, including analysis to re-evaluate the balance between project size, reservoir storage, and project impacts.</td><td colspan="2">Area of Study</td><td colspan="2">Hoole Canyon + Fortin Lake Dam</td></tr>
<tr><td rowspan="3">1</td><td>Enviro. (Fisheries)</td><td colspan="2">H</td></tr>
<tr><td>Enviro. (Aquatic SAR)</td><td colspan="2">L</td></tr>
<tr><td>Enviro. (Terrestrial SAR)</td><td colspan="2">M</td></tr>
<tr><td>2</td><td>Surface/Subsurface Tenure</td><td colspan="2">H</td></tr>
<tr><td>3</td><td>Constructability</td><td colspan="2">H</td></tr>
<tr><td rowspan="2">4</td><td>Economic (Meeting Gap)</td><td colspan="2">M</td></tr>
<tr><td>Economic (Size vs. Need)</td><td colspan="2">M</td></tr>
</table>

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Site Info	Pros, Cons, and Recommendations	Development Constraint Findings

Name: Middle (or Lower) Canyon (Large & Small)

Estimated Maximum Size: 14 → 75 MW

Pros:
- Constructability risks deemed low
- Terrestrial Species-at-Risk noted, but no major constraints expected
- Small Version Only: More efficient use of water available (not oversized in medium term outlook)
- Large Version Only: Better ability to meet long term (50 year) future energy gaps

Cons:
- Frances River is flagged for potential Trans-boundary fisheries issues
- Frances Lake (upstream) is noted as fisheries Conservation Waters and depressed fisheries stocks
- Aquatic Species-at-Risk present in watershed
- Presence of Interim Protected Lands noted
- Small version has lesser ability to meet all energy gaps in long term horizon (50 years)
- Large Version Only: Relocation of existing highways and bridges required

Recommendation: Study further, including scalability analysis to re-evaluate project size

	Area of Study	*Small Version*	*Large Version*
1	Enviro. (Fisheries)	H	H
	Enviro. (Aquatic SAR)	H	H
	Enviro. (Terrestrial SAR)	L	L
2	Surface/Subsurface Tenure	H	H
3	Constructability	L	L
4	Economic (Meeting Gap)	H	L
	Economic (Size vs. Need)	L	M

Name: NWPI (Low)

Estimated Maximum Size: 55 MW

Pros:
- Constructability risks deemed low
- Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- River deemed as having a high suitability for fish habitat
- Teslin Lake is flagged for potential Transboundary fisheries issues and potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Possible Aquatic Species-at-Risk in watershed
- Terrestrial Species-at-Risk flagged as having significant mitigation issues noted
- Presence of Land Tenure and First Nations Settlement Lands noted

Recommendation: Study Further, including analysis to re-evaluate the balance between project size, reservoir storage, and project impacts.

	Area of Study	*NWPI (Low)*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	M
	Enviro. (Terrestrial SAR)	H
2	Surface/Subsurface Tenure	H
3	Constructability	L
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	M

Name: Slate Rapids (Diversion Scheme)

Estimated Maximum Size: 42 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps
- Project currently sized closed to long term need (not oversized)

Cons:
- River deemed as having a high suitability for fish habitat
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Terrestrial Species-at-Risk flagged as having moderate mitigation issues
- Presence of Land Tenure and First Nations Interim Protected Lands noted
- Constructability risks deemed high

Recommendation: Study Further, including analysis to re-evaluate the balance between project size, reservoir storage, and project impacts.

	Area of Study	*Slate Rapids (Diversion Scheme)*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	L
	Enviro. (Terrestrial SAR)	M
2	Surface/Subsurface Tenure	H
3	Constructability	H
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	L

Name: Two Mile Canyon

Estimated Maximum Size: 53 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps
- Terrestrial Species-at-Risk noted, but no major constraints expected

Cons:
- River deemed as having a high suitability for fish habitat
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Presence of Land Tenure and First Nations Settlement Lands noted
- Constructability risks deemed moderate

Recommendation: Study further, including scalability analysis to re-evaluate project size

	Area of Study	*Two Mile Canyon*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	L
	Enviro. (Terrestrial SAR)	L
2	Surface/Subsurface Tenure	H
3	Constructability	M
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	M

Name: Upper Canyon (Large, Medium, & Small)

Estimated Maximum Size: 25 → 75 MW

Pros:
- Small Version Only: More efficient use of water available (not oversized in medium term outlook), although limitations noted when approaching 50 year outlook
- Medium and Large Versions Only: Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- Frances Lake (which is flooded) is noted as fisheries Conservation Waters and as having depressed fisheries stocks
- Frances River is flagged for potential Trans-boundary issues
- Terrestrial Species-at-Risk flagged as having significant mitigation issues noted
- Presence of Land Tenure and Interim Protected Lands noted
- Constructability risks deemed high (known bedrock faults in dam area)
- Medium and Large Versions Only: May be over-sized relative to long term need

Recommendation: Study further, including scalability analysis to re-evaluate project size (potentially finding a project that has lower impacts to Frances Lake by operating reservoir within (or closer to) the range of natural lake levels)

	Area of Study	*Small*	*Med*	*Large*
1	Enviro. (Fisheries)	H	H	H
	Enviro. (Aquatic SAR)	H	H	H
	Enviro. (Terrestrial SAR)	H	H	H
2	Surface/Subsurface Tenure	H	H	H
3	Constructability	H	H	H
4	Economic (Meeting Gap)	M	L	L
	Economic (Size vs. Need)	L	M	M

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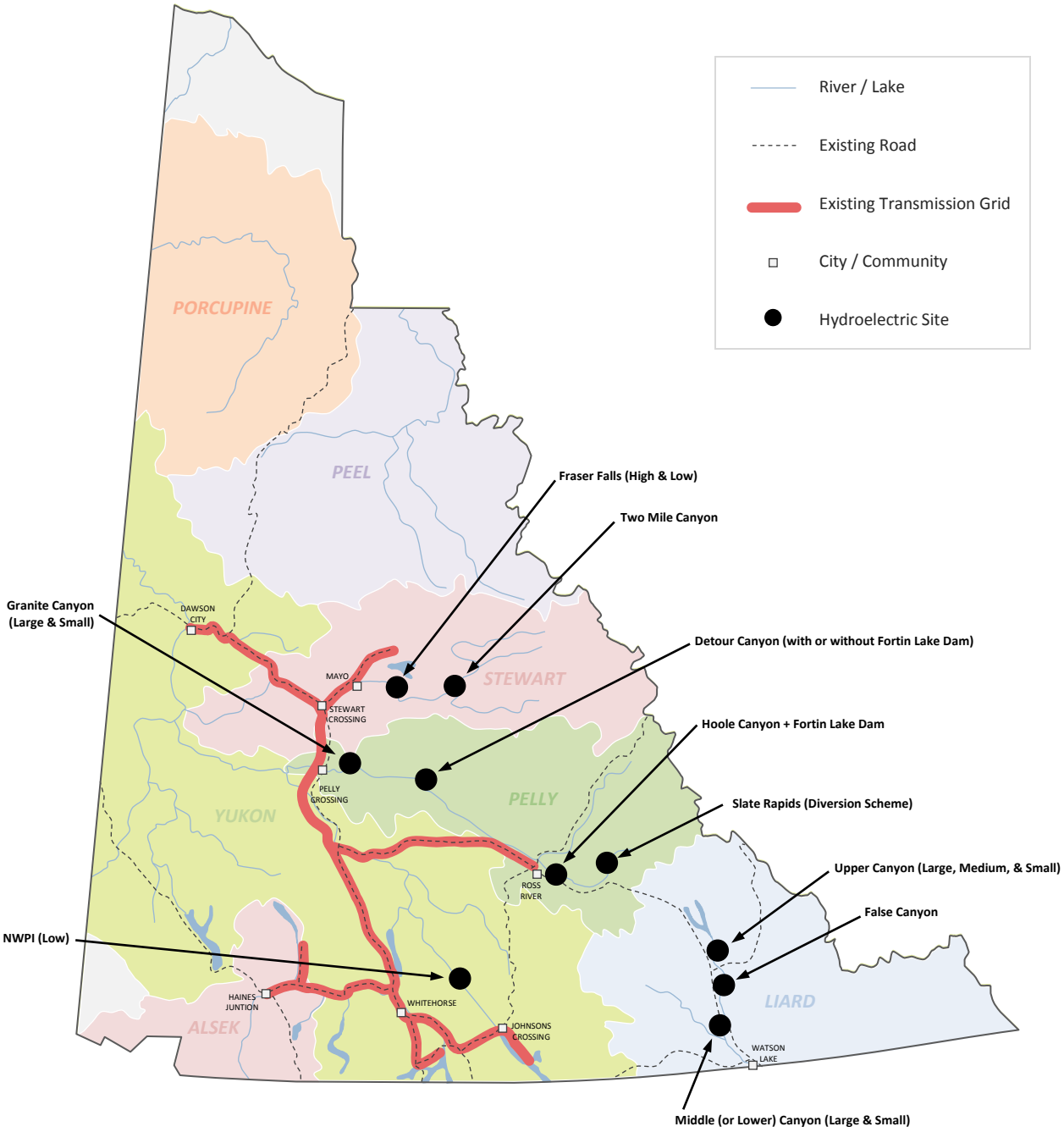
The ten (10) sites of interest (as detailed in Table 3 above) are indicated on a map of the Yukon Territory in Figure 1 below. Drainage basins, major settlements, major roadways, and the existing transmission grid are also included for context.

Figure 1: Site Screening Inventory Map of Final Ten Sites



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1 Introduction

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This report is part of the first deliverable in a series of technical papers with the goal of identifying, evaluating, categorizing, and ranking potential hydroelectric projects in the context of current economic, environmental, and societal expectations. The overall objective of the technical paper series is to narrow the list of potential hydroelectric projects under consideration by YDC from over 200 projects to a few leading candidate sites.

The main objective of the *Site Screening Inventory* is as follows:

> ***OBJECTIVE: Identify a group of hydroelectric sites that represent the best potential for development in the Yukon Territory so that through further study project sizing can be matched to balance the need for electricity with project impacts.***

It is important to emphasize that no work to balance needs and impacts has been completed at this stage of study; therefore previously identified hydroelectric projects have not yet been modified to better match current societal, environmental, and economic expectations. Future studies under the broader *Yukon Next Generation Hydro and Transmission Viability Study* will address the balancing process. The purpose of the *Site Screening Inventory* is to consolidate and screen previously identified hydroelectric projects to locate the top sites for further investigation.

This report presents the methodology, assumptions, and results of the *Site Screening Inventory* completed by Midgard and its team of sub-consultants.

1.1 Assessment Team

The assessment team for the *Site Screening Inventory* consists of the following industry experts:

- *Midgard Consulting Incorporated ("**Midgard**")* - Midgard provides consulting services to the electrical power and utility industry. Midgard is the lead consultant for the *Yukon Next Generation Hydro and Transmission Viability Study*, with specific components of the assignment sub-contracted to other leading industry experts.
- *SLR Consulting Global Environmental Solutions ("**SLR**")* - SLR is part of a multi-disciplinary consultancy providing worldwide environmental sciences, engineering, and socio-economic expertise and high-

value advisory services. SLR is recognized as a global leader in the provision of environmental and engineering consulting services with strong Quality Assurance programs and rigorous Health & Safety Systems. SLR has 19 offices and approximately 200 employees across Canada including an office in Whitehorse, Yukon Territory.

- *Hatfield Consultants ("**Hatfield**")* - Hatfield's core expertise is environmental monitoring and assessment, particularly the design and deployment of environmental evaluation and monitoring programs for aquatic environments. In addition, services include environmental impact assessments, GIS applications, environmental information systems, aquatic ecology, and biodiversity assessments.
- *J.D. Mollard and Associates (2010) Limited* ("**JDMA**") - JDMA has experience reaching back to 1956 and has carried out upwards of 5000 consulting assignments for governments, academia, and private industry, across Canada and around the world. JDMA has a long tradition of excellence in applied civil and geological engineering, geology, hydrogeology, geography, biology, remote sensing, terrain analysis, and environmental studies.
- *Yukon Peer Review Panel ("**YPRP**")* - The YPRP is an internal review panel that is comprised of four senior and respected Yukoners that provide oversight, feedback, and advice at all stages of the project. The four members of the YPRP ensure that a strong Yukon voice, knowledge, and experience is brought to the project from the perspective of long term residents who collectively have over 130 years of experience living in the Yukon Territory.

1.2 Approach to Screening of Potential Sites

The *Site Screening Inventory* is divided into two parts:

1) *Part 1* - Three stages of screening (Screen 0, Screen 1, and Screen 2) identify sites of interest and eliminate sites that have little to no potential for development. The screening includes: reconciliation of known sites based on historic studies, fundamental development barriers, and fundamentally uneconomic sites. Part 1 was completed in January 2015 and resulted in the identification of 16 projects of interest.
2) *Part 2* - Part 2 contains a site ranking based on four areas of general study: Environmental Considerations (Area 1), Surface / Subsurface Tenure Considerations (Area 2), Constructability Considerations (Area 3), and Economic Considerations (Area 4). The findings are combined to rank the 16 projects of interest identified at the end of Part 1 and a recommendation is made to "Short List" sites for further study.

The two-part delivery of the Site Screening Inventory is summarized in Figure 2 below.

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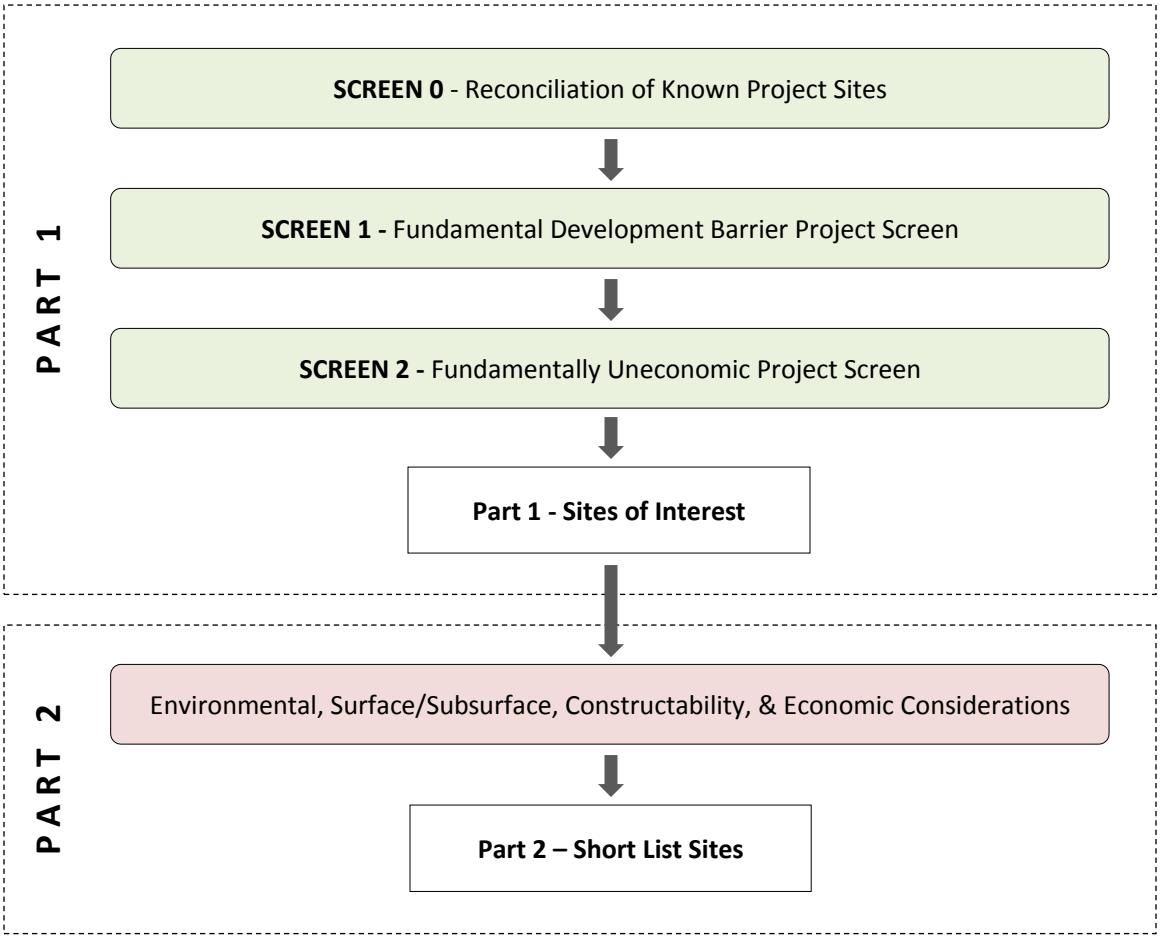
Figure 2: Yukon Hydroelectric Inventory Process



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2 Summary of Part 1 Results

Part 1 of the *Site Screening Inventory* narrowed known hydroelectric projects from 200+ to 16 sites of interest through a three step screening process. The screening stages and respective refinement of potential hydroelectric sites are summarized in Table 4 below:

Table 4: Screening Stages and Resulting Site Refinement

#	Description	Site Refinement
Screen 0	Reconciliation of Known Project Sites	200+ → 108 Sites
Screen 1	Fundamental Development Barrier Project Screen	108 → 47 Sites
Screen 2	Fundamentally Uneconomic Project Screen	47 → 16 Sites

2.1 Summary of Part 1 Methodology

The methodology used in Part 1 of the *Site Screening Inventory* is presented below:

1) ***Screen 0: Reconciliation of Known Project Sites*** - Review and extraction of information from previous reports to create a single, reconciled project listing. The Yukon Development Corporation ("**YDC**") and Yukon Energy Corporation ("**YEC**") provided 25 data sources to Midgard for review. Analysis of these data sources reveals over 200 hydroelectric sites previously studied in the Yukon Territory. A reconciliation and pre-screening process resulted in a list of 108 sites.
2) ***Screen 1: Fundamental Development Barrier Project Screen*** - A "showstopper" screening process to take out projects with a poor development outlook and/or unfavourable economic conditions due to prohibitive features that prevent further project development. These prohibitive features are listed in Table 5.

Table 5: Screen 1 Development Showstoppers

#	Showstopper	Showstopper Descriptions
1	Minimum Project Size	Project, or cluster of scalable projects, is less than or equal to 10 MW in size
2	National Park	Project located in, or inundates (floods), National Park Lands
3	Urban Flooding	Project inundates a titled property or private dwelling within the boundaries of any of the 36 Census Subdivisions (as defined by Statistics Canada) in the Yukon
4	Main Stem of Yukon River Exclusion	Project is located on the main stem of the Yukon River
5	Incorrect Project Type	Projects that are non-hydroelectric generation projects (i.e. water diversion only, water storage only, pumped storage)

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3) ***Screen 2: Fundamentally Uneconomic Project Screen*** - This step was an economic screening of projects remaining at the end of Screen 1. High-level parametric costing models in combination with energy production assumptions result in Levelized Costs of Energy ("**LCOE**") for the listed projects. Fundamentally uneconomic projects were screened out from further study.

2.2 Summary of Part 1 Results

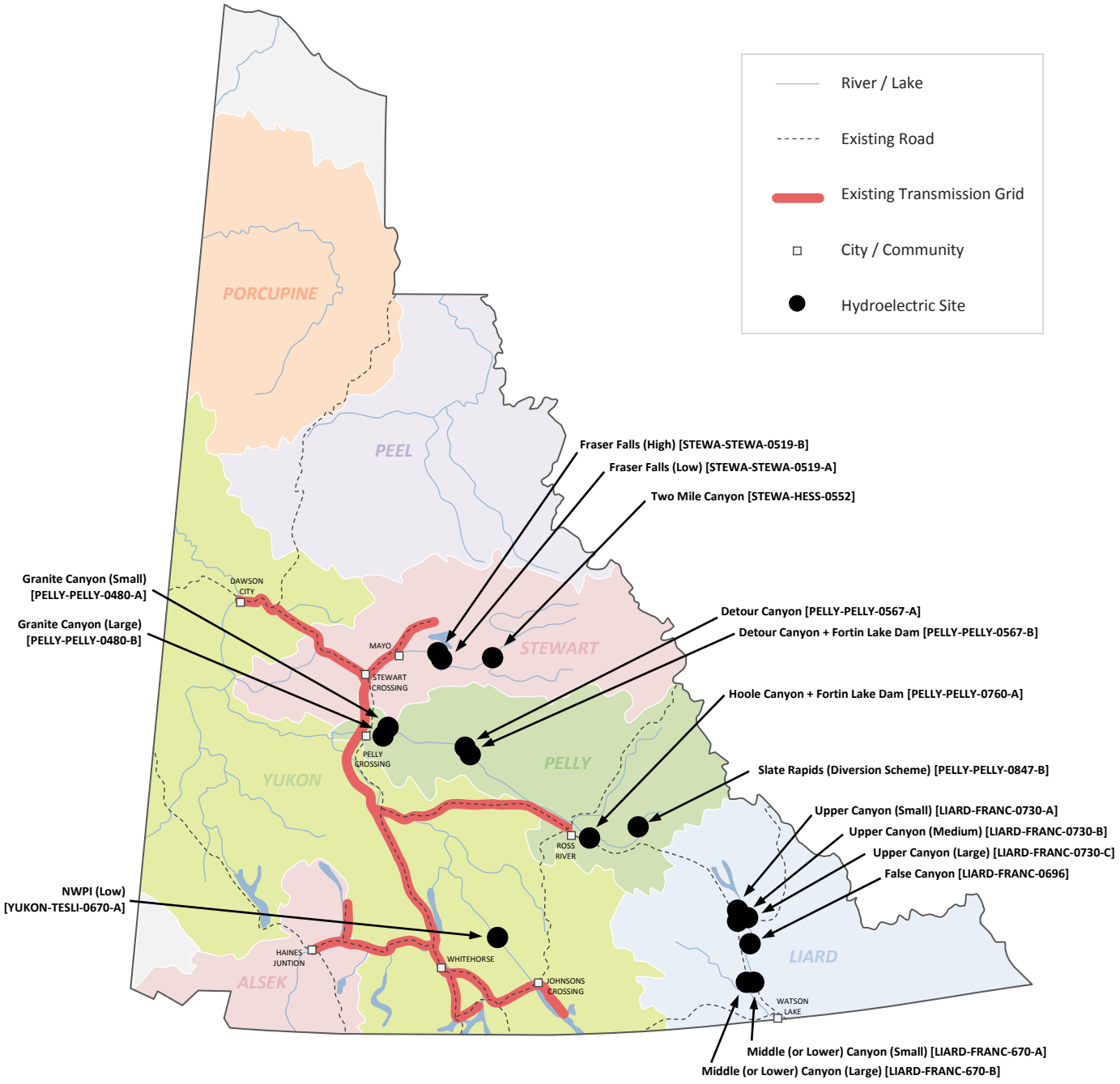
The complete listing of Part 1's 16 sites of interest is shown in Table 6 below (sorted alphabetically and not in any preferred order or ranking). The 16 site of interest listed in Table 6 represent the scope of study and starting point for Part 2 of the *Site Screening Inventory*.

Table 6: Site Screening Inventory Part 1 – Sites of Interest

Project Name	Site ID	Estimated Maximum Size (MW)
Detour Canyon	PELLY-PELLY-0567-A	65
Detour Canyon + Fortin Lake Dam	PELLY-PELLY-0567-B	100
False Canyon	LIARD-FRANC-0696	58
Fraser Falls (High)	STEWA-STEWA-0519-B	300
Fraser Falls (Low)	STEWA-STEWA-0519-A	100
Granite Canyon (Large)	PELLY-PELLY-0480-B	254
Granite Canyon (Small)	PELLY-PELLY-0480-A	80
Hoole Canyon + Fortin Lake Dam	PELLY-PELLY-0760-A	40
Middle (or Lower) Canyon (Large)	LIARD-FRANC-0670-B	75
Middle (or Lower) Canyon (Small)	LIARD-FRANC-0670-A	14
NWPI (Low)	YUKON-TESLI-0670-A	55
Slate Rapids (Diversion Scheme)	PELLY-PELLY-0847-B	42
Two Mile Canyon	STEWA-HESS -0552	53
Upper Canyon (Large)	LIARD-FRANC-0730-C	75
Upper Canyon (Medium)	LIARD-FRANC-0730-B	58
Upper Canyon (Small)	LIARD-FRANC-0730-A	25

In addition to the list above, the 16 sites are mapped and labeled as presented in Figure 3 below.

Figure 3: Site Screening Inventory Part 1 Results Map of Sites



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3 Project Specific Descriptions of Part 1 Hydroelectric Projects

To provide additional context for Part 2 of the *Site Screening Inventory*, a series of summary project descriptions are provided below. The information is largely extracted from previous engineering studies (dating from 1966 to 2011) with some modifications by Midgard to bring projects to an equivalent level of information detail. It is important to emphasize that no work to balance need and impacts has been completed at this stage of study; therefore previously identified hydroelectric projects have not yet been modified to better match current societal, environmental, and economic expectations, and are simply presented as previously designed.

3.1 Detour Canyon [Site ID: PELLY-PELLY-0567-A]

"Detour Canyon", as previously designed, is a potential 65 MW hydroelectric project on the Pelly River, located in the Pelly River Basin approximately 80 km downstream (northwest) of Faro. The total drainage area is estimated to be 28,500 km^2. The project first appeared in T. Ingledow & Associates Limited's report titled "Hydroelectric Resources Survey of the Central Yukon Territory" in 1968. It was subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report and AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Sigma Resource Consultants Limited in 1975, the preliminary project layout includes a single 61 m high earthfill dam straddled by a spillway control structure on the north abutment of the river. The water intake, conveyance, and powerhouse are also located on the north abutment of the river. Two diversion tunnels are located under the south abutment of the Pelly River to facilitate de-watering of the dam site during construction.

Midgard estimates the full supply level of the water reservoir to be 621 meters above sea level, flooding a total area of approximately 135 km^2. Approximately 90 km of new road and 80 km of new transmission line are required to access and interconnect the project.

3.2 Detour Canyon + Fortin Lake Dam [Site ID: PELLY-PELLY-0567-B]

"Detour Canyon + Fortin Lake Dam", as previously designed, is a two dam project that expands on the above mentioned "Detour Canyon" project with the addition of a storage reservoir on Fortin Lake and Pelly Lakes. The Fortin Lake dam is located approximately 95 km east of the community of Ross River and provides additional storage capability by flooding Fortin Lake (15 km^2) and Pelly Lakes (19 km^2). While the design and layout of the main power dam in Detour Canyon remains the same, the additional storage from the upstream Fortin Lake allows for an increased installed capacity of 100 MW (from 65 MW). In addition to the previously mentioned engineering studies in 1968, 1975, and 2009, the 100 MW "Detour Canyon + Fortin Lake Dam" project was also studied in Moneco Consultants Pacific Limted's 1983 "The Inventory of Yukon Hydroelectric Sites" report.

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Civil works for the additional Fortin Lake Dam includes a 20 m high earthfill dam to provide water storage and water flow shaping on the Pelly River. The Fortin Lake dam water reservoir is estimated to be 891 meters above sea level, flooding an additional area of approximately 80 km^2 (for a total combined project flooded area of 215 km^2, 34 km^2 of which is the existing Fortin and Pelly Lakes). Fortin Lake's level would be increased by approximately 9 m and the Pelly Lakes' levels increased by approximately 8 m.

3.3 False Canyon [Site ID: LIARD-FRANC-0696]

"False Canyon", as previously designed, is a potential 58 MW hydroelectric project on the Frances River, located in the Liard River Basin approximately 75 km north of Watson Lake. The total drainage area is estimated to be 12,200 km^2. The project first appeared in T. Ingledow & Associates Limited's report entitled "Power Survey of the Liard River Basin and Northwest Territories" in 1970 and subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report. The False Canyon project was also mentioned in several reports in the early 1980's[1], but most importantly in Shawinigan Stanley's 1982 "False Canyon Prefeasibility Study". Most recently, the project was also included in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Shawinigan Stanley (1982), the preliminary project layout includes a single 50 m high earthfill dam with a spillway structure located on the east abutment of the river. The water intake, conveyance, powerhouse, and tailrace structures are located on the west abutment of the river. River diversion during construction is completed in two stages. Stage one includes in-river culverts to divert water under the dam site. Stage two includes the plugging of the culverts and diversion through the partially completed spillway structures on the east river abutment. Shawinigan Stanley also notes that the relocation of 12 km of existing road and two bridges is required to accommodate flooding. The False Canyon project and the Upper Canyon project are mutually exclusive.

Midgard estimates the full supply level of the water reservoir to be 742 meters above sea level, flooding a total area of approximately 265 km^2 (this includes raising the existing 105 km^2 Frances Lake by 8 m). Assuming a future transmission corridor between Ross River and Watson Lake, less than 10 km of transmission line and less than 10 km of new road are required to interconnect and access the project. Without a future transmission corridor, approximately 310 km of transmission line is required.

3.4 Fraser Falls (High) [Site ID: STEWA-STEWA-0519-B]

"Fraser Falls (High)", as previously designed, is a potential 300 MW hydroelectric project on the Stewart River, located in the Stewart River Basin approximately 40 km upstream of Mayo. The total drainage is estimated to be 30,700 km^2. The project first appeared in T. Ingledow & Associates Limited's report titled "Hydroelectric Resources Survey of the Central Yukon Territory" in 1968. It was subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report, in Moneco

[1] Including Moneco Consultants Pacific Limited's 1980 and 1982 reports and Northwest Hydraulics Consultants Limited's 1982 report

Consultants Pacific Limted's 1983 "The Inventory of Yukon Hydroelectric Sites", and in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Sigma Resource Consultants Limited in 1975, the preliminary project layout includes a single 85 m high rockfill dam straddled by a spillway control structure on the west abutment of the river. The water intake, conveyance, and powerhouse are located on the east abutment of the river. Diversion tunnels are located under the east abutment of the Stewart River to facilitate de-watering of the dam site during construction.

Midgard estimates the full supply level of the water reservoir to be 597 meters above sea level, flooding a total area of approximately 570 km^2. Approximately 40 km of new road and 80 km of new transmission line are required to access and interconnect the project.

3.5 Fraser Falls (Low) [Site ID: STEWA-STEWA-0519-A]

"Fraser Falls (Low)", as previously designed, is a 100 MW hydroelectric project that is a smaller alternative to the above mentioned "Fraser Falls (High)" project. The Fraser Falls (Low) project is located at the same location (approximately 40 km upstream of Mayo on the Stewart River) and has the same estimated drainage area (approximately 30,700 km^2). This smaller version of the Fraser Falls project has been studied in the same reports as the Fraser Falls (High) project (although with no mention in the 1983 Moneco Consultants Pacific Limited report).

As per Sigma Resource Consultants Limited in 1975, the preliminary project layout is identical to "Fraser Falls (High)", with the exception of a smaller 50 m high rockfill dam. Midgard estimates the full supply level of the water reservoir to be 561 meters above sea level, flooding a total area of approximately 240 km^2.

3.6 Granite Canyon (Large) [Site ID: PELLY-PELLY-0480-B]

"Granite Canyon (Large)", as previously designed, is a potential 254 MW hydroelectric project on the Pelly River, located in the Pelly River Basin approximately 20 km east of Pelly Crossing. The total drainage area is estimated to be 45,900 km^2. The project first appeared in T. Ingledow & Associates Limited's report entitled "Hydroelectric Resources Survey of the Central Yukon Territory" in 1968 and subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report. The "Granite Canyon (Large)" project was also mentioned in several reports in the early 1980's[2], but must importantly in Acres Consulting Services Limited's 1982 "Granite Canyon Development Prefeasibility Study". Most recently, the project was also included in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Acres Consulting Services Limited in 1982, the preliminary project layout includes a single 100 m high concrete arch dam with a gated crest spillway structure built into the dam. The water intake, conveyance, powerhouse, and tailrace structures are located on the west abutment of the river. Diversion tunnels are located under the east abutment of the river to facilitate de-watering of the dam site during construction.

[2] Including Northwest Hydraulics Consultants Limited's 1982 report and Moneco Consultants Pacific Limited's 1983 report

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Midgard estimates the full supply level of the water reservoir to be 555 meters above sea level, flooding a total area of approximately 420 km^2. Approximately 15 km of new road and 15 km of new transmission line are required to access and interconnect the project.

3.7 Granite Canyon (Small) [Site ID: PELLY-PELLY-0480-A]

"Granite Canyon (Small)", as previously designed, is an 80 MW hydroelectric project that is a smaller alternative to the above mentioned "Granite Canyon (Large)" project. The Granite Canyon (Small) project is located at the same location (approximately 20 km east of Pelly Crossing) and has the same estimated drainage area (approximately 45,900 km^2) and the larger version of this project.

This smaller alternative was detailed in Acres Consulting Services Limited's 1982 "Granite Canyon Development Prefeasibility Study" and includes provisions to be the first stage of development for the Granite Canyon site. The preliminary project layout is identical to "Granite Canyon (Large)", with the exception of a smaller 50 m high concrete arch dam. As designed, "Granite Canyon (Small)" is meant to be the first stage of hydroelectric development at the site followed by a second stage (involving a second concrete pour to increase the total dam height by 30 m) at a later time.

Midgard estimates the full supply level of the water reservoir to be 525 meters above sea level, flooding a total area of approximately 170 km^2.

3.8 Hoole Canyon + Fortin Lake Dam [Site ID: PELLY-PELLY-0760-A]

"Hoole Canyon + Fortin Lake Dam", as previously designed, is a potential 40 MW hydroelectric project on the Pelly River, with the main power dam located in the Pelly River Basin approximately 30 km upstream of the community of Ross River. The Fortin Lake storage dam is located upstream of the main power dam approximately 95 km east of the community of Ross River, providing additional storage capability by flooding Fortin Lake (15 km^2) and the Pelly Lakes (19 km^2). The total drainage area for the main power dam is estimated to be 9,900 km^2. The project first appeared in T. Ingledow & Associates Limited's report entitled "Hydroelectric Resources Survey of the Central Yukon Territory" in 1968 and was subsequently revisited several times in the 1960's, 1970's, 1980's, and most recently in AECOM Canada Limited's 2010 "Large Hydro Stage 1". The key data source was completed in 1982 by Crippen Consultants, the "Hoole Canyon Hydroelectric Project Prefeasibility Study".

As per Crippen Consultants in 1982, the preliminary project layout includes a 46 m high earthfill power dam with a spillway structure located on the west abutment of the river. The water intake is also located on the west abutment and conveys water into a 600 m buried penstock that cuts across the downstream river meander to the powerhouse. River diversion during construction is completed in two stages. Stage one includes in-river culverts to divert water under the dam site. Stage two includes plugging the culverts and diverting the water through the partially completed spillway structures on the west river abutment. In

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addition to the main power dam, a secondary 20 m high earthfill dam at Fortin Lake is included in the design to provide water storage and water flow shaping on the Pelly River.

Midgard estimates the full supply level of the water reservoir at the main power dam to be 807 meters above sea level, flooding a total area of approximately 25 km^2. The Fortin Lake dam water reservoir is estimated to be 891 meters above sea level, flooding a total area of approximately 80 km^2 (for a total combined project flooded area of 105 km^2, 34 km^2 of which is the existing Fortin and Pelly Lakes). Fortin Lake's level would be increased by approximately 9 m and the Pelly Lakes' levels increased by approximately 8 m. Assuming a future transmission corridor between Ross River and Watson Lake, less than 10 km of transmission line and approximately 50 km of new road are required to interconnect and access the project. Without a future transmission corridor, approximately 85 km of transmission line is required.

3.9 Middle (or Lower) Canyon (Large) [Site ID: LIARD-FRANC-0670-B]

"Middle (or Lower) Canyon (Large)", as previously designed, is a potential 75 MW hydroelectric project on the on the Frances River, located in the Liard River Basin approximately 40 km northwest of Watson Lake. The total drainage area is estimated to be 13,000 km^2. The project first appeared in Sigma Resource Consultants Limited's report entitled "The Development of Power in the Yukon" in 1975 and subsequently revisited in Moneco Consultants Pacific Limited's 1983 "The Inventory of Yukon Hydroelectric Sites" report. Most recently, the project was also included in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Sigma Resource Consultants Limited in 1975, the preliminary project layout includes a single 52 m high concrete dam. The spillway, water intake, and powerhouse are expected to be built within the dam structure in the middle of the channel. River diversion for construction purposes was not detailed in previous reports.

Midgard estimates the full supply level of the water reservoir to be 711 meters above sea level, flooding a total area of approximately 90 km^2 (with no flooding of the existing Frances Lake). Assuming a future transmission corridor between Ross River and Watson Lake, less than 10 km of transmission line and less than 10 km of new road are required to interconnect and access the project. Without a future transmission corridor, approximately 340 km of transmission line is required.

3.10 Middle (or Lower) Canyon (Small) [Site ID: LIARD-FRANC-0670-A]

"Middle (or Lower) Canyon (Small)", as previously designed, is a 14 MW hydroelectric project that is a smaller alternative to the above mentioned "Middle (or Lower) Canyon (Large)". The Middle (or Lower) Canyon (Small) project is located at the same location (approximately 40 km northwest of Watson Lake) and has the same estimated drainage area (approximately 13,000 km^2) as the larger project version.

This smaller project alternative was detailed in T. Ingledow & Associates Limited's 1970 "Power Survey of the Liard River Basin and Northwest Territories" and includes a single 30 m high rockfill dam straddled by a spillway control structure on the northwest abutment of the river. The water intake, conveyance, and

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powerhouse are located on the southeast abutment of the river. River diversion for construction purposes was not detailed in previous reports.

Midgard estimates the full supply level of the water reservoir to be 690 meters above sea level, flooding a total area of approximately 3 km^2 (with no flooding of the existing Frances Lake). Assuming a future transmission corridor between Ross River and Watson Lake, less than 10 km of transmission line and less than 10 km of new road are required to interconnect and access the project. Without a future transmission corridor, approximately 280 km^3 of transmission line is required.

3.11 NWPI (Low) [Site ID: YUKON-TESLI-0670-A]

"NWPI (Low)", as previously designed, is a potential 55 MW hydroelectric project on the Teslin River, located in the Yukon River Basin approximately 65 km downstream of Johnsons Crossing and 60 km east of Whitehorse. The total drainage area is estimated to be 32,800 km^2. The project first appeared in T. Ingledow & Associates Limited's report entitled "Hydroelectric Resources Survey of the Central Yukon Territory" in 1968 and was subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report, in Shawinigan Engineering's 1980 "Teslin River Hydro power Study", in Moneco Consultants Pacific Limited's 1983 "The Inventory of Yukon Hydroelectric Sites" report, and in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Shawinigan Engineering in 1980, the preliminary project layout includes a single 30 m high earthfill dam with an adjacent spillway structure on the west abutment of the river. The combined water intake / powerhouse is also located on the west abutment of the river between the spillway structure and main dam. River diversion for construction purposes was not detailed in previous reports.

Midgard estimates the full supply level of the water reservoir to be 691 meters above sea level, flooding a total area of approximately 55 km^2 (not enough to reach Teslin Lake) Approximately 70 km of new road and 110 km of new transmission line are required to access and interconnect the project.

3.12 Slate Rapids (Diversion Scheme) [Site ID = PELLY-PELLY-0847-B]

"Slate Rapids (Diversion Scheme)", as previously designed, is a potential 42 MW hydroelectric project on the Pelly River, located in the Pelly River Basin approximately 75 km east of the community of Ross River. The total drainage area is estimated to be 5,400 km^2. The project first appeared in Moneco Consultants Pacific Limited's report entitled "Slate Rapids Hydropower Development" in 1983. It was subsequently revisited in A.S. Demers' 1989 "Yukon Energy Corporation: 1989 Hydro Investigations", and in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

[3] Note: This distance is 60 km shorter than the large version of the project as it is considered a low enough installed capacity to connect to the (closer) 25 kV distribution system located in Ross River. For more details on interconnection assumptions, see Appendix B of Part 1 of the *Site Screening Inventory*.

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As per Monenco Consultants Pacific Limited in 1983, the preliminary project layout includes a 43 m high earthfill main dam / spillway and several saddle dams and dykes to contain and divert water south to the proposed intake structure. A penstock conveys water from the intake structure back to a powerhouse located on the Pelly River, approximately 20 km downstream of the main dam. River diversion to accommodate de-watering and construction of the main dam is achieved by diverting water through a partially completed spillway structure on the south abutment of the river.

Midgard estimates the full supply level of the water reservoir to be 892 meters above sea level, flooding a total area of approximately 170 km^2 (34 km^2 of which is the existing Fortin and Pelly Lakes). Fortin Lake's level would be increased by approximately 10 m and the Pelly Lakes' levels increased by approximately 9 m. Assuming a future transmission corridor between Ross River and Watson Lake, less than 10 km of transmission line and less than 10 km of new road are required to interconnect and access the project. Without a future transmission corridor, approximately 145 km of transmission line is required.

Also, Slate Rapids may represent a viable option to replace the Fortin Lake storage dam to provide regulation of water flows in addition to generation (consideration to be given to this option in future studies).

3.13 Two Mile Canyon [Site ID: STEWA-HESS -0552]

"Two Mile Canyon", as previously designed, is a potential 53 MW hydroelectric project on the Hess River, located in the Stewart River Basin approximately 100 km east of Mayo. The total drainage area is estimated to be 14,200 km^2. The project first appeared in T. Ingledow & Associates Limited's report entitled "Hydroelectric Resources Survey of the Central Yukon Territory" in 1968 and was subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report, in Moneco Consultants Pacific Limited's 1983 "The Inventory of Yukon Hydroelectric Sites" report, and in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per T. Ingledow & Associates Limited in 1968, the preliminary project layout includes a single 69 m high concrete dam / spillway / powerhouse structure located within the approximately 2.5 km long rock canyon. Diversion tunnels are the likely choice to facilitate de-watering of the dam site during construction.

Midgard estimates the full supply level of the water reservoir to be 610 meters above sea level, flooding a total area of approximately 105 km^2. Approximately 110 km of new road and 140 km of new transmission line are required to access and interconnect the project.

3.14 Upper Canyon (Large) [Site ID: LIARD-FRANC-0730-C]

"Upper Canyon (Large)", as previously designed, is a potential 75 MW hydroelectric project on the Frances River, located in the Liard River Basin approximately 95 km north of Watson Lake. The total drainage area is estimated to be 11,100 km^2. The project first appeared in T. Ingledow & Associates Limited's report entitled "Power Survey of the Liard River Basin and Northwest Territories" in 1970. It was subsequently revisited in Sigma Resource Consultants Limited's 1975 "The Development of Power in the Yukon" report, in Montreal

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Engineering's 1977 "Francis River – Upper Canyon: Preliminary Study of a 25.2 MW Medium Head Hydro Plant" report, in Moneco Consultants Pacific Limited's 1983 "The Inventory of Yukon Hydroelectric Sites" report, and in AECOM Canada Limited's 2010 "Large Hydro Stage 1" report.

As per Sigma Resource Consultants Limited in 1975, the preliminary project layout includes a 58 m high rockfill dam straddled by a spillway control structure on the south abutment of the river. The water intake, conveyance, and powerhouse are also located on the south abutment of the river and draw from the spillway approach channel. A diversion tunnel located under the north abutment of the Frances River would facilitate de-watering of the dam site during construction. Sigma Resource Consultants Limited also notes that the relocation of 20 km of existing road is required to accommodate flooding. Mapping also indicates that a short control dyke may be required southwest of the main dam to contain the water reservoir. The False Canyon project and the Upper Canyon project are mutually exclusive.

Midgard estimates the full supply level of the water reservoir to be 772 meters above sea level, flooding a total area of approximately 340 km^2 (this includes raising the existing 105 km^2 Frances Lake by 38 m). Assuming a future transmission corridor between Ross River and Watson Lake, less than 10 km of transmission line and less than 10 km of new road are required to interconnect and access the project. Without a future transmission corridor, approximately 290 km of transmission line is required.

3.15 Upper Canyon (Medium) [Site ID: LIARD-FRANC-0730-B]

"Upper Canyon (Medium)", as previously designed, is a 58 MW hydroelectric project that is a smaller alternative to the above mentioned "Upper Canyon (Large)"project. The Upper Canyon (Medium) project is located at the same location (approximately 95 km north of Watson Lake) and has the same estimated drainage area (approximately 11,100 km^2) as Upper Canyon (Large).

This medium project alternative was detailed in Montreal Engineering's 1977 "Francis River – Upper Canyon: Preliminary Study of a 25.2 MW Medium Head Hydro Plant" and includes a single 49 m high dam with intake, spillway, and powerhouse works located at the dam site. Mapping also indicates that a short control dyke may be required southwest of the main dam to contain the water reservoir. The False Canyon project and the Upper Canyon project are mutually exclusive. Midgard estimates the full supply level of the water reservoir to be 768 meters above sea level, flooding a total area of approximately 325 km^2 (this includes raising the existing 105 km^2 Frances Lake by 34 m).

3.16 Upper Canyon (Small) [Site ID = LIARD-FRANC-0730-A]

"Upper Canyon (Small)", as previously designed, is a 25 MW hydroelectric project alternative that is smaller than both the above mentioned "Upper Canyon (Large)" and "Upper Canyon (Medium)" project. The Upper Canyon (Small) project is located at the same location (approximately 95 km north of Watson Lake) and has the same estimated drainage area (approximately 11,100 km^2) as the two larger project variants.

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This smaller alternative was detailed in Montreal Engineering's 1977 "Francis River – Upper Canyon: Preliminary Study of a 25.2 MW Medium Head Hydro Plant" and includes a single 38 m high dam with intake, spillway, and powerhouse works located at the dam site. The False Canyon project and the Upper Canyon project are mutually exclusive. Midgard estimates the full supply level of the water reservoir to be 757 meters above sea level, flooding a total area of approximately 270 km^2 (this includes raising the existing 105 km^2 Frances Lake by 23 m).

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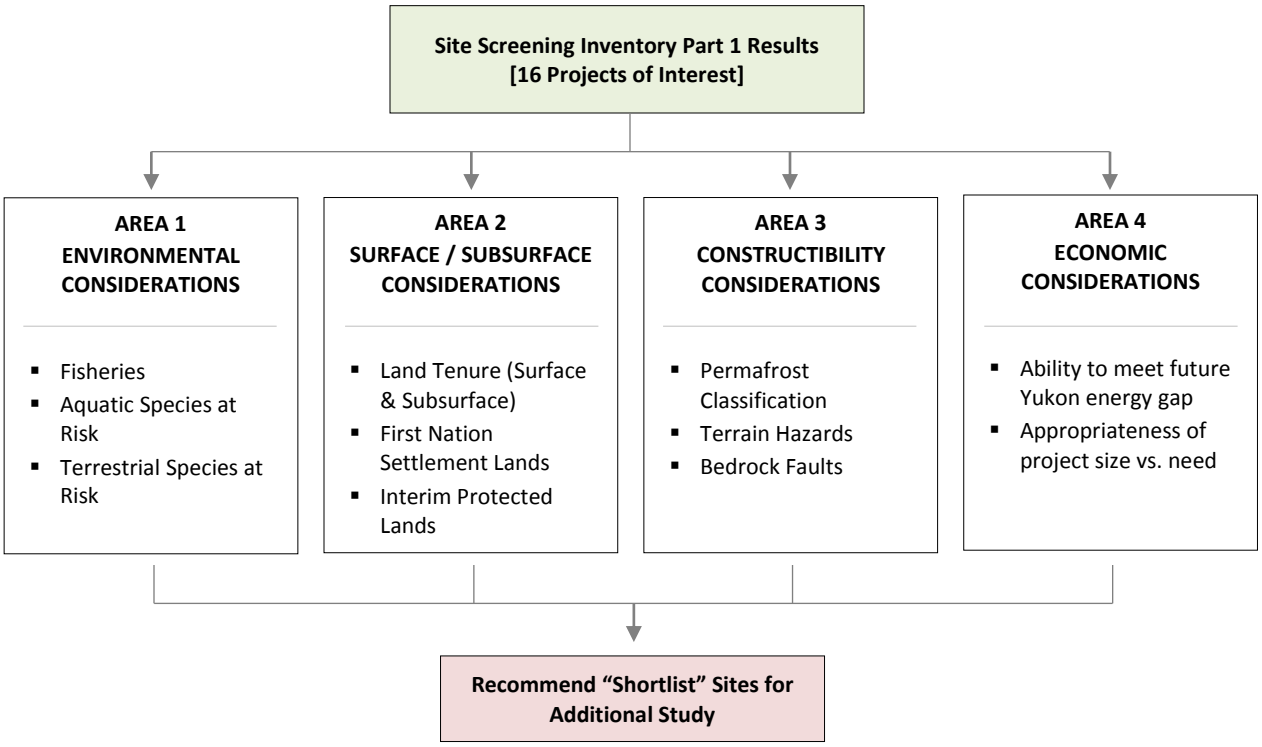
4 Site Screening Inventory Part 2 Process Overview

The methodology, assumptions, and results of Part 2 of the *Site Screening Inventory* are presented within the framework defined in Figure 4 below.

Figure 4: Site Screening Inventory Part 2 Detailed Process



The remainder of this report is structured as per the areas of study as presented in Figure 4 above. The results from each area are subsequently aggregated and an overall project ranking is completed (see Section 9). Finally, a total of 10 sites are recommended for "Shortlisting" and additional study (see Section 9).

A brief introduction to each area is presented below:

- ***Area 1 - Environmental Considerations:*** The Environmental Considerations assessment includes three subsections of study: Fisheries (identifying constraints based on fish habitat suitability and special areas of consideration within project footprints), Aquatic Species at Risk (identifying the presence, potential presence, or known absence of at risk aquatic species), and Terrestrial Species at Risk (identifying the presence, potential presence, or known absence of at risk terrestrial species).
- ***Area 2 – Surface / Subsurface Tenure Considerations:*** The Surface / Subsurface Tenure Considerations assessment aims to identify an initial high level list of potential surface and subsurface land tenure constraints in terms of overlap with reservoir and dam infrastructure footprints. Examples of land tenure considered for this review includes Fee Simple Lands, Leases and

Licenses of Occupation, Quartz Claims, Placer Claims, and other forms of surface and subsurface tenure including First Nations Settlement Lands (i.e.: Category A, Category B, and Fee Simple), and Interim Protected Lands[4]. The mapping exercises also aims to provide initial information for the planning and engagement decision making within the project area, and is part of the support framework for the optimization of hydroelectric infrastructure location selection.

- ***Area 3 – Constructability Considerations:*** Constructability Considerations includes the identification of any terrain issues that may affect the engineering planning and "constructability" of the 16 potential hydro projects. The presence of terrain issues does not preclude the ability to construct a project, it simply indicates there may be an increased risk factor that will need to be considered during the design, planning and construction of the facility. Constructability characteristics that were considered include permafrost classification, terrain hazards, and bedrock faulting.
- ***Area 4 - Economic Considerations:*** The Economic Considerations assessment is designed to understand and quantify the ability of a given project to deliver reliable energy during times of the year with peak power requirements (e.g. winter time). To help accomplish this task, hydroelectric projects will rely on natural river flows plus the ability of the reservoir to store water (or fuel) during low value times and save it for release during peak load times in the winter months. In the Yukon context, this means storing water in the higher natural water flow summer season and releasing water for generation during the lower natural water flow winter months. The ultimate goal is to understand: *how well Yukon hydroelectric projects can match territorial electricity need requirements*.

A colour-coded scoring system is implemented across all areas of study to allow for comparisons and ranking at the end of the report. The three-colour system is detailed in Table 7.

Table 7: Site Screening Inventory Scoring System

Score	Description
H	Parameter poses significant development constraint
M	Parameter poses moderate development constraint
L	Parameter poses no/minor development constraint

Finally, the following areas of study include extensive referencing within the text and in the tables. In an effort to streamline the report, detailed sourcing is separated in Appendix A.

[4] Lands within the traditional territory of non-ratified First Nations that are protected for First Nation Settlement Lands.

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5 Area 1 - Environmental Considerations

The Environmental Considerations area of study is divided into three subsections: Fisheries (Section 5.1), Aquatic Species at Risk (Section 5.2), and Terrestrial Species at Risk (Section 5.3).

5.1 Fisheries

The first area of study under Environmental Considerations looks at generalized fisheries values within the project footprints and assigns scores based on information extracted from the Yukon Placer Secretariat Fish Habitat Management System and the 2014-2015 Yukon Fishing Regulations Summary.

5.1.1 Assessment Methodology

Potential hydroelectric project effects to important fisheries resources have been assessed using the Yukon Placer Secretariat Fish Habitat Management System for Yukon Placer Mining and the 2014-2015 Yukon Fishing Regulations Summary. A breakdown of these data sources is as follows:

- ***Yukon Placer Secretariat Fish Habitat Management System:*** Using a watershed-based approach, the Yukon Placer Fish Habitat Management System was developed as a means of identifying and rating streams in terms of their quality, sensitivity, productive capacity, and suitability for fish. The Fish Habitat Management System was developed by the Yukon government, in conjunction with Fisheries and Oceans Canada and the Council of Yukon First Nations, to guide decision-making for the authorization of Placer Mining activities in the Yukon. Streams in the Yukon are designated with the following classifications based on this system (Table 8).

Table 8: Yukon Fish Habitat Management System Suitability Score Definitions

Habitat Rating	Habitat Description
High	Areas with identified spawning areas for Pacific Salmon [including Chinook (*Oncorhynchus tshawystcha*), chum (*O. keta*), coho (*O. kisutch*), sockeye (*O. nerka*)], Lake Trout (*Salvelinus namaycush*), Rainbow Trout (*O. mykiss*), Bull Trout (*S. confluentus*), and/or Dolly Varden (*S. malma*)
Moderate to High	Areas with highly suitable habitat for rearing juvenile Chinook salmon. May also have high suitability and/or use by resident fish species including whitefish (*Coregonus* sp.), Arctic grayling (*Thymallus arcticus*), and burbot (*Lota lota*).
Moderate	Areas with moderately suitable habitats for rearing juvenile Chinook salmon. May also be highly suitable for resident fish species.
Moderate to Low	Areas containing suitable rearing habitat for Chinook salmon but unlikely to support large densities or abundance of fish due to limiting factors.
Low	Areas that are unsuitable for rearing juvenile Chinook salmon but may be highly suitable and used by resident fish species, including northern pike (*Esox lucius*) and longnose sucker (*Catostomus catostomus*).

Habitat Rating	Habitat Description
Low – Water Quality	Areas that may be inaccessible to fish but that contribute flows and nutrients to downstream habitats.
Areas of Special Consideration	Areas containing fisheries or aquatic resources of ecological (rare or locally significant species) or cultural importance (directly support subsistence, traditional, commercial, or sport fisheries); or areas providing significant, critical linkages to upstream habitats for fish. Areas of Special Consideration include spawning areas and migration routes for chum, coho, sockeye, rainbow trout, bull trout, or Dolly Varden.

The Yukon Placer Watershed Atlas is used to determine the fish habitat rating for each site according to the Yukon Placer Fish Habitat Management System.

- ***2014-2015 Yukon Fishing Regulations Summary:*** The Yukon Fishing Regulations include a designation for Conservation Waters and for Special Management Waters for those waterbodies containing sensitive stocks. Trans-boundary Waters are also identified in the Yukon Fishing Regulations due to their shared management between the Yukon and British Columbia.

Table 9: Yukon Fishing Regulations Definitions

Category	Definition
Conservation Waters	Waters that are protected to allow for stocks to recover, to maintain high quality angling opportunities, or to prevent over-exploitation (for waters that are easily accessible and/or close to communities).
Special Management Waters	Waterbodies that are protected and managed due to declining or depressed stocks, or for a species of interest. Waterbodies designated as Special Management Waters are identified through community and government planning processes, including, but not limited to, community management planning processes, land claims, and Renewable Resources councils.
Transboundary Waters	Trans-boundary refers to fishing regulation between Yukon and British Columbia.

Transboundary Waters are also covered in three additional agreements:

- ***Mackenzie River Basin Transboundary Waters Master Agreement:*** Under the multi-lateral *Mackenzie River Basin Transboundary Waters Master Agreement* signed by the Governments of Canada, British Columbia, Alberta, Saskatchewan, the Northwest Territories, and Yukon (in 1997) the governments commit to cooperative management of the basin.
- ***Yukon-Northwest Territories Transboundary Water Management Agreement:*** A bilateral agreement between the Yukon and Northwest Territories that commits the governments to "cooperatively manage, protect, and conserve the ecological integrity of the aquatic ecosystem of

the Mackenzie River Basin." As such, development of these sites could entail notification and information sharing with the Government of Northwest Territories.

- ***Yukon River Salmon Agreement:*** An agreement between Canada and the United States, under the Pacific Salmon Treaty (Annex IV, Chapter 8), having the principal goal to rebuild and conserve stocks of salmon fisheries and to provide fisheries benefits to both countries.

To conclude, Transboundary Waters were noted based on the Yukon Fishing Regulations, the *Mackenzie River Basin Transboundary Waters Master Agreement*, the *Yukon-Northwest Territories Transboundary Water Management Agreement,* and the *Yukon River Salmon Agreement.*

Each of the 16 potential hydroelectric sites were examined to determine potential fisheries constraints as per the Yukon Placer Fish Habitat Management System ratings and any special designations under the Yukon Fishing Regulations. Studied areas include the dam site, the associated reservoir footprint, and any areas immediately upstream or downstream of the site.

The three stage scoring system is ranked according to the level of constraint (see Table 10).

Table 10: Fisheries Scoring System

Score	Description
H	Projects with a High or Area of Special Consideration designation under the Placer Fish Habitat Management System, and/or projects designated as Conservation Waters or Special Management Waters due to their sensitive nature, and/or projects designated as Trans-boundary Waters, and/or sites that extend into any designated Habitat Protection Areas.
M	Projects with a Moderate or Moderate to High rating or any fishery that was identified as a high quality fishery but not a designated fishery under the Yukon Fishing Regulations.
L	Projects with a Moderate to Low, Low or Low-Water Quality rating, or for any site without an identified high quality fishery or a special designation under the Yukon Fishing Regulations.

5.1.2 Results

All 16 projects of interest receive a score of high (H) as per the Fisheries scoring system defined in Table 10 above. The scored results with supporting commentary for each of the 16 project sites are listed in Table 11 below.

Table 11: Fisheries Scoring Results

Project Name	Fish Habitat Suitability Score	Other Findings	Score
Detour Canyon	High suitability, Special Consideration (Anvil Creek).	Chinook presence noted in watershed. Reservoir extends past Anvil Creek. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H

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Project Name	Fish Habitat Suitability Score	Other Findings	Score
Detour Canyon + Fortin Lake Dam	High, Special Consideration (Anvil Creek). Also, High suitability north of Fortin Lake along Pelly Mainstem to Pelly Lakes, mod-high suitability north of Fortin Lake, mod-low suitability south of Fortin Lake.	Chinook, whitefish, and lake trout presence noted in watershed. Reservoir extends past Anvil Creek. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
False Canyon	No data (area not rated). Bull trout/Dolly Varden presence noted.	Frances Lake noted as Conservation Waters (reservoir floods the lake). Bull trout/Dolly Varden and whitefish presence noted in watershed. Watershed noted as Transboundary (Mackenzie River Basin) under *Yukon-Northwest Territories Transboundary Water Management Agreement.*	H
Fraser Falls (High)	High suitability throughout, including Hess River.	Chum, Chinook, whitefish, and arctic grayling presence noted in watershed. Proposed dam site is located downstream of the Horseshoe Slough Habitat Protection Area and reservoir is expected to extend into the Protection Area. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
Fraser Falls (Low)	High suitability throughout, including Hess River.	Chum, Chinook, whitefish, and arctic grayling presence noted in watershed. Proposed dam site is located downstream of the Horseshoe Slough Habitat Protection Area and reservoir is expected to extend into the Protection Area. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
Granite Canyon (Large)	High suitability, Area of Special Consideration (Needlerock and Mica Creek).	Chinook presence noted in watershed. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
Granite Canyon (Small)	High suitability, Area of Special Concern (Needlerock and Mica Creek).	Chinook presence noted in watershed. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H

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Project Name	Fish Habitat Suitability Score	Other Findings	Score
Hoole Canyon + Fortin Lake Dam	High suitability throughout.	Chinook presence noted in watershed. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
Middle (or Lower) Canyon (Large)	No data (area not rated). Bull trout/Dolly Varden presence noted.	Bull trout/Dolly Varden, chum, Arctic cisco, Arctic grayling, and whitefish presence noted in watershed. Watershed noted as Transboundary (Mackenzie River Basin) under *Yukon-Northwest Territories Transboundary Water Management Agreement.* Frances Lake upstream noted as Conservation Waters.	H
Middle (or Lower) Canyon (Small)	No data (area not rated). Bull trout/Dolly Varden presence noted.	Bull trout/Dolly Varden, chum, Arctic cisco, Arctic grayling, and whitefish presence noted in watershed. Watershed noted as Transboundary (Mackenzie River Basin) under *Yukon-Northwest Territories Transboundary Water Management Agreement.* Frances Lake upstream noted as Conservation Waters.	H
NWPI (Low)	High suitability throughout.	Special Management Waters. Chinook, chum, arctic grayling, whitefish, northern pike also noted in watershed. Watershed noted as Trans-boundary (Teslin Lake) under Yukon Fishing Regulation. Watershed also noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
Slate Rapids (Diversion Scheme)	High suitability throughout.	Chinook presence noted in watershed. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H
Two Mile Canyon	High suitability throughout.	Chinook, whitefish, and lake trout presence noted in watershed. Watershed noted as Transboundary (Yukon River Basin) under *Yukon River Salmon Agreement.*	H

Project Name	Fish Habitat Suitability Score	Other Findings	Score
Upper Canyon (Large)	No data (area not rated). Bull trout/Dolly Varden presence noted.	Frances Lake noted as Conservation Waters (reservoir floods the lake). Bull trout/Dolly Varden, chum, Arctic cisco, whitefish, and Arctic grayling noted in watershed. Watershed noted as Transboundary (Mackenzie River Basin) under *Yukon-Northwest Territories Transboundary Water Management Agreement.*	H
Upper Canyon (Medium)	No data (area not rated). Bull trout/Dolly Varden presence noted.	Frances Lake noted as Conservation Waters (reservoir floods the lake). Bull trout/Dolly Varden, chum, Arctic cisco, whitefish, and Arctic grayling noted in watershed. Watershed noted as Transboundary (Mackenzie River Basin) under *Yukon-Northwest Territories Transboundary Water Management Agreement.*	H
Upper Canyon (Small)	No data (area not rated). Bull trout/Dolly Varden presence noted.	Frances Lake noted as Conservation Waters (reservoir floods the lake). Bull trout/Dolly Varden, chum, Arctic cisco, whitefish, and Arctic grayling noted in watershed. Watershed noted as Transboundary (Mackenzie River Basin) under *Yukon-Northwest Territories Transboundary Water Management Agreement.*	H

5.2 Aquatic Species at Risk

The second area of study under the Environmental Considerations area looks at aquatic species at risk within the project footprints and assigns scores based on known presence, potential presence, or known absence.

5.2.1 Assessment Methodology

The Yukon Conservation Data Centre ("**YCDC**") animal track list was used to compile a list of all aquatic species at risk (YCDC 2014). The compiled list includes species designated as endangered, threatened, or of special concern by the Committee on the Status of Endangered Wildlife in Canada (or "**COSEWIC**") or by Canada's *Species at Risk Act* ("**SARA**"). The compiled list also includes species of conservation concern in the Yukon. A coding system (as defined by NatureServe based on rarity, range restrictions, or declining numbers[5]) ranks species as follows:

[5] Data Source: http://explorer.natureserve.org/ranking.htm

- ***S1*** - Critically imperiled due to extreme rarity or steep population declines making species especially vulnerable to extirpation (i.e. local extinction)
- ***S2*** **-** Imperiled due to rarity, restricted range, small number of populations, and/or steep population declines
- ***S3*** **-** Vulnerable to becoming imperiled

Any aquatic species with a S1, S2, or S3 rating are considered "at risk". For the purposes of this ranking system, the "degree of risk" (i.e.: S1, S2, or S3 designation) of the species identified is not used to differentiate projects. That is, species classed as S3 are given the same consideration and weighting as those classed as S1. This choice was made as any noted species at risk (regardless of being S1, S2, or S3) is considered a development constraint.

Given the above, each of the 16 potential hydroelectric sites was examined to determine potential constraints due to aquatic species at risk. The three stage scoring system is ranked according to the level of constraint (see Table 12).

Table 12: Aquatic Species at Risk Scoring System

Score	Description
H	Aquatic species at risk have been documented, are expected to occur, or for any projects areas that extend into protected areas/areas with a depressed stock
M	Aquatic species at risk have not been ruled out and/or there is potential to impact areas with species at risk that cannot be fully ruled out
L	Aquatic species at risk are not documented or expected to be present and where impacts to species at risk are not expected to result from project development

5.2.2 Results

The analysis resulted in the identification of two listed species at risk:

- ***Bull Trout*** - Bull trout are designated as Species of Special Concern under COSEWIC and are awaiting listing under SARA. The species is ranked as an S3 under the Yukon species of conservation concern list.
- ***Dolly Varden Western Arctic Populations*** - The Western Artic populations of Dolly Varden are designated as Species of Special Concern under COSEWIC and are awaiting listing under SARA. The species is ranked as an S3/S4[6] under the Yukon species of conservation concern list (this combination ranking is for species for which there is not sufficient data available to determine whether it is secure

[6] In some cases, Dolly Varden Western Arctic populations can be considered as an S4 rating (uncommon but not rare; some cause for long-term concern due to declines or other factors). For the purposes of this study, Dolly Varden Western Arctic populations have been considered as an S3 classification.

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or potentially vulnerable to becoming imperiled). For the level of study used in the *Site Screening Inventory*, bull trout and Dolly Varden have been considered equivalent. This decision was made due to the difficulty in distinguishing one species from the other in the absence of genetic testing and also due to their similar rankings both federally and by the Yukon government.

One additional species, the Squanga whitefish (*Coregonus* sp.), was noted in the Teslin watershed basin. Squanga whitefish have been designated as a species of Special Concern by COSEWIC. Squanga whitefish are a genetically distinct population of whitefish known to occur in only four lakes in the Yukon, including Squanga Lake (Species at Risk Public Registry 2014). Squanga Lake is located upstream of the proposed "NWPI (Low)" project (Site ID = YUKON-TESLIN-0670-A). Although the current dam location and headpond elevations for "NWPI (Low)" are not expected to impact Squanga Lake, the species' presence has been noted for future considerations.

The scored results for each of the 16 project sites are listed in Table 13 below with corresponding commentary justifying the findings.

Table 13: Aquatic Species at Risk Scoring Results

Project Name	Findings / Notes	# of Species at Risk	Score
Detour Canyon	No Species at Risk noted.	0	L
Detour Canyon + Fortin Lake Dam	No Species at Risk noted.	0	L
False Canyon	Bull trout/Dolly Varden presence noted in watershed.	1	H
Fraser Falls (High)	Proposed dam site is located downstream of the Horseshoe Slough Habitat Protection Area and reservoir is expected to extend into the Protection Area.	0	H
Fraser Falls (Low)	Proposed dam site is located downstream of the Horseshoe Slough Habitat Protection Area and reservoir is expected to extend into the Protection Area.	0	H
Granite Canyon (Large)	No Species at Risk noted.	0	L
Granite Canyon (Small)	No Species at Risk noted.	0	L
Hoole Canyon + Fortin Lake Dam	No Species at Risk noted.	0	L
Middle (or Lower) Canyon (Large)	Bull trout/Dolly Varden presence noted in watershed. This site may affect Frances Lake upstream which has a depressed stock.	1	H

Project Name	Findings / Notes	# of Species at Risk	Score
Middle (or Lower) Canyon (Small)	Bull trout/Dolly Varden presence noted in watershed. This site may affect Frances Lake upstream which has a depressed stock.	1	H
NWPI (Low)	Possibility of Bull trout/Dolly Varden presence noted in watershed. Squanga whitefish noted in Squanga Lake upstream (unlikely to be impacted).	0	M
Slate Rapids (Diversion Scheme)	No Species at Risk noted.	0	L
Two Mile Canyon	No Species at Risk noted.	0	L
Upper Canyon (Large)	Bull trout/Dolly Varden presence noted in watershed. Headpond extends into Frances Lake upstream, which is a designated Conservation Water and which has a depressed stock.	1	H
Upper Canyon (Medium)	Bull trout/Dolly Varden presence noted in watershed. Headpond extends into Frances Lake upstream, which is a designated Conservation Water and which has a depressed stock.	1	H
Upper Canyon (Small)	Bull trout/Dolly Varden presence noted in watershed. Headpond extends into Frances Lake upstream, which is a designated Conservation Water and which has a depressed stock.	1	H

5.3 Terrestrial Species at Risk

The third area of study under Environmental Considerations looks at terrestrial species at risk within the project footprints and assigns scores based on known presence, potential presence, or known absence.

5.3.1 Assessment Methodology

The Yukon Conservation Data Centre ("**YCDC**") animal track list was used to generate a list of all amphibians, birds, and mammals at risk (YCDC 2014). The compiled list includes species designated as endangered, threatened, or special concern by the Committee on the Status of Endangered Wildlife in Canada ("**COSEWIC**") or by Canada's *Species at Risk Act* ("**SARA**"). The compiled list also includes species of conservation concern in the Yukon. A coding system (as defined by NatureServe based on rarity, range restrictions, or declining numbers[7]) ranks species as follows:

[7] Data Source: http://explorer.natureserve.org/ranking.htm

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- ***S1*** - Critically imperiled due to extreme rarity or steep population declines making species especially vulnerable to extirpation (i.e. local extinction)
- ***S2*** **-** Imperiled due to rarity, restricted range, small number of populations, and/or steep population declines
- ***S3*** **-** Vulnerable to becoming imperiled

Any species with a S1, S2, or S3 rating are considered "at risk". For the purposes of this ranking system, the "degree of risk" (i.e.: S1, S2, or S3 designation) of the species identified is not used to differentiate projects. That is, species classed as S3 are given the same consideration and weighting as those classed as S1.

A variety of literature and information sources were consulted to identify the home range or territory or any species identified by the above screens. Sources include:

- Yukon Environment's wildlife species accounts and distribution mapping
- YCDC's species at risk spatial database of known occurrences, and
- Environment Yukon's Wildlife Key Area ("**WKA**") mapping. WKA are geographical locations used by wildlife for critical, seasonal life functions, such as ungulate winter ranges, mineral licks, raptor nesting cliffs; they typically represent areas where animals aggregate in large numbers, making populations vulnerable to disturbance or direct habitat loss.

Additional life history and distribution data was gathered from Banfield (1974; mammals), Sinclair et al. (2003; birds), Yukon Environment (2011; bats), Yukon Environment (2013; amphibians), and Adamczewski et al. (2010; caribou).

Combining all of the above information, each of the 16 potential hydroelectric sites was examined to determine potential constraints due to terrestrial species at risk. Sites and their reservoirs were evaluated for their potential overlap and interaction with at-risk species using a 3-tiered ranking system (see Table 14).

Table 14: Terrestrial Species at Risk Scoring System

Score	Description
H	The site has a high potential for difficult-to-mitigate conflict with terrestrial wildlife species at risk because there was a confirmed sighting and/or a species is present in large concentrations at a certain time of year to perform a critical life function.
M	The site has a potential terrestrial wildlife conflict based on overlap with WKA boundaries.
L	The site has no known conflict with wildlife species at risk (i.e.: no known species at risk occurrences, and no overlap with current WKA boundaries).

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5.3.2 Results

This compilation process resulted in a list of 68 species (3 amphibians, 46 birds, and 19 mammals). Each of the species was then screened for potential physical (home range or territory) overlap with, or interaction with, any of the 16 potential hydroelectric project locations. Table 15 presents the results of the Terrestrial Species at Risk scoring.

Table 15: Terrestrial Species at Risk Scoring Results

Project Name	Noted Species at Risk[8]	Commentary	Score
Detour Canyon	*6 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Sharp-tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	No known constraints, however several potential species at risk may be present; most active nest/roost/den sites can likely be mitigated for.	L
Detour Canyon + Fortin Lake Dam	*8 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Peregrine Falcon, Sharp Tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Confirmed bank swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population); overlaps mapped caribou herd.	M
False Canyon	*10 Species* – Pileated Woodpecker, Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Fisher, Western Jumping Mouse, Rusty Blackbird, Bank Swallow	Confirmed barn swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population).	M
Fraser Falls (High)	*8 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Peregrine Falcon, Sharp Tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Overlaps mapped caribou herd.	M
Fraser Falls (Low)	*7 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Sharp Tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Overlaps mapped caribou herd.	M

[8] Aggregate of Yukon Designated Species at Risk (S1, S2, and S3 only), COSEWIC, and SARA

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Project Name	Noted Species at Risk[8]	Commentary	Score
Granite Canyon (Large)	*8 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Trumpeter Swan, Sharp Tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Higher score based on overlap with trumpeter swan habitat area. Overlaps mapped caribou herd.	H
Granite Canyon (Small)	*8 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Trumpeter Swan, Sharp Tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Higher score based on overlap with trumpeter swan habitat area. Overlaps mapped caribou herd.	H
Hoole Canyon + Fortin Lake Dam	*10 Species* – Little Brown Myotis, Columbia Spotted Frog, American Kestrel, Common Nighthawk, Barn Swallow, Western Jumping Mouse, Sharp Tailed Grouse, Rusty Blackbird, Bank Swallow, Northern Mountain Caribou	Confirmed bank swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population); overlaps mapped caribou herd.	M
Middle (or Lower) Canyon (Large)	*10 Species* – Pileated Woodpecker, Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Fisher, Western Jumping Mouse, Rusty Blackbird, Bank Swallow	No known constraints, however several potential species at risk may be present; most active nest/roost/den sites can likely be mitigated for.	L
Middle (or Lower) Canyon (Small)	*8 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Peregrine Falcon, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	No known constraints, however several potential species at risk may be present; most active nest/roost/den sites can likely be mitigated for.	L
NWPI (Low)	*12 Species* – Pileated Woodpecker, Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Fisher, Western Jumping Mouse, Sharp-tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow, Trumpeter Swan	Higher score based on overlap with trumpeter swan habitat area. Overlaps mapped caribou herd.	H

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Project Name	Noted Species at Risk[8]	Commentary	Score
Slate Rapids (Diversion Scheme)	*11 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Woodchuck, Fisher, Western Jumping Mouse, Sharp-tailed Grouse, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Confirmed bank swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population); overlaps mapped caribou herd.	M
Two Mile Canyon	*6 Species* – Little Brown Myotis, American Kestrel, Common Nighthawk, Sharp-tailed Grouse, Rusty Blackbird, Bank Swallow	No known constraints, however several potential species at risk may be present; most active nest/roost/den sites can likely be mitigated for.	L
Upper Canyon (Large)	*12 Species* – Pileated Woodpecker, Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Fisher, Western Jumping Mouse, Trumpeter Swan, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Higher score based on overlap with trumpeter swan habitat area. Confirmed barn swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population); overlaps mapped caribou herd; overlaps trumpeter swan key habitat area.	H
Upper Canyon (Medium)	*12 Species* – Pileated Woodpecker, Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Fisher, Western Jumping Mouse, Trumpeter Swan, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Higher score based on overlap with trumpeter swan habitat area. Confirmed barn swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population); overlaps mapped caribou herd; overlaps trumpeter swan key habitat area.	H
Upper Canyon (Small)	*12 Species* – Pileated Woodpecker, Little Brown Myotis, American Kestrel, Common Nighthawk, Barn Swallow, Fisher, Western Jumping Mouse, Trumpeter Swan, Rusty Blackbird, Northern Mountain Caribou, Bank Swallow	Higher score based on overlap with trumpeter swan habitat area. Confirmed barn swallow within proposed reservoir (colonies are more vulnerable to disturbance than solitary nests as they may harbour a large proportion of a regional population); overlaps mapped caribou herd; overlaps trumpeter swan key habitat area.	H

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6 Area 2 – Surface / Subsurface Tenure Considerations

The second area of study in Part 2 of the *Site Screening Inventory* is Surface / Subsurface Tenure Considerations.

In evaluating the surface / subsurface tenure at this early stage of study, the focus is on identifying potential constraints associated with project activities that may impact surface and subsurface tenure. Mapping surface and subsurface constraints provides a guideline for determining the types of development and project-related activities that can and cannot occur within particular areas. The constraints mapping also aims to provide information for planning and development decision making within the project area, and informs early stage engagement regarding hydroelectric infrastructure location selection. The outcome of the constraints mapping summary is to identify opportunities to minimize direct and indirect adverse land effects.

6.1 Geographic Information System ("GIS") Methodology

6.1.1 Data Sourcing

The process of mapping the surface and subsurface tenure that intersect the proposed reservoir footprints started with compiling tenure information from a range of mostly public domain and government data sources. A total of 74 data sources were compiled for the initial phase of the project and further refined to support the hydroelectric site ranking process.

6.1.2 Generation of Reservoir Elevation Footprints

Water reservoir footprints were generated for each of the proposed project scenarios using two key data sets; an accurate representation of the regional topography (a digital elevation model), and reservoir elevation. Reservoir elevations for each of 16 potential hydroelectric sites are considered (extracted from designs available in previous engineering studies of the projects):

- Full Supply Level ("**FSL**")
- Average Operating Level[9] ("**AOL**")
- Minimum Operating Level ("**MOL**")

Reservoir footprints were extracted from the digital topography based on the FSL, AOL, or MOL elevation values. Each reservoir elevation is assigned a unique identifier that relates to one of the proposed hydro scenarios. Area calculations are performed on all surface and subsurface features that intersect with a reservoir footprint. Reservoir footprints and the areas of overlap with surface and subsurface tenure are then evaluated.

[9] Defined as the average of the FSL and MOL.

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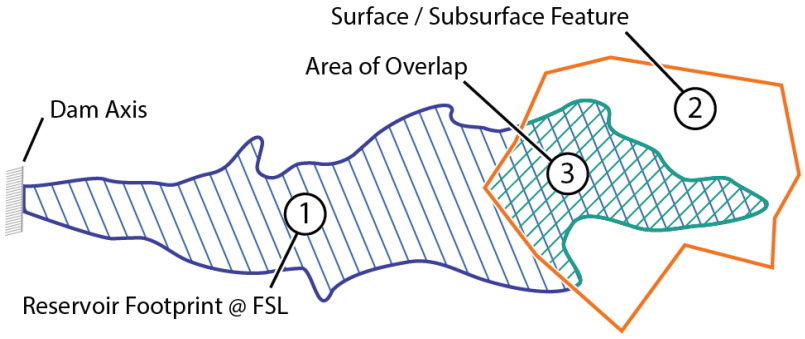
Figure 5 illustrates the relationship between the Surface / Subsurface Feature (labeled as ②), the Reservoir Footprint (labeled as ①), and the area of overlap (labeled as ③) as presented in the summary results in the sections below.

Figure 5: Simple GIS Methodology Illustration



6.1.3 Surface and Subsurface Themes

Area calculations and amounts of intersection for the surface / subsurface tenure considerations are summarized within three themes:

a) ***Land Tenure:*** Investigated land tenure data sources include:
   a. Land Leases
   b. Private Land
   c. Other Surface Tenure, including: land licenses and land dispositions easements
   d. Subsurface Tenure, including: quartz leases, quartz claims, placer claims, placer operations, placer leases, coal leases, coal licenses, coal exploration licenses, and quarry permits

b) ***First Nations Settlement Lands:*** Yukon First Nations and Tetlit Gwich'in settlement lands include both rural blocks (R-block) and Fee Simple lands of the First Nations that have ratified their agreements. Settlement Land is land identified in a First Nation's final agreement as settlement land of the first nation. There are three types of settlement land:
   a. Category A: Complete ownership of surface and subsurface
   b. Category B: Complete ownership of surface only
   c. Fee Simple: Private ownership

   Area calculations were also performed for areas of Settlement Lands that are set out in the Umbrella Final Agreement[10] for hydroelectric or water storage projects. Pursuant to Section 7.8.0 of the

[10] The Umbrella Final Agreement specifically references the hydroelectric potential of the Hess River and the Granite Canyon site on the Pelly River. These potential project sites are located within the Na-Cho Nyak Dun and Selkirk First Nation Settlement Lands, respectively. (*Umbrella Final Agreement between the Government of Canada, the Council for Yukon Indians and the Government of Yukon, signed 1993).*

Umbrella Final Agreement, the Government may expropriate Settlement Land for hydroelectric or water storage projects on the condition that compensation, not exceeding 3% of project construction cost, will be paid to the affected Yukon First Nation.

c) ***Interim Protected Lands:*** Interim Protected lands represent lands within the traditional territory of First Nations that have not yet concluded and ratified a final land claim agreement. Such lands are protected for possible future First Nation settlement land.

6.1.4 Scoring System

Combining all of the above information, each of the 16 potential hydroelectric sites are examined to determine potential surface / subsurface tenure constraints. The 2-tiered ranking system is presented in Table 16.

Table 16: Surface / Subsurface Tenure Considerations Scoring System[11]

Score	Description
H	Presence of any Land Tenure, First Nations Settlement Lands, or Interim Protected Lands.
L	Absence of Land Tenure, First Nations Settlement Lands, and Interim Protected Lands.

6.2 Results

The results are presented in Table 17 (Land Tenure) and Table 18 (Interim Protected Lands and First Nation Settlement Lands). The tables summarize the GIS findings by presenting the percentage of reservoir overlapping the given feature (referring back to Figure 5, this means ③ [Area of Overlap] divided by ① [Reservoir Footprint @ FSL]).

Table 17: Land Tenure

	% of Reservoir Flooded Area Overlapping…			
Site Name	**Land Leases**	**Private Lands**	**Other Surface Tenure**	**Subsurface Tenure**
Detour Canyon	-	-	-	2%
Detour Canyon + Fortin Lake Dam	<1%	-	-	2%
False Canyon	<1%	-	-	<1%
Fraser Falls (High)	<1%	-	-	<1%
Fraser Falls (Low)	-	-	-	-
Granite Canyon (Large)	-	-	-	3%
Granite Canyon (Small)	-	-	-	<1%

[11] Note that, given the current level of study, a simplified binary scoring system for the Surface / Subsurface Tenure Considerations is used based on presence / absence of potential constrains.

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	% of Reservoir Flooded Area Overlapping…			
Site Name	**Land Leases**	**Private Lands**	**Other Surface Tenure**	**Subsurface Tenure**
Hoole Canyon + Fortin Lake Dam	<1%	-	-	2%
Middle (or Lower) Canyon (Large)	-	-	-	-
Middle (or Lower) Canyon (Small)	-	-	-	-
NWPI (Low)	<1%	-	-	-
Slate Rapids (Diversion Scheme)	<1%	-	-	<1%
Two Mile Canyon	-	-	-	4%
Upper Canyon (Large)	<1%	-	-	<1%
Upper Canyon (Medium)	<1%	-	-	<1%
Upper Canyon (Small)	<1%	-	-	<1%

Table 18: Interim Protected Lands and First Nation Settlement Lands

	% of Reservoir Flooded Area Overlapping…	
Site Name	**Interim Protected Lands**	**First Nation Settlement Lands**
Detour Canyon	17%	<1% (with Selkirk First Nation Category B Lands)
Detour Canyon + Fortin Lake Dam	20%	<1% (with Selkirk First Nation Category B Lands)
False Canyon	6%	-
Fraser Falls (High)	-	2% and 11% (with First Nation Na-Cho NyäK Dun Category A and Category B Lands, respectively)
Fraser Falls (Low)	-	1% and 8% (with First Nation Na-Cho NyäK Dun Category A and Category B Lands, respectively)
Granite Canyon (Large)	-	24% and 25% (with Selkirk First Nation Category A and Category B Lands, respectively)
Granite Canyon (Small)	-	19% and 30% (with Selkirk First Nation Category A and Category B Lands, respectively)
Hoole Canyon + Fortin Lake Dam	24%	-
Middle (or Lower) Canyon (Large)	45%	-
Middle (or Lower) Canyon (Small)	24%	-
NWPI (Low)	-	20% and <1% (with Teslin Tlingit Council Category A and Category B Lands, respectively)
Slate Rapids (Diversion Scheme)	26%	-
Two Mile Canyon	-	19% (with First Nation Na-Cho NyäK Dun Category B Lands)
Upper Canyon (Large)	10%	-
Upper Canyon (Medium)	9%	-
Upper Canyon (Small)	5%	-

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With the above information available, the scoring of the 16 projects of interest was completed by assessing presence / absences of Land Tenure, Interim Protected Lands, and First Nation Settlement Lands. The results are listed in Table 19 below.

Table 19: Surface / Subsurface Tenure Considerations Risk Scoring Results

Project Name	Land Tenure	Interim Protected Lands	First Nation Settlement Lands	Score
Detour Canyon	Present	Present	Present	H
Detour Canyon + Fortin Lake Dam	Present	Present	Present	H
False Canyon	Present	Present	-	H
Fraser Falls (High)	Present	-	Present	H
Fraser Falls (Low)	-	-	Present	H
Granite Canyon (Large)	Present	-	Present	H
Granite Canyon (Small)	Present	-	Present	H
Hoole Canyon + Fortin Lake Dam	Present	Present	-	H
Middle (or Lower) Canyon (Large)	-	Present	-	H
Middle (or Lower) Canyon (Small)	-	Present	-	H
NWPI (Low)	Present	-	Present	H
Slate Rapids (Diversion Scheme)	Present	Present	-	H
Two Mile Canyon	Present	-	Present	H
Upper Canyon (Large)	Present	Present	-	H
Upper Canyon (Medium)	Present	Present	-	H
Upper Canyon (Small)	Present	Present	-	H

Finally, a set of supporting map packages are available for Land Tenure (Appendix C), Interim Protected Lands (Appendix D), and First Nation Settlement Lands (Appendix E).

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7 Area 3 – Constructability Considerations

The third area of study in Part 2 of the *Site Screening Inventory* is Constructability Considerations.

The purpose of Constructability Considerations is to identify key geoscientific issues that may impact the design and constructability of the 16 projects of interest. The presence of geoscientific related issues does not preclude the ability to construct a project; it simply indicates there may be increased constructability risks that will need to be considered in the design and construction planning which could increase overall capital and operations costs for the project. The key constructability considerations that were assessed include permafrost classification, terrain hazards, and bedrock faulting.

Permafrost is a thermal condition of soil and rock defined by a 0°C ground temperature (for a minimum period of two years) and when soil moisture occurs as ground ice (Natural Resources Canada, 1993). Permafrost conditions are an important consideration because of the effect on the stability of various terrain types due to a disruption of the ground thermal regime. Permafrost conditions are also affected by topographical, biological, and climatic variables such as vegetation, hydrology, snow cover, and slope orientation (Brown, 1978). Permafrost conditions need to be considered due to potential effects on terrain stability, including slope stability, sediment erosion sources, and other concerns such as project constructability, site monitoring and operations management. Landslide and mass wasting potential is increased by exposure and thawing of ground ice, due to both natural causes (river erosion, forest fires, sustained soil saturation, etc.) and land development activities (Lipovsky and Huscroft, 2007).

7.1 Assessment Methodology

Potential constraints to hydroelectric site development related to local permafrost conditions and terrain hazards were assessed using two sources of geoscientific information:

- ***Empirical-statistical model created by researchers at Queen's University and the University of Ottawa****:* The model is designed to predict the probability of permafrost over an area of 500,000 km^2 in southern Yukon and British Columbia (Bonnaventure et al. 2012). The model is a combination of seven local empirical statistical models, each using the basal temperature of snow method in winter, and extensive ground-truthing of frozen ground presence in summer. Permafrost probability classification zones were adopted from the small-scale, 1:7,500,000 Permafrost Map of Canada (Heginbottom et al. 1995). The permafrost classification zones that were used include: continuous, extensive discontinuous, sporadic discontinuous, and isolated patches. The model presents a number of advantages for geohazard planning relative to previous small-scale maps and local models. The main advantage, for the purposes of this assessment, is that the model is more detailed than previous works and takes into account topography and individual climatic characteristics (e.g. micro climates) of the region at a high-resolution (30 x 30 m grid cells).

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- ***GEOPROCESS File maps developed by the Yukon Geological Survey and Indian and Northern Affairs Canada:*** The GEOPROCESS File is a series of 1:250,000 scale geological maps that present a compilation of information and knowledge on geological processes and terrain hazards, including mass movement processes, permafrost, flooding risks, bedrock faulting, seismic activity, and recent volcanism (Mougeot and Walton, 1999). Various terrain hazards and geological processes can be interpreted using the map units shown in the GEOPROCESS map legend. Each potential hydroelectric site was located on a GEOPROCESS file map, with the exception of "Two Mile Canyon" (Site ID = STEWA-HESS-0552)[12], and potential constraints to development were inferred based on the risk level associated with mapped terrain hazards and geological processes.

In summary, the methodology followed for the constructability assessment is as follows:

- The empirical-statistical permafrost probability model for Yukon and Northern BC is used to locate the potential hydroelectric sites within continuous, extensive discontinuous, sporadic discontinuous, and isolated patches of permafrost classifications zones.
- GEOPROCESS File maps are used to infer risks to development posed by terrain hazards and site-specific geological processes.
- The potential constraint level to hydroelectric development posed by permafrost conditions and terrain hazards for each proposed project is determined.

A numerical weighing system was then applied to the findings as per the following logic:

- ***Permafrost:*** Continuous = 4, Extensive Discontinuous = 3, Sporadic Discontinuous = 2, and Isolated Patches = 1
- ***Terrain Hazards:*** Presence of high risk hazards = 1, Presence of low risk hazards / no hazards = 0

Each project's risk factor rating is then represented by the summation of the permafrost rating and the terrain hazard rating. The highest risk factor rating possible is a "5". The potential hydroelectric sites are categorized into three levels of development constraint determined by bounding the risk factor ratings as per Table 20.

Table 20: Constructability Considerations Scoring System

Score	Description
H	Permafrost type and/or terrain hazards noted are deemed high in risk (risk factor score of 4 or 5)
M	Permafrost type and/or terrain hazards noted are deemed moderate in risk (risk factor score of 3)
L	Permafrost type and/or terrain hazards noted are deemed low in risk (risk factor score of 1 or 2)

[12] Two Mile Canyon STEWA-HESS-0552 is located outside the coverage are of GEOPROCESS file maps. A surficial geology and geomorphology map produced by the Geological Survey of Canada was used to infer the potential for geohazard development constraints (Hughes, 1979).

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7.2 Results

All 16 projects of interest included some form of permafrost (either Extensive Discontinuous or Sporadic Discontinuous type). With regards to terrain hazards, two types are considered high risk:

1) Glaciolacustrine terrain (terrain composed of silt, fine sand, and clay deposited from melting glaciers) with thermokarst (hollows, ridges, fissures, and sinkholes created by the selective melting of permafrost) upgradient or downgradient of potential sites.
2) Bedrock faults located in dam area.

The scored results for each of the 16 project sites of interest are listed in Table 21 below with corresponding commentary describing the permafrost types and any terrain hazards noted (based on GEOPROCCESS map interpretations).

Table 21: Constructability Considerations Scoring Results

Project Name	Permafrost Type	Terrain Hazards Noted	Perma-frost Rating	Terrain Hazard Rating	Total Rating	Score
Detour Canyon	Extensive discontinuous permafrost	No hazards noted	3	0	3	M
Detour Canyon + Fortin Lake Dam	Extensive discontinuous permafrost in main dam area and bordering Fortin Lake dam area	No hazards noted in main dam area, but organic glaciolacustrine terrain with thermokarst in places downgradient of Fortin Lake dam	3	1	4	H
False Canyon	Sporadic discontinuous permafrost	Glaciolacustrine sediments in area	2	0	2	L
Fraser Falls (High)	Extensive discontinuous permafrost	Glaciolacustrine terrrain with thermokarst downgradient of dam site	3	1	4	H
Fraser Falls (Low)	Extensive discontinuous permafrost	Glaciolacustrine terrrain with thermokarst downgradient of dam site	3	1	4	H

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Project Name	Permafrost Type	Terrain Hazards Noted	Perma-frost Rating	Terrain Hazard Rating	Total Rating	Score
Granite Canyon (Large)	Extensive discontinuous permafrost	Small area of glaciolacustrine terrain with thermokarst upgradient of site	3	1	4	H
Granite Canyon (Small)	Extensive discontinuous permafrost	Small area of glaciolacustrine terrain with thermokarst upgradient of site	3	1	4	H
Hoole Canyon + Fortin Lake Dam	Extensive discontinuous permafrost in main dam area and bordering Fortin Lake dam area	Glaciolacustrine sediments in main dam reservoir area; organic glaciolacustrine terrain with thermokarst in places downgradient of Fortin Lake dam	3	1	4	H
Middle (or Lower) Canyon (Large)	Sporadic discontinuous permafrost	Wetlands upgradient of dam location	2	0	2	L
Middle (or Lower) Canyon (Small)	Sporadic discontinuous permafrost	Wetlands upgradient of dam location	2	0	2	L
NWPI (Low)	Sporadic discontinuous permafrost	No hazards noted	2	0	2	L
Slate Rapids (Diversion Scheme)	Extensive discontinuous permafrost	Thermokarst present upgradient and downgradient of dam	3	1	4	H
Two Mile Canyon	Extensive discontinuous permafrost	**There is no GEOPROCESS file coverage for this site;** however, the project is in glacial-fluvial complex which could include minor silt deposits	3	0	3	M

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Project Name	Permafrost Type	Terrain Hazards Noted	Perma-frost Rating	Terrain Hazard Rating	Total Rating	Score
Upper Canyon (Large)	Both extensive discontinuous permafrost and sporadic discontinuous permafrost	Bedrock faults in dam area and wetlands upgradient of dam	3	1	4	H
Upper Canyon (Medium)	Both extensive discontinuous permafrost and sporadic discontinuous permafrost	Bedrock faults in dam area and wetlands upgradient of dam	3	1	4	H
Upper Canyon (Small)	Both extensive discontinuous permafrost and sporadic discontinuous permafrost	Bedrock faults in dam area and wetlands upgradient of dam	3	1	4	H

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8 Area 4 - Economic Considerations

The fourth and final area of study in Part 2 of the *Site Screening Inventory* is Economic Considerations.

Generation assets that have dependable capacity (also called "firm" or "dispatchable" energy) are those assets that can be called on at any time to generate electricity. Assets that generate energy only when their fuel supply is available, but not necessarily when the energy is required by the load, are called intermittent generators. Therefore, the critical difference between a generation resource being firm and dispatchable versus being intermittent is the generator's ability to call on its fuel supply as, and when, needed. In the context of hydroelectric generation, large storage projects (e.g. dams with larger water reservoirs) can be considered as providing more dependable capacity than intermittent generation because water (i.e. fuel) is stored and available when needed. In contrast, hydroelectric projects without storage, also known as run-of-river facilities, can only use the natural river flows (i.e. fuel) as it is available (e.g. more water/fuel is available in the summer and less in the winter).

To determine the ability of different hydroelectric projects to generate energy when it is required in the future (i.e. from 2035 to 2065), Midgard analyzed the ability of the different projects to deliver energy generation (i.e. water flows) in months of higher electricity need. The ability to deliver energy generation is the combination of natural river flows and ability to store water. The ultimate goal is to understand how well Yukon hydroelectric projects can meet territorial winter electricity requirements.

8.1 Assessment Methodology

A storage and energy modeling process is used to measure two key metrics for each of the 16 projects of interest:

- ***Metric 1 - Ability to Meet Future Yukon Energy Gap:*** The forecasted baseline monthly energy gap in 2065 is selected as an indicative year and is extracted from Table D-2 on page 62 of Midgard's "Yukon Electrical Energy and Capacity Need Forecast (2035 to 2065)" report. The monthly baseline energy gap data is presented in Table 22.

Table 22: 2065 Expected Baseline Monthly Energy Gap

Month	Energy Gap (GWh)	Month	Energy Gap (GWh)
Jan	35	Jul	11
Feb	28	Aug	12
Mar	38	Sep	13
Apr	27	Oct	16
May	19	Nov	23
Jun	15	Dec	29

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Project technical parameters (early estimates for hydraulic head, design flow, quantity of live storage, and hydrology[13]) are combined with a logic system (governed by the above defined baseline energy gaps) and produces a quantification of the ability to generate electricity when it is needed. The model provides a single output to measure the effectiveness of the project: *% of 2065 Baseline Monthly Energy Gap Filled*.

- ***Metric 2 - Appropriateness of Project Size (vs. Need):*** A second metric is used to determine how appropriate the project size is in comparison to the need. The main purpose of this metric is to identify any over-sized project designs. The utilization of a project is defined as the energy that is actually produced in a given year divided by the maximum amount of energy that could possibly be produced (assuming unlimited fuel). In the storage and energy model, once a project has generated enough energy to meet the Yukon's need in a given month, the remaining natural water flow is stored if possible (for future use) or otherwise spilled over the dam. Operating in this way, an oversized project would spill a large proportion of the available water (because this water is not used for generation) and therefore result in a low utilization. To measure the appropriateness of project size vs. electricity need, the model outputs a single metric: *Utilization*.

It is noted that at this level of study, no consideration is given to instream flow requirements (i.e. minimum water releases throughout a year to minimize environmental impacts / transboundary issues).

Finally, a scoring system (presented in Table 23) is used to assess specific ranges of the two metrics.

Table 23: Economic Considerations Scoring System

Score	Metric 1: Ability to Meet Future Yukon Energy Gap	Metric 2: Appropriateness of Project Size (vs. Need)
H	Projects that can meet between 0% and 50% of future baseline energy gaps	Projects that have a utilization between 0% and 33%.
M	Projects that can meet between 50% and 75% of future baseline energy gaps	Projects that have a utilization between 34% and 67%.
L	Projects that can meet between 75% and 100% of future baseline energy gaps	Projects that have a utilization between 68% and 100%.

The "high, medium, and low" of the scoring system is used to indicate whether or not the given factor is a barrier to project development. That is, a score of "L" indicates that for the given project, the metric in question represents a "low" barrier to development.

[13] Additional detail on creating the average hydrological string for each site is included in Appendix B.

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8.2 Results

The results of the modeling process are summarized in Table 24. Some additional information is provided in the table, including Live (or "usable") Storage Volume (stated in millions of cubic meters) and Estimated Maximum Size (stated in megawatts).

Table 24: Economic Considerations Scoring Results

			Metric 1: Ability to Meet Future Yukon Energy Gap		*Metric 2: Appropriateness of Project Size vs. Need*	
Project Name	**Est. Max Size (MW)**	**Live Storage (M m³)**	**% of 2065 Baseline Monthly Energy Gap Filled**	**Score**	**Utilization**	**Score**
Detour Canyon	65	1,400	100%	L	47%	M
Detour Canyon + Fortin Lake Dam	100	1,900	100%	L	30%	H
False Canyon	58	1,900	100%	L	36%	M
Fraser Falls (High)	300	7,600	100%	L	10%	H
Fraser Falls (Low)	100	3,400	100%	L	30%	H
Granite Canyon (Large)	254	6,200	100%	L	10%	H
Granite Canyon (Small)	80	1,400	100%	L	25%	H
Hoole Canyon + Fortin Lake Dam	40	700	72%	M	51%	M
Middle (or Lower) Canyon (Large)[14]	75	1,100	100%	L	40%	M
Middle (or Lower) Canyon (Small)[14]	14	40	38%	H	84%	L
NWPI (Low)	55	300	82%	L	45%	M
Slate Rapids (Diversion Scheme)	42	800	94%	L	69%	L
Two Mile Canyon	53	1,200	100%	L	57%	M
Upper Canyon (Large)	75	3,800	100%	L	40%	M
Upper Canyon (Medium)	58	3,800	100%	L	53%	M
Upper Canyon (Small)	25	1,300	74%	M	88%	L

The results listed in Table 24 above indicate that many of the 16 projects of interest are likely too large given the future electrical energy needs of the Yukon, and that many of the projects are able to meet all (or most of) the estimated energy gaps given a 50 year outlook. It is important to note that a poor score in Metric 2

[14] Note that "Middle (or Lower) Canyon (Large)" and the "Middle (or Lower) Canyon (Small)" are designed in previous reports as run-of-river projects (no storage) based on the assumption that they would be constructed as second stage projects after the "Upper Canyon" site, therefore relying on the upstream project to regulate water flows. To fairly assess these two projects on a stand-alone basis, the average drawdown from the other 14 projects has been assumed in order to estimate Live Storage volume.

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does not necessarily indicate a poor site, but rather that the project design is over-sized relative to the forecast electricity need. Future work will re-evaluate project sizes to better balance Yukon electricity needs and project impacts.

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9 Hydroelectric Project Ranking & Recommendations

The final step of Part 2 of the *Site Screening Inventory* is to aggregate the findings from the four areas of study and recommend which projects should advance for further study. The four areas of study are: Environmental Considerations (Area 1), Surface / Subsurface Tenure Considerations (Area 2), Constructability Considerations (Area 3), and Economic Considerations (Area 4).

Table 25 (located on the following page) provides the final summary of the *Site Screening Inventory* results. Note that the 16 projects of interest (identified in the Part 1 report) are consolidated into the 10 underlying site locations they represent. In addition, supporting information and findings are included:

- Range of Installed Capacity (as per previous study designs)
- Summary of site pros and cons
- Recommendations for further study
- Summary of Development Constraints noted, as per the four areas of study (for more details, see Section 4):
    - Area 1 - Environmental Considerations (Fisheries, Aquatic Species-at-Risk ("**SAR**"), and Terrestrial SAR)
    - Area 2 - Surface/Subsurface Tenure Considerations
    - Area 3 - Constructability Considerations
    - Area 4 - Economic Considerations (the ability to meet long term electricity need, and an assessment to determine if the project configuration is appropriately sized)

There are two final notes to highlight:

1) Many of the sites contain previously designed projects that appear too large for the future needs of the Yukon Territory. This does not necessarily indicate a poor site, but rather an over-sized design. Future studies will reduce project sizes to better balance the needs of, and impacts to, the Yukon.
2) Regardless of the project, there will always be challenges when developing a hydroelectric site. These challenges include environmental and socio-economic impacts, surface and subsurface tenure issues, design, engineering, constructability planning, and the overall economics of a major capital project.

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Table 25: Site Screening Inventory Summary Table and Recommendations

Site Info	Pros, Cons, and Recommendations	Development Constraint Findings

Name: Detour Canyon (with or without Fortin Lake Dam)

Estimated Maximum Size: 65 → 100 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps
- Terrestrial Species-at-Risk noted, but no major constraints expected

Cons:
- River deemed as having a high suitability for fish habitat (in both the Detour Canyon and Fortin Lake areas)
- Anvil Creek (which is flooded) is a Special Consideration zone for fisheries
- Presence of Land Tenure, First Nations Settlement Lands, and Interim Projected Lands
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- The 100 MW version (with Fortin Dam) is likely oversized
- Fortin Lake Dam Only: Terrestrial SAR flagged as having moderate mitigation issues
- Fortin Lake Dam Only: Constructability risks deemed high

Recommendation: Study further, including scalability analysis to re-evaluate project size (likely resulting in a smaller project)

	Area of Study	*Without Fortin Dam*	*With Fortin Dam*
1	Enviro. (Fisheries)	H	H
	Enviro. (Aquatic SAR)	L	L
	Enviro. (Terrestrial SAR)	L	M
2	Surface/Subsurface Tenure	H	H
3	Constructability	M	H
4	Economic (Meeting Gap)	L	L
	Economic (Size vs. Need)	M	H

Name: False Canyon

Estimated Maximum Size: 58 MW

Pros:
- Constructability risks deemed low
- Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- Relocation of existing highways and bridges required
- Frances Lake (which is flooded) is noted as fisheries Conservation Waters with depressed fisheries stocks
- Frances River is flagged for potential Transboundary fisheries issues
- Aquatic Species-at-Risk present in watershed
- Terrestrial Species-at-Risk flagged as having moderate mitigation issues
- Presence of Land Tenure and Interim Projected Lands noted

Recommendation: Study further, including scalability analysis to re-evaluate project size

	Area of Study	*False Canyon*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	H
	Enviro. (Terrestrial SAR)	M
2	Surface/Subsurface Tenure	H
3	Constructability	L
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	M

Name: Fraser Falls (High & Low)

Estimated Maximum Size: 100 → 300 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- River deemed as having a high suitability for fish habitat
- Horseshoe Slough (which is flooded) is deemed a Habitat Protection Area
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Terrestrial Species-at-Risk flagged as having moderate mitigation issues
- Presence of Land Tenure (for High option only) and First Nations Settlement Lands noted
- Constructability risks deemed high
- Both the 100 MW and 300 MW versions are likely oversized

Recommendation: Study further, including scalability analysis to re-evaluate project size (likely resulting in a smaller project)

	Area of Study	*Low Version*	*High Version*
1	Enviro. (Fisheries)	H	H
	Enviro. (Aquatic SAR)	H	H
	Enviro. (Terrestrial SAR)	M	M
2	Surface/Subsurface Tenure	H	H
3	Constructability	H	H
4	Economic (Meeting Gap)	L	L
	Economic (Size vs. Need)	H	H

Name: Granite Canyon (Large & Small)

Estimated Maximum Size: 80 → 254 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- River deemed as having a high suitability for fish habitat
- Needlerock and Mica Creek are Special Consideration Zones
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Terrestrial Species-at-Risk flagged as having significant mitigation issues
- Presence of Land Tenure and First Nations Settlement Lands noted
- Constructability risks deemed high
- Both the 80 MW and 254 MW versions are likely oversized

Recommendation: Study further, including scalability analysis to re-evaluate project size (likely resulting in a smaller project)

	Area of Study	*Small Version*	*Large Version*
1	Enviro. (Fisheries)	H	H
	Enviro. (Aquatic SAR)	L	L
	Enviro. (Terrestrial SAR)	H	H
2	Surface/Subsurface Tenure	H	H
3	Constructability	H	H
4	Economic (Meeting Gap)	L	L
	Economic (Size vs. Need)	H	H

Name: Hoole Canyon + Fortin Lake Dam

Estimated Maximum Size: 40 MW

Pros:
- No Aquatic Species-at-Risk noted
- Able to meet majority of future energy gaps, although limitations noted when approaching 50 year outlook

Cons:
- River deemed as having a high suitability for fish habitat
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Terrestrial Species-at-Risk flagged as having moderate mitigation issues noted
- Presence of Land Tenure and First Nations Interim Protected Lands noted
- Constructability risks deemed high

Recommendation: Study Further, including analysis to re-evaluate the balance between project size, reservoir storage, and project impacts.

	Area of Study	*Hoole Canyon + Fortin Lake Dam*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	L
	Enviro. (Terrestrial SAR)	M
2	Surface/Subsurface Tenure	H
3	Constructability	H
4	Economic (Meeting Gap)	M
	Economic (Size vs. Need)	M

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Site Info	Pros, Cons, and Recommendations	Development Constraint Findings

Name: Middle (or Lower) Canyon (Large & Small)

Estimated Maximum Size: 14 → 75 MW

Pros:
- Constructability risks deemed low
- Terrestrial Species-at-Risk noted, but no major constraints expected
- Small Version Only: More efficient use of water available (not oversized in medium term outlook)
- Large Version Only: Better ability to meet long term (50 year) future energy gaps

Cons:
- Frances River is flagged for potential Trans-boundary fisheries issues
- Frances Lake (upstream) is noted as fisheries Conservation Waters and depressed fisheries stocks
- Aquatic Species-at-Risk present in watershed
- Presence of Interim Protected Lands noted
- Small version has lesser ability to meet all energy gaps in long term horizon (50 years)
- Large Version Only: Relocation of existing highways and bridges required

Recommendation: Study further, including scalability analysis to re-evaluate project size

	Area of Study	*Small Version*	*Large Version*
1	Enviro. (Fisheries)	H	H
	Enviro. (Aquatic SAR)	H	H
	Enviro. (Terrestrial SAR)	L	L
2	Surface/Subsurface Tenure	H	H
3	Constructability	L	L
4	Economic (Meeting Gap)	H	L
	Economic (Size vs. Need)	L	M

Name: NWPI (Low)

Estimated Maximum Size: 55 MW

Pros:
- Constructability risks deemed low
- Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- River deemed as having a high suitability for fish habitat
- Teslin Lake is flagged for potential Transboundary fisheries issues and potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Possible Aquatic Species-at-Risk in watershed
- Terrestrial Species-at-Risk flagged as having significant mitigation issues noted
- Presence of Land Tenure and First Nations Settlement Lands noted

Recommendation: Study Further, including analysis to re-evaluate the balance between project size, reservoir storage, and project impacts.

	Area of Study	*NWPI (Low)*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	M
	Enviro. (Terrestrial SAR)	H
2	Surface/Subsurface Tenure	H
3	Constructability	L
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	M

Name: Slate Rapids (Diversion Scheme)

Estimated Maximum Size: 42 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps
- Project currently sized closed to long term need (not oversized)

Cons:
- River deemed as having a high suitability for fish habitat
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Terrestrial Species-at-Risk flagged as having moderate mitigation issues
- Presence of Land Tenure and First Nations Interim Protected Lands noted
- Constructability risks deemed high

Recommendation: Study Further, including analysis to re-evaluate the balance between project size, reservoir storage, and project impacts.

	Area of Study	*Slate Rapids (Diversion Scheme)*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	L
	Enviro. (Terrestrial SAR)	M
2	Surface/Subsurface Tenure	H
3	Constructability	H
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	L

Name: Two Mile Canyon

Estimated Maximum Size: 53 MW

Pros:
- No Aquatic Species-at-Risk noted
- Good ability to meet long term outlook (50 year) future energy gaps
- Terrestrial Species-at-Risk noted, but no major constraints expected

Cons:
- River deemed as having a high suitability for fish habitat
- Potential Transboundary issues as per Yukon River Salmon Agreement with USA
- Presence of Land Tenure and First Nations Settlement Lands noted
- Constructability risks deemed moderate

Recommendation: Study further, including scalability analysis to re-evaluate project size

	Area of Study	*Two Mile Canyon*
1	Enviro. (Fisheries)	H
	Enviro. (Aquatic SAR)	L
	Enviro. (Terrestrial SAR)	L
2	Surface/Subsurface Tenure	H
3	Constructability	M
4	Economic (Meeting Gap)	L
	Economic (Size vs. Need)	M

Name: Upper Canyon (Large, Medium, & Small)

Estimated Maximum Size: 25 → 75 MW

Pros:
- Small Version Only: More efficient use of water available (not oversized in medium term outlook), although limitations noted when approaching 50 year outlook
- Medium and Large Versions Only: Good ability to meet long term outlook (50 year) future energy gaps

Cons:
- Frances Lake (which is flooded) is noted as fisheries Conservation Waters and as having depressed fisheries stocks
- Frances River is flagged for potential Trans-boundary issues
- Terrestrial Species-at-Risk flagged as having significant mitigation issues noted
- Presence of Land Tenure and Interim Protected Lands noted
- Constructability risks deemed high (known bedrock faults in dam area)
- Medium and Large Versions Only: May be over-sized relative to long term need

Recommendation: Study further, including scalability analysis to re-evaluate project size (potentially finding a project that has lower impacts to Frances Lake by operating reservoir within (or closer to) the range of natural lake levels)

	Area of Study	*Small*	*Med*	*Large*
1	Enviro. (Fisheries)	H	H	H
	Enviro. (Aquatic SAR)	H	H	H
	Enviro. (Terrestrial SAR)	H	H	H
2	Surface/Subsurface Tenure	H	H	H
3	Constructability	H	H	H
4	Economic (Meeting Gap)	M	L	L
	Economic (Size vs. Need)	L	M	M